

Jan. 23, 1934.

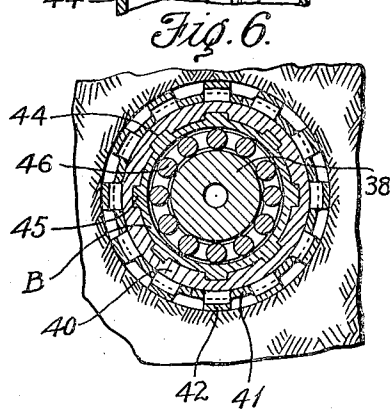
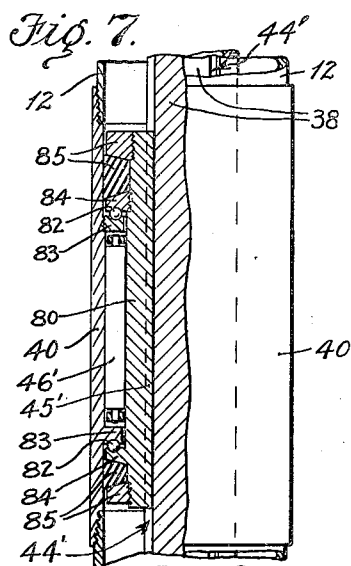
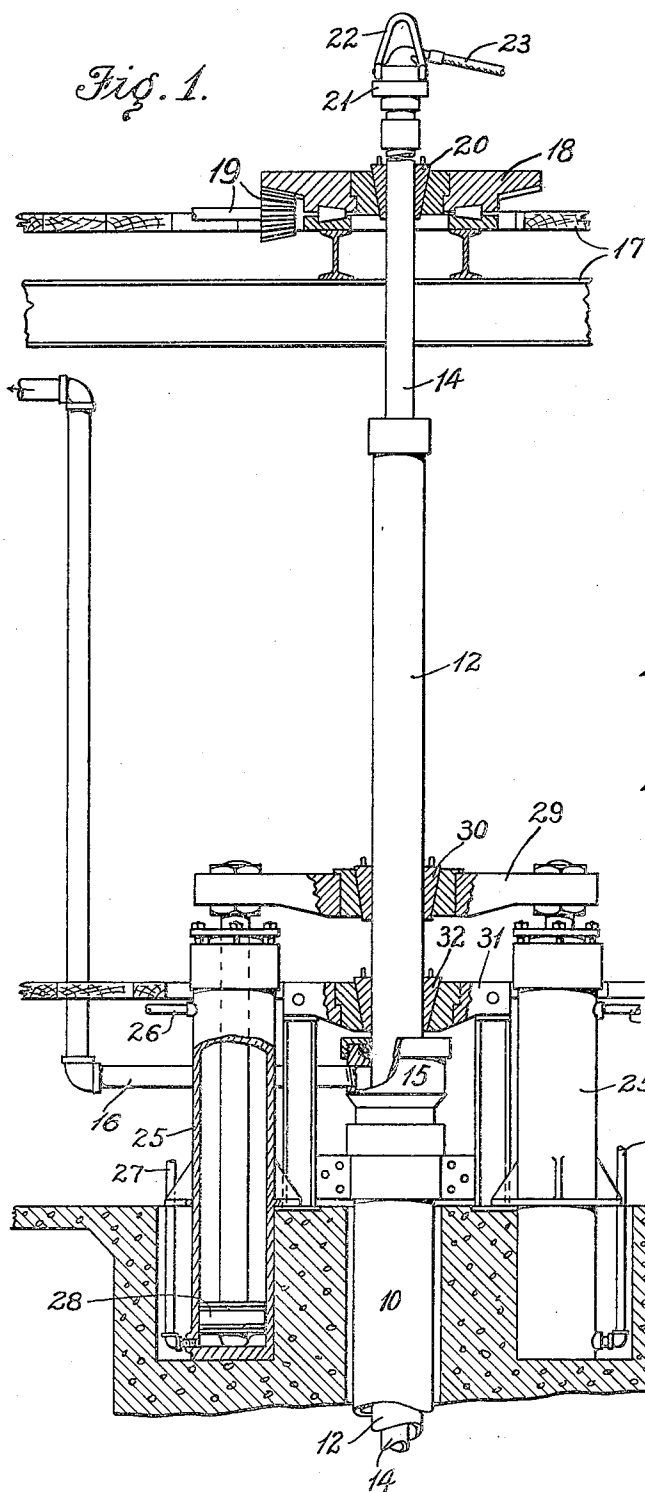
F. F. HILL

1,944,838

METHOD AND APPARATUS FOR CONTROLLING THE ANGLE IN EARTH BORING

Filed March 6, 1929

2 Sheets-Sheet 1



INVENTOR.
Frank F. Hill
 BY *Philip S. Siskow*
 ATTORNEY.

Jan. 23, 1934.

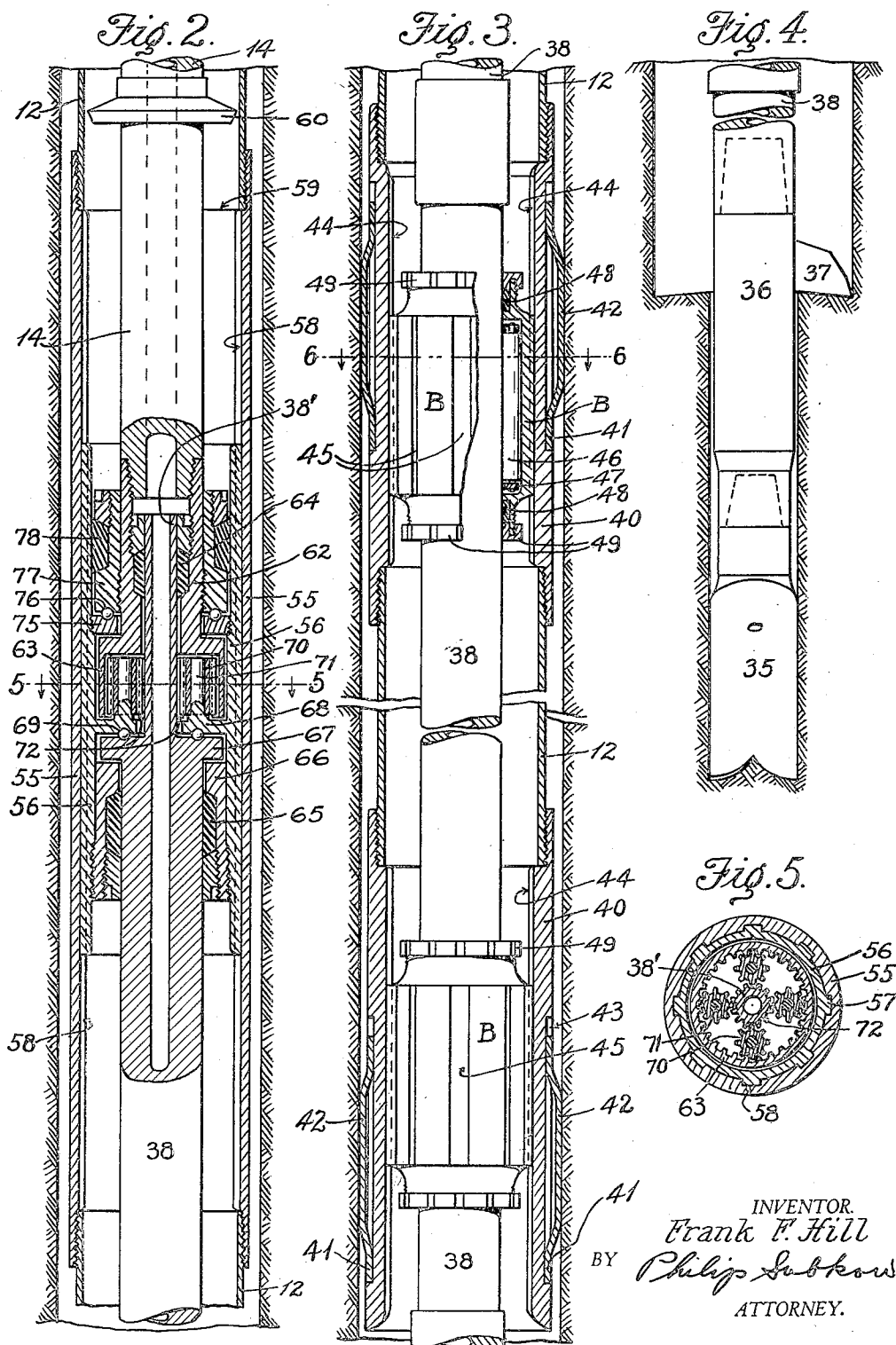
F. F. HILL

1,944,838

METHOD AND APPARATUS FOR CONTROLLING THE ANGLE IN EARTH BORING

Filed March 6, 1929

2 Sheets-Sheet 2



INVENTOR.
Frank F. Hill
 BY *Philip Subkow*
 ATTORNEY.

UNITED STATES PATENT OFFICE

1,944,838

METHOD AND APPARATUS FOR CONTROLLING THE ANGLE IN EARTH BORING

Frank F. Hill, Los Angeles, Calif., assignor to
Union Oil Company of California, Los Angeles,
Calif., a corporation of California

Application March 6, 1929. Serial No. 344,653

11 Claims. (Cl. 255—32)

This invention relates particularly to the art of drilling deep wells, and has been developed especially for use in connection with the drilling of oil wells, although it could be adapted for other purposes and could be extended to horizontal drilling.

As deep well drilling operations have been conducted commonly heretofore, a drill stem carrying a bit on its lower end has been rotated with more or less freedom within a casing extending from the surface to a point somewhat above the drill bit. This free positioning of the drill stem and the bit with respect to the casing and the axis of the hole has permitted variation in the direction of the bit under influences tending to change its direction, with the result that nearly all oil wells which have been surveyed show great variations from the perpendicular and many are badly twisted.

The prime object of the present invention is to present a method and suitable apparatus to be used in conjunction with the method, whereby substantially straight holes may be formed.

In working upon the problem above stated, with a view to overcoming the difficulties mentioned, I have discovered that a substantially straight hole may be drilled where a drill stem is rotated within a casing, by maintaining the lower end of the casing at only a relatively short distance above the bit, maintaining the axis of the casing in fixed relation with the axis of the hole, maintaining the axis of the drill stem in fixed relation with the axis of the casing and of the hole, and lowering the casing substantially simultaneously with the advancement of the bit in order that the necessary mechanical boring devices which retain the relation of the parts may be properly advanced so as to maintain the necessary close proximity of the lower end of the casing to said bit.

In a preferred form guides are provided at properly spaced points on the lower section or sections of the casing to fix the latter with respect to the axis of the hole, and guides in the form of suitable bearings properly spaced serve to position the lower end of the drill stem with respect to the casing so that the relation of the axes remains fixed during all operations. In order to simplify the step of advancing the casing with respect to the drill stem I have found it desirable to provide for a limited amount of longitudinal movement between the drill stem and the casing, this being preferably accomplished by means of splines in the guides. In order that the drill stem and bit may run in and out of the

hole freely without disturbing the casing, a bit is used of size sufficiently small to pass through the guides and a collapsible under-reamer is employed above the bit for reaming out the hole under the end of the casing to permit the casing to advance. It is preferred to circulate drilling mud outside the casing rather than through the casing, and in order to accomplish this the bearings are made to serve at the same time as packers so that the mud may not enter the space above said packers and between the casing and the drill stem. In order to obtain the maximum benefits from the positioning mechanisms, I have found also that it is desirable to rotate the bit at relatively high speeds, and in order to overcome the difficulty of the transmission of high speed to the drill stem at the surface especially when operating at greater depths, a speed step-up device is provided on the drill stem a relatively short distance above the positioning means.

The invention may be stated broadly as residing in rotating a drill stem within a casing which is so mounted at the surface that it may be advanced as the drill advances in order to maintain the inner end of the casing always at only a limited distance from the bit, and in maintaining the axes of the hole, the casing and the bit in fixed relation with respect to one another. The invention also resides in employing means on the lower end of the casing for properly guiding the latter with respect to the walls of the hole, and spaced bearing and guiding means within the lower end of the casing to position the drill stem, these bearing means being spaced by a sufficiently great distance to insure maintenance of proper alignment of the stem with respect to the casing axis. The invention resides further in the use of guides which will permit the withdrawal of the drill stem and bit without disturbing the casing. Another feature of the invention is found in causing the bearing and guiding means between the stem and casing to serve as packing means therebetween in order that mud may be circulated between the casing and the walls of the hole, and may be excluded from the space between the casing and the stem. Also the invention includes the employment of step-up means a short distance above the bit in order that the bit may be driven at high speed from a drill stem which extends to the surface and is there driven by a low speed transmission.

In the accompanying drawings a preferred embodiment of the invention is disclosed by way of illustration.

Fig. 1 representing in elevation the surface mechanisms required for handling the casing and drill stem.

Fig. 2 is a vertical section through the casing and drill stem showing a planetary gear set splined in the casing for vertical movement and provided for the purpose of driving the lower end of the drill stem at a relatively high rate as compared with the rate of rotation of the upper portion of the drill stem.

Fig. 3 is a vertical section through the portion of the drill stem lying below the planetary drive of Fig. 2, and showing a pair of spaced bearings provided upon the lower end of the drill stem for positioning the latter with respect to the casing, said bearings being splined in guides carried by the casing, these guides in turn being provided externally with spaced positioning elements which serve to center the casing within the hole.

Fig. 4 is an elevational detail showing a bit and reamer carried at the lower extremity of the drill stem.

Fig. 5 is a cross section taken on the line 5—5 of Fig. 2 through the planetary gear set.

Fig. 6 is a cross section taken on the line 6—6 of Fig. 3 and showing the construction and mounting of each bearing.

Fig. 7 is a vertical sectional detail showing a modified form of bearing arrangement and construction.

In these drawings a conventional outer conductor casing 10 is shown as being supported from the surface, this casing receiving an inner casing 12 through which a drill stem 14 extends, this drill stem being provided with the usual channel therethrough for the circulation of drilling mud and the casing 10 being provided with a conventional head 15 for the circulation of said mud through the annular space between the casings 10 and 12 and out by the exit pipe 16 leading from said casing head 15. At 17 there is indicated the usual derrick platform provided with a rotary 18 which may be driven through a shaft and gear 19 in order that the drill stem 14 may receive such rotary movement through the medium of slips 20 or other suitable mechanisms for transmitting the motion. The outer end of the drill stem 14 is equipped with a swivel 21 which is provided with a supporting bail 22 and with a mud circulation connection 23 as well understood in the art. By this means the drill stem 14 may be lowered into the well as it is rotated by the table 18 and mud may be simultaneously circulated.

One of the features of this invention resides in the lowering of the inner casing 12 as the drilling proceeds, and for this purpose there is provided a pair of hydraulic jacks 25 having the requisite liquid connections 26 and 27 by means of which the liquid is introduced selectively to the opposite sides of the plungers 28, these plungers serving to actuate a spider 29 having rings and slips 30 to support said inner casing 12. Said rings and slips 30 preferably are reversible from the position shown in order that said casing 12 may be forced downward into the hole if necessary. In order that the casing 12 may be supported independently of the jacks 25, a stationary support 31 provided with slips 32 is located below the spider 29. In this manner said inner casing 12 may be supported at any desired height during adjustment of the jacks 25 or the slips 30.

When a well is being drilled, drill stem 14 car-

ries at its lower end a drill bit 35 of any desired type which is mounted on a section 36 equipped with a reaming element 37, both the bit 35 and the reamer 37 being driven through the medium of a high speed drill bit section 38 carried in the lower part of the casing 12 and driven from the main drill stem 14. Normally the bit 35 and the reamer 37 are positioned only a relatively short distance below the lower end of the said inner casing 12. Usually projection of four or five feet is most efficacious although in some instances comparatively straight holes can be drilled with a projection of as much as twenty feet.

In any event, the lower portion of the casing 12 is provided with two spaced guides 40 within which two spaced bearings generally indicated at B are respectively mounted, these bearings receiving the drill bit stem 38. Each guide 40 is provided externally with positioning devices 41 in the form of sleeves from which spring fingers 42 are cut and struck up so that the middle portions of said spring fingers will engage the walls of the hole and one end of each spring will slide between the portions not outwardly bent and upon the underlying walls of the respective guide 40. For the proper retention of these positioning elements 41, each guide 40 is annularly counter sunk so that the outer face of the guide will be flush with the outer face of the sleeve portions of said elements.

The inner wall of each guide 40 is grooved at 44 to receive splines 45 of the respective bearing B, and the body of said bearing B interiorly receives a plurality of roller bearings 46 upon which the drill bit stem 38 rotates. According to the specific construction shown these bearings 46 are positioned by means of cages 47 or the like, and each bearing B as a unit is held against movement with respect to the stem 38 through the medium of rings 48 rigidly secured upon the stem as by welding or by being shrunk thereupon, collars 49 being threaded upon the extremities of the bearing housing B, as indicated, in order to maintain the relation of the parts and at the same time act as packing means to exclude foreign matter.

It will be noted that the lowermost guide 40 and respective bearing B are located at the lower extremity of the casing 12. The other guide 40 and bearing B are located at such a distance above the lower end of the casing that such spacing will result in maintaining the axis of the stem 38 in fixed relation to the axis of the casing 12, whereby the trend of the bit 35 will be in alignment with the axis of the casing. Since the casing is retained in fixed relation with the axis of the hole by means of the positioning members 41, 42, the constant alignment of the axis will insure a continuously straight hole. The spacing of the guides 40 and the bearings B may be varied somewhat according to conditions and strength of materials, but in nearly all cases will lie within the limits of twenty to forty feet. Thus if the guides 40 and bearings B are spaced at twenty feet apart and the bit 35 extends beyond the lower guide 40 a distance of only four or five feet, the maintenance of the relation of the axes of the drill bit stem, the casing 12 and the hole, will insure a hole with little or no variation in direction.

I have found that the drilling of such a hole may be facilitated to an appreciable extent by driving the lower portion of the drill stem, which portion in the present instance is represented by

the drill bit stem 38, at a considerably higher rate of speed than the usual rate imparted to the main length of the stem 14. In order to accomplish this drive there is a provision for a speed step-up, and a device for this purpose is located in the casing 12 at a relatively short distance above the upper bearing B. This mechanism is shown in Figs. 2 and 5. It comprises a guide 55 set in the casing 12 somewhat after the fashion of the guides 40, and a gear housing 56 provided with splines 57 (Fig. 5) working in grooves 58 in said guide 55. As in the case of the bearings B, the splines provide for a limited amount of longitudinal movement between the guide 55 and the housing 56, but in order that such movement may never be sufficient for the lowermost bearing B to leave its guide 40, the upper edge 59 of the guide 55 is made to underhang the casing 12 thereabove so as to serve as an abutment to be engaged by a stop collar 60 carried by the drill stem 14.

To provide the speed step-up, the lower end of the stem 14 is threaded into the hub 62 of an internal ring gear 63 through which the reduced upper end 38' of the drill bit stem 38 projects, said reduced end 38' being packed within the hub 62 as indicated at 64 to exclude mud passing through the axially aligned bore of the drill stem 14 and the drill bit stem 38. The upper portion of the stem 38 is packed in the housing 56 as indicated at 65 and is retained against downward displacement by means of a hollow nut 66 engaging under an annular flange integral with the stem 38. The housing 56 is provided with a transversely disposed web or partition 68 apertured to receive the reduced sleeve 38. Between the web 68 and the flange or shoulder 67 ball thrust bearings 69 are disposed. The upper side of the web 68 is provided with a plurality of planet gears 70 trunnioned upon spindles 71 extending from said web 68, and these gears 70 mesh both with the internal gear 63 above described and with a pinion or sun gear 72 formed in or carried by the sleeve extension 38'. In this fashion a step-up planetary gear system is provided whereby the drill bit stem 38 may be rotated at a much higher rate of speed than the main drill stem 14. In order that the weight of the drill stem 14 may be relieved from the planetary gear system, an annular ball race 75 is threaded into the upper end of the housing 56 and screwed down to a rigid seat, said race receiving ball thrust bearing 76 upon which there travels a bearing ring 77 which carries a packing 78 to exclude foreign matter from the bearing 76. By the bearing arrangement just described the weight of the stem 14 is transferred by way of ring 77 and balls 76 to the ball race 75 and housing 56, thence through the web or partition 68 and by way of the balls 69 and shoulder 67 to the upper end of the drill bit stem 38.

In operation of the mechanism here disclosed and in accordance with the present method the drill stem 14 is rotated in the usual manner from the rotary table 18, the bit 35 resting upon the bottom of the hole and under-reamer 37 acting to cut out under the casing 12 as indicated in Fig. 4. Drilling mud is introduced to the central bore of the drill stem through the connection 23 and is injected from the bit 35 into the bottom of the hole as usual. But instead of circulating the mud upward outside the bit and within the casing 12, the mud is caused to pass between the said casing 12 and the walls of the

hole through the passage assured by the spacing elements 41, 42, the mud rising thence to the surface and being taken off from casing head 15 through the eduction pipe 16. The fit of the bearings B within the guides 40 and the mounting of the rings 48 and the nuts 49 in relation to the drill stem pipe 38, prevent the passage of appreciable quantities of mud through the annular space between the stem 38 and the casing 12, and the mounting of the lower housing 56 together with the packing 65 further retard such upward passage of mud.

As the drilling proceeds and the drill stem sinks in the hole, the hydraulic jacks 25 are operated to lower the inner casing 12 at a rate approximating the rate of drilling. Since it is awkward if not almost impossible to lower the casing in exact synchronism with the rate of drilling, the splined connections at 44, 45, and 57, 58 are made sufficiently long to permit a reasonable amount of relative motion longitudinally between the drill stem and the casing 12. In this manner the casing 12 may be lowered frequently by small amounts. However, if desired the splined connections could be made sufficiently long to permit of less frequent lowering operations, the amount of movement in each instance being greater than that previously stated. It is desirable in any event that the lowering of the casing follow the advance of the bit rapidly enough to insure proper alignment of the axis of the bit with respect to the axis of the hole at all times, and to prevent a continuation of any possible misalignment which might result if one of the positioning members 41, 42 were to drop into a soft or enlarged spot in the wall of the hole, since a more or less continuous lowering of the casing would result in the early withdrawal of such positioning means from such misaligning spot.

Due to the positioning of the casing in the hole by the members 41, 42, and to the positioning of the drill bit stem 38 and the bearings B, the drilling of a straight hole is assured because of the fact that no opportunity is afforded for the bit to continue in a misaligned direction for any appreciable length of time. The high rate of drilling afforded by the step-up gear set of Figs. 2 and 5 assists the attainment of these conditions. The circulation of the mud between the casing and the walls of the hole serves to insure a clear passage for the casing and proper descent thereof, and at the same time avoids interference of the mud with the respective elements of the bearings B and said gear set.

While the roller bearings 46 for the stem 38 are shown as being in engagement with the stem, and the bearing housing B is shown in Fig. 3 as having a splined connection with the guides 40, this arrangement might be reversed as seen in Fig. 7 in which instance the stem 38 would carry spline grooves 44' and the guide would be the member 80, this part having splines 45' received in grooves 44'; member 40 could then be the bearing and would receive the roller bearings 46'. In this instance ball thrust bearings 82 would be received between ball races 83 on the member 40 and ball races 84 on the guide 80, suitable packing glands 85 being provided to exclude foreign matter.

It is to be understood that the specific disclosures herein are to be considered only as illustrative and not as limiting, since various modifications of the inventions can be made within the

scope of the appended claims by those skilled in the art.

I claim:

1. A method for earth boring comprising lowering a casing into a hole being bored, drilling below the lower end of the casing with a bit driven from a stem rotated within the casing, advancing the casing as the bit advances, circulating mud through the stem and between the casing and the walls of the hole to insure advancement of the casing, and directing the mud stream to prevent entrance of mud into the annular space between said casing and drill stem.

2. A method according to claim 1 wherein the operation of lowering the casing is independent of the operation of lowering the bit.

3. Apparatus for earth boring comprising in combination a casing depending within a hole being bored, a drill stem depending within the casing from the surface, means to rotate the stem, means to lower the casing as the drill advances, means to position the casing with respect to the axis of the hole, means within the casing to position spaced points of the lower portion of the drill stem to maintain the axis of the stem in substantially fixed relation with respect to the axis of the casing, and a speed step-up transmission interposed in the drill stem a short distance above the lower end of the casing.

4. An apparatus for earth boring comprising a casing extending into a hole being bored, a drill stem extending within the casing and having a bit on its inner end projecting somewhat from the inner end of the casing, means to position the drill stem within the casing at spaced points, means to seal the space between the drill stem and the casing, said drill stem having a passage therethrough, and means for forcing mud into the upper end of said passage, whereby mud circulated through said passage will pass upward between the casing and the walls of the hole.

5. Apparatus for controlling the drilling angle in earth boring comprising a casing positioned within a hole being bored, a drill stem within said casing depending from the surface and having a bit on its inner end, means to operate the stem, means to advance the casing as the bit advances, means to position the axis of the casing with respect to the axis of the hole, spaced guides between the casing and the drill stem for maintaining the axis of the bit in fixed relation with respect to the axis of the casing, said guides being non-rotatable with respect to the casing and being slidable axially with respect to the casing.

6. A construction according to claim 5 wherein bearings are provided within said guides between the guides and the drill stem to permit rotation of the latter.

7. Apparatus for controlling the drilling angle in earth boring operations comprising a casing to be lowered in a hole being bored, a drill stem within the casing and having a bit on its inner end, means to operate the stem and bit, means to advance the casing when the bit advances, means for centering the lower end of the casing

within the hole, spaced guides within the lower end of the casing and splined within the casing, bearings for said drill stem within said guides to permit rotation of the stem, certain of said guides and bearings being constructed to serve as packing devices between the casing and stem, said guides and bearings serving to maintain the axis of the bit fixed with respect to the axis of the casing.

8. Apparatus for controlling the drilling angle in earth boring comprising a casing positioned within a hole being bored, means at the surface to support the casing, a drill stem within said casing and having a bit on its inner end, means to operate the stem, means to position the axis of the casing with respect to the axis of the hole, spaced guides between the casing and the drill stem for maintaining the axis of the bit in substantially constant relation with respect to the axis of the casing, said guides being non-rotatable with respect to the casing and being slidable axially with respect to the casing.

9. Apparatus for earth boring comprising a drill stem depending from the surface within a hole being bored, means to rotate said stem from the surface, a bit connected with the lower end of the stem, a speed step-up transmission at a short distance above the bit for rotating the bit at a relatively higher rate of speed, and means between the drill stem and the walls of the hole for maintaining the axis of the bit in substantially fixed relation with respect to the axis of the hole.

10. Apparatus for controlling the drilling angle in earth boring comprising a casing positioned within a hole being bored, a drill stem within said casing and having a bit on its inner end, means to operate the stem, means to advance the casing as the bit advances, means to position the axis of the casing with respect to the axis of the hole, spaced guides between the casing and the drill stem for maintaining the axis of the bit in fixed relation with respect to the axis of the casing, said guides being non-rotatable with respect to the casing and being slidable axially with respect to the casing, said guides serving as packing devices between the drill stem and the casing.

11. Apparatus for controlling the drilling angle in earth boring comprising a casing positioned within a hole being bored, a drill stem within said casing and having a bit on its inner end, means to operate the stem, means to advance the casing as the bit advances, means to position the axis of the casing with respect to the axis of the hole, spaced guides between the casing and the drill stem for maintaining the axis of the bit in fixed relation with respect to the axis of the casing, said guides being non-rotatable with respect to the casing and being slidable axially with respect to the casing, and bearings provided within the guides and between said guides and the drill stem to permit rotation of the latter, said guides and bearings being constructed to act as packing devices between the casing and the stem.

FRANK F. HILL. 140