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EARTH DRILLING APPARATUS

Filed Nov. 23, 1927

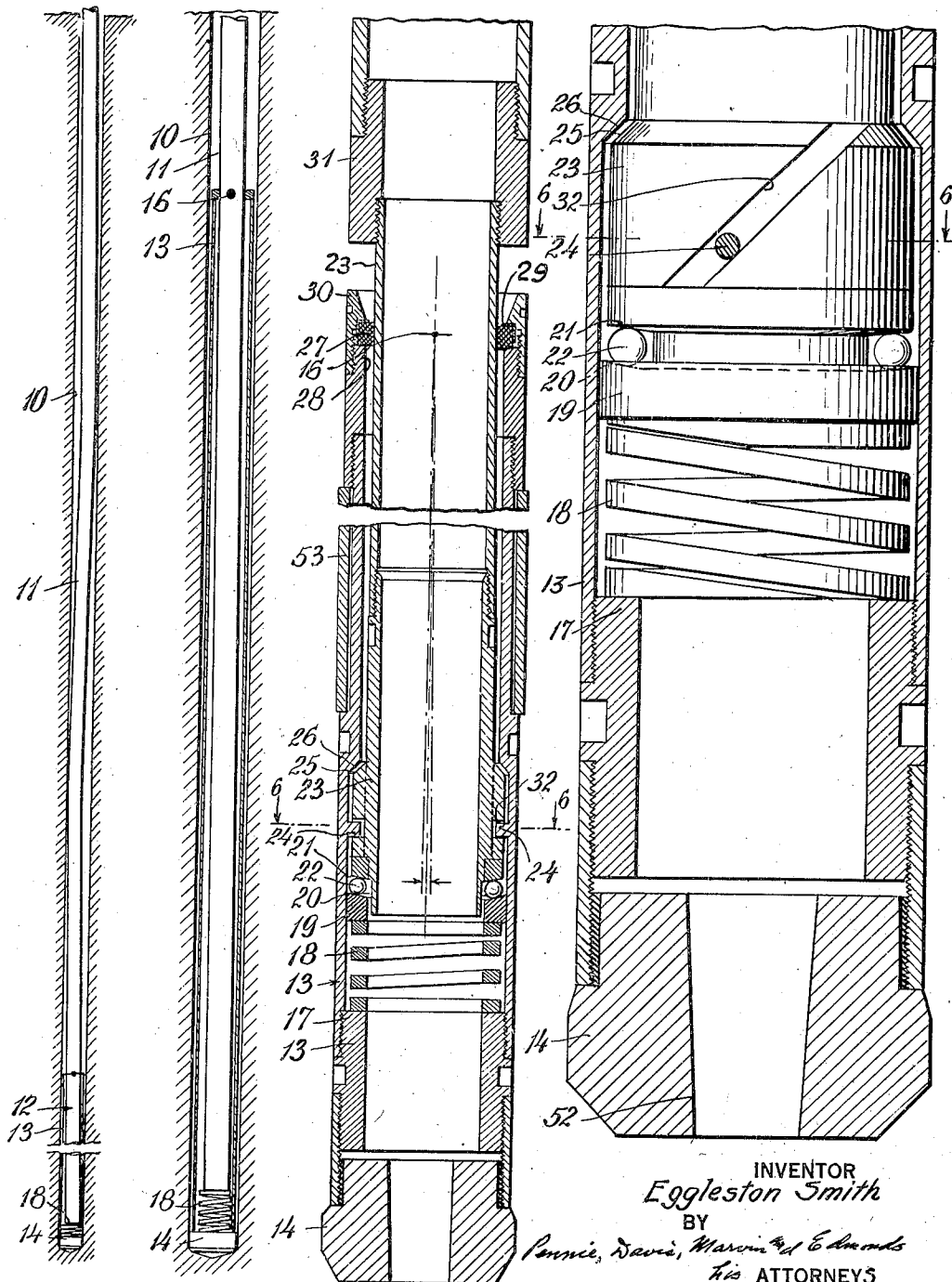
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Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.



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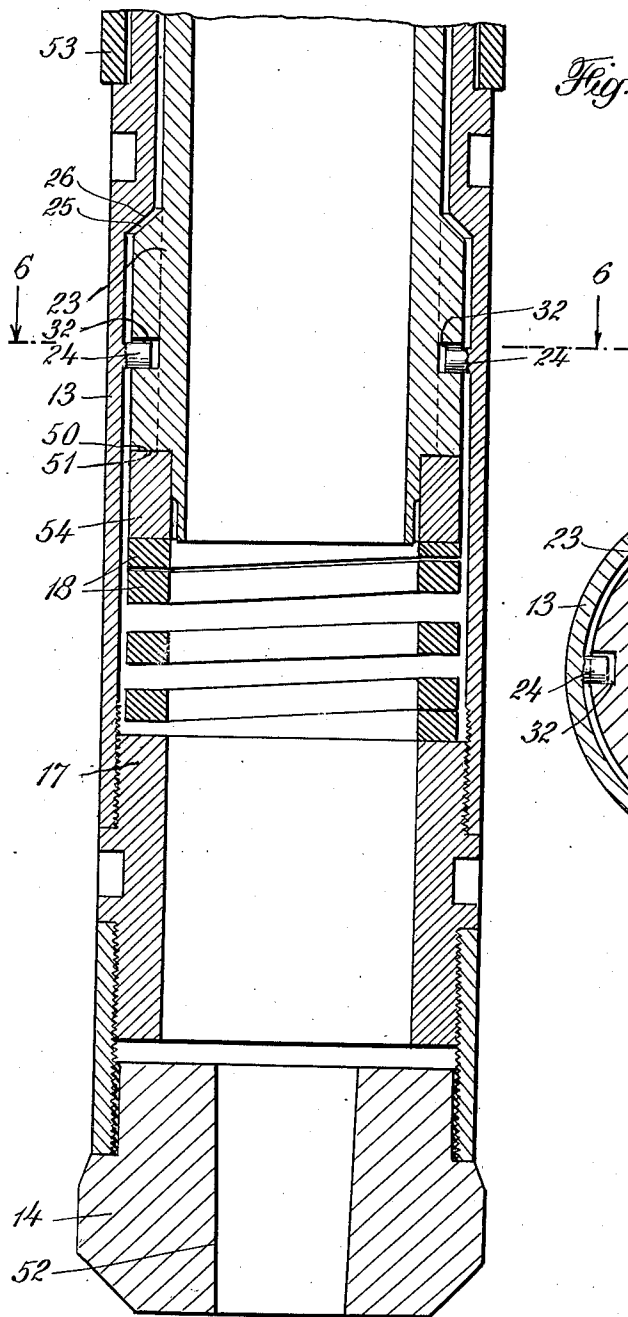
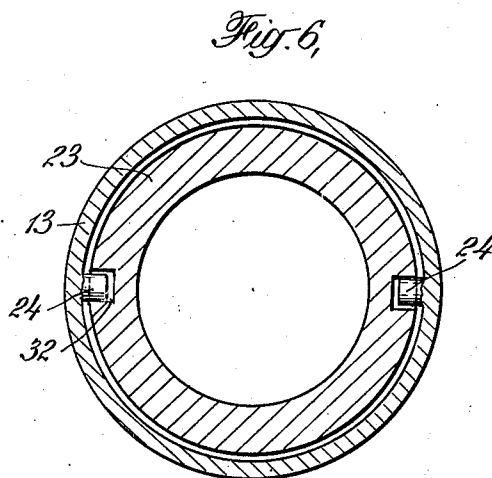
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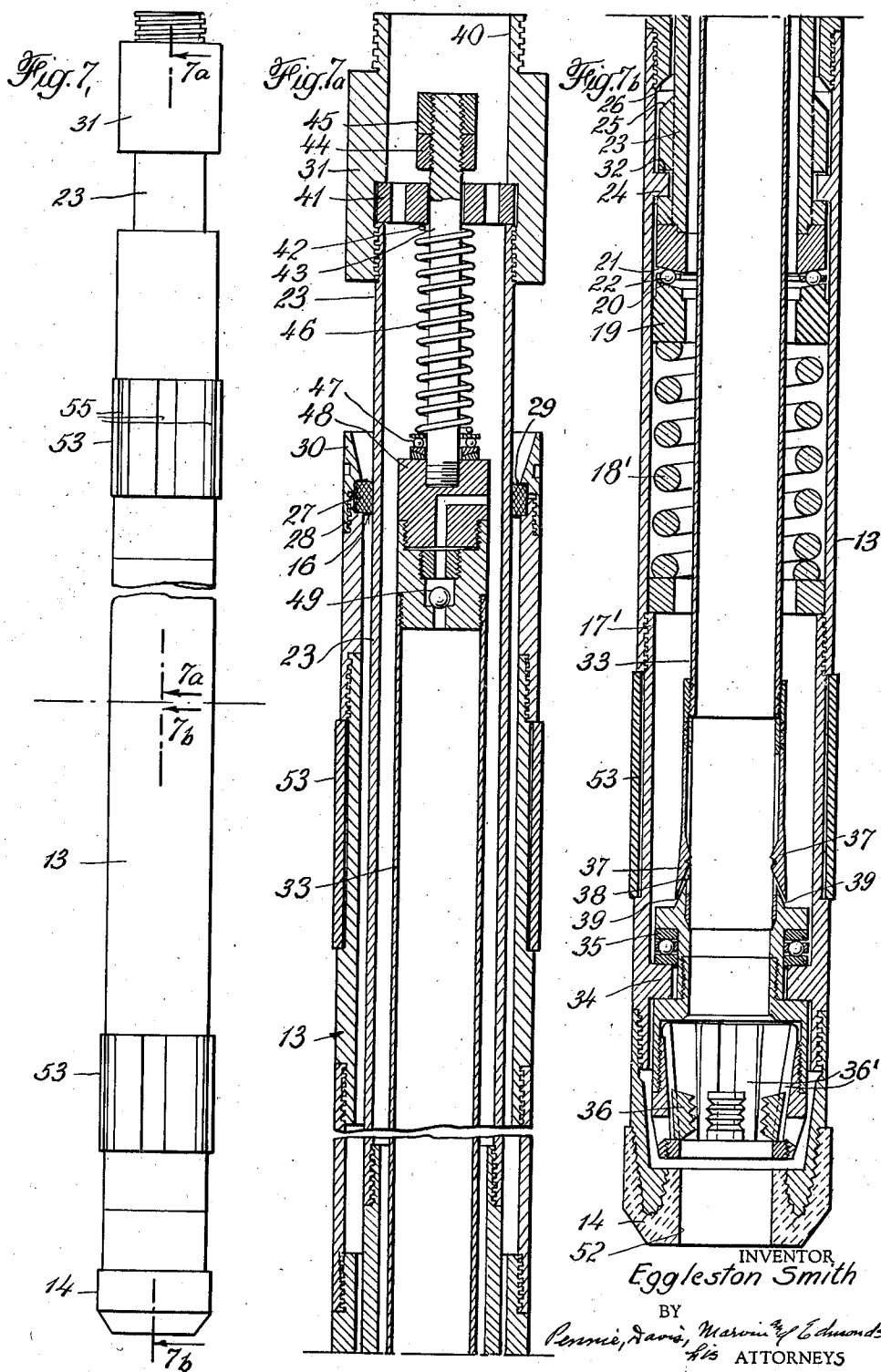
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3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

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EARTH DRILLING APPARATUS

Application filed November 23, 1927. Serial No. 235,173.

The present invention relates to methods and apparatus for drilling holes and has for its object the provision of an improved method and apparatus for drilling holes. More particularly, the present invention aims to provide an improved method and apparatus for drilling holes which eliminates to a large extent the chatter of the drilling bit and at the same time admits the use of composition bits, such, for example, as carborundum bits, in all types of formations, reducing to a minimum the danger of shattering the abrasive bit.

The present invention relates particularly to the rotary system of drilling. In well drilling of this character, a great majority of the drilling must be done at several hundred, or even several thousand feet below the surface of the ground, where the operator of the drill is stationed. In all drilling operations, the rate at which the drill is fed into the material is of great importance. The rate of feed of the drilling tool depends upon the feeding pressure employed, and too great a feeding pressure results in an excessive depth of cut by the drilling tool which, when drilling through relatively soft material almost inevitably results in the tool becoming encased in a mass of unground material from the bottom of the hole, which clings to the surface of the tool and completely stops its progress. When drilling through relatively hard material, too great a feeding pressure not infrequently causes the jamming and breakage of the tool.

Although, improper feeding pressure is a prolific cause of trouble in drilling operations, there are many other causes of grief. Chief among these are the wobble of the drilling shaft in the drill hole and the chatter of the bit when cutting certain formations. These difficulties may in part be overcome by a very skillful operator, but frequently this type of operator is not obtainable. The elimination or lessening of the importance of this human factor and at the same time the obtaining of satisfactory drilling speeds without damaging the hole or drilling mechanism is highly desirable. The practice of the present invention makes this possible.

In accordance with the present invention the drill bit is caused to operate with an even rotary motion and a predetermined pressure by making use of and combining the inventions included in my prior applications, Serial No. 137,840, filed September 27, 1926 and Serial No. 681,032 filed June 9, 1924, the latter having issued on October 23, 1928 as Patent No. 1,688,994. The former of these applications disclosed a universal joint structure which compensates for the side sway or wobble of the driving shaft in the drill hole and transmits the rotary motion of the driving shaft to the drilling bit in such a manner that the cutting face of the drill is at all times in alignment with the operating face of the material which is being drilled.

The second of these two applications discloses a method and apparatus which provides for the recession of the drilling bit away from the face of the material being drilled whenever an obstruction or friction is encountered which normally would cause the bit to stick, or tend to stick, even though momentarily. This recession of the bit is accomplished by making use of a two part helical drive in which the driving member has a helical tongue and groove sliding joint which wedges itself under the driven member and thus retracts the driven member or bit portion by a counterbalancing of the forces applied to the driven member.

The combination of these inventions produces a condition which permits of the application to the drilling bit of an even predetermined pressure and at the same time a retraction of the bit when it encounters undue resistance thus permitting the bit to operate without chatter.

The invention will be better understood by reference to the accompanying drawings, which are intended to assist in the description of the invention, and not to define the limits thereof, in which:

Fig. 1 is a diagrammatic vertical cross-section of a drill hole with the improved drilling mechanism in place;

Fig. 2 is an enlarged diagrammatic vertical cross-section of the lower portion of the drill hole;

Fig. 3 is a vertical cross-section through the center of the drilling mechanism partially cut out to indicate shortening;

Fig. 4 is a view of the interior portion of the drilling mechanism partially in section taken at right angles to Fig. 3;

Fig. 5 is a detail vertical section through part of the universal and retracting drives of a modified form of apparatus;

Fig. 6 is a horizontal cross-section through the helical retracting drive of Fig. 5;

Fig. 7 is a diagrammatic exterior view of the drilling mechanism assembly partially cut out to indicate shortening;

Fig. 7a is a detail vertical cross-section through the upper portion of the drilling mechanism assembly partially cut out to indicate shortenings; and

Fig. 7b is a continuation of Fig. 7a showing the lower portion of the drilling mechanism assembly.

The drill hole illustrated in Fig. 1 comprises the hole 10 bored in the earth in which is disposed and diagrammatically illustrated the improved drilling apparatus of the invention. The drilling apparatus comprises the drive shaft 11 which extends throughout the greater portion of the drill hole and serves to transmit the rotary motion from the driving apparatus (not shown) above ground to the improved drilling apparatus 12 in the bottom of the hole.

The drill hole illustrated in Fig. 2 comprises the lower portion or bottom of the drill hole 10 in which is operatively disposed the improved drilling apparatus 12 which comprises the main drill barrel 13 to which is attached at its lower extremity the drill bit 14. The drill bit 14 receives its rotary motion from the drive shaft 11 transmitted indirectly through the drill barrel 13. The pressure is transmitted to the drill bit 14 from the drive shaft 11 through a flexible connection diagrammatically illustrated by the coil spring 18. The drive shaft 11 is permitted a pivoting movement at a joint 16 which when taken in connection with the flexible connection at the coil spring 15 permits the drive shaft 11 a freedom of pivoted lateral movement which is not transmitted to the drill barrel 13, and at the same time permits a vertical movement of the drill barrel 13 and drill bit 14 which is not transmitted to the drive shaft 11. Thus, the drive shaft 11 which may be considerably smaller than the bore of the drill hole 10 is permitted a considerable wobble or side movement which is only limited by the sides of the drill hole.

The size of the drill barrel 13 is approximately the size of the drill hole 10. Since the wobble of the drive shaft 11 is completely absorbed in the drilling mechanism, the drill barrel 13 fits the hole in a perfectly perpendicular position at all times. Thus, the tendency for the hole to become crooked is

reduced to a minimum. In order that the drill barrel 13 may fit more closely to the sides of the drill hole, guide rollers are placed in recesses along the outer shell of the drill barrel 13. These guide rollers are slightly larger in diameter than the diameter of the drill barrel 13, and substantially the same diameter as the diameter of the drill bit 14. The guide rollers fit closely about the sides of the hole and remain stationary in reference to the sides of the hole. They are free to turn upon the drill barrel so that while the drilling apparatus is in operation there is a relative motion between the guide rollers and the drill barrel 13. The water passing from the drilling apparatus and carrying the abraded material, is permitted to pass the guide rollers by means of corrugations in the guide rollers. These corrugations or indentures in the surface of the guide rollers are sufficient to carry the entire volume of water which is forced through the drilling apparatus. By means of the guide rollers, which fit tightly against the sides of the drill hole, and the sliding contact between the guide rollers and the drill barrel, the drill barrel will always maintain the position in which the hole was started at the surface. Thus, if the hole was started in a perpendicular manner at the surface, it will maintain this position no matter to what depth the hole may be drilled.

The section of the drilling apparatus illustrated in Figs. 3, 4 and 5 comprises the drill bit 14 which is appropriately fastened to the drill barrel 13. A shoulder 17 is provided on the interior portion of the drill barrel 13 upon which is supported the pressure spring 18. The lower flat edge of the spherical ball bearing race 19 rests upon the upper portion of the pressure spring 18 and serves as a means of compressing the pressure spring 18, so that a predetermined pressure may be transmitted therethrough to the drill barrel 13 and the drill bit 14.

The concentrically disposed spherical surfaces 20 and 21 of the ball bearing form with the balls 22 the ball bearing seating portion of a universal joint. This universal joint permits the lower bearing surface 20 to remain stationary, while the upper bearing surface 21 pivots about its axis at the flexible joint 16. Both the universal joint and the flexible joint situated above are provided to compensate for or absorb the wobble of the driving shaft.

The drill barrel 13 is in concentrically spaced relation to the universal joint and the driving member 23 against which the upper flat face of the ball bearing race 21 seats. The driving member 23 transmits its rotating movement through pins 24 to the drill barrel 13. The driving member 23 is provided with the annular sloping face 25 which engages a corresponding sloping face 26 on the in-

terior of the drill barrel. These coacting sloping faces prevent the drill barrel from slipping down and falling away from the rest of the drilling mechanism when not in active operation.

The drill barrel 13 extends upwardly a predetermined distance to a flexible joint 16 which is the axis or pivoting point of the drive shaft wobble. This point may be approximately determined by the size of the drive shaft 11 and the bore of the drill hole 10. At this point a flexible packing 27 of soft rubber or the like is placed upon a shoulder 28 provided on the interior of the drill barrel 13. The flexible packing 27 fills the annular space between the drill barrel 13 and the driving member 23 and is held in fixed compressed position by an angular ring 29 and a threaded adjuster 30.

The driving member 23, above the flexible joint 16, is attached in a suitable manner as by a threaded connection, to a bushing 31 which extends upwardly and in an appropriate manner is connected to the drive shaft. The driving member 23 transmits its rotary motion to the drill barrel 13 by means of a helical tongue and groove drive in which helical grooves 32 are placed at an angle of approximately 45° in the body of the driving member 23. Cooperating with the helical grooves 32 are pins 24 which protrude from the inner surface of the drill barrel 13. The driving member 23 in transmitting its power to the drill barrel 13 will thus cause the pins 24 to rise in the helical grooves 32. The amount of this rise depends upon the forces which are applied in the drilling operation. These forces are governed by the factors of pressure permitted upon the drill bit and the friction of the drill bit and the torque of the rotary drive.

The helical drive provides that the drill bit 14 shall be at all times in moving contact with the material which is being abraded. When the friction becomes too great, the retracting drive draws the face of the drill bit 14 slightly upward so that the friction is materially reduced, thus permitting the drill bit 14 to resume normal speed. This infinitesimal retraction of the bit decreases the friction to within the working limits of the mechanism and the drill bit reseats itself and continues to abrade the surface against which it bears. The momentary retraction is so slight that the abrading action continues at a slower rate during the instant of diminished friction while the drill picks up its normal speed. This action is totally different from the action of a chattering drill bit of the customary type. In the older customary type of drill the chattering is probably caused by an excess friction upon one side of the hole, plus the tendency to unevenly seat, produced by the wobble of the shaft. These factors cause one side of the bit to rise and

the other side to bear more heavily against the surface being drilled. Thus, the drill bit tends to pivot upon the single point of contact and not to rotate upon its axis. During this pivoting motion, which is momentary, the drill bit partially stops, pivots, and then starts again on its rotary motion, thus the chatter is produced. While practicing the present invention, this can never happen because the drill barrel at all times guides the drill bit in a perfectly perpendicular position and the retracting drive permits the mechanism to compensate for excess friction at the point of contact.

The drill bit 14 may be provided with a centrally located opening 52, which during the rotation of the bit permits the drill core to remain standing within the drill hole. In order that the drill bit 14 shall not bear against this core, the interior surface of the opening 52, from the point of contact with the surface being abraded, is slightly sloped away or tapered from the drill core.

In Fig. 5 the lateral motion at the lower end of the universal joint is absorbed in the pressure spring 18. The spherical ball bearing races are replaced with horizontal surfaces 50 and 51. The lower free member 54 is in spaced relation to the drill barrel 13. As the driving member 23 pivots in synchronism with the drive shaft wobble the pressure spring 18 not only absorbs the side movement but at the same time, one side of the spring is contracted as the other expands to accommodate the relative positions of the bottom edge of the driving member 23 as it pivots.

The apparatus illustrated in Fig. 6 which is a horizontal cross-section on the line 6—6 of Figs. 3, 4 and 5 comprises a drill barrel 13, driving pins 24, cooperating with the helical grooves 32 which are located in the driving member 23. The driving member 23 is concentrically spaced from the drill barrel 13.

The apparatus illustrated in Figs. 7, 7a and 7b comprises the working assembly of the apparatus of the invention. The apparatus illustrated in Fig. 7 comprises the general assembly in which Fig. 7a comprises the upper portion and Fig. 7b comprises the lower portion of the assembly. The lower portion of the assembly, Fig. 7b, comprises the drill bit 14 which is appropriately secured to the drill barrel 13. The interior of the drill barrel 13 is provided with projections 34 which carry the core barrel ball bearing support 35. This ball bearing permits the drill barrel 13 to rotate while the core barrel 33 remains stationary. Within the interior of the drill barrel 13 is disposed a core catcher 36. The jaws of the core catcher 36 are supported upon inclined planes 36' within the drill barrel 13. These jaws are permitted a free vertical movement

converging as they move downward.. The gripping portions of the jaws are in frictional contact with the drill core as it is produced within the drilling mechanism.

5 This type of core catcher is commonly designated as the slip type and only exerts a gripping or catching action when the drilling mechanism assumes an upward motion in relation to the stationary core.

10 At the lower end of the core barrel 33 there are provided spring operated core holders 37. These core holders 37 during the drilling operation are maintained in a position with the springs retracted so that the
15 core holding teeth are not in frictional contact with the core. This retraction of the core holders is accomplished by contact of the inclined faces 38 of the core holders with coating inclined faces 39 which are carried
20 by the core barrel ball bearing support. Thus, when the core barrel is removed from the rest of the apparatus, these core holders are released and grip the core, preventing it from falling out of the core barrel. The
25 interior of the drill barrel 13 is provided with the shoulder 17' which supports the coil spring 18'. Supported on the upper portion of the coil spring 18' is the universal joint. Above the universal joint is the helical
30 drive by which the driving member 23 transmits its rotary motion through the pins 24 to the drill barrel 13. The lower portion of the driving member 23 is provided with the sloping face 25 which cooperates with a
35 corresponding sloping face 26 on the interior of the drill barrel 13. These sloping faces prevent the drill barrel from falling down and separating from the rest of the mechanism when the drill is not in position to
40 operate.

The apparatus illustrated in Fig. 7a which is the upper portion of the drilling assembly, comprises the drill barrel 13 and the concentrically disposed driving member 23. A flexible
45 joint 16 is provided between the driving member 23 and the drill barrel 13. This flexible joint rests on a projection 28 on the interior of the drill barrel. The flexible material 27 is held in a compressed condition
50 by the threaded block 30 and the angular ring 29.

The driving member 23 is connected in any appropriate manner as by a threaded connection to the bushing 31, which is provided
55 with a threaded connection 40, for attachment to the drive shaft. Attached to the interior of the bushing 31 is the core barrel support 41. In the center of the core barrel support 41 there is provided a bearing 42.
60 Operatively disposed in the core barrel support bearing is the core barrel pin 43. The core barrel pin is supported within this bearing by the nut 44 and the lock nut 45. The core barrel tension spring 46 surrounds the
65 main portion of the core barrel pin 43. The

upper portion of this spring bears against the lower portion of the core barrel support 41 while the lower portion of the spring bears against the upper ball race of the ball bearing 47. The ball bearing 47 accommodates the thrust of the core barrel as it extends upwardly within the drilling mechanism during operation. Since the core barrel remains stationary during operation, there may be a relative motion between the
75 core barrel support 41 and the core barrel pin 43 in the bearing 42, as well as a relative motion which is mainly taken up by the thrust ball bearing 47 at the lower portion of the pin.

The core barrel pin 43 is threaded securely into the upper portion of the core barrel block 48 and to the lower portion of the core barrel block is securely fastened, in any appropriate manner as by threads, the core barrel
80 33. In the interior portion of the core barrel block 48 there is provided the ball check valve 49. The ball check valve 49 prevents the entrance into the interior of the core barrel of the flushing medium, and at the same time provides an exit for any liquid or gases which may accidentally become entrapped in the
85 core barrel above the core.

The operation of the drilling apparatus of the invention will be understood from the foregoing description. When the apparatus has been assembled and is lowered to a position in which the drill bit 14 is in contact with the material to be drilled, pressure is applied on the drive shaft 11. In case the hole being
90 drilled is already of considerable depth, the weight of the drive shaft itself will be sufficient to take the place of pressure applied at the surface. The main pressure spring 18 partially collapses under the pressure which
95 is applied to the drilling mechanism, which in turn permits the pins 24 to slide partway up the helical grooves 32. The tension of the spring 18 will eventually equalize the pressure being applied to the drive shaft and the
100 drive pins 24 will come to rest somewhere in the helical grooves 32. The compression of the spring 18 causes the sloping face 25 to be in spaced relation to the sloping face 26.

The compression of the spring 18 causes
105 also the driving member 23 to slide through the flexible packing 27 and at the same time causes the core barrel 33 and core barrel pin 43 to assume a different relative position in respect to the core barrel support 41, so that
110 in the operating position there is a spaced relation between the nut 44 and the core barrel support 41. At the same time the core barrel tension spring 36 is placed under tension, helping to steady the core barrel.

A rotary motion is applied to the drive shaft 11 at the surface from a source not shown. This rotary motion is transmitted from the drive shaft 11 to the bushing 31 and from thence to the driving member 23. The
120 130

rotary motion of the driving member 23 is transmitted through the helical drive by means of the grooves 32 and the pins 24 to the drill barrel 13. The drill barrel 13 is firmly attached to the drill bit 14. Thus the drill bit 14 is given a rotary motion.

The drive shaft 11 being smaller than the bore of the drill hole 10 consequently wobbles within this hole. The wobble or swaying of the drive shaft normally is transmitted through a rigid drilling apparatus to the bit. In the practice of the present invention this wobble is absorbed by the universal joint provided for this purpose. The pivoting point of this joint is the flexible packing 27 of joint 16. The lower or loose end of the driving member 23 terminates in the spherical surface of the ball race 21. This ball race 21 is a segment of a sphere of which the radius is equal to the distance between the ball race 21 and the pivot 16. This distance is substantially equal to the point above on the drive shaft where the drive shaft comes in contact with the wall of the hole, or a given fraction thereof depending upon the freedom of movement permitted the ball race 21. During the wobble of the drive shaft the driving member 23 is free to move within the drill barrel 13 in the opposite direction to the wobble of the shaft. This motion is freely taken up by the balls 22 of this ball bearing support. The lower face 20 of the ball bearing support is a concave face of a segment of a concentric sphere slightly larger than the sphere of which the convex face 21 is a segment. The wobble of the drive shaft 11 and driving member 23 is completely absorbed in this bearing so that the lower race member 19 of the bearing remains relatively stationary in respect to the drill barrel 13.

The rotary drive from the drive shaft 11 and the driving member 23 is transmitted through the helical drive with substantially no relative motion between the pins 24 and the grooves 32, until the drill bit 14 strikes a formation which produces greater friction between the cutting face of the drill bit and the material being drilled. This friction may become great enough to cause the drill bit to stick or refuse to move. When this condition occurs the helical drive causes the walls of the grooves 32 to wedge themselves under the pins 24. Thus the core barrel 13 is raised and the cutting surface of the drill bit 14 is released, and as a consequence, the friction diminishes. Thus, when the frictional force applied to the drill bit 14 becomes less than the driving force applied to the driving member 23, the pressure spring 18 immediately expands and the drill bit 14 is resealed in its normal position. This relative change of position of the driving parts during normal operation is only momentary and the retraction of the drill bit is very minute. This retraction and replacing movement causes a rel-

ative movement between the driving member 23 and the drill barrel 13, and is compensated for by the flexible packing material 27.

The combination of the universal joint which absorbs the wobble of the drive shaft and the retracting and expanding action of the helical drive, along with the compression spring 18 causes the drill bit 14 at all times to run smoothly and evenly with substantially no chatter. This absence of chatter permits of the use of a composition carborundum bit in place of the steel or steel and diamond bits which are commonly used, and at the same time, causes the drill to form a straighter hole with less chance of being deflected by a hard formation, which may be encountered on one side of the hole. Such a formation as this with the chattering bits commonly used causes the usual form of bit to slide off of the harder formation and cause a crooked hole to be drilled.

In practicing the present invention, when increased friction is encountered on the drilling face, the bit retracts slightly to compensate for the increased friction and then reseats itself in the same place that it was before. Thus all types of formations may be drilled without chatter and without causing a crooked hole to be formed.

A core of the formations being drilled is often desirable. This core is obtained by means of the apparatus of the present invention, by making use of a drilling bit 14 with a hollow center 52; thus, only the edges of the hole are drilled and the core left standing. As the drill bit works its way through the formations, this core protrudes into the interior of the drilling apparatus, and is enclosed in the stationary core barrel 33. When the core has substantially filled the core barrel 33, the rotary motion is stopped and the drilling mechanism withdrawn from the hole. The first upward motion of the drilling mechanism causes the jaws 36 which are in sliding contact with the core, to slide downward and inward on their sloping seats, thus clamping the core between the jaws 36. The grip of these jaws 36 is tenacious enough to cause the core to be broken off and retained by the jaws within the core barrel 33.

This type of core catcher is entirely new as a component part of drilling apparatus. In the customary type of drilling apparatus, there is not enough space left above the drilling bit to provide for the sloping seats of the core catcher jaws. It is customary to provide a spring operated core catcher which bears against the core with considerable pressure. This pressure must be great enough to provide for the withdrawal of the core from the hole when the drilling apparatus is lifted. The spring operated core catcher bearing against a core of these soft formations will cause the core to crumble and thus be mixed with the water which is being used

in the drilling operation. The loss of these soft cores, especially when drilling oil formations, is to be guarded against in every way, for the soft formations are normally the best indicators of anticipated oil bearing strata. If these cores are lost, a very incomplete record of the strata is obtained. The core catcher of the present invention places substantially no pressure against the core until the rotary motion of the apparatus has been stopped, and the lifting of the drilling mechanism commences. Thus only sufficient pressure is brought to bear upon the core to cause it to break away from the formation which is being drilled.

The drilling mechanism is then brought to the surface of the ground until the upper portion including the flexible joint 27 protrudes above the ground. The rest of the drilling mechanism is permitted to stay in the hole. The drill barrel 13 is then appropriately secured in this position and the bushing 31 unscrewed from the driving member 23. The core barrel may then be released from the rest of the drilling apparatus by lifting up the core barrel support 41. The raising of the core barrel releases the spring operated core holders 37 so that the jaws thereof grip the core and retain it within the core barrel 33. The upward movement of the core causes the release of the jaws 36 and the core and core barrel are removed from the drilling apparatus. When the core barrel is above ground, the core may be released from the core barrel and the core barrel replaced within the drilling mechanism. As the core barrel seats itself in the drilling mechanism the core holders 37 are retracted into a position where they do not bear against the core by the angular faces 38 and 39. The bushing 31 is then secured to the driving member 23 and the drive shaft 11, and the drilling mechanism again lowered to the bottom of the hole.

The material being abraded by the drill bit 14 is continually flushed away by a sheet of water. This water is supplied to the drilling mechanism through the interior of the drill shaft 11. The water passes downwardly through the bushing 31 and through holes provided in the core barrel support 41 and thence between the core barrel 33 and the driving member 23. From thence it passes around the compression spring between the core barrel 33 and the drill barrel 13. It then works its way down alongside of the core and past the jaws 36 of the core catcher, and then through channels provided on the interior of the drill bit 14 alongside of the core. The rotary motion of the drill bit 14 causes the water which is under considerable pressure to spread out from these channels in a sheet of water which continually flushes the abraded material away from between the surface of the drill 14 and

the material being drilled or abraded. The pressure on the water is sufficient to cause the abraded material to be washed entirely free from the drill bit 14 so that the individual grains of carborundum of the bit are left free for cutting fresh material in the formation being drilled. This water with its load of abraded material is then carried up the drilled hole 10 outside of the drill barrel 13 through channels 55 in the guide rolls 53 on the outside of the core barrel 13 and from thence through the hole 10 outside of the drive shaft 11 to the surface of the ground. If it is desired to reuse this water in the drilling operation, the water is first permitted to clarify itself by settling and decanting and returned to the drilling operation carrying only the finest of the slimes. These slimes are useful in plugging or making impervious porous strata which may be encountered in the drilling operations.

In the practice of the present invention, the use of composition carborundum bits is made possible. The carborundum bit is brittle and shatters very easily. This shattering of the bit has in the past precluded it from general use, because there was no way of stopping the destructive chatter. The use of the helical drive which retracts the bit along with the universal joint which eliminates the wobble of the drive shaft, makes possible such a smooth driving of the drill bit that the chatter is entirely eliminated and the bit always seats smoothly upon the material which is being drilled. The application of this smooth, even drive to the drill bit and the use of the more effective cutting edges of the particles of carborundum cause the carborundum bit to drill faster in all types of formations than was possible with the older type of bit.

In the practice of the present invention, the same bit is used for cutting both hard and soft formations, thus eliminating the necessity of numerous round trips to change bits. Drilling speeds up to 30 inches per minute with no jamming have been made in clays and soft shales. Speeds up to 8 inches per minute are made in marble and speeds up to 2 inches per minute are made in compact quartz grained sandstones with very little wear on the cutters.

The smooth driving of the rotary bit eliminates all shock in the formations being drilled. Thus the shattering of the wall of the hole is eliminated and consequently there is a marked reduction in the caving of the hole and in subsequent fishing jobs. When drilling with the apparatus of the present invention, the drill will drive a straighter hole since it continually seeks the vertical position and is not liable to be pushed aside by hard formations. The absence of chatter permits of drilling at far greater depths than is possible with other equipment.

In practicing the present invention a straight hole is assured, since all of the wobble of the drive shaft is absorbed in the universal joint which is entirely encased within the drilling mechanism. The drill barrel or the guide rollers which are attached to the outside of the drill barrel, bear tightly against the side of the hole so that the drill mechanism itself always remains in a vertical position regardless of the wobble of the drive shaft.

The improved core catcher which is used in the present invention permits a core of the entire formations being drilled to be obtained. The core barrel itself remains stationary in respect to the core which it contains, so that there is no tendency for the core barrel to disrupt loose formations as would occur if the core barrel were in rotary motion in reference to the core. The obtaining of the entire core furnishes data for systematic and thorough handling of all future drilling, casing and recovery problems which is not possible when only the hard portions of the core or obtained.

The application of drilling pressure to the drilling apparatus is at a point close to the bottom of the drill barrel 13. Because of the application of the drilling pressure at this point, there is very little, if any, tendency for the drilling pressure to cause the drill barrel to be pushed out of alignment. Thus, the drilling apparatus of the invention will continually seek the perpendicular position during drilling operation. The length of the drill barrel itself and the tight fit of the guide rollers against the sides of the hole also assist materially in maintaining a straight hole during the drilling operation.

Throughout this specification the force tending to retard the drill bit during the drilling operation, has been referred to as the drilling friction or simply as friction. It is conceivable that a projection on the drill bit may jam against some projection within the hole or material being drilled. This actual contact of two opposed surfaces has been referred to as drilling friction. It is believed that this term is not too broad to cover all of the resisting forces which are encountered in drilling operations. During the infinitesimal retraction of the drill bit by the helical drive, the drilling friction is lessened, but the retraction is of such a small amount and the duration of such a short period, that the drilling friction does not actually cease during the retraction, but is only diminished permitting abraded material between the drill bit and the surface being drilled to assume different relative positions and to be flushed away more readily, thus relieving the drilling friction. When the drilling friction is relieved the drill reseats itself and proceeds to abrade the face being drilled at an acceler-

ated rate over the rate which existed during the retraction period.

I claim:

1. An earth drilling apparatus comprising a rotary drilling bit, a rotary drive shaft extending throughout the drilled portion of the hole, and a device for operatively connecting the bit to the drive shaft including means for permitting the axis of the bit to move angularly with respect to the axis of the drive shaft so as to allow the drilling bit to seat upon the surface being cut when the axis of the drive shaft diverges from the axis of the hole, resilient means for transmitting feeding pressure from the drive shaft to the bit, and means for retracting the bit from the surface being cut when the resistance to rotation exceeds a predetermined amount.

2. An earth drilling apparatus comprising a rotary drilling bit, a rotary drive shaft extending throughout the drilled portion of the hole and a device for operatively connecting the bit to the drive shaft including a universal joint for permitting the drilling bit to seat upon the surface being cut when the axis of the drive shaft diverges from the axis of the hole, resilient means for transmitting feeding pressure from the drive shaft to the bit and means for retracting the bit from the surface being cut when the resistance to rotation exceeds a predetermined amount.

3. An earth drilling apparatus comprising a rotary drilling bit, a rotary drive shaft extending throughout the drilled portion of the hole and a device for operatively connecting the drill bit to the drive shaft including a universal joint for permitting the drilling bit to seat upon the surface being cut when the axis of the drive shaft diverges from the axis of the hole, a spring for transmitting feeding pressure from the drive shaft to the bit and means for retracting the bit from the surface being cut when the resistance to rotation exceeds a predetermined amount.

4. An earth drilling apparatus comprising a rotary drilling bit, a rotary drive shaft extending throughout the drilled portion of the hole and a device for operatively connecting the bit to the drive shaft including a universal joint for permitting the drilling bit to seat upon the surface being cut when the axis of the drive shaft diverges from the axis of the hole, a spring for transmitting feeding pressure from the drive shaft to the bit and a helical drive for retracting the bit from the surface being cut when the resistance to rotation exceeds a predetermined amount.

5. An earth drilling apparatus of the character described comprising a rotary drilling bit, a rotary drive shaft extending throughout the drilled portion of the hole and a device for operatively connecting the bit to the shaft comprising a shell on the lower end of which the bit is mounted, a curved seat resiliently mounted within the shell near the bot-

tom thereof, the center of curvature of the seat being substantially at the top of the shell, a drive member secured to said drive shaft and extending loosely within the shell, the lower end of said member being shaped to conform to said curved seat and resting thereupon whereby the wobble of the drill shaft is prevented from unseating the drilling bit from the surface being cut, and inclined co-acting surfaces on said drive member and shell respectively for imparting rotation there-between and for retracting the bit from the surface being cut when the drilling friction exceeds a predetermined amount.

6. An earth boring drill comprising an elongated cylindrical shell having a rotary drilling bit secured to its lower end, said shell having a downwardly-facing shoulder therein, a hollow drive member having an enlargement at its lower end terminating in an upwardly-facing shoulder, said drive member being insertible from the lower end of the shell and projecting beyond the upper end of the shell for attachment to a drill shaft, said drive member fitting loosely throughout the shell, said shoulders coacting to cause the shell to be supported by the drive member when the drilling bit is out of contact with the bottom of the hole, packing means near the upper end of the shell for preventing the drilling liquid from escaping between the loosely fitting surfaces of the drive member and the shell, a helical spring having its lower end resting upon a portion of the shell adjacent its lower end and supporting an annular ring which fits the interior of the shell closely but without restricting its freedom of longitudinal movement, a curved bearing arranged between said annular ring and the enlargement on the lower end of the said drive member, the center of curvature of said bearing lying substantially in the plane of said packing means, these parts thus permitting feeding pressure to be transferred from the drive member to the shell without tending to divert the progress of the bit from a straight line, and without increasing the pressure at one side of the bit when the axis of the drill shaft does not coincide with the axis of the hole, a helical slot in said enlargement on the drive member, and a pin projecting loosely into said slot from the wall of the shell by which the rotary motion of the drive member is imparted to the shell and the drilling bit is retracted from the surface being cut when the drilling friction exceeds a predetermined amount.

7. In an earth drilling apparatus having a device for connecting the drill bit to the drive shaft including resilient means for transmitting feeding pressure from the drive shaft to the drill bit and means for retracting the drill bit from the surface being cut when the drilling friction exceeds a predetermined amount, the combination of a core barrel and means

for supporting the core barrel within the drilling apparatus including a second resilient means for maintaining the lower end of the core barrel in fixed relation to the bit when the bit is retracted.

8. An earth drill of the character described comprising a shell having a rotary drilling bit mounted upon the lower end thereof, a hollow rotary driving member telescoped within the shell at the upper end thereof, resilient means for transmitting a longitudinal force from the driving member to the shell, retractive driving means connecting the driving member and the shell by which rotation is imparted to the bit and the bit retracted from the surface being cut when the drilling friction exceeds a predetermined amount, a core barrel within said drill, a support for the lower end of the core barrel within the shell near the drilling bit, and a support on the upper end of the driving member for slidably engaging the core barrel to maintain the same in axial alignment with the drill to permit the core barrel to be retracted with the shell with respect to the driving member.

9. An earth drill of the character described comprising a shell having a rotary drilling bit mounted upon the lower end thereof, a hollow rotary driving member telescoped within the shell at the upper end thereof, resilient means for transmitting a longitudinal force from the driving member to the shell, retractive driving means connecting the driving member and the shell by which rotation is imparted to the bit and the bit retracted from the surface being cut when the drilling friction exceeds a predetermined amount, a core barrel within said drill, a support for the lower end of the core barrel within the shell near the drilling bit, a support on the upper end of the driving member for slidably engaging the core barrel to maintain the same in axial alignment with the drill to permit the core barrel to be retracted with the shell with respect to the driving member, and a spring associated with said sliding support for keeping the core barrel in engagement with its lower support when the shell moves with respect to the driving member.

10. An earth drill of the character described comprising a shell having a rotary drilling bit mounted upon the lower end thereof, a core barrel within the shell, a support rotatable with respect to the shell and fixed therein near the lower end thereof, said support having a seat for receiving the lower portion of the core barrel, a support near the upper end of said shell for maintaining the core barrel in axial alignment with the shell, and means at the upper end of the shell by which said support may be removed so as to permit the core barrel to be taken out from the upper end of the drill.

11. An earth drill of the character described comprising a shell having a rotary drilling bit mounted upon the lower end thereof, a hollow rotary driving member telescoped into the upper end of said shell, a core barrel within said drill, a support for the core barrel rotatable with respect to the shell and fixed therein near its lower end, said support having a seat for the reception of the lower portion of the core barrel, and an upper support for the core barrel in the driving member said support including a slide bearing for permitting the driving member to slide with respect to the core barrel as it slides with respect to the shell.

12. An earth drill of the character described comprising a shell having rotary drilling bit mounted upon the lower end thereof and a core barrel therein, a lower support for the core barrel rotatable with respect to the shell and fixed therein at its lower end, said support having a seat for receiving the lower portion of the core barrel, an upper core barrel support for maintaining the core barrel in axial alignment with the drill, a core-breaking device mounted within the shell near its lower end for breaking off a section of core, and core holders mounted on the core barrel for engaging the core and lifting the same after it has been broken off.

13. An earth drill of the character described comprising a shell having a rotary drilling bit mounted upon the lower end thereof and a core barrel therein, a lower support for the core barrel rotatable with respect to the shell and fixed therein at its lower end, said support having a seat for receiving the lower portion of the core barrel, an upper core-barrel support for maintaining the core barrel in axial alignment with the drill, a core-breaking device mounted within the drill near its lower end for breaking off a section of core, core holders mounted on the core barrel for engaging the core and lifting the same after it has been broken off, and means associated with said lower core barrel support for withdrawing the core holders from the path of the core when the core barrel rests upon the support.

14. An earth drill of the character described comprising a shell having a rotary drilling bit mounted upon the lower end thereof, a rotary driving member telescoped into the upper end of said shell, a core barrel within said drill, a support for the core barrel rotatable with respect to the shell and fixed therein near its lower end, said support having a seat for the reception of the lower portion of the core barrel, an upper support for the core barrel in the driving member, said support including a slide bearing for permitting the driving member to slide with respect to the core barrel as it telescopes into the shell, a core-breaking device on the shell for pulling the core loose at its base, core

holders on the core barrel for lifting the loosened core, and means associated with the lower core barrel support for withdrawing the core holders from the path of the core when the core barrel rests upon said support.

15. An earth boring drill comprising an elongated cylindrical shell having a rotary drilling bit secured to its lower end, a drive member fitting loosely within the shell having its lower end near the bottom of the shell and projecting above the upper end of the shell for attachment to a drill shaft, packing means near the upper end of the shell for preventing drilling liquid from escaping between the loosely fitting surfaces of the drive member and shell, a resilient device coacting between the lower portion of the shell and the lower portion of the drive member for transmitting feeding pressure from the drive member to the shell substantially without restricting the lateral movement of the lower end of the loosely fitting drive member within the shell, these parts thus permitting feeding pressure to be transferred from the drive member to the shell without tending to divert the progress of the bit from a straight line and without increasing the pressure at one side of the bit when the axis of the drill shaft does not coincide with the axis of the hole, and a helical drive between the drive member and the shell by which the rotary motion of the drive member is imparted to the shell and the drilling bit is retracted from the surface being cut when the drilling friction exceeds a predetermined amount.

16. An earth boring drill comprising an elongated cylindrical shell having a rotary drilling bit secured to its lower end, said shell having an enlarged chamber at its lower end and a downwardly facing shoulder at the top of said chamber, a hollow drive member having an enlargement at its lower end terminating in an upwardly facing shoulder, said drive member being insertible from the lower end of the shell and projecting beyond the upper end of the shell for attachment to a drill shaft, the enlargement on the lower end of the drive member being within the chamber in the shell and said shoulders coacting to cause the shell to be supported by the drive member when the drilling bit is out of contact with the bottom of the hole, said drive member fitting loosely throughout the shell, packing means near the upper end of the shell for preventing drilling liquid from escaping between the loosely fitting surfaces of the drive member and the shell, a resilient device having its lower end resting upon the portion of the shell adjacent its lower end and coacting with the drive member adjacent its lower end, said device permitting lateral movement of the lower end of the loosely fitting drive member within the shell, these parts thus permitting feeding pressure to be transferred from the drive

member to the shell through said resilient device without tending to divert the progress of the bit from a straight line, and without increasing the pressure at one side of the bit when the axis of the drill shaft does not coincide with the axis of the hole, and a helical drive between the drive member and the shell by which the rotary motion of the drive member is imparted to the shell and the drilling bit is retracted from the surface being cut when the drilling friction exceeds a predetermined amount.

In testimony whereof I affix my signature.
EGGLESTON SMITH.

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