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WELL DRILLING APPARATUS

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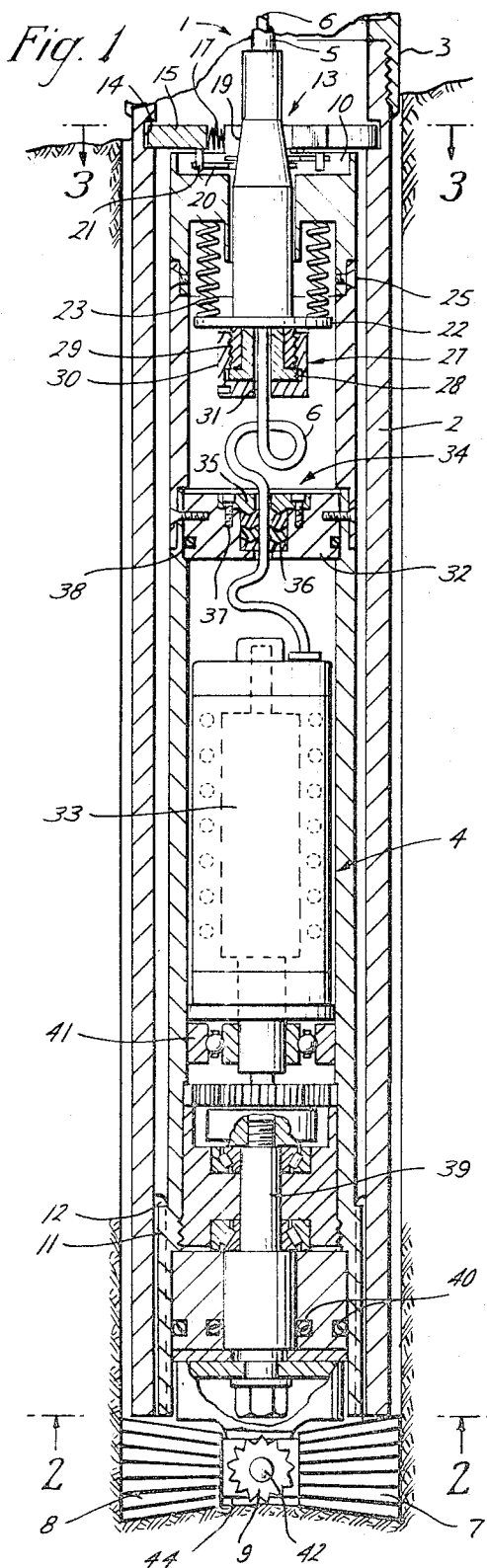


Fig. 2

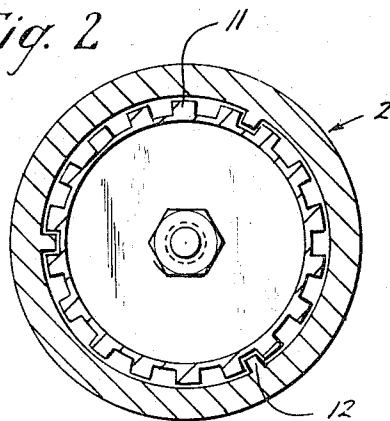


Fig. 3

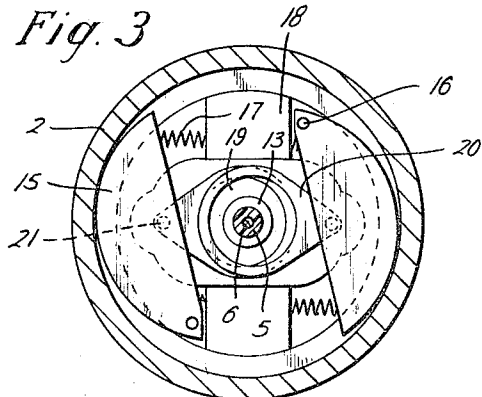
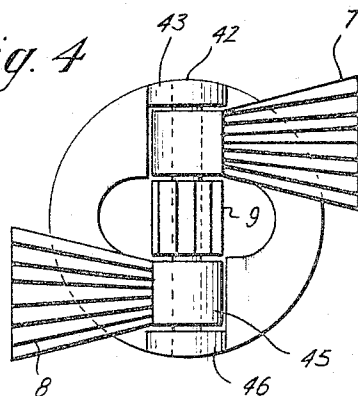


Fig. 4



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WELL DRILLING APPARATUS

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ABSTRACT OF THE DISCLOSURE

A cable suspended drilling tool having releasable means to engage a well casing is provided with one or more roller cutters mounted from a horizontal spindle at the bottom of the tool so that the roller cutters are self positioning. During insertion or retraction of the tool from the borehole, the roller cutters hang vertically and assume an outer diameter smaller than the well casing to enable passage through the casing, but upon commencement of rotation of the tool with the cutters positioned below the casing, the cutters assume a horizontally extended position for underreaming beneath the casing.

This invention relates to drilling apparatus and more specifically to a drill tool that is suspendable from a cable so as to be easily removable for changing of cutters and so as to avoid the problem of having to handle long lengths of mechanically linked drill string.

Rotary drill heads, or cutters, heretofore have been lowered to their position of use into deep well bores by two main methods: (1) Attached to a mechanically linked string of pipe lowered from the surface of the well and (2) by way of cables suspended from the surface. Among the advantages of the first type is that pressure can be exerted via the pipe against the cutters at the bottom of the hole. Chief among the disadvantages of using a solid, mechanically linked string of pipe is the inconvenience and long delays in drilling occasioned when it is necessary to remove the drill string from the bore hole during drilling operation to change the drill heads when they become dull. It is readily apparent that the disconnecting and subsequent reconnecting of the multiple joints of pipe in the extreme lengths of drill string which are commonly required is very time consuming and therefore costly.

The chief advantage of the cable-suspended tool is the quick removal and reinsertion feature lacking in the mechanically linked string. However, among the disadvantages of such a system is the complete reliance on the cutting or drill head to affect drilling since no pressure can be exerted on the drill tool via the lowering means.

Therefore, the apparatus illustrated and described herein is an embodiment of a drilling apparatus which incorporates the desirable features of the mechanically linked string and tool and the cable-suspended tool while eliminating the fundamental shortcoming of each of these apparatuses. What is described is one embodiment of a drilling apparatus which is suspended from a power- and weight-supporting cable and suitable for operating in a well casing, comprising releasable means for securing the drilling apparatus to the well casing near its lower end, a cutter or drill head secured at the lower end of the drilling apparatus and gravity positioned so as to be freely movable longitudinally within the confines of the casing while being lowered into position and removed from position of use, said cutter being positioned by the drilling operation so as to extend beyond the radial limits of the lower edge of the casing, and a motor contained within the apparatus for operating said cutter, said releasable means securing the apparatus to the casing being released upon upward movement of the cable, all whereby pressure can be exerted on the cutters via the well casing, and whereby the drilling apparatus is easily remov-

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able via the cable from which it is suspended so that the cutters can be changed without having to raise the casing.

In a specific embodiment illustrated, the novel device of this invention provides a drilling tool wherein the cutters are roller cutters swivelly mounted on a horizontal axis at the lower portion of the tool enabling the tool to be passed through a well casing, but further providing that the cutters assume a horizontally extended position for underreaming beneath the casing upon commencement of rotation of the tool once it is in position at the bottom of the well casing.

More particular description of the invention may be had by reference to the appended drawings, which form a part of this specification. It is to be noted, however, that the appended drawings illustrate only a typical apparatus embodying the invention and, therefore, are not to be considered limiting of its scope for the invention will admit to other equally effective embodiments depending on the particular application and field conditions.

In the drawings:

FIG. 1 is a vertical section partially broken away for clarity of an embodiment of the invention shown in the position of use.

FIG. 2 is a sectional view taken through line 2-2 shown in FIG. 1.

FIG. 3 is a sectional view taken through line 3-3 shown in FIG. 1.

FIG. 4 is a bottom view of the embodiment of the invention shown in FIG. 1 when the tool is in the position of use.

Generally, this invention pertains to a drilling tool comprising a latching means, a motor means, and movable cutters of special design, all of which forms a composite assembly capable of being lowered into drilling position within a well casing. The weight of the cutters cause them to hang approximately vertical, or longitudinal with respect to the casing, as the tool is lowered to permit passage of the drill tool within the confines of the casing. When the tool is close to being in position, matching guide splines on the tool and the casing engage to lock the drill tool against rotational movement. When the tool is in its position of use with respect to the casing, the latching means engage to fix the tool with respect to the casing. In this position of use, the cutters longitudinally extend below the limits of the casing.

To achieve cutting, the casing and the drill tool are lowered together until the cutters contact the earth at the bottom of the hole. The cutters of the drill tool are driven by an internal electric motor deriving its power through conductors from the top of the casing. When the cutters begin to spin, the centrifugal force of the spinning action and the contact of the cutters with the ground cause the movable cutting blades to rotate on their spindles thereby expanding radially beyond the limits of the casing wall. The hole thus defined is larger than the well casing.

Referring now to the drawings and first to FIG. 1, a well casing 1 is shown inserted into a bore hole being drilled by the illustrated embodiment of this invention. The lowermost casing joint, or section of casing, 2 is attached to the next lowest joint via a threaded connector 3, secured externally to the two joints via their accommodating screw threads.

The drill tool 4 is lowered inside the casing so that it is positioned within the lowermost casing joint 2 via a cable 5, suitably fastened at the top of the well to a derrick or other apparatus from which it is payed out during drilling and reeled up when a change of drill heads or cutters is required. The cable 5, of course, is sturdy enough to support the weight of the drill tool by an appreciable safety factor. Internal to the cable 5 are electrical conductors 6 for providing control and power

to the electric motor that operates the drill cutters 7, 8, and 9 during their drilling operation.

Located in spaced relationship around the outside circumference of the lower portion of the housing 10 of the drill tool 4 are the splines 11, which project radially somewhat from the surface of the tool, as is perhaps best shown in FIG. 2. Similarly, located at spaced intervals around the inside surface of the lowermost casing joint 2 are nominally three inwardly projecting casing splines 12. As the drill tool 4 is lowered into position for drilling, the splines 12 on the casing interengage with the splines 11 on the drill tool to prevent rotational movement of the drill tool with respect to the casing. It will be noted that since there are multiple drill tool splines, eighteen being illustrated, that there are many different orientations that the drill tool might assume with respect to the casing as it is lowered. Any of the multiple positions assumed by the drill tool are acceptable since the precise rotational starting point position is not critical.

It should also be noted that with the tool in the position of use, there are fifteen openings defined by the splines 11 of the drill tool and the inside wall of the casing joint 2. If drill mud is used in conjunction with the drill tool, these passages permit free flow of such mud.

The cable 5 is attached to the support member 13, which, in turn, operates a releasing means for securing the drill tool in a relatively fixed position longitudinally within the casing joint 2. As is shown, the casing joint 2 has an internal recess 14 around its inner wall for accommodating the latching means 15, which are a part of the drill tool 4. As best shown in FIG. 3, there are two latching means 15, which are movable external projections concentrically actuated about the center, longitudinal axis of the drill tool 4. Each of the latching means 15 is affixed to the housing 10 to pivot about a connector 16. Each coiled spring 17 maintains a radially outward urging pressure on its respective latching means 15 to direct it away from mount 18. When the drill tool 4 is properly aligned with respect to the casing joint 2 and without the unlatching forces, described below, applied, this urging pressure will cause the latching means 15 to secure the drill tool 4 into the recess 14, as shown in FIG. 1.

The support member 13 has a conical sloping shoulder 19 gradually increasing from a position near its upper edge. This shoulder makes contact with two oppositely disposed unlatching means 20, each of which is secured to a latching means 15 via a depending pivot connector 21. It is apparent that upward movement of the support member 13, typically by a pull on the cable 5, causes both unlatching means 20 to move inward toward the center longitudinal axis of the drill tool as the shoulder 19 coming in contact with the unlatching means 20 gradually becomes larger. As an unlatching means 20 moves toward the center axis, it overcomes the bias of its spring 17 and causes its latching means 15 to pull out of recess 14. When there is sufficient movement, the drill tool 4 is released from the casing joint 2.

Actually, an appreciable pull on the cable 5 is required to unlatch the means 15 since there is a built-in protection against accidental release in the form of the mounting base 22 and the compression springs 23. The support member 13 is rigidly secured to base 22. Compression springs 23 are energized between the base or platform and recessed walls in the housing 10 so as to resist upward strain on the cable 5. To limit the upward movement of the cable 5 with respect to the housing 10, the shape of the recess is cut to provide the stops 24. This limits the effective movement of the support member 13 in a range such that the unlatching means 20 always makes contact with the shoulder 19, regardless of how hard the upward pull might be.

Successive housing units are secured together at overlapping locations with screws, such as at the screws 25 and 26. These connections are located to facilitate main-

tenance, for instance to allow access to the compression springs 23.

Attached to the lower side of the mounting base 22 is sealing assembly 27, for preventing leaks to the electrical conductors 6 and for preventing breaks or cracks in the insulation of the electrical conductors as the base 22 moves longitudinally with respect to the housing of the drill tool. The conductors 6 pass entirely through the support member 13 and the base 22 emerging through a center opening in the sealing portion 28. The portion 28 is located inside the extending depending portion 29 fixed to the base 22. Screwed onto this extending portion and around the portion 28 is a protective housing 30. This housing also has a central opening 31 for allowing the conductors to extend therethrough. The contact at the opening 31 with the conductors 6 is suitably snug and rounded to assist in preventing wear of conductors 6.

Spaced longitudinally below sealing assembly 27 within the housing of the drill tool is a divider unit 32 which isolates the support member 13, the latching means 15, and their associated parts described above from the remainder of the parts in the drill tool. The divider is secured to the housing of the drill tool by the screws 26. A center opening through the divider permits the conductors 6 to pass through to connect to the electric motor 33.

Imbedded in the top surface of the divider is a sealing assembly 34 comprising a pressure plate 35 and a compliant material 36. On assembling the unit and after the conductors 6 are placed through the center hole, the compliant material is energized against the conductors by applying pressure to the plate 35 via the screws 37. This assures that there will be sufficient sag in the conductors 6 to prevent torsion pull directly on the conductors. The seals 38 help prevent moisture from entering the chamber housing the electric motor 33.

The electric motor 33 is of conventional design, preferably operated from a three-phase source, for turning the drill cutters. The rotating shaft 39 is free to rotate as provided by the bearings 40 and 41.

Cutters 7, 8, and 9 are shown in their cutting positions in FIGS. 1 and 4. In order for the cutters to be capable of being lowered through the casing to their position of use, the cutters 7 and 8 are mounted to swivel about the spindle 42. The spindle 42 passes through all three cutter units as shown best by FIG. 4. From top to bottom as illustrated the spindle 42 passes through the mounting extension 43, housing 44, through the cutter 9, and through the housing 45, and finally through mounting extension 46.

When the electric motor is operating, the spin of the shaft causes the lower part of the housing comprising the cutters to whirl. The whirling motion creates a centrifugal force applied to the cutters 7 and 8, tending to cause them to pivot outwards on spindle 42 and away from the approximately vertical at rest position.

As the cutters begin to bite into the ground surface, the rotational action of the cutters causes the cutters 7 and 8 to swivel even more on spindle 42, effectively spreading them beyond the limits of the casing wall, as shown in FIG. 1. The housing block is shaped to prevent swivel past the 90-degree point as shown. The cutter 9 is not pivoted on spindle 42 and therefore is not rotated. Complete coverage of the ground surface at the bottom of the hole is accomplished by the three cutters 7, 8, and 9 as they are spun about by the drill motor.

When drill mud is used in conjunction with the drill tool, the aforementioned passages between the splines of the drill tool and the casing permit free flow of such mud. The return path for the mud is outside the casing, the cutters having drilled a larger hole than the casing itself. If extremely high pressure mud is used, it may be desirable to incorporate channels in the tool to direct the mud around the cutters and thereby prevent the mud from damaging the cutters.

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When the drill tool 4 is removed from the hole by the cable 5, besides the latching means 15 becoming unlatched, the splines 12 and 11 disengage and the movable side cutters 7 and 8 swivel about spindle 42 by the force of gravity to return to the approximately vertical position so that the drill tool can be pulled up through the casing.

It should be noted that when the tool is in the cutting position, pressure can be brought to bear on the drilling cutters via the casing. This pressure path is from the surface through the casing, to the latching means 15, to the drill tool. Notice that this pressure path does not affect either the unlatching means or bring the casing wall at the lower end closer to the cutters, the full pressure being transferred by the recess 14 and the latching means 15.

It should also be noted that when drilling mud is used, it may be desirable to protect the workings of the latching and unlatching means from being hampered by the placement of a shield or barrier over these parts to keep them relatively free from contamination.

While only one embodiment of the invention has been described, it is obvious that various substitutes and modifications of structure may be made without varying from the scope of the invention.

What is claimed is:

1. In a cable-supported drilling apparatus suitable for being lowered down a well casing and for underreaming a borehole below said casing, said drilling apparatus having releasable means to engage said casing and to prevent vertical and rotational movement between said apparatus and said casing, the combination which includes:

self-positioning roller cutting means at the lower end of said apparatus, said roller cutting means comprising at least one rotatable cutter swivelly mounted from its upper end on a horizontally disposed spindle to gravitationally assume an outer diameter smaller than the casing when spaced from the bottom of the borehole, and to inertially assume a horizontally extended position for underreaming a hole beneath said casing when rotated below said casing in contact with the bottom of the borehole.

2. The apparatus of claim 1 including:

a horizontal spindle disposed as a diameter across the axis of rotation at the lower end of said drilling apparatus, and

two eccentrically disposed roller cutting means swivelly mounted on each side of said spindle spaced from the axis of rotation of said drilling apparatus, the said roller cutting means being adapted to gravita-

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tionally assume a vertical position when spaced from the bottom of the borehole, and to inertially assume a horizontally extended position for underreaming beneath said casing when rotated below said casing in contact with the bottom of the borehole.

3. The apparatus of claim 2 including:

a third roller cutting means axially rotatable about said spindle between said two eccentrically disposed roller cutting means.

4. A drilling apparatus suspended from a power and weight supporting cable and suitable for operating in a well casing comprising:

releasable means for securing the drilling apparatus to the well casing near its lower end and releasable upon upward movement of the cable,

self-positioning roller cutting means comprising at least one rotatable cutter swivelly mounted from its upper end on a horizontally disposed spindle to gravitationally assume an outer diameter smaller than the casing when spaced from the bottom of the borehole, and to inertially assume a horizontally extended position for underreaming a hole beneath said casing when rotated below said casing in contact with the bottom of the borehole, and

a motor contained within said apparatus for rotating said roller cutting means.

5. The drilling apparatus of claim 4 including:

guide means attached to the lowermost well casing joint and to the drilling apparatus for preventing rotational movement of said drill tool with respect to said casing.

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