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APPARATUS FOR DRILLING DEEP WELLS

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2 SHEETS—SHEET 1

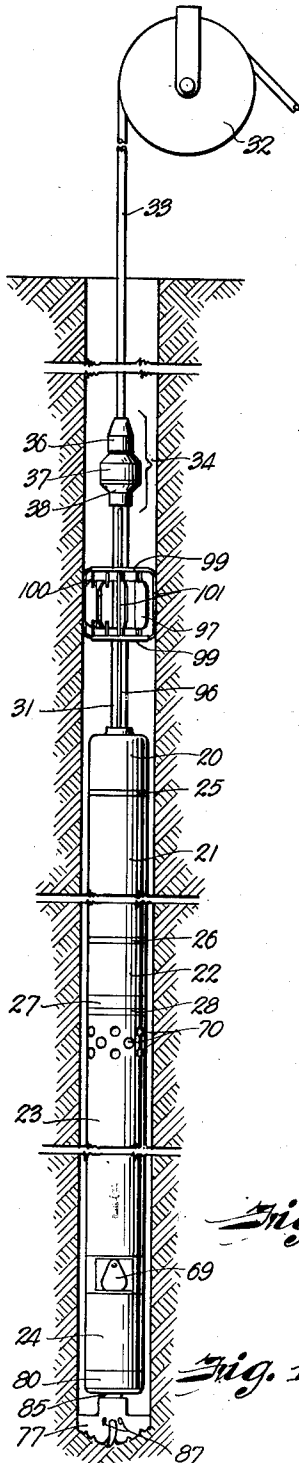


Fig. 1.

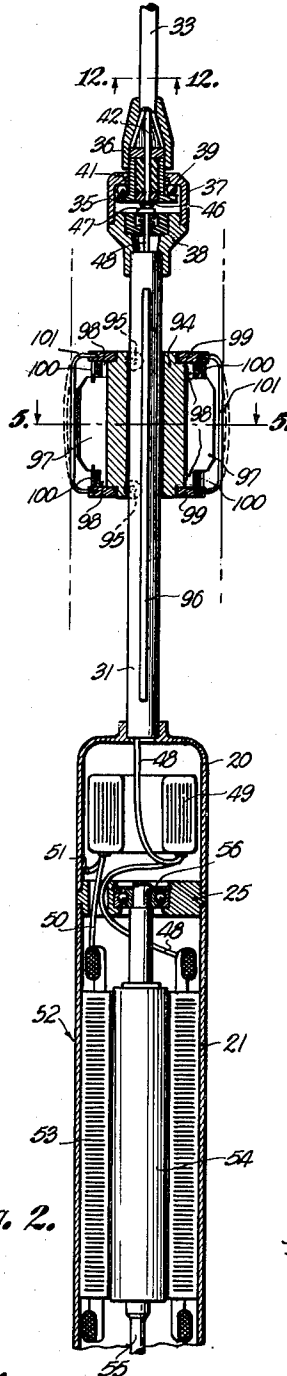


Fig. 2.

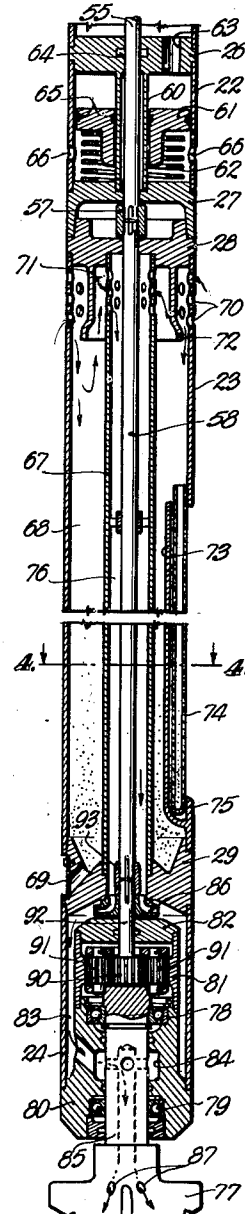


Fig. 3.

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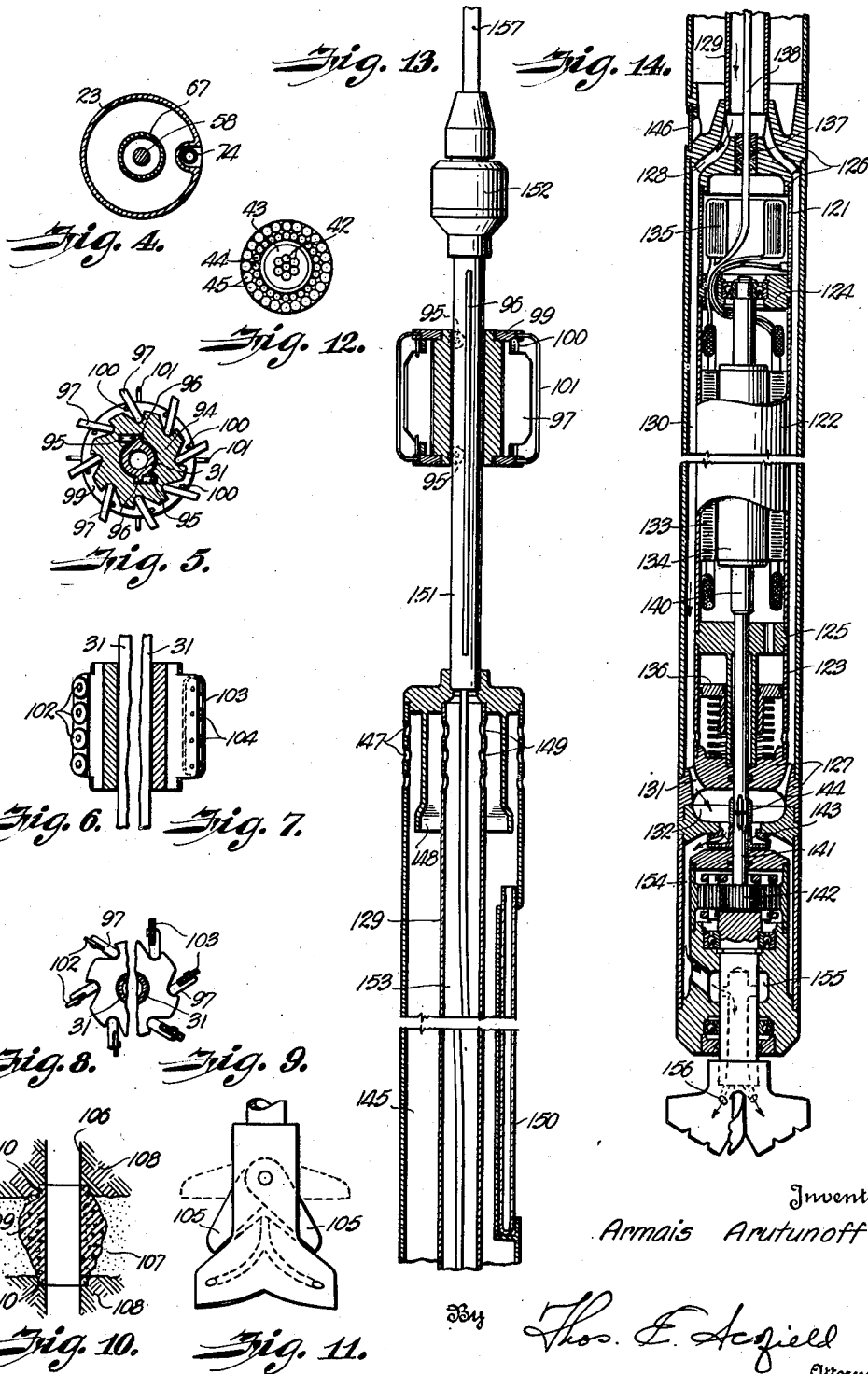
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2 SHEETS—SHEET 2



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UNITED STATES PATENT OFFICE

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APPARATUS FOR DRILLING DEEP WELLS

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8 Claims. (Cl. 255—4.8)

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My invention relates to the drilling of deep oil wells and has for its main objective the provision of a method which is superior to the existing and well-known rotary and cable-tool methods.

For shallow depths, cable drilling with its free falling bit action has some advantages over the rotary method of drilling, but these advantages disappear with increasing well depth so at great depth rotary methods are used in spite of the fact that productive strata may be easily missed and passed unnoticed due to masking of bore walls by mud which must be employed to carry out the cuttings.

The cable-tool method requires withdrawal of bit and bailing of cuttings, whenever the bit has advanced but a few feet. The cable-tool method also requires the setting of strings of casing where loose side wall material tends to sluff into the bore hole. It should be noted that cementing off of sluffing formations as proposed hereinafter cannot be employed when drilling with ordinary cable tools because of the chattering action and pounding of the bit in subsequent drilling of the cement, while with the rotating bit employed in my device the cement may be readily drilled without impairing the strength or soundness of casing.

When using the rotary method, sluffing formations are usually overcome by the use of heavy circulating pumps at great cost which circulate large volumes of mud or other reagents to increase wall plastering properties of circulating fluid.

The objects of my invention therefore are:

(a) To provide a drilling unit suspended on a cable together with an improved suspension coupling whereby attachment of the drilling unit to the cable automatically completes electrical connections to the motor; said coupling also providing a swivel action so that any incidental rotation of the unit will not result in twisting of the cable on which the unit is suspended.

(b) To reduce the number of electrical conductors in the suspension cable to an absolute minimum (i. e., a single conductor) by using, as a driver in the suspended drilling unit, an induction motor together with a capacitor located inside the unit, the weight carrying wires of the cable being grounded and acting as a return conductor.

(c) To provide a locking device whereby the drilling unit is locked against rotation and at the same time is free to slide vertically within the well bore.

(d) To provide a cable operating through a

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stuffing box which will not leak under high pressure conditions encountered when drilling-in into some productive formations.

(e) To provide a practical form of apparatus which will keep the surface being drilled clean by local circulation of water in the bottom of the well bore, and will segregate and accumulate by sedimentation the cuttings in a container of sufficient capacity to require a minimum number of withdrawals for their disposal.

(f) To provide an apparatus which will produce samples of all drilled strata in their proper geological sequence and show the thickness of the strata in easily inspectable, visual form.

(g) To provide a drilling method whereby a well drilled by tools suspended on a cable can be completed to full depth without use of strings of casing to prevent sluffing of the side walls and whereby when sluffing formation is encountered drilling is continued to a safe depth, after which the well bore is underreamed and cemented, then redrilled leaving a strong tube of cement where the rotating bit penetrates the cement without impairing the strength or soundness of tube which remains.

With the above objects in view as well as others which will appear as the description proceeds, my invention consists in the novel features herein set forth, illustrated on the accompanying drawings and more particularly pointed out in the appended claims.

In the accompanying drawings which form a part of the specification and are to be read in conjunction therewith and in which like reference numerals are employed to indicate like parts of the various views,

Fig. 1 is a side elevation of my drilling unit,

Figs. 2 and 3 are enlarged longitudinal cross sections of the drilling unit showing, respectively, the upper and lower portions thereof,

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 3 in the direction of the arrows,

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 2 in the direction of the arrows,

Figs. 6 and 7 are longitudinal cross sections illustrating two modifications of the antirotation collar for my drilling unit,

Fig. 8 is an end view of the modification shown in Fig. 6,

Fig. 9 is an end view of the modification shown in Fig. 7,

Fig. 10 is a cross section of the underreamed portion of a well after same has been cemented and drilled,

Fig. 11 is a view showing an underreamer,

Fig. 12 is an enlarged cross section taken along the line 12—12 of Fig. 2 in the direction of the arrows, and

Figs. 13 and 14 are longitudinal cross sections of a modified form of drilling unit showing, respectively, the upper and lower portions thereof.

Referring more particularly to Figs. 1, 2 and 3 of the drawings, the main casing of my drilling unit is made up of five generally cylindrical sections 20, 21, 22, 23 and 24 connected end to end by the coupling members 25, 26, 27, 28 and 29. A tube 31 which hereinafter will be referred to as the torque tube is rigidly secured to the upper section of the casing, the whole elongated assembly thus formed being suspended from the derrick pulley 32 by means of a cable 33.

Mechanical connection between the cable and the upper end of the torque tube is effected through a swivel coupling 34 in order to permit relative rotation between the two. This coupling has a flanged support 35 attached to the cable by a gripping member 36, and, cooperating therewith, a complementary collar or hanger 37 attached to the torque tube by the member 38; the hanger is rotatable with respect to the flanged support, bearings 39 being interposed between the two to carry the weight of the drilling unit. A packing gland 41 prevents intrusion of water into the upper end of the torque tube.

As shown in enlarged cross section in Fig. 12, the aforementioned cable is made up of a group of central conductors 42 surrounded by insulation 43 and by two rows of high tensile strength armor wires 44 and 45 laid on in opposite directions to give the cable a nonspinning or non-twisting characteristic. The interstices between the latter wires are filled with a rubber-like material of such physical properties that it welds itself to the steel wires and form a voidless cable of smooth exterior. It should be noted that while the material fills the exterior grooves between adjacent wires of the outer layer it does not wholly cover the wires, but instead leaves the crest or outermost portion of each exposed.

At the swivel coupling the armor wires of the cable make electrical connection with member 36 and serve to ground the drilling unit, while the central conductors 42 terminate in an insulated contact 46 against which the spring loaded contact 47 is urged. From contact 47 a conductor 48 extends downwardly through the tube 31 and connects to one side of drill motor 52, the other side of the motor being grounded (i. e., connected electrically with the armor wires of the cable) by means of a conductor 50 which is connected to a terminal 51 on the upper section of the drill casing.

The motor 52 is single phase, and preferably of the induction type, having in addition to its main winding a starting winding having capacitor 49 in series therewith for starting purposes. Its field structure 53 is fixedly positioned in the shell 21 and its armature 54 is mounted on the shaft 55, the upper end of the shaft in turn being supported in a bearing 56 while the lower end is journaled in member 26. The weight of the armature is supported by a collar 57 splined to the lower extremity of the motor shaft which collar rests on member 28 and also serves to couple the motor shaft to an extension shaft 58.

Around the lower end of the motor shaft is a stationary sleeve 60 depending from the member 26. Together, this sleeve and the outer shell 22 form an annular chamber in which a piston 61 is free to move. A heavy coiled spring 62 urges

the piston upwardly while standing on the piston is a column of oil which extends up through aperture 63 on through the motor chamber and capacitor chamber and finally up through tube 31 filling the interior of the swivel coupling clear to the packing gland 41. This body of oil surrounds and encloses all electrical parts effectively insulating same. Packing gland 64 prevents leakage of the oil in the motor chamber downwardly around shaft 55 and glands 65 prevent similar leakage around the piston.

The chamber immediately below the piston communicates with the space outside the unit through breather holes 66 whereby the piston may adjust its position automatically to accommodate the changes in the volume of the oil which occur as the result of heating and the like. It also should be noted that oil is under higher pressure than is the fluid outside of the drilling unit and accordingly that any clearance developed at the gland 41 due to swivel action of the coupling 34 will merely allow leakage of a little oil without permitting intrusion of outside fluid into the upper end of the unit.

Below the breathing arrangement just mentioned is a sleeve 67 which, with the shell 23, forms an elongated annular chamber 68 hereinafter to be referred to as the cutting accumulator. At the bottom of the accumulator is a dump valve 69. Intake apertures 70 are provided at the top of the accumulator and corresponding apertures 71 are provided in the upper end of sleeve 67, the two sets of apertures being separated from one another by a deflector skirt or baffle 72 extending down between them from member 28.

In the outer shell is a longitudinal trough-like depression 73 which accommodates an easily removable and replaceable transparent sampling tube 74. The open upper end of the tube extends into chamber 68 through an aperture in the top of the depressed section of the shell, while the lower end is held in place by a lip 75 which forms a socket at the bottom of the depressed section.

The bit 77 of the drilling unit is supported in suitable bearings 78 and 79 carried by the bottom piece 80, the latter part being secured to the casing section 24. Rigidly affixed to the upper end of the bottom piece is an internally toothed ring gear 81 and this in turn is surmounted by a stationary cap 82, the whole assembly being of such diameter as to leave an annular passageway 83 around it. The passageway communicates with a small annular chamber 84 encircling the drill stem 85 and, as will be described presently, a centrifugal impeller 86 drives drilling fluid through the passageway into the chamber wherefrom it escapes through the hollow drill stem and apertures 87.

The ring gear 81 forms part of an epicyclic gear train which includes a driving pinion 90 and also a plurality of planet gears 91 meshing both with the pinion and the ring gear. These planet gears are carried by a yoke provided at the upper end of the drill stem, and thus they turn the bit 77 as they move in their orbit around the driving pinion. The driving pinion and the impeller 86 are rotated by a shaft 92 journaled in the cap 82, this shaft being coupled to shaft 58 by a collar 93. The bearings and the gears are sealed off by packing glands as shown to prevent injury thereof by the drilling fluid.

Returning now to the torque tube 31, attention is directed to the collar-like member mounted thereon. This member which hereinafter will be referred to as the antirotation collar com-

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prises a hub 94 splined to the torque tube so that it is movable axially thereof without being rotatable relative to the tube. Rollers 95 are arranged on the hub to cooperate with the longitudinal ribs of splines 96 as shown. Around the periphery of the hub is a series of circumferentially spaced vertical slots, and in each slot there is a flap or dog 97 having vertically aligned trunnions 98 about which the dog can pivot to a certain extent within its associated slot. A pair of rings 99 carrying actuating pins 100, one for each dog, are arranged on the top and bottom of the hub. These rings are rotatable with respect to the hub and are connected to each other by four springs 101, the normal shape of which is shown by dotted lines in Fig. 2.

Having thus described the structure of my deep well drilling unit, I now will explain the manner in which it is used. The surface equipment associated with the unit is not shown but it will be understood that it includes in addition to the cable hoist, a suitable source of electrical current for the drill motor. Conveniently this may be a generator driven by the same prime mover used to operate the hoist, one output terminal of the generator being connected through a suitable switch to the central conductors 42 of the cable and the other output terminal being connected to the cable's armor wires 44 and 45 as a ground.

Construction of the well begins with the drilling of a large hole to accommodate the so-called surface pipe. The drilling unit, suspended from cable 33, is lowered through the derrick floor and allowed to advance slowly with its motor running. Through shaft 55 and its extensions 58 and 92 the motor drives pinion 90 causing planet gears 91 to move in an orbit around the interior of the stationary ring gear 81. This movement of the planet gears turns the bit 77 at a fraction of the motor speed, and thus is drilling effected as the unit advances. Cuttings are carried away from the bit in a manner presently to be described.

The rotation of the motor and drill in one direction naturally produces a torque tending to rotate the casing in the opposite direction, and therefore suitable surface clamps (not shown) are provided to hold the unit against rotation as it descends through the derrick floor. When the full length of the unit is in the bore hole the clamps are removed. Now however springs 101 of the antirotation collar engage the interior wall of the hole and resist rotation of their associated rings 99; consequently, as the backward thrust of the motor urges the casing, the torque tube 31 and the hub 94 in a counterclockwise direction (see Fig. 5) the pins 100, by remaining stationary pivot the flaps or dogs 97 outwardly causing all of them to engage and bite into the side wall of the bore hole simultaneously. After the initial engagement of the dogs, the backward thrust of the motor increases the grip of the collar on the side wall, and this effectively prevents further rotation of the drilling unit. Although it is locked against rotation, the torque tube 31 still is free to move axially relative to the hub 94 and hence the drilling unit will advance due to its own weight as the cable is payed out. Rollers 95 facilitate such advance by minimizing the friction set up between the torque tube and the hub 94 as a result of the backward thrust of the motor.

When drilling has progressed to the point where the shoulder of coupling member 38 rests on hub 94 a material reduction in the force exerted on

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the bit due to the weight of the unit takes place. The bit 77 therefore does not get a proper "bite" and there is an immediate drop in the motor's consumption of electrical power. This is registered at the surface by suitable electrical instruments connected to the motor circuit and the operator witnessing the change may now open the circuit to halt the motor; doing this eliminates the torque which theretofore maintained the dogs 97 engaged with the side wall and, thus released, the antirotation collar at once slides down the length of the torque tube because of its weight.

If the motor now is restarted the backward thrust will cause the dogs 97 to lock the antirotation collar firmly to the side wall in its new location, after which by paying out the cable the operator may cause drilling to take place as before. When the unit has again advanced a distance equal to the length of the torque tube 31, the motor may be halted momentarily to release and drop the antirotation collar; it then will be restarted to reset the collar and carry the drilling further, this cycle being repeated as often as necessary.

It should be noted that there automatically is a sharp reduction in the backward thrust on the casing of the unit and the antirotation collar, when as a result of the member 38 reaching hub 94 the bit 77 fails to get a proper bite. This reduction in the backward thrust reduces the grip of the dogs 97 on the side wall so that even if the motor is not halted the device will creep forward due to its own weight and continue drilling at somewhat slower speed than otherwise. The creeping characteristic may be improved if desired by providing wheels 102 on the dogs as shown in Figs. 6 and 8 or by providing each dog with a caterpillar tread or chain 103 mounted on suitable sprockets or wheels 104 as shown in Figs. 7 and 9.

As the drilling unit advances it naturally is necessary to carry the cuttings away from the bit and this is accomplished at the start of the drilling operation simply by inserting a hose into the bore hole beside the unit to flush the cuttings out of the hole as the unit descends through the derrick floor. When the full length of the drilling unit is in the hole the hose is removed and thereafter it is necessary only to keep sufficient fluid in the hole to insure that the unit is entirely submerged.

With the unit submerged the rotating impeller 85 draws the fluid into the casing through intake apertures 70, thence through apertures 71 and duct 76, and expels same by driving it through the annular passage 83, chamber 84, the hollow drill stem and apertures 87. The fluid thus expelled carries the cuttings from the bit upwardly around the outside of the casing and they subsequently are drawn into the cutting accumulator 68 through the intake apertures 70. Instead of passing out of the accumulator through apertures 71, however, the cuttings are deflected downwardly at high velocity by the skirt or baffle 72 and due to their higher specific gravity they continue downwardly and settle to the bottom. Part of the cuttings will, of course, enter the mouth of the transparent tube 74 so that, as drilling progresses through different strata, specimens of the strata will be built up in the tube in proper geological sequence and in proper relative thickness.

When the accumulator is full of cuttings the unit is lifted out of the hole and emptied. In

doing this it is convenient to insert a water hose securely in one of the intake apertures 70 as same appears at the surface and then continue raising the unit with the hose thus secured thereto. When the entire unit is out of the ground it is displaced to one side of the hole; dump valve 69 is opened and water introduced into the upper end of the accumulator and through the hose previously inserted flushes out the cuttings. The dump valve then is reclosed, the water hose unhooked, the unit lowered back into the bore hole and the drilling cycle resumed.

With a drilling unit 150 feet in length operating from a 186 foot derrick it is necessary to lift the unit from the hole to remove the cuttings in this fashion on the average of about once for each 60 foot advance in drilling. This withdrawal of the unit from the hole also offers an opportunity for inspecting the bit at proper intervals and resharpening or replacing it if necessary. At the same time the operator may examine the samples which have been collected in the transparent tube 74 to determine the character of the formation drilled. The tube is removed and emptied by raising it slightly, swinging its lower end away from the casing and then lowering it to withdraw the upper end.

It will be convenient at this point to refer to Figs. 13 and 14 which illustrate a drilling unit of modified construction wherein the cutting accumulator is above, rather than below, the motor and its associated equipment. The lower section of the drilling unit is identical to that shown in Fig. 3 and need not again be described. Immediately above this section and centrally disposed within the exterior casing 120 is an auxiliary housing of reduced diameter, made up of cylindrical sections 121, 122 and 123 fastened end to end by coupling members 124 and 125. This housing is supported and covered at its ends by coupling members 126 and 127, the member 126 containing ducts 128 which extend from the interior of sleeve 129 to the annular passageway 130 surrounding the auxiliary housing and the member 127 containing ducts 131 which extend from the annular passageway to chamber 132.

Within the auxiliary housing is a motor having a field structure 133 and an armature 134, together with an associated capacitor 135 and a breather piston 136. The essential arrangement and function of these parts is like that in the drilling unit previously described, it being understood, however, that the column of insulating oil standing on the piston extends only up through the motor chamber and capacitor chamber, the upper end of the latter chamber being sealed by a stuffing box 137 around the electrical conductors 138. The motor shaft 140 is coupled directly to the shaft 141 of the driving pinion 142 and the impeller 143 by means of a collar 144 splined to both shafts.

Above the auxiliary housing is an annular chamber 145 which forms the cutting accumulator. This has a dump valve 146 at its bottom and intake apertures 147 at the top. An annular baffle 148 separates the latter apertures from apertures 149 in the top of sleeve 129 while a removable transparent sampling tube 150 is provided in one wall of the casing as shown. The torque tube 151 rigidly secured to the top of the cuttings accumulator, and the antirotation collar mounted thereon, are like those previously described, the same being true of the swivel coupling 152.

In general, the mode of operation of the modi-

fied drilling unit is like that of the unit shown in Figs. 2 and 3. When the motor is operated to drive the bit, impeller 143 draws fluid from the bore hole into the casing through intake apertures 147 thence through apertures 149 and ducts 153, 128 and 130 into chamber 132 and expels same by driving it through the annular passageway 154, chamber 155, the hollow drill stem and apertures 156. The cuttings, carried upwardly from the bit by the fluid thus expelled, enter the accumulator through apertures 147 and there are collected. The antirotation collar functions to hold the casing against rotation, as previously described, while at the same time permitting the unit to advance axially of the hole as drilling progresses. If any rotation of the drilling unit does occur this will have no tendency to twist the cable 157 in view of the swivel action permitted by coupling 152.

It will be observed that the modified construction uses a motor of smaller diameter than that illustrated in Figs. 2 and 3, but it brings the motor close to the bit, thus avoiding a long drive shaft.

If in the course of using either type of drilling unit a loose and sluffing formation is encountered, the level of cuttings in the transparent sampling tube will be higher than usual for a given footage drilled, so that the driller will discover the situation when the unit is withdrawn from the hole and the tube is examined. The condition may be verified by inserting an empty sampling tube, lowering the unit until the drill is near the bottom but not in contact therewith, running the motor for an interval and then withdrawing the unit. When operated in this fashion no drilling takes place but the unit serves as a bailer, collecting loose matter in the accumulator as the fluid is circulated there-through. The presence of undrilled formation in the accumulator and sampling tube when the unit returns to the surface thus will confirm the original indication and the bailing operation then may be repeated one or more times until the accumulator ceases to collect loose matter. This, of course, will occur when the sluffing has stopped and a cavity has been formed in which the rock matter has assumed its natural angle of repose.

A centrifugally expanding underreamer (Fig. 11) next is fitted to the unit in place of the bit and lowered into the bore hole to the level of the cavity. The underreamer has blades 105 which remain folded during the descent and which are extended by centrifugal force (see dotted lines) when subsequently rotated by the motor. After the regions immediately above and below the cavity have been enlarged by the underreamer the motor is stopped, the unit is withdrawn from the hole and a quick-setting cement compound is introduced into the cavity. The cement is permitted to set, then the drilling unit with the bit once more attached thereto is lowered into the hole and the drilling proceeds as before, thereby to extend the hole through the cement and on down deeper into the formation. The resultant hole (106) is illustrated in Fig. 10 where the numeral 107 indicates a strata at which sluffing has occurred, 108 represents the solid formation above and below that strata and 109 is the cement. It will be noted that the solid formation has been underreamed at 110 so that the cement which seals off the sluffing strata is firmly anchored thereto.

In the event that gas formation is encountered, the well is loaded with water to overcome gas

pressure and drilling is continued. Should the gas pressure be excessive, however, so that the gas breaks through the water, the bore hole is underreamed in the same fashion as described above except that the well meanwhile is shut in, a so-called lubricator or stuffing box being arranged around the cable by which the unit is suspended; after underreaming the high pressure zone is cemented and redrilled, leaving around the hole a tube of cement capable of withstanding the pressure. It will be noted that the smooth exterior of the cable facilitates the use of a stuffing box around same to seal the well.

My drilling unit may be run in or out of the bore hole in about one-tenth of the time required to assemble and lower, or disassemble and raise, the sections of the drill pipe used in the rotary method of drilling. This saving in time is an exceedingly important factor because in practicing the rotary method the bit must be changed on the average of about once for each 60 foot advance in drilling (in other words, about as often as my unit must be raised to empty the cuttings accumulator). The total time saved by use of my device in drilling a deep well thus will be very great.

Bringing cuttings out of the hole by my method also is more economical and efficient than doing this by the mud circulation method employed in rotary drilling, as will be apparent from the fact that such mud circulation requires continuous operation of pumps of several hundred horsepower.

A further advantage over the rotary method resides in the fact that with my unit there is no danger of productive strata being passed unnoticed due to masking of the side walls by the circulating mud, as frequently happens in rotary drilling. Neither is there any danger of passing a sluffing formation. (In the rotary method, on the other hand, sluffing formations usually are not recognized until the drill has advanced a considerable distance past the formation and the drill stem has twisted off; to remedy the situation when this happens ordinarily requires setting a string of casing, with a consequent reduction in the size of the bore hole.)

Obviously, bits, underreamers, and core barrels of any type commonly employed in rotary drilling can be used effectively on my unit.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinbefore set forth together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

Inasmuch as many possible embodiments of the invention may be made without departing from the scope thereof it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. A bailer for wells comprising a pump having an intake line and an exhaust line, means for lowering the pump into the well so that its intake is submerged, a motor operated to drive the pump, said intake line including a vertically elongated reservoir through the upper portion of which fluid flows under the influence of the pump, the fluid in the lower portion of said reservoir being rela-

tively undisturbed whereby collection of sediment therein is encouraged, a vertical trough-like groove in a wall of the reservoir, a transparent elongated tube open at the top and closed at the bottom removably positioned outside the reservoir in the groove, and an aperture at the top of the groove through which the upper end of the tube extends into the reservoir to receive part of the sediment deposited.

2. In well drilling equipment of the type wherein a bit is driven by a motor that is lowered into the bore behind the bit and follows the bit downwardly as drilling progresses, said equipment being at least partially submerged, during drilling, in liquid introduced into the bore hole; the improvement which comprises a vertically elongated vessel connected to the motor housing and lowered into the bore hole therewith, said vessel having at its top an inlet port submerged below the surface of said liquid, said vessel also having at its top an outlet port, a pump driven by said motor, a duct connecting the intake side of the pump to said outlet, a duct extending from the discharge side of the pump and opening into the bore hole adjacent the bit, whereby liquid drawn into said vessel through said inlet port is discharged at the bit and recirculated upwardly in the bore hole back to said inlet port, and baffle means in said vessel between said inlet port and said outlet port for deflecting the liquid stream to induce the deposit in said vessel by sedimentation of detritus carried by said stream.

3. In well drilling equipment of the type wherein a bit is driven by a motor that is lowered into the bore hole behind the bit and follows the bit downwardly as drilling progresses, said equipment being at least partially submerged, during drilling, in liquid introduced into the bore hole; the improvement which comprises a vertically elongated vessel connected to the motor housing and lowered into the bore hole therewith, said vessel having at its top an inlet port submerged below the surface of said liquid, said vessel also having at its top an outlet port, a pump driven by said motor, a duct connecting the intake side of the pump to said outlet, a duct extending from the discharge side of the pump and opening into the bore hole adjacent the bit, whereby liquid drawn into said vessel through said inlet port is discharged at the bit and recirculated upwardly in the bore hole back to said inlet port, and means for sharply altering the course of the liquid stream flowing from said inlet port to said outlet port thereby to discharge from the stream detritus carried thereby and cause same to collect by sedimentation in said vessel.

4. In well drilling equipment of the type wherein the bit is driven by a motor that is lowered into the bore hole behind the bit and follows the bit downwardly as drilling progresses, said equipment being at least partially submerged, during drilling, in liquid introduced into the bore hole; the improvement which comprises a vertically elongated vessel connected to the motor housing and lowered into the bore hole therewith, said vessel having at its top an inlet port submerged below the surface of said liquid, said vessel also having at its top an outlet port, a pump driven by said motor, a duct connecting the intake side of the pump to said outlet port, and a duct extending from the discharge side of the pump and opening into the bore hole adjacent the bit, whereby liquid drawn into said vessel through the inlet port and across the upper portion of the vessel is discharged at the bit and recirculated

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upwardly in the bore hole back to said inlet port, the liquid in the lower portion of said vessel being relatively undisturbed whereby collection of sediment therein is encouraged.

5. In well drilling equipment of the type wherein the bit is driven by a motor that is lowered into the bore hole behind the bit and follows the bit downwardly as drilling progresses, said equipment being at least partially submerged, during drilling, liquid introduced into the bore hole; the improvement which comprises a vertically elongated vessel connected to the motor housing and lowered into the bore hole therewith, said vessel having in its top an inlet port submerged below the surface of said liquid, said vessel also having in its top an outlet port, a pump driven by said motor, a duct connecting the intake side of the pump to said outlet port, a duct extending from the discharge side of the pump and opening into the bore hole adjacent the bit, whereby liquid drawn into said vessel through the inlet port and across the top thereof is discharged at the bit and recirculated upwardly in the bore hole back to said inlet port, the liquid in the lower portion of said vessel being relatively undisturbed whereby collection of sediment therein is encouraged, a vertical trough-like groove in the wall of the vessel, an elongated tube open at the top and closed at the bottom positioned outside the vessel in the groove, and an aperture in the top of the groove through which the upper end of the tube extends into the vessel to receive part of said sediment.

6. In well drilling equipment of the type wherein the bit is driven by a motor that is lowered into the bore hole behind the bit and follows the bit downwardly as drilling progresses, said equipment being at least partially submerged, during drilling, in liquid introduced into the bore hole; the improvement which comprises a vertically elongated vessel connected to the motor housing and lowered into the bore hole therewith, said vessel having at its top an inlet port submerged below the surface of said liquid, said vessel also having at its top an outlet port, a pump driven by said motor, a duct connecting the intake side of the pump to said outlet port, a duct extending from the discharge side of the pump and opening into the bore hole adjacent the bit, whereby liquid drawn into the vessel through said inlet port is discharged at the bit and recirculated upwardly in the bore hole back to said inlet port, means for sharply altering the course of the liquid stream flowing from said inlet port to said outlet port thereby the discharge from the stream detritus carried thereby and cause same to collect by sedimentation in said vessel, and a vertically elongated tube open at the top and closed at the bottom detachably mounted on the vessel with the upper end of the tube inside the vessel to receive part of the detritus discharged from said stream.

7. In well drilling equipment of the type wherein a bit is driven by a motor that is lowered into the bore hole behind the bit and follows the bit downwardly as drilling progresses, said equipment being at least partially submerged, during drilling, in fluid introduced into the bore

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hole; the improvement which comprises a vertically elongated container connected to the motor housing and lowered into the bore hole with the motor, said container having near its top an intake port and an exhaust port, means including a pump driven by the motor for inducing a local circulation of the fluid at the bottom of the bore hole such that the fluid travels upwardly from the bit into the intake port of the container and thence out of the exhaust port, the fluid in the lower portion of the container remaining substantially undisturbed, a baffle device in the container in the path of the fluid flowing between said two ports for deflecting the fluid to induce sedimentation of the cuttings of the bit which are carried by the fluid, whereby said cuttings are collected in the container, a vertical trough-like groove in a wall of the container, an elongated tube open at the top and closed at the bottom removably positioned outside said container in the groove, and an aperture at the top of the groove through which the upper end of the tube extends into the container to receive part of the cuttings deposited.

8. Equipment as claimed in claim 7 wherein said tube is transparent.

ARMAIS ARUTUNOFF.

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158,865	Pontez	Jan. 19, 1875
478,791	Gardner	July 12, 1892
1,077,620	Mathews	Nov. 4, 1913
1,090,919	Kitsee	Mar. 24, 1914
1,109,446	Melberg	Sept. 1, 1914
1,269,449	Hughes	June 11, 1918
1,315,422	Roberson	Sept. 9, 1919
1,342,814	Huston	June 8, 1920
1,348,325	Shean	Aug. 3, 1920
1,350,059	Blackwell	Aug. 17, 1920
1,362,775	Bunker	Dec. 21, 1920
1,378,056	Reed et al.	May 21, 1921
1,431,528	Keith	Oct. 10, 1922
1,461,687	Strobel	July 10, 1923
1,477,563	Hirschfeld et al.	Dec. 18, 1923
1,525,235	Hansen	Feb. 3, 1925
1,530,803	Anderson	Mar. 24, 1925
1,753,440	Miller	Apr. 8, 1930
1,799,559	Hunicke	Apr. 7, 1931
1,870,696	Taylor	Aug. 9, 1932
1,880,214	Simmons	Oct. 4, 1932
2,064,936	McQuiston	Dec. 22, 1936
2,070,370	Miller	Feb. 9, 1937
2,072,320	Thomas	Mar. 2, 1937
2,128,547	Wells	Aug. 30, 1938
2,167,393	Muncy	July 25, 1939
2,170,527	Culbertson	Aug. 22, 1939
2,193,219	Bowie et al.	Mar. 12, 1940
2,200,758	Thaheld	May 14, 1940
2,224,439	Lee	Dec. 10, 1940
2,421,997	Crake	June 10, 1947
2,445,206	Bynum	July 13, 1948
2,454,945	Reynolds	Nov. 30, 1948
2,463,590	Arutunoff	Mar. 8, 1949