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2,643,087

SELF-POWERED ROTARY DRILLING APPARATUS

Filed Dec. 22, 1950

3 Sheets-Sheet 1

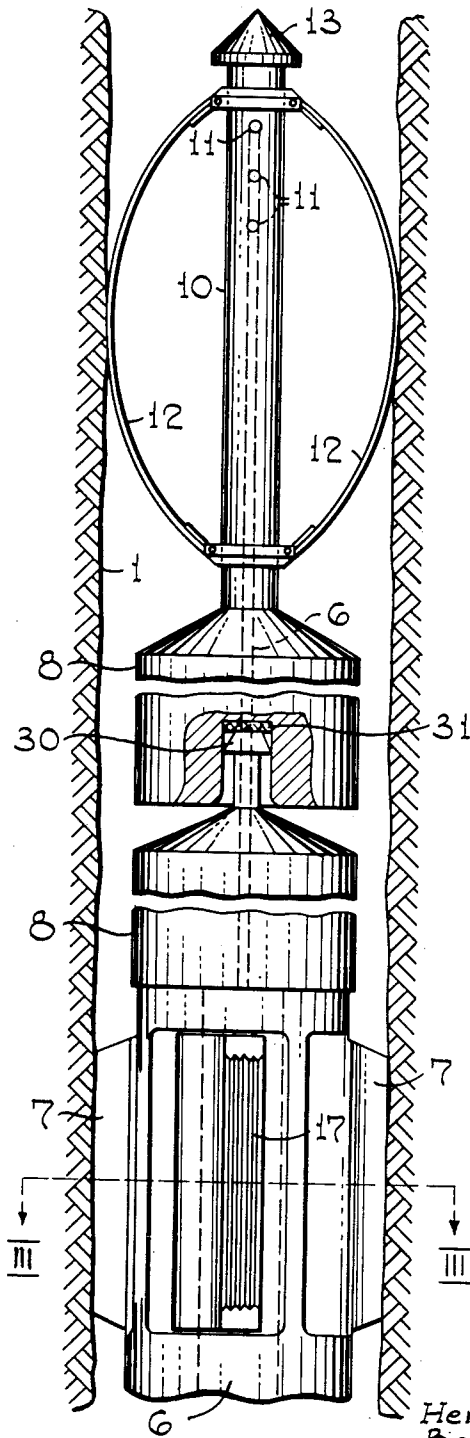


FIG. 1

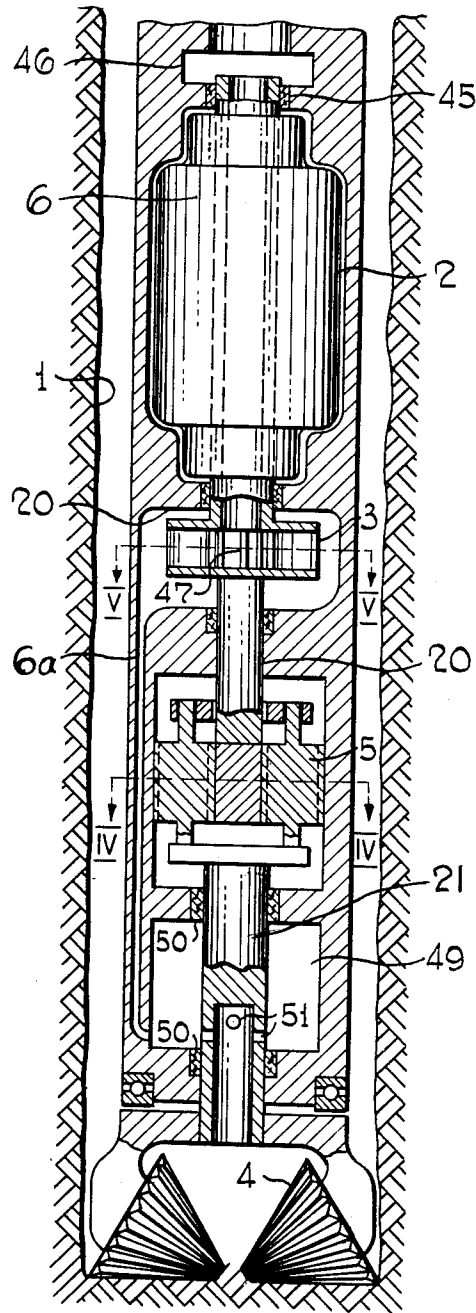


FIG. 2

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3 Sheets-Sheet 2

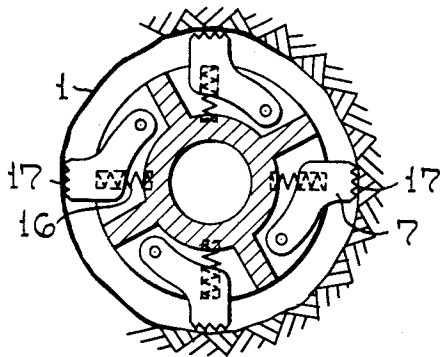


FIG. -3

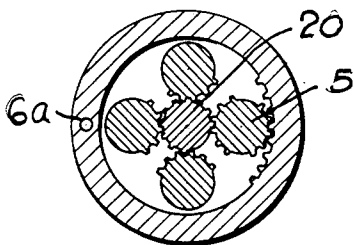


FIG. -4

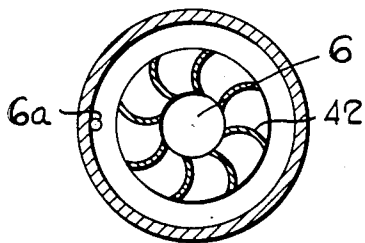


FIG. -5

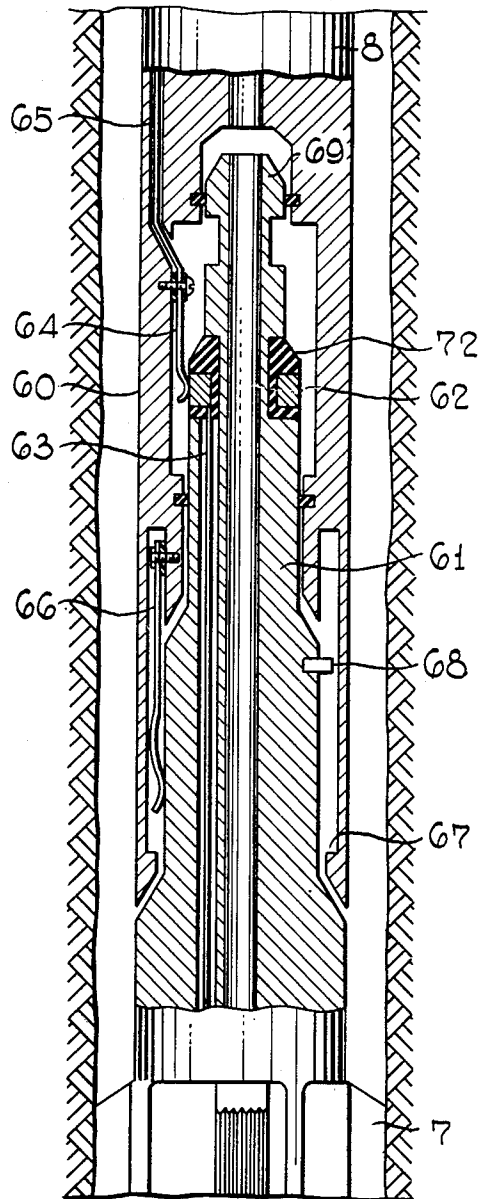


FIG. -8

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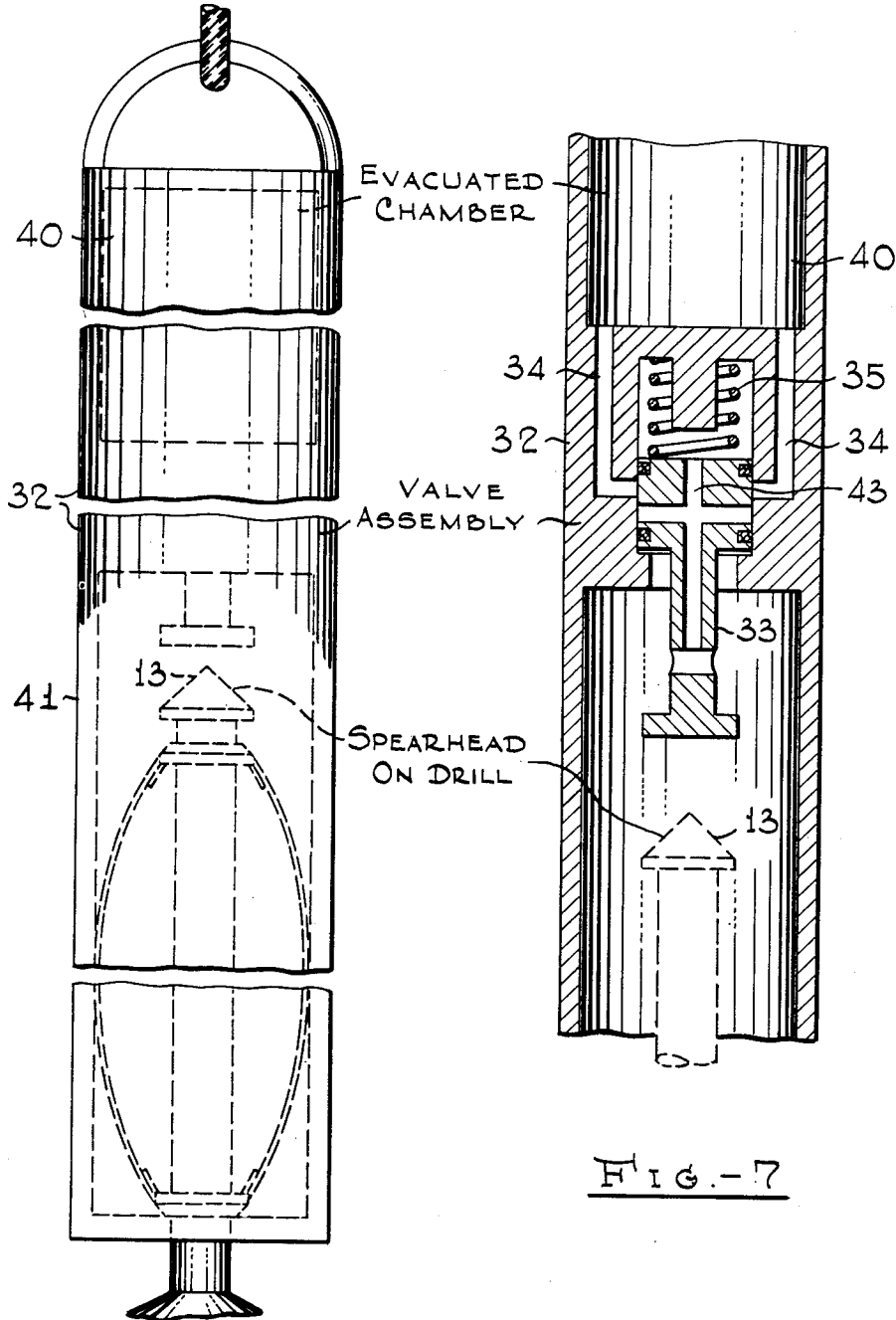


FIG.-7

FIG.-6

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UNITED STATES PATENT OFFICE

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SELF-POWERED ROTARY DRILLING
APPARATUS

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6 Claims. (Cl. 255—4.8)

1

This invention concerns a novel apparatus for the drilling of bore holes, as conducted for example, in the drilling of oil wells. This invention provides a drilling apparatus containing a stored supply of energy which is released at the bottom of the bore hole to power conventional drilling bits. The drilling tool or power supply units of the tool may be periodically removed from the hole in order to renew the store of energy. Drill cuttings are removed from the hole by means of bailing equipment. The entire apparatus may be operated in the bore hole without necessity for mechanical connection to any units at the surface of the earth.

At the present time, the majority of drilling operations are conducted by employing "rotary drilling equipment." In conventional rotary drilling, a hollow jointed steel shaft called the drill stem is rotated from the surface of the earth. This shaft, extending downwardly into the earth to any desired depth, rotates a drill bit. For a number of purposes, a weighted fluid called drilling mud is circulated in one direction through the drill stem and in the opposite direction through the annulus between the drill stem and the bore hole. This general drilling technique is an extremely expensive operation. For example, a large capital investment is required to provide the high-power generating and transmitting capacity necessitated; to provide the necessary equipment to assemble, support, and turn the drill stem in the bore hole; and to provide the necessary apparatus for circulating the drilling mud. As a consequence of these and other factors, there is a demand for alterations in drilling technique and apparatus of a nature to materially reduce the cost of drilling wells and to overcome many of the disadvantages of the rotary drilling method.

In accordance with this invention, these general objectives are satisfied by the provision of a novel drilling apparatus. As will be seen, the invention eliminates the necessity for employing the thousands of feet of drill stem heretofore required, thus eliminating the necessity for the equipment heretofore required to support, turn, and to assemble or disassemble the drill stem. Again, this invention eliminates the necessity for providing the high capacity, high power pumping apparatus heretofore required for maintaining the circulation of drilling mud throughout the entire bore hole.

These objectives are achieved by a drilling apparatus which may operate as an integral, self-powered unit in a bore hole without necessity

2

for support or physical connection to any apparatus at the surface of the earth. Thus, the apparatus includes a stored power source, preferably a battery, operative to drive a motor. The motor performs a dual function; operating a pump positioned in the apparatus so as to secure a desired circulation of drilling mud in the vicinity of the bottom of the bore hole, and operating a conventional drilling bit. Operation is conducted by dropping the apparatus to the bottom of the bore hole and periodically removing at least a portion of the batteries for replacement by fresh units. "Bailing" is periodically or continuously carried out during drilling to remove drill cuttings preferentially accumulated adjacent the top of the drilling apparatus by virtue of the mud circulation provided.

In order to fully disclose the concepts of this invention, the accompanying drawings illustrating a preferred embodiment of the apparatus of this invention will be described. In these drawings:

Figure 1 diagrammatically illustrates in elevation, partly in section, the upper portion of the drilling equipment of this invention;

Figure 2 is a continuation of Figure 1 showing the lower portion of the apparatus, so that together, Figures 1 and 2 depict the integral apparatus;

Figure 3 is a section of Figure 1 along the lines III—III showing the nature of the friction dogs provided to prevent rotation of any portion of the apparatus except the drill bit;

Figure 4 is a cross section through the gear reduction system along the line IV—IV of Figure 2;

Figure 5 is a section of Figure 2 along the line V—V, illustrating the mud pump which may be employed;

Figures 6 and 7 show in elevation and in elevational cross section, respectively, a suitable type of bailing apparatus for use in removing the drill cuttings produced by the apparatus, and finally;

Figure 8 is an elevational view, partly in section, of a preferred arrangement for connecting the batteries of the apparatus.

Referring now to Figures 1 and 2 of the drawings, the general nature of the drilling apparatus may be understood. As illustrated, the entire integral apparatus is to be operated in a bore hole 1 in the earth. It is to be understood that, depending upon the progression of the drilling apparatus into the earth, bore hole 1 may be of any desired depth. As will be explained, the bore

3

hole is maintained completely filled with a substantially static head of drilling mud. The actual drilling apparatus may be considered to consist of three assembled units. The lowermost unit may be identified as a motor section, above which is positioned a stored power source or a battery section and above which is an uppermost section operative to separate drill cuttings from drilling mud and to permit recirculation of the drilling mud to the bottom of the apparatus adjacent the drill bit.

The motor section contains an electric motor 2 which is coupled to a mud pump 3 and to a drill bit 4 through a reduction gear system 5. It is contemplated that the electric motor may be directly coupled to the mud pump 3 while it is generally preferred that reducing gears 5 be employed so as to permit operation of the drill bit 4 at a speed less than the rotational speed of the motor. As will be understood, a passageway 6 extends completely through the apparatus from an upper portion thereof to a point adjacent the drill bit 4 at the lower portion of the apparatus. Thus, drilling mud may be pulled downwardly through passageway 6 to be driven by the mud pump 3 toward the drill bit 4 and thence upwardly through the bore hole. The top of the motor section is surmounted by a number of friction dogs 7 which are urged outwardly by springs so as to fix this portion of the apparatus in the bore hole, preventing rotation of the motor and enabling rotation of the drill bit 4 with respect to the motor section.

The battery section above the motor section is preferably composed of a number of individual power units 8. While any desired type of battery may be employed, it is particularly contemplated that a battery of the familiar lead-acid type be used. The plates of this battery may be assembled as parallel annular discs permitting placement of the mud conduit 6 through the central portion of the battery. Electrical connections to the plates of the battery may be made in any desired manner, as for example, by passage of electrical conductors through a clearance space provided at the outer terminations of the plates of the battery. It is convenient, for example, to assemble the battery sections in units about 10 feet long. Connectors are provided at each end of a given battery unit so that additional units may be connected and so that any desired number of units may be connected to the motor section of the apparatus. Various provisions may be made to permit a portion but not all of the batteries to be removed. For example, as illustrated, the top of a battery section may be provided with a spear head 30, fitting within a hollow cavity of the next higher battery section. This permits removal of the upper battery section while permitting retrieving of the lower battery section when desired. By providing an elastic sealing disc 31 at the top of the cavity, the upper battery section may seat on spear head 30 to connect conduit 6 of adjacent battery sections. For simplicity, the electrical connections between battery sections have not been illustrated in Figure 1, although it is apparent that the connections may be made in a number of ways. A preferred manner of connecting the batteries will be described in connection with Figure 8. As battery packs of this general nature are well known, no further description will be offered as to this element of the apparatus. It may, however, be noted that the power capacity required is not unreasonable. The power requirements imposed on the battery consist of the rotation

4

of the drill bit and the circulation of drilling mud through the apparatus and along the lower portion of the bore hole. However, these power requirements are relatively low as compared to the power required in circulating drilling mud through the entire bore hole and in rotating the tons of drill stem in the bore hole, as required in conventional rotary drilling operations.

Finally, in the apparatus of Figure 1, a cutting separator section is employed as indicated by the numeral 10. The cutting separator section is simply an upwardly extending portion of the apparatus having a materially reduced cross sectional area as compared to the cross sectional area of the remainder of the equipment. As a result, drilling mud forced upwardly in the annular space between the motor or battery section and the bore hole, on entering the enlarged annular space at the separator section will have a greatly reduced rate of flow. This will cause cuttings forced upwardly by the swiftly flowing drilling mud to preferentially accumulate at the upper section of the apparatus. This reduced diameter section of the apparatus thus essentially provides a settling region, from the upper portion of which drilling mud may be removed substantially free of drill cuttings. Consequently, by placing orifices 11 at the uppermost portion of the apparatus, relatively clear drilling mud may be pulled downwardly through channel 6 and through the mud pump for recirculation to the drill bit 4. As will be described, the drill cuttings accumulating in the separator section are periodically or continuously removed from this section by, for example, a bailing technique.

It is preferred that centering springs 12 be positioned near the top of the apparatus so as to maintain the apparatus in true alignment with the bore hole. The springs may be leaf springs fixed to collars sliding on shaft 10 to permit expansion or contraction without buckling. Finally, a spear head 13 of the conventional type is provided at the top of the drilling apparatus so that a suitable retrieving tool may be dropped downwardly into the bore hole to permit pulling the upper battery section to the surface of the earth when desired for renewal or replacement of the battery section.

In order to fully disclose an operable embodiment of this invention, the remaining figures of the drawings are concerned with essential mechanical details. Thus, Figure 3 illustrates a suitable arrangement of friction dogs to prevent rotation of any portion of the apparatus other than the drill bit. As illustrated in Figure 3, a number of friction dogs 7 may be arranged around a central tubular supporting member 15. It will be recalled that the central opening of member 15 provides the necessary drilling mud conduit through this portion of the apparatus. Springs 16 are placed between each of the friction dogs 7 and the support 15 so as to urge the friction dogs outwardly against the bore hole 1. These friction dogs are preferably designed so as to have vertical serrations 17 of a nature to permit the apparatus to pass upwardly or downwardly in the bore hole 1 but to prevent rotation of the apparatus. Alternatively, or as a modification, latching mechanisms may be provided to normally hold the friction dogs in non-engaging position but to permit release of the friction dogs when the apparatus contacts the bottom of the bore hole.

Referring now to Figure 4, a section of the gear reducing system for coupling of the motor

5

to the drill bit is illustrated. Thus, a motor shaft 20, directly coupled to the motor drive is connected to the planetary gear system illustrated. As a result, the shaft 21 driven by the planetary gear system will turn at a reduced rotational speed. As planetary gear reducers of this nature are well known, no further description of this element of the invention is considered necessary.

Referring to Figure 5, a section of the mud pump is diagrammatically illustrated. The shaft of the pump 20 is directly coupled to the motor and is provided with a central passageway 6 through which drilling mud may flow into the pump. The impeller 42 connected to shaft 20 may be of the configuration shown in Figure 5, causing mud to be forced from the periphery of the pump, through lower channel 6a downwardly toward the drill bit.

Figures 6 and 7 illustrate a suitable form of bailing apparatus to be used in removing the drill cuttings from the cuttings separator portion of the apparatus heretofore described. As shown in Figure 7, the bailer comprises an upper evacuated chamber 40 joined to or integral with a downwardly extending hollow portion 41 suitable for passing over the spear head 13 and separator section 10. Fluid passageway to chamber 40 is provided through suitable conduits and valve mechanism 32. A suitable valve assembly may consist of a slide valve 33 normally closing conduit 34 by virtue of spring 35 maintaining valve 33 in its downward or closed position. Port 43 in valve 33 is provided to equalize the pressure across the valve. As a result of this assembly, when the integral bailing apparatus is lowered downwardly in the bore hole over the spear head and over the centering springs of the drilling apparatus, the spear head will cause operation of slide valve 33 to permit fluid adjacent the spear head to flow upwardly through conduit 34 into chamber 40. This flow occurs since chamber 40 may either be evacuated or simply filled with air at atmospheric pressure so the drilling fluid will be forced into the chamber under the high pressures existing at the bottom of the bore hole. The preferential concentration of drill cuttings beneath spear head 13 as formerly described permits the bailer to directly remove the greater part of the drill cuttings from the bore hole. In operation, the bailer is repeatedly lowered to the bottom of the bore hole to remove these cuttings at whatever rate is required.

Referring now to Figure 8 of the drawings, a preferred manner of connecting the individual battery units and the motor section of the apparatus is illustrated. It may be noted that in Figure 8 the portion of the apparatus shown is intermediate battery unit 8 and the motor section surmounted by the friction dogs 7. Essentially then the drawing illustrates the manner of connecting a battery unit 8 to the lower motor section although it is to be understood that the same configuration may be employed between individual battery units as well. The battery unit 8 is terminated at its lower portion in a downwardly extending tubular member 60. This provides a hollow cavity within which an upwardly extending plug 61 from the next lower battery unit or from the motor section may enter. Plug 61 is preferably formed in stepwise sections of smaller cross-sectional diameter. A cylindrical electrical contact 62 is positioned around a portion of plug 61 having an intermediate cross-sectional area. Insulating material 72 serves to electrically insu-

6

late the metallic contactor 61 from the remaining portion of the apparatus. An electrical lead 63 extends from contact 61, through a passage provided, downwardly to the motor section of the apparatus or, if desired, to a lower battery section. A spring contact 64 carried within the hollow cavity provided by tubular member 60 of the battery unit 8 is positioned to make contact with the contact 61, and a conductor 65 from the spring contact 64 extends upwardly to the upper battery section. As described, electrical contact from an upper battery section 8 to the lower motor section may be made through conductor 65, leaf contact 64, cylindrical contact 62, and conductor 63. The remaining electrical connection required may be provided by grounding the battery and motor of the apparatus to the metallic shells in which they are contained. A ground contact 66 may then be positioned within tubular member 60 so as to make contact with the plug 61 so as to complete the electrical circuit. The tubular termination of the battery section 8 is preferably provided with lugs or shoulders 67. The shoulders 67 are intended to contact pins or collars 68 fixed to or positioned on plug 61. By this provision, when the entire apparatus is supported from above, the battery unit 8 will carry the motor section by contact of the shoulder 67 with the collar 68. In this condition contact 64 will not make contact with contact 61. However, when the apparatus has been lowered to the bottom of the bore hole, the weight of battery unit 8 and the upper portion of the apparatus will cause the battery unit to slide downwardly to the position illustrated. This will complete the electrical circuit as formerly described.

This arrangement to permit the sliding of battery 8 downward into electrical contact with the motor section causes the motor to begin operation when the apparatus has reached the bottom of the bore hole.

In order to permit certain of the battery units to be withdrawn for replacement at the surface of the earth without interrupting the operation of the drill bit, it is particularly contemplated that at least one battery unit above the lowermost battery unit be built without the pin or collar 68. As a result, if a retrieving tool is dropped down the bore hole to engage the spearhead at the uppermost portion of the apparatus, the upper battery units may be pulled from the bore hole while leaving one or more of the lower battery units at the bottom of the bore hole. These units will serve to power the drill bit during the period of time required to introduce fresh or recharged units by dropping them downwardly into the bore hole.

When drilling operations are completed, and it is desired to pull the entire apparatus from the bore hole, it will then be necessary to first retrieve the replaceable battery units and to then recover the lowermost section of the apparatus by engaging the spearhead 69.

As described, the apparatus is of a nature to permit mud circulation from the uppermost part thereof downwardly through the entire apparatus to a point adjacent the drill bit. To follow the passage of mud through the apparatus it will be noted that the drilling mud enters the apparatus through the ports 11 at the upper portion of the cuttings separator section. The drilling mud is passed downwardly through channel 6 through the battery sections of the apparatus. Beneath the battery sections channel 6 enters the cavity 46, adjacent the shaft of motor 2.

Packing glands 45, sealing off cavity 46 cause the drilling mud to pass into the shaft 20 of motor 2. The drilling mud then passes into pump 3 through the ports 47 arranged on the impeller of the pump and opening into the channel 6 of the motor shaft 20. The drilling mud is forced by the pump into the lowermost channel 6a which may be arranged adjacent the outer portion of the apparatus housing to permit the mud to bypass the gear reduction system 5. The drilling mud is then brought into a lower cavity 49 surrounding the shaft 21 of the drill bit 4. Again packing glands 50 are employed above and below cavity 49 to contain the drilling mud in the cavity adjacent drill bit shaft 21. The lower portion of shaft 21 is hollow and is provided with ports 51 so that the drilling mud from cavity 49 may pass to the inside of shaft 21 through ports 51. The drilling mud may then be expelled through the lower termination of the channel in the drill bit shaft 21.

It will be noted that the motor shaft 20 is directly coupled to both the mud pump 3 and to the gear reduction system 5. In the manner illustrated and described, this permits the motor to power both the drill bit and the mud pump.

It is apparent that in place of the batteries described, other stored power sources may be employed together with suitable motors to be driven thereby. For example, a compressed gas system, or a chemical power system may be employed.

What is claimed is:

1. A self-powered apparatus for drilling a borehole comprising an elongated body, a drill bit rotatably supported on the lower end of said body, a motor in said body driving said drill bit, a pump in said body driven by said motor, borehole engaging means carried by said body to prevent rotation of said body in the borehole, at least one stored power section connected to the top of said body, means for furnishing power from said power section to said motor, a fluid passageway extending through said body from a port adjacent said drill bit to a port at the top of said body, and a fluid passageway extending vertically through said stored power section and communicating with said passageway in said body whereby fluid circulation through a path within the entire length of the apparatus in the bore hole and a path through the entire length of the annulus between the apparatus and the bore hole may be established.

2. Apparatus as defined by claim 1 in which at least one of said stored power sections is releasably connected to said body whereby said section may be removed from the borehole by retrieving means lowered into the borehole.

3. Apparatus as defined by claim 1 in which at least the uppermost stored power section terminates at its upper end in a portion of reduced cross sectional area, thereby defining with the borehole an enlarged annulus of larger cross sectional area than the annulus surrounding the body, said passageway through said stored power section terminating in ports above the lower end of said reduced portion, whereby cuttings will tend to settle in said enlarged annulus below the point of entry of fluid into said passageway.

4. Apparatus as defined by claim 1 in which said stored power sections are electric battery sections, said motor is an electric motor and said means for furnishing power to said motor is an electrical circuit.

5. Apparatus as defined by claim 4 wherein the battery section immediately adjacent the body is mounted in slidable relation to the body for limited movement between a first position and a second position, said electrical circuit including contacts in said battery section and in said body whereby the battery is connected to said motor in only one of said positions.

6. A self-powered apparatus for drilling a borehole comprising an elongated body adapted to pass through the borehole, a drill bit rotatably supported on the lower end of said body, a pump in said body, a motor in said body driving said drill bit and said pump, borehole engaging means carried by said body to prevent rotation of said body in the borehole, a first battery section connected to the top of said body, a second battery section releasably connected to said first battery section whereby said second battery section may be removed from the borehole by retrieving means, a fluid passageway extending through said body from a port adjacent said drill bit to a port at the top of said body, fluid passageways extending vertically through each of said battery sections and communicating with said passageway in said body, and an electrical circuit connecting each of said battery sections to said motor.

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