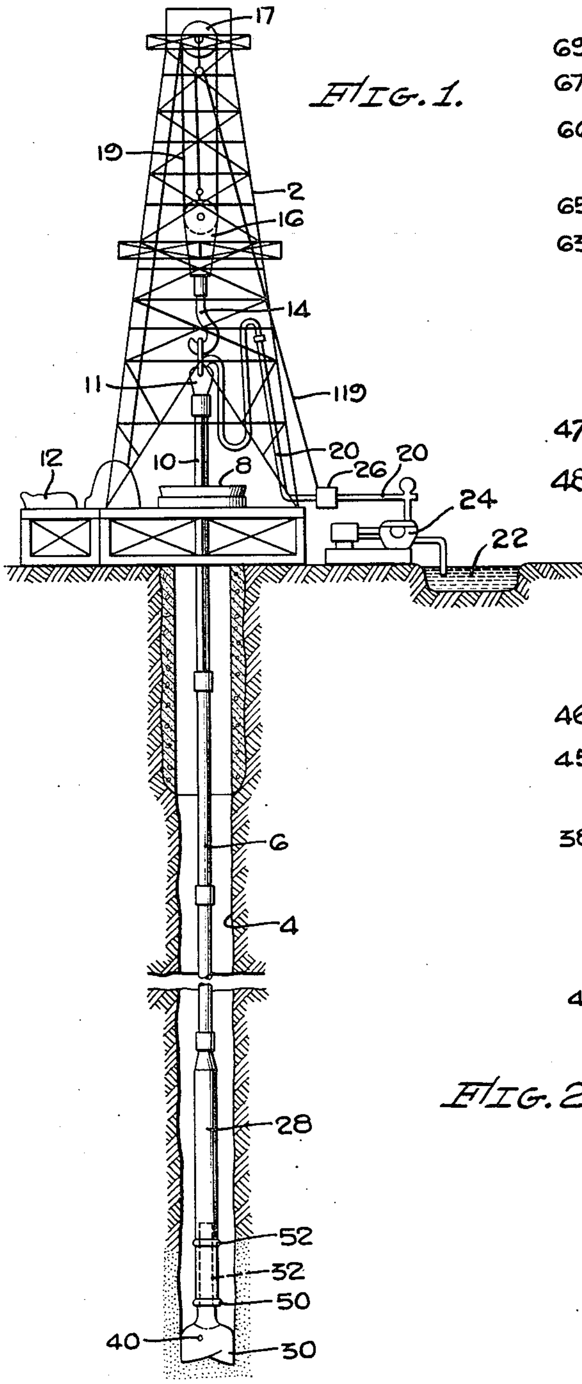
April 2, 1957 J. J. ARPS 2,787,759

APPARATUS FOR LOGGING WELLS

Filed Aug. 31, 1950 3 Sheets-Sheet 1

FIG. 1.



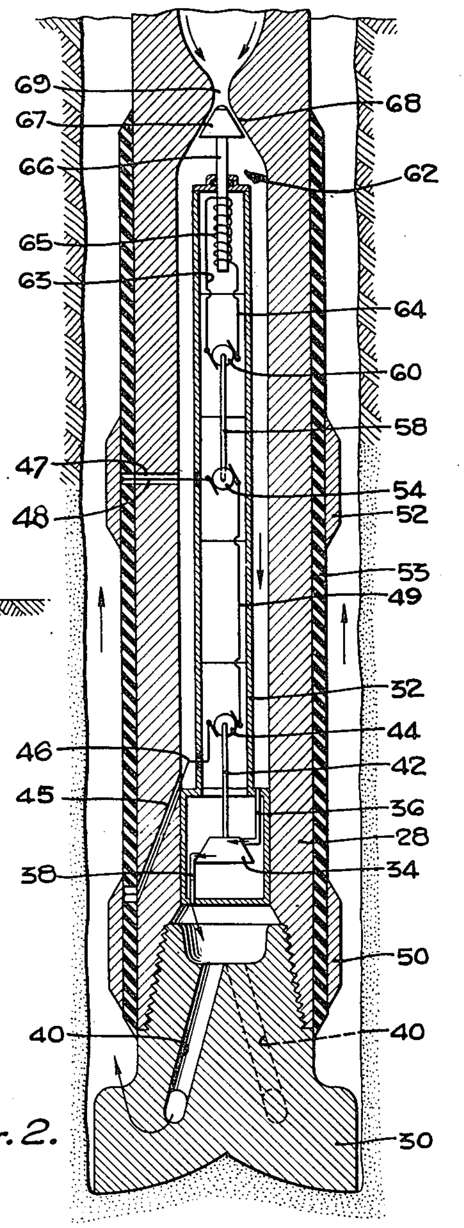


FIG. 2.

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APPARATUS FOR LOGGING WELLS

Filed Aug. 31, 1950 3 Sheets-Sheet 2

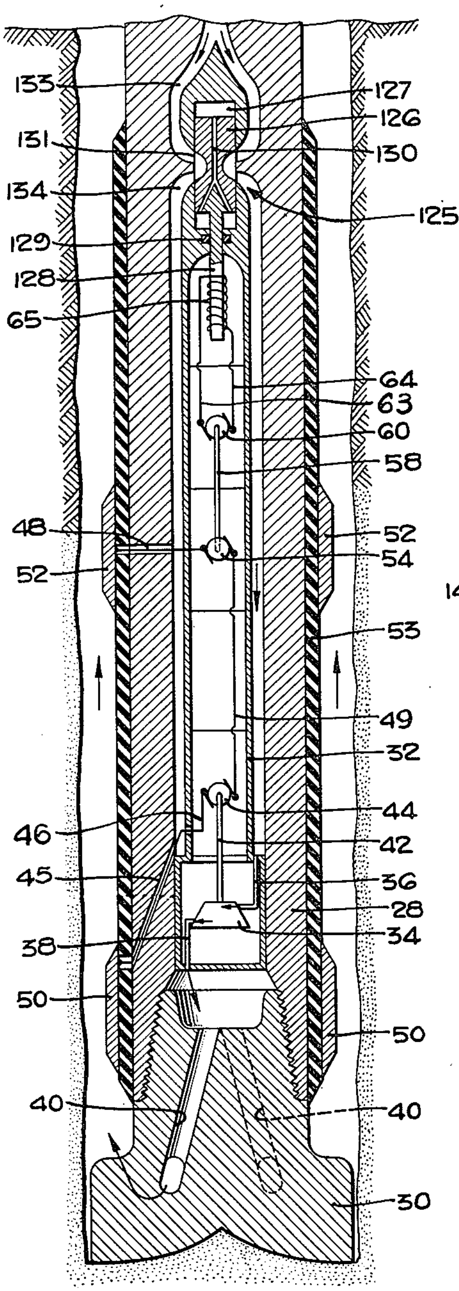

FIG. 3.

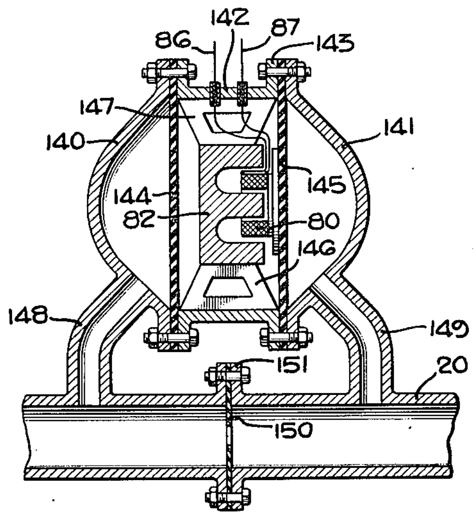

FIG. 5.

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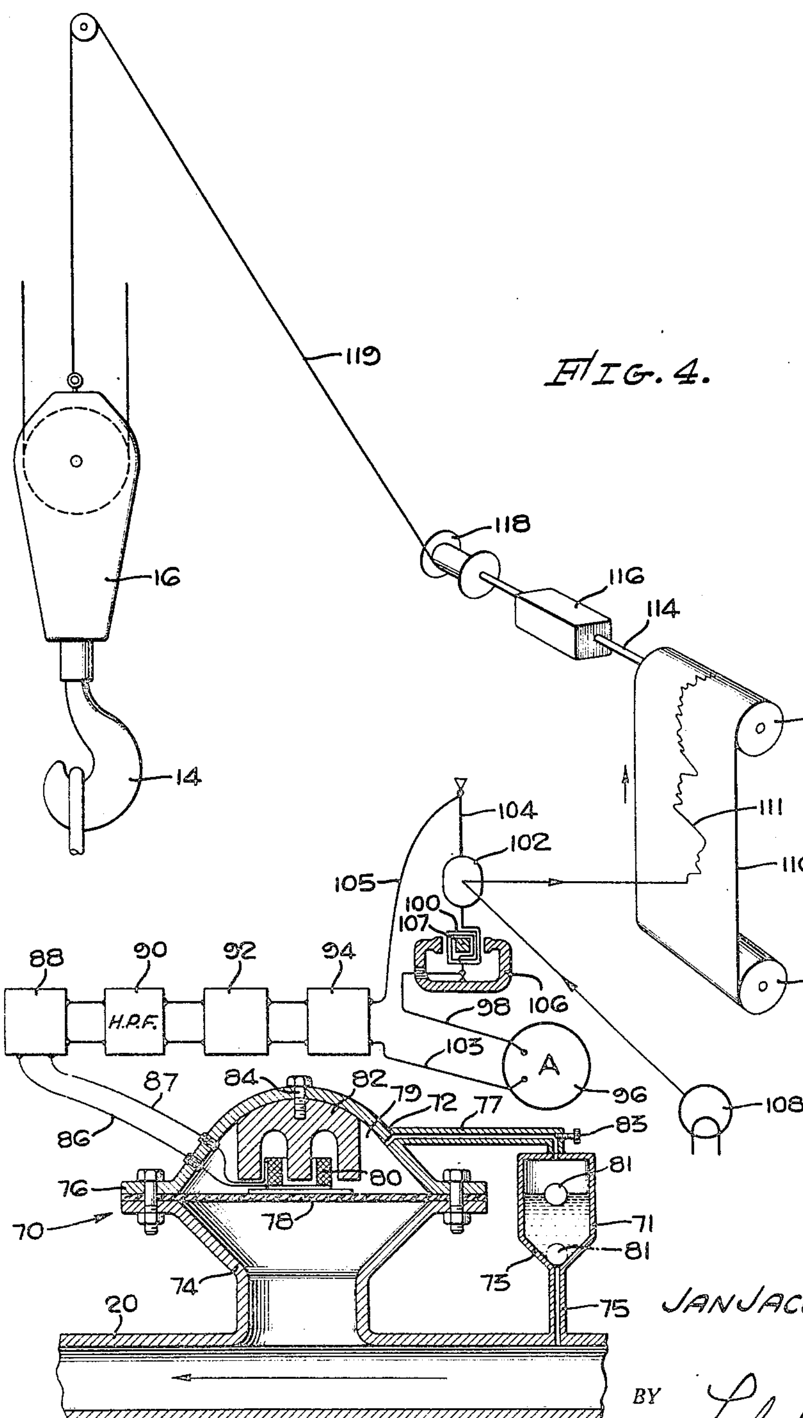
April 2, 1957 J. J. ARPS 2,787,759

APPARATUS FOR LOGGING WELLS

Filed Aug. 31, 1950 3 Sheets-Sheet 3

FIG. 4.



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APPARATUS FOR LOGGING WELLS

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Application August 31, 1950, Serial No. 182,604

2 Claims. (Cl. 324—1)

This invention relates in general to the exploration of the geological strata traversed by earth boreholes and more particularly to methods and apparatus for determining the electrical characteristics of the various subsurface geological formations penetrated by a well borehole, particularly methods and apparatus by means of which simultaneous electrical logging and drilling of well boreholes may be carried on.

This application is a continuation in part of the applicant's co-pending application, Serial No. 619,629, filed October 1, 1945, now Patent No. 2,524,031. The subject matter of this earlier filed application relates to a system of earth borehole logging in which signals representing an electrical characteristic of earth formations penetrated by the borehole are impressed upon and transmitted through the drilling fluid circulating through a drill string, without any appreciable effect upon the flow of the drilling fluid. The subject matter of the present disclosure relates to a logging system in which the signals representing the results of investigations in the borehole are transmitted by way of positive changes of considerable magnitude made in the circulation of the drilling fluid in the drill string, as, for example, by pressure-changes created by valving the flow of drilling fluid through a valve means in the drill string.

Many prior methods have been proposed for measuring the various characteristics of the subsurface formations penetrated by a borehole and a common practice has been to employ an insulated conductor cable for supplying electrical energy from the surface to the well logging or investigation apparatus within the borehole, and a separate insulated conductor therein for transmitting the response of the investigation apparatus to an indicating means at the surface of the borehole. Such logging apparatus can only be run into the well at intervals after the drill pipe is removed from the borehole and in many cases it is found that possible productive horizons unknowingly have been drilled through or passed by during the drilling, causing subsequent completion or continuance of drilling to be difficult and costly. It is also known that during the process of drilling through a prospective producing formation water from the drilling mud invades such formation and if too much times passes between the time of drilling through the formation and the time the electric logging survey is made, this invasion is often of such extent as to change the natural electric resistivity of the formation sufficiently to result in confusion in the proper interpretation of its characters. These disadvantages relative to the undesirable invasion of the penetrated formations by liquid from the drilling fluid are largely overcome by the present invention because the natural electric resistivity or other electrical measurement is made substantially, simultaneously with or immediately after the formation is drilled into, and thus before substantial infiltrations and flooding of the drilled formation by water from the drilling fluid can take place.

In general, the present invention provides a method and

apparatus for logging the formation characteristics of a well borehole, continuously during drilling operations or at suitable intervals thereof, wherein the source of electrical energy for the investigation apparatus is generated or supplied adjacent the bottom of the well borehole and the signals related to the electrical characteristics of the adjacent penetrated strata to be measured are transmitted to the top of the well borehole without the use of any auxiliary conductors, cables or the like, and the signals are picked up by surface indicating apparatus and from which the values of the electrical characteristics to be measured are obtained and are constantly available to the drilling operator.

More specifically but not by way of limitation, this invention utilizes the circulation of the drilling fluid in the drill stem for supplying the electrical energy utilized by the investigating apparatus. Furthermore, the drilling fluid stream is utilized as a transmission medium for transmitting flow variation signals from the investigation apparatus within the well borehole to the top of the well.

It is accordingly an object of the present invention to provide a method and apparatus for continuously indicating the electrical characteristics of the subsurface, geological formation penetrated by a borehole and which indication can be continuously transmitted to the surface of the borehole without the necessity of employing the usual electrical connecting cables.

It is another object of this invention to provide a method and apparatus for logging a well borehole during the process of drilling and in which variations in the physical properties of the penetrated strata will produce variations in an electrical investigation apparatus located opposite the strata, which variations are transmitted to the surface of the borehole through the drilling fluid to provide, at the top, a continuous indication of the electrical characteristics of the penetrated strata.

A still further object of this invention is to provide a method and apparatus for logging the electrical characteristics of freshly drilled subsurface formations wherein a periodic valving device is utilized in the drill string to periodically vary the flow therethrough of the circulating drilling fluid stream at a frequency representative of the electrical characteristics of the freshly penetrated formations to be measured.

The objects of this invention are attained in brief by utilizing the drilling fluid circulating stream as a signal transmission medium and creating in the drilling fluid stream, at a remote point within the borehole, periodic variations in its rate of flow, the frequency of variation of which is modified by suitable means within the well borehole in accordance with the electrical characteristics of the adjacent subsurface formations to be measured, and utilizing the thus affected periodic variations in the character of the fluid flow appearing at the earth's surface at the top of the well borehole to generate or form electrical signals which are functions of the said frequency of variation of fluid flow and can be measured and which are therefore representative of the beforementioned electrical characteristics of the subsurface formations.

Other objects, advantages and features of novelty will be evident hereinafter in the more detailed description of the invention.

In the drawings which illustrate preferred embodiments and modes of operation of the invention and in which like reference characters designate the same or similar parts throughout the several views:

Figure 1 is a diagrammatic elevational view of a drilling rig showing in vertical section a typical well borehole and rotary drilling string in which the apparatus of the invention is employed;

Figure 2 is a longitudinal sectional view of the lower portion of Figure 1 showing therein an enlarged detail view of the portion of the logging apparatus illustrated schematically in Figure 1 in the lower part of the drill collar;

Figure 3 is a longitudinal sectional view of the same portion of the apparatus illustrated in Figure 2 but containing an alternative form of logging apparatus;

Figure 4 is a schematic view partly in cross-section and partly in diagram form showing the general arrangement of the surface detecting and receiving apparatus as well as the apparatus for correlating the depth of the well borehole with the recording means;

Figure 5 is a cross-sectional view of a modification of a portion of the apparatus of Figure 4.

Referring now primarily to Figures 1 and 4, reference character **2** indicates a well derrick disposed over a borehole **4** in which is located a string of drill pipe **6** extending through a rotary table **8** on the derrick floor. The upper end of the drill stem **6** is attached to a square kelly **10** which passes through and is grasped by the table **8**, which in turn is rotated by a conventional drive means from a suitable source of motor power such as the engine illustrated at **12**. The drill string is supported through the kelly **10** and a swivel **11** by means of a hook **14** extending downward from a traveling block **16** which is in turn supported by suitable drilling lines **19** which pass over a crown block **17** in the top of the derrick. A mud pump **24** takes drilling mud from a sump **22** and discharges drilling mud under pressure through pipe line **20** and swivel **11** into the top of the kelly **10** and drill stem **6**. Connected in an intermediate point in the mud line **20** is a surface detecting device **26** which will be described hereinafter in detail in connection with Figure 4. The lower end of the drill stem **6** is provided with a drill collar **28** of an increased outside diameter and having a suitable drill bit **30** connected to the lower end thereof.

The logging apparatus to be hereinafter referred to is disposed within the drill collar **28** a suitable distance above the top of the drill bit **30** and is preferably contained in a cylindrical housing unit in the position illustrated in dotted lines at **32** in Figure 1. The housing **32** is fluid tight with the exception of certain inlet and outlet ports and passages as will be hereinafter more fully explained.

Referring now to the beforementioned investigation or logging apparatus in detail and more particularly to Figures 2 and 3, a vertical turbine **34** is arranged inside the housing **32** in a position above the rotary bit **30** and to which an inlet flow passage **36** is provided in communication with the drilling fluid or mud present in the drill stem **6** outside of the housing **32**. The drilling fluid flowing downward through the drill string toward the drill bit and into the passageway **36**, under pressure, drives the turbine **34** and then is discharged therefrom through an outlet passage **38** which in turn communicates with discharge ducts **40** of the drill bit **30**. The turbine **34** thus driven by the drilling mud is directly coupled by means of a vertical shaft **42** with a direct current or alternating current generator **44**. The generator **44** is preferably equipped with a voltage regulator (not shown) in order to maintain its output voltage at a constant value independent of variation in the speed of the turbine **34** which variations would normally be caused by any fluctuations in the velocity or pressure of the mud stream flowing downward in the drill stem. The electrical output or current from the generator **44** is conducted by conductors **46** and **48** extending through respective apertures **45** and **47** in the drill collar, to two metal electrode bands **50** and **52** respectively. These annular electrodes are insulated from and are disposed around the drill collar **28** in vertically spaced relationship. The outer surface of the drill collar is provided with an insulating sleeve or covering **53** which is interposed between the annular electrodes **50** and **52** and the outer surface of the drill collar. In the electrical circuit extending from the generator **44** through the conductors **49** and **48** to the electrode **52**, is a direct current or alternating current electric motor **54** connected in series therewith and of such type that the speed of rotation varies directly with or in accordance with a suitable function of the magnitude of the current flowing therethrough.

From the foregoing it will be apparent that the complete circuit activated by the generator **44** includes in series therewith the variable speed motor **54**, a portion of the drilling fluid in the annular space surrounding the electrodes **50** and **52** and a portion of the formation strata extending between and located adjacent the electrodes **50** and **52**. The electrical resistance of the adjacent formation opposite the two electrodes **50** and **52** and also to some extent that of the drilling mud passing through the annular space surrounding the drill collar and between the annular electrodes **50** and **52** and the walls of the borehole, will thus determine the amount of current flowing through the beforementioned series circuit which in turn will determine the speed of rotation of the motor **54**.

The motor **54** is coupled through a shaft **58** with a generator **60**, preferably an alternating current generator, which is disposed immediately thereabove in the housing **32**. The generator **60** in the case where it is an alternating current generator is preferably constructed in such a manner that the frequency of the alternating current generated thereby will vary directly with the velocity or speed of rotation of the variable speed motor **54** which obviously will in turn depend upon the resistivity of the current path through the drilling fluid and the adjacent strata located opposite the two electrodes **50** and **52**. From the foregoing, it will be apparent that during the drilling operation or during an interval thereof, if a stratum is penetrated which contains mainly salt water normally having a low electric resistivity, the electrical output or current through the series circuit comprising electrode **50**, conductor **46**, generator **44**, conductor **49**, motor **54**, conductor **48** and electrode **52**, and the beforementioned surrounding formations, will be increased, thereby causing a corresponding increase in frequency of the alternating current generated by the generator **60**. However, on the other hand, when an oil or gas bearing stratum is penetrated, which is normally characterized by a higher electrical resistivity, then the current through the beforementioned series circuit will be reduced in accordance with the increased electrical resistance of the beforementioned adjacent oil or gas bearing strata, which in turn will result in a reduced speed of the motor **54** and a corresponding lower frequency of the alternating current output from the generator **60**. From the foregoing, it will be apparent that the generator **44** and motor **54** are operating in a series circuit which includes the formation in which the characteristic of the formation is measured in terms of its electrical resistivity. Either direct current or alternating current may be utilized in this circuit without changing the basic principle of the invention. In the case where an alternating current generator is employed at **44** and an alternating current motor at **54**, the annular electrodes **50** and **52** will be supplied with an alternating current, and in the case where a direct current generator is employed at **44** and a direct current motor at **54** the electrodes will accordingly be supplied with a direct current. In the case of the use of an alternating current the formation characteristic measured may be considered as the impedance rather than the normal resistivity. The use of an alternating current may be preferable in cases where the electrolytes in the drilling fluid cause polarization of the electrodes **50** and **52**.

Disposed immediately above the generator **60**, within the housing **32**, is an electromagnetically operated valving mechanism **62** which is connected to the generator through conductors **63** and **64**. The valving mechanism comprises a solenoid electromagnet field coil **65**, a magnetized solenoid armature or plunger **66** and a conically shaped valve head 67 fixed on the upper end of the plunger 66. The valve head 67 working in conjunction with the adjacent conical surface 68 is adapted, upon being moved longitudinally relative to the surface 68, to valve the flow of fluid therebetween. The valving mechanism 62 is thus constructed so that it will have a valving action upon the drilling fluid stream flowing down through the drill collar and through the passageway 69, and since the windings of the solenoid 65 are connected through conductors 63 and 64 to the output connection of the generator 60 as beforementioned, the valving action would occur at a frequency corresponding to that of the alternating current from generator 60.

The solenoid armature or plunger 66 is permanently magnetized with opposite magnetic poles at opposite ends thereof. When the solenoid winding 65 is energized by alternating current the plunger 66 is thereby caused to have a longitudinal, reciprocating motion through the solenoid winding in synchronism with the alternating current, resulting in valving of the mud stream flowing between the valve head 67 and the surface 68 and through the drill pipe at a frequency equal to the frequency of the alternating current. This variation in flow will appear in the drill pipe at the top of the well where it may be detected by one of the beforementioned detecting devices which are illustrated in detail in Figures 4 and 5 and which will be described hereinafter.

Referring now primarily to Figure 4, the detecting device indicated generally at 26 in Figure 1, comprises a housing member 70 connected to the mud line 20. The housing member 70 is formed of two portions, an upper hemispherical head or cover section 72 and a lower conical section 74 secured together by bolted flanges as shown at 76. Interposed between the flanges is a suitable flexible diaphragm 78 which may be subject to gas or air pressure in the chamber space 79 under the cover section 72. To equalize the gas or air pressure with the drilling fluid pressure in line 20 a surge chamber 71 is preferably used which consists of a vertical vessel 73 communicating through a bottom connection 75 with the drilling mud line 20 and through an upper pipe connection 77 to the space 79 in the housing 70 above the diaphragm 78. A floating ball 81 is provided in the vessel 71 to keep the gas from bleeding out into the mud line 20 when the pumps 24 are shut down and the liquid level therein falls to the bottom of the vessel 71. An adjustable needle valve 83 is provided in the pipe connection 77 to allow relatively slow changes in mud pressure occurring during drilling to become equalized on opposite sides of the diaphragm 78. A coil 80 is attached to the diaphragm 78, which is thereby adapted to be vibrated in a strong magnetic field produced from a permanent field magnet 82. The field magnet 82 is secured to the top of the cover section 72 by means of a bolt 84. Movement of the diaphragm 78 and the coil 80 attached thereto is caused by pressure variations in the pipe 20 incident to the flow variations caused by the valving mechanism 62 and transmitted through the drill stem and through the pipe 20. Slight movement of the diaphragm 78 and coil 80 attached thereto will induce an alternating current or potential in coil 80 which is passed through conductors 86 and 87 to an amplifying unit 88, of a conventional type. The output voltage or current generated by the coil 80 will have a frequency corresponding to the frequency of the valving action of the valving mechanism 62 and this will be superimposed upon a low frequency alternating current or voltage generated by the coil 80 at the same time and in the same manner, corresponding in frequency to the normal pulsations of the mud pump 24. After amplification of the alternating current or voltage in amplifier 88 the amplified output signal therefrom is transmitted to a standard or conventional high-pass filter circuit 90, for filtering out of the lower frequency components thereof corresponding to the beforementioned mud pump frequency. The remaining higher frequency alternating signal component passing through the high-pass filter 90 is conducted to an electrical transducer 92 which is designed to translate or transform the frequency modulated input signal into a corresponding amplitude modulated output signal. Since the frequency of the input signal generated in coil 80 and passing through the high-pass filter 90 necessarily varies in accordance with the variation of the frequency of the valving action of the valving device 62 which in turn is representative of the resistance or impedance of the borehole strata opposite the electrodes 50 and 52, the amplitude modulated output signal from the transducer 92 will therefore likewise vary in amplitude in a similar manner representative of the resistance or impedance of the beforementioned strata. From the transducer 92 the amplitude modulated alternating signal is transferred to a rectifying unit 94 in which the amplitude modulated signal input thereto is changed into a D.-C. or unidirectional signal output. As illustrated in Figure 4, the resultant D.-C. signal from the rectifier unit 94 may be transferred to a sensitive ammeter or galvanometer such as illustrated at 96 from which, if desired, the magnitude of the D.-C. signal can be read directly. However, as shown in Figure 4, the ammeter or galvanometer 96 may be connected in series with a movable coil 100 having a mirror 102 attached to the torsion supporting conductor member 104 which is in turn connected through conductor 105 with the rectifier 94. The opposite side of the rectifier 94 is connected to the ammeter 96 through conductor 103. Surrounding the coil 100 is a stationary permanent field magnet 106 which produces a magnetic field which, upon transmission of a current through the coil 100 causes rotation of the coil with a corresponding angular rotation of the mirror 102. A source of light 108 is arranged to throw a light beam onto the mirror 102 from which it is reflected onto a sensitive photographic film 110 disposed in the path thereof, in order that a permanent record of the logging data may be photographically recorded thereon as illustrated at 111.

The film 110 is disposed in a suitable light proof container (not shown) on rolls 112 and 113 and the take-up roll 112 is directly connected through a drive shaft 114 to a gear box 116 which in turn is coupled through a pulley 118 and cable 119 to the traveling block 106. From the foregoing it will be apparent that the film 110 may be scaled longitudinally to indicate the depth within the borehole to which penetration of the bit has progressed and with the gear arrangement 116, the photographed graph 111 on the film 110 will indicate the electrical characteristics of the formation at the exact depth of the drilling operation.

Referring now to Figure 3 showing a modification of the investigating apparatus, parts of the apparatus such as the turbine 34 impelled by the drilling fluid, the generators 44 and 60 may be identical with those of the embodiment disclosed in Figure 2. However, an alternative form of valving device 125 is utilized in lieu of the one shown at 62 in Figure 2. The alternative valving device comprises a balanced piston 126 reciprocable longitudinally within a cylinder 127 formed in the upper end portion of the housing 32. A plunger 128 extends from the lower end of the piston 126 through a suitable stuffing box 129 into the interior of the housing 32 and into the solenoid electromagnet 65. The piston 126 is provided with longitudinally extending pressure equalization ducts 130 extending from end to end thereof. The central portion of the piston is provided with a circumferentially extending annular channel or groove 131 which in the normal position of the piston 126 serves as a flow channel interconnecting the upper and lower annular drilling fluid ducts 133 and 134, respectively. Upon effecting longitudinal reciprocation of piston 126 the flow passage between the upper fluid passage 133 and the lower fluid passage **134** is valved as hereinafter more fully described.

In operation the alternative apparatus shown in Figure 3 functions in a manner similar to that of the preferred embodiment shown in Figure 2 in that an alternating current is transmitted from the generator **60** and with a frequency which varies directly with the speed of the variable speed motor **54** dependent upon and representative of the resistivity or impedance of the formation surrounding the well borehole adjacent the electrodes **50** and **52**. The generator **60**, as in the previous illustration, is directly connected through conductors **63** and **64** to the windings of the solenoid electromagnet **65**. Since the plunger **128** is permanently magnetized in the same manner as hereinbefore described in connection with plunger **66** the solenoid will induce longitudinal reciprocation of the plunger **128** when it is excited with the alternating current applied to it from generator **60** through the beforementioned conductors **63** and **64**. Thus the piston valve **126** is caused to reciprocate longitudinally and to thereby periodically valve the passage of drilling fluid from the upper channel **133** to the lower channel **134**. A periodic variation in the rate of flow of the drilling fluid will thus be induced which will be reflected in a similar periodic variation in the flow of the drilling fluid in the drill stem at the top of the well borehole and through the pipe connection **20** to which the detecting apparatus of Figure 4 is connected. As in the case of the apparatus of Figure 2 the pressure variations due to the variations in flow will be transmitted to the diaphragm **78** and the resultant movement of the diaphragm and coil **80** will generate a corresponding alternating current or potential in the coil **80** which is conducted through conductors **86** and **87** to the amplifier unit **88** and thence through the circuit to the recording apparatus as hereinbefore described.

Referring now to Figure 5 in which a modified version of the detecting device is shown, a housing is shown formed of two oppositely positioned, dome-shaped head members **140** and **141** separated by and bolted to an intermediate, cylindrical body member **142**, the sections being secured together by suitable bolted flanges as shown at **143**. Interposed between the two flanged connections between the head members **140**, **141** and the center body member **142** are a pair of flexible diaphragms **144** and **145**. A coil **80** of the same type as that shown at **80** in Figure 4 is attached to the inner face of the flexible diaphragm **145**, the coil **80** being thereby adapted to vibrate in a strong magnetic field from a permanent magnet **82** of the same type as that hereinbefore described in connection with Figure 4. The permanent magnet **82** is secured stationary within the center body member **142** by means of a plurality of radially positioned, interconnecting web members as shown at **146** and **147**, the web members making connection at their outer edges with the inside surface of the cylindrical body member **142** and at their inner edges with the metal of the magnetized member **82**.

The opposite head members **140** and **141** are connected through suitable pipe connections **148** and **149** to the drilling mud pipe line **20**, the points of entrance of the said connecting pipes **148** and **149** into the line **20** being on opposite sides of an orifice plate **150** bolted between suitable flanges in the pipe line as shown at **151**. The space within the central cylindrical body member **142** between the flexible diaphragms **144** and **145** is adapted to be filled with oil or other similar liquid which will be noninjurious to the electrical apparatus contained therein and will protect the coil **80** and the magnet **82** from the entrance of any matter which might obstruct the free relative movement of the parts therein. The spaces between the outer surfaces of the flexible diaphragms **144** and **145** enclosed under the head members **140** and **141**, respectively, are adapted to be filled with and contain drilling fluid under pressure from the pipe line **20**.

Movement of the diaphragms **144** and **145** and the coil **80** attached to diaphragm **145** will be caused by differential pressure variations transferred through connections **148** and **149** from either side of the orifice plate **150** resulting from corresponding variations in the rate of flow of fluid through the pipe line **20** caused by the valving action of the apparatus of Figures 2 and 3 as hereinbefore described. The resultant slight movement of the diaphragm **145** and the coil **80** attached thereto will induce an alternating current or voltage in the coil **80** which current or voltage is passed through conductors **86** and **87** to an amplifying unit such that that shown at **88** in Figure 4, and thence through the electrical apparatus of the same or similar type as that illustrated in Figure 4.

The terms measuring the frequency, amplitude or the like as employed in the specification and claims are not to be limited in meaning to the actual quantitative determination of such values but are to include the control or actuation of any circuit, indicator or recorder means or device such as a meter or galvanometer or the like device whereby a visual indication or graphical record of a measure of such values or an indication or graphical record of a value or values which are indicative of, representative of or bears a predetermined functional relationship to the aforesaid values may be obtained.

It is to be understood that the foregoing is illustrative only and that the invention is not limited thereby but may include various modifications and changes made by those skilled in the art without distinguishing from the spirit of the scope of the invention as defined in the appended claims.

What is claimed is:

1. In apparatus for making well borehole quantity measurements while drilling including a drill stem having a fluid circulating duct therethrough and pump means for circulating fluid down through said duct in said drill stem; the combination comprising: flow restriction means in said drill stem in the vicinity of the lower end thereof actuatable for effecting a variable resistance to flow of fluid through said duct; actuating means to actuate said flow restriction means; sensing means for taking measures of the varying value of an electric quantity exisiting within a well borehole; timing means responsive to the said measures taken by said sensing means operatively connected to said actuating means for actuating said flow restricting means at times having an interval therebetween bearing a predetermined functional relationship to the said value of said quantity.

2. In apparatus for making well borehole quantity measurements while drilling including a drill stem having a fluid circulating duct therethrough and pump means for circulating fluid down through said duct in said drill stem; the combination comprising: flow restriction means in said drill stem in the vicinity of the lower end thereof actuatable for effecting a variable resistance to flow of fluid through said duct; actuating means to actuate said flow restriction means; sensing means for taking measures of the varying value of an electric potential existing within a well borehole; timing means responsive to the said measures taken by said sensing means operatively connected to said actuating means for actuating said flow restricting means at times having an interval therebetween bearing a predetermined functional relationship to the said value of said quantity.

References Cited in the file of this patent

UNITED STATES PATENTS

2,297,399	Fuscaldo	Sept. 29, 1942
2,329,732	Varney et al.	Sept. 21, 1943
2,352,833	Hassler	July 4, 1944
2,380,520	Hassler	July 31, 1945
2,435,934	Varney et al.	Feb. 10, 1948
2,480,674	Russell	Aug. 30, 1949
2,524,031	Arps	Oct. 3, 1950