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SPONTANEOUS POTENTIAL WELL LOGGING METHOD AND APPARATUS

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FIG.I.

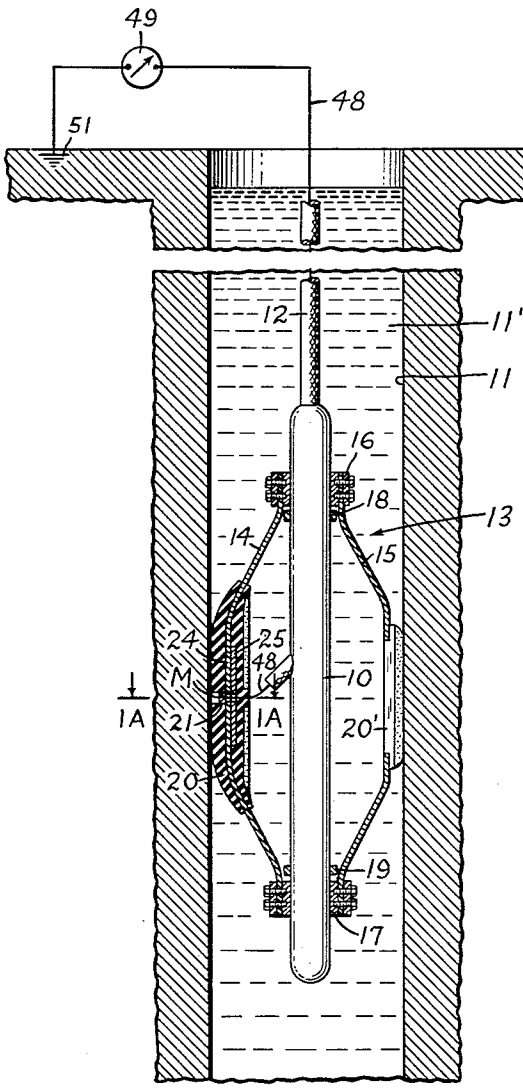
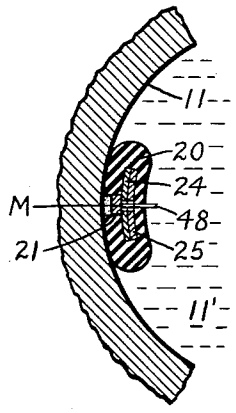


FIG.IA.



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SPONTANEOUS POTENTIAL WELL LOGGING METHOD AND APPARATUS

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Original application October 18, 1949, Serial No. 122,102, now Patent No. 2,669,690, dated February 16, 1954. Divided and this application June 3, 1953, Serial No. 359,361

6 Claims. (Cl. 324—1)

The present invention relates to well logging methods and apparatus and more specifically to novel and improved methods and apparatus for obtaining indications of spontaneous potentials traversed by a well drilled into the earth.

The application is a division of my copending application Serial No. 122,102, filed October 18, 1949, for "Resistivity Method for Obtaining Indications of Permeable Formations Traversed by a Bore Hole," which is now Patent No. 2,669,690.

It is almost the universal practice today to utilize the well known spontaneous potential method for locating permeable formations traversed by a well. According to the method, an electrode is moved through a bore hole while a log is obtained of spontaneous potentials between the electrode and a reference point as a function of the depth of the electrode in the bore hole. While this technique has proved highly successful, the logs obtained opposite certain formation structures are sometimes difficult to interpret accurately. For example, where a plurality of thin, permeable formations are sandwiched between a plurality of thin, relatively impermeable formations such as shaly sands, the spontaneous potential log may be somewhat lacking in detail, or where a thin formation is embedded in a thick formation, one being permeable, the other impermeable, the spontaneous potential value obtained opposite such thin formation will differ considerably from the true or "static SP" value, all as explained in an article entitled "The S. P. Log: Theoretical Analysis and Principles of Interpretation" by H. G. Doll, Petroleum Technology, September, 1948 (TP 2463). Thus under these conditions, the conventional spontaneous potential log is difficult to interpret, and without auxiliary data, may in fact lead to an erroneous analysis.

It is an object of the invention, accordingly, to provide a novel method and means affording a more detailed log of spontaneous potentials in a bore hole than has been available heretofore.

Another object of the invention is to provide a novel method and means of the above character which enables spontaneous potential indications of substantial magnitude to be obtained even opposite a thin permeable bed.

These and other objects of the invention are attained by maintaining the exploring electrode in the bore hole in very close proximity to and in electrical communication with the side wall of the bore hole, while preventing direct electrical communication between the electrode and the electrically conductive liquid which is usually present in the hole.

The invention may be better understood from the following detailed description of a typical embodiment thereof, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic diagram, partially in longitudinal section, showing typical well logging apparatus constructed according to the invention, in position in a bore hole drilled into the earth; and

Fig. 1A is a view in transverse section taken along the line 1A—1A of Fig. 1 and looking in the direction of the arrows.

In the form of the apparatus shown in Fig. 1, the electrode assembly comprises a tubular support 10 which is adapted to be lowered into a bore hole 11 on a supporting cable 12 which may be raised and lowered in the well by suitable means (not shown) located at the surface of the earth. The bore hole 11 usually contains a column of more or less conducting liquid 11'.

Mounted on the tubular support 10 is a spring cage assembly 13 comprising a plurality of bowed springs 14 and 15 whose opposite ends may be rigidly secured to a pair of collars 16 and 17, respectively, which are slidably mounted on the tubular member 10. The springs 14 and 15 are so shaped that the intermediate portions thereof are continually urged towards the wall of the bore hole. Stop means 18 and 19 may be formed on the tubular member 10 to provide for limited longitudinal movement of the spring cage assembly 13 with respect to the tubular member 10.

The bowed spring 14 carries a wall engaging cushion member 20 made of suitable flexible insulating material such as rubber, for example. Formed in the side wall of the cushion 20 is a recess 21 within which is embedded an electrode M. Preferably, the electrode M lies beneath the surface of the cushion 20 so that it is spaced a short distance away from the wall of the bore hole when the apparatus is disposed in the well, as shown in Fig. 1, electrical communication between the electrode and the adjacent formation being effected through bore hole liquid entrapped in the recess 21. With this construction, rubbing of the electrode against the wall of the bore hole is prevented so that spurious electric potentials which might be created by the rubbing action are avoided.

In order to maintain the electrode M in fixed, closely spaced relationship with respect to the wall of the bore hole 11, the bowed spring 14 is provided with an intermediate straight portion 24 to which is secured a straight, rigid reenforcing member 25. By virtue of this construction, the electrode M is always maintained in proper relation to the wall of the bore hole 11 as the bowed springs 14 and 15 expand and contract in response to variations in the size of the bore hole. The bowed spring 15 may also be provided with a flexible cushion 20' made of rubber, or other suitable material, to facilitate movement of the spring cage assembly 13 through the bore hole 11.

The cushion 20 may be further designed so that it is not only straight and rigid longitudinally, but is also round and flexible in a radial direction, as shown in Fig. 1A. With this construction, the cushion 20 will exert sufficient pressure against the wall of the hole, for all bore hole diameters lying in a given range, to squeeze out the bore hole fluid from between the cushion 20 and the wall, so that the shunting effect of any remaining film of fluid on the measurements will be negligible.

In order to facilitate lowering the apparatus in bore holes of small diameter, it is desirable to provide suitable means for locking one of the spring cage collars, say the collar 17, to the tubular member 10 at a position far enough away from the other collar 16 so that the cushions 20 and 20' will be out of engagement with the wall of the bore hole 11. Several typical locking devices suitable for this purpose are shown in the aforementioned application Serial No. 122,102 and it will not be necessary to include a description thereof herein.

The electrode M is connected by a conductor 48 to one terminal of a conventional high impedance potential recording instrument 49 located at the surface of the earth, the other terminal of which may be grounded at the point 51.

In operation, the recording instrument 49 records a

log of spontaneous potentials as a function of depths in the well while the electrode M is moved through the well. By virtue of the fact that the electrode M is maintained in close proximity with the wall of the bore hole **11** and in electrical communication therewith, direct electrical communication between the electrode M and the conductive bore hole liquid **11'** being prevented by the pad **20**, the log recorded is nicely detailed and of substantial amplitude even opposite thin beds.

Desirably, the support **10** and the spring cage assembly **13** should be designed so as not to provide a conducting path of any substantial length for the naturally occurring currents in the bore hole which might disturb the spontaneous potential field distribution normally prevailing.

The specific embodiment described above by way of illustration is obviously susceptible of modification in form and detail within the scope of the invention. For example, additional electrodes may be carried by the pad **20'** as required for making formation resistivity logs. The invention, therefore, is not to be restricted to the particular embodiment disclosed herein but is to be considered as broad as the scope of the following claims will allow.

I claim:

1. In a method for investigating earth formations traversed by a bore hole containing a column of conductive liquid, the steps of disposing an electrode in close proximity to and in electrical communication with the wall of the bore hole, preventing direct electrical communication between said electrode and the column of conductive bore hole liquid, and providing indications of spontaneous potentials between said electrode and a reference point.

2. In a method for investigating earth formations traversed by a bore hole containing a column of conductive liquid, the steps of disposing an electrode in close proximity to and in electrical communication with the wall of the bore hole at one depth in the bore hole, preventing direct electrical communication between said electrode and the column of conductive bore hole liquid, providing indications of spontaneous potentials between said electrode and a reference point, and repeating said steps at different depths in the bore hole.

3. A method of investigating the earth formations traversed by a bore hole containing a column of conductive liquid which comprises electrically segregating a small portion of the wall of the bore hole from the column of conductive liquid, establishing electrical contact with said

bore hole portion by placing a solid electrical conductor in electrical communication with said bore hole wall portion, and obtaining indications of naturally occurring potentials at the level of said bore hole wall portion by determining the potential of said conductor relative to another location in said earth formation.

4. In apparatus for investigating earth formations traversed by a bore hole, the combination of a flexible insulating member mounted for movement through a well and having an outer surface, an electrode embedded in said member outer surface, means urging said member laterally to bring said member outer surface into engagement with the wall of the well, and electrical indicating means connected to said electrode and to a reference point so as to exhibit significant indications of naturally occurring potentials at the level of said electrode in the bore hole.

5. A method of investigating the earth formation traversed by a bore hole containing a columm of conductive fluid which comprises electrically segregating a small horizontal section of said earth formation from direct electrical communication with the column of fluid, establishing electrical contact with said small horizontal section by pressing a solid electrical conductor against said horizontal section, and determining the spontaneous potential difference between said small horizontal section and another section of said earth formation.

6. An apparatus for logging a bore hole wherein said bore hole contains a conductive fluid which apparatus comprises electrical insulating means for electrically segregating a small horizontal section of earth formation surrounding said bore hole from direct electrical communication with the column of fluid, a solid electrode adapted to press against said small horizontal section and establish electrical communication therewith for picking up spontaneous potentials, an electrical indicating instrument, and electrically insulated conducting means for conveying spontaneous potentials from said electrode to said electrical indicating instrument for indication by the latter.

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