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METHOD OF EXPLORING THE POROSITY OF GEOLOGIC STRATA TRAVERSED BY BOREHOLES

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Fig. 1.

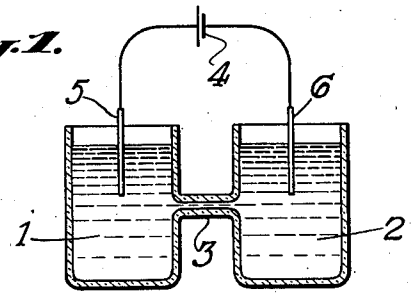
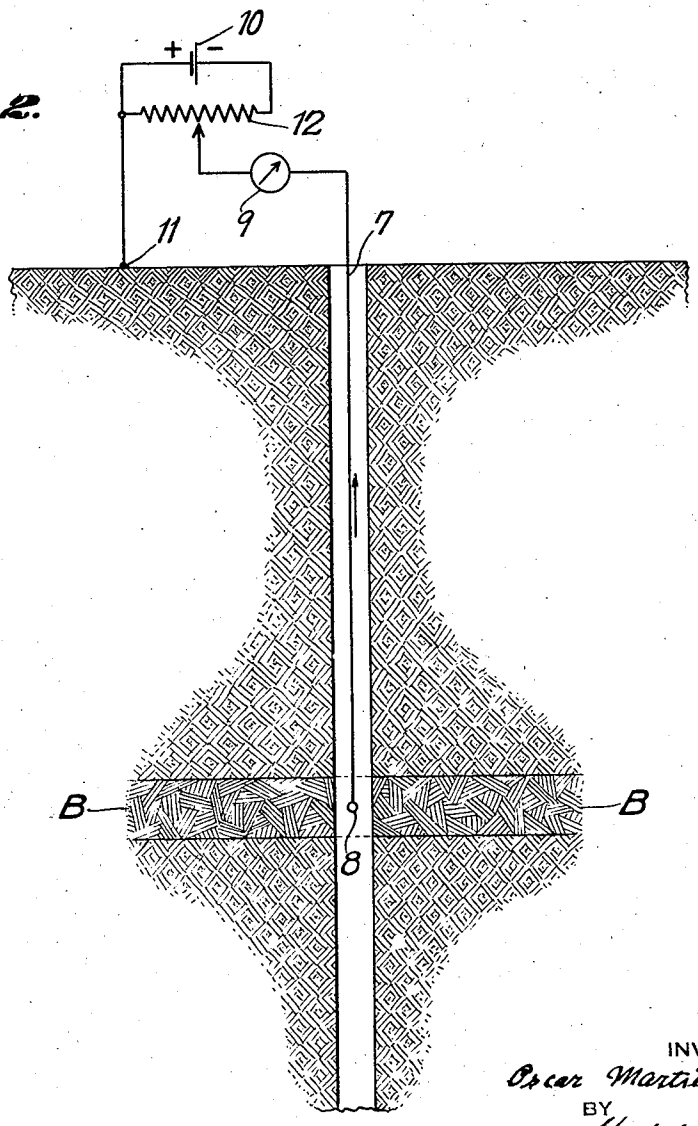


Fig. 2.



INVENTOR

Oscar Martienssen

BY

Kenyon & Kenyon

ATTORNEYS

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METHOD OF EXPLORING THE POROSITY OF GEOLOGIC STRATA TRAVERSED BY BOREHOLES

Oscar Martienssen, Kiel, Germany

Substitute for abandoned application Serial No. 203,606, April 22, 1938. This application October 21, 1938, Serial No. 236,254. In Germany November 10, 1937

2 Claims. (Cl. 175—182)

My invention relates to a method for exploring the porosity of strata traversed by boreholes. For ascertaining the porosity of such strata, it has been proposed to measure the natural potential differences which are created by the porosity of the borehole walls between the boring sludge and the adjacent stratum. For this purpose, an electrode connected to a conductor is lowered into the borehole, and the potential difference is measured by means of a potentiometer between this electrode and an electrode which is grounded aboveground.

The object of the present invention, for which an application was filed originally on April 22, 1938, Serial No. 203,606, now abandoned and for which the present application is a substitute is to improve on the several methods heretofore practiced in this art, and proposes to explore the porosity of the borehole-traversed strata by supplying a direct current of constant voltage of no more than few volts from a source located aboveground by means of an electrode lowered into the borehole. As this electrode traverses the different strata, the variation of the intensity of the current supplied to the electrode is measured and recorded. The other pole of the current source is grounded aboveground. From the results of such observation, curves can be plotted which give to the observer the relation of the porosity betwen the different strata traversed by the electrode.

My invention is illustrated in the accompanying drawing, in which

Figure 1 represents an explanatory diagram, and

Figure 2 shows diagrammatically the arrangement of the current source and the exploring electrode with relation to the borehole.

This method of exploring is based on the following well-known phenomenon. Referring to Figure 1, two vessels 1 and 2, which contain a slightly electrolytically conducting liquid, are connected by a capillary tube 3. 4 is a source of direct current, and 5 and 6 represent the electrodes by which the current from the source 4 is conducted into the liquid contained in the vessels. If thus an electric current flows through the electrolyte, a weak liquid current flows through the capillary tube in the same direction as the electric current. This phenomenon remains essentially the same if, instead of one capillary tube 3, a bundle of capillary tubes is used between the two vessels, or if instead a porous wall is placed between the vessels, which may consist of any porous material, such as fired clay or the like, through which the electric conductivity between the vessels can be established.

Since the stream of liquid must overcome the friction caused by the porous wall, a constant expenditure of energy is necessary in order to maintain this liquid flow. This energy must be furnished by the source of current. By the flow of liquid a counter electromotive force, the so-called flow potential, is produced, and the energy required per second for maintaining the liquid flow is equal to this electric counter potential multiplied by the electric current intensity.

This phenomenon is comparable in its manner of operation with an electric motor. If an electric motor is moved by the electric current, a counter voltage is produced by the motion of the armature, which voltage, multiplied with the current consumed by the motor, constitutes the energy which is necessary for operating the motor.

If we apply this principle to the purpose of exploring the porosity of subterranean strata traversed by a borehole, and if we lower an electrode by means of an insulated cable into the borehole which is filled with sludge, and if we supply electric current of constant potential to this electrode from a source aboveground, the other pole of which source is connected to ground, the electric current which flows when the borehole electrode traverses a porous stratum sends a liquid current by means of electro-osmosis through the porous stratum. By this liquid current a flow potential is generated which opposes the constant potential of the source aboveground, and which therefore weakens the current flowing through the cable. The greater the porosity, the more the electric current in the cable is weakened. Thus, if the electric current intensity is continuously recorded in relation to the lowering of the electrode, the resulting curve represents a picture of the varying porosity of the layers traversed by the borehole.

The present method, which appears to be quite different in principle as well as in operation and result from those practiced heretofore in this art, has great advantages, particularly over the direct measuring of the aforedescribed natural flow potentials which are produced by liquid seeping due to the higher hydrostatic pressure in the borehole through the porous wall. The measuring of such natural flow potentials always involves in practice a substantial energy consumption by the measuring instrument, as compared with the amount of energy available through this natural phenomenon. This energy

consumption by the measuring instrument discharges the porous layer and thereby disturbs the potential to be measured. Besides, such a natural flow potential represents, at constant hydrostatic pressure in the borehole, such small values, even at comparatively great conductivity of the sludge, that it can be measured only with great difficulties. In order to make such measurements at all with any kind of satisfactory results, an extremely sensitive voltmeter with very low energy consumption is necessary. Now the mounting of such an instrument in the measuring car, which must be brought to the mouth of the borehole, involves great difficulties. On the other hand, the measuring of the varying currents according to the method involved in the present invention may be made with comparatively rugged commercial milliammeters, because the operator is free to choose his constant operating potential and thus the normal current intensity. Thereby the values to be measured are not disturbed by the measuring itself. Further, any greater conductivity of the sludge in the borehole does not hinder the exactness of the measurement, because with constant potential the current intensity increases with the conductivity.

Furthermore, the prior art has suggested transition resistance measurements between the stratum under investigation and an electrode for instance by insulating the drill bit from the remainder of the boring gear lowered into the borehole, feeding electric current which may be direct or alternating, to the bit, and measuring the transition resistance between the bit and the side of the borehole at the place of working by measuring the current strength and voltage in the circuit closed through the ground. Such measurements require, however, voltages of the order of 100 volts to 200 volts, in order to enable the investigator to neglect all natural potentials such as natural flow potentials aforementioned, occurring in the boreholes, with respect to the measuring potential. By such high direct current potentials or by an alternating current potential, also suggested in the prior art, those phenomena which are to be observed according to the present invention—namely, the variation of a current, sent into the ground, due to the natural counter potentials developed in the ground at the point of observation—would be completely masked and their observation rendered impossible. Therefore, in contradistinction to the prior art and as one of the important features of the present invention I propose to usefully employ the natural flow potentials which the prior art attempted to overpower by high voltages, and I propose to use for this purpose a relatively very small direct current potential, namely of the same order of magnitude as the natural flow potentials, such as two volts or less, and a single exploring electrode.

In Figure 2, the layout for such a measurement is diagrammatically shown. The insulated cable 7, which runs over a drum aboveground, but not shown, carries at its end an electrode 8 which is fixed to the end of the cable and has as low a contact resistance as possible with respect to the surrounding medium. This electrode can be raised and lowered in the borehole. This cable is connected to a source of constant potential 10 by means of the potentiometer 12, by which any desired low operating voltage within the potential of the source can be adjusted. The other pole of the source 10 is connected to ground at 11 near the mouth of the borehole. During each measuring period, the operating D. C. voltage adjusted at resistance 12 is kept constant. The current which flows from the stratum adjacent the electrode 8, and through the latter and cable 7, is continually observed at the ammeter 9, while the electrode is lowered from the mouth of the hole through the whole length of the hole. As soon as the electrode passes a certain porous stratum, for instance the stratum B, the electric current causes liquid to emanate from the porous stratum by means of electro-osmosis. This liquid current in turn produces a flow potential which, being contrary to the potential of the current of the source 10, weakens the operating current in flowing through cable 7 and ammeter 9, and this change in current can thus be observed at the ammeter. As the electrode passes different strata of different porosity, different indications will be given at the ammeter.

In the method according to the present invention, not only the above-mentioned electro-osmotic flow potentials but also the so-called concentration potentials as occurring between different strata have an effect on the current intensity of the measuring circuit. Consequently, the ammeter indicates a sudden increase or decrease of current intensity when the electrode passes by different strata. The method thus allows determining the porosity of a stratum, this porosity being indicated by a very considerable change of the current intensity, as well as each change of stratum.

As apparent from Fig. 2, the electrode is connected with the negative pole of the voltage source. This cathodic connection prevents disturbing polarization potentials at the electrode.

I claim:

1. Method of exploring the porosity of strata traversed by a borehole, consisting of freely suspending in the borehole a plummet electrode from an insulated cable, supplying by means of the electrode through the liquid in the borehole and the adjacent ground a direct current of a constant potential of not more than two volts and in the same order of magnitude as the electro-osmotic flow potentials due to the porosity of the adjacent strata, and observing the changes of intensity of the direct current as a measure of the porosity to be determined while the electrode travels by the strata.

2. Method of exploring the porosity of strata traversed by a borehole, consisting of freely suspending in the borehole a plummet cathode from an insulated cable, supplying by means of the cathode through the liquid in the borehole and the adjacent ground a direct current of a constant potential in the same order of magnitude as the electro-osmotic flow potentials due to the porosity of the adjacent strata, and observing the changes of intensity of the direct current as a measure of the porosity to be determined while the electrode travels by the strata.

OSCAR MARTIENSSEN.