

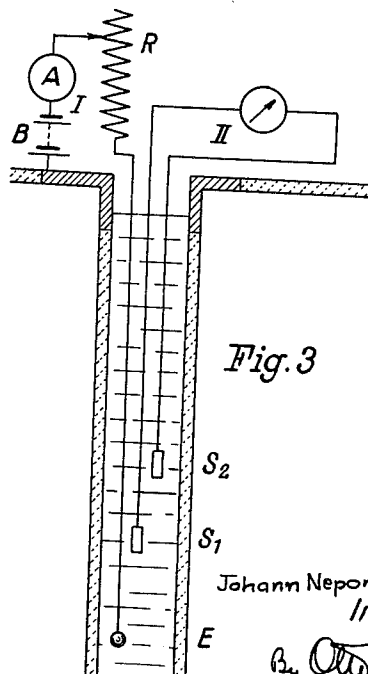
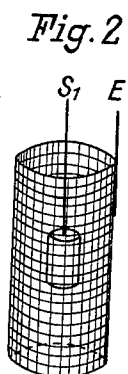
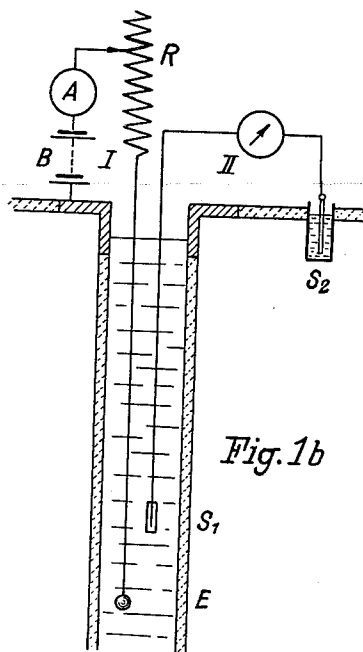
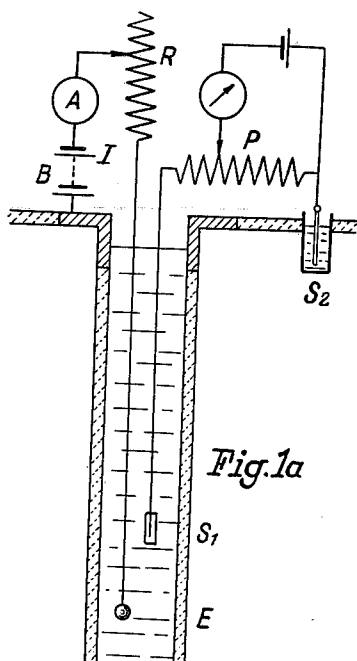
June 15, 1937.

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2,084,143

PROCESS FOR INSPECTING THE GROUND

Filed June 3, 1936



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UNITED STATES PATENT OFFICE

2,084,143

PROCESS FOR INSPECTING THE GROUND

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Application June 3, 1936, Serial No. 83,318. In Germany January 2, 1935

2 Claims. (Cl. 175-182)

The present invention relates to an improvement in a process and an apparatus for determining the nature of the ground traversed by a bore hole by measuring with the aid of electrodes at various depths in the uncased part of the bore hole which is filled with water, the intensity and the direction of the natural electrochemical currents occurring in the ground. The present invention provides for a complete or partial compensation of the natural potentials and currents within the bore hole. For this purpose a current taken from a special source is supplied to the ground and the direction and the intensity of current required for compensating are determined.

In bore holes without casing several factors can cause the appearance of natural electrochemical currents and of differences of potential in the bore mud and the ground traversed by the hole. As examples of such potentials in the following specification the potentials of diffusion, the potentials between adjoining phases and the convection potentials resulting from the phenomenon known as electro-filtration are referred to. The potentials of diffusion depend upon the kind and concentration of the dissolved electrolyte in the mud, whereas the potentials between adjoining phases depend on the kind of solvent. The convection potentials are caused by the combination of the bore hole without tubing with the adjoining porous layers of the ground. In bore holes of that kind an exchange between the liquid of the hole and the liquid contained in the ground or rock may occur, the liquid passing from the ground into the hole in some layers and being forced from the hole into the ground in other layers. Then arise according to the capillary equation

$$V = \frac{G \cdot P \cdot e}{4\pi \cdot E \cdot \eta}$$

the so-called convection potentials V to which the corresponding convection currents belong. In this equation G determines the potential of adsorption, P the difference of hydrostatic pressure between the ends of the capillary, e the dielectric constant, E the specific electric conductivity and η the viscosity of the liquid.

By producing an artificial current which is sent through the ground the natural current arising in consequence of the electrochemical conditions resulting from the bore hole and flowing in the bore liquid and in the adjoining ground can be wholly or partially compensated. For instance convection currents and convection potentials

can be eliminated by endosmosis. The amount of the artificial current required for said compensation represents a measure for the amount of the natural electrochemical currents flowing in the ground. The degree of compensation can be observed by potential measurements, for instance by determining the potentials in the bore hole by the aid of an electrode or by determining the potential gradient by means of two electrodes. It is then possible to deduce the electrochemical condition of the ground and thereby the nature of the traversed rock, more particularly the variations of the strata from the data thus obtained.

In principle it is possible to determine the potentials, the current intensity or resistance when inspecting the electrical condition of the ground. The current field and the potential field, though dependent on each other, are not wholly determined by each other, but the relation between said values may be influenced by other factors especially by the conductivity of the mud and of the traversed rock. The current defined by its intensity and direction is therefore a very characteristic value furnishing special information with respect to the condition of the ground.

The compensation of the natural electrochemical earth currents and potentials in the bore hole by an artificial current possesses two important advantages over the known proposal to measure the natural potential or potential difference. Said advantages will be illustrated by the examples of the convection currents and of the convection potential. Under certain circumstances the sensitivity or exactness of the measurement can be increased by eliminating to a certain degree the influence of the conductivity in consequence of the compensation; whereas the conductivity is a disturbing factor in the potential measurement. Said elimination results from the remarkable fact that the convection potentials can be obtained only in solutions poor in electrolyte. This is a consequence of the potential of adsorption G being as a rule considerably reduced by an increase of the concentration of salt and by the convection potential V produced by a certain potential of adsorption and at a certain pressure being considerably reduced, since the conductivity is in the denominator in the above formula. In spite of the porosity of the rock and of a high pressure the conductivity of the liquid is too large to permit more than a minimum convection potential which in practice makes difficulties in determination. The case is different with convection currents which in spite of a low convection potential and in view of the large

conductivity of the liquid may be considerable. In comparison with the other method these can be exactly determined. They are ascertained by compensation and registering the artificial currents required.

The variations in conductivity of the mud also make it difficult to give a meaning to the convection potential, since the conductivity is included in the formula as an unknown factor. Now, if the convection potential is made equal to zero at the place of measurement by artificially producing a corresponding potential V' with reversed polarity, so that V' is equal to $-V$, then the current flow can locally be interrupted, whereby the conductivity is eliminated from the formula and, therefore, can no longer have any influence upon the electric condition. Thus it is possible by measuring the current required for compensating not only to provide a more sensitive measuring method but also to obtain more definite results than is possible by a direct measurement of the distribution of natural potential.

In the following a suitable device adapted to carry out the new method will be described as an example and with reference to the accompanying drawing.

Figure 1a gives a general illustration of the scheme.

Figures 1b, 2, and 3 show three embodiments of the method.

Above or below the unpolarizable electrode S_1 an electrode E is inserted into the bore hole by means of an insulated conductor. Thereby the ground is supplied with a current the intensity and direction of which can be regulated. The second electrode of said circuit is in direct contact with the surface of the earth. An amperemeter A, a current source B and a regulating resistance R are introduced into said circuit I. The measuring circuit II with the electrodes S_1 and S_2 serves to control the degree of compensation and contains a potentiometer P which permits a reading of the potential differences between the electrodes. It is possible to arrange the electrode serving for measurement on the surface of the earth and to determine the potential between the place S_1 and the earth. Then the artificial current which is introduced into the ground can be regulated in such a manner that the potential disappears at the point S_1 and the intensity of current therefor required is determined. If the potential difference is completely compensated it is not necessary to determine quantitatively the potential in the circuit. In this case it is sufficient to insert a sensitive galvanometer as null-instrument into the circuit (Fig. 1b).

The electrode E is advantageously arranged laterally to the electrode S_1 in the shape of a perforated cylinder concentrically surrounding the electrode S_1 (Fig. 2). In this case it can be assumed that the artificially produced current

passing the electrode and horizontal convection currents which may be present possess opposite directions if the poles are suitably arranged.

According to Figure 3 the circuit may be arranged in such a manner that the electrode which is placed at the surface of the earth in the arrangement according to Fig. 1, is located within the bore hole in a comparatively small distance above or below the electrode S_1 , whereby the potential gradient of the natural earth currents is measured in the direction of the axis of the bore hole. By suitably selecting the intensity of the compensating current introduced into the ground the resulting potential gradient becomes equal to zero. The intensity of current therefor required is determined, the size of which renders an explanation of the natural electrochemical condition produced by the bore hole and thereby also of the condition of the ground.

Generally the inspection of the bore hole is effected by inserting the whole construction, i. e. those electrodes which are not in direct contact with the surface of the earth, uniformly and with a constant distance between them into the bore hole and to withdraw them in the same manner, graphically designing the results of measurement upon a suitable registering device in a continuous and if possible automatic manner. Then the results are obtained as functions of the depth in the form of curves.

If such a curve would represent only the distribution of the natural potential, it would not show the intensity of the electrochemical currents. Only by compensating said currents with the aid of artificial currents can the knowledge of the condition of natural currents produced by a bore hole in the ground be obtained.

What I claim and desire to secure by Letters Patent of the United States is:

1. Process for inspecting the ground traversed by a bore hole comprising measuring the intensity and direction of the natural electrochemical currents in different depths of the bore hole by annulling the said natural potentials and currents in the locus of measurement by sending a current taken from an external source into the ground and measuring the intensity and direction of the current required for the said annulment.

2. Process for inspecting the ground traversed by a bore hole comprising inserting into the bore hole two electrodes, one electrode being connected to a circuit containing an amperemeter, a resistance and a current source, producing therein a current annulling the natural potentials and currents occurring in the bore hole in the locus of measurement and regulating the degree of said annulment by measuring the difference of potential between two places one of which at least being located in the said bore hole.

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