

Aug. 14, 1934.

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1,970,342

PROCESS FOR THE RECONNAISSANCE OF THE GEOLOGICAL FORMATIONS,
AND ESPECIALLY FOR THE STUDY OF POROUS
STRATA, ENCOUNTERED BY A BORE HOLE
Filed May 25, 1933

Fig:2

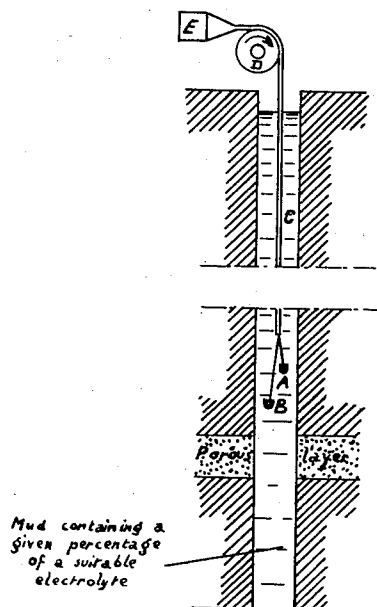
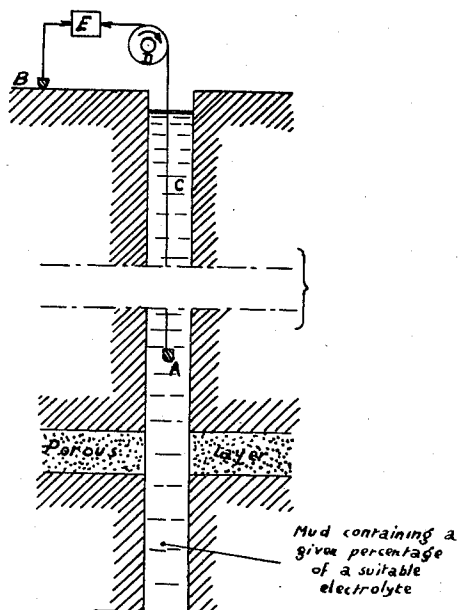


Fig:1



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UNITED STATES PATENT OFFICE

1,970,342

PROCESS FOR THE RECONNAISSANCE OF
THE GEOLOGICAL FORMATIONS, AND ES-
PECIALLY FOR THE STUDY OF POROUS
STRATA, ENCOUNTERED BY A BORE HOLEConrad Schlumberger, Paris, France, assignor to
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Schlumberger, Paris, France, a corporation of
FranceApplication May 25, 1933, Serial No. 672,900
In France January 11, 1933

3 Claims. (Cl. 175-183)

In patent application Serial No. 588,445, filed January 23, 1932 (which has matured to Patent No. 1,913,293, granted June 6, 1933) a method is described for the geological survey of formations, and more particularly of the pervious layers, encountered by a bore hole. This method consists in filling the bore hole with drilling mud and measuring the differences of potential spontaneously generated in this fluid at the various depths where these different strata are located.

It is indicated in said patent that the potential differences thus measured in the mud fluid filling the bore hole were caused for the greater part by electrical phenomena resulting from the penetration of this mud fluid into the porous strata (since the rock pressure in the strata is usually smaller than the head of the fluid filling the hole). But it was indicated also that differences of potential could be caused by physico-chemical reactions.

Finally, it is shown in the above mentioned patent how the rock pressure existing within porous strata could be determined by modifying the head of the drilling fluid in the bore hole and observing the accompanying variations of potential occurring in same.

It has been discovered that it was possible to determine, to a certain extent, the nature of the liquids present in the porous strata traversed by the bore hole, and in particular their degree of salinity, by means of the following additional invention. This invention consists in modifying the chemical composition of the mud fluid introduced into the bore hole and particularly its salinity. As a result of this chemical conditioning of the drilling mud, variations occur in the magnitude of the differences of potential spontaneously existing along the drill hole in front of the porous strata, and by measuring these variations, it is possible to deduce valuable information regarding the nature of the liquid carried by the said porous strata.

I will now discuss in greater detail a preferred method for the study of the salinity of the fluids contained in porous strata traversed by drill holes. Such study presents a considerable practical interest in oil exploration and exploitation for, in such a case, it is very desirable to ascertain the degree of salinity of the various water-bearing strata encountered, without incurring the necessity, to achieve this end, of causing the water of said strata to discharge into the bore hole (in order that samples of water may be collected for analysis purposes). It is a well known fact that this latter procedure can easily pro-

voke a blow out of oil or gas from the bore hole.

It is understood, however, that the invention is not limited to the particular application which is about to be described below and that its full scope is set forth in the various claims appended further.

If I suppose, for example, that the pressure existing in the stratum under consideration is approximately the same as that in the bore hole filled with mud, then no filtration occurs since the mud fluid filling the hole will not penetrate the water bearing stratum, nor does the liquid contained in the latter tend to flow into the bore hole. Nevertheless, if the sodium chloride content of the two liquids in contact is appreciably different a difference of potential will be observed in the mud of the hole at the very depth of the porous stratum. This difference of potential may amount to several tens of millivolts. If the water of the stratum is more saline than the drilling mud, the diagram recording the potentials spontaneously existing along the hole will exhibit at the depth of the stratum a depression corresponding to a negative potential difference (the definition and detailed explanations concerning the electrical diagrams just mentioned will be found in the patent referred to above). Inversely, a hump or more precisely a positive difference of potentials will be obtained on the electrical diagram if the water-bearing stratum is less saline than the mud of the bore hole.

The phenomenon which occurs, here, is identical to one which is observed with the so-called "concentration elements", and to be ascribed to osmotic pressure and to the unequal mobility of the chlorine and sodium ions. The mud in the bore hole, the water in the porous stratum and the surrounding formations constitute an actual "concentration element" electro-motive force of which is given by the formula:—

$$(1) \quad E = K. \log \frac{C_1}{C_2}$$

where K is a constant factor dependent on the nature of the rock, C_1 , the concentration of sodium chloride in the drilling fluid and C_2 the corresponding datum for the water of the stratum.

The value of C_2 is the unknown quantity which I want to determine and this determination is made as follows.

The salinity of the mud is caused to vary and is brought up to a value C'_1 greater than C_1 , by addition of brine. A new value E' of the elec-

tro-motive force E will be obtained which is given by the formula:

$$(2) \quad E' = K \cdot \log \frac{C'_1}{C_2}$$

The two formulæ (1) and (2) make it possible to express the unknown quantity C_2 in terms of the other quantities which are easily measurable. I then obtain:

$$\log C_2 = \log C_1 - \frac{1}{E' - E} \cdot \log \frac{C'_1}{C_1}$$

In the second member of the equation everything is known. The two concentrations C_1 and C'_1 of sodium chloride in the mud of the hole can be obtained either by analysis or more conveniently by measuring the electrical resistivity of same.

The coefficient

$$\frac{E' - E}{E}$$

is the relative variation of the electro-motive force corresponding to the variation of the salinity of the mud and is measured by comparing the two diagrams of potentials measured in the hole, as specified in the aforesaid Patent 1,913,293, with the two kinds of mud.

Instead of varying the salinity of the mud and deducing therefrom the unknown salinity of the water filling a given layer, it is also feasible to take advantage of other chemical modifications of the mud, provided that such modifications act according to a well known law on the phenomenon of spontaneous polarization described by the inventor. For instance the addition of a soluble mercury salt may facilitate the electro-filtration studies because mercuric ions give greater electromotive forces of filtration than other ions.

In the accompanying drawing, Figs. 1 and 2 show schematically the procedure utilized for

the observation of the electromotive forces inside the drill hole. A and B are impolarizable electrodes connected to a potentiometer E by means of insulated cables running on a pulley D. This potentiometer, located at the surface, measures the electromotive forces developed in the hole. These two figures are similar to those appearing in the aforesaid Patent 1,913,293, with the difference that, in the present case, the chemical composition of the mud plays a capital role in the generation of the electrical phenomena.

What I claim is:—

1. The method of determining the degree of salinity of the water contained in a porous stratum encountered by a bore hole, which consists in measuring in a mud of a given salinity filling the bore hole the electromotive force of the concentration element constituted by the water in the stratum, the mud in the bore hole and the surrounding rocks and then repeating the said measurement with a mud of a different salinity in the bore hole.

2. The method of determining the degree of salinity of the water contained in a porous stratum encountered by a bore hole, which consists in measuring in a mud of a given salinity contained in the bore hole the electro-motive force of the concentration element constituted by the water in the stratum, the mud in the bore hole and the surrounding rocks and then repeating the said measurement after the addition of a soluble salt to the mud in the bore hole.

3. The method of determining the degree of salinity of the water in a porous stratum encountered by a bore hole, which consists in measuring in a mud of a given salinity contained in the bore hole the electro-motive force of the concentration element constituted by the water in the stratum, the mud in the bore hole and the surrounding rocks and then repeating the said measurement after the addition of a soluble mercury salt to the mud in the bore hole.

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