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METHOD OF GEOPHYSICAL PROSPECTING

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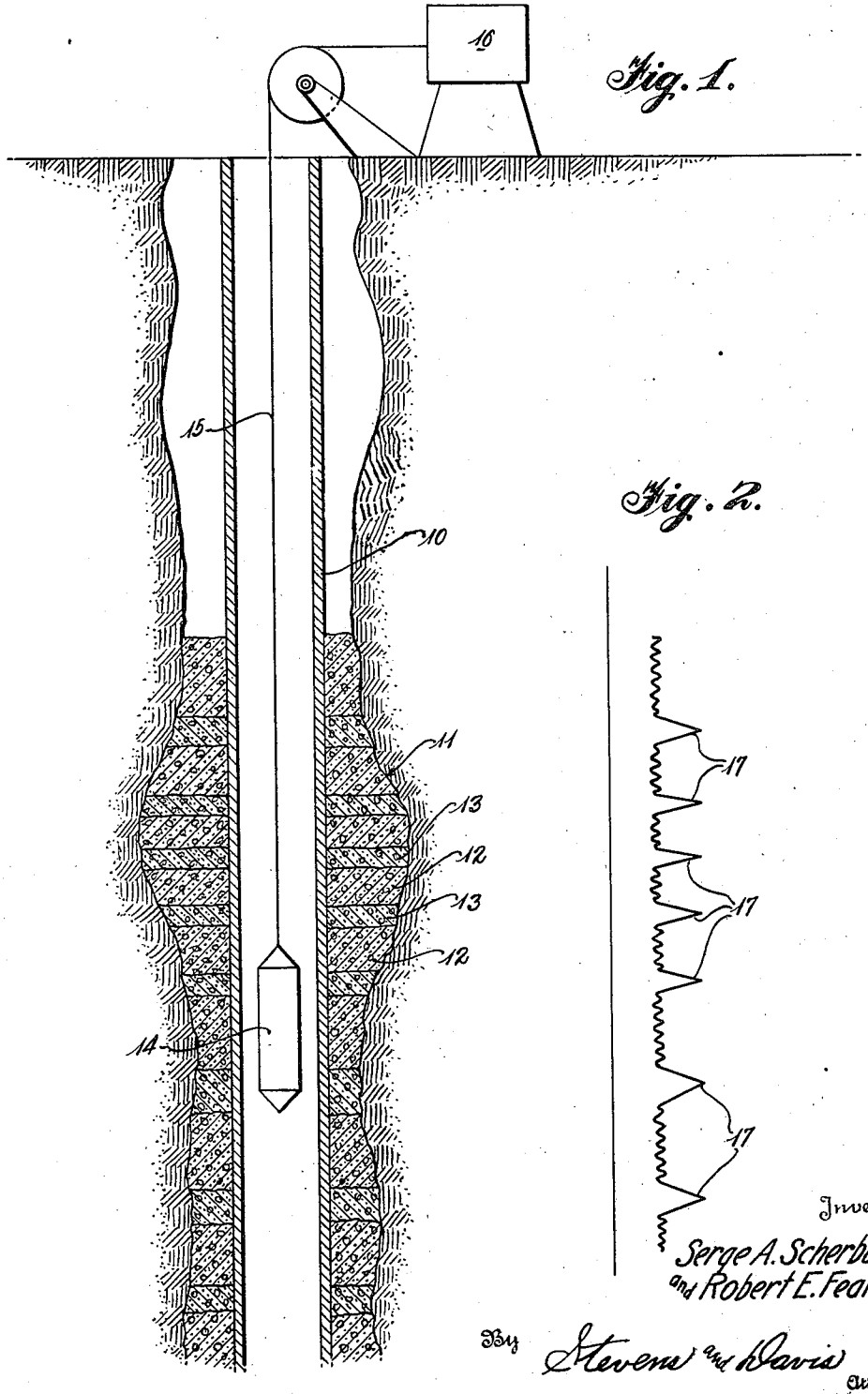


Fig. 1.

Fig. 2.

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METHOD OF GEOPHYSICAL PROSPECTING

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8 Claims. (Cl. 250—83.6)

This invention relates to the location of cement behind the casing in an oil or other well.

It is common practice in the preparation of a well for the withdrawing of oil, gas, water or other fluid products from the earth to drill a hole in the earth, place steel tubing or casing in this hole and then surround the casing throughout all or part of its length with cement which seals it to the walls of the hole. There are a number of reasons for doing this, one being to position the casing in place, and another being to prevent the movement of fluids from one stratum to another through the space between the casing and the walls of the hole. Mainly because it is often desirable to be certain that there is a seal between certain strata, for example, between strata that contain water and strata that contain oil, it is necessary to know just where the cement is placed and to where it spreads.

In United States Letters Patent No. 2,220,205, issued to Stuart E. Buckley on November 5, 1940, a method is disclosed according to which the cement is made radioactive and its position in the well around the casing is thereafter determined by making a gamma ray well log in the usual manner as described for example in United States Letters Patents Nos. 2,219,273 and 2,219,274, both issued to Serge A. Scherbatskoy on October 22, 1940. This method satisfactorily determines where there is cement and where there is not cement but is subject to the disadvantage of being quite expensive because of the expense of the radioactive material that must be utilized, and to the further disadvantage that it does not distinguish very satisfactorily between areas in which a large amount of cement has been deposited and areas in which only a relatively small amount has been deposited.

Obviously, the gamma ray log of the Buckley process will give some indication of the distribution of cement by the intensity of the radiation at various points, but if the thickness of the cement considerably exceeds the average distance which radiations produce by the radiation emitting contaminant, then the amplitude will be approximately constant at a maximum value and will not vary appreciably in accordance with any changes of thickness of the cement layer.

According to the present invention a much more economical process of locating cement has been discovered and also a method which gives a much more accurate indication of the amount of cement at various locations. This new method consists in placing the cement in position around the well bore in layers, alternate ones of which contain radioactive materials and the remainder of which do not. Thus when a radiation well log is made of the well it will show a series of peaks or increases in amplitude at the points where the radioactive layers are located.

If the volume of cement placed in each of the on-radioactive layers is the same, then the radioactive layers will lie closer together in areas containing large quantities of cement and further apart in areas containing relatively small quantities of cement. Furthermore, the amount of radioactive material necessary to contaminate these alternate layers of cement is not nearly as great as would be necessary to contaminate the whole body of cement and, since the radioactive layers of cement do not need to be nearly as great in volume as the non-radioactive layers of cement the amount of radioactive material used can easily be cut to one-tenth or less of the amount necessary according to the Buckley process.

As described in copending application Serial No. 401,835, filed July 10, 1941, by Robert E. Fearon, the radioactive material utilized according to this process may be short-lived instead of long-lived as naturally radioactive substances usually are. Thus the radioactive substance used may be one of the substances described in United States Letters Patent No. 2,206,634, granted to Fermi et al. on July 2, 1940, or may be any other radioactive material having a relatively short life.

The amount of radioactive material which it is necessary to use may also be reduced by making two well logs, one during the life of the radioactive material and another either before the cement is placed in the well or after the radioactive material has partly deteriorated, again in accordance with the copending application of Robert E. Fearon mentioned above. By this process the amount of radioactive material which is necessary to use may be still further reduced.

It has further been discovered that the radioactive material used to contaminate the cement is quite prone to settle out of the cement, particularly if it has a high specific gravity. According to this invention, that very undesirable characteristic may be overcome by grinding the radioactive material to a relatively small particle size, preferably, but not necessarily colloidal size, by selecting a radioactive material of the same specific gravity as the cement or by using a dispersing agent in the mixture.

For further illustration of the principles of this invention and a more complete understanding of the preferred method of its application and its many advantages, reference may be had to the appended drawing and the following detailed description thereof.

The preferred embodiment about to be shown and described, however, is but illustrative of the principles of this invention and is not intended as a limitation upon its scope.

In the drawing:

Figure 1 is a vertical cross-section of a cased well the casing of which is partially surrounded by cement. In this figure a gamma ray well logging apparatus is shown in the process of making a gamma ray well log of the part of a well about which information is desired; and

Figure 2 is an illustration of a well log of the area illustrated in Figure 1.

As shown in Figure 1 a casing 10 has been lowered into an opening in the earth 11 and cemented in place by layers of cement 12 and 13. Radioactive material has been included in the layers 13 but no radioactive material is included in the layers 12.

This layer arrangement of cement may be produced by pumping into the well, first a measured quantity of cement that has not been contaminated with radioactive material, then a second measured quantity of cement that has been contaminated with radioactive material, then another measured quantity that has not been contaminated, and so on. Preferably the quantity of uncontaminated cement will be ten or twenty times the quantity of contaminated cement and the contaminated cement will contain a sufficient amount of radioactive material to make it easily detectable. This radioactive material may be radio-sodium, uranium x—1 or any other artificially made radioactive substance or may be a naturally radioactive substance such as carnotite.

It is quite important in order to prevent the radioactive material from settling or floating out of the cement to put the radioactive material in the cement in such a way that the tendency toward separation will be minimized. To this end it is desirable to select a radioactive material that approaches as nearly as possible the specific density of the cement and/or alternatively, to finely grind a radioactive material, preferably to colloidal dimensions. This can be done by the use of any of the known colloid mills. Several types are described on pages 62 to 65 of "Colloidal Phenomena," by E. A. Hauser, published by the McGraw-Hill Book Company, Inc., in 1939.

After the cement has been placed in position its location may be determined by lowering a radiation measuring device 14 down the well at the end of a cable 15 which carries signals indicating the measurements made to a recorder 16 on the surface of the earth. This recorder is arranged, as is customary, so that it will record the measurements made in correlation with indications of the depth at which they are made.

Figure 2 shows a typical log made in accordance with this invention. The peaks 17 that are noticeable in the log indicate the position of radioactive layers of cement and when these are close together it is apparent that the hole around the casing is relatively large in size and that a relatively large amount of cement is contained in the hole around the casing in that area. Where they are further apart it is apparent that the casing more nearly fills the hole, or at least that there is less cement in that area.

As previously mentioned a log may be made prior to the cementing of the well, or temporarily radioactive materials may be used and a second log made after the radiation has decayed at least to some extent. In either of these cases the log of Figure 2 may be compared with the other logs so as to obtain a clear indication of the position of the radioactive layers. When there are two logs for the purpose of comparison it is not necessary that the peaks 17 stand out as sharply as they are shown to do in Figure 2 and hence less radioactive material may be used.

Mention has been made in this specification of the use of radioactive materials which produce radiations in the cement. It is to be understood that these radiations may be either gamma rays or any other type of casing penetrating radiation.

We claim:

1. A method of locating cement behind a casing in a well that comprises making layers of radioactive cement separated by layers of non-radioactive cement, said non-radioactive cement layers being formed of measured quantities of cement, and determining the location of said radioactive layers.

2. A method of locating cement behind a casing in a well that comprises making layers of radioactive cement separated by layers of non-radioactive cement, said non-radioactive cement layers being formed of measured quantities of cement, and, after the cement has been placed, making a radioactivity well log of said well.

3. A method of locating cement behind a casing in a well that comprises making layers of temporarily radioactive cement separated by layers of non-radioactive cement, said non-radioactive cement layers being formed of measured quantities of cement, making a radioactivity well log of said well while said cement layers are radioactive, making a second radioactivity well log of said well in the absence of at least a portion of said radioactivity, and comparing the well logs to determine the location of the radioactive layers.

4. A method of locating cement behind a casing in a well that comprises making layers of radioactive cement separated by layers of non-radioactive cement, said non-radioactive cement layers being formed of measured quantities of cement, making a radioactivity well log of said well with said cement in place and comparing said well log with a second radioactivity well log made prior to the placing of said cement.

5. A method of determining the position of cement behind a casing in a well that comprises placing said cement in the well by inserting alternate measured quantities of radioactive and relatively non-radioactive cement and thereafter determining the location of the radioactive cement.

6. A method of determining the position of cement behind a casing in a well that comprises placing said cement in the well by inserting alternate measured quantities of radioactive and non-radioactive cement, and thereafter making a radioactivity well log of said well.

7. A method of determining the position of cement behind a casing in a well that comprises placing said cement in the well by inserting alternate measured quantities of temporarily radioactive and relatively non-radioactive cement and thereafter making a radioactivity well log in said well.

8. A method of determining the position of cement behind a casing in a well that comprises placing said cement in the well by inserting alternate measured quantities of temporarily radioactive and relatively non-radioactive cement and thereafter making a radioactivity well log of said well during the life of the radioactivity in the cement, making a second radioactivity well log of said well after the radioactivity of said cement has decreased, and comparing the well logs to determine the location of the radioactive cement.

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