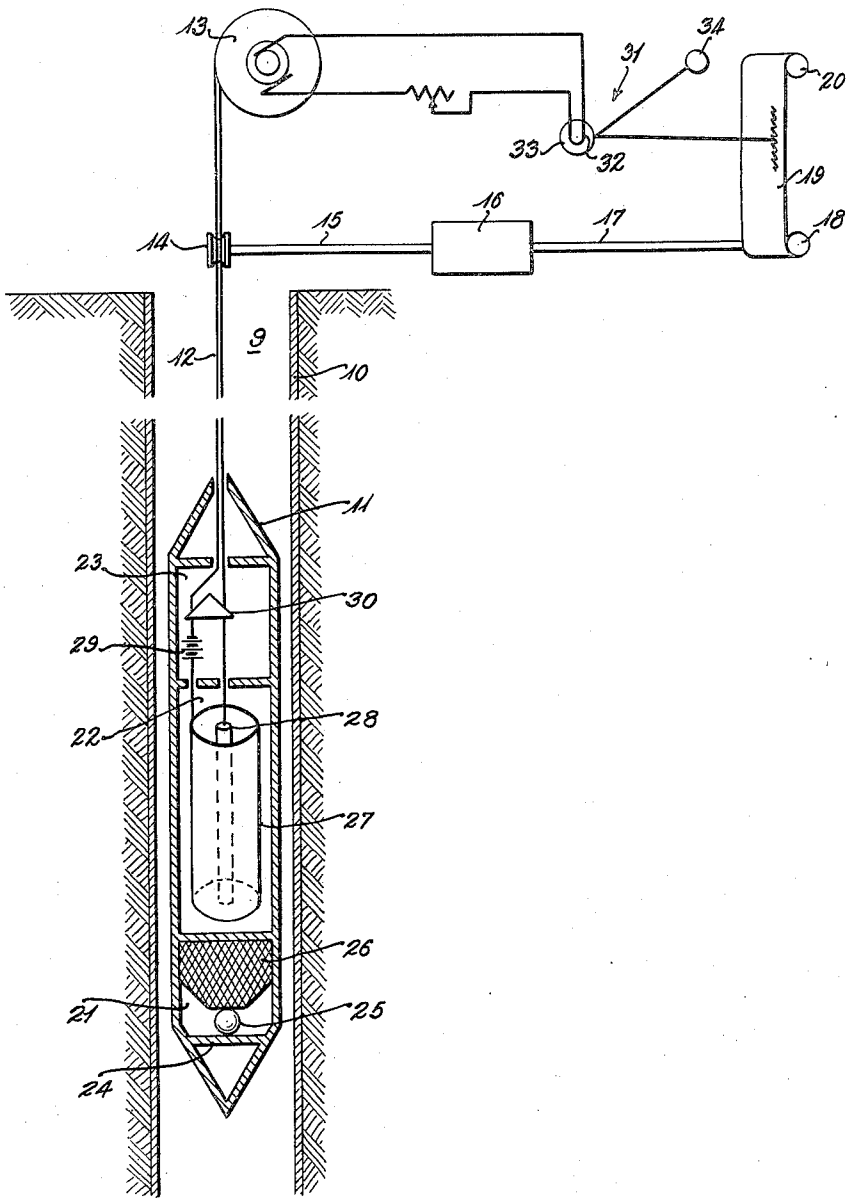
May 23, 1944. R. E. FEARON 2,349,712

WELL LOGGING METHOD AND DEVICE

Original Filed Nov. 10, 1938



Inventor

Robert E. Fearon

By Stevens and Davis

Attorneys

Patented May 23, 1944 2,349,712

UNITED STATES PATENT OFFICE

2,349,712

WELL LOGGING METHOD AND DEVICE

Robert Earl Fearon, Tulsa, Okla., assignor to Well Surveys, Incorporated, Tulsa, Okla., a corporation of Delaware

Original application November 10, 1938, Serial No. 239,781. Divided and this application January 28, 1942, Serial No. 428,594

4 Claims. (Cl. 250—83.6)

The present invention relates to a method of and apparatus for conducting investigations inside of bore or drill holes or other uniform openings in the earth and renders it possible to identify and locate various formations traversed by such holes without resorting to the expensive method of collecting cores at intervals during the progress of the drilling operation.

In carrying out these investigations the different physical properties of the strata are utilized. Among those the most prominent are: electrical resistivity, porosity, specific inductive capacity, temperature and acoustic absorptivity. It has been found that these physical characteristics do not always render it possible to distinguish various formations, and the measurements performed do not always give reliable results.

It is the object of the present invention to improve the results obtained in the prior art and to examine one additional physical property by means of which various formations traversed by a drill hole may be differentiated.

This invention is based essentially upon the fact that when a beam of radiations strikes the formation constituting the wall of the drill hole, part of the radiations becomes scattered by the formation or dispersed which in effect is equivalent to stating that a considerable portion of the radiations have their direction altered.

It is well known by those skilled in the art that the ability of a given material to scatter the impinging radiations is a definite and characteristic property of the material and I am therefore, proposing a method for measuring the above property at various depths of a drill hole in connection with mapping of formations penetrated by oil wells, water wells and the like.

An object of my invention is to reduce the cost and time required in exploring earth formations while at the same time increasing the amount of useful information obtainable from the exploration.

A further object of my invention is to explore formations traversed by cased drill holes and to investigate the physical properties of the formations lying behind the casing of a drill hole and thus to determine the depths at which the valuable strata are located and at which the casing should be perforated in order to produce oil or gas.

Various other objects and features of the invention will be disclosed in a detailed description with reference to the drawing which shows one of the preferred embodiments of my invention.

Referring now particularly to the drawing, a drill hole 9 is shown penetrating the formation to be explored. The drill hole may be provided with a tubular metallic casing such as designated by 10. The presence of the metallic casing in the drill hole is not an essential feature of the invention. The casing is merely shown for the purpose of illustrating the conditions under which the method may be practiced and it is understood that the process herein described may be applied in cased as well as in uncased holes.

The exploratory apparatus proper consists of a housing 11 which is lowered into the bore hole by means of a cable 12, containing insulated conductors. The cable has a length somewhat in excess of the length of the hole to be explored and is normally wound on a drum 13 positioned adjacent to the top of the drill hole. The cable may be unwound from the drum 13 to lower the exploring apparatus into the hole and may be rewound upon the drum to raise the exploring apparatus. Between the drum 13 and the hole there is a measuring reel 14 which is adjusted to roll on cable in such a manner that the number of revolutions of the reel corresponds to the amount of cable which has passed up or down in the drill hole. The reel is mounted on a shaft 15, and the motion of the shaft is transmitted through a gear box 16 to another shaft 17 which turns a spool 18 to wind a photographic film 19, the film being supplied from a feed spool 20.

The housing 11 of the exploratory apparatus comprises three parts respectively designated by the numerals 21, 22 and 23.

In the partition 21 I provide upon a solid support 24 an appropriate quantity of radioactive material such as, for instance, mesothorium 2, which I designate by the numeral 25 and a piece of lead 26 or other material relatively opaque to the penetrating radiations produced by mesothorium 2, which I have placed above the mesothorium 2 so as to shield it from a direct communication with the upper partition 22. I have chosen mesothorium 2 merely as an example and it is understood that I may use any other suitable radioactive material, such as for instance a mixture of radium and beryllium, the said mixture being characterized by an intense emission of neutrons.

The partition 22 contains an ionization chamber having a cylindrical outer electrode 27 and a central wire electrode 28. The ionization chamber is filled with inert gas such as nitrogen preferably under pressure of about 300 pounds

per square inch. I have illustrated the above ionization chamber merely as an example. Instead of nitrogen, I may choose propane under pressure or carbon disulphide or any other suitable material.

The partition 23 contains a battery 29 to apply a voltage to the ionization chamber and an amplifier 30 to amplify the current passing through the ionization chamber. The battery 29 has one of its terminals connected to the cylindrical electrode 27 and the other terminal connected to the input terminal of the amplifier. The central electrode 28 is directly connected to the other input terminal of the amplifier.

The output terminals of the D. C. amplifier 30 are connected to the cable 12 which conveys the current from the amplifier to a recording galvanometer 31 located at the surface of the earth. The recording galvanometer includes a moving coil 32 connected to the cable and a mirror 33 attached to the moving coil. The mirror is adapted to reflect a beam of light from a lamp 34 onto the sensitive film 19 to produce (after the film has been developed) a record of the well log.

The operation of my invention may be explained as follows:

The mass 25 is subject to a continuous and progressive disintegration which is well known in the art as a radioactive process and transforms itself from mesothorium 2 into an element known as radiothorium. Various radioactive materials which may be used emit radiations which usually include helium particles known as α rays, electrons, known as β rays, penetrating electromagnetic impulses known as γ rays, and may include any other radiations or material particles of any nature such as positrons, protons, neutrons and others.

The radiations transmitted from 25 tend to propagate themselves in all directions. I have provided, however, an absorbing block 26 formed of materials, for example, such as lead and paraffin which is relatively opaque to penetrating radiations, the paraffin being relatively opaque to neutrons and the lead being relatively opaque to other radiations. I am, therefore, preventing a direct path between 25 and the ionization chamber. Consequently the radiations emitted from 25 are directed sideways into the adjacent formations and the amount of radiations going upwards through the absorbing block is negligible.

It is well known by those skilled in the art that when a formation constituting the wall of the bore hole is exposed to the radiations which may impinge from a definite direction it becomes itself a source of radiations and these radiations proceed outwards in all directions. These radiations are called scattered radiations and the phenomenon is known as scattering. The radiations coming directly from the mass 25 are called primary radiations to distinguish them from the scattered radiations. It is then apparent that the radiations scattered by the walls of the bore hole enter into the partition 22 wherein they are detected by the ionization chamber.

The operation of the ionization chamber is well known in the art. Under normal operating conditions the battery 29 maintains between the central electrode 28 and the cylindrical electrode 27 a voltage of such a magnitude that a discharge will just not pass between them. When, however, a quantum of energy emitted from the adjacent earth stratum and due to radiation scattering enters the ionization chamber and is absorbed in the gas it creates a large number of ions in the gas which permit a current delivered by the battery 29 to pass between the electrodes 27 and 28. This current becomes amplified in 30 and is transmitted through the cable 12 to the recording apparatus at the top of the drill hole.

It is seen thus that the output voltage of the amplifier 30 depends upon the particular formation adjacent to the exploring apparatus and is influenced by the ability by this formation to scatter penetrating radiations produced by 25. It is also well known in the art that the scattering ability of a given material is directly related to its density, i. e. the larger the amount of scattering produced, the greater is the density of the material. Consequently the output voltage of the amplifier 30 represents also the density of the material constituting the wall of the formation. Therefore, when the exploring apparatus is being moved to various depths within the drill hole, the variation in density of various formations cause variations in the output of the amplifier 30 which variations are transmitted to the top of the drill hole through the cable 12 and produce deflections in the galvanometer 31 causing the beam of light reflected from the mirror 33 onto the film 19 to describe an irregular line upon the film.

It will be apparent from the foregoing description that as the exploring apparatus is lowered through the hole a record indicating the approximate variation in the scattering ability or density of the formations adjacent the hole is made by the galvanometer.

It is to be understood that measurements may also be taken by moving the exploring apparatus from the bottom of the hole up to the surface while making recordings instead of or in addition to making recordings while lowering the exploring apparatus. The records produced in the manner described are preferably made on film which is calibrated longitudinally in accordance with the distance traversed by the exploring housing in the well hole.

Various modifications may be made of apparatus shown in the drawing. Thus instead of coordinating the movement of the film with that of the cable by the mechanical linkage shown in the drawing, the cable and the film may be caused to move in synchronism with each other by any known synchronizing mechanism such as the well known Selsyn motors.

It is understood here that this method includes all processes by which an effect may be observed in the ionization chamber due indirectly to a source such as 25. For example, instead of the simple shape indicated for the block 26 the opaque material may be so disposed as to limit the emergent radiations to a beam or pencil of rays directed along a particular line or axis and further that the observation of these rays may also be arranged in such a manner that the observing device is sensitive only in a particular direction. This will be useful as it is well known to those skilled in the art that gamma rays and other penetrating radiations are deflected strongly in certain directions by certain crystalline substances by diffraction. Also this method includes the principle of observing the intensity of scattering on one side of the apparatus or the other by suitably disposing the opaque material such

as 26. The usefulness of such an observation on one side and then on the other lies in the fact that one could observe whether particular sharp lithological changes corresponded exactly in depth or were higher on one side or the other. Such a method would enable one to conclude whether the formations were horizontal or were sloping at the point at which they intersect the drill hole.

Also included in this method is the procedure of observing the after effect of exposure of the formations to the radiations arising from the source 25. This measurement can be accomplished in either of two ways, first by running the apparatus very slowly downward in the well so that an appreciable time elapses between exposure of the formations adjacent to 25 and the observation of the same formations by the ionization chamber or secondly, by making the distance between the source 25 and the ionization chamber considerable. It is understood that the shape of the absorbing block 26 will be so changed that rays scattering from the formation will be excluded from the ionization chamber as well as those which would otherwise pass directly from the source 25 to the ionization chamber.

The usefulness of this method is increased by the fact that it will work if the hole is lined with a steel casing. For example, it is a well known fact that several of the strongly penetrating radiations from radioactive substances are decreased to approximately half in intensity in about 2 inches of iron. Such a calculation shows clearly that these radiations would easily penetrate the average thickness of casing which is used to line a well and the scattering from the formations behind the casing would experience little difficulty in emerging to be measured in the ionization chamber.

It is understood that any penetrating radiations may be used including those which arise indirectly from radioactive processes such as for example, streams of neutrons produced by the action of alpha particles from radium upon beryllium. Further it is considered to be an obvious modification to produce penetrating radiations identical with gamma rays from radioactive substances by some other direct method such as the use of a high voltage X-ray tube.

The term "penetrating radiations" as used here is meant to include not only electromagnetic radiations such as gamma rays but also all other penetrating radiations including those which consist of material particles ejected directly or indirectly from radioactive substances or produced by any of the other common methods known to those skilled in the art.

In view of my invention and disclosure variations and modifications to meet individual whim and particular need will doubtless become evident to others skilled in the art to obtain part or all of the benefit of my invention without copying the structure shown. I therefore, claim all such in so far as they fall within the reasonable spirit and scope of my invention.

In the claims when reference is made to radiations caused by radioactive processes, it is meant to designate any emission of energy which accompanies radioactive processes and may include emission of electromagnetic radiations of any nature or emission of material particles of any nature such as electrons, positrons, barytrons, protons, neutrons, helium nuclei, ions and others.

Under the term "scattering" is understood a phenomenon in which a radiation along a particular direction causes another radiation in all directions.

This application is a division of United States patent application Serial Number 239,781, filed November 10, 1938.

I claim:

1. The method of determining the nature of formations penetrated by a drill hole which comprises inserting in the drill hole a neutron-emitting source and measuring gamma ray radiations from the formations as influenced by the said neutron-emitting source at different depths therein.

2. An apparatus for determining the nature of formations penetrated by a drill hole which comprises a neutron-emitting source, a detector of gamma radiations capable of translating the strength of the gamma radiations received by it into an electrical current which is a function of the strength of said gamma radiations, a shield relatively opaque to radiations from said source of neutrons disposed between the detector and the source of neutrons, means for lowering the aforesaid elements into a drill hole, means for determining the depth to which said elements are lowered and means for charting the depth of said lowering and the determinations made by said detector in correlation.

3. The method of determining the nature of formations penetrated by a drill hole which comprises inserting in the drill hole a neutron-emitting source and measuring the gamma radiations from the formations as influenced by said neutron-emitting source at different depths therein, by impressing an electrical potential on an ionizable medium of relatively high density and exposing said ionizable medium to the gamma radiations intercepting said drill hole whereby ionization of said ionizable medium is caused and electrical current permitted to flow, measuring the magnitude of the current, and continuously changing the locus of the measurament so as to obtain a continuous series of measurements corresponding to a continuous range of localities.

4. An apparatus for determining the nature of formations penetrated by a drill hole which comprises a neutron-emitting source, a detector of gamma radiations capable of translating the strength of the gamma radiations received by it into an electrical current which is a function of the strength of said gamma radiations, a shield positioned to protect said detector from gamma radiations from said source of neutrons, means for lowering the aforesaid elements into a drill hole, means for determining the depth to which said elements are lowered and means for charting the depth of said lowering and the determinations made by said detector in correlation.

ROBERT EARL FEARON.