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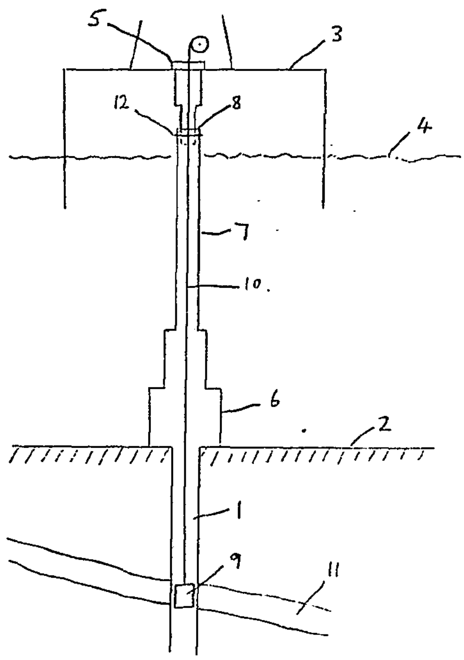
(71) Applicants: CONTINENTAL OIL COMPANY, 1000 SOUTH PINE, PONCA CITY, OKLAHOMA 74601, UNITED STATES OF AMERICA
(72) Inventor: GEOFFREY MICHAEL HODSON
(74) Agents: FRANK B. DEHN & CO.

(54) MEASURING DEPTH IN BOREHOLES

(57) A method of determining the depth of a rock stratum or other feature in a borehole comprises mounting a marker at a fixed position at or above the top of the borehole, suspending on a line an instrument sensitive to the marker and the feature, lowering the instrument past the marker and the feature and measuring the length of line supplied.

Referring to the drawing, in the preferred embodiment a radioactive marker 12, such as a source of gamma rays, is positioned near the top of the riser 7 of a sub-sea wellhead structure. A radiation detector 9 is lowered between the marker 12 and a radioactive stratum 11 and the length of line 10 supplied is measured on the floating platform 3. This enables the depth of the stratum 11 to be measured irrespective of tidal variations of the height of the platform 3.



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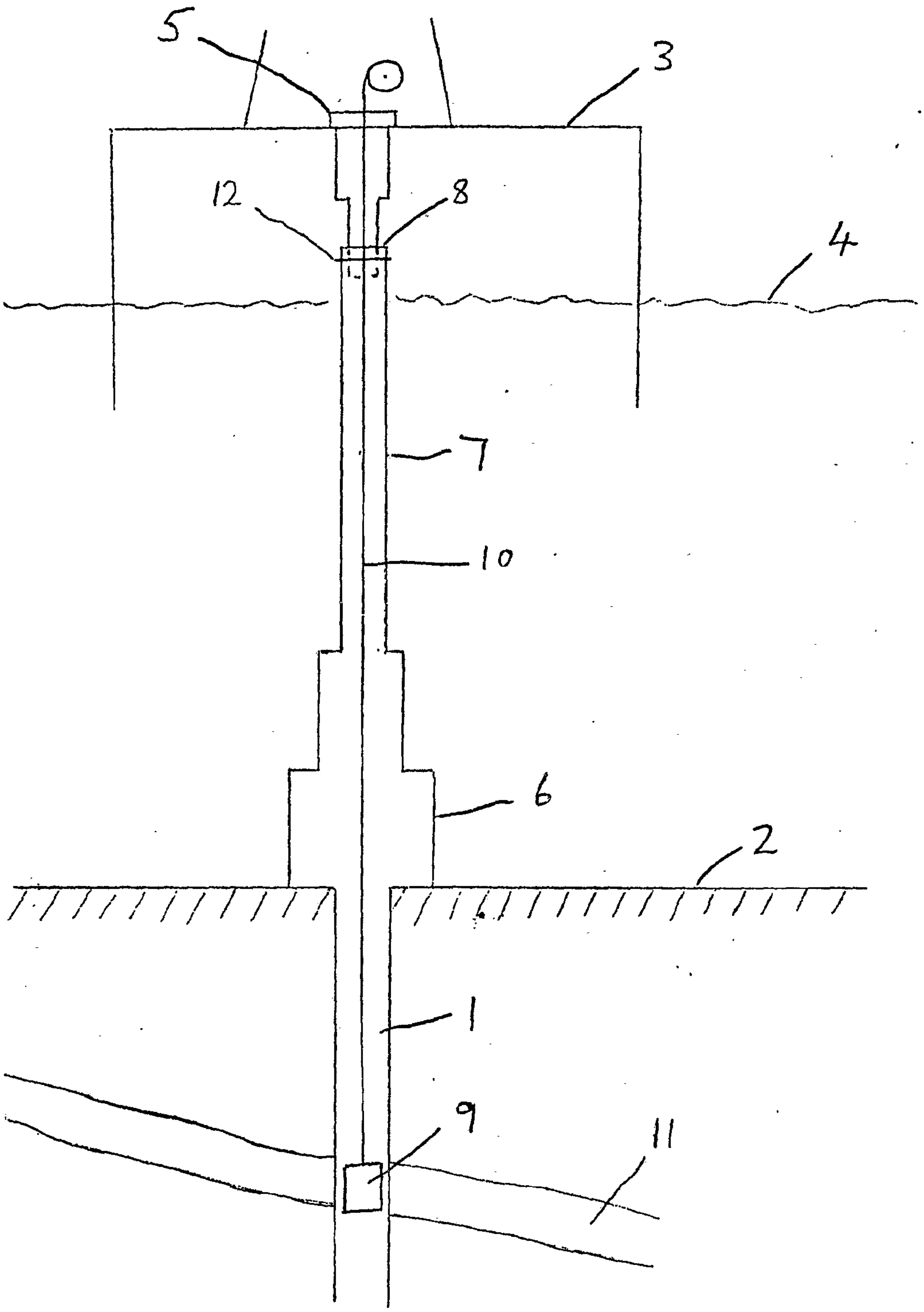
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SPECIFICATION

MEASURING DEPTH IN BOREHOLES

This invention relates to a method of determining the depth of rock strata and other features of a borehole. The invention may be employed with particular advantage when access to the top of the borehole is difficult, for example in underwater operations.

In prospecting an area for deposits of minerals, it is common practice to drill a number of boreholes throughout the area and to measure and record the variation with depth of the properties of the rocks penetrated by the boreholes. Apparatus for measuring such variations typically comprises a measuring head suspended from a line within the borehole. The measuring head may be used to measure natural radioactivity, resistivity, electron density or sound transmission properties, for example. The length of the line is measured as it is wound into or out of the borehole so as to indicate the depth of the measuring head from the point from which the line is suspended. The variation of physical properties with depth determined in this manner is known as a "wireline log".

In order to determine the extent and direction of rock strata and other features, it is necessary to compare the wireline logs of the various boreholes. It is therefore necessary to relate the individual depth measurements to a common reference level. This presents little difficulty on land because the height of the supporting point for the line above the ground can be measured and the height of the ground at each borehole above a fixed reference level (such as mean sea level) can be determined by known surveying techniques.

In some situations, however, the vertical position of the supporting point for the line may not be fixed. For example, the height above the sea bed of a floating platform will vary with the height of waves and with tidal variations. Under these circumstances it is difficult to relate the wireline logs to a fixed reference level, such as the sea bed, or mean sea level, and inaccuracies often result.

According to the invention, we provide a method of determining the depth of a rock stratum or other feature in a borehole, comprising positioning a marker at a fixed position at or above the top of the borehole, suspending on a line from a point above the marker an instrument capable of indicating when it is adjacent said feature, the marker being such that the instrument can indicate when it is adjacent the marker, lowering the instrument into the borehole so as to pass both the marker and said feature, and measuring the length of line supplied or taken up as the instrument moves between the marker and said feature.

The term "line" is intended to include single or multiple strand wires and other elongate substantially inextensible elements, such as chains and tubular pipe.

When the borehole is under water, such as under the sea, depth measurements are usually taken from a floating platform which is connected by means of a slip joint to a fixed structure including a stack and a riser and resting on the sea floor. Thus the platform is free to move vertically with respect to the sea floor. In this case the marker will be positioned on the fixed structure, preferably at the top of the riser for ease of access. In the case of sub-sea production systems the marker may be positioned within the sub-sea completion equipment such as on the Christmas tree. This may be useful if wells are re-worked after several years of production and new intervals are perforated by wireline equipment.

The instrument may be one of several known logging instruments, employing, for example, sonic, electron density, neutron, gamma ray, electrical resistivity or electromagnetic measurements and it may operate in conjunction with sensors or sources outside the borehole or it may itself be responsive to the properties of the rock strata.

Preferably, the instrument includes a detector for detecting radioactivity, such as an ionisation detector, and the marker includes a source of radioactivity. A source of γ-radiation, such as a commercially-available radioactive isotope or a quantity of a naturally radioactive rock, may be used.

Preferably a continuous log is made of the variation with depth of a property of the rock strata starting from a point at or above the marker. The position of the marker will then appear on the log enabling simple and rapid comparisons of the logs from different boreholes to be made. This feature may be advantageous even when the point of suspension is fixed, such as in drilling operations on dry land.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawing in which the sole figure is a schematic representation of an underwater borehole and associated structure.

Referring to the drawing there is shown a borehole 1 drilled into the sea floor 2. A floating platform 3 is positioned above the borehole and enables drilling operations to be directed from above the surface 4 of the sea. The platform 3 includes a conventional Kelly bushing and a rotary table 5.

Resting on the sea floor 2 is a stack 6 and riser 7. The platform 3 is able to move vertically with respect to the stack and riser as the height of the sea surface 4 varies, by means of a slip joint 8.

In prospecting for minerals it is usual to log the variation with depth of the properties of the rocks in the borehole. This operation is normally carried out before casing is positioned in the borehole by means of an instrument suspended on a line. Various properties, such as sound transmission properties, electron density and electrical properties can be logged, but in the preferred embodiment an instrument 9 sensitive to natural radioactivity is suspended on a wire 10. The instrument 9, known as a "gamma ray tool", may include an ionisation detector. The "gamma ray log" obtained with this instrument is particularly useful in prospecting for petroleum products. In operation the gamma ray tool 9 is lowered into the borehole and then raised. Variations in the level of radioactivity within the borehole 1 are communicated (usually via the suspension wire 10) to the platform 3. The depth of the features, such as the rock stratum 11, causing variations in the indication of the instrument 9 is determined by measuring the length of wire supplied or taken up as the instrument is lowered or raised. This enables the depth of the features below a point on the platform 3, such as the Kelly bushing or rotary table 5, to be determined.

A problem arises, however, in that the vertical position of the platform 3 with respect to the sea floor, mean sea level or other known reference levels, is not fixed. Although it is to some extent possible to calculate from tide tables the height of the rotary table above the sea bed, inaccuracies and variations with time do occur.

In accordance with the invention, a marker which can be indicated by the instrument is positioned in a fixed position above the top of the borehole. In the present embodiment a radioactive marker 12 is fixed near the top of the riser 7. The marker 12 may be fixed by any means, such as welding, bolting or clamping, and may comprise a commercially-available isotope such as K^{40}, or a quantity of naturally radioactive material. The marker 12 may be positioned anywhere on the fixed structure resting on the sea floor, but the top of the riser 7 is preferred for easy of access.

In operation, the gamma ray tool 9 is moved past the marker 12 before and after entering the borehole 1, and indications of the detected radioactivity are logged against depth. The log will indicate the marker and the various features in the borehole and thus the distance of the features below the marker will be accurately known. The position of the marker 12 with respect to the sea floor 2 is accurately known and so the depth of the underground features below known reference levels can be accurately determined.

This enables the comparison of logs obtained from different boreholes to be made rapidly and accurately.

CLAIMS

1. A method of determining the depth of a rock stratum or other feature in a borehole, comprising positioning a marker at a fixed position at or above the top of the borehole, suspending on a line from a point above the marker an instrument capable of indicating when it is adjacent said feature, the marker being such that the instrument can indicate when it is adjacent the marker, lowering the instrument into the borehole so as to pass both the marker and said feature, and measuring the length of line supplied or taken up as the instrument moves between the marker and said feature.

2. A method as claimed in claim 1 wherein the instrument includes a detector for detecting radioactivity and the marker includes a source of radioactivity.

3. A method as claimed in claim 2 wherein the marker includes a source of gamma radiation.

4. A method as claimed in claim 2 or 3 wherein the detector is an ionisation detector.

5. A method as claimed in any preceding claim comprising making a continuous log of the variation with depth of a property of the rock strata starting from a point at or above the marker.

6. A method as claimed in any preceding claim wherein the borehole is under water, comprising measuring the length of line from a floating platform which is connected by means of a slip joint to a fixed structure resting on the ground below the water, the marker being positioned on the fixed structure.

7. A method as claimed in claim 6 wherein the fixed structure includes a stack and a riser and the marker is positioned at the top of the riser.

8. A method of determining the depth of a feature in a borehole, substantially as hereinbefore described with reference to the accompanying drawing.

9. A wellhead structure having a radioactive marker mounted thereon in a position fixed with respect to the underlying rock strata so as to be detectable by an ionisation detector lowered into the structure.

10. A wellhead structure as claimed in claim 9 comprising a stack and a riser, the marker being mounted at the top of the riser.

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