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WELL SURVEYING DEVICE

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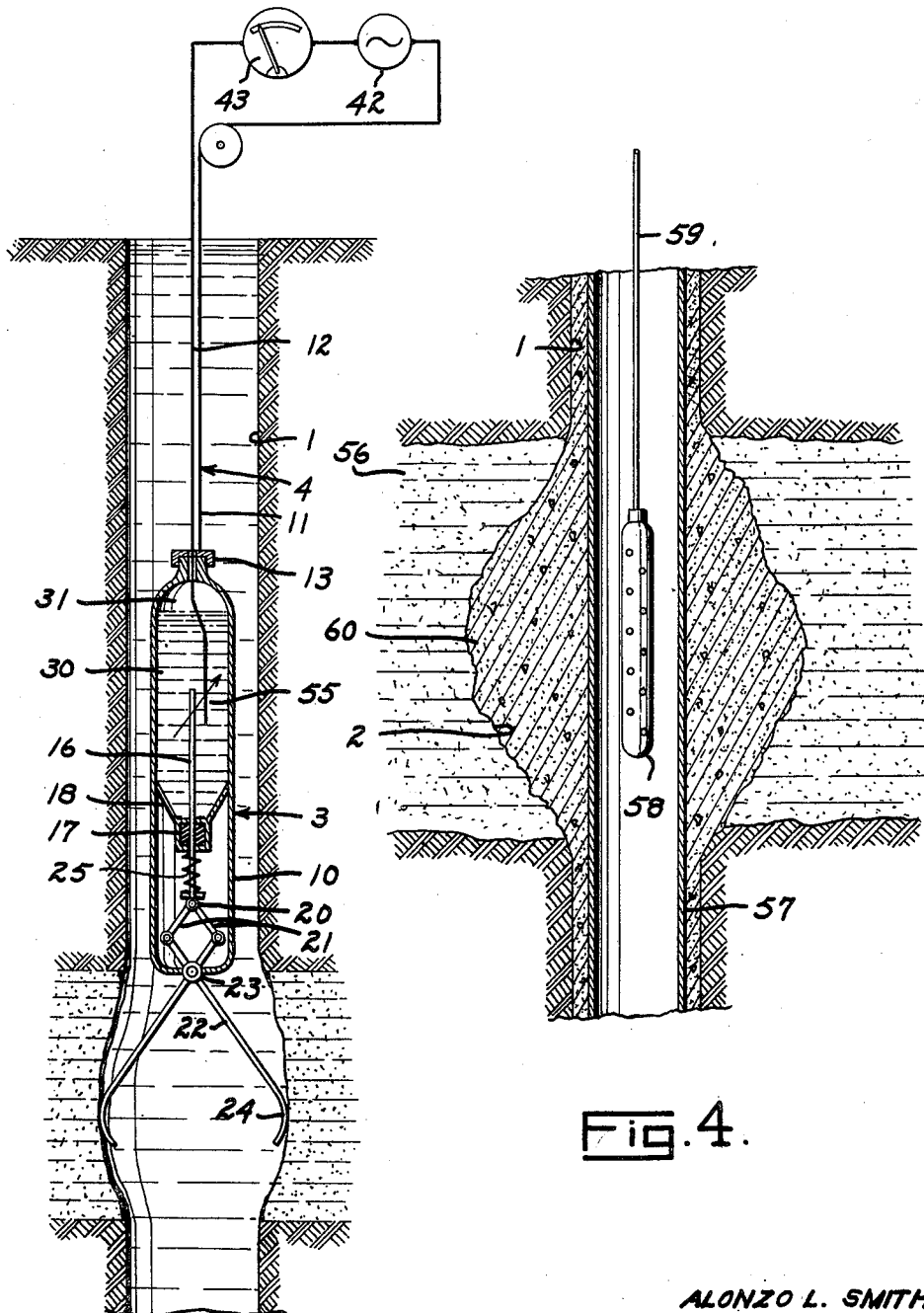


Fig. 4.

Fig. 3.

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WELL SURVEYING DEVICE

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4 Claims. (Cl. 166—1)

1

This invention relates to a method of and means for surveying well bores by determining the configuration of the wall of the bore at various elevations.

In the drilling of well bores by the rotary method, mud is circulated in the well bore to flush the cuttings out of the bore, cool the bit, overcome formation pressures, prevent sticking of the drill pipe, and aid in the rate of penetration by the hydraulic wash of the mud jetting out of the bit under high pressure against the formations.

The hydraulic wash by the drilling fluid of the formations sometimes causes considerable trouble in completing oil wells, especially when the petroleum formation is relatively soft such as a sand formation. Mud pumped out through the bit under high pressure may wash out the formation for a considerable distance radially of the well bore, depending on the relative hardness of the formation, and hence cause an area of large diameter to be created.

Under present practices such conditions are now known to exist. Also under present practices an electric log survey is generally made of the well bore for geological information. Naturally such a cavity existing in a bore of small diameter is certain to cause an error in the resistivity or self potential log when the electrodes are moving through the cavity area, since a material portion of the reading obtained by the log would relate to characteristics of the mud filling the cavity and not to the characteristics of the formation about the well bore. If the well bore contour were known, a correction factor could be used for correcting the readings in accordance with variation in the size of the bore. At the same time, the variations in the contour of the well bore would be indicative of the relative hardness and extent of the various formations and hence information as to contour variations would additionally constitute a log of the well bore.

After a well is logged, casing is set therein and is cemented. During the cementing process, cement is pumped outside the casing and the cavity is filled with cement. The usual method of completing a well is to perforate the well casing at a designated formation with a gun or by a mechanical perforator which produces holes or slots in the casing. If the cavity which was filled by cement was in the formation to be produced, attempts to perforate and complete the well at that level might be unsuccessful since the shots might not effect desired penetration through the casing and cement. The operator

2

not knowing that an attempt was made to perforate through a substantial thickness of solid cement rather than a thin wall thereof would conclude that the penetrated formation is non-productive. If the condition of the well bore as to diameter were known, in accordance with the present invention, an improved practice can be followed in well completion and thereby the difficulties above mentioned are eliminated.

It is the primary object of the invention to provide a method of and means for measuring the well bore diameter and comparing such measurements with relationship to depth with an electric log for correlation purposes and for making necessary corrections in the log to eliminate the effect of changes in the diameter of the well bore.

Another object of the invention is to measure the well bore diameter with relationship to depth and to associate such measurements with completing practices to be used under existing and known conditions.

Another object is to measure the well bore diameter with relationship to depth to provide a log which is a measure of the relative hardness of the penetrated formations and hence provides information of the nature and extent of the respective formations.

Still another object is to provide a means of recording volumetric capacities of a well bore with relationship to depth for cementing practices.

A further object is to measure the diameter of a well bore by utilizing the movement of a caliper to actuate electrical induction coupling means for obtaining desired measurements.

A still further object is to provide mechanism having two or more caliper legs connected to a common drive for providing a single measurement which is indicative of the well bore diameter.

Still another object is to provide means for measuring a well bore diameter by actuating a single drive to change the electrical resistance or impedances of a calibrated electric circuit.

Other and more specific objects of the invention will be apparent from the following description considered in connection with the accompanying drawings in which:

Fig. 1 is a schematic sectional view through a well bore illustrating the technique and one embodiment of apparatus of the invention;

Fig. 2 is a view similar to that shown in Fig. 1 but showing a modification of the measuring mechanism of the calipering element;

3

Fig. 3 is a sectional view showing a further modification of the caliper element;

Fig. 4 is a sectional view through a bore in the earth and illustrates perforating conditions encountered in present practice.

The reference character 1 represents a well bore in which is formed a bit of a given diameter but which bore is variable in diameter as above explained, an enlargement being shown at 2 as illustrative of this condition.

In accordance with the invention a surveying unit 3 is lowered in the bore hole 1 upon a conductor cable 4, the construction being such that desired measurements are made available at the mouth of the well bore as the unit 3 is made to move therein.

The unit 3 comprises an elongated housing 10 to which the conductor cable 4 is attached so that the unit may be made to traverse the well bore and also that one or more of the conductors in the cable may comprise an electric measuring circuit. As illustrated, the conductor 11 is grounded to the housing 3 while the conductor 12 sealably passes through the cap 13 and, as illustrated in Fig. 1, terminates at its lower end in a variable resistor 14 which includes the sliding contact 15 attached to rod 16 passing through packing 17 in the conical partition 18 intermediate the ends of the housing. The lower end of the rod 16 is pivotally attached at 20 to the upper end of links 21 which are in turn pivotally connected to the upper ends of the arms 22. The arms 22 are pivoted at 23 to the housing 10. The lower ends 24 of the arms 22 are constantly urged outwardly into engagement with the walls of the well bore by means of a compression spring 25 surrounding the rod 16 below the packing 17.

The conductors 11 and 12 are connected to a source of electrical energy which is shown in Fig. 1 as a battery 26 in series with an indicating instrument 27 and also a recorder 28 so that either or both a visual indication or a record of the current flowing in the measuring circuit is provided. It seems apparent that the measurement thus obtained is indicative of the relative movement of the arms 22 and hence of the variations in the diameter of the bore 1.

The chamber within the housing 10 and above the partition 18 is partially filled with a suitable liquid 30, such as a light oil, the space 31 above such liquid serving as a displacement chamber so that the rod 16 may readily move as the diameter of the bore 1 varies.

As above explained, spontaneous earth potentials or the measurement of resistivity are affected by the electrical characteristics of the drilling fluid in the well bore and hence information of variations in the diameter of the bore and correlation of the electrical well log therewith are important in determining those earth formations which are potentially productive. Accordingly, when a log of spontaneous earth potentials is to be obtained, a pair of electrodes 32 comprise a part of the unit 3 and are connected by means of conductors 33 in cable 4 to the recorder 34 at the mouth of the well bore, so that an electrical log and the log provided by the recorder 28 are simultaneously produced, it being understood that such logs may be produced either separately as shown or in a single record as is well known in the art. It is also understood that in accordance with current practice the logs shall contain information as to the respective depths at which measurements

4

are made. By means of the apparatus and the technique of the invention as thus far described there is provided desired information for additional steps to be taken in cementing a well casing within the bore 1 and perforating such casing to bring the well into production.

The construction shown in Fig. 2 is similar to that shown in Fig. 1 and like parts are identified by the same reference characters. It is to be noted also that the electrical logging equipment is omitted in this figure. In this embodiment the conductor 12 is connected to a coil 40 which surrounds the rod 16 and which has its other terminal grounded at 41 to the housing 10. An alternating current is supplied to this circuit from a suitable source 42 and the instrument 43 indicates the current flowing in this circuit. A second coil 44 and a resistor 45 are carried by the rod 16 so that the coils 40 and 44 are held in inductive relation to each other, the coupling between the coils being varied as the rod 16 moves due to variations in the diameter of the well bore 1. Conductors 46 in the cable 4 are connected to the terminals of the resistor 45 and the coil 44 and to a double pole double throw switch 50 by means of which a connection may be made to the terminals of a resistor 51 or to an indicating or recording instrument 52.

When the switch 50 is closed to include the resistor 51 it seems apparent that the circuit thus formed will absorb energy which depends upon the coupling between the coils 40 and 44 and such condition will be reflected by the instrument 43 whereby such instrument will indicate the movements of the arms 22 as the unit 3 is made to traverse the well bore. If the switch 50 is thrown to the left so that the instrument 52 is included in the secondary electric circuit then the indication or record obtained by the instrument 52 will similarly indicate the movements of the arms 22, it being understood that under such circumstances the conditions in the primary electric circuit will be maintained constant.

The modified construction shown in Fig. 3 is the same as that already described except that the movements of the rod 16 are utilized to vary a capacitance 55 in the electric circuit which includes the source of alternating current 42 and the instrument 43. The variations in the capacitance 55 produce similar variations in the current flowing in the circuit and hence desired information is made available by observing or recording the variations of the reading of the instrument 43.

It seems apparent that by means of the construction and technique above described correlatable traces are obtainable whereby the volume of a bore hole is measured and hence information is made available of the amount of cement that will be necessary for cementing casing within such bore hole. At the same time the trace showing the variations in the diameter of the well bore constitutes a log showing the location, nature and extent of the respective formations. This trace is also correlatable with the electrical log of the bore to thereby provide additional and more accurate information as to the formation or formations at which perforation of the casing should be effected in order to bring the well into production.

The invention is also instrumental in avoiding a condition such as that shown in Fig. 4. As above pointed out, there is a particular tendency

2,534,632

5

for hydraulic washing or jetting of the relatively soft formation such as the oil sand 56 whereby the cavity 2 is formed therein. The successively adjacent formations 61 and 62 being relatively harder are washed to a lesser extent and the bore in these formations is of smaller diameter, depending upon the hardness of these formations.

When a casing 57 is landed in the bore hole 1 and cementing is effected in accordance with usual procedure a block of cement 60 is formed within the cavity 2. When it is desired to perforate the casing within the sand 56 a gun perforator 58 is lowered therein upon the cable 59.

Perforating operations will, however, be unsuccessful since it is impossible for projectiles from the gun 58 to penetrate the cement 60 and enter the sand 56 to admit formation fluids to the interior of the casing 57. Accordingly, a conclusion may, and frequently is, reached, that the formation 56 is unproductive.

The present invention avoids this condition since the accurate information obtained through correlation enables resort to squeeze cementing above and below the cavity 2 and in this manner such cavity is not filled with cement. Hence when cementing is completed a perforator 58 may be lowered to the sand 56 and the well can thus be brought into production.

From the above description it may be seen that the invention provides novel method and means for surveying a well bore whereby difficulties heretofore experienced in bringing a well into production are minimized.

This application is a continuation of my application Serial No. 411,761, filed September 20, 1941.

What is claimed is:

1. In a well surveying device the combination of a housing having a chamber therein and adapted to be lowered into a well bore, a rod carried by said housing and extending into said chamber, means for moving said rod in accordance with variations in the diameter of the well bore, means operable by the movements of said rod for indicating at the surface the variations in the diameter of the well bore which cause such movement, and a quantity of liquid partially filling said chamber so as to provide a space in the chamber above the liquid to serve as a compression chamber to compensate for volumetric changes produced in the chamber by movement of the rod.

2. In a well surveying device the combination of a housing having a chamber therein and adapted to be lowered into a well bore, a rod carried by said housing and extending into said chamber, means for moving said rod in accordance with variations in the diameter of the well bore, means operable by the movements of said rod for indicating at the surface the variations in the diameter of the well bore which cause such movement, a quantity of liquid partially filling said chamber so as to provide a space in the chamber above the liquid to serve as a compression chamber to compensate for volumetric

6

changes produced in the chamber by movement of the rod, additional means carried by said housing to simultaneously electrically log the well bore comprising electrodes at the elevation of said first means and a device at the surface to indicate the electrical characteristics of the formation being calipered and logged.

3. A combination well bore, electric logging and bore diameter measuring tool comprising, a body, an electrical cable connected thereto to raise and lower the body in the well bore and to provide an electrical potential to the tool, a bore diameter measuring caliper carried by the body which is operable as a function of the diameter of the bore to transmit a signal to the surface which is an indication of such measured diameter, and electrical logging means also carried by said body and provided with a potential through said cable which logging means is affected by the spontaneous earth potential of the formation being traversed to transmit a signal thereof through said cable, both said caliper and electrical logging means being supported by said body and so constructed and arranged that the signals of such caliper and log are transmitted simultaneously from the same well bore elevation.

4. A combination well bore, electric logging and bore diameter measuring tool comprising, a body, an electrical cable connected thereto to raise and lower the body in the well bore and to provide an electrical potential to the tool, a bore diameter measuring caliper carried by the body which is operable as a function of the diameter of the bore to transmit a signal to the surface which is an indication of such measured diameter, and electrical logging means also carried by said body and provided with a potential through said cable which logging means is affected by the spontaneous earth potential of the formation being traversed to transmit a signal thereof through said cable, both said caliper and electrical logging means being supported by said body and so constructed and arranged that the signals of such caliper and log are transmitted from the same well bore elevation.

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