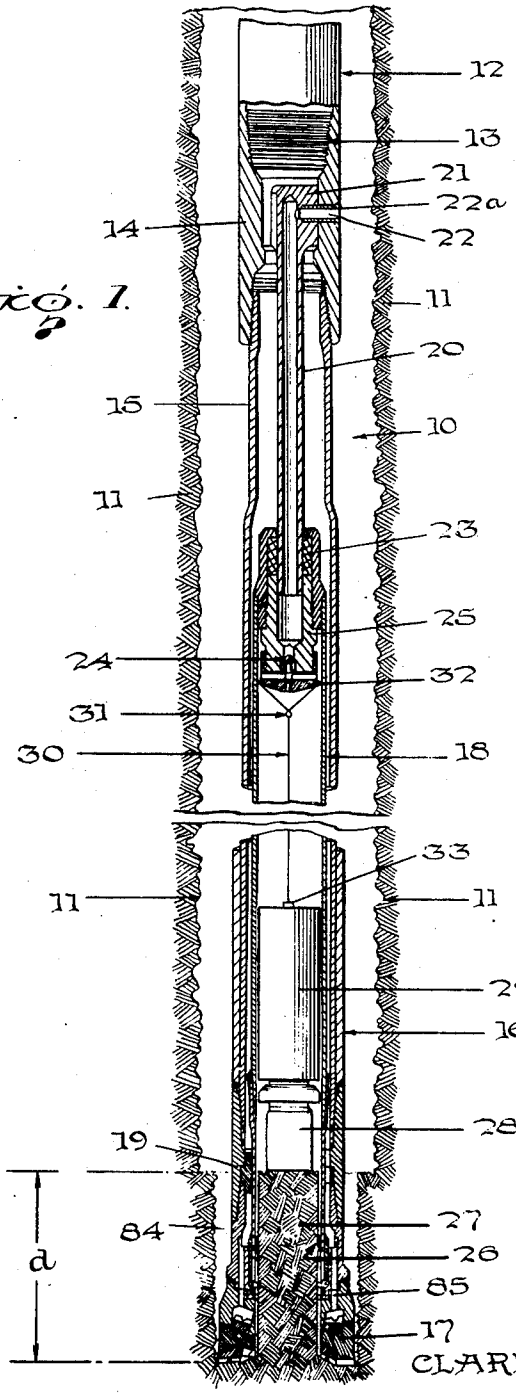
May 29, 1951 C. D. MILLISON 2,555,275

ART OF WELL DRILLING

Filed May 20, 1946 3 Sheets-Sheet 1

Fig. 1.



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ART OF WELL DRILLING

Filed May 20, 1946 3 Sheets-Sheet 2

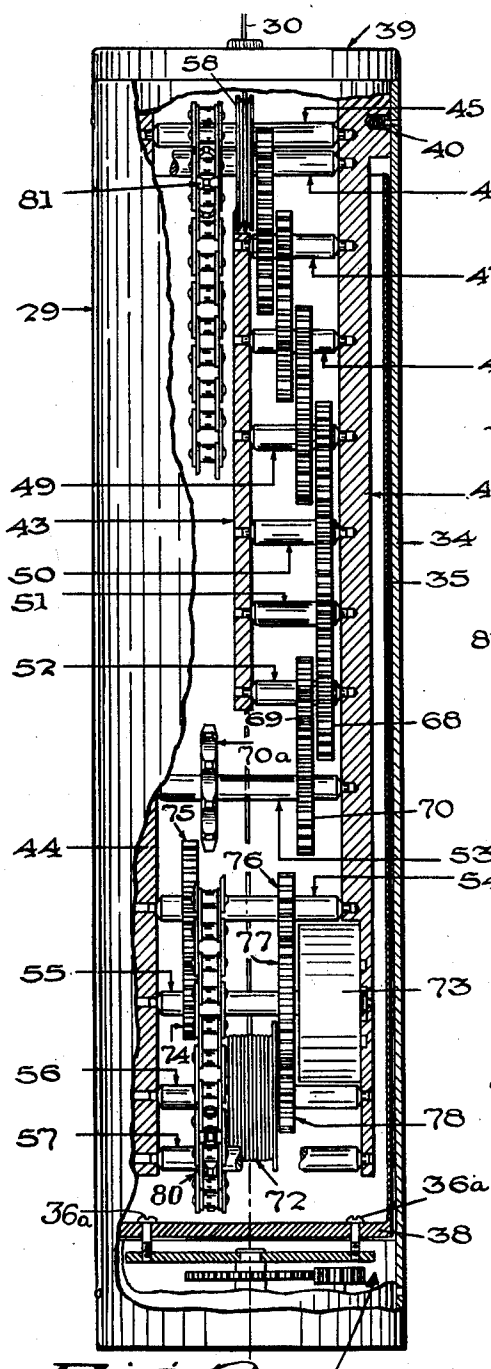

Fig. 2.

CLOCKWORK MECHANISM

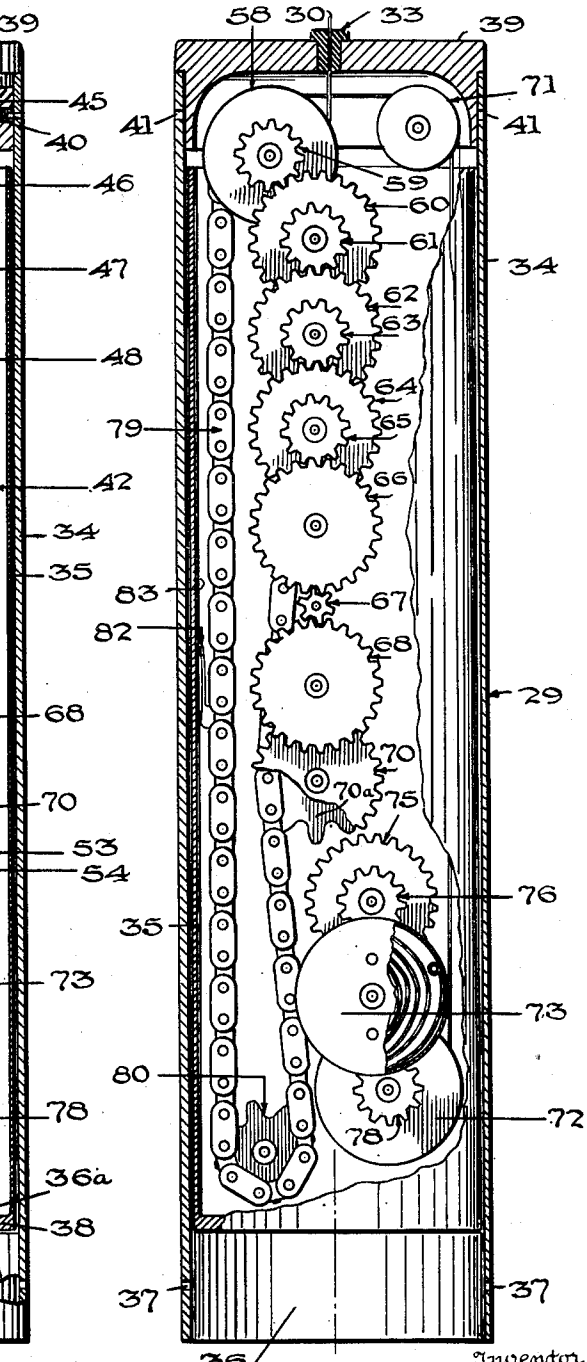

Fig. 3.

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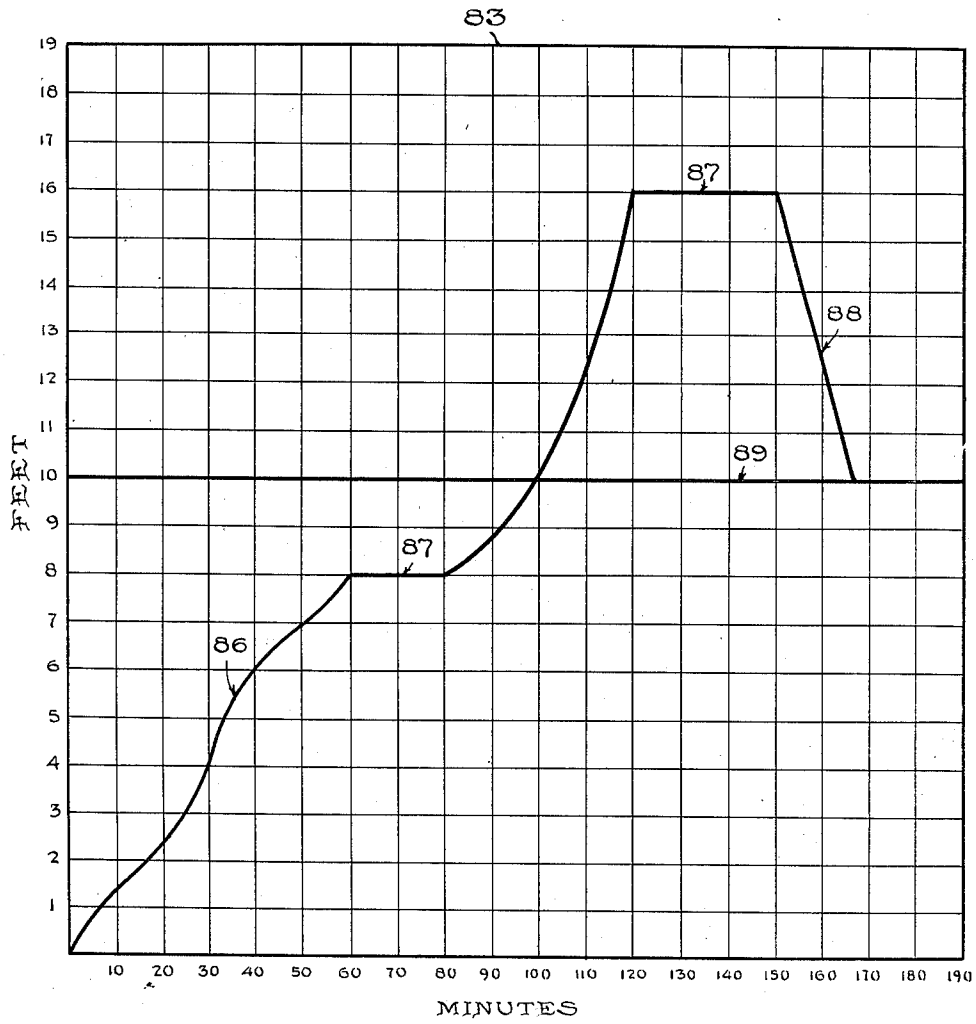

Fig. 4.

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Patented May 29, 1951

2,555,275

UNITED STATES PATENT OFFICE

2,555,275

ART OF WELL DRILLING

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Application May 20, 1946, Serial No. 671,023

8 Claims. (Cl. 255—1.4)

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The present invention relates generally to the art of well drilling.

More particularly it relates to an improved oil well surveying instrument adapted to be employed in conjunction with rotary core drilling equipment to determine the character and location of the various earth strata through which the well is drilled.

In the normal operation of a rotary drill rig for the drilling of oil and gas wells, the cutting tool or rock bit is supported at the lower end of a string of drill pipe known as the drill string, which is rotated by machinery at the surface adjacent the top of the well. A column of weighted fluid known as "drilling mud" is continuously forced under pressure down through the drill string and out at the bottom adjacent the cutting tool where it serves to lubricate the latter and control the well pressure, as well as to wash the cuttings and bits of formation material encountered through the outer casing which surrounds the drill string and up to the surface where it is discharged into a slush pit. The personnel in charge of operations carefully observes the drilling mud as it returns to the surface and thereby estimates the nature of the formation in which the cutting tool is operating. This method of determining the character of the formation is necessarily inexact and accordingly it is common practice to restort to coring operations periodically, particularly as the drilling approaches a depth where producing formations may be anticipated.

The core drilling operation is accomplished by substituting an annular-shaped core bit for the usual cutting tool and providing a hollow cylindrical chamber called a core barrel open to the center of this core bit for receiving a centrally projecting plug of formation material which is left relatively intact at the bottom of the well as the core bit progresses downwardly. As soon as the core drilling has proceeded the desired distance, suitable steps are taken, such as speeding up the drilling, to break off the projecting core which is retained by a suitably designed core catcher within the core barrel and may be brought to the surface and removed from the well for observation to determine the precise nature of the formation which has been drilled through. However, it happens in many cases, and particularly where potentially productive formations are being cored, that a substantial portion of the core sample may escape from the core barrel or be otherwise lost so that a complete sample of each formation encountered is not obtained.

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Accordingly, the present invention has for its principal object the provision of an improved core drilling apparatus wherein means are provided for determining the amount obtained and time rate of recovery and loss of the core sample.

Another object of the invention is the provision of a novel instrument for use in conjunction with core drilling apparatus including a recording device which is driven at a timed rate and which is also responsive to movement of the core sample within the core barrel for automatically recording the direction and time rate of such movement.

A further object of the invention resides in the provision of a novel instrument of the type referred to including a spring tensioned wire line and reduction gearing mounted therewithin for recording the direction of movement of the core sample within the core barrel at a reduced rate as the instrument itself moves within the core barrel under the influence of gravitational force.

An additional object of the invention is to provide an instrument for recording the direction and time rate of movement of a core sample of formation material within a core barrel wherein the instrument is practically self-contained and is sealed in such manner as to prevent the entrance of drilling fluid or foreign particles.

A still further object of the invention resides in a novel method of surveying an oil well whereby the amount and time rate of recovery and loss of the core sample are accurately measured, recorded for each increment drilled and correlated with the core sample obtained.

Other and further objects and advantages of the present invention as well as a more complete understanding thereof will become more readily apparent from a consideration of the following detailed specification taken in conjunction with the accompanying drawings and illustrating a preferred embodiment thereof, wherein:

Fig. 1 is a longitudinal section through the bottom of a bore hole having a core drilling apparatus in accordance with the present invention in operative position therein;

Fig. 2 is a partially sectioned front elevational view of the novel instrument constituting a principal part of the present invention;

Fig. 3 is a partially sectioned side view of the instrument shown in Fig. 2; and

Fig. 4 is a typical record chart obtained by use of the instrument illustrated in Figs. 1 to 3.

Referring now in more detail to the various figures of drawing and in particular to Fig. 1, there is illustrated the bottom portion of a boring wherein the drill hole is designated generally by

reference numeral 10 and the formation material constituting the solid walls of the hole is designated by reference numeral 11. The lower tip of the drill string or tubing 12 is shown fragmentarily at the top of Fig. 1 and connected thereto, as by means of a tool joint 13, collar 14, and swaged sub 15, is a tubular outer core barrel 16 at the bottom of which is mounted the cutting tool or core bit 17. A tubular inner core barrel 18 having an outside diameter appreciably smaller than the internal diameter of the sub 15 is mounted in suitable bearings 19 within the outer core barrel 16 and is provided with a section of tubing 20 constituting a fluid connection from the inside of the inner core barrel to the well 10 through a fitting 21, the latter being provided with an aperture 22 and pipe 22a extending through a matching aperture in the side wall of the collar 14. A suitable packing 23 is provided at the juncture of the tube 20 with the inner core barrel 18, and a one-way ball check valve 24 is mounted in a plug 25 secured in the top of the inner core barrel 18 to permit the escape of fluid from the interior of the inner core barrel while preventing the entrance of drilling fluid or extraneous material.

A core catcher 26 which may be of any suitable construction is mounted in the lower portion of the inner core barrel 18 and serves to retain the core sample 27 therein upon the completion of a core drilling operation. A typical plug 28 is provided in the lower portion of the inner core barrel 18 to prevent the entrance of drilling fluid or other foreign material into the bottom thereof until the core drilling operation is started at which time the plug 28 rides relatively freely upon the top of the core sample 27. The recording instrument 29, in accordance with the present invention, is generally cylindrical in shape and rests upon the top of the plug 28 in such manner that it may be freely moved longitudinally within the inner core barrel 18 by the plug 28 as the latter is forced inwardly relative to the inner core barrel by the core sample 27 as drilling progresses. The instrument 29 and plug 28 are also free to move downwardly relative to the inner core barrel 18 under the influence of gravity should any relative motion in a downward direction of the core sample 27 occur. A wire line 30 is secured to a swivel 31 attached to an apertured cap 32 which in turn is mounted on the bottom of the plug 25. The wire line 30 extends downwardly through a suitable packing gland 33 in the top of the instrument 29 for a purpose to be described.

Referring now particularly to Figs. 2 and 3, the instrument 29 is seen to comprise generally an outer cylinder 34 and an inner cylinder 35. The bottom end of the outer cylinder 34 is closed by a relatively flat cylindrical housing 36, suitably mounted therein as by means of spring-pressed plungers 37. (See same element 40 for details.) The housing 36 contains a "Clockwork Mechanism," partially shown in Fig. 2, secured in driving relationship as by means of screws 36a to the bottom plate 38 of the inner cylinder 35 for rotating the cylinder 35 relative to the cylinder 34 at a timed rate. The top end of the outer cylinder 34 is substantially closed by a cap piece 39 which is releasably secured therein by means of a plurality of spring-pressed plungers 40, the reduced outer end portions of which fit into apertures 41 formed in the side wall of the outer cylinder 34. As will be particularly noted in Fig. 3, the packing gland 33 is in sealing engagement with the wire line 30 to prevent the entrance of fluid or foreign particles to the interior of the instrument 29.

Depending from the upper cap piece 39 are a plurality of journal frames 42, 43 and 44, which project downwardly within the inner cylinder 35 in spaced relation to the inner and bottom walls thereof. These journal frames are formed to provide aligned journal bearings for a plurality of parallel shafts 45 to 57, inclusive, which are freely rotatable therein. A pulley 58 secured to the shaft 46 is connected in driving relation, by means of a train of reduction gears 59 to 70, inclusive, to a sprocket 70a secured to the shaft 53. Power for operating the sprocket 70a and its associated gear train is supplied by means of the wire line 30 which extends through the packing gland 33 in the top of the outer cylinder, around the pulley 58 in driving relation thereto, over an idler pulley 71, and thence downwardly into the inner cylinder 35 where it is wound upon a drum 72 secured to the shaft 56. The drum 72 is tensioned to constantly draw the wire line 30 into the cylinder 39 by means of a spring motor 73 mounted in the lower portion of the journal frame 42 and connected in driving relation to the drum 72 by means of a train of gears 74 to 78, inclusive. The sprocket 70a is in turn connected in driving relation to an endless link chain 79 which is freely movable over a pair of idler sprockets 80 and 81, and carries a recording element in the form of a stylus 82 adapted to move relatively across the surface of a chart 83 in contact with the latter. The chart 83 is removably attached to the inner wall of the inner cylinder 35 and cooperates with the stylus 82 to produce a graphic record of relative movement between the stylus 82 and the inner cylinder 35.

The operation of the device is as follows: Referring again to Fig. 1, the core drilling apparatus is shown in the position which it assumes at the bottom of the well a short time after the core drilling operation has begun. The cutting tool or core bit 17 has progressed downwardly a short distance d cutting into the formation and producing an annular hole 84 as the drill stem 12 is rotated. During this core drilling operation the drilling fluid has been forced downwardly through the drill stem, into the sub 15, through the annular space between the sub 15 and the inner core barrel 18, through an annular passage 85 formed in the body of the tool and out around the core bit 17, lubricating the latter and washing the cuttings to the surface at the top of the well through the outer portion of the drill hole 10. As the core drilling proceeds, the inner core barrel 18 is forced downwardly around the inner plug 27 of formation material. The plug 28 which rests upon the upper surface of the core sample 27 is thus forced upwardly relative to the inner core barrel 18 carrying with it the instrument 29 which rests upon the top of the plug 28 by its own weight. Actually, of course, the inner core barrel 18 is forced downwardly about the instrument 29, the plug 28, and the core sample 27, but this is immaterial since it is the relative movement between the instrument 29 and the inner core barrel 18 which is of primary importance. At the conclusion of the core drilling operation the core sample 27 is broken off at the bottom in any well known manner and the entire apparatus brought to the surface, the core sample being retained in the inner core barrel 18 by means of the core catcher 26. The core sample 27 is ultimately extracted from the core

barrel 18 in any common manner and may then be analyzed to determine the nature of the formations at the bottom of the well.

As the inner core barrel 18 moves downwardly about the instrument 29, the wire line 30 which moves with the core barrel is drawn into the instrument by the action of the spring-tensioned drum 72. Since the wire line 30 is connected in driving relation to the pulley 58, this movement of the wire line 30 into the instrument serves to rotate the pulley 58 and, through its associated gear train 59 to 70, inclusive, the drive sprocket 70*a*, and link chain 79, imparts a vertical movement to the stylus 82. This movement is proportional to the relative movement between the instrument 29 and the inner core barrel 18 but of much smaller magnitude due to the action of the reduction gear train 59 to 70, inclusive. At the same time, and throughout the core drilling operation, the inner cylinder 35 carrying the record chart 83 is being rotated at a timed rate by means of the clockwork mechanism in housing 36. Thus the line which is traced by the stylus 82 upon the record chart 83 is a resultant of the rotational movement of the chart 83 relative to the stylus 82 and the longitudinal, translational movement of the stylus produced by the relative movement of instrument 29 and the inner core barrel 18 through the action of the wire line 30, the spring-tensioned drum 72, and the link chain 79 and its reduction gear train and pulley system 58 to 70*a*.

A typical curve produced during a core drilling operation as just described is illustrated in the chart of Fig. 4. This chart has ordinates defining the relative distance moved in feet between the instrument 29 and the inner core barrel 18 and has abscissae measuring in minutes the total time elapsed during the particular core drilling operation. That portion of the curve designated by the reference numeral 86 is produced as core drilling progresses normally with a formation sample moving relatively into the core barrel 18 as the hole is deepened. Those portions of the curve indicated by reference numeral 87 are produced as drilling is continued but no core sample is obtained, or by a temporary discontinuance of the core drilling operation (the time period for which would be observed or recorded at the surface), in either of which events no relative movement between the instrument 29 and the inner core barrel 18 will take place. That portion of the curve designated by reference numeral 88 illustrates a relative movement between the instrument 29 and the core barrel 18 in an opposite sense, that is, one in which the sample of formation material has moved relatively out of the core barrel and is lost. The portion 89 of the curve indicates a uniform rotational movement of the chart relative to the stylus during which no relative motion between the instrument 29 and the inner core barrel 18 takes place and is normally produced after the core drilling operation has ceased and while the core barrel is being lifted out of the well. When considered with the known times of core drilling and removal operations, the resultant curve illustrated in Fig. 4 serves to give a complete picture of the amount of core sample recovered and lost and, in conjunction with the known total depth drilled, also indicates the precise location of the core recovered and lost. It will be understood that the slope of the curve at any point corresponds to the rate at which the core drilling operation was proceeding at that particular time and accordingly serves as a further indication of the nature of the formation material through which the drill was progressing. The chart 83 may eventually be used in completing the well survey in accordance with any of several recognized procedures.

While there have been disclosed in detail a preferred form of apparatus and a preferred method for practicing this invention, it is to be understood that numerous variations can be made therein without departing from the spirit thereof and the scope of the appended claims.

Having thus described my invention, what I claim as novel and desire to secure by Letters Patent of the United States is:

1. Core drilling apparatus comprising a core barrel adapted to receive a core sample of formation material therein, and an instrument disposed within the core barrel for recording the direction and time rate of movement of the core sample within said core barrel, said instrument comprising an outer, hollow cylinder responsive to such movement, a clock mechanism in the bottom of said outer cylinder, an inner hollow cylinder concentrically mounted within said outer cylinder and having a record chart secured to its inner wall, said inner cylinder being connected to said clock mechanism for rotation thereby relative to said outer cylinder, a journal frame depending from the top of said outer cylinder within but spaced from said inner cylinder, first and second gear trains journaled in said frame, said first gear train including a pulley and a link chain having a stylus thereon engageable with said chart, and said second gear train including a spring motor and a drum at opposite ends thereof, and a wire line tensioned from the top of said core barrel extending around said pulley to said drum, whereby said stylus is moved vertically along said chart in response to vertical movement of said outer cylinder and said chart is rotated by said clock mechanism relative to said stylus.

2. In a core drilling apparatus having a core barrel adapted to receive a sample of formation material therein, an instrument disposed within the core barrel for recording the direction and time rate of movement of the sample within the core barrel comprising a first generally tubular member having its ends substantially closed, a second generally tubular member mounted within said first member, means for relatively rotating said members, a chart attached to said second member, a frame secured to said first member and lying within said second member, a stylus operatively associated with said chart, means including a pulley and reduction gearing mounted in said frame for moving said stylus over said chart, a flexible line secured at one end to the core barrel and passing around said pulley in driving relation thereto, and a spring-tensioned drum mounted in said frame and having the other end of said line wound thereon, said drum being arranged constantly to urge said line into said members whereby said stylus is moved over said chart in response to relative movement between said instrument and the core barrel.

3. In a core drilling apparatus having a core barrel adapted to receive a sample of formation material therein, an instrument disposed in the core barrel and comprising a first member movable within the core barrel in response to movement of the sample therein, a second member movable at a timed rate relative to said first mem-

ber, a record chart attached to said second member, a recording stylus operatively associated with said first member, mechanism for moving said stylus over the surface of said chart in response to relative movement of sample and core barrel to record the direction and amount of movement of the sample within the core barrel, and drive means for producing uniform relative rotation between said first and second members whereby the stylus will also record the time rate of movement of the sample within the core barrel.

4. The method of surveying an oil well which comprises the steps of drilling a core sample of the formation material at the bottom of the well, incrementally and continuously measuring the amount and time rate of recovery and loss for the core sample obtained, removing the core sample from the well, and determining by correlation of the measurements of amount and time rate of recovery and loss of core sample with an analysis of the core sample removed the characteristics of the formation material in the various drilled strata.

5. In combination with a core drilling apparatus having a core barrel adapted to receive a sample of formation material therein, a self-contained, sealed and generally cylindrical instrument disposed within the core barrel and comprising first means responsive to movement of the sample within the core barrel, second means movable relative to said first means, driving means for moving said second means at a timed rate relative to said first means, and indicator means operatively associated with both said first and said second means and constructed and arranged to record the direction and time rate of movement of the sample within the core barrel.

6. The combination of claim 5 including a plug movable upwardly within the core barrel on top of the sample.

7. Drilling apparatus comprising a tubular cutting tool, a core barrel mounted in said tool and adapted to receive a core sample of formation material therein, an elongated generally cylindrical recording instrument disposed in the core barrel and including enclosed recording means continuously responsive to movement of formation material within said core barrel, and enclosed record receiving means continuously movable at a time rate relative to said recording means for indicating the direction and time rate of such formation material movement.

8. A core drilling recording instrument adapted to be disposed in a formation sample receiving core barrel for recording the direction and time rate of movement of the sample within the core barrel, said instrument comprising a first tubular member having its ends substantially closed and sealed, a second tubular member mounted within said first member, means for relatively rotating said members, a chart attached to the inside of said second member, a frame secured to said first member and lying within said second member, a stylus operatively associated with said chart, means including a pulley and reduction gearing mounted in said frame for moving said stylus over said chart, a flexible line extending from one end of first tubular member and having an inward portion passing around said pulley in driving relation, and a spring-tensioned drum mounted in said frame and having the other end of said line wound thereon, said drum being arranged constantly to urge said line into said members whereby said stylus is moved over said chart in response to relative movement between said line and said tubular members.

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