June 11, 1940. C. R. DALE 2,203,720

APPARATUS FOR DETECTING WATER INTRUSION IN BOREHOLES

Filed Dec. 10, 1934 2 Sheets-Sheet 1

Fig. I

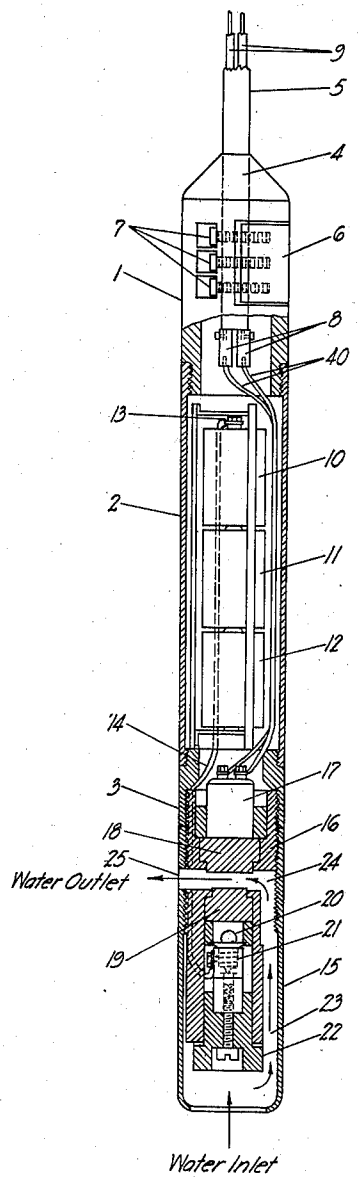
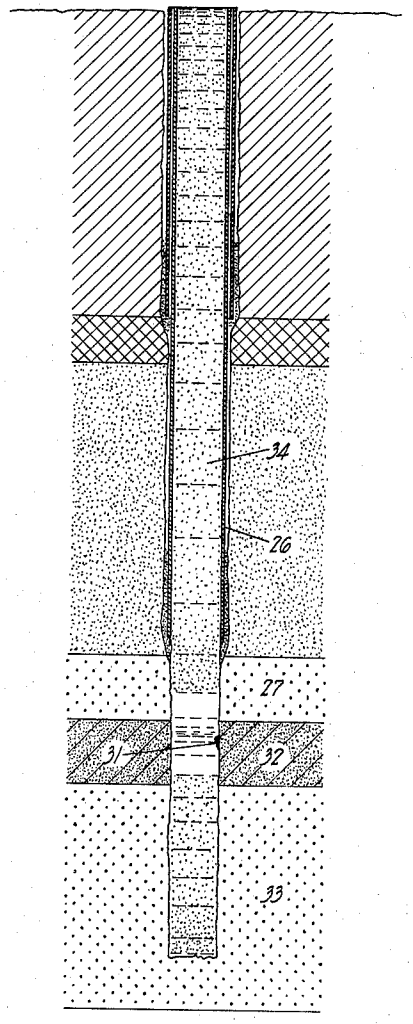


Fig. II



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Filed Dec. 10, 1934 2 Sheets-Sheet 2

FIG. III

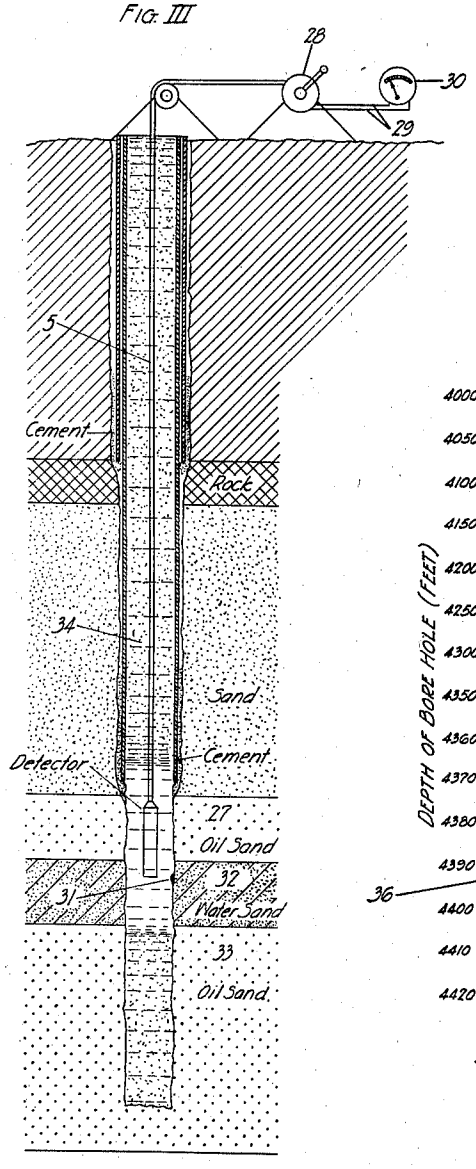
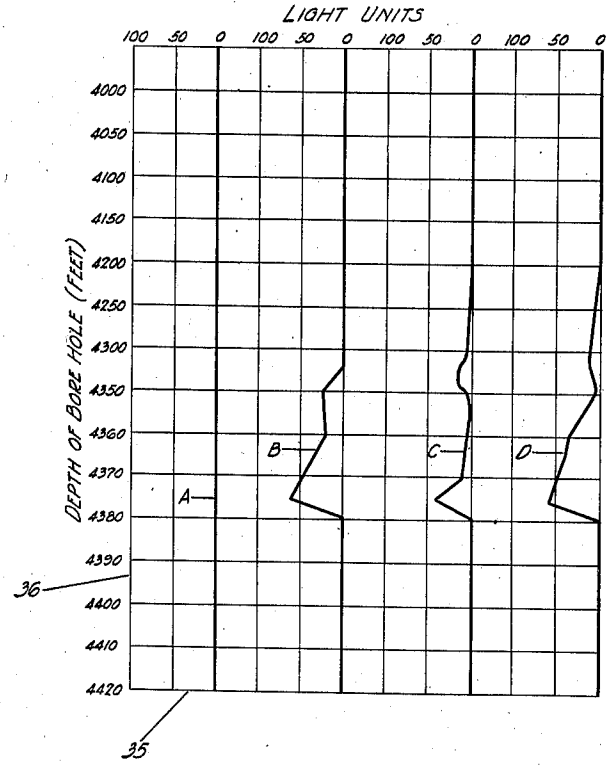


FIG. IV



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2,203,720

APPARATUS FOR DETECTING WATER INTRUSION IN BOREHOLES

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Application December 10, 1934, Serial No. 756,765

1 Claim. (Cl. 73—51)

As is well known when an oil well is drilled, water bearing strata are often encountered, necessitating the shutting off of these strata. It is generally very difficult to ascertain the exact location of the intrusion point without resort to special water detecting means. Having found the point or points of water intrusion, a string of casing is run down to below the water strata and cemented in place by well known methods.

After the cement has set, it is desirable and often required by government regulations that the water shut off be tested. For this purpose also special water detecting means can be used. Having effected a satisfactory water shut off the well is carried down by drilling through the casing with drilling tools of smaller diameter. In carrying down a well several water shut offs may be necessary before the oil sand is reached. Besides encountering water strata above the oil sand, water strata between oil sands and below them are often encountered necessitating the ascertaining of its source and its shutting off from the borehole.

Even after a well is completed and has been producing for some time water will appear in the oil produced from the well in such quantities that it is necessary to find its location and shut it off.

It will thus be readily seen that the accurate locating of points of intrusion of water into boreholes is of the utmost importance in order that the necessary remedy can be applied effectively.

Several methods have been devised for locating the points of intrusion of the water. One method for example primarily consists in placing an electrolyte in the hole, lowering spaced electrodes into the hole and reading the voltage registered on a voltmeter at the well head. The point of intrusion will be indicated by a lowering of the E. M. F. by reason of the dilution of the electrolyte by the water.

Another method consists in replacing the mud or other liquid in the well by fresh water, generating an alternating current at the well head and lowering two spaced electrodes into the well. The resistance of the water is measured at the well head by means of a Wheatstone bridge. The usual subterranean water being saline, the point of intrusion is indicated by a lowering of the resistance of the water between the electrodes.

The above systems have the disadvantages of requiring elaborate conditioning of the well prior to test and heavy and expensive surface equipment.

My invention overcomes these difficulties and provides a positive method for ascertaining the point of water intrusion.

In brief, my invention contemplates the ascertaining of the point of water intrusion by photo-electric means.

The accompanying drawings illustrate by way of example the method and means by which my invention may be carried into effect.

Referring to these drawings:

Fig. I is a longitudinal sectional view of the detector.

Fig. II is a diagrammatic section of a borehole in condition for test.

Fig. III is a diagrammatic section of the borehole shown in Fig. II but with the detector in lowered position in the hole.

Fig. IV is a chart showing results of tests made according to my method and with my apparatus.

Referring in particular to Fig. I the detector in the main comprises three sections:—an upper section 1 by which a cable is securely attached, called the cable attaching section; a middle section 2 in which is housed an electric battery, called the battery section; and a lower section 3 containing a source of light and a photo-electric cell called the light section. The three sections are assembled one on top of the other by screwing them together.

The cable attaching section 1 has a hole 4 along its longitudinal axis of sufficient size to accommodate a two wire electric cable 5. A segment of the side wall 6 of the cable attaching section is removable and is held in position by suitable bolts 7 so that it, together with the complementary part of the cable attaching section forms an effective clamp for the cable 5.

The upper end of the cable attaching section is tapered so that the instrument will not be so likely to catch on any obstruction in the boreholes into which it is designed to be lowered as is hereinafter explained. The lower part of the cable attaching section is tubular and houses the end of the cable 5 and the couplings 8 for connecting the ends of the insulated wires 9 of the cable to the insulated wires 40 leading into the battery section 2. This latter section is tubular and contains an electric battery which may for example, consist of three cylindrical cells 10, 11 and 12 connected in series in the usual manner. The bottom of the lowermost cell 12 is grounded to the body of the instrument. The central electrode of the uppermost cell 10 contacts an insulated metallic button 13. From this button 13 an insulated wire 14 leads into the light section 3. This light section consists in the main of an

open ended tube 15 having mounted therein an inner cylinder 16. At the upper end of this cylinder 16 is mounted a photo-electric cell 17 with its light sensitive part facing downward. A lens 18 is positioned in front of the cell 17. Facing the lens 18 but at a short distance therefrom is a second similar lens 19. Below this second lends 19 an electric light bulb 20, for example, an ordinary flashlight bulb, is mounted in a suitable holder 21. A metallic plug 22 seals the lower end of the cylinder 16. A groove 23 is cut in the outside wall of the cylinder 16 from the plug end to a point between the two lenses 18 and 19.

A traverse passageway 24 between the two lenses 18 and 19 is provided at right angles to groove 23. It should be here noted that the lenses are so arranged that their faces protrude slightly into the passageway for reasons which will hereinafter appear.

The outer tube 15 is screw threaded into position over the cylinder 16. An opening 23 in this outer tube 15 coincides with the end of the lateral passageway 24 opposite the passageway 23.

The insulated wire 14 from the battery section 2 is connected to the light bulb holder 21. The circuit is completed by screwing in a set screw in the end plug 22 thus grounding one of the contacts of the light bulb 20.

The two wires 40 leading from the cable are connected to the terminals of the photo-electric cell 17. In the above disclosure it should be borne in mind that various items such as packing glands, gaskets et cetera for rendering the desired parts watertight and means for adding weight to the detector have not been shown or particularly described as such will be apparent to those skilled in the art.

In order to illustrate one use to which my detector can be put, reference is made to Fig. II and Fig. III as well as Fig. I; Fig. II represents a drilled well in which the water string 26 has been successfully cemented in place just above an oil sand 27 as is a usual practice.

Water is known to be entering the hole; it is assumed for example, that it is necessary to ascertain its location in order that it may be sealed off before completing the well.

Having obtained a uniform concentration of mud 34 throughout the hole for example, by circulating mud down through the drill pipe and bit, (not shown), the tools are withdrawn from the hole.

In many cases the pressure in the water strata is not high enough to force its water into the hole in sufficient quantities to enable the point of intrusion to be detected when the hole is full of liquid owing to the high hydrostatic head. Therefore, in order to produce an appreciable flow of water into the hole, the level of liquid in the hole is reduced by bailing as for example, has been done for a considerable number of years to test the water shut off after the cementing of casing. When the liquid in the hole is at the desired level the current to the light bulb of the detector is turned on and the detector lowered into the hole by means of the cable 5, part of which is shown in section in Fig. I. The cable is gradually payed out from a drum 28 at the surface.

The uppermost ends of the two insulated wires 9 in the cable are arranged to contact the leads 29 of a micro-ammeter 30.

As the detector is lowered through the muddy water, a stream thereof continually passes through the passageway 23 of the detector (see Fig. I) across the instrument between the lenses 18 and 19 and out through the opening 25. As little or no light will reach the photo-electric cell during the time the detector is passing through the uniformly muddy water 34, little or no current will be registered on the micro-ammeter 30. As the point of water intrusion is approached, which for the sake of illustration is shown indicated at 31 in the strata 32 between two oil sands 27 and 33, the opaqueness of the muddy water passing between the lenses will be reduced gradually due to the diluting of the muddy water by the water seeping into the hole from 31. More light will therefore reach the photo-electric cell 17 which in turn will generate more current, resulting in a greater reading on the microammeter 30.

At the point of water intrusion the water may be perfectly clear producing a considerable increase in the reading of the microammeter. On lowering the detector past the point of water intrusion the reading on the microammeter suddenly decreases as the muddy water is not diluted below the point of intrusion.

Having a record of the length of cable lowered into the hole, the point of intrusion is thus readily ascertained.

In some cases, it is not practical to previously circulate the mud in the hole and in some cases an opaque liquid can often be made uniform enough by running a bailer or the detector itself up and down the well several times so that an improvised stirring is effected.

The detector can also be used in flowing wells as the opaqueness of the crude oil is sufficient to render an appreciable contrast with the entering water.

However, it is preferable to displace the liquid in the hole from the bottom up with a cloudy aqueous liquid for example, a rotary drilling mud of about 63 lbs. per cubic foot has been very satisfactory.

I have found in practice that with the selenium photo-electric cell I am now using, that it is necessary to amplify the current by the use of flashlight batteries in series with the microammeter. These may either be located in the instrument or at the surface.

In detecting water intrusion at considerable depths it may sometimes be desirable to amplify the variations in current produced by the photo-electric cell before transmitting them to the surface as the initial current may not be of sufficient amplitude to show an appreciable reading on the meter at the surface.

In using the detector in boreholes containing oil it is desirable to coat the lenses 18 and 19 with a transparent colloid which will prevent the adhesion of oil to the lenses, for example, I have found agar agar to be satisfactory although it should be remembered that I may also use glycerine or any other substance which will produce the desired effect.

By arranging the lenses 18 and 19 so that their faces protrude slightly into the stream of liquid passing between them the likelihood of oily or other material adhering to the lenses is greatly reduced.

By means of my detector it is possible to locate points of intrusion of water without the usual expense and delay.

My detector can be readily run during the drilling of the well or after its completion for little or no conditioning is necessary as both drilling mud and oil are relatively opaque and the incoming water relatively transparent. Fig. IV shows a section of a chart upon which are plotted actual

readings taken in testing a well for water intrusion in southern California.

As it had been previously ascertained that a certain intensity of light gave a particular reading on the microammeter, the microammeter was graduated in terms of light units.

On the chart traverse lines 35 indicate distances from the surface and the longitudinal lines 36 indicate light units.

The particular runs were made with the well full of muddy water.

Run A shows no deflection on the instrument, the water being of uniform opaqueness throughout the borehole. After run A, the level of liquid in the well was reduced by bailing so as to reduce the hydrostatic head on the strata.

Run B indicates a point at depth of 4375 feet, at which the water is clearest denoting intrusion in this area. The detector was next run up and down the well several times fairly rapidly in the vicinity of the leak to render the opaqueness uniform in this area. The detector was then withdrawn to a point considerably above the intrusion area i. e. to the 3000 ft. level and a period of about fifteen minutes allowed to lapse.

Test C was thereafter made. The object of the above mixing by running the detector up and down was to narrow down the area of intrusion indicated in test B.

A final test D was made to verify the results of tests B and C. It will be noted that by the time test D was made the area of appreciable dilution had increased in size, owing to the greater amount of clear water that had come into the borehole.

It should be understood that I do not limit myself to the particular example of my invention as above described and that I may make any changes therein within the scope of the appended claim.

It should be particularly noted that instead of using muddy water or crude oil in the borehole to provide an opaque liquid medium, I may fill the borehole with clear water and thereafter provide a uniform opaqueness of the liquid by dissolving a dye in the water by running a bailer containing the dye up and down the length of the hole. The dye can also be added to the water before it is placed in the borehole.

I claim as my invention:

Apparatus for detecting water intrusion in a borehole comprising a casing, a photo-electric cell traversely mounted in said casing, a source of light in said casing, an L-shaped open passageway passing from the end of said casing between said source of light and said photo-electric cell and emerging through the side wall of said casing, means for raising and lowering said casing assembly in a borehole filled with liquid, a microammeter on the surface of the earth and leads electrically connecting said photo-electric cell to said microammeter.

CLARENCE R. DALE.