Aug. 8, 1950 D. SILVERMAN 2,517,603

FLUID INGRESS WELL LOGGING

Filed April 12, 1945 2 Sheets-Sheet 1

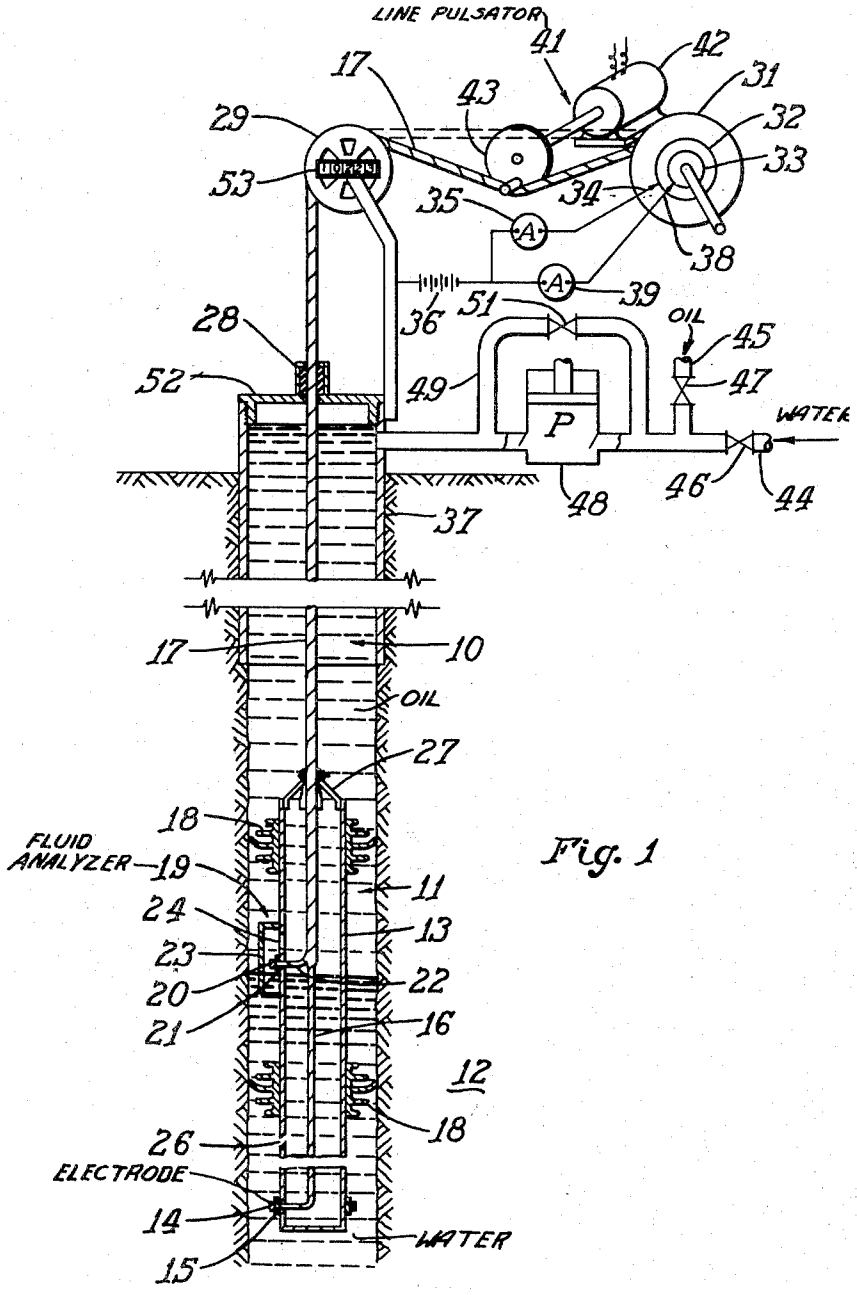


Fig. 1

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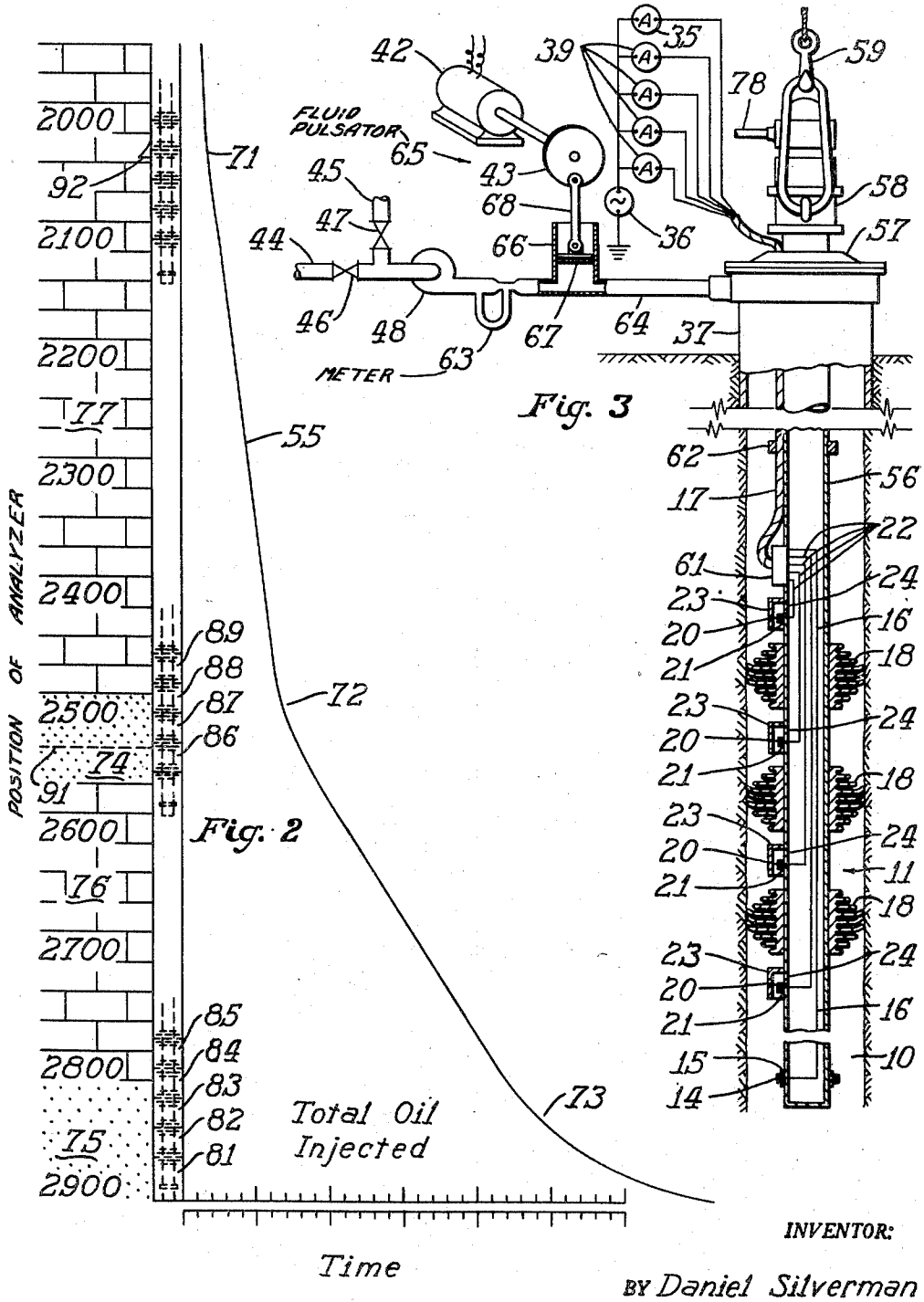


Fig. 2

Fig. 3

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Patented Aug. 8, 1950 2,517,603

UNITED STATES PATENT OFFICE

2,517,603

FLUID INGRESS WELL LOGGING

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Application April 12, 1945, Serial No. 587,970

2 Claims. (Cl. 73—155)

1

This invention relates to the testing of wells to determine the points of entry of fluids into said wells and to the determination of the nature of such fluids. More particularly, it relates to an improvement in the art of determining the points of oil, water, or gas entry into an oil or gas well.

Reference is hereby made to copending application Serial Number 572,878, filed January 15, 1945, on an improved method and apparatus for testing wells. More specifically, that application discloses a method and apparatus for subdividing a portion of a well to be tested into a multiplicity of sections more or less isolated from each other and then identifying in place the fluids produced from the surrounding formations into each such isolated section before the fluids are intermingled with fluids from other formations in the well. In other words, as fluids enter the well from the formations, they are obstructed from flowing along the well for any substantial distance by suitable flexible dividers in the well. These isolated fluids are analyzed or otherwise identified and then pass through a port in the tubing where they are mixed with fluids produced from other formations and pumped to the surface. In that method and apparatus each isolated section of the well being tested is in complete pressure equilibrium with all other isolated sections in that each such section opens into a common tubing and each produces according to its individual capacity regardless of the fact that the fluid is at one time more or less isolated from the other fluids in the well. Thus it will be apparent that inasmuch as there is no pressure drop between contiguous isolated sections the separation of the fluids may be accomplished effectively with a mere impervious divider.

That invention has contributed much toward the advancement of the art in that with it the cumbersome, time-consuming, and expensive well conditioning process is not required. That is, with that invention it is not necessary as in prior art methods of making a fluid ingress survey to unbalance the regular flowing conditions by filling the well with an extrinsic fluid having the proper qualities and then determining within a few minutes after flow into the well from the formations is initiated where a particular fluid is entering the well. I have found, however, that under certain conditions, due to the nature of the apparatus, errors are introduced. That is, since all sections of a well under test are at all times under equilibrium conditions and since there is no pressure drop between the isolated sections of the

2

well even when fluid is being produced, the fluid in any isolated section will not be disturbed where that section is at the elevation in the well of an impermeable formation. An error therefore arises and false data are obtained when, for example, salt water is trapped in an isolated section of a well which is disposed at the elevation of an impermeable formation. Inasmuch as there is no fluid entering the isolated section, the salt water is not flushed therefrom and the fluid analyzer will accordingly continue to identify erroneously the formation as salt water-producing. A similar error will arise where oil or gas is trapped in an isolated section opposite an impermeable formation. In this case, however, the particular detector will continue to indicate either oil or gas, as the case may be, irrespective of the amount of fluid produced from the well.

It is therefore an object of this invention to provide a novel and improved method for determining the location and nature of fluid entry into wells. Another object is to provide an accurate method for determining the location and nature of fluid entry into wells without interfering appreciably with the production of a well. A still further object is to provide a rapid method for determining the location and nature of fluid entry into wells by utilizing a minimum of apparatus. A more specific object of this invention is to provide an accurate method for determining the character of fluids produced from the various formations penetrated by a well by determining the permeability of such formations as well as the character of the fluid produced. Another more specific object of this invention is to provide a rapid method of making a fluid ingress survey of only the permeable formations penetrated by a well by first locating the permeable formations in the well and then determining the character of the fluid entering the well from these formations. Other and more detailed objects, uses, and advantages of the invention will become apparent as the description thereof proceeds.

In the description of my invention reference is made to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of one embodiment of apparatus as employed in a well which is suitable for carrying out my invention;

Figure 2 is a diagrammatic cross section of a well and a juxtaposed permeability log thereof;

Figure 3 illustrates alternate means suitable for carrying out my invention.

In general this invention comprises the logging of a well to determine which of the formations

traversed by the well are permeable, subsequently placing a fluid-character detector in the well in accordance with the permeable formations as indicated by said log, and determining the character of fluid produced from these formations. The invention comprises more specifically the conditioning of a well by covering the permeable formations therein with a dense fluid and thereafter introducing into said well on top of the first fluid a light fluid immiscible with the dense fluid and distinguishable therefrom by a physical or chemical characteristic. As the light fluid is added the interface between the dense and light fluids is caused to be depressed in the well and the position thereof with respect to the amount of light fluid added to the well is logged as an indication of the permeability of the formations penetrated by the well. Knowing the elevation of the permeable formations penetrated by the well, suitable detector apparatus is located in the well at the elevation of a permeable formation and the character of the fluid egressing therefrom is determined. As will become more apparent hereinafter, this method of determining the points and nature of fluid ingress into a well has numerous advantages over the prior art in accuracy and in the conservation of time required to make a survey. The invention will now be described in greater detail.

In Figure 1 I have shown a well 10 with a detector 11 therein which is suitable for determining the permeability of the formations 12 and for determining the character of the fluids entering well 10 from the formations 12. This detector more specifically consists of a tubular housing 13 which is preferably metalic, but when convenient this housing may be made of any material such as a solid synthetic resin if weight is provided to cause the housing to fall through the fluids in the well at sufficient velocity. A ring electrode 14 is mounted on insulation 15 near the lower end of housing 13. An insulated conductor 16 which is electrically connected at one end to this electrode 14 extends to the surface within an insulated multiconductor cable 17. At least two dividers 18 are disposed on the outside of housing 13. This divider may comprise, for example, a unit containing a number of flexible disks of different diameter as shown. As will be shown later, it is not necessary that these dividers constitute what is generally known as formation packers, inasmuch as there is at no time during the operation of my invention any differential fluid pressure across the dividers. In short, they serve merely to prevent contamination of the fluid on one side with fluid on the other side of the divider. At some point between the dividers 18 a fluid analyzer 19 is disposed on the housing 13. This analyzer consists of an electrode 20 electrically insulated from housing 13 by insulation 21. The electrode is then electrically connected to an insulated conductor 22, which like insulated conductor 16 extends to the surface through multiconductor cable 17. A shield 23 open at one end only which surrounds electrode 20 is adapted to cause all fluid entering housing 13 through port 24 to pass in contact with electrode 20. The housing 13 is provided with an opening 26 below the bottom divider 18 and preferably a substantial distance, for example 1 to 5 feet, above the electrode 14. The upper end of housing 13 is provided with a bail 27 which is adapted to be connected to multiconductor cable 17 for the purpose of supporting the detector 11 in the well on the multiconductor cable.

At the surface multiconductor cable 17 extends through a packing gland 28 and over a measuring sheave 29 to the reel 31. The ends of insulated conductors 16 and 22 are connected respectively to insulated collector rings 32 and 33. A brush 34 associated with collector ring 32, insulated conductor 16, and insulated electrode 14 is electrically connected through an ammeter 35 to a battery 36. Battery 36 is in turn connected to casing 37 or any other suitable ground whereby a return circuit is provided. A brush 38 associated with collector ring 33, insulated conductor 22, and insulated electrode 20 is electrically connected through ammeter 39 to battery 36. A line pulsator 41 consisting of a motor 42 and a crank 43 is adapted to displace laterally a portion of the multiconductor cable 17 between measuring sheave 29 and reel 31. Motor 42 which may, for example, be an electrical motor turns crank 43 at a relatively low speed, for example at from 0.1 to 20 cycles per minute, preferably within the range 1–5 cycles per minute. By this means detector 11 may be intermittently raised and lowered in the well 10 for reasons hereinafter shown. Two sources of fluid, for example a source of salt water and a source of oil, are attached respectively to the pump supply lines 44 and 45. Valves 46 and 47 or other control means on salt water supply line 44 and oil supply line 45 respectively are provided so that the supply of fluid to pump 48 may be controlled as hereinafter shown. The discharge from pump 48 is connected into casing 37. A bypass 49 permits fluids produced from the well to flow around pump 48 when valve 51 is open.

This apparatus is employed in carrying out the above objects of my invention as explained below. Detector 11 is placed inside of casing 37 and casinghead 52 is closed. Lubricator means may, of course, be provided for inserting detector 11 into the casing as is well known in the art. Valve 51 in pump bypass 49 and valve 47 in oil supply line 45 are closed. Valve 46 in water supply line 44 is opened. Well 10 is filled from water supply line 44 by pump 48. Some oil which was previously in well 10 will be superimposed in this water and an oil-water interface will be formed at some position in the well. When the well is filled to the surface as above indicated, valve 46 on water supply line 44 is closed and valve 47 on oil supply line 45 is opened. By thus adding oil at the surface above the oil-water interface in well 10 the interface is caused to be depressed in the well. Pump 48 may be a centrifugal pump, but preferably I employ a positive displacement type pump inasmuch as it is desirable that oil be added above the oil-water interface at a substantially constant rate.

The apparatus described above may be employed to follow this movement of the oil-water interface. In this connection detector 11 will be lowered in the well by unreeling multiconductor cable 17 off reel 31. Inasmuch as electrode 14 is disposed in oil, a dielectric, when it is at or near the surface no current flow will be indicated on ammeter 35. If the detector 11 is lowered at a rapid rate it will pass the oil-water interface. When electrode 14 passes this interface, it will be disposed in salt water, an electrical conductor, and current flow in the circuit will be initiated. That is, current flow will be indicated in the electrical circuit through ammeter 35. At this point line pulsator 41 is started causing detector

11 to be intermittently raised and lowered in the well as indicated above. By unreeling multiconductor cable 17 from reel 31 at a relatively uniform rate the electrode 14 may be kept at such a position with reference to the oil-water interface that current flow through ammeter 35 will be intermittent. Since oil is being added to well 10 through pump 48 at a constant rate, the depth of the detector, which is a log of the permeability of formations 12 when plotted as a function of time, may then be recorded when the detector is at a given position in each cycle. This log may be made by plotting the depth of electrode 14 as indicated by depth gauge 53 at short, equal time increments, but preferably I provide automatic depth-recording means. It will be noted that even though dividers 18 appear to swab well 10 as the detector 11 is raised and lowered, means are provided for permitting free movement of the detector through the fluid. That is, fluid may enter through port 25 below the bottom divider 18, travel through housing 13, and exit through the open upper end of housing 13. Fluid may also flow through intermediate port 24 in either direction so as to keep the pressure between the various zones isolated by dividers 18 in complete pressure equilibrium at all times. As indiciated above, it is highly desirable that indicator 11 have sufficient weight to fall at a relatively rapid velocity as pulsator 41 permits it to fall.

The oil-water interface is thus followed by unreeling multiconductor cable 17 at a rate such that intermittent current flow will be indicated on ammeter 35 until the oil-water interface reaches the bottom of the well 10 or until it passes the section of the well to be tested. A representative log 55 which has been made by plotting the position of detector 11 as a function of time is shown in Figure 2. While the construction of such a log has been described with reference to the addition of oil at the surface at a constant rate and the position of the oil-water interface in the well has been logged with respect to time, it will be obvious that oil can be added at different or constantly varying rates and that a permeability log can be constructed by plotting the elevation of detector 11 in the well 10 as a function of the quantity of oil flowing into the well through well pump 48. In this case, however, some measuring means such as a meter or pump stroke counter must be provided for determining the quantity of oil added.

When the detector has traversed the test section of well 10 and permeability log 55 has been constructed, the flow of oil through pump 48 into the well is stopped. Valve 51 in pump bypass 49 is opened permitting oil to flow from the well through oil supply line 45 and valve 47 to a tank or other suitable means (not shown). Fluid will thus enter the well from all of the permeable strata penetrated by the well. The detector 11 which has previously been explained with reference to its use as an interface detector may be employed to determine the character of the fluid entering the well from the permeable strata. When thus employed its operation is substantially identical to the operation of the multiple-unit detector shown in Figure 3. Accordingly the operation of the detertor 11 in the determination of the character of the fluid entering the well from the permeable strata will be described in conjunction with the description of the operation of the multiple-unit detector.

In Figure 3 I have shown multiple-unit detector apparatus in well 10 which is suitable for carrying

out my invention. The apparatus is in general that described in the above-mentioned copending application Serial Number 572,878. It comprises a tubing 56 which may be slidably mounted in tubinghead 57. Tubinghead 57 may be, for example, an ordinary bradenhead or stuffing box tubinghead without slips, but an automatic blowout preventer is preferred inasmuch as it permits the use of regular tubing with external collars. Thus tubing 56 may be moved through tubinghead 57 while at the same time keeping even a flowing well under control. Tubing 56 is raised or lowered in well 10 by means of a tubing elevator 58, hook 59, and associated hoisting apparatus (not shown). Means may be provided for pumping, swabbing, or otherwise causing a non-flowing well to produce, but for convenience I have shown my invention in an application to a flowing well. It will be readily apparent to those skilled in the art that it can be adapted to testing a pumping well.

A multiple-unit fluid detector 11 is disposed at the lower end of the tubing 56. It consists of a multiplicity of substantially identical units which are adapted, first, to isolate the fluid entering the well within a short section of the well from that fluid entering the well at other sections, and, second, to identify the isolated fluid before it is commingled with fluid from other sources in the well. The fluids are isolated by dividers 18 which are in this case disposed on the tubing 56 at spaced intervals. The distance between dividers 18 may be from about 1 to about 30 feet, or more, but for reasonable accuracy it is preferred that they be spaced along tubing 56 at a distance of from about 2 to 5 feet. Again these dividers 18 are specifically distinguished from packers as commonly employed in wells inasmuch as (*a*) there is no need for packers since contiguous sections of the well are at all times in complete pressure equilibrium and (*b*) the expansibility of packers is quite often inadequate to prevent communication of fluids between two sections in an uncased portion of a well. These dividers, on the other hand, are highly flexible, are adapted to being moved with ease, and will conform to rough walls of the well. The tubing 56 has ports 24 of sufficient area to permit free movement of fluid into the tubing from each isolated section. Consequently, as stated above, each isolated section is in complete pressure equilibrium with every other isolated section and there is no tendency for the fluid to bypass the dividers 18. Between each divider 18 a fluid analyzer 19 (Figure 1) is provided for identifying the nature of the fluid disposed within that particular isolated section of the well. This fluid analyzer may be of any type known to the art such as an electrical conductivity or light-transparency cell. Sometimes it may be advisable to determine the points of entry of water, oil, and/or gas and two or more types of fluid analyzers especially adapted to distinguish oil, water, or gas from the other fluids may be employed in series. For purposes of illustration an electrical conductivity cell which consists of shields 23 and insulated electrodes 20 is employed. Shields 23 are closed on the top and sides so that all fluid passing through ports 24 from an isolated section of the well passes between a shield 23 and an insulated electrode 20. Insulated electrodes 20 are individually connected by insulated electrical conductors 22 through a coupling box 61, an insulated multiconductor cable 17, and ammeters 39 or other current-indicating means to a source of electric energy 36. Insulated multiconductor cable 17 is suspended on

tubing 56 and held in place by means of straps 62. This insulated cable is also adapted to move vertically through tubinghead 57 in cooperation with tubing 56.

A ring electrode 14 is mounted on insulation 15 near the lower end of tubing 56. An insulated conductor 16 which is electrically connected at one end to electrode 14 extends through coupling box 61, insulated multiconductor cable 17, and ammeter 35 to the energy source 36.

At the surface means are provided whereby fluids such as salt water and oil may be introduced into casing 37. A source of salt water and a source of oil are attached respectively to pump suction lines 44 and 45. Valves 46 and 47, or other control means on salt water supply line 44 and oil supply line 45 respectively are provided so that the supply of fluid to pump 48 may be controlled as hereinafter shown. A fluid metering device 63 is inserted in pump flow line 64 so that the amount of fluid flowing into well 10 through pump 48 can be determined. This fluid also passes through fluid pulsator 65. This pulsator is adapted to introduce oscillations in the fluid and cause an interface in well 10 between salt water and oil to rise and fall intermittently and repeatedly. The pulsator consists of a cylinder 66, an associated piston 67, a connecting arm 68, a crank 43, and motor 42. The motor reciprocates piston 67 in cylinder 66 either by direct connection as shown or through a speed reducer. The motor may be, for example, of the variable speed variety whereby the frequency of pulsations may be varied at will.

In determining the permeability of the various formations penetrated by well 10 the electrode 14 is lowered on the tubing 56 to a point just above the section of the well which is to be tested. For example, it is usually located at a point in the well just above the casing shoe or the top of the perforations. Steps are then taken to condition the well 10 in preparation for making a permeability log of the formations below the casing shoe. The well is filled to a point substantially above the test section with a dense fluid such as salt water by closing valve 47 on oil supply line 45, opening valve 46 on salt water supply line 44, and starting pump 48. A light fluid, for example oil, which is immiscible with the dense fluid and which has one or more physical or chemical properties that make it distinguishable from the dense fluid even at remote points in the well is then introduced into the well on top of the salt water by closing valve 46 and opening valve 47 on oil supply line 45. As oil is added the salt water surrounding tubing 56 is displaced through tubing ports 24 into the lower portion of the well and into the permeable formations, and the interface which forms between the oil and salt water will be depressed in the well. The travel of this interface after it reaches the electrode 14 is then followed to determine the relative permeabilities of the various formations penetrated by the well. The method of following this interface with the above described apparatus and the method of making a permeability log will now be described.

Pulsator 65 is started causing the oil which is being introduced into the well above the oil-salt water interface to travel intermittently down the well. The interface between the oil and salt water will tend to oscillate in the well, the frequency and amplitude of the oscillations depending upon the frequency of the pulsator. The oscillations are usually maintained at about 0.1 to about 20 cycles per minute, preferably at about 1 to 5 cycles per minute, depending upon the depth of the interface. As oil is added at the surface it tends to displace the salt water into the permeable formations at the bottom of the well and the oil-salt water interface will fall. Until this interface reaches electrode 14 the electrode will be submerged in salt water, an electrolyte, and ammeter 35 will indicate current flow in the interface detector circuit which comprises the energy source 36, the ammeter 35, insulated conductor 16, electrode 14, the electrolyte, and the return through the tubing 56 or the earth. After the oil-salt water interface reaches electrode 14, no current will flow in the above-mentioned circuit inasmuch as the salt water, an electrolyte, has been replaced by oil, a dielectric. Thus by observing ammeter 35 the operator will be able to determine whether the oil-salt water interface is below or above electrode 14. Since this interface is pulsating longitudinally in the well, there will be a very definite on-off signal when the electrode 14 is within the proper range. In fact, the operator is able to determine very accurately the mean position of the interface by noting the ratio of time current is flowing to the time current is not flowing in the signal circuit as indicated by ammeter 35. As the mean position of the interface passes electrode 14, the electrode is lowered by lowering the tubing 56. Additional joints of tubing are added as required to keep the electrode substantially at the mean elevation of the vibrating oil-salt water interface. Valve 47 on oil supply line 45 is closed when necessary to add tubing joints so that the mean elevation of the oil-salt water interface will not move appreciably during the time the tubing cannot be lowered.

The permeability log is made by plotting manually or automatically the depth of electrode 14 against the amount of oil added to the well at the surface. I have found it convenient, for example, to record the amount of oil passing through metering device 63 for each foot of tubing passing through tubinghead 57. This information may be plotted as shown in Figure 2 to obtain a permeability log 55 of the formations penetrated by well 10. This log may be made manually or, if preferred, automatic means may be provided for plotting the position of the interface locator with respect to the amount of oil added.

For the purpose of describing the operation of this invention permeability log 55, obtained as described above, is plotted in Figure 2 alongside a diagrammatic representation of well 10 and the formations penetrated thereby. It will be noted that there are inflections 71, 72, and 73 in the permeability log; i. e., the slope of the permeability log (oil injected as a function of depth of interface) changes. By reference to this permeability log and the juxtaposed depth chart it will be apparent that the slope of the permeability log changes at 2020 feet, the elevation of the casing shoe. The slope of this log is also gradually changing between about 2470 feet and about 2560 feet, indicating permeable formations 74 between these two limits. This log also goes through a gradual change in slope between about 2800 feet and total depth, indicating that the formations 75 in this zone are also permeable. In all zones except those mentioned the log is substantially linear; i. e., in these zones the movement of the interface is proportional to the amount of oil added above the interface, indicating that the formations 76 and 77 are impermeable.

As indicated above, it is the ultimate purpose of this invention to provide a method for determining accurately the nature of the fluid or fluids produced from the permeable zones penetrated by a well. Therefore when the interface has reached the lower limit of the test section in the well and the permeability log is completed, the flow of oil is in this multiple-unit system as in the single-unit system described above reversed by stopping the injection of oil and opening flow line 78, causing the fluid in the formations to reenter the well and flow to the surface through tubing 56. Under this condition the well soon reaches equilibrium conditions and fluid will be produced from all of the permeable sections in a normal manner even with the test apparatus located in the well. Inasmuch as the operation of the multiple- and single-unit detectors in determining the character of the fluid entering the well at the permeable formations is substantially identical, this step will be described with reference to a multiple-unit detector system.

The tubing 56 will then be placed in such a position in the well that the dividers 18 will isolate short sections of the well at the elevation of the permeable formation penetrated by the well. By reference to the permeability log the tubing can be placed in the well in a position such that the fluids from the permeable formation 75 will enter one or more of the isolated sections 81, 82, 83, 84, 85. Fluid entering any one of these isolated sections will pass through the corresponding fluid analyzer 19 as it flows into tubing 56 through the associated port 24. The character of the fluid entering a particular isolated section of the well from the contiguous formation can thus be determined by its conductivity, for example. Where the permeable zone 75 produces only salt water, for example, the ammeters 39 associated with each of the analyzers 19 in isolated sections 81, 82, 83, 84 would indicate a high current flow. The ammeters associated with fluid analyzers 19 in the isolated section 85 would indicate that no current is flowing in the circuit; i. e., that the formations opposite this isolated section produce oil. More specifically, since the well was full of oil when production from the well was initiated, and since the formations 76 opposite isolated section 85 is impermeable, and since there is no way to remove the fluid from this particular isolated section, the oil would be retained therein and but for the permeability log an oil-water contact in the formations would erroneously be indicated at 2800 feet. Inasmuch as no permeability is indicated at this point on the permeability log, the conclusion is readily drawn that no oil is being produced in this region.

The lower end of the tubing is then moved to other permeable sections of the well as indicated by permeability log 55 where a similar test is made to determine the nature of the fluid being produced. Having the permeability log, and from it determining that the section 2560–2800 feet is impermeable, the lower end of tubing 56 is directly positioned such that fluid from permeable formations 74 is produced into one or more of the isolated sections 86, 87, 88, 89.

The analysis of fluid produced from permeable formations 74 is carried out in the manner described above for the analysis of fluids produced from permeable formations 75. Surface information will in this case be correct for the isolated sections 86, 87, 88 inasmuch as isolated section 89 is located opposite impermeable formation 77. Surface information as disclosed by the ammeter

39 associated with isolated section 89 will be erroneous and will accordingly be disregarded. Where, for example, permeable formation 74 produces oil above oil-salt water contact 91 and salt water below, the ammeter associated with the fluid analyzers in isolated sections 87, 88 would properly indicate oil production from permeable formations 74 above the oil-salt water contact, and the ammeter associated with the fluid analyzer in isolated section 86 would properly indicate that water is produced from permeable formations 74 below oil-salt water contact 91. The surface indication from isolated section 89 would be disregarded inasmuch as the permeability log clearly shows that this isolated section is opposite impermeable formations 77. Thus by isolating the production from permeable formation 74 into short sections of the well where it is separately analyzed the oil-salt water contact 91 is accurately and readily determined. The character of the fluid entering well 10 at casing shoe 92 is quickly and accurately determined by the process described for determining the character of the fluid entering the well from permeable formations 74, 75. It will thus be apparent that inasmuch as it is unnecessary to make a fluid analysis at the impermeable formations 76, 77 penetrated by the well 10, much time can be saved in making a survey of an oil well to determine at which points oil and water are entering the well.

It will be apparent from the above description of my invention that it has many important advantages over methods heretofore employed for accuracy, speed, economy, and reliability in the location of the points of fluid entry into an oil well. It will also be apparent that the invention herein disclosed and for clarity described by reference to certain specific details and apparatus is not necessarily so limited.

The following claims are therefore not to be limited to the specific details and apparatus shown but are to be interpreted as broadly as the prior art will permit.

I claim:

1. A method of determining the fluid-producing characteristics of formations traversed by a well comprising establishing in said well above said formations an interface between salt water and oil, causing said interface to be lowered in said well by introducing oil into said well above said interface, making a log of the amount of said oil introduced into said well as a function of the depth of said interface, subsequently causing well fluid to enter said well from said formations, locating a detector in said well at only elevations corresponding to a point of inflection on said log, isolating sections of said formations which are permeable, and individually sensing a characteristic of said fluid entering said well within said isolated sections.

2. A method of determining the fluid-producing characteristics of formations traversed by a well comprising filling said well with salt water, introducing oil into said well on top of said salt water whereby an oil-salt water interface is formed in said well and said interface is lowered in said well, following the movement of said interface with an electrical interface detector, making a log of the position of said interface detector with respect to the amount of said oil introduced into said well above said interface, determining from said log the elevation in said well of the permeable formations penetrated by said well, releasing the pressure on said oil so that well fluids will enter said well from said formations,

isolating the well fluids thus produced into said well by a permeable formation from all other fluids in said well by locating flexible impervious dividers above and below said permeable formation, and determining the conductivity of said isolated well fluids before they are intermingled with said other fluids in said well.

DANIEL SILVERMAN.

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