April 25, 1944. O. E. BARSTOW 2,347,589

LIQUID LEVEL INDICATING SYSTEM FOR USE IN TREATING WELLS

Filed Sept. 2, 1941 2 Sheets-Sheet 1

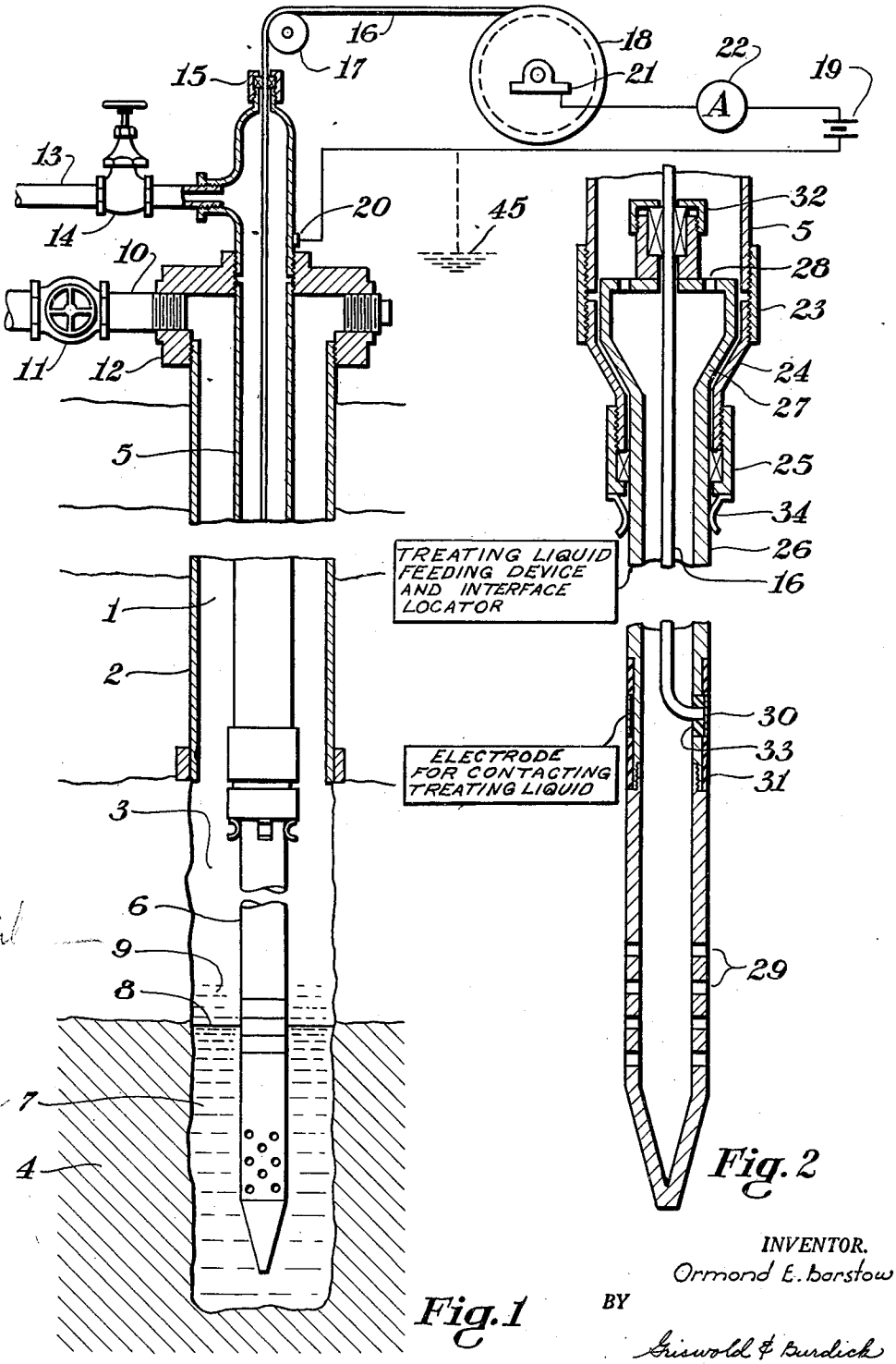


Fig. 1

Fig. 2

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73 MEASURING & TESTING.
151
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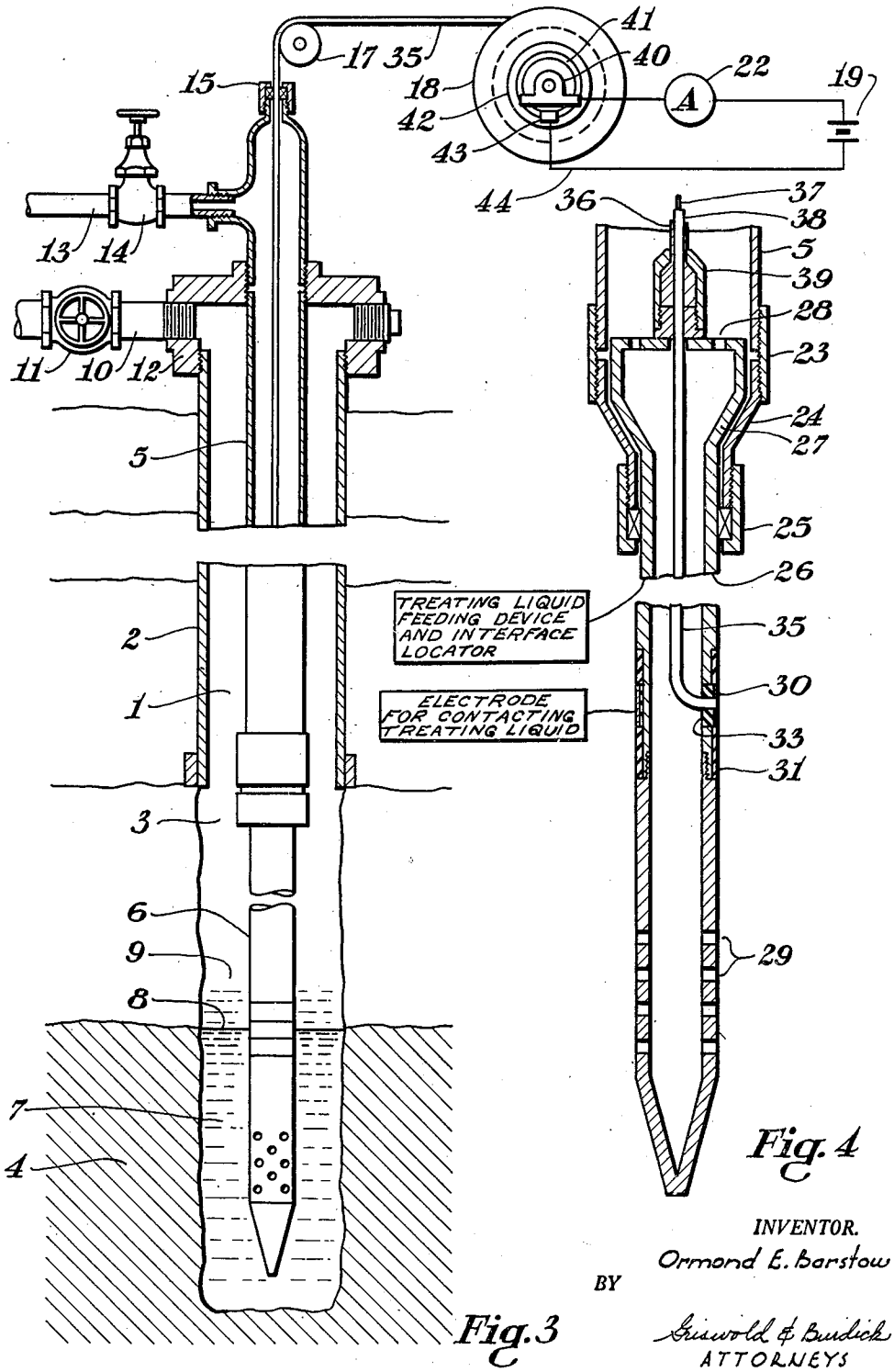


Fig. 3

Fig. 4

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UNITED STATES PATENT OFFICE

2,347,589

LIQUID LEVEL INDICATING SYSTEM FOR USE IN TREATING WELLS

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Application September 2, 1941, Serial No. 409,200

6 Claims. (Cl. 73—51)

The invention relates to a method and apparatus useful in connection with the treatment of an earth or rock formation penetrated by a well bore with an electrically conductive liquid. It more particularly concerns an apparatus whereby the level to which an acid solution rises in the well bore can be accurately ascertained at all times during an acid treatment of an earth or rock formation penetrated by the bore of a well.

In introducing liquid agents into an earth or rock formation, such as for example, when introducing an acid solution into the porous calcareous formation penetrated by the bore of an oil well, it is the conventional practice to attempt to control the level to which the acid rises during its introduction by maintaining the acid solution under a column of oil or the like as it is forced into the formation. However, it oftentimes happens that the formation adjacent a portion of the oil column is highly porous allowing the oil to escape into the formation, with the result that the acid rises in the well bore and escapes into a section of the formation which may be of an unproductive nature or already highly porous. Waste of the treating solution thus occurs. In addition, it sometimes happens when carrying out such a treatment that the acid may rise in the well bore during treatment to a point where it attacks and disintegrates the cement around the casing necessitating another cementing operation before the well can be satisfactorily produced.

It is, therefore, the principal object of the invention to provide an apparatus which may be suitably used in connection with treating a well with an electrically conductive liquid whereby the level to which said liquid rises in a well bore during its introduction into the earth and rock formation surrounding the well bore can be ascertained at all times during the treatment.

Still other objects and advantages of the invention will be apparent during the course of the following description.

The invention, then, consists in the apparatus hereinafter more fully described and particularly pointed out in the claims, the accompanying drawings and following description setting forth in detail one mode of carrying out the invention, such mode illustrating, however, but one of various ways of carrying out the invention.

In the drawings:

Fig. 1 is a diagrammatic view partly in section of an oil well equipped for carrying out a treatment according to the method of the invention.

Figure 2 is a detailed view in cross section of the lower portion of the level measuring device shown in Figure 1.

Figure 3 is a diagrammatic view similar to that of Figure 1 showing, however, a slightly modified apparatus arranged for carrying out a treatment according to the method of the invention.

Figure 4 is a detailed view of the lower portion of the measuring device shown in Figure 3.

As shown, the upper portion 1 of the well bore is cased with a metal pipe 2, while the lower portion 3 of the well bore is uncased and ends in productive stratum 4. Extending from the well tubing string 5 with its lower end adjacent the productive stratum 4, the fluid level measuring device 6 is shown in position for carrying out a treatment in accordance with the method of the invention. The lower portion of the well bore is shown filled with acid solution 7 up to a point 8 adjacent the upper level of the productive stratum. The remainder of the well is shown filled with a pressuring fluid 9, such as oil. Above the ground level, pipe 10, controlled by valve 11, communicates with the interior of the well through casing head 12, while pipe 13, controlled by valve 14, communicates with the well through tubing string 5. Extending through packing gland 15, attached to the upper end of tubing string 5, insulated conducting cable 16 passes over sheave 17 to carrying reel 18. The insulated conducting cable 16 is shown connected at its lower end tc the fluid level measuring device 6. An electric circuit is employed in connection with the measuring device 6, for the purpose of indicating the level of the conducting liquid in the well bore, and consists of a source of electric current, such as battery 19, one pole of which is shown connected to tubing 5 by clamping means 20. The other pole of the battery 19 communicates with the reel shaft 21, which in turn is in electrical contact with cable 16. Disposed in the circuit is an electrical current measuring device 22, such as an ammeter suitable to indicate the current that may flow through the circuit. In the more detailed view of the fluid level measuring device shown in Figure 2, a conventional iron collar or coupling 23 engages the lower end of the tubing 5, and a tapered seat member 24. Attached to the seat member 24 in screw threaded engagement therewith is a packing gland 25, through which the cylindrical tubular member 26 can be slidably moved in a sealing relationship. The tubular member 26, formed of metal or other electrically conducting material is shown enlarged at the upper portion to form a tapered seating portion 27, which conforms to the inner surface of seat mem-

ber 24, thus producing a seal when the surfaces are maintained in a contacting relationship. The seat member 24 also serves as a stop, preventing the measuring device from being lowered out of the tubing. Entry ports 28 and exit ports 29 are provided at the upper and lower ends, respectively, of the tubular member 26, and serve as a means whereby liquid can enter the well bore from tubing 5.

An electrode 30, which may suitably be a cylindrical band made of copper or other suitable conducting metal, is shown mounted on the outer surface of tubular member 26 a short distance above the fluid exit ports 29, and is electrically insulated from the tubular member by an insulating shell 31 made of Bakelite, hard rubber, or the like. Insulated conducting cable 16, carried by reel 18, extends into the well and is attached to the tubular member 26 with a suitable clamp 32, and serves as a means whereby the measuring device can be raised and lowered in the well. The cable 16 continues through the clamping means 32 and is connected through an insulated bushing 33 with electrode 30. Spring fingers 34 depend from packing gland 25 and engage the tubular member 26 in electrical contacting relationship as it is slidably moved through the packing gland.

In the modification shown in Figures 3 and 4 a cable 35 having two conductors 36 and 37 separated from each other by electrical insulation 38 as shown in Figure 4 has been substituted for the cable 16 having the single conductor shown in Figures 1 and 2. One of the conductors of cable 35 may consist of an outer layer of woven steel wire 36 which serves to support the level measuring device as it is being lowered into the well. The cable 35 is attached to tubular element 26 by clamping means 39. The outer conductor 36 is grounded to the clamping means 39 and may be secured thereto as by soldering, brazing, or the like. The insulated inner conductor extends through the tubular element and is electrically connected to electrode 30, being electrically insulated from tubular element 26 by bushing 33. With the arrangement of Figures 3 and 4 the spring fingers 34 shown in Figure 2 may be eliminated since the well tubing is not used to complete the circuit. Instead, the current travels down the outer conductor and through the tubular element 26 and is completed by conducting fluid 7 through electrode 30 and conductor 37. At the top of the well the cable 35 is carried by reel 18 which is provided with suitable means for electrically connecting the cable conductors with measuring instrument 22 and battery 19. Such means may consist of a suitable shaft support 40 making contact with the reel shaft which is in turn contacted by one of the cable conductors. The other conductor contacts ring 41 insulated from the reel 18 by insulation 42. A brush 43 is provided to maintain electrical contact with ring 41 while electrical lead 44 connects the battery 19 to the brush 43.

In employing the method of the invention illustrated by Figures 1 and 2 in carrying out an acid treatment, for example, the assembled measuring device is positioned in the well bore so that as the fluid level measuring device 6 is raised and lowered the electrode 30 will be located in the vicinity of the upper level of the productive stratum 4, which is to be subjected to the action of the acid. The well is then preferably filled with oil to render it hydrostatically controllable, by pumping the oil into the well through pipe 13, while the valve 11 in pipe 10 is maintained in an open position. After the well has been filled with oil, the introduction of acid into the well through pipe 13 in communication with the tubing 5 is started, while oil is allowed to escape at the casing head through pipe 10. When the acid reaches the bottom of the well and rises in the well bore to a point where it makes contact with electrode 30, electric current will flow through the circuit completed between the well tubing and the electrode 30 by the acid solution 7. The flow of current through the circuit will be indicated on the current indicating device 22, in this case an ammeter. Valve 11 is then closed and pressure is applied to force the acid solution into the formation. By raising and lowering the measuring device as the introduction of the acid is continued and observing the level at which current ceases to flow through the electrical circuit, knowledge of the level at which the acid is entering the formation is available at any time during the treatment. If at any time during the treatment, the acid rises above the level at which its entry into the formation is desired, indicating that oil is escaping into the formation, additional oil may be pumped into the well through pipe 10 communicating with the casing, so as to control the level of the acid at any desired point. Also, if the acid level, as indicated by the measuring device, falls below the desired level indicating that the acid is draining away into the formation adjacent the lower portion of the well bore, a quantity of blanketing medium, such as a solution of an organic jellifying material described in U. S. Patent No. 1,998,756, may be introduced into the bottom of the well to prevent such drainage.

Although it is usually preferable to carry out a treatment in the manner just described, wherein the measuring device is raised and lowered during the course of the treatment in order to ascertain the level of the acid at all times, in some instances, it may be merely desirable to keep the level of the acid from rising above a certain point in the well bore. In this case the means provided for maintaining a sealing relationship between the well tubing and fluid level measuring device as it is raised and lowered may be dispensed with and the measuring device allowed to rest on the sealing seat member in a fixed position.

Instead of connecting one electrical lead to the tubing string to complete the circuit as described above, other means of completing the path of the current may be provided. For example, the earth or rock surrounding the well bore may be made to act as an electrical conductor and the current caused to pass through the earth between a suitable ground connection such as shown at 45 Figure 1, and the conducting liquid in the well bore, in place of the connection to the tubing 5 by the clamping means 20.

The operation of the method and apparatus employing the structure of Figures 3 and 4 is similar to that described in connection with Figures 1 and 2. In this instance, however, the tubing does not serve as a conductor to complete the electrical circuit and, therefore, it is unnecessary for the tubular element 26 to maintain electrical contact with the well tubing. As the level of the conducting liquid 7 rises in the bore and contacts the electrode 30 the electric circuit is completed between the outer cable conductor

73 MEASURING & TESTING
151
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36, tubular element 26, conducting liquid 7, electrode 30, and cable conductor 37.

It is, of course, evident that two separate and suitably insulated conducting cables may be employed instead of the single cable or the cable and the well tubing to complete the electric circuit.

Although the apparatus has been described with particular reference to its use in connection with an acid treatment of a well, it is to be understood that it may be suitably used in treating a well wherein any electrically conductive liquid is employed. It will also be apparent that the device may be used to ascertain the lower level of an acid or other conducting fluid in those instances wherein a non-conducting blanketing medium such as is disclosed in U. S. Patent 1,998,756 is employed.

In the foregoing manner, the treatment of a well with an acid reagent or other electrically conductive liquid may be carried out much more effectively, since the point of entry of fluid into the formation can be accurately determined and controlled at any time during the treatment.

This application is a continuation-in-part of my co-pending application Serial No. 265,753, filed April 3, 1939 and not forfeited.

Other modes of applying the principle of my invention may be employed instead of those explained, change being made as regards the means herein disclosed, provided those stated by any of the following claims or their equivalent be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In apparatus for introducing into a well an electrically conducting liquid and measuring its level therein, the combination of a tubing string, a tubular member removably engaging the lower end of the tubing string and provided with openings permitting the passage of liquid through it into the well, an electrode mounted on the tubular member between its ends and insulated therefrom, an insulated conductor threaded through the tubing string and connected to the electrode, an electrical circuit including the conductor and means for detecting current flow when an electrically conducting liquid in the well makes contact with the electrode.

2. In a fluid level indicating device for wells the combination of a tubing string, a tubular member adapted to pass through the tubing string, said tubular member being provided with openings to allow flow of fluid from the tubing string therethrough into the well bore, means carried by the lower end of the tubing string adapted to engage the tubular member in sealing relationship, an electrode mounted on the outer surface of the tubular member and electrically insulated therefrom, an electrical circuit including a single cable having two conductors insulated from each other one of said conductors being grounded to the tubular member and the other conductor being connected to the electrode, and means to indicate flow of current when a conducting liquid makes contact between the electrode and the tubular member.

3. In apparatus for introducing into a well an electrically conducting liquid and measuring its level therein, the combination of a tubing string having a seating member at its lower end, an electrode carrying member adapted to pass through the seating member in fluid tight telescopic engagement therein provided with openings for the passage of liquid through it into the well, an electrode mounted on the outside of the electrode carrying member intermediate its ends and insulated therefrom, an insulated conductor threaded through the tubing string and connected to the electrode, an electrical circuit including the conductor and means for detecting current flow when an electrically conducting liquid in the well makes contact with the electrode.

4. In apparatus for introducing into a well an electrically conducting liquid and measuring its level therein, the combination of a tubing string having a seating member at its lower end, an electrode carrying member adapted to pass through the seating member in telescopic engagement therewith provided with openings for the passage of liquid through it into the well, an electrode mounted on the outside of the electrode carrying member intermediate its ends and insulated therefrom, a cable attached to the electrode carrying member adapted to lower or raise the same through the tubing string, said cable including an electrically insulated conductor connected to the electrode, an electrical circuit including the conductor and means for detecting current flow when an electrically conducting liquid in the well makes contact with the electrode.

5. In apparatus for introducing into a well an electrically conducting liquid and measuring its level therein, the combination of a tubing string having a seating member at its lower end, an electrode carrying member having a head portion adapted to engage the seating member and a tubular portion adapted to pass through the seating member in telescopic engagement therewith provided with openings near its lower end for the passage of liquid through it into the well, an electrode mounted on the outside of the tubular portion of the electrode carrying member intermediate its end and insulated therefrom, an insulated conductor threaded through the tubing string and connected to the electrode, an electrical circuit including the conductor and means for detecting current flow when an electrically conducting liquid in the well makes contact with the electrode.

6. In apparatus for introducing into a well an electrically conducting liquid and measuring its level therein, the combination of a tubing string having a seating member at its lower end, an electrode carrying member having a head portion adapted to engage the seating member and a tubular portion adapted to pass through the seating member in fluid tight telescopic engagement therewith provided with openings near its lower end for the passage of liquid through it into the well, an electrode mounted on the outside of the tubular portion of the electrode carrying member intermediate its ends and insulated therefrom, a supporting cable attached to the electrode carrying member adapted to lower or raise the same through the tubing string, said cable including an insulated conductor connected to the electrode, an electrical circuit including the electrode a source of current and a current indicator connected to the conductor for detecting current flow when an electrically conducting liquid in the well makes contact with the electrode.

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