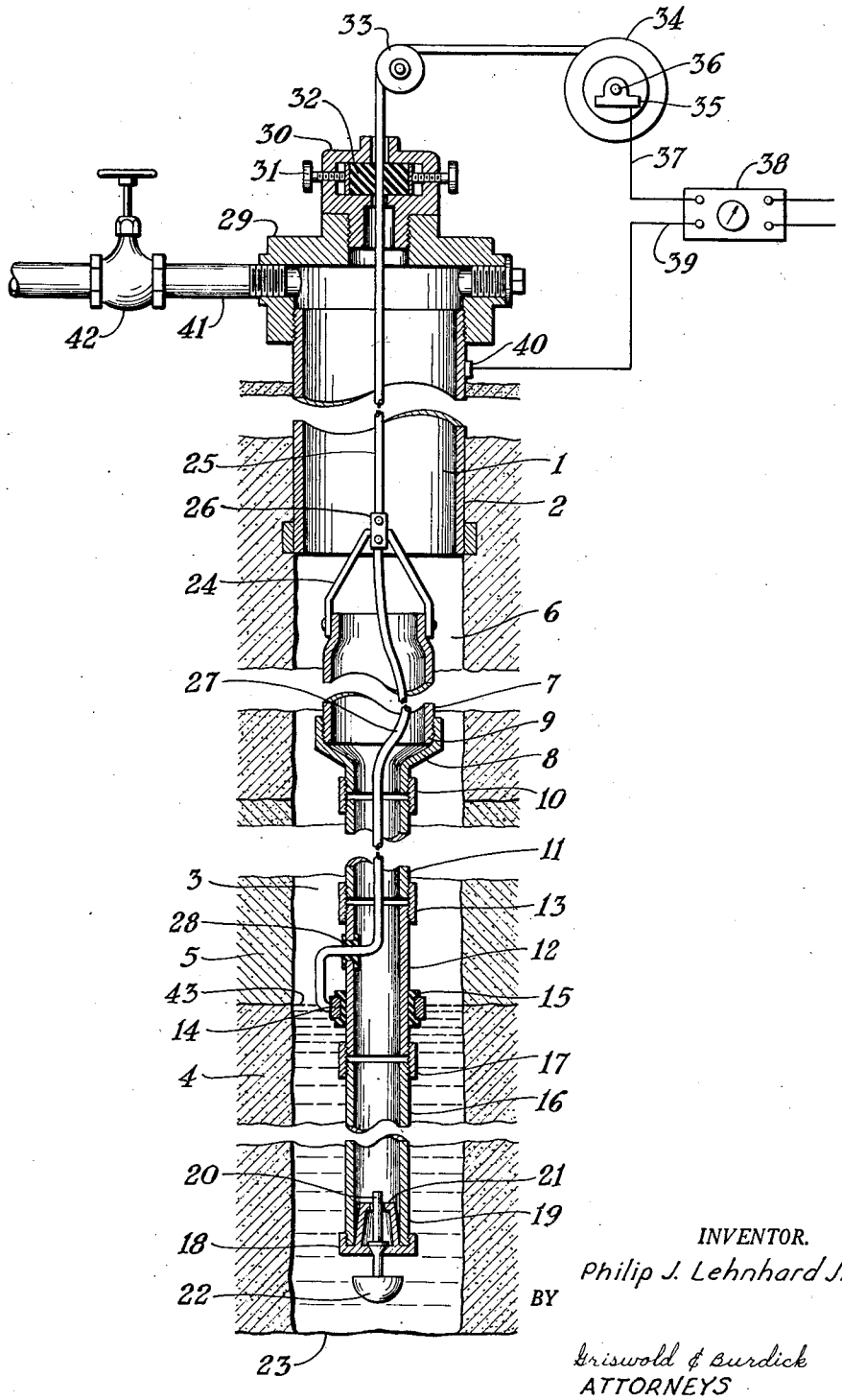
166-66

SEARCH ROOM

Nov. 23, 1948. P. J. LEHNHARD, JR 2,454,740

APPARATUS FOR TREATING WELLS

Filed Jan. 31, 1945



INVENTOR.
Philip J. Lehnhard Jr.

BY

Griswold & Burdick
ATTORNEYS

SEARCH ROOM

Patented Nov. 23, 1948

2,454,740

UNITED STATES PATENT OFFICE

2,454,740

APPARATUS FOR TREATING WELLS

Philip J. Lehnhard, Jr., Midland, Tex., assignor to The Dow Chemical Company, Midland, Mich., a corporation of Delaware

Application January 31, 1945, Serial No. 575,404

2 Claims. (Cl. 166—1)

1

The invention relates to an apparatus for treating the bore of a deep well with a liquid treating agent. It more particularly concerns a method and apparatus for placing a liquid treating agent in a well so that the bore may be filled from the bottom to a predtermined depth ascertainable by a prearranged adjustment of the apparatus.

One of the principal uses of the invention is in placing in a well bore liquids used to form a seal shutting off unwanted fluids from entering the well. In such operations, it is highly desirable that the amount of liquid used and the depth of the bore filled be subject to exact control so that either one of the two evils, namely, an over-dose or an under-dose of sealing liquid can be carefully avoided. Among the sealing liquids now being used are some which spontaneously harden in a predictable lapse of time to form a solid oil- and water-insoluble resin mass in situ, such liquids usually penetrate the face of the earth formation to a variable extent and give a good bond when set. The volume used is, therefore, somewhat in excess of the volume of the bore of the well between the top and bottom of the portion to be sealed, the excess varying with the permeability of the formation and applied pressure.

In using such a liquid, the ordinary procedure of introducing it through the well tubing string presents a number of disadvantages. One of these is that some of the liquid is retained as a coating in the well tubing, the amount thus retained being unknown and variable so that the exact amount entering the well is unpredictable. This is of importance when it is realized that more or less of a valuable productive zone may become plugged because the amount of sealing agent retained in the tubing introduces an unknown but significant error in the computed elevation to which the sealing liquid should rise in the well bore, and these liquids have a non-selective sealing action in that they seal off oil-bearing strata as well as water-bearing strata.

The conventional uses of available bailers for introducing treating liquids are unsuitable because such methods and devices do not provide for filling the bore with an amount of treating liquid such that the bore is filled to just the proper predetermined depth. Similarly, irregularities in the cross section of the well hole and its permeability to the treating liquid can and often do militate against the accurate placement of treating liquids whether the introduction be made through the tubing or in a bailer lowered into the well. In addition, it is sometimes desirable to apply pressure to the treating liquid so as to cause it to penetrate well into the earth formation and also maintain the bore filled to a known level while under pressure without the disadvantages attendant upon the use of either the well tubing or conventional bailers for the introduction of the treating liquid. Such a procedure requires some method for exactly compensating for the amount of agent which penetrates the formation.

2

One of the objects of the invention is to provide an apparatus for introducing a liquid agent into a well bore so as to be assured that it becomes filled to a preselected depth.

Another object is to provide an apparatus of the aforesaid character whereby the liquid agent may be subjected to the action of a pressuring fluid while the depth of the liquid in the well is under control.

Other objects and advantages will appear as the description proceeds.

According to the invention, the treating liquid is introduced into the well by means of a bailer device adapted to be lowered into the well on a cable. The bailer is provided with a tail pipe having a foot valve at the bottom through which the contents of the bailer may be dumped, filling the bore from the bottom upward when the valve is opened by contact with the bottom of the well. An electric interface locator is attached to the tail pipe at a distance from the bottom corresponding to the depth of the well bore it is desired to fill. The lowering cable comprises an insulated conductor for carrying the signal current from the electric interface locator so that the arrival at the interface locator of the surface of the treating liquid in the well may be ascertained and additional agent may be released from the bailer as necessary to maintain the level in the well. The invention will be readily understood from the following detailed description of a mode of practicing the same and by reference to the accompanying drawing showing a suitable form of the apparatus.

In the drawing, the single figure is a diagrammatic view in elevation and largely in section of a well showing the apparatus arranged for carrying out the placement of a liquid treating agent in the bore so as to fill the same to a predetermined depth.

As shown, the upper portion of the well bore is cased with metal pipe 2 while the lower portion 3 of the well bore ends in a water stratum 4 which is over-laid by a productive stratum 5. Shown within the well is the bailer apparatus

designated generally by numeral 6 and consists of a cylindrical container 7 of slightly less diameter than the interior of the well. It is provided with a reducing coupling 8 forming an outlet attached to the lower end of the container as by screw threads 9. Attached to the reducing coupling by threaded collar 10 is a section of pipe 11 which, in turn, is attached to the pipe section 12 by threaded collar 13. Carried by section 12 is a metal electrode 14 which acts as the interface locator and is supported in insulation 15 mounted on section 12. Below the section 12 is another pipe section 16 attached to section 12 by threaded collar 17. The sections of pipe 11, 12 and 16, together with their connecting collars, form a tail pipe for the charge container 7. The cross section of the tail pipe assembly is made relatively small compared to that of the container so that the volume of the tail pipe is only a small fraction, e. g. 3 to 7 per cent of that of the same length of well bore. The pipe section 16 is provided with a foot valve 18 having a closure 19 carried by a spindle 20 operating in a guide 21. The lower end of spindle 21 carries a foot 22 for engaging the bottom 23 of the well. The top of the bailer apparatus is provided with a bail 24 by which it is suspended in the well on insulated cable 25 attached to the bail by means of a clamp 26. The portion 27 of the cable below the bail passes through the bushing 28 which makes a fluid tight seal between the wall of the tubular section 12 and the cable, the lower end of which is electrically connected to the electrode 14. Above the clamp 26, the cable 25 extends through the top of the well, the casing of which is provided with a casing head 29 having a packing gland 30 arranged to make a seal surrounding the cable by means of adjusting screws 31, pressing against the split rubber ring 32. The cable passes over a pulley 33 onto a reel 34 to which the reeled end of the conductor is connected. The bearing 35 which supports the reel shaft 36 is connected by a lead 37 to current indicating device 38 such as a conductivity bridge which may comprise a Leeds and Northrup or any other suitable alternating current conductivity bridge connected to a suitable source of A. C. such as a 110 volt 60 cycle source. Another lead 39 connects the current indicating device with the ground as by connection to the casing at 40. The casing head is provided with a fluid inlet 41 controlled by valve 42.

The lower portion of the well bore is shown filled with a treating liquid having the property of electrical conductance sufficient to complete the circuit between the ground and the electrode 14 with which it is shown in contact. The length of the tubular section 16 is made such that the electrode 14 is at the level 43 corresponding to the top of the formation, the bore in which is to be treated. The length of the section 11 is selected so as to create sufficient pressure head difference between the inside and outside of the container 7 to enable liquid in the container to flow into the well.

It will be apparent that the tubular section 12 can be made of non-conducting material in which case the electrode 14 can be mounted directly on the surface of the section. Another modification of the device shown may consist in employing a two-wire conducting cable instead of the single cable shown in which one of the two wires is connected to the electrode and the other to the bailer when it and its appended

tubular sections are of metal instead of employing the ground connection shown to the casing.

The operation of the apparatus may be illustrated by the following description of its use in sealing off the water-bearing stratum 4 below the productive stratum 5 by employing a sealing solution of the type which solidifies in situ after a predetermined lapse of time, although the apparatus may be used with liquids other than sealing agents. Such sealing solutions are well known in the art and examples are disclosed in U. S. Patents Nos. 2,274,297 and 2,330,145. In accordance with the invention, the tail pipe portion 16 of the bailer is chosen as regards its length so that the electrode 14 will be at the elevation opposite the top of the water-bearing stratum 4 (the level to which the well hole is to be filled with sealing liquid) when the foot 22 of valve 18 rests upon the bottom 23 of the well. The length of the section 11 is also chosen so that the container 7 stands sufficiently high in the well bore to create adequate hydrostatic head to allow the sealing liquid to flow from the bailer into the well and rise therein to the desired elevation.

In carrying out the treatment, the bailer is charged with a volume of treating agent, e. g. a sealing liquid, preferably somewhat more than sufficient to fill the well bore up to the level of the top of stratum 4, and suitably suspended at the surface of the ground while the cable 25 is brought through the packing gland 30 in the casing head and thereafter attached to the bailer by means of the socket 26. The lower portion 27 of the cable is attached to the socket 26 so that there is a complete conductor circuit from the current indicating device or bridge 38 to the electrode 14. The bailer is then placed in the casing, the casing head attached to the casing and the bailer lowered into the well bore. At the same time, current is applied to the electric circuit comprising the conductor cable, the electrode and return path by the ground (when conducting liquid in the well hole contacts the electrode 14) and the conductivity bridge adjusted so that the galvanometer shows no deflection thereby indicating the resistance of circuit before the treating liquid contacts the electrode. The bailer is then lowered sufficiently to bring the foot 22 into contact with the well bottom 23 and open valve 18, thereby allowing treating liquid to flow from the bailer into the annular space in the well around the tail pipe. As the liquid rises in the well hole, it displaces upwardly any fluid already in the well, lighter than itself, and the rise is continued until contact is made by the upper surface of the liquid, i. e. the interface between it and any lighter fluid above it, with electrode 14, such contact being ascertained by observing when the galvanometer needle deflects from the position of balance previously arranged. When the circuit has thus been unbalanced by the treating liquid having risen to the elevation of the electrode and made contact with it, the bailer is lifted off the bottom by means of the cable 25 so that the foot valve 18 closes; but in order to be assured that the level reached by the treating liquid does not fall seriously below the intended level, as by penetrating into the formation while the liquid is being allowed to set, the bailer assembly may be again lowered after a short time so as to permit the electrode either to make contact with the surface of the treating fluid, if it be at such elevation as to make contact possible, or to again open the foot valve

SEARCH ROOM

allowing additional treating liquid to enter the well, thereby raising the level of the sealing liquid, the foot valve being left open until the bridge circuit indicates the liquid level in the well has again been restored to that of the electrode. The bailer assembly is then raised sufficiently to close the foot valve. This procedure is repeated as often as necessary to assure the filling of the well bore to the proper level, then the bailer is withdrawn and the sealing agent allowed to set.

In some wells, a single charge of the bailer may be insufficient to fill the bore to the preselected elevation. In these instances, repeated charges may be introduced employing the same method of determining when the liquid has reached the selected elevation.

In some instances, it is desirable to force the treating agent into the surrounding formation by the application of pressure. The method described above may be used advantageously in conjunction with pressure to effect such penetration of the formation, this being accomplished by introducing a pressuring medium, such as a gas, e. g. air or a liquid, e. g. oil, water, through valve 42 and pipe 41 into the casing head after the bailer assembly is in position in the well. In operating under a pressuring medium, it may be desirable to apply the pressure during the time the liquid treating agent is being discharged from the bailer or afterward depending upon the type of treatment it is desired to give the well formations. In sealing operations of the type herein described in which it is desired to form a plug in a well hole up to a certain predetermined level, application of a pressure in excess of the counterbalancing hydrostatic pressure is generally undesirable, if not unnecessary. On the other hand, when the object sought is to force the liquid treating agent into the earth formation some distance beyond the face of the well bore a pressure considerably in excess of the hydrostatic pressure of the well may be applied. If during the application of pressure, the level of the treating agent falls in the well, the foot valve of the bailer may be set on the bottom of the well again so as to release additional liquid until the interface again contacts the electrode 14. Repeated charges of the bailer may be made if necessary to fill the wall to the desired level in those instances where a single change is insufficient.

It will be evident that the position of the electrode 14 may be varied with respect to its elevation above the foot valve 18 by selecting an appropriate length of pipe for section 16 so that the position of the electrode will be opposite the elevation to which it is desired to control the level of the introduced liquid treating agent when the foot valve of the bailer is resting on the bottom of the well in the open position.

It will be understood that the apparatus may be used to place in a well bore any commonly used treating fluid having a measurablydifferent conductivity from that of the fluid in contact with it at the interface, and to control the level to which it rises so that the treating effect is confined to a predetermined section of the well bore. For example, the apparatus may be used to introduce into the well to a controlled predetermined depth a relatively non-conducting liquid as by first introducing into the well a liquid having a higher conductivity, as by pouring it into the casing, and thereafter a relatively non-conductive liquid in the manner already described. In this case, the conductivity bridge is adjusted so as to show the conductivity or resistance of the circuit when the relatively conductive liquid is in contact with electrode 14 before introducing the relatively non-conductive liquid; then, as the relatively non-conductive liquid is released from the bailer and rises in the well bore, it displaces upwardly the relatively conductive liquid without changing the resistance of the circuit until the non-conductive liquid has contacted the electrode 14, whereupon the conductivity of the circuit decreases indicating its arrival at the elevation of 14. In carrying out the method in this manner, it is desirable that the specific gravity of the non-conductive liquid be greater than that of the conductive liquid in order that the relatively conductive liquid will float on the other liquid.

The treatment of a well with a liquid treating agent, using the apparatus of the invention, has the advantage that the depth of the bore subjected to the action of the treating liquid is under precise control and the amount of treating liquid which enters the bore is easily and readily determined so that loss into the formation can be accurately compensated.

This application is a continuation-in-part of my application Serial No. 438,111, filed April 8, 1942, which is now abandoned.

What is claimed is:

1. An apparatus for introducing a liquid agent into a well containing fluid and depositing the same on the bottom thereof so as to fill the well from the bottom to a predetermined depth, comprising the combination of a cylindrical container adapted to hold a charge of liquid agent and having an outlet at the bottom, a tail pipe attached to the outlet and having a smaller cross section than that of the container, said tail pipe having a length exceeding the depth of the portion of the well to be filled, a foot valve on the lower end of the tail pipe adapted to be opened by contact with the bottom of the well to release the liquid agent from the container, an electrode mounted externally on the tail pipe and electrically insulated therefrom at a distance above the lower end corresponding to the predetermined depth of the filling of the well by the liquid agent, an insulated cable connected to the electrode, means for suspending the container on the insulated cable, and a circuit means including an electric current indicating means, connected to the cable and a ground connection, adapted to indicate the difference in resistivity of the circuit when the liquid agent makes or breaks contact with the electrode.

2. An apparatus for introducing a liquid agent into a well containing fluid and depositing the same on the bottom thereof so as to fill the well from the bottom to a predetermined depth, comprising the combination of a cylindrical container adapted to hold a charge of liquid agent and having an outlet at the bottom, a tail pipe attached to the outlet and having a smaller cross section than that of the container, said tail pipe having a length exceeding the depth of the portion of the well to be filled, a foot valve on the lower end of the tail pipe adapted to be opened by contact with the bottom of the well to release the liquid agent from the container, an insulator externally mounted on the tail pipe at the distance above the lower end corresponding to the predetermined depth of the filling of the well by the liquid agent, an electrode mounted on the insulator, an insulated cable threaded through the tail pipe and container and having its lower end connected to the electrode, said cable be-

ing adapted to suspend the container in the well, means for suspending the container on the insulated cable, and a circuit means including an electric current indicating means connected to the upper end of the cable and a ground connection, adapted to indicate the difference in resistivity of the circuit when the liquid agent makes contact with the electrode.

PHILIP J. LEHNHARD, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,385,760	Swartz	July 26, 1921
1,552,675	Bruce	Sept. 8, 1925
2,168,735	Gilstrap et al.	Aug. 8, 1939
2,171,840	Armentrout et al.	Sept. 5, 1939
2,207,345	Hammer	July 9, 1940
2,210,205	Elliott	Aug. 6, 1940
2,217,857	Byck	Oct. 15, 1940
2,274,297	Irons et al.	Feb. 24, 1942
2,330,145	Reimers	Sept. 21, 1943
2,347,589	Barstow	Apr. 25, 1944