

Nov. 12, 1929.

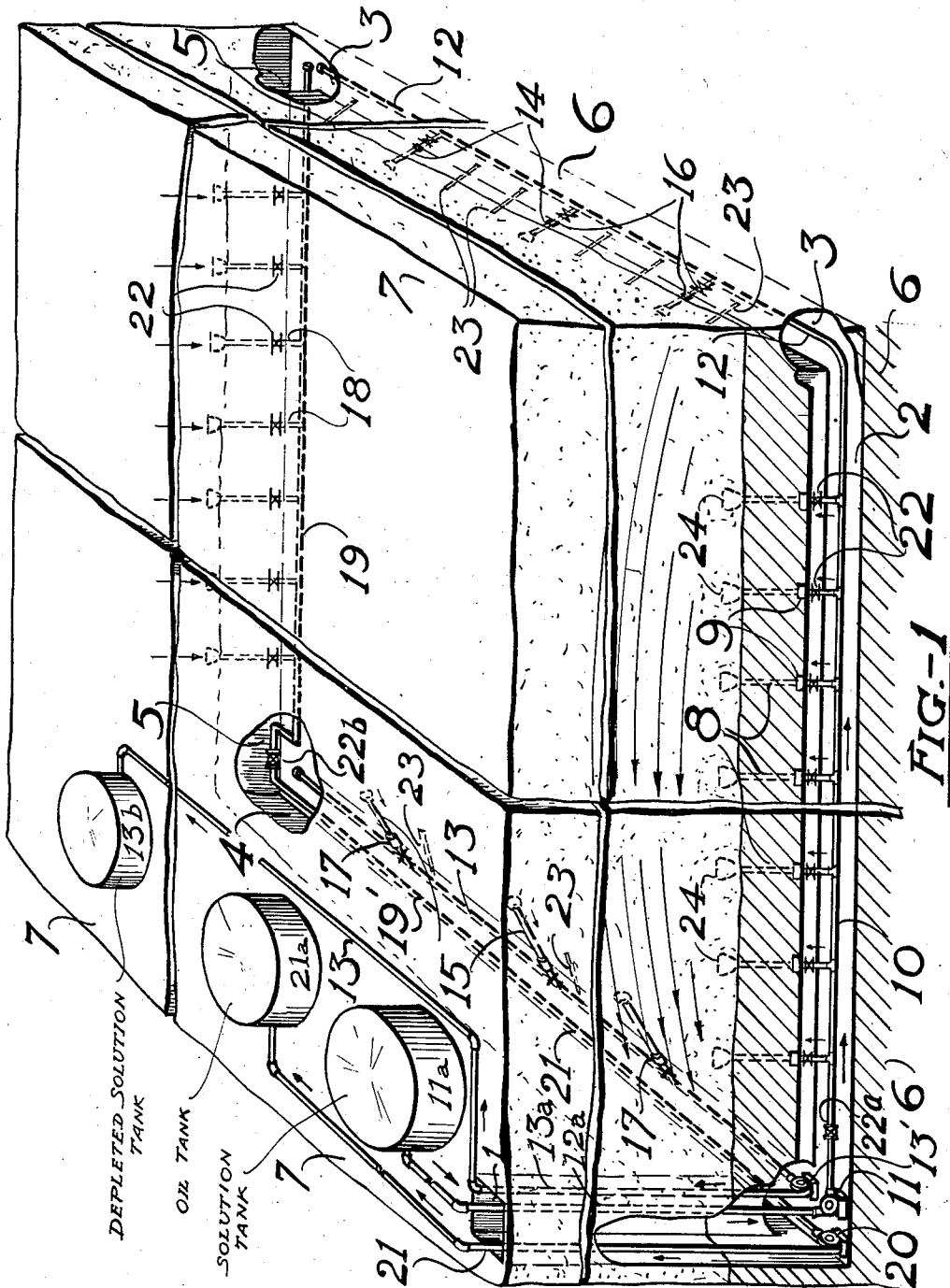
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FLOODING METHOD FOR RECOVERING OIL

Filed Sept. 17, 1927

2 Sheets-Sheet 1



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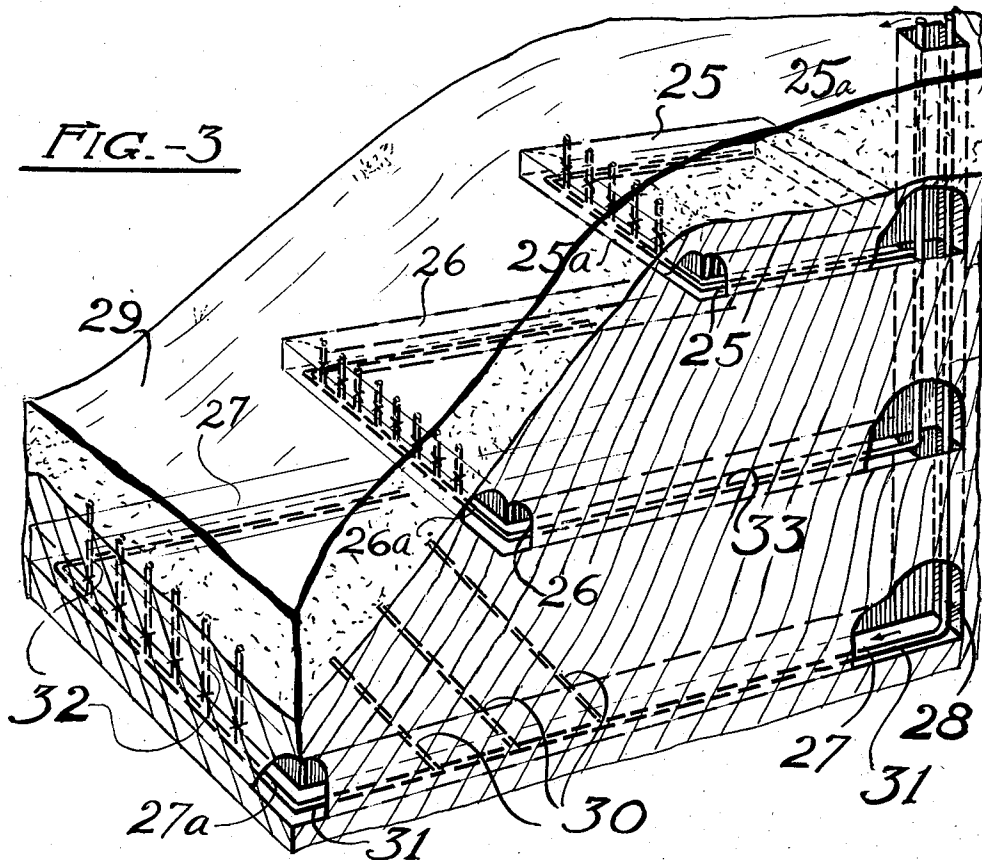
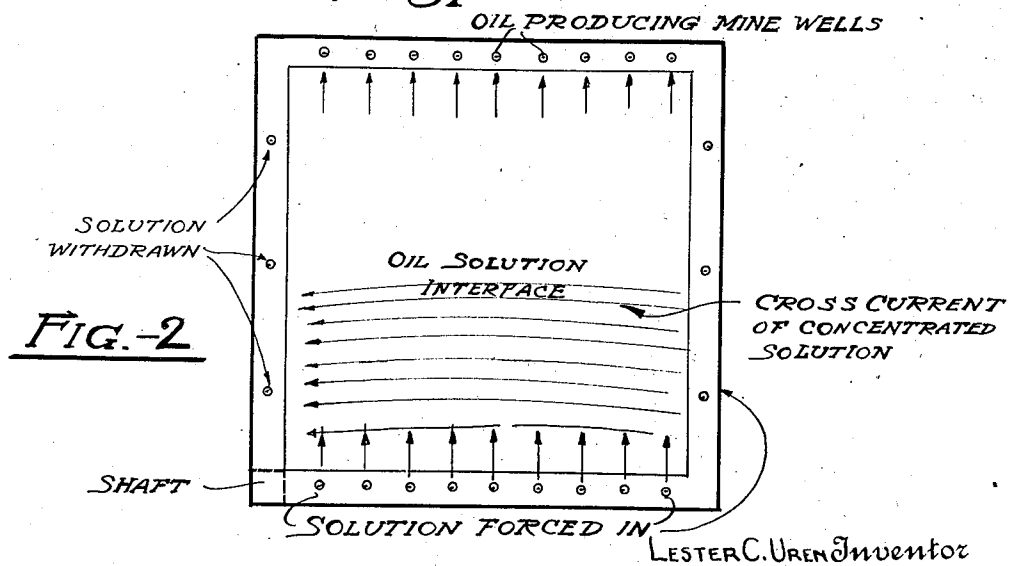
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By his Attorney *Atthaw*

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UNITED STATES PATENT OFFICE

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FLOODING METHOD FOR RECOVERING OIL

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This invention relates to improvements in flooding methods for the recovery of oil from oil reservoir sands. Such methods, particularly those involving the use of water solutions of electrolytes (sodium carbonate, etc.) have been extensively investigated in recent years. The solution is forced into the oil sand through one or more surface wells, and the displaced oil is collected through other surface wells. The percentage recovery is necessarily low because the solution reacts with the sand, the oil, or both. The effectiveness of the solution is practically destroyed after it has progressed a relatively short distance from the point of introduction.

The object of the present invention is to maintain an efficient concentration of oil-displacing agent, or to regenerate or restore it. In a preferred embodiment of my method, this is accomplished by projecting a substance facilitating oil-displacement as a cross-current at the interface between the oil and the body of liquid expelling the oil from the sand.

In carrying the invention into effect, a mine gallery installation is utilized, for example, of the general type described and claimed in United States Patents 1,634,235 and 1,634,236, granted to Leo Ranney on June 28, 1927. As described in these patents, a mine shaft is sunk to the level of the oil sand and galleries are driven adjacent the sand in the upper or lower cap rock. Holes are drilled from the galleries into the sand, forming mine wells for the collection of oil, introduction of oil-expelling media, etc.

The present invention will be fully understood from the following description, read in connection with the accompanying drawings, in which—

Fig. 1 is a diagrammatic perspective view of an inclined block of oil sand, and means for working it by my method;

Fig. 2 is a plan view of the same;

Fig. 3 is a perspective view showing an alternative installation.

Referring first to Figs. 1 and 2, 1 denotes a mine shaft from which galleries 2, 3, 4 and 5 are driven. These galleries lie in a lower cap rock or foot wall 6, underlying an oil sand 7.

They preferably extend entirely around the block of sand to be worked. In the lowest or down-dip gallery 2, mine wells 8 are formed and are connected through nipples 9 with a pipe 10 for supplying the flooding solution. In order to secure a good distribution of the solution, the ends of the mine wells are preferably enlarged as shown at 24. A pump 11 is provided, if necessary, for forcing the solution through pipe 10 from an above-ground storage tank 11^a. The hydrostatic head in deep wells will usually provide enough pressure. The pressure necessary varies widely, depending on conditions in the sand.

Galleries 3 and 4, which run up the dip of the sand, respectively contain pipes 12 and 13, connected at their lower ends with pipes 12^a and 13^a for supplying or withdrawing flooding solution. A tank 13^b receives depleted solution from pipe 13^a. At suitable intervals, for example, every 100 ft. when working a loose sand, mine wells 14 and 15 are formed from the galleries 3 and 4. Nipples 16 and 17 connect the pipes 12 and 13 with these mine wells.

The highest or up-dip gallery 5 has a series of mine wells 18 discharging into an oil collecting pipe 19, which leads through a pipe 19' to pump 20. This pump forwards the oil through a pipe 21 to a storage tank 21^a above ground. Valves 22 are provided on all the mine well nipples, so that the flow of solution and oil may be controlled as desired. A valve 22^a is installed in pipe 10 and a valve 22^b in pipe 19. A number of test holes 23 are formed from the galleries 3 and 4 to tap the oil sand.

A preferred operation is as follows: The oil which will flow naturally from the mine wells is collected. When the flow of oil diminishes considerably or stops, a solution of sodium hydroxid, sodium carbonate, sodium silicate, or other substance hydrolyzing to produce hydroxyl ions, is forced in through pipe 10, nipples 9, and mine wells 8. An N/10 solution is often sufficiently concentrated, but stronger solutions may be desirable in cases where there is a tendency to rapid depletion. When sodium carbonate is used, as the solution advances it is gradually

converted into bicarbonate by reaction with the sand.

As soon as the concentration of carbonate has fallen to about the minimum effective amount, a fresh solution, preferably concentrated, is injected through a nipple 16 and mine well 14, preferably immediately below the plane of contact of the flooding agent and the oil in the sand. At this time the valve in the correspondingly located nipple 17 is opened, so that some exhausted solution runs out through it and by pipes 13 and 13^a to tank 13^b. Valves controlling influx of solution through mine wells 8 are meanwhile closed. The injection of solution from the side of the sand block and withdrawal from an opposite point on the other side induces a cross-current. The concentrated reagent in this cross-current is taken up by the depleted solution, which is in this way substantially returned to its original effectiveness. A fresh concentrated solution may be supplied if desired through a pipe (not shown) instead of from the solution tank 11^a.

The proper point for introducing the restorative agent may be determined by observing conditions at the test holes 23. These holes may be plugged and opened at intervals for inspection. When the flooding solution reaches the level of a test hole, a portion of the solution is collected and analyzed. If depleted, more reagent is added.

The distance between the galleries 3 and 4 should ordinarily be from 300 to 1,000 ft., depending on the permeability of the sand and other conditions. If more than this, the cross-current of restorative agent cannot generally be well established. The gallery 5 may be 300 ft. or more from the gallery 4, the distance being measured along the dip. The method is best applied to the whole productive area of the sand. In some cases, however, portions of the sand are so protected that they can be worked individually without much loss of the flooding solution to adjoining portions of the sand. For example, a porous streak of productive sand sometimes follows a circuitous course both up and down the dip. Such streaks, if walled in by dense strata, are effectively operated by my method.

The advance of the solution through the sand should be as uniform as possible, to avoid pocketing or trapping any of the oil. Substantial uniformity can be obtained by observing the indications at the test holes and regulating valves 22 to diminish or increase the flow of solution into the sand and the withdrawal of oil therefrom. The rate of flow through the sand should be low, say about six to twelve inches a day. At this rate ample time is given for displacement of the oil held both by surface adhesion and capillarity, and to permit equalization of the advancing solution level.

Although only one upper gallery has been

shown, it will be understood that other galleries running generally parallel to the strike of the deposit may be made at suitable intervals, up to its crest. As the flooding solution advances, expelling the oil before it, the mine wells in each up-dip gallery in turn become the points for injecting the solution, and the next higher gallery is used for collecting the oil.

In the installation shown in Fig. 3, a plurality of pairs of mine galleries 25, 26 and 27, are driven laterally at increasing depths from a shaft 28 to points adjacent and below an inclined oil sand 29. Connecting branch galleries 25^a, 26^a and 27^a are driven parallel to the strike. If the structure makes it desirable to do so, the mine galleries may be formed in the cap rock above the sand. Drill holes 30 from the gallery 27 extend upwardly to tap the sand at intervals. The flooding solution is forced through a pipe 31 in the gallery 27 and mine wells 32 in gallery 27^a. Additional solution or other restorative agent to maintain an effective concentration is injected as required through the drill holes 30 near the interface between oil and solution. Oil is collected through a pipe system 33 in the up-dip gallery 26 and shaft 28. As above described, each of the up-dip galleries is first used for oil recovery and then for injecting the flooding solution.

The solution may be heated before passing it into the sand, or heat may be applied to the sand, for example, as described in the patents above mentioned. Instead of adding fresh sodium hydroxid, sodium carbonate or the like, the solution in the sand may be regenerated. This may be done in the case of sodium carbonate by withdrawing the solution and heating to convert the bicarbonate into carbonate. The regenerated solution may then be returned to the sand, with or without an additional quantity of oil displacing agent.

The installations and methods described are merely illustrative of preferred forms, and various changes and alternative procedures may be adopted within the scope of the appended claims, in which it is my intention to claim all novelty inherent in the invention as broadly as the prior art permits.

I claim:

1. The improvement in flooding methods for recovering oil from an oil-bearing stratum, which comprises forcing a flooding agent into the stratum, causing the flooding agent to advance through the stratum and adding fresh flooding agent at a point in the line of advance remote from the point of origin, whereby the concentration of the advancing flooding agent is substantially maintained.

2. The improvement in recovering oil from an oil-bearing stratum to which access is gained by a mine gallery, which comprises passing an oil-expelling medium from the

gallery into the stratum to flow therethrough, passing an agent for reinforcing the expulsive action of said medium into the stratum at an angle to the direction of said flow, and withdrawing a portion of said medium from a point in opposition to that at which the agent is introduced.

3. The improvement in electrolyte solution flooding methods for recovering oil from oil sands, which comprises forcing the solution to flow through the sand, introducing concentrated solution in a direction transverse to such flow in a region where the original solution has become depleted, and withdrawing the depleted solution from a point opposite to that at which the concentrated solution is introduced, whereby a cross-current of concentrated solution is formed.

4. Method according to claim 3, in which the cross-current is established near the interface between the solution and the oil in the sand.

5. Method according to claim 2, in which the oil-expelling medium is caused to flow up the dip of the oil-bearing stratum and the reinforcing agent is introduced through a branch gallery running up the dip.

6. The improvement in electrolyte solution flooding methods for recovering oil from an oil sand, which comprises forcing the solution into the sand from a plurality of closely spaced mine wells to form a body of solution advancing through the sand, directing a stream of fresh solution of a reagent, facilitating displacement of oil, into the sand at a point remote from that at which the body of solution enters the sand for admixture with the body of solution to maintain an effective concentration therein, and withdrawing oil through other mine wells.

7. The improvement in recovering oil from an oil sand, which comprises driving a down-dip gallery in the cap rock or foot wall and generally parallel with the strike of the deposit, driving spaced, upwardly-inclined branch galleries from said down-dip gallery, and an up-dip gallery connecting said branch galleries, forming mine wells in each gallery, forcing an oil-expelling agent into the sand from the mine wells in the down-dip gallery, replenishing the agent from the mine wells in the branch galleries, and collecting the oil from the mine wells in the up-dip gallery.

8. Method according to claim 7, in which an electrolyte solution is used, the condition of the solution is tested at various points in the branch galleries, and a reagent facilitating displacement of oil is added through the mine wells therein, so as to maintain an effective concentration throughout the progress of the solution through the sand.

9. Method according to claim 7, in which an electrolyte solution is used, a current of concentrated solution is directed across the interface between oil and solution in the

sand, by injecting concentrated solution from one branch gallery, and withdrawing depleted solution from an opposed point in the other branch gallery.

10. Method according to claim 7, in which an electrolyte solution is used, and the inflow of solution is regulated to produce a substantially uniform advance of solution through the sand.

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