OIL RECHARGING AND RECOVERY METHOD AND APPARATUS

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Fig. 3

Fig. 4

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By his Attorney
This invention relates to improvements in the recovery of oil from earth strata, especially strata containing oil in relatively gas-free condition. The principal object of the invention is to recharge the oil with gas, thereby "enlivening" the oil or increasing its tendency to flow. In the method described herein gas is not primarily caused to form a moving barrier which drives oil before it. On the contrary, the oil is directly modified by the gas so that flow without applied pressure is possible. This application is a continuation in part of my co-pending applications Serial No. 127,228, filed August 6, 1926, and Serial No. 100,739, filed January 13, 1927.

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

Fig. 1 is a diagrammatic vertical section showing a portion of a mine gallery and illustrating the first stage of the recharging operation;

Fig. 2 is a similar view showing the second stage of that operation;

Fig. 3 is a similar view showing the oil collecting stage;

Fig. 4 is a diagrammatic plan showing a preferred arrangement of the mine galleries;

Fig. 5 is a vertical section through a control valve arranged in a mine well; and

Fig. 6 is a similar view showing an alternative form of valve.

Referring first to Figs. 1 to 4 of the drawings, 1 denotes a mine gallery driven in a lower cap rock 2 underlying an oil sand 3, which contains shale partings 4 or the like. An upper cap rock 5 covers the oil sand. Conduits 6 and 6' are set in holes 7, drilled upwardly into the lower cap rock, but preferably not through into the oil sand. The holes may be drilled vertically as shown, or at an angle. The lower part of each hole is enlarged to receive a sealing material 8, (cement, lead wool, or the like) which makes a fluid-tight seal between the cap rock 2 and the conduits 6, 6'. Openings 9, drilled through the conduits as extensions of holes 7, tap the oil sand and form what I term "mine wells". Openings 9 are preferably enlarged at their ends by reaming or blasting to form fluid distributing or collecting areas 10.

Conduits 6 are connected to a pipe 11 which is in turn connected to a source of gas or air under pressure, and conduits 6' are connected to an oil collecting pipe line 12. Control valves 13, preferably of the gate type, are installed in each conduit.

While the described method of tapping the oil sand is preferred, it will be understood that any method may be adopted which permits gas under pressure to be injected into the sand or near the bottom. Instead of working from below as illustrated, it is evident that an equivalent result may be obtained by drilling from above, provided of course that the opening through the sand is cased or cemented so that gas cannot escape into the sand except near its bottom.

For best results the mine gallery should be formed about the margin of the tract to be worked, for example as shown in Fig. 4, which represents a square 40 acre tract encompassed by a gallery from which numerous mine wells 9 are drilled into the sand.

In the preferred operation of my method, a gas under pressure is passed into the oil sand through conduits 6. I prefer natural gas for this purpose, though air, mixtures of air and natural gas, etc., may be used. In the first stage of the recharging operation, as illustrated in Fig. 1, the pressure is kept relatively low (10 to 50 lbs. per square inch for sands of average porosity). This is to insure the formation of a gas layer throughout the bottom area of the sand.

If high pressure is initially applied, there is a tendency for the gas to break through, as between the shale partings 4, and spread throughout the upper region of the sand, leaving the lower part untouched. Gas tends to pass laterally more readily than vertically through the oil sand, and if the initial pressure is not too high, a good distribution of gas can be obtained throughout the whole lower area.

When this has been accomplished the pressure is increased, say to about 75 to 150 lbs. per square inch. The gas enters the charged lower layer and ascends through the sand.
This condition is illustrated in Fig. 2. During the recharging operation the gas moves outwardly and upwardly from the intake wells and gradually rises toward the top of the sand. In so doing it charges the oil with gas.

I do not wish to be limited to the particular pressures specified, as these will naturally vary in accordance with porosity of the sand, the initial gas content of the oil, and other conditions. The pressure in the preliminary charging stage will ordinarily be within the range of 10 to 50 lbs. per square inch and for the second stage between 50 and 300 lbs. per square inch. More than two stages of pressure may, of course, be applied where conditions necessitate more gradual pressure increase.

In some cases it is desirable to remove a portion of the oil from the bottom layers of sand before entering the stage of higher pressure, the purpose being to make the bottom layers of sand more permeable to the gas during the second stage. This partial extraction of oil from the sand bottom is accomplished by removing the applied pressure and allowing the occluded gas in the bottom oil to expand and drive the oil to the nearest producing well. Once the bottom layers of sand are partially cleared of oil, the gas, when again applied under pressure, spreads rapidly throughout the sand bottom.

The time required for recharging will vary greatly. In porous sands, for example, distribution of gas throughout the lower area may be obtained by holding pressure on a 40 acre tract for three or four weeks. A similar period will be required for charging the upper areas at higher pressure. In tight sands much longer application of pressure is required. The gas may be heated and in special cases “unexcavated drainage tunnels” may be formed, as described in my applications referred to above.

During the recharging period all of the oil outlets are preferably closed. When the oil in the sand has been recharged substantially throughout, the gas is shut off and the oil collecting conduits 6' are opened to permit flow of oil into line 12. If desired the gas line 11 may also be utilized for the collection of oil. Suitable pumps, separators, etc., are provided for forwarding the oil and gas to the earth's surface, for example as shown in my U.S. Patent 1,660,819, granted February 28, 1928.

In some cases it is permissible to withdraw oil during the recharging stage. In general, however, I prefer to complete this stage before any oil is withdrawn. In the present method I do not, in any case, use the initial charging gas as a moving barrier to expel oil. Although it is not generally necessary, I may aid in the expulsion of the charged oil by applying fluid pressure (water, gas, etc.) or by applying suction.

Recovery of oil through mine wells as described is normally most convenient, but other means are also suitable. For instance, in many fields which are no longer producing oil because of gas depletion, there are abandoned surface wells which can be used for oil recovery, after the oil has been “enlivened” as described. When recovery of oil is through mine wells, the valves therein may be operated to control flow of oil so as to prevent too great an escape of gas through oil collecting outlets, or to prevent other undesirable results. When mine wells are producing oil it is sometimes desirable to keep an oil seal above the valve to retain free gas, but at other times it is desirable to allow the gas to flow freely at various intervals to create a differential of pressure within the sand, the lowest pressure being at the producing well. This sudden release of pressure enables the occluded gas to expand and to push the oil to the producing well. The periodic venting may be by manual operation of valves, or pressure responsive devices, float controlled valves, or the like, may be used to vent gas automatically when required.

In Fig. 5 a pressure responsive valve is illustrated. This comprises a valve head 13 and a valve seat 14 in the form of an annulus mounted in the pipe 15. A centrally perforated plate 16 is adjustably arranged below the valve seat in the pipe. A coil spring 17 is secured to the valve head and encircles a valve stem 18 which runs through seat 14 and plate 16. The spring is supported by the latter plate, which may be adjusted to regulate the tension on the spring so as to cause the valve to open at the desired pressure. After the pressure is relieved, the valve closes.

Fig. 6 shows a float operated valve. This comprises a valve head 19 and a valve seat 20. The orifice in this should be beveled downwardly to prevent sand grains from collecting and keeping the valve open. A float 21 is attached to a stem 22 secured to the valve head, preferably by adjustable means. When the level of oil in the mine well reaches a predetermiend level, the valve opens to permit temporary outflow into the collecting line 12.

The valves in the gas injection conduits 6 may be selectively regulated to control the introduction of gas. In this way the distribution of gas may be adjusted in accordance with the structure or pressure conditions of the sand. Information on these matters may be available from the logs of surface wells or may be obtained by test devices such as are shown in my United States Patent No. 1,607,269, granted April 24, 1928. My invention is to be distinguished from prior methods in which gas is forced into an oil sand without insuring that it shall enter.
at the bottom. If the gas has free access to the upper portion of the sand, it will preferentially fill that portion of it, since the upper part is relatively oil-free and therefore offers less resistance to the entry of the gas. The barrier of gas thus formed above the oil can be used to force it out to a substantial extent, but will not serve effectively to recharge the oil with gas. The latter result is obtained by the present method. Oil properly recharged with gas flows freely and can be readily withdrawn from the sand, irrespective of applied pressure, which in some cases is ineffective due to interposed shale barriers or other obstructions in the sand. Recharged oil contains its own expulsive agent (occluded gas) and this becomes operative whenever the pressure is released, even in part.

The methods described above are preferred, but it will be understood that 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. Method of recovering oil from an oil-bearing stratum, comprising passing gas into the stratum from near the bottom only and below the level of oil in the stratum, and withdrawing oil charged with gas.

2. Method of recovering oil from an oil-bearing stratum, comprising passing gas at relatively low pressure into the stratum from near the bottom only and below the level of oil in the stratum, selectively regulating the introduction of the gas, and withdrawing oil charged with gas.

3. Method of recovering oil from an oil-bearing stratum, comprising introducing gas first under relatively low pressure and then under higher pressure into the stratum from near the bottom only and below the level of oil in the stratum, and withdrawing oil charged with gas.

4. Method of recovering oil from an oil-bearing stratum, comprising introducing gas under relatively low pressure into the stratum from near the bottom only and below the level of oil in the stratum, until the lower area of the stratum is substantially filled with gas, then introducing gas under a higher pressure so as to cause the upper portion of the stratum to be substantially filled with gas, and withdrawing oil charged with gas from the stratum.

5. Method of recovering oil from an oil-bearing stratum, comprising passing gas at relatively low pressure into the stratum from near the bottom only and below the level of oil in the stratum, then injecting gas at a higher pressure from below the level of oil in the stratum, selectively regulating the introduction of the gas, and withdrawing oil charged with gas.

6. Method of recovering oil from an oil sand in which the oil is relatively free of gas, comprising introducing gas into the sand below the level of oil from about the margin of the tract to be worked until oil in the sand is substantially charged with it, and thereafter opening oil outlets so that the oil charged with gas may flow from the sand.

7. Method of recharging oil within the pores of an oil sand in a natural earth stratum, comprising the introduction of gas under pressure at a point near the bottom of the sand and below the level of oil in the sand, so that the gas moving outwardly and upwardly from the intake may gradually rise toward the top of the sand, recharging the oil in its path.

8. Method of recharging oil within an oil sand, comprising the introduction of gas under relatively low pressure near the bottom of the sand and below the level of oil in the sand, withdrawing the oil so charged, and filling such partially drained area with gas under higher pressure for movement outwardly and upwardly through the remainder of the sand body.

9. In an installation for working an oil sand from a mine gallery located adjacent the sand but spaced therefrom, the improvement which comprises gas inlets opening near the bottom only of the sand, means for passing gas through the openings to recharge the oil with gas, and means for withdrawing oil.

10. The method of charging oil in a tract of natural earth stratum with gas, which comprises injecting the gas into the stratum below the level of oil in the stratum from the outer horizontal edges of the tract.

11. The method of charging oil in a natural earth stratum with gas, which comprises injecting the gas into the stratum below the level of oil in the stratum under progressively increasing pressures to cause the gas to flow laterally into the oil impregnated stratum and upwardly through the oil carrying portion of the stratum.

12. The method of charging oil in natural earth stratum with gas, which comprises injecting the gas into the stratum below the level of oil in the stratum at slightly greater than atmospheric pressures to cause the gas to flow laterally through the stratum, and elevating the pressure of the gas whereby the gas flows upwardly through the stratum.

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