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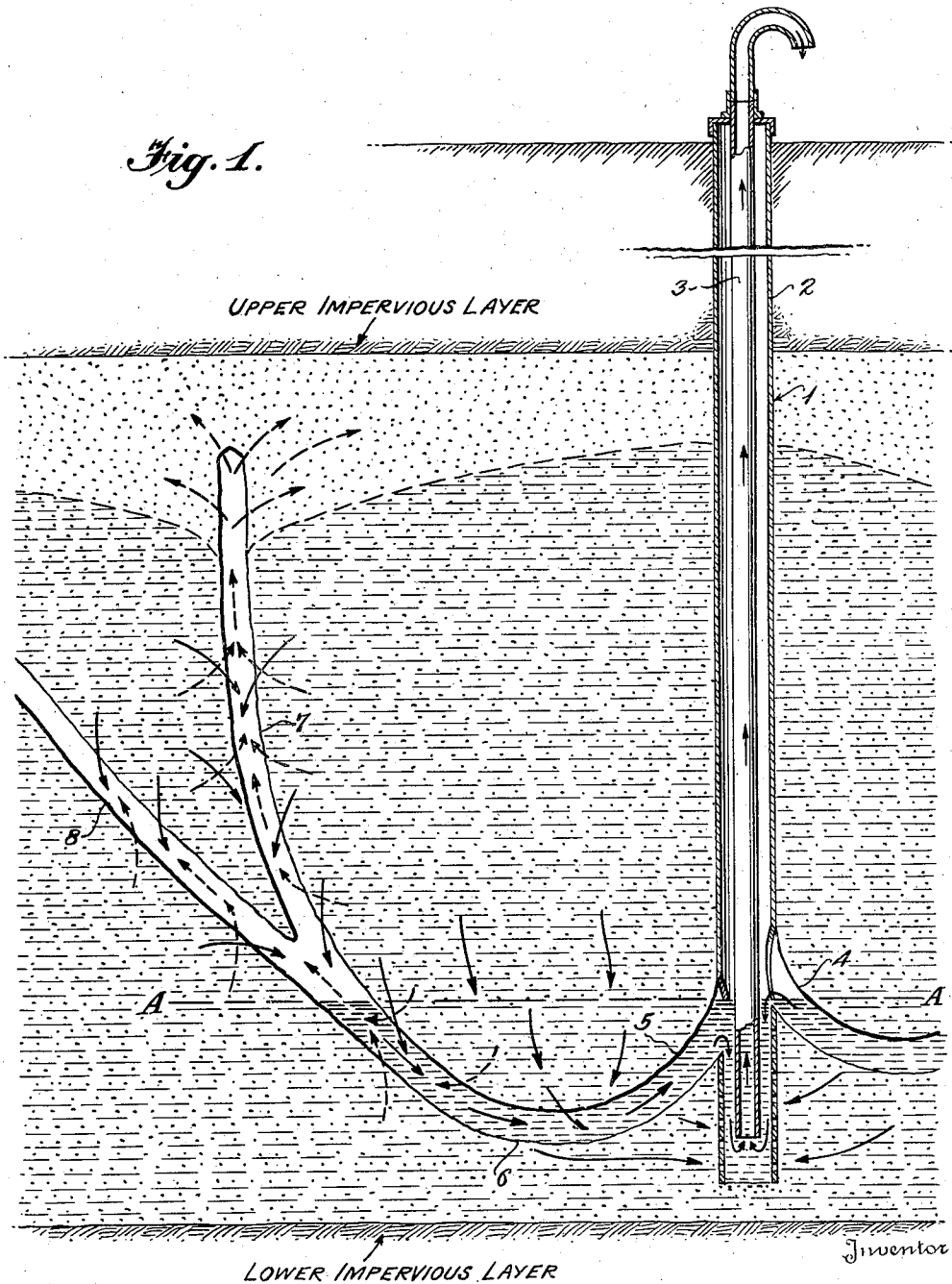
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2,404,341

METHOD OF PRODUCING OIL AND RETAINING GAS THROUGH DEVIATING BORES

Filed June 15, 1944

2 Sheets-Sheet 1



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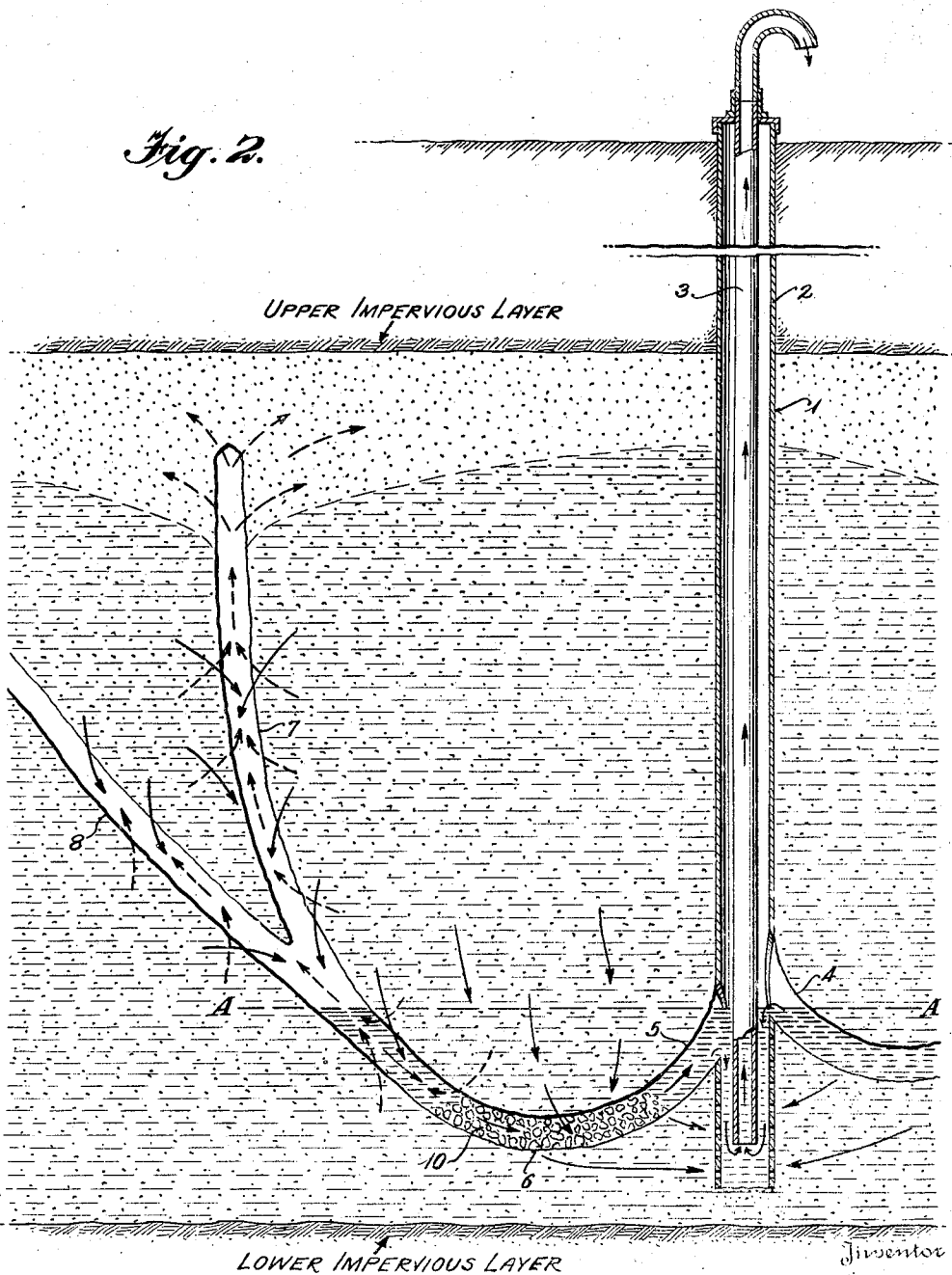
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Fig. 2.



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Abstract

UNITED STATES PATENT OFFICE

2,404,341

METHOD OF PRODUCING OIL AND RETAINING GAS THROUGH DEVIATING BORES

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3 Claims. (Cl. 166—21)

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The present invention relates to an improved method for producing oil. It relates primarily to an improved expedient for producing oil by so-called gas cap drive.

It is recognized that the mechanism of so-called dissolved gas drive has inherently the lowest efficiency of oil recovery, since it depends solely on the relatively limited quantity of the dissolved gas for the expulsion of the oil from the sand. Both the rate of oil flow and the ultimate yield of oil are primarily dependent on the degree or extent of exhaustion of the gas. It has been ascertained that the possible ultimate yield usually runs from 20% to 40% of the total original oil present in the formation.

It has been suggested that by proper control of the dissolved gas drive type of oil field production, other and more efficient recovery mechanism may be brought about. The dissolved gas drive is wasteful, since it may be initiated under open flow conditions and waste of gas from a free gas cap permitted to occur with damaging effects on oil recovery.

The gas displacement mechanism known generally as gas cap drive is capable of yielding substantially higher oil recovery than obtainable through the so-called dissolved gas drive. In the gas cap drive mechanism, the displacement action of a downwardly expanding gas cap maintains pressure on the oil sand and retards the evolution of gas from solution in the oil.

The degree to which the maximum recovery of oil may be attained through the employment of a gas cap drive mechanism is, in large part, dependent upon the degree to which gravitational segregation of oil and the free gas, to maintain a separate and distinct expanding gas cap, is effected during the productive life of a given field. The recovery expectancy, therefore, covers a wide range. However, the mechanism of the gas cap drive may be said generally to yield from 50 to 100% more oil than recovered under the so-called dissolved gas drive, with potential yields under favorable conditions approaching the limit of minimum residual oil saturation.

It has been pointed out that practical requirements for effective gravitational segregation of oil and free gas include highly permeable sands, gas conservation, and usually pronounced structural relief. It has also been noted that where a free gas cap does not originally exist it is often feasible to create one by the injection of gas at the crest of the oil bearing structure, or gas injection may be used to maintain and enlarge an original gas cap. Such an operation is common-

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ly known as "pressure maintenance" and probably represents the most efficient form of gas cap drive.

Withdrawal of free gas from a gas cap must be avoided in order to realize the full benefits of gas cap drive, and similarly careful control of the production rates from a well must be employed to avoid channeling or bypassing of free gas and to favor its accumulation and retention in the gas cap by gravitational segregation.

I have now discovered that it is possible to facilitate the separation of dissolved gas from oil in an oil formation and to permit the separated gas to augment the gas cap and thereby facilitate and increase the production of oil from a given formation.

More specifically, it is a feature of my invention to drill one or more bores deviating from a vertical well bore and to extend such deviating bore or bores upwardly through the oil bearing formation into the zone of the gas cap. I have ascertained that such deviating bores not only facilitate the flow of oil from the oil bearing formation into the vertical well, but also form, due to their more or less open connection with the well, a low pressure area which causes oil with its dissolved gas content to flow into the deviating bore followed by the expansion of the dissolved gas content thereof into free gas. It is, therefore, an object of the present invention to drill curved drain holes deviating from a vertical well bore not only horizontally but also upwardly, even to the extent of providing a substantially vertical bore terminating at its upper end in the zone of the gas cap. It is, therefore, a specific object of the invention to facilitate oil production, more particularly under gas cap drive, by drilling one or more deviating bores from a vertical well in such manner as to terminate at a much higher level than the point of take-off of the deviating bore or bores from the vertical well.

In such an arrangement, when oil with its dissolved gas content flows into the vertically extending deviating bore, it will, within the low pressure area of the deviating bore, expand its dissolved gas into free gas and while the liquid oil gravitates to the lower part or curved portion of the deviating bore, the light gas will flow upwardly within the deviating bore until it reaches the uppermost surrounding portion of the formation which, particularly when partly depleted by previous oil drainage, will absorb the thus released gas, augmenting the gas cap drive for the particular formation.

It is a feature of the invention to so control the withdrawal of oil from the vertical well as to maintain in the lower or curved portion of the deviating bore a liquid seal which functions to preclude escape of the free gas from the gas cap and into the vertical well under pressure conditions prevailing in the formation.

It is also possible to effect repressuring of the oil producing formation by injecting gas under high pressure from the surface of the ground through the deviating bores, which permit the gas thus injected to readily pass into the gas cap area of the formation. Due to the differential pressure, the gas thus introduced will pass through the liquid seal which may, during the repressuring operation, be materially reduced.

It will be apparent, therefore, that an object of the present invention relates to the flow of oil from the formation through deviating bores having a substantially vertical extension into a vertical producing well, accompanied by a separation of dissolved gas from the oil as it moves from the formation through the deviating bore to the vertical producing well and the accumulation of the separated gas in the upper portion of the formation to augment the gas cap drive.

It is a further object of the invention to provide for the repressuring of oil sands by forcing compressed gas from the surface of the ground downwardly through the vertical well and thence outwardly through one or more deviating curved drain bores having substantially vertical extensions, whereby the compressed gas can follow the deviating drain bores as a path of least resistance to the upper portion of the particular oil bearing strata and force the oil into like deviating bores associated with a producing well.

Other objects and advantages of the invention will become apparent as the description proceeds which will be given by reference to the accompanying drawings forming a part of the specification, wherein:

Fig. 1 is a diagrammatic view in cross-section of an exemplary oil producing strata showing the application of the invention thereto; and

Fig. 2 is a view similar to Fig. 1, but illustrating a modified form of sealing arrangement in the lower curved portion of the deviating bore.

Referring to the drawings, Fig. 1 illustrates an exemplary cross-section through an oil sand and a well bore provided with deviating drain bores. The oil sand lies between a more or less impervious upper layer and a lower impervious layer. To the extent that dissolved gas separates from the oil in the oil bearing strata, it accumulates in the "gas" zone immediately below the impervious upper layer, whereas the oil, containing gas in solution therein, occupies the lower portions of the oil bearing strata.

The vertical well 1 having the casing 2 is more or less of conventional form and may be provided with a line 3 for conveying oil from the lower regions of the well to the ground surface. In conformity with the present invention, the vertical well 1 has drilled therefrom one or more deviating bores such as 4 and 5. As will be observed by reference to the drawings, the deviating bore 5 has a downwardly curved portion, indicated generally at 6, relatively close to the vertical well 1. The deviating bore 5 then extends generally upwardly, as indicated at 7, into the upper regions of the oil producing strata. The deviating bore 5 may also be provided with a branch bore as indicated at 8. The method and apparatus for effecting the drilling of deviating

bores of this character from an existing vertical well are disclosed in my prior Patents Nos. 2,336,338 and 2,344,277.

When oil, containing gas in solution therein, flows into the substantially vertically extending bore 7 or the branch bore 8, it finds a comparatively low pressure zone wherein the dissolved gas expands into free gas and the separation of the oil and free gas is facilitated, the oil tending to flow to the vertical well 1 and the gas to join the gas in the upper region of the oil bearing strata and thus augment the tendency to create a gas cap drive. To further facilitate the separation of the dissolved gas from the oil and preclude the escape of the free gas to and through the vertical well 1, I preferably control the rate of withdrawal of oil from the well 1 so as to maintain a liquid seal in the lower curved portion 6 of the deviating bore 5. A similar liquid seal can be maintained in respect to any other deviating bore.

The liquid seal functions to mitigate against the escape of gas, either separated from solution in the oil, or gas that has been injected under high pressure for purposes of repressuring the particular formation. In the drawings, the flow of free gas is indicated by the dotted arrows and the flow of the oil by the full line arrows. The level of the liquid seal in the curved portion 6 of the deviating bore 5 is shown at the horizontal dotted line A—A, which is sufficiently high so that the oil readily overflows into the bottom portions of the vertical well 1, from where it flows through the tube 3 to the ground surface. Some oil, which filters from the lower curved portion 6 of the deviating bore 5, passes through the oil sand reaching the bottom of the well 1 through the perforations as indicated in the drawings. It is within the province of the invention to treat the inner surface of the deviating bore 5 adjacent the well 1 so as to render the same relatively impervious, and thus provide additional security against the escape of gas from this portion of the formation into the vertical well.

It will be appreciated that the arrangement of the deviating bore having the lower curved portion 6 and the relatively vertical portion 7 presents the elements of a large syphon, the bottom of which, filled with liquid, forms a seal for the gas above. So long as there is an adequate flow of liquid from the formation into the bottom of the deviating bore to maintain the required liquid level, there is little or no escape of gas from the formation, thus ensuring the maintenance of an effective gas cap drive. It will be appreciated that the withdrawal of oil can be conveniently regulated at the surface of the well in a conventional manner, and this is true whether the well is operated so as to flow under primary or secondary recovery or whether it is flowing entirely under a gas lift or where the oil is pumped to the surface by mechanisms installed near the bottom of the well. The branch bore 8 merely further facilitates the flow of gas to the gas zone of the formation and serves to tap a part of the oil sand more distant from the vertical well 1 than the vertical portion 7 of the deviating bore 5.

In Fig. 2 I have illustrated the lower curved portion 6 of the deviating bore 5 as packed with gravel 10. This gravel packing increases the resistance to the flow of gases, and therefore definitely augments the effectiveness of the liquid seal at this point in the deviating bore. Additionally, the gravel packing 10 serves the important purpose of preventing the caving in and ob-

struction of the deviating portion at the point of greatest likelihood of such deterioration thereof. In some types of oil bearing formations, this expedient is highly desirable and may be resorted to where the character of the formation is such as to render cave-in of the deviating bore a likely hazard.

It will be appreciated that the deviating bores having substantially vertical extensions reaching into the gas region of the oil bearing strata form ideal low pressure elongated vessels into which the oil, with gas in solution, can flow, and separate, flowing thereafter in two different directions; i. e. the oil downwardly toward the well and the gas upwardly to augment the gas cap drive available in the formation.

In the repressuring of an oil field to increase oil production therefrom, it is highly advantageous to drill a plurality of properly spaced vertical wells each having deviating bores provided with substantially vertical terminal extensions, and to use one or more of such wells for the introduction of high pressure gas while recovering oil from a different one of said wells. In this way, the gas for repressuring is delivered through the deviating bores of the intake wells into the zone of the gas cap of the formation and there functions to drive oil from the formation into the vertical extensions of the deviating bores of the producing well, the gas being largely retained against escape by the liquid seals provided in the lower curved portions of each deviating bore associated with the producing well.

It will be appreciated that the drawings are merely illustrative of the principle of the invention, and that the relative dimensions are not to be construed in limitation of the invention. Substantial benefits may be derived without extending the deviating bores to the extent diagrammatically illustrated in the drawings. However, the general arrangement as depicted in the drawings will be found to give good results.

Having thus described my invention, what I claim is:

1. An improved method for producing oil from an oil and gas bearing formation comprising drilling from a vertical well a deviating bore outwardly and thence upwardly from the point of take-off from the vertical well and until said deviating bore extends into the upper area of the oil and gas bearing formation, permitting oil and gas to separate in said deviating bore at a point remote from the vertical well whereby the gas ascends into said upper area of the oil and gas bearing formation and the oil flows to the vertical well, and controlling the rate of the removal of oil from the vertical well so as to maintain a liquid seal intermediate the upper portion of the deviating bore and the vertical well.

2. A method for improving the production of oil by gas cap drive comprising drilling at least one bore deviating from a vertical well bore at a point near the lower level of an oil bearing strata, and extending said deviating bore upwardly to a point relatively close to the upper level of the oil bearing strata and thereafter controlling the rate of the removal of oil from the vertical well so as to maintain a liquid seal intermediate the upper portion of the deviating bore and the vertical well.

3. A method for producing oil from an oil and gas bearing formation comprising drilling from a vertical well bore a deviating bore outwardly and thence upwardly from the point of take-off from said vertical well until said deviating bore extends into the upper portion of the oil bearing formation, packing the lower portion of the deviating bore with gravel and controlling the rate of removal of the oil from the vertical well so as to maintain a liquid seal intermediate the upper portion of the deviating bore and the vertical well which embraces that portion of the deviating bore packed with gravel.

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