MULTIPLE HORIZON SIMULTANEOUS PRESSURIZATION AND PRODUCTION METHOD

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Application November 15, 1956, Serial No. 622,361

5 Claims. (Cl. 166—10)

This invention relates to methods of producing oil wells having access to more than a single producing horizon within one well by a vertical drive gaseous pressurization method and refers more particularly to such a method of producing oil wells wherein gaseous pressurization is applied to the top portion of the upper horizon to be produced and fluid oil is forced from the bottom portion of the upper horizon to be produced into the top portion of the lower horizon to be produced and oil is recovered from the bottom portion of the lower horizon to be produced.

An object of the invention is to provide a method of producing oil from oil wells having multiple horizons within a single borehole, wherein gaseous pressurization is employed to force the oil downwardly within the oil horizons, the method such that gaseous pressurization need only be applied to the top portion of one horizon to effect motion of the oil downwardly in both horizons.

Another object of the invention is to provide a method of producing oil from oil wells having more than a single producing horizon contacted by a single borehole, the method employing gaseous pressurization to drive the oil vertically within the horizons, oil being moved simultaneously in more than one horizon yet being removed only from a single horizon.

Another object of the invention is to provide a method of producing oil from oil wells having a plurality of producing horizons within one well, the method employing vertical drive gaseous pressurization and permitting the application of excess pressure from one horizon pressurized to another horizon pressurized without recycling and with a minimum loss of pressurization medium.

Another object of the invention is to provide a method for producing oil from oil wells having multiple oil horizons within a single well, the method permitting production of substantially all of the oil from each of the plurality of producing horizons although pressurization is only applied to one horizon and oil is only withdrawn from one horizon.

Another object of the invention is to provide a method of producing multiple horizons within a single well, the method being of extreme simplicity and offering a minimum opportunity to foul up the well completions, a minimum amount of casing being employed and a minimum amount of accurate casing sealing being employed, some of the casing being recoverable after finish of the application of the method.

Another object of the invention is to provide a method of producing oil wells having a plurality of producing horizons within a single well, the method employing vertical drive gaseous pressurization to move the oil through the horizons to be produced, the method requiring a minimum amount of regulation of the pressurization of the horizons and a minimum amount of regulation of the production flow from the wells, only one horizon being pressured and one horizon being produced whereby regulation of pressurization and production of separate horizons within a single well is obviated, the pressurization being applied to the same horizon at all stages in production even when the pressurization horizon is scavenged of substantially all of the oil therein.

Other and further objects of the invention will appear in the course of the following description thereof.

In the drawings, which form a part of the instant specification and are to be read in conjunction therewith, there are shown embodiments of the invention and, in the various views, like numerals are employed to indicate like parts.

The four figures on the single sheet of drawings are shown in the same earth formation and, therefore, the parts of the earth formation, shown in cross section, will be numbered alike in the various figures.

Fig. 1 is a cross-sectional view through an earth formation having a plurality of producing horizons therein, a well completion shown therein adaptable to pressurize the top portion of the upper horizon and flow oil from the lower portion of the upper horizon into the upper portion of the lower horizon.

Fig. 2 is a cross-sectional view through the same earth formation showing a well adapted to pressurize the top portion of the upper horizon and produce oil from the lower portion of the lower horizon.

Fig. 3 is a cross-sectional view through the same earth formation showing a well adaptable to flow oil from the lower portion of the upper horizon to the upper portion of the lower horizon.

Fig. 4 is a cross-sectional view through the same earth formation showing a well adaptable to pressurize the top portion of the upper horizon, flow oil from the lower portion of the upper horizon into the upper portion of the lower horizon and produce oil from the lower portion of the lower horizon.

Referring to Fig. 1, therein is shown a well completion adaptable to pressurize the top portion of the upper horizon and flow oil from the lower portion of the upper horizon into the upper portion of the lower horizon. As in all the figures, ground level is indicated at 10, the earth formations above the upper oil horizon by 11, the cap rock above the upper oil horizon by 12, the upper oil horizon at 13, the earth formations between the upper and lower horizons by 14, cap rock to the lower horizon at 15, the lower oil horizon at 16 and the earth formations below the lower oil horizon at 17. In Fig. 1, borehole 18 is drilled through the upper oil horizon 13 at least to the top of lower horizon 16 and preferably slightly therein. Primary casing 19, having an open lower end or perforations 20 in the lower end thereof, is run at least to, and preferably slightly into the top of the lower oil horizon and sealed to the earth formations along its length from the top of the lower horizon to a level above the top of the upper horizon by annular sealing column of cement or other sealing substance 21. The lower end of the casing 19 may be gravel packed as at 22. Primary casing 19 has flow line 23 extending from one side of the upper end thereof with valve 24 therein. The casing 19 and its surrounding annular seal 21 are perforated as at 25 adjacent the bottom portion of the upper oil horizon 13 and as at 26 adjacent the upper portion of the upper oil horizon 13. Tubing 27 is run within casing 19 below the upper perforations 26 and is sealed to the inner surface of the casing 19 between the perforations by sealing means such as packer 27a. Tubing 27 has flow line 28 with valve 29 at the upper end thereof and is sealed through an opening in the sealed bradhead of casing 19.

In operation of the method in the Fig. 1 showing, gaseous pressurization medium such as air or other gas inert to the oil horizon 13 fluids, is forced through flow line 23, open valve 24 and into casing 19 where it is passed out through perforations 26 into the top portion of the
upper oil horizon. The packer 28 prevents the pressurizing medium from going below it in the casing 19 annulus. Under the application of the gaseous pressurization medium to the top portion of the oil horizon, the oil within the horizon is forced downwardly therein by a gas cap, either an original cap already present in the sand expanded by the pressurization or a new cap formed by the pressurization medium which moves outwardly and downwardly driving the oil before it. Oil passing through the perforations 25 falls down the casing 19 below the packer 28 to the lower end thereof where, when sufficient pressure is exerted thereon, the oil is forced outwardly through the perforations 20 into the top portion of the lower oil horizon, thereby forcing the oil therewith to move downwardly. There is no provision in the Fig. 1 modification for recovering oil from the bottom portion of lower oil horizon 16. After substantially all of the oil is forced through the perforations 25 from the horizon 13, at least in the vicinity of the well bore 18, the gas cap formed by pressurization through perforations 26 reaches the lower perforations 25 and the gaseous pressurization medium then passes through the perforations 25 into the casing 19 again and out the perforations 20 at the top of the lower horizon driving the oil therein downwardly with the formation of a gas cap which expands outwardly and downwardly in the lower horizon. If desired, after the oil has been removed from the upper horizon, the tubing 37 may be removed so any pressurization medium put in through flow line 23 will pass directly down the casing into the perforations 20. The level of pressure in the horizon 13 relative the pressure within the casing 19 determines whether or not the pressurization medium will enter the horizon 13 rather than in the lower horizon. Should the valves 24 and 29 be shut off during pressurization of the upper formation before all the oil is produced therefrom, the sealed-in pressures in the formation will continue to produce the oil through the perforations 25 should the pressure differential within the horizon be sufficient. Again, after all the oil is driven from the upper formation 13, by pressurization of the top portion thereof, the valves 29 and 24 may be closed and pressurization medium will pass from the lower perforations 25 into the top portion of the lower horizon 16. Lower horizon medium may be reduced under the sealed-in pressurization medium from the upper horizon without additional pressurization medium added thereto.

Referring to Fig. 2, therein is shown a well completion for pressurizing the top portion of the upper horizon and producing from the lower portion of the lower horizon. Bore hole 31 is drilled through the earth formations to the bottom or very nearly the bottom of the lower horizon 16. Primary casing 32 is run in the well bore to the bottom or the vicinity of the bottom of the hole bore and the lower horizon 16. Casing 31 is sealed to the well wall from its bottom to a level above the top of the upper oil horizon by an annular column 32 of cement or other sealing substance. Casing 31 has a sealed bradenhead 33 and flow line 34 extending from one side thereof with valve 35 therein. The casing and its surrounding annular seal are perforated as at 36 adjacent the bottom portion of the casing and as at 37 adjacent the top portion of the upper oil horizon. The casing 31 preferably has a sealed lower end 38. Tubing 39 which is sealed at its upper end through the bradenhead 33 extends preferably adjacent to the bottom of the casing 31 and at least below the upper perforations 37. Tubing 39 is sealed to the inside of casing 31 below the upper perforations 37 and preferably close thereto by sealing means such as packer 40. Tubing 39 has conventional T 41 at the upper end thereof with flow line 42 having valve 43 therein extending from one side and plug 44 in the upper end thereof.

In operation of the Fig. 2 modification, gaseous pressurization medium is forced in through flow line 34 and open valve 35 on casing 31. Due to packer 40 blocking the annulus below the perforations and a packed down medium passes out through the perforations into the top portion of the upper horizon 13. The pressurization medium forms a gas cap or adds to the existing gas cap which expands outwardly and downwardly in the oil horizon driving the oil downwardly therein. No provision is made for moving the oil from the lower portion of the upper horizon either to the surface or into the top portion of the lower horizon. Thus, this modification must be employed with one of the other three modifications shown in the sheet of drawings, all of which have access channels between the bottom of the upper horizon and upper portion of the lower horizon. However, the oil in the upper horizon gets into the top portion of the lower horizon, it drives the latter downwardly therein and oil may be recovered through the perforations 36 at the bottom portion of the lower horizon. Again, when the oil has been produced from the first horizon, the gaseous pressurization medium, when the gas cap reaches the bottom of the horizon 13 has no access to the top portion of the lower horizon and must employ means such as is shown in the other three figures. Oil in the perforations 36 may be withdrawn through tubing 39 which has an open lower end. A pumping string may be inserted in the T 44 to 27 and the packer 40 may be removed so any pressurization medium put in through flow line 23 will pass directly down the casing into the perforations 20. The level of pressure in the horizon 13 relative the pressure within the casing 19 determines whether or not the pressurization medium will enter the horizon 13 rather than in the lower horizon. Should the valves 24 and 29 be shut off during pressurization of the upper formation before all the oil is produced therefrom, the sealed-in pressures in the formation will continue to produce the oil through the perforations 25 should the pressure differential within the horizon be sufficient. Again, after all the oil is driven from the upper formation 13, by pressurization of the top portion thereof, the valves 29 and 24 may be closed and pressurization medium will pass from the lower perforations 25 into the top portion of the lower horizon 16. Lower horizon medium may be reduced under the sealed-in pressurization medium from the upper horizon without additional pressurization medium added thereto.

In Fig. 3 is shown a well completion designed to transfer oil from the bottom portion of the upper horizon and pressurization medium eventually therefrom into the top portion of a lower oil horizon. Bore hole 45 is drilled to the top of the lower horizon 16 and preferably slightly thereinto. A cement bridge or seal 46 may be placed at the lower end of the well bore if desired. Surface casing 47 is preferably run and sealed to the surrounding earth formations 11 as at 48 by cement or other suitable sealing substance. A section of casing 49 is extending either an open lower end (in which case the cement seal 46 is not employed) or performances 50 therein is run in the well bore and extends at least from the top of the lower oil formation 16 to the bottom of the upper oil horizon 13. Casing section 49 is sealed to the well wall from the top of the lower horizon 16 to the bottom of the upper horizon 16 by an annular column of cement or other sealing substance 51. The portion of the casing extending within the lower horizon 16 may be gravel packed as at 52 if desired. In some instances, where there are no permeable formations between the upper formation 13 and the lower oil horizon 16, the casing 49 and its surrounding annular seal 51 are not required and the open borehole will serve to convey fluids from the lower portion of the upper horizon to the top portion of the lower horizon. However, this is rarely the case and, even where there are relatively impermeable formations, performance of this type is routine. Fluid flow from the lower portion of oil horizon 13, some of the lower portion of oil horizon 13, some of it may be lost between the horizons and, therefore, the casing 49 and its seal are preferred. The upper formation 13 is sealed from a level adjacent the bottom thereof to a level above the top of the upper horizon whereby to prevent fluid flow along the well bore wall in the horizon or
thereabove. Preferably, this is accomplished by forming an annular column of cement 52 by conventional well practice which is solid and extends as related previously.

In operation of the Fig. 3 modification, it is necessary for the top portion of the upper horizon 15 to be pressurized through some separate well, any of the other three modifications shown in the drawings thereof. When such is the case, and oil is driven downwardly within the horizon, it will pass under the cement plug 52 and into casing 49 and out the perforations 50 thereof into the top portion of the lower horizon. When the gas cap in the upper horizon passes below the plug 52, the pressurization of the top portion thereof will force the oil through and out into the top of the lower horizon 16 thus driving the oil which has been forced therein and the natural oil in the formation downwardly to be recovered from the bottom thereof. There is no provision for recovering oil from the bottom of the horizon in Fig. 3 and it must be recovered therefrom by completions such as are shown in Fig. 2 or 4 or other like vertical drive gaseous pressurization completions.

In Fig. 4 there is shown a well completion adapted to pressurize the top of the upper formation, remove oil from the lower portion of the upper horizon, and put the oil back into the top portion of the lower horizon and remove oil from the lower portion of the lower horizon. This well, alone, of all those shown is alone sufficient to accomplish all aspects of the method in one borehole. The completion of Fig. 1 must be combined with a production well as in Fig. 2 or 4, the completion of Fig. 2 with a showing such as in Fig. 1 or 3, and the completion of Fig. 3 as previously noted, must be combined with the completion as in Fig. 2 or 4.

The borehole 53 of the well is drilled through the earth formations 11, 12, 13, 14, 15 and 16 at least to a level adjacent the bottom of the latter. Casing 54 is run in the borehole to a level adjacent the bottom of the oil horizon 16 and the hole bore 53. Casing 54 preferably has sealed lower end 55. In Figs. 2 and 4, the well bores 31 and 53 may extend below the oil horizon 16 but in each case, the cement seal should extend through the horizon to completely seal off the lower horizon. Casing 54 is sealed to the well bore wall from its lower end to a level above the top of the upper oil horizon by an annular column 56 of cement or other suitable sealing substance. Casing 54 is perforated as at 57 adjacent the bottom portion of horizon 16, as at 58 adjacent the top portion thereof, as at 59 adjacent the bottom portion of the casing drawings is at the production of the upper horizon. Casing 54 preferably has sealed bradenhead 61 with flow line 62 extending from one side thereof with valve 63 therein. Tubing 64 is run within casing 54 to a level below the perforations 58 adjacent the top portion of lower horizon 16 and is sealed to the inside surface of casing 54 between the perforations 57 and 58 in the lower horizon by sealing means such as packer 65 and between the perforations 59 and 60 in the upper formation by sealing means such as packer 66. Tubing 64 preferably has T 67 adjacent the upper end thereof sealed at its upper end by plug 68 and having flow line 69 extending from one side thereof with valve 70 therein. Tubing 64 is preferably sealed through an opening in bradenhead 61.

In operation of the method in the Fig. 4 completion, gaseous pressurization medium may be forced through flow line 62 and opened valve 63 into casing 54 whence it leaks through the upper portion of the upper horizon or expands a gas cap in this formation which drives any oil therein downwardly in the formation. Packer 66 prevents pressurization medium passing below the lower perforations 59. Oil within the horizon 13 may be driven in the perforations 59 and down through the casing 54 below the upper packer 66 to be recovered through perforations 58 in the lower horizon 16. Packer 65 prevents any passage of this oil below the perforations.

Oil driven through perforations 58 drives the oil within the horizon 16 downwardly where it may be recovered through perforations 57 below the packer 65 and withdrawn through tubing 64. A pumping string may be inserted through T 67 upon removal of plug 68 therein to aid in raising the oil to the surface if desired. Continued pressurization of the top portion of the upper horizon will bring the gas cap eventually to the perforations 59 and the pressurization medium will then pass downwardly and out the perforations 58 to pressurize the top portion of the lower oil horizon. Oil may be withdrawn from the perforations 57 until the gas cap finally reaches these perforations. It is evident that any access to the top portion of the formation should be as near the top thereto as possible to avoid by-passing any of the oil therein and any access to the lower portion of a formation to produce oil therefrom should be as close to the bottom of the horizon as possible to avoid the gas cap reaching the access points before all of the oil is produced from the horizons. These considerations apply to all of the modifications described. In all of the modifications shown, since the formations are sealed off, there may be produced by sealed-in pressures for some time after stopping the gaseous pressurization of the horizons. This is a fact determined by actual test.

It should be noted at this point that a gaseous pressurization method such as is set forth here is feasible and workable only when the casings of the wells employed are properly sealed throughout the designated portions of their length, as well as above and below, the horizon to be produced. All casing seals in both pressure and production wells must be of sufficient strength to secure whatever pressures are employed in driving the fluid and gaseous hydrocarbons downwardly through the sand body and must offer no means of escape for those pressures except at the points designated within the oil sand.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth together with other advantages which are obvious and which are inherent to the method. It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter hereinabove set forth or shown in the accompanying drawings is as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. A method of producing oil from earth formations containing more than a single oil horizon accessible to a single well comprising the steps of establishing a first sealed flow channel between the surface and the top portion of an upper oil horizon communicating only with the surface and said top portion of the upper oil horizon, establishing a second sealed flow channel between the bottom portion of said upper oil horizon and the top portion of a lower oil horizon communicating only between the said bottom portion and top portion, establishing a third sealed flow channel between the surface and the bottom portion of the said lower oil horizon communicating only between the surface and said bottom portion, flowing gaseous pressurization medium into the first flow channel and top portion of the upper oil horizon to drive any oil therein downwardly through the said bottom portion of the upper oil horizon, flowing gas to the top portion of the lower oil horizon, and producing oil from said third flow channel and bottom portion of the lower oil horizon at least partially under the imput of the pressurization of the upper oil horizon through said first flow channel.

2. A method as in claim 1 wherein the flowing of gaseous pressurization medium into the first flow channel and top portion of the upper oil horizon continues
after all of the oil has been forced from the upper horizon whereby the gaseous pressurization medium passes through the second flow channel and oil is continued to be produced from the bottom portion of the lower horizon through said third flow channel.

3. A method as in claim 1 wherein the first and second flow channels are positioned within a single well.

4. A method as in claim 1 wherein the first and third flow channels are positioned in a single well.

5. A method as in claim 1 wherein the first, second and third flow channels are all positioned within a single well.

References Cited in the file of this patent

UNITED STATES PATENTS

2,548,059 Ramsey ------------ Apr. 10, 1951
2,754,911 Spearow ------------ July 17, 1956