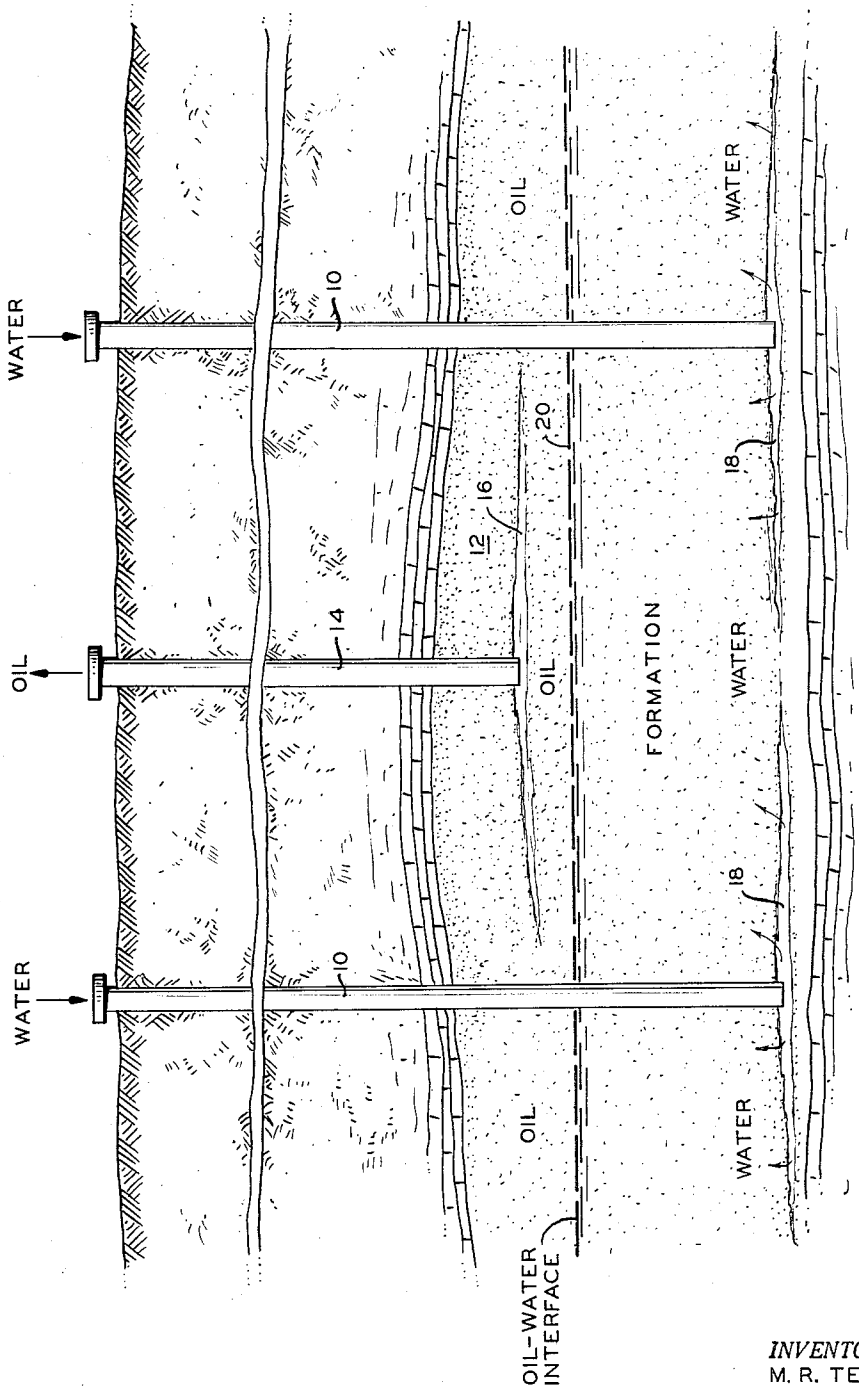
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WATER FLOODING METHOD

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INVENTOR.
M. R. TEK

BY Hudson & Young

ATTORNEYS

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WATER FLOODING METHOD

Mehmet R. Tek, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

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This invention relates to a process for producing oil from an oil-bearing formation by applying water drive thereto.

Production of oil from underground oil-bearing formations by water flooding is a current practice in the petroleum industry. This method is usually applied as a secondary recovery method but is also applicable to primary production. After a substantial portion of the oil in the formation has been recovered by other means, residual oil is frequently recovered by injecting water into a series of bore holes or wells surrounding a somewhat centrally located well (producing well) and forcing the water radially or horizontally toward the producing well so as to drive oil thereto.

In water flooding as currently practiced a number of problems or difficulties arise which lower the economic advantage of this type of oil recovery. There is a very slow response in the way of oil production to water flooding as currently practiced, necessitating a great deal of effort and expense in saturating the formation before any appreciable quantity of oil is produced. In many formations subjected to water flooding, channeling interferes with the displacement of oil from large sections of the formation. There is a long flood-out time which adds to the cost of oil production and defers the time at which the production program yields a financial return. Another disadvantage lies in the fact that conventional water flooding results in the by-passing of large areas which contain appreciable amounts of recoverable oil. Other disadvantages in water flooding are known to those in the industry.

The invention is concerned with a method or process for recovering oil by water drive which eliminates or minimizes the above enumerated disadvantages inherent in current water flooding techniques.

Accordingly, it is an object of the invention to provide an improved method for oil recovery by water flooding. Another object is to provide a method of oil recovery which utilizes vertical water drive. A further object is to provide oil recovery by water drive which eliminates or minimizes any of the problems inherent in currently practiced water flooding. Other objects of the invention will become apparent from a consideration of the accompanying disclosure.

The method of the invention comprises forming horizontal fractures in an oil-bearing formation at substantially different levels so that the fractures at one level overlap, at least in part, the fractures at the other level; injecting water into the fractures at one level to fill the same and form a pancake-type water layer; and thereafter applying pressure to the water layer to force water thru the formation to the fractures at the other level, thereby driving oil thereto so that it can be recovered from a bore hole or production well penetrating the formation in the area of the fractures into which water is not initially introduced. The preferred procedure comprises fracturing the oil-bearing formation around a centrally positioned production well surrounded by a number of injection wells

and also fracturing the formation around the injection wells at a substantially different level in the formation than the level of the fractures in the production well. The fractures in the formation around the injection wells are preferably made at a lower level or adjacent the bottom of the formation and the fractures around the production well are made at a higher level or adjacent the top of the formation so that the water drive is upwardly from the fractures at the lower level to the fractures at the higher level, thereby taking advantage of the buoyancy of oil in water. However, it is feasible to operate in the reverse manner and may be advantageous to do so in certain applications and formations.

In most oil bearing formations the permeability is sufficiently low to offer substantial resistance to water flooding but upon fracturing the formation the water readily flows into the fracture to form a thin layer of water extending over an appreciable area surrounding an injection well. In the process of the invention where a fractured area overlaps the pancake-type water layer, continued application of hydraulic pressure to the water layer provides a very effective linear vertical water drive of the flood front which effects substantially an immediate yield of oil from the water flooding effort with a minimum consumption of water. Ordinarily after the injection fractures are filled with water and pressure is applied to force the water through the formation there is competition between radial flow at the periphery of the fracture and vertical flow; however, the vertical distance between the upper and lower fracture levels is relatively short so that even though the penetration radially from the periphery of the water layer is equal to the distance between the two fracture levels, the water loss is relatively insignificant. A factor which tends to minimize the peripheral radial flow of water is the lower pressure drop between the fracture levels as compared to the pressure drop horizontally thru the formation for a substantially greater distance. This assumes, of course, that the resistance to horizontal flow thru the fractures is substantially negligible. In order to obtain adequate vertical flow from one fracture level to the other, it is only necessary that the input pressure exceed the formation pressure by at least the hydrostatic head of the vertical drive desired. Practically, however, if recovery over the entire area of fracture is desired the input pressure should be additionally increased a calculated amount to compensate for the pressure drop between fractures.

A more complete understanding of the invention may be had by reference to the schematic drawing which shows a broken vertical section through an oil bearing formation penetrated by bore holes or wells and fractures in accordance with the invention.

Referring to the drawing, wells 10 are utilized as water injection wells and penetrate to a level near the bottom of the oil bearing formation 12, while the well 14 is a producing well and penetrates the formation to an upper level thereof near the top of the formation. The formation is fractured by any suitable means, such as by hydraulic fracturing, around producing well 14 as shown at 16 and the formation is also fractured around injection wells 10 as at 18 so that fracture 16 overlaps a substantial portion of fractures 18. It is to be understood, of course, that other water injection wells surrounding well 14 are fractured in the manner shown for wells 10. The 5 or 7 spot pattern or any other suitable well pattern may be utilized in recovery of oil by the method of the invention. After the fracturing is effected around the injection and producing wells at the desired levels, water is injected by conventional methods through wells 10 so as to fill the fractures with water and thereby form or establish a series of pancake layers of water in the fractures around the injection wells in a pattern surrounding the producing

well. At this point additional pressure is applied to the water in the injection wells and in the fractures extending out therefrom so as to force water upwardly toward fracture **16** and thereby drive oil from the lower section of the formation upwardly to fracture **16**. As this procedure continues the oil-water interface **20** progresses upwardly until water reaches fracture **16** and the oil driven from the formation is recovered thru well **14**.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for applying water drive to an underground oil-bearing formation which comprises horizontally fracturing said formation at a lower level therein around at least one well; horizontally fracturing said formation at an upper level therein around at least one additional well so that the upper and lower fractures overlap; forcing water into the formation thru the fractures at one level so as to drive oil in said formation toward the fractures at the other level; and recovering oil from said other level.

2. The process of claim 1 wherein water is forced into the fractures at said lower level and oil is recovered from the fractures at said upper level.

3. The process of claim 1 wherein said formation is fractured around several injection wells near the bottom

of said formation and around a centrally positioned production well near the top of said formation.

4. A process for applying water drive to an underground oil-bearing formation substantially free of vertical fractures which comprises horizontally fracturing said formation at an upper level therein around a production well; horizontally fracturing said formation at a lower level around a plurality of wells surrounding said production well so that the upper and lower fractures overlap; introducing water to the lower fractures and forcing same toward the upper fractures so as to drive oil to said upper fractures and to said production well.

5. A process for producing oil from an oil-bearing underground formation which comprises forming horizontal fractures in said formation at substantially different levels therein so that the fractures at one level overlap, at least in part, the fractures at the other level; injecting water into the fractures at one level to fill same and form a pancake-type water layer; and applying pressure to force water from said layer thru said formation to the fractures at the other level so as to drive oil to last said fractures.

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