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FLUID DRIVE RECOVERY OF OIL

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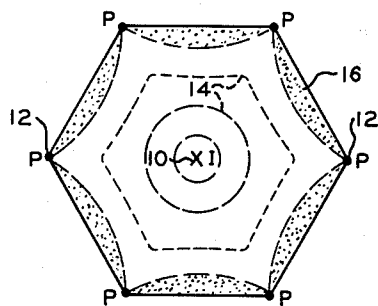


FIG. 1

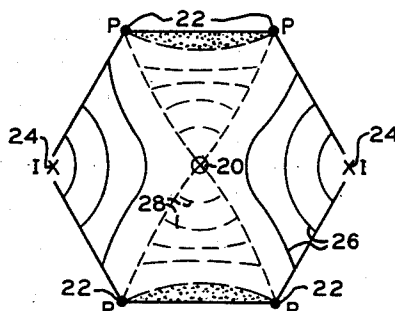


FIG. 2

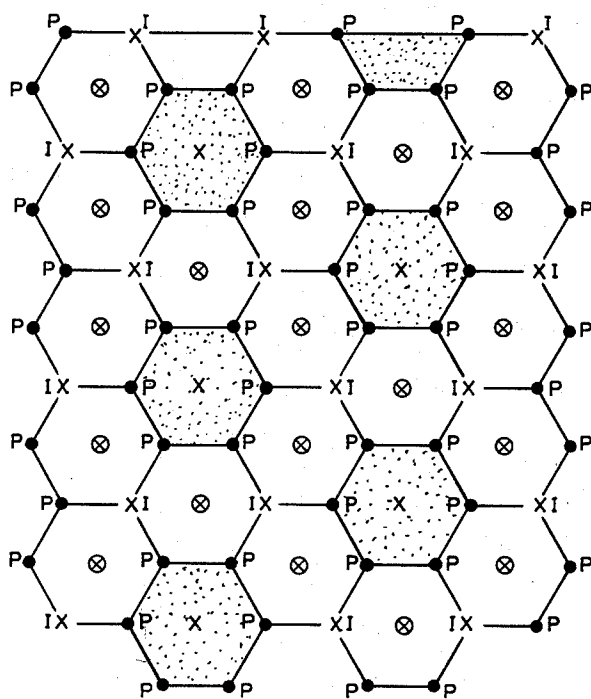


FIG. 3

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FLUID DRIVE RECOVERY OF OIL

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This invention is concerned with an improved process or method for recovering hydrocarbons from an oil-bearing stratum by fluid drive displacement. A specific aspect of the invention relates to an improved method of producing oil from an oil bearing stratum utilizing a seven-spot well pattern.

The conventional seven-spot well arrangement, consisting of a center well and six surrounding wells, is one of the few basic well patterns known to the oil industry. If a field is developed into a number of seven-spot well patterns, and is considered for secondary or tertiary oil production, the operators would choose either the conventional seven-spot (six corner injection wells and a center producer) or the inverted seven-spot (center injection well and six corner producers) well arrangement to flood the reservoir. From an economic standpoint it is more likely that the latter would be chosen as the flooding pattern, since the swept area in either case is the same.

This invention is directed to an improved flooding pattern in a seven-spot well arrangement for producing hydrocarbons from an oil-bearing stratum with a displacing fluid.

Accordingly, it is an object of the invention to provide an improved method for producing oil from a subterranean-oil bearing stratum. Another object is to provide a novel flooding pattern for use in a seven-spot well arrangement which is more efficient than conventional flooding patterns. A further object of the invention is to produce or sweep a greater proportion of a seven-spot well pattern than is produced by conventional practice, leaving lower percentage of unswept area within the well pattern. Other objects of the invention will become apparent upon consideration of the accompanying disclosure.

In accordance with a broad aspect of the invention, a seven-spot well pattern in an oil field is produced by injecting a driving and displacing fluid thru diametrically opposite wells in the ring and producing oil thru the central well and thru the other four wells in the ring. Injection of driving fluid and production of oil is continued in this pattern until the driving fluid has swept thru at least three-fourths of the distance from the injection wells to the central well, and preferably, until break thru of driving fluid at the central well has occurred. At this time the central well is closed to production and driving fluid is injected therethru while continuing the injection of driving fluid thru the two injection wells in the ring and producing thru the other four wells in the ring. It is preferred to maintain back pressure on the producing wells and to control the back pressure so as to reach break thru of displacing fluid at the five producing wells substantially at the same time.

A more complete understanding of the invention may be had by reference to the schematic drawing of which FIGURE 1 is a plan view of a seven-spot well pattern showing conventional injection practice; FIGURE 2 is a plan view of a conventional seven-spot well pattern illustrating the novel flow pattern of the invention at break-thru in the central well and other production wells; and FIGURE 3 is a plan view of an oil field to which the seven-spot well and flow pattern of the invention has been applied.

Referring to FIGURE 1, a central well designated 10 is surrounded by a ring of six wells 12 uniformly spaced. Well 10 is used as an injection well while wells 12 are

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production wells. Dotted lines 14 illustrate the progressive boundary of the displacing fluid during the course of the process. The six shaded areas 16 are left unswept because it is difficult and uneconomical to carry the displacing process further.

FIGURE 2 illustrates a similar well pattern to that shown in FIGURE 1 but one in which a different flooding or displacing pattern has been utilized. Here again, a central well 20 is surrounded by a ring of six wells of which wells 22 are production wells, along with well 20, and wells 24 are injection wells. Injection thru well 24 is continued until driving or displacing fluid is produced thru well 20 or until the driving fluid approaches the vicinity of this well such as at least three-fourths of the distance thru the stratum from wells 24 to well 20. Solid lines 26 represent the progress of the displacing fluid front thru the stratum toward the production wells. At the time of break thru at wells 20 and 22, the pattern covered by dotted lines 28 is unswept. By terminating production thru well 20 at about the time of break thru at the well and utilizing well 20 as an injection well, along with wells 24 while producing thru wells 22 (the other four wells in the ring) most of the unswept portion of the pattern is produced so that only the shaded portions are unswept at the time when it becomes impractical and uneconomical to continue the production process further. At this point in the project or process the unswept region of the pattern is greatly diminished from that illustrated in FIGURE 1, representing conventional practice. In other words, the process of the invention reduces the unswept area of the pattern utilizing conventional displacement as illustrated in FIGURE 1, by approximately 67 percent.

The application of the process illustrated in FIGURE 2 to an oil field is illustrated in FIGURE 3. The well patterns which are shaded are produced by fluid drive or flooding in the manner illustrated for FIGURE 1, i.e., inverted seven-spot well pattern drive. Each of these shaded patterns is surrounded by six other seven-spot patterns which are produced in accordance with the invention by utilizing two diametrically opposite wells as injection wells and the other four wells in the ring as production wells with the central well being converted from a production well to an injection well approximately at the time of break thru. In FIGURE 3 the initial production wells are designated "P" and the injection wells are designated "I." Central wells in the unshaded well patterns are designated "X" and enclosed in a circle since they are producing wells during the early phase of the process and injection wells during the terminal phase of the process.

In practice, various displacing fluids have been utilized. The most common comprises steam or water to which may be added various soluble materials in minor amounts. Normally gaseous hydrocarbons are also injected under high pressure so that the hydrocarbons go into solution in the oil, thereby reducing the viscosity and surface tension of the oil as well as increasing its volume. This amounts to a miscible fluid drive because the light hydrocarbons are miscible in the oil. Because of the cost of these hydrocarbons, the practice of injecting a certain percent of the pore volume of the formation to be flooded and following this with a cheaper fluid, such as air, steam, or water, is followed. Another method comprises injecting liquid hydrocarbons of lower viscosity than the crude oil to be produced and driving the liquid hydrocarbon thru the formation with a cheaper driving fluid. Some methods utilize alternate slugs of miscible fluid and driving fluid, such as propane and gas, such as natural gas, air, CO₂, etc., which can be followed by water or steam.

It is advantageous to keep the miscible displacing fluid in the formation as long as possible and therefore this displacing fluid should not be produced thru any one of the boreholes until breakthrough at each of the boreholes is

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approached or arrived at. If break thru of displacing fluid is sensed at any of the producing wells, such well should be closed until break thru at the other wells is sensed or is imminent. This preserves the miscible displacing fluid in the formation until the maximum sweep of the formation has been effected with the given well pattern.

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 method for producing an oil-bearing stratum by fluid drive displacement using a seven-spot well pattern consisting of a central well and a ring of six surrounding wells spaced substantially uniformly in said ring which comprises injecting driving fluid into said stratum thru a pair of diametrically opposite wells in said ring so as to produce oil thru said central well and the other four wells in said ring; continuing injection of said fluid thru said pair of wells until said fluid has swept at least three fourths of the distance to said central well; thereafter and before producing any appreciable quantity of said fluid thru said central well, terminating production thru said central well and injecting said fluid therethru while continuing injection of said fluid thru said pair of wells; and continuing production of oil thru said other four wells.

2. The process of claim 1 wherein said fluid comprises liquid phase.

3. The process of claim 1 wherein said fluid comprises gas phase.

4. The process of claim 1 wherein said fluid comprises water.

5. The process of claim 1 wherein said fluid comprises hydrocarbon.

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6. The process of claim 1 wherein said fluid comprises normally gaseous hydrocarbon.

7. The process of claim 1 wherein production thru said central well is continued until break thru of said fluid therein.

8. The process of claim 1 wherein break thru at any one of the producing wells is sensed first and said one well is closed until break thru at the other wells occurs.

9. The process of claim 1 wherein production at break thru is terminated at each well except the last until break thru has occurred at all production wells.

10. A method for producing an oil-bearing stratum by fluid drive displacement using a seven-spot well pattern consisting of a central well and a ring of six surrounding wells spaced substantially uniformly in said ring which comprises injecting driving fluid into said stratum thru a pair of diametrically opposite wells in said ring so as to produce oil thru said central well and the other four wells in said ring; continuing the injection of said fluid thru said pair of wells and production of oil thru the central and four ring wells until break thru at said central well; terminating production thru said central well at break thru and injecting said fluid therethru while continuing the injection of said fluid thru said pair of wells; and producing oil thru said four wells.

11. The process of claim 10 including maintaining back pressure on the production wells during production so as to control the time of break thru on said wells.

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