March 31, 1964 M. SANTOURIAN 3,126,951

MISCIBLE PHASE FLOODING IN OIL PRODUCTION

Filed April 2, 1962

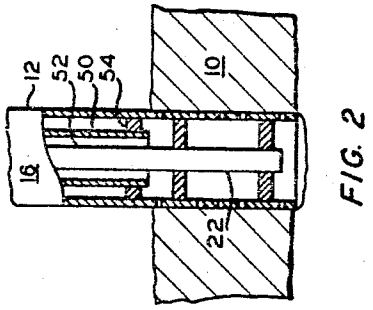

FIG. 2

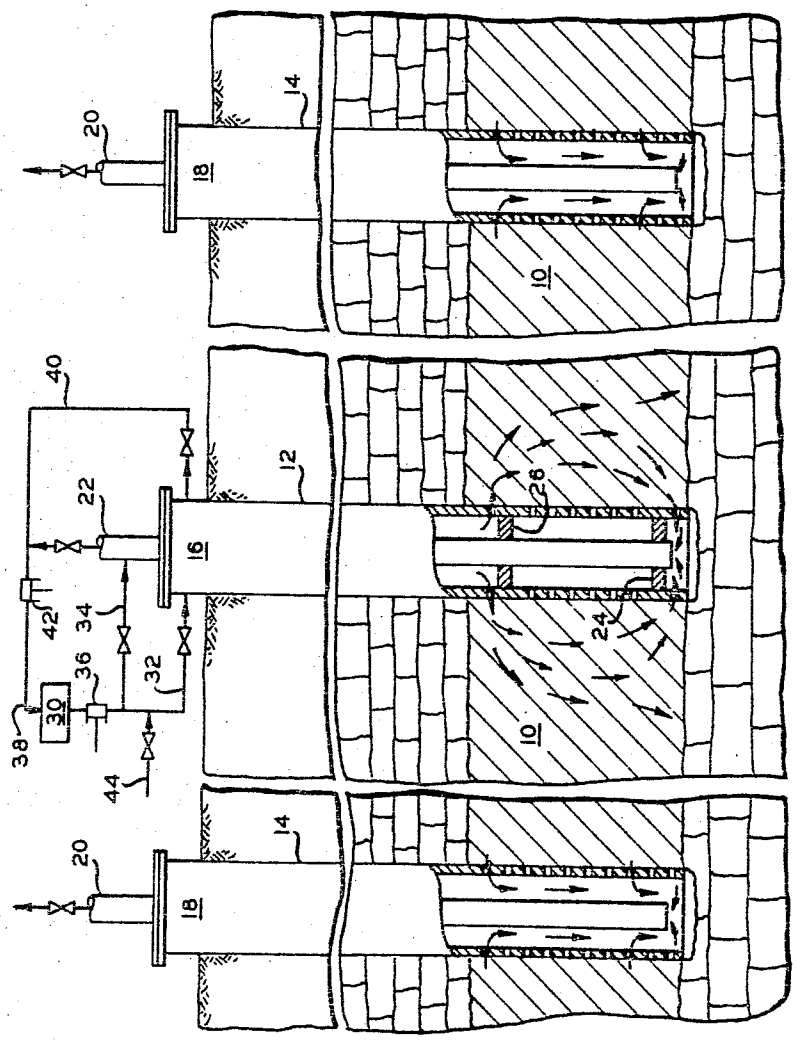

FIG. 1

INVENTOR.
MELCON SANTOURIAN

BY Young & Quigg

ATTORNEYS

United States Patent Office 3,126,951
Patented Mar. 31, 1964

3,126,951

MISCIBLE PHASE FLOODING IN OIL PRODUCTION

Melcon Santourian, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

Filed Apr. 2, 1962, Ser. No. 184,279
16 Claims. (Cl. 166—9)

This invention relates to a method of establishing a transition zone downhole around an injection well in a miscible fluid drive process in recovering oil from an oil-bearing stratum and utilizing this method in such a fluid drive process to produce oil.

The need for a transition zone in a miscible fluid flood or drive of a miscible fluid transition zone thru an oil-bearing stratum to produce oil thru one or more production wells is clearly taught in U.S. Patent 2,867,277 to C. F. Weinaug et al. The prior art method utilizing this technique involves mixing some of the oil from the stratum to be produced with a less viscous, miscible fluid which forms a mixture of intermediate viscosity relative to the petroleum and to the miscible displacement fluid. The premix is formed above ground and injected into the stratum thru an injection well to displace oil radially outwardly from the injection well and a driving fluid is then injected to drive the transition phase thru the stratum toward the production wells thereby producing oil in the production wells.

This invention is concerned with a unique method of forming a better transition zone in the stratum around an injection well and to the use of this zone in displacing oil from the stratum by fluid drive.

Accordingly, it is an object of the invention to provide an improved method of forming a miscible phase transition zone in an oil bearing stratum around an injection well. Another object is to provide an improved transition zone which varies gradually in viscosity from the forward area adjacent the in-place oil to the area adjacent the injection well and in which the viscosity gradually varies substantially from that of the in-place oil to that of the miscible fluid utilized in forming the transition zone with the oil. A further object is to provide an improved fluid drive process utilizing a more efficient transition zone. Other objects of the invention will become apparent under consideration of the accompanying disclosure.

A broad aspect of the invention comprises passing a fluid miscible with the in-place oil in an oil-bearing stratum vertically thru an annular section of the stratum around an injection well therein so as to form a solution of the fluid and oil which is produced either thru the annulus or thru the tubing of the well and recycled to the stratum until a substantial annular section of the stratum contains the solution of oil and fluid. During circulation of the solution thru the stratum, the production wells surrounding the injection well are preferably left open to flow so that there is appreciable flow of the miscible fluid and solution to a substantial depth into the stratum from the injection well. This creates a larger transition zone where this is desired.

In order to permit vertical flow or miscible fluid and solution thru an annular section of stratum around the injection well, packers are placed on a tubing string in the well extending to a level adjacent the bottom of the stratum. A first packer is set just above the bottom of the stratum and a second packer is placed just below the top of the stratum to provide sections of the stratum below the first packer and above the second packer for ingress and egress of fluid. Circulation is effected either thru the annulus into the upper section of the stratum and out the lower section of stratum into the tubing string of vice versa.

Any of the fluids of the prior art ranging in viscosity from natural gas to kerosene which are miscible with the in-place oil may be utilized in establishing the transition zone. These include in addition to natural gas and kerosene, L.P.G., any of the normally gaseous light hydrocarbons, garoline boiling range hydrocarbons, etc. Mixtures of these fluids may also be utilized in establishing a transition zone in accordance with the invention. It is feasible to use one of the heavier fluids for establishing the transition zone by circulation of the same thru the stratum to pick up oil and recycling the resulting solution to the stratum, and then using one of the lighter fluids as the driving fluid or as another phase behind the transition phase and in front of the driving fluid. The driving fluid may comprise natural gas or any of the light hydrocarbons. It may also comprise water, steam air, or other relatively cheap gas such as combustion gas. Nitrogen may also be utilized.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing of which FIGURE 1 is an elevation in partial section of an arrangement of wells and equipment for effecting the invention, and FIGURE 2 is a partial elevation in partial section of another injection well arrangement for effecting the invention.

Referring to FIGURE 1, an oil-bearing stratum **10** is penetrated by an injection well **12** and offset production wells **14**. The wells are provided with casings **16** and **18**, respectively, which extend thru stratum **10** and are perforated for ingress and egress of fluids. The production wells **14** are provided with tubing strings **20** and injection well **12** contains a tubing string **22** which extends approximately to the bottom of the stratum. A first packer **24** is set adjacent the lower end to tubing **22** and above the bottom of the stratum. A second packer **26** is positioned on tubing string **22** subjacent the top of stratum **10**. This arrangement allows flow of fluids as indicated by the arrows from the annulus of well **12** generally vertically thru an annular section of stratum surrounding this well and into the well below packer **24** for flow up thru the tubing. This illustrates flow when injection of miscible fluid is thru the annulus with production out thru the tubing. The flow may be in the reverse order, i.e., thru the tubing into the bottom of the well and up thru the stratum to the annulus above packer **26**, and out of the well.

A storage tank **30** is connected with casing **16** thru line **32** and with tubing **22** thru line **34** for injection of fluid under the impetus of pump **36**. Line **38** connects tubing string **22** with storage tank **30** for flow of produced fluid when producing thru the tubing. Line **40** connects the well annulus with line **38** for flow of produced fluids when producing thru the well annulus. Pump **42** is positioned in line **38** to assist in flow of produced fluids to the storage tank **30**. Line **44** connects with line **32** for injection of miscible fluid at any time during the operation in which additional miscible fluid is desired. This line may also connect with a source of driving fluid to be injected to drive the transition zone thru the stratum to produce oil in the production wells.

FIGURE 2 shows a concentric tubing **50** around inner tubing **22** forming an annulus **52** for flow of fluids to and from the stratum. The casing annulus is packed off by packer **54**. This arrangement is advantageous in deep wells in decreasing the volume of liquid required in the annulus. When using the arrangement of FIGURE 2, lines **32** and **40** connect with annulus **52** or tubing **50**.

To start the operation, the selected miscible fluid is injected either thru line **32** or thru line **34**. The source of this miscible fluid may be line **44** or a stored supply in tank **30**. Assuming that miscible fluid is injected thru the annulus of well **12** from line **32**, this injected fluid

passes thru the perforations in casing **16** above packer **26** into the stratum **10**; and, since the least resistance to flow is vertically thru the stratum to the perforations in casings **16** below packer **24**, the flow is substantially thru this path as indicated by the arrows. In passing into the stratum, the miscible fluid mixes and forms a solution with the in-place oil which is produced thru tubing string **22** and deposited in storage tank **30** for recycling thru line **32** by means of pump **36**. As recycling is continued, the viscosity of the produced fluid approaches the viscosity of the in-place oil and the recycling can be terminated at any suitable time with a substantial annular section of the stratum containing the solution.

In this method of setting up the transition zone surrounding well **12** there is a lateral or radial drive of the miscible fluid and solution due to the pressure gradient between well **12** and wells **14** even though wells **14** are not open to flow. In order to increase the size of the transition zone, it is desirable to open wells **14** to flow thru tubing **20**. It is inherent in the method of the invention that the outermost section of the transition zone has a viscosity very closely approaching the viscosity of the in-place oil because of the fact that the concentration of miscible fluid in the deepest penetration thereof is very low and increases toward well **12**. Hence, a much more uniformly and gradually varying viscosity gradient is found in the transition zone established by the method of the invention than can be effected by premixing formation oil and miscible fluid above ground and injecting the same into the stratum around an injection well.

After establishing the desired transition zone comprising a solution of oil and miscible fluid of uniformly and gradually increasing viscosity from the injection well outwardly to the outermost area of the desired zone, sometimes called the interface between the transition zone and the oil being displaced, a driving fluid is injected thru injection well **12** so as to force the transition zone radially outwardly toward the production wells. The injection of driving fluid may be initiated without removing packers **24** and **26** by injecting thru both lines **32** and **34** from a source connected with line **4**. However, it is preferred to remove packers **24** and **26** before injecting the driving fluid.

Oil produced in wells **14** by the miscible fluid drive is recovered by conventional means thru tubing **20**. Of course, the process is continued until the miscible fluid and transition zone fluid are produced in wells **14** and recovered.

Well **12** may be a central well surrounded by a ring of production wells **14** in a 5-, 7-, or 9-spot pattern. In the arrangement shown in the drawing, well **12** may be by one injection well in a line of injection wells, while wells **14** are production wells in parallel lines of production wells on either side of a line of wells **12**. Other lines of injection wells may flank the lines of production wells **14** on the opposite side from injection wells **12**. Production in such a pattern may be effected simultaneously thru the various injection wells or successively.

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 of establishing a transition zone downhole around an injection well for use in a miscible fluid drive process in recovering oil from an oil-bearing stratum prior to injection of a driving fluid and forcing same thru said stratum from said injection well to at least one offset production well, which method comprises providing said injection well with a tubing extending to a lower level of said stratum to form an annulus with the wall of the well; positioning a first packer on said tubing adjacent the lower end thereof so as to leave a bottom section of said stratum below said first packer; positioning a second packer on said tubing subjacent the top of said stratum so as to leave a top section of said stratum above said second packer; injecting a light fluid miscible with the oil in said stratum thru one of said tubing and annulus and thru said stratum intermediate said top and bottom sections to produce a solution of said fluid and oil from said stratum thru the other of said tubing and annulus; recycling said solution thru said tubing and annulus so as to displace more oil from said stratum; and continuing the injection of said fluid and the recycling of said solution until a substantial section of said stratum around said injection well as filled with a solution of oil and said fluid miscible with in-place oil to form said transition zone preparatory to driving with a driving fluid.

2. The method of claim 1 wherein said miscible fluid is L.P.G.

3. The method of claim 1 wherein said miscible fluid is natural gas.

4. The method of claim 1 wherein said miscible fluid is a mixture of light normally gaseous hydrocarbons.

5. The process of claim 1 wherein said miscible fluid is a mixture of light normally liquid hydrocarbons.

6. The process of claim 1 wherein said at least one production well is open to flow during circulation of fluid thru said stratum between the tubing and annulus so as to cause expansion of the transition zone.

7. The method of claim 1 wherein said miscible fluid is injected thru said tubing and said solution is produced thru said annulus.

8. The method of claim 1 wherein said miscible fluid is injected thru said annulus and said solution is produced thru said tubing.

9. A process for producing oil from an oil-bearing stratum penetrated by an injection well and at least one offset production well which comprises establishing a transition zone around said injection well by the method of claim 1; thereafter, driving said solution and said transition zone radially outwardly from said injection well toward said at least one production well so as to produce oil therein by injecting a driving fluid into said injection well; and recovering the produced oil from said production well.

10. The process of claim 9 using natural gas as said driving fluid.

11. The process of claim 9 using normally liquid light hydrocarbons as said driving fluid.

12. The process of claim 9 using normally gaseous hydrocarbons as said driving fluid.

13. The process of claim 9 using water as said driving fluid.

14. The process of claim 9 using air as said driving fluid.

15. The process of claim 9 wherein said packers are removed from the well prior to the driving step.

16. The process of claim 9 wherein said packers are left in place during the driving step and said driving fluid is injected thru both the tubing and the annulus.

References Cited in the file of this patent

UNITED STATES PATENTS

2,725,106	Spearow	Nov. 29, 1955
2,765,850	Allen	Oct. 9, 1956