# United States Patent [19]

**Brown et al.**

[11] **4,177,752**

[45] **Dec. 11, 1979**


[54] **HIGH VERTICAL CONFORMANCE STEAM DRIVE OIL RECOVERY METHOD**


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[51] **Int. Cl.**² .............................................. **E21B 43/24**

[52] **U.S. Cl.** .................................... **166/263**; 166/245; 166/261; 166/272

[58] **Field of Search** ............... 166/272, 245, 268, 261, 166/263


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[57] **ABSTRACT**


The vertical conformance of a steam drive process is improved and steam override reduced by penetrating the zone between one injector and one producer, with an infill well which is in fluid communication with the bottom half of the formation, and producing petroleum from the infill well after steam channeling has occurred at the production well. After the water cut of the fluids being produced from the infill well reaches 95 percent, the infill well is converted from a producer to an injector and hot water is injected into the lower portion of the formation via the infill well and fluids are produced from the production well. By this means, oil is recovered from the lower portions of the formation adjacent the production well. After water breakthrough occurs at the production well, steam is injected into the infill well and fluids are recovered from the production well. By this multi-step process involving the infill well, the amount of oil recovered from the portion of the formation in the recovery zone defined by the injection and production well is increased significantly.


**14 Claims, 8 Drawing Figures**

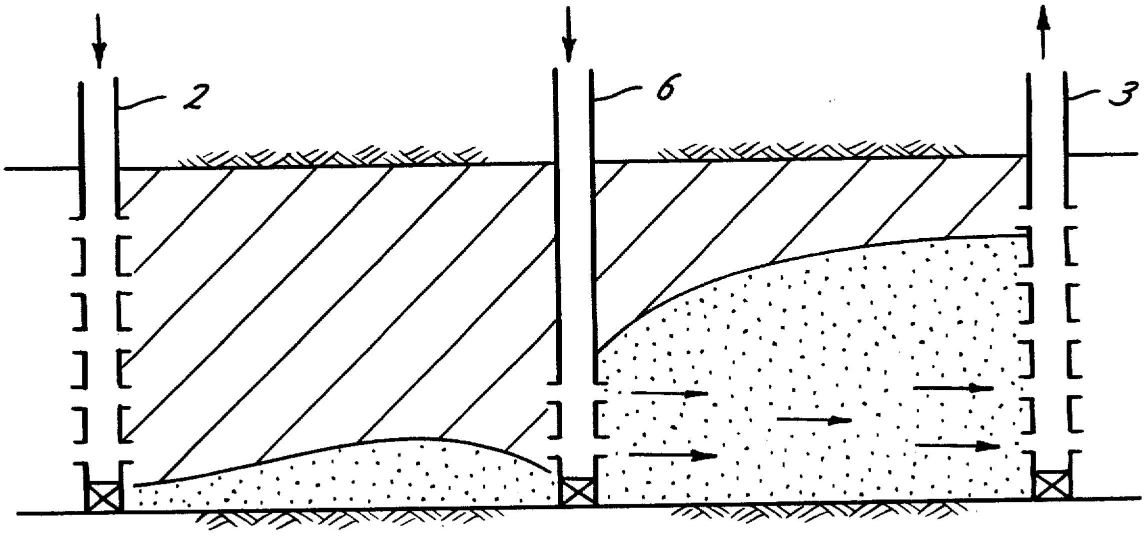


Fig. 1
PRIOR ART

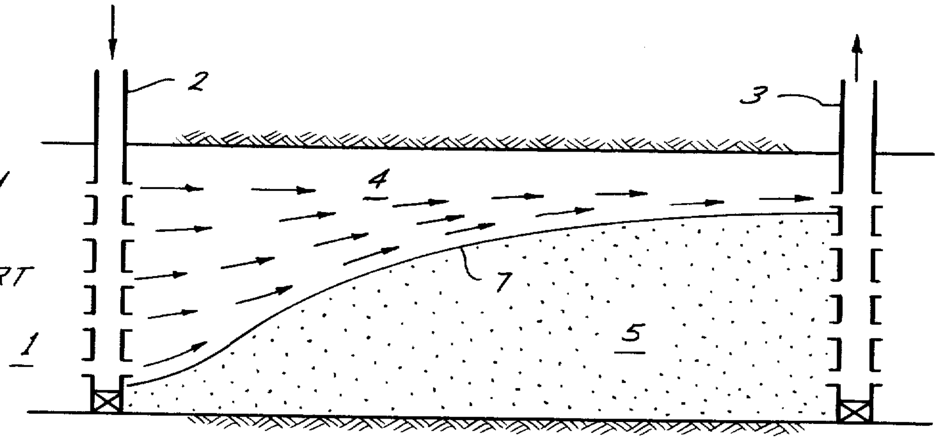



Fig. 2

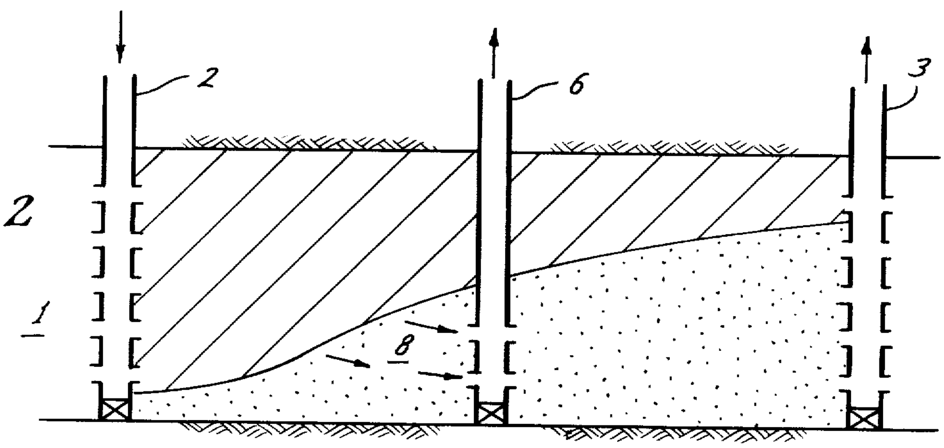



Fig. 3

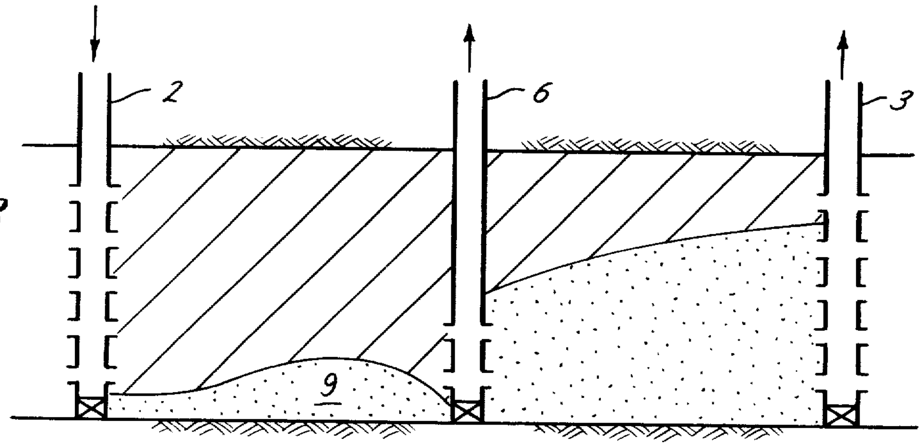


Fig. 4

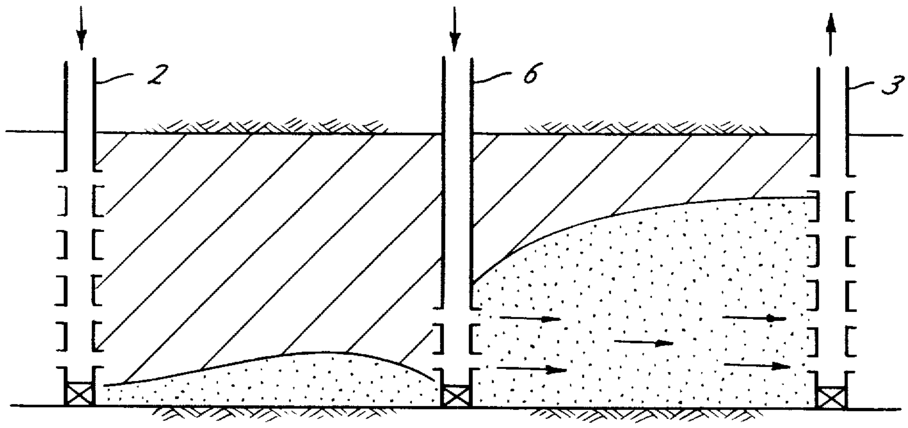
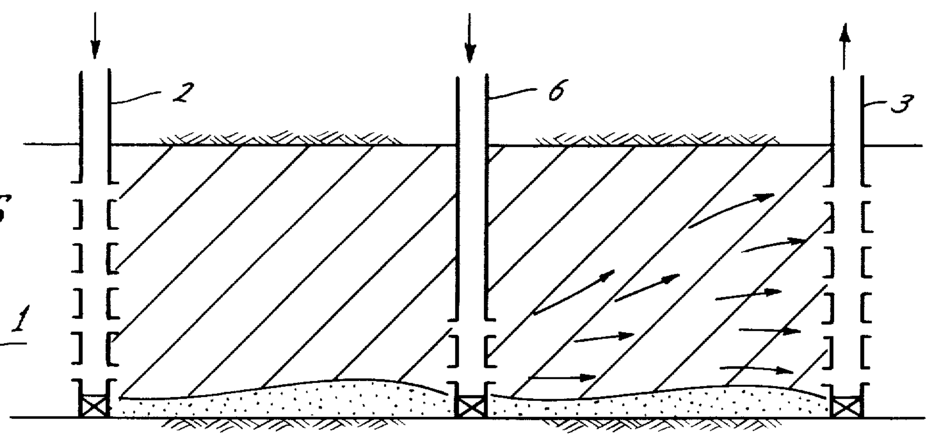



Fig. 5



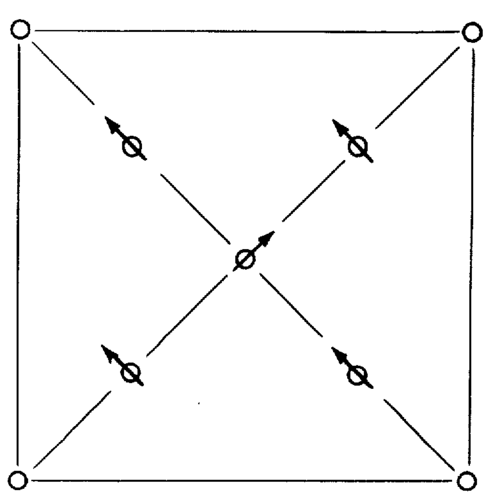



Fig. 6

INJECTION WELL
INFILL WELL
PRODUCTION WELL

Fig. 7

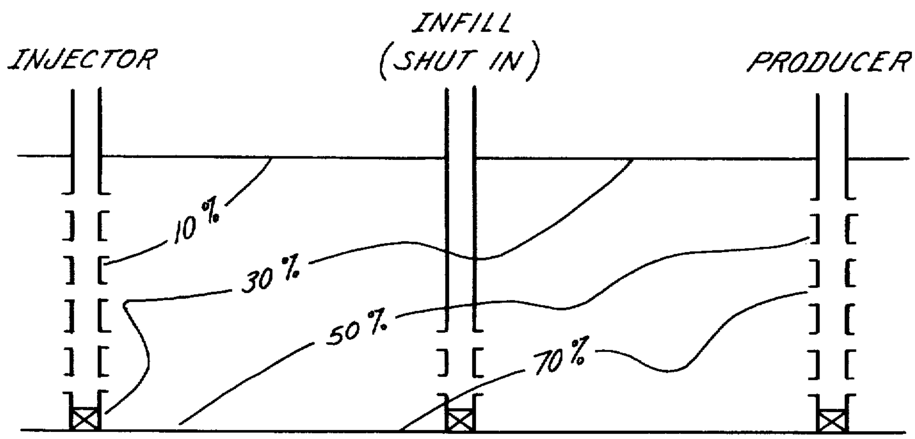
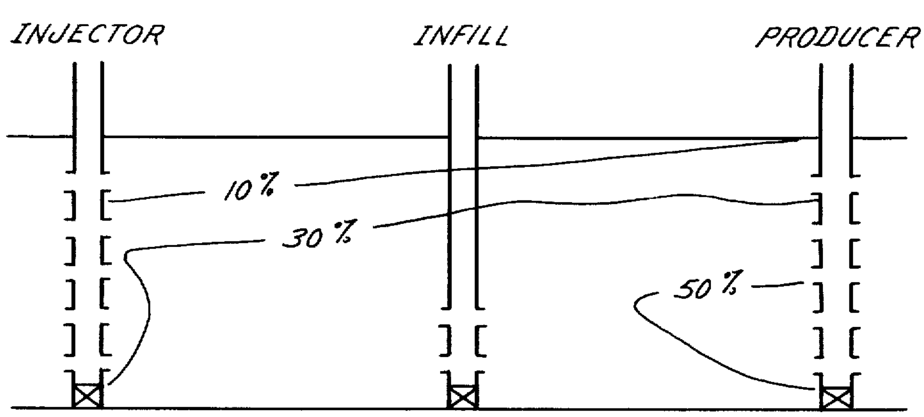

INFILL
(SHUT IN)
INJECTOR
PRODUCER
10%
30%
50%
70%

Fig. 8


INJECTOR
INFILL
PRODUCER
10%
30%
50%

# HIGH VERTICAL CONFORMANCE STEAM DRIVE OIL RECOVERY METHOD

## FIELD OF THE INVENTION

The present invention concerns a steam throughput or steam drive oil recovery method. More particularly, the present invention involves a steam drive oil recovery method especially suitable for use in relatively thick, viscous oil-containing formations, by means of which viscous oil may be recovered from the formation without experiencing poor vertical conformance caused by steam channeling and overriding which reduces the amount of oil recovered from the formation.

## BACKGROUND OF THE INVENTION

It is well recognized by persons skilled in the art of oil recovery that there are formations which contain petroleum whose viscosity is so great that little or no primary production is possible. Some form of supplemental oil recovery must be applied to these formations which decreases the viscosity of the petroleum sufficiently that it will flow or can be displaced through the formation to production wells and then through to the surface of the earth. Thermal recovery techniques are quite suitable for viscous oil formations, and steam flooding is the most successful thermal oil recovery technique yet employed in commercial application. Steam may be utilized for thermal stimulation for viscous oil formations by means of a "huff and puff" technique in which steam is injected into a well, allowed to remain in the formation for a soak period, and then oil is recovered from the formation by means of the same well as was used for steam injection. Another technique employing steam stimulation is a steam drive or steam throughput process, in which steam is injected into the formation on a more or less continous basis by means of an injection well and oil is recovered from the formation from a spaced-apart production well. This technique is somewhat more effective in many applications than the "huff and puff" steam stimulation process since it both reduces the viscosity of the petroleum and displaces petroleum through the formation, thus encouraging production from a production well. While this process is very effective with respect to the portions of the recovery zone between the injection well and production well through which the steam travels, poor vertical conformance is often experienced in steam drive oil recovery processes. A major cause of poor vertical conformance is associated with the fact that steam, being of lower density than other fluids present in the permeable formation, migrates to the upper portion of the permeable formation and channels across the top of the oil formation to the remotely located production well. Once steam channeling has occurred in the upper portion of the formation, the permeability of the steam-swept zone is increased due to the desaturation or removal of petroleum from the portions of the formation through which steam has channeled. Thus subsequently-injected steam will migrate almost exclusively through the steam-swept channel and very little of the injected steam will move into the lower portions of the formation, and thus very little additional petroleum from the lower portions of the formation will be experienced. While steam drive processes effectively reduce the oil saturation in the portion of the formation through which they travel by significant amount, a portion of the recovery zone between the injection and production systems actually contacted by steam is often less than 50 percent of the total volume of that recovery zone, and so a significant amount of oil remains in the formation after completion of the steam drive oil recovery process. The severity of the poor vertical conformance problem increases with the thickness of the oil formation and with the viscosity of the petroleum contained in the oil formation.

In view of the foregoing discussion, and the large deposits of viscous petroleum from which only a small portion can be recovered because of the poor conformance problem, it can be appreciated that there is a serious need for a steam drive thermal oil recovery method suitable for use in recovering viscous petroleum from relatively thick formations which will result in improved vertical conformance.



## SUMMARY OF THE INVENTION

The process of our invention involves a multi-step process involving at least one injection well and at least one production well for injecting steam into the formation and recovering petroleum from the formation as is done in the current practice of state-of-the-art steam drive oil recovery processes. A third well, referred to herein as an infill well, is drilled into the formation and fluid communication between the well and the formation is established with only the lower 50 percent and preferably the lower 25 percent of the viscous oil formation. This well may be completed at the same time the primary injection well and production well are completed, or it may be completed in the formation when it is needed. Steam is injected into the injection well and petroleum is recovered from the production well as is conventionally practiced in the art until steam breakthrough at the production well occurs. At this time, as little as 50 percent or less of the formation will have been swept by steam due to steam channeling through the upper portions of the formation. At this point, production of petroleum is taken from the infill well, which recovers oil from the lower portion of the formation between the primary injection well and the infill well. This step is continued until the fluid being recovered from the infill well reaches about 95 percent water (referred to in the art as 95 percent water cut). At this point, the infill well is converted from production well service to injection well service and hot water is injected into the infill well. Because the specific gravity of the hot water is greater than the specific gravity of steam, and about equal to or greater than the specific gravity of the viscous oil present in the unswept portion of a formation, the hot liquid phase water passes into and through the lower portion of the formation, and displaces oil therefrom toward the production well. This results in recovering viscous petroleum from the lower portion of that portion of the recovery zone between the infill well and the production well, which would ordinarily not be swept by steam. Once the water cut of the fluid being produced from the production well reaches a value of about 95 percent, injection of hot water into the infill well is terminated and steam injection into the infill well is begun. During the period when the infill well is used for fluid production or for fluid injection, steam injection into the original injection well is continued and fluid production from the original production well is ordinarily also continued. Steam injection into the infill well continues until live steam production at the production well occurs.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a subterranean formation penetrated by an injection well and a production well being employed in a state of the art steam drive oil recovery method, illustrating how the injected steam migrates to the upper portions of the formation as it travels through the recovery zone within the formation and between the injection well and production well, thus bypassing a significant amount of petroleum in the recovery zone.

FIG. 2 illustrates the location of the infill well and its use in the first phase of our process in which fluids are recovered from the formation by means of the infill well.

FIG. 3 illustrates the state of the formation at the conclusion of the foregoing step, before hot water injection into the infill well has begun, illustrating the additional portion of the formation swept at that stage of the process.

FIG. 4 illustrates the portion of the process of our invention in which hot water injection is being applied to the formation by means of the infill well, illustrating how water passes through the lower portion of the recovery zone in the formation between the infill well and the production well.

FIG. 5 illustrates the next step of the process of our invention in which steam is injected into the infill well, passing through bolt the lower and other portions of the recovery zone between the infill well and the production well.

FIG. 6 illustrates a plan view of that unit showing how the process of our invention may be applied to a conventional five-spot pattern with infill wells located between a central injection well and production wells on the corner of the patterns.

FIG. 7 illustrates the oil saturation contour lines in a three-dimensional cell illustrating the oil saturation in various portions of the cell after a steam drive oil recovery process according to prior art teachings.

FIG. 8 illustrates the oil saturation contour lines in a three-dimensional cell illustrating the oil saturation in various portions of the cell after a steam drive oil recovery process according to the process of our invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The process of our invention may best be understood by referring to the attached drawings, in which FIG. 1 illustrates how a relatively thick, viscous oil formation 1 penetrated by an injection well 2 and a production well 3 is used for a conventional steam drive oil recovery process. Steam is injected into well 2, passes through the perforations in well 2 into the viscous oil formation. Conventional practice is to perforate or establish fluid flow communications between the well and the formation throughout the full vertical thickness of the formation, both with respect to injection well 2 and production well 3. Not withstanding the fact that steam is injected into the full vertical thickness of the formation, it can be seen that steam migrates both horizontally and in an upward direction as it moves through the formation between injection well 2 and production well 3. The result is the creation of a steamswept zone 4 in the upper portion of the formation and zone 5 in the lower portion of the formation through which little or no steam has passed. Once steam breakthrough at production well 3 occurs, continued injection of steam will not cause any steam to flow through section 5, because (1) the specific gravity of the substantially all vapor phase steam is significantly less than the specific gravity of the petroleum and other liquids present in the pore spaces of the formation, and so gravitational effects will cause the steam vapors to be confined exclusively in the upper portion of the formation, and (2) steam passage through the upper portion of the formation displaces and removes petroleum from that portion of the formation through which it travels, and desaturation of the zone increases the relative permeability of the formation significantly as a consequence of removing the viscous petroleum therefrom. Thus any injected fluid will travel more readily through the desaturated portion of the formation 4 than it will through the portion of the formation 5 which is near original conditions with respect to viscous petroleum saturation.

FIG. 2 illustrates how infill well 6 is drilled into the formation, with respect to injection well 2 and production well 3. Infill well 6 must be drilled into the recovery zone within the formation defined by injection well 2 and production well 3. It is not essential that infill well 6 be located on a line between injection well 2 and production well 3, and may be offset in either direction from a straight line arrangement, although the most convenient and preferred location of infill well 6 would be in alignment with wells 2 and 3. Similarly, it is not essential that well 6 be located exactly midway between injection well 2 and production well 3, and it is adequate for our purposes if a distance between injection well 2 and infill well 6 be from 25 to 75 percent and preferably from 40 to 60 percent of the distance between injection well 2 and production well 3. Infill well 6 is perforated or other fluid flow communication is established between well 6 and the formation, only in the lower 50 percent and preferably the lower 25 percent of the formation. This is essential to the proper functioning of our process.

It is immaterial for the purpose of practicing our process, whether infill well 6 is drilled and completed at the same time as injection well 2 and production well 3, and/or if such drilling and completion of infill well 6 is deferred until steam breakthrough has occurred at production well 3, or some intermediate time. If completed prior to use, infill well 6 is simply shut in during the first phase of the process of our invention.

The fluid injected into injection well 2 during all of the steps described herein, as well as that injected into infill well 6 in the subsequent portion of the process of our invention, will comprise steam, although other substances may be used in combination with steam as is well described in the art. For example, noncondensible gases such as nitrogen or carbon dioxide may be comingled with steam for the purpose of improved oil stimulation or to achieve other objectives. Materials which are miscible in formation petroleum may also be mixed with the steam, such as hydrocarbons in the range of $C_1$ to $C_{10}$, for the purpose of further enhancing the mobilizing effect of the injected fluids. Air may also be comingled with steam in a ratio from 0.05 to 2.0 standard cubic feet of air per pound of steam, which accomplishes a low temperature, controlled oxidation within the formation, and achieves improved thermal efficiency under certain conditions. So long as the fluid injected into injection well 2 comprises a major portion of vapor phase steam, the problem of steam channeling will be experienced in the steam drive process no matter what other fluids are included in the injected steam, and the process of our invention may be incorporated into the steam drive oil recovery process with the resultant improvement in vertical conformance.

Turning again to the drawings, our invention in its broadest aspect comprises a minimum of four steps to be applied to an oil formation. FIG. 2 illustrates a minimum three-well unit for employing the process of our invention, wherein formation **1** is penetrated by an injection well **2** which is in fluid communication with the full vertical thickness of the formation. Spaced-apart production well **3** is a conventional production well, which is also in fluid communication with the full vertical thickness of the formation. Infill well **6** is shown located about midpoint between well **2** and **3**, and within the recovery zone defined by wells **2** and **3**, i.e. on or adjacent to a line between wells **2** and **3**, and fluid communication is established between well **6** and the lower portion of the formation, in this instance being something less than 50 percent of the total thickness of the formation.

In the first step, a thermal recovery fluid comprising steam is injected into the formation by means of injection well **2**. Steam enters the portion of the formation immediately adjacent to well **2** through all of the perforations in well **2**, and initially travels through substantially all of the full vertical thickness of formation **1**. Because the specific gravity of vapor phase steam is significantly less than the specific gravity of other fluids, including the viscous petroleum present in the pore spaces of formation **1**, steam vapors migrate in an upward direction due to gravitational effects, and as can be seen in FIG. **1**, the portion **4** of the formation **1** swept by steam vapors in the first step represents an increasingly diminished portion of the vertical thickness of the formation as the steam travels between the injection well and production well **3**. Thus by the time steam arrives at production well **3**, only a small fraction of the full vertical thickness of the formation is being contacted by steam. Oil is recovered from the portion of the formation through which the steam vapors travel, although the total recovery from the recovery zone defined by wells **2** and **3** will be significantly less than 50 percent of the total amount of petroleum in the recovery zone. Even though significantly more than 50 percent of the oil present in portion **4** of the formation is swept by steam, the large amount of oil unrecovered from that portion **5** through which very little of the steam passes causes the total recovery efficiency to be very low. The recovery efficiency as a consequence of this problem is influenced by the thickness of the formation, the well spacing, the viscosity of the petroleum present in the formation at initial conditions, as well as by other factors. Recoveries substantially below 50 percent are not uncommon in field application of steam drive processes.

FIG. **2** illustrates how the infill well is positioned between the injection well and the production well, and as stated above it is immaterial to the process of our invention whether the well is drilled and completed at the same time wells **2** and **3** are drilled and completed, or whether either the drilling or the completion or both are deferred until infill well **6** is needed.

The first step comprising injecting steam into injection well **2** and recovering fluids from the formation by means of production well **3** continues until steam or steam condensate production at well **3** is detected. The preferred method comprises continuing this step until live steam production occurs at well **3**. Once steam is being produced in well **3**, further production of oil will be at a much diminished rate, since the only mechanism by means of which additional oil can be recovered from the formation below the steam-swept zone **4** will be by a stripping action, in which oil is recovered along the surface **7** between the steam-swept portion **4** of the formation and portion **5** of the recovery zone through which steam has not passed. Although this mechanism may be continued for very long periods of time and oil can be recovered from zone **5** by this means, the stripping action is extremely inefficient and it is not an economically feasible means of recovering viscous oil from the formation after steam breakthrough occurs at well **3**.

In the second step in the process of our invention, infill well **6** is utilized as a production well. It should be understood that a significant amount of oil is recovered from the formation by this step alone which is not recovered at the economic conclusion of the first step. It has been found that the oil saturation in zone **8**, that being the portion of the recovery zone between the infill well and injection well **2**, occupying the lower thickness of the formation, is actually increased during the period of recovering oil from swept zone **4** in FIG. **1**. This is caused by migration of oil mobilized by injected steam, into the portion of the formation through which steam does not travel during this first period. Thus, if the average oil saturation throughout viscous oil formation **1** is in the range of about 55 percent (based on the pore volume), injection of steam into the formation may reduce the average oil saturation throughout depleted zone **4** to 15 percent, but the oil saturation in zone **8** may actually increase to a value from 60 to 70 percent. The second step in the process of our invention, in which fluids are recovered from infill well **6**, accomplishes steam stimulated recovery of petroleum fron zone **8** in the drawing which is not recoverable by processes taught in the prior art. Because fluid communication only exists between well **6** and the lower portion of the formation, at least the lower 50 percent and preferably the lower 25 percent of the formation, movement of oil into these perforations results in sweeping a portion of the formation not otherwise swept by steam. In FIG. **3**, it can be seen that a portion **9** still remains unswept by the injected steam, but it is significantly less than the volume of zone **8** prior to application of the second step of the process of our invention. Once the water cut of the fluid being produced from the formation by means of well **6** increases to a predetermined value, preferably at least 95 percent, production of fluids from the formation by means of well **6** is terminated and well **6** is converted to an injection well.

During the above described second step of the process of our invention, steam injection into well **2** must be continued, and production of fluids from well **3** may be continued or may be discontinued depending on the water cut of fluid being produced at that time.

After conversion of infill well **6** from a producing well to an injection well, hot water is injected into well **6** and fluid production is taken from well **3**. It is essential that the fluid being injected into well **6** be substantially all in the liquid phase during this step of the process of our invention. The reason the fluid must be substantially all liquid phase is that gravity forces must be relied on to ensure that the injected fluid travels in the lower portion of that zone of the recovery zone between infill well **6** and production well **3**. This can be seen in FIG. **4**, wherein the injected liquid travels principally through the lower portion of the section of the formation between infill well 6 and production well 3. During this step, production of fluids must be taken from well 3, and injection of steam or hot water into well 2 is continued in order to maintain a positive pressure gradient between injection well 2 and infill well 6. The pressure gradient is needed to avoid migration of oil back into the zone between wells 2 and 6. The volume rate of fluid injection should be maintained at a level sufficient to accomplish the desired positive pressure gradient. Ordinarily the fluid injection rate at well 2 should exceed the injection rate at infill well 6 and preferably the injection rate at well 2 is twice the rate at well 6. Because the specific gravity of liquid phase water is substantially greater than the specific gravity of vapor phase steam, the fluids are confined to the lower flow channels within the formation, and thus travel through a portion of the formation not contacted by vapor phase steam during the previous steps. Hot water mobilizes viscous petroleum, although its effectiveness is less than steam. Hot water injection will, however, reduce the oil saturation in the lower portion of the zone between infill well 6 and production well 3, and will therefore increase the permeability of that portion of the recovery zone. Hot water injection is continued until the water cut of the fluid being produced from well 3 rises to a value greater than about 80 percent and preferably greater than a value of about 95 percent. This ensures the optimum desaturation of the lower portion of the zone between infill well 6 and production well 3 which is necessary to increase the permeability of that section of the recovery zone sufficiently that the next phase of the process can be successful.

In a slightly different preferred embodiment of the process of our invention, the fluid being injected into well 6 in the foregoing steps comprises a mixture of hot liquid phase water and hydrocarbons. In this embodiment, it is preferred that the hydrocarbon be in the liquid phase to ensure that it travels through substantially the same flow channels as the liquid phase water, and so the boiling point of the hydrocarbons should be below the temperature of the hot water being injected into the formation. One especially preferred hydrocarbon for this purpose comprises the hydrocarbons being separated from produced fluids in the same or other zones in the formation as a consequence of steam distillation. This appears to be an optimum hydrocarbon for this purpose, possibly because the material is necessarily fully miscible with the formation petroleum, having been obtained therefrom by steam distillation.

After the water cut of fluids being produced from well 3 during this phase of the process of our invention reaches the above-described levels, injection of liquid phase water into infill well 6 is terminated and steam injection into infill well 6 is thereafter initiated. Because of the previous step, during which hot water injection passed through the lower portion of the formation between infill well 6 and producing well 3, at least a portion of the steam being injected into infill well 6 passes through the lower portion of the formation. It must be appreciated that steam would not travel through the lower portion of the formation under these conditions if hot water had not first been injected for the purpose of desaturating the lower portion of the zone between wells 6 and 3, which established a zone of increased permeability, thereby ensuring that the flow channel permeability is sufficient that at least a portion of the steam will pass through the lower portions of the formation. This will result in some steam underriding the residual oil in the portion of the zone between wells 6 and 3, although a degree of steam override may be encountered in this portion of the process as communication between the point where steam is entering the formation through perforations in well 6 and previously depleted zone 4 occurs. Steam injection is continued, and the oil production rate is significantly better as a result of the previous formation of flow channels in the lower portion of the formation, since the stripping action is more efficient with respect to overlying oil saturated intervals than it is with respect to an underlying oil saturated interval. The reasons for this involve the fact that oil mobilized by thermal contact with the fluid passing under an oil saturated interval migrates downward by gravitational forces into the flow channel, and also because steam movement occurs in an upward direction into the oil-saturated interval more readily than downward, due to gravitational forces.

The above described fourth step is continued with steam being injected into infill well 6 with steam or hot water being injected into well 2 and fluid production being taken from well 3, until steam or steam condensate production at well 3 occurs to a predetermined extent. This step is preferably continued until the water cut of fluids being taken from the formation by well 3 reaches a value greater than 80 percent and peferably at least 95 percent.

A variation of the above described process is especially suitable for formations having very high viscosity oil, i.e. those formations which contain petroleum whose API gravity is less than 15 and preferably less than 10° API. This preferred embodiment involves one additional step, which occurs prior to the injection of hot water into infill well 6. In this embodiment, after fluid production from infill well 6 has terminated and infill well 6 has been converted to an injection well, cold water is injected into infill well 6. For the purpose of this process, by "cold water", it is meant water whose temperature is less than 160° and preferably less than 80° F. Ordinarily, it is sufficient to inject water at surface ambient conditions. The passage of cold water into portions of the formation immediately adjacent to the perforations in infill well 6 causes the condensation and collapse of the steam vapor occupying the formation, increasing the liquid water saturation of that portion of the formation, and therefore decreases the permeability of the portion of the formation in which steam condensation has occurred. This further encourages the passage of the subsequently injected hot water into the lower flow channels in the portion of the recovery zone between well 6 and well 3.

## EXPERIMENTAL EVALUATION

For the purpose of demonstrating the operability of the process of our invention, and of showing the magnitude of results achieved from application of the preferred embodiments of our invention, the following laboratory experiments were performed.

A laboratory cell was constructed, the cell being 3 inches wide, 8½ inches high and 18½ inches long. The cell is equipped with three wells, an injection well and production well in fluid communication with the full height of the cell and a central infill well which is in fluid communication with lower 15 percent of the cell, the well arrangement being similar to that shown in FIG. 2. A base steam drive flood was conducted in the cell to demonstrate the magnitude of the steam override condition. The cell was first packed with sand and saturated with 14 degree API gravity crude to initial oil saturation of 53.0 percent. The infill well was not used in the first run, this run being used to simulate a conventional throughput process according to the steam drive processes described in the prior art. After steam injection into the injection well and fluid production from the production well continued to a normal economic limit, the average residual oil saturation in the cell was 46.3 percent. In the second run, the process of our invention was applied to the cell, with steam being injected into the injection well and oil production taken from the production well until live steam breakthrough was detected at the production well, followed by production from the infill well, followed by first injecting cold water, then hot water and then steam into the cell by means of the infill well and recovering fluid from the producing well to a water cut of 98 percent. The overall residual oil saturation at the conclusion of this run was 30.1 percent compared with the initial oil saturation of 53 percent in both cases, it can be seen that the base flood recovered only 12.6 percent of the oil present in the cell whereas application of the process of our invention resulted in recovering 43 percent of the oil, or about 3.4 times as much oil as the base run.

Thus we have disclosed and demonstrated in laboratory experiments how significantly more viscous oil may be recovered from an oil formation by a throughput, steam drive process by employing the process of our invention with infill wells located between injection and production wells, and a multi-step process as described above. While our invention is described in terms of a number of illustrative embodiments, it is clearly not so limited since many variations of this process will be apparent to persons skilled in the art of viscous oil recovery methods without departing from the true spirit and scope of our invention. Similarly, while mechanisms have been discussed in the foregoing description of the process of our invention, these are offered only for the purpose of complete disclosure and is not our desire to be bound or restricted to any particular theory of operation of the process of our invention. It is our desire and intention that our invention be limited and restricted only by those limitations and restrictions appearing in the claims appended immediately hereinafter below.

We claim:

1. A method of recovering viscous oil from a subterranean, viscous oil containing formation, said formation being penetrated by at least three wells, one injection well and one production well, both of said injection and production wells being in fluid communication with a substantial portion of the vertical thickness of the formation, and an infill well located within the recovery zone defined by the injection well and production well and in fluid communication with only the lower 50 percent or less of the formation, comprising:

(a) injecting a thermal oil recovery fluid comprising steam into the formation via the injection well and recovering fluid including oil from the formation by the production well until the fluid being recovered from the production well comprises a predetermined amount of steam or water;

(b) thereafter recovering fluids including oil from the formation by the infill well and continuing injecting said thermal oil recovery fluid into said injection well until the fluid being recovered comprises a predetermined fraction of steam or water;

(c) thereafter injecting hot water into the infill well and recovering fluids from the formation by means of the production well until the percentage of water in the fluids being recovered reaches a predetermined value; and thereafter

(d) injecting steam into the infill well;

(e) injecting an aqueous fluid into the injection well simultaneously with steps (c) and (d) at a rate sufficient to maintain a positive pressure gradient from the injection well to the infill well; and

(f) recovering fluids from the formation via the production well until the fluids being recovered comprise at least 80 percent water.

2. A method as recited in claim 1 comprising the additional step of injecting unheated water into the formation via the infill well between the step of recovering fluids from the formation by the infill well and the step of injecting hot water into the formation via the infill well.

3. A method as recited in claim 1 wherein steam injection into the formation according to step (a) is continued until vapor phase steam production occurs at the production well.

4. A method as recited in claim 1 wherein the production of fluids from the formation by the infill well according to step (a) is continued until the percentage of water of said fluids rises to a value of at least 80 percent.

5. A method as recited in claim 4 wherein fluid production is continued until the water content reaches 95 percent.

6. A method as recited in claim 1 wherein hot water injection into the infill well is continued until the percentage of water in the fluid being recovered from the formation via the production well rises to a value of at least 95 percent.

7. A method as recited in claim 1 wherein the step of injecting steam into the infill well as defined in step (c) is continued until the fluid being recovered from the formation is at least 95 percent water.

8. A method as recited in claim 1 wherein the thermal fluid injected into the formation comprises a mixture of steam and hydrocarbon.

9. A method as recited in claim 8 wherein the hydrocarbon comprises $C_1$ to $C_{10}$ hydrocarbons.

10. A method as recited in claim 8 wherein the boiling point of the hydrocarbon is less than the temperature of the hot water being injected into the infill well.

11. A method as recited in claim 1 wherein the aqueous fluid of step (e) is water, hot water or steam.

12. A method as recited in claim 1 wherein the fluid injection rate at the injection well during step (e) is at least equal to the fluid injection rate at the infill well.

13. A method as recited in claim 12 wherein the fluid injection rate at the injection well is at least twice the fluid injection rate at the infill well.

14. A method as recited in claim 1 wherein the infill well is in fluid communication with only the lower 25 percent of the formation.

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