April 21, 1964 P. J. CLOSMANN 3,129,758

STEAM DRIVE OIL PRODUCTION METHOD

Filed April 27, 1961 2 Sheets-Sheet 1

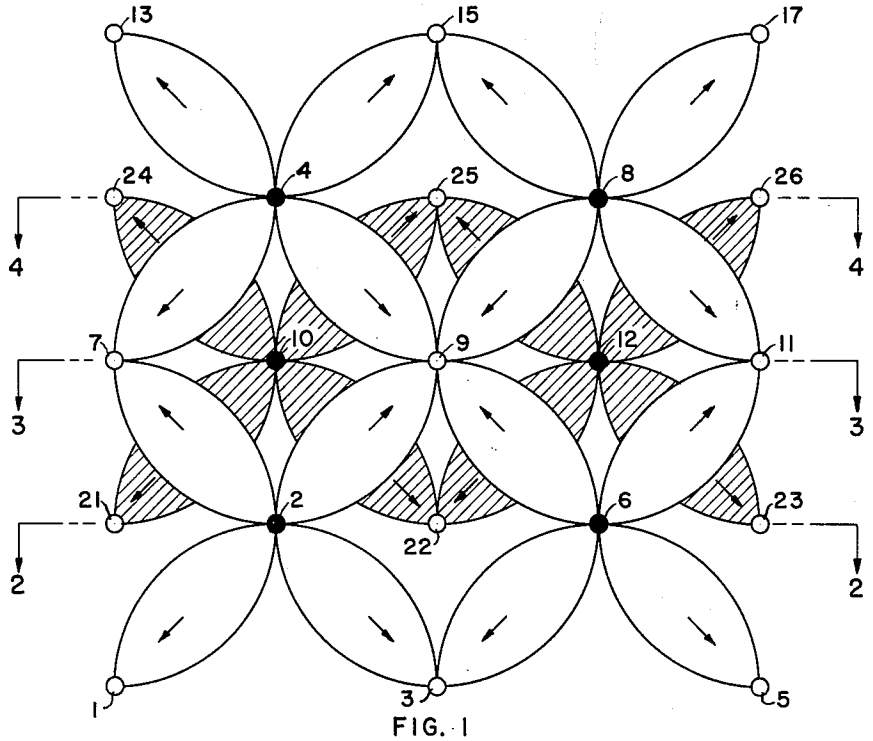



FIG. 1

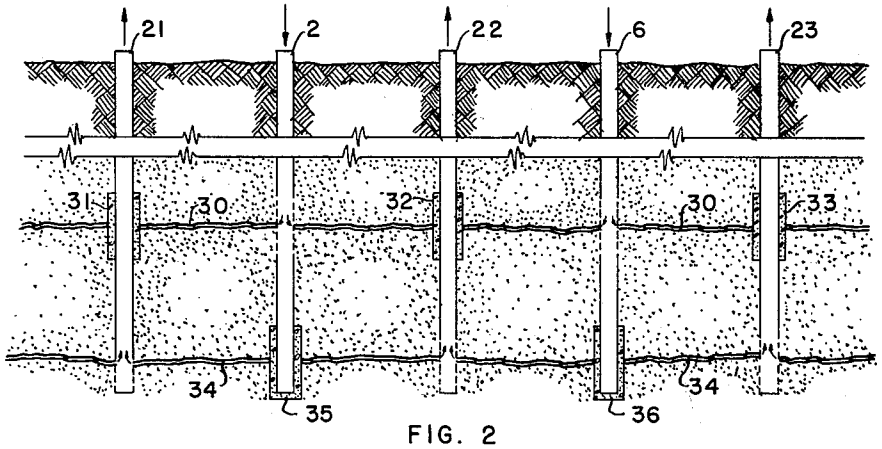



FIG. 2

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STEAM DRIVE OIL PRODUCTION METHOD

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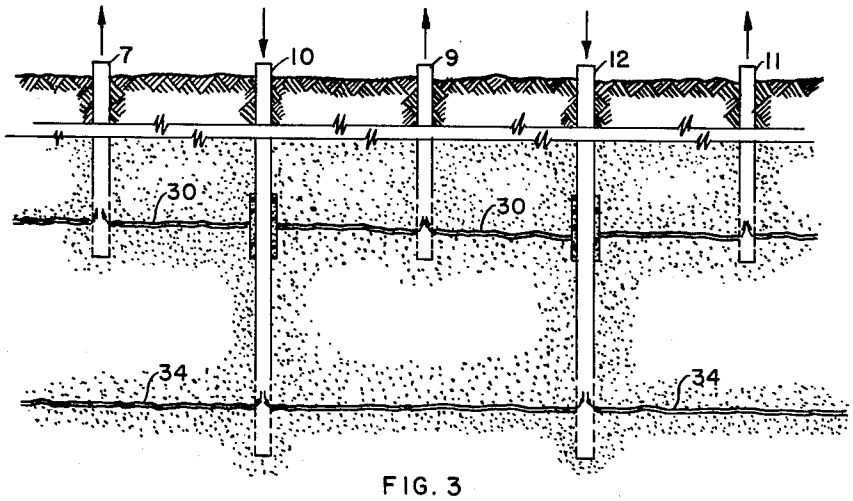



FIG. 3

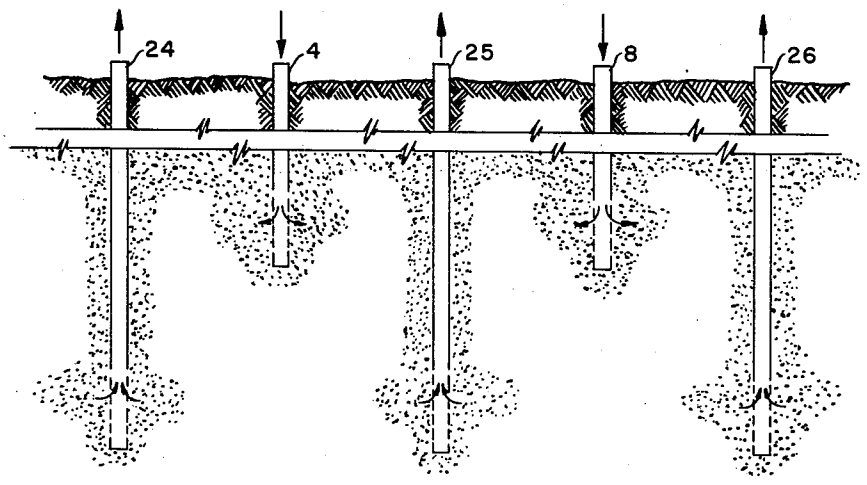



FIG. 4

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3,129,758

# STEAM DRIVE OIL PRODUCTION METHOD

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4 Claims. (Cl. 166—11)

This invention relates to a method for producing oil from underground formations and pertains more particularly to a method of flooding a formation in order to recover oil therefrom which, because of the characteristics of the oil or the state that is is in, could not be produced by normal oil producing methods. The method of the present invention is especially applicable for hydrocarbon reservoirs where the injectivity is relatively low, such for example as, tar sands.

In some regions oil-bearing formations contain an oil whose viscosity or state is such that the oil does not flow from the formation. Attempts have been made to heat the formation with varying degrees of success. The use of heaters in a well is not very satisfactory since the heat cannot penetrate a great distance from the well bore. It is often difficult to create a steam flood or drive since the steam condenses and cools in the formation to interfere with the further injection of steam thereinto.

It is, therefore, an object of the present invention to provide an oil field with a series of injection and production wells and to heat a zone of the oil-bearing formation close to the production wells, as well as a zone close to injection wells, in order to reduce the viscosity of the oil moving from an intermediate zone as oil is produced.

Another object of the present invention is to provide a method of recovering oil from an underground formation in a manner to preheat a zone around the production well in order to open this zone at the start of a steam flood so that an area is created through which oil can be readily forced.

A further object of the present invention is to provide an oil recovery method wherein the production formation is preheated in overlapping flood patterns at two levels which are vertically displaced one from the other so that a vertical flood of heated fluid cleans the maximum area possible.

Still another object of the present invention is to provide an oil recovery method wherein interconnecting fractures are formed in the producing formation prior to heating the formation with steam so that the condensate formed in the formation has a chance to drain off rather than fill the fractures and block the entrance of more steam thereinto.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a diagrammatic plan view of super-imposed horizontal flood patterns at the start of the dual steam injection preheating period of the method of the present invention, the shaded area representing the flow pattern of steam being injected into the lowermost portion of the formation; and,

FIGURES 2, 3 and 4 are longitudinal views taken in cross-section along lines 2—2, 3—3 and 4—4 of FIGURE 1, diagrammatically illustrating the input and output wells of the present invention.

The oil recovery method of the present invention contemplates the use of a plurality of alternately-disposed steam input, condensate output and production output wells which penetrate an oil-bearing formation. The method comprises establishing communication between the steam input wells and the oil-bearing formation near the top thereof and between the condensate removal wells and the same portion of the formation, while at the same time establishing communication between the output wells



and their portion of the oil-bearing formation at a level lower than that communicating with the input and condensate wells. In the event that the wells are cased, which is the normal condition, communication would be established between a well and the desired level of the producing formation by means of perforating the casing. The oil-bearing formation is then horizontally fractured from the series of input and condensate wells at the upper level and from the series of output wells at a lower level. The fracturing operation is carried out in a manner such that the fractures at each level are in open communication with each other, but not with the series of vertically displaced fractures from the other series of wells. If desired, the fractures may be propped open with suitable propping agents in the event that steam pressures are employed which do not keep the fractures open. In the event that any of the fractures from the input wells extend into the production wells, they are sealed off in the production wells.

Prior to producing the formation, the oil-bearing formation is preheated adjacent the upper and lower fractures simultaneously with steam being injected through some of the input wells and condensate removed from the condensate wells, while at the same time steam is injected through some of the output wells while removing condensate from other of the output wells. After preheating the formation from the two levels for a predetermined period, which period depends upon the character of the formation, the number of wells employed, the vertical spacing between the fractures, etc., the injection of steam into the output wells is subsequently discontinued. A downward steam drive of oil from the oil-bearing formation is now carried out by injecting steam through the input wells into the upper portion of the oil-bearing formation to produce the oil downwardly and horizontally into the output wells from which the oil may be recovered in any desired manner well known to the art.

Referring to FIGURE 1 of the drawing, one typical arrangement of wells is illustrated wherein wells 2, 4, 6 and 8 are steam input wells extending to the upper fractured zone of the oil-bearing formation, while wells 10 and 12 are steam input wells, during the preheat period, extending to the lower fractured zone of the formation. After the formation has been preheated and the downward steam drive has been started through input or injection wells 2, 4, 6 and 8, steam input to wells 10 and 12 is cut off and the wells 10 and 12 are either closed or opened as production wells from the lower zone.

The condensate removal wells for removing steam condensate from the upper fracture zone of the oil-bearing formation are represented by numerals 1, 3, 5, 7, 9, 11, 13, 15 and 17. Wells 21, 22, 23, 24, 25 and 26 extend to the lower fractured zone of the oil-bearing formation and are employed as condensate removal wells during the preheat period, and as oil production wells after the steam drive has started from the upper fractured formation.

As shown in FIGURE 2, if necessary, the upper fractures 30 which extend from the input wells 2 and 6 and from any adjacent condensate wells are closed off from the production wells 21, 22 and 23 to prevent steam escaping up the production wells or along the well casing positioned therein. Steam shutoff may be accomplished by spotting cement 31, 32 and 33 adjacent the bore of the wells or outside the well casings thereof. In a like manner the lower fracture at 34 may be sealed off at the input wells 2 and 6, as by cement plugs 35 and 36. If desired, the cement plugs may be positioned in the injection wells just below the fracture at 30.

In FIGURE 3, a series of condensate removal wells 7, 9 and 11 are illustrated in communication with fracture 30 for removing condensate formed therein due to steam

injection through wells 2 and 6 of FIGURE 2. In FIGURE 3 the wells 10 and 12 in communication with the lower fracture 34 are illustrated during the preheat period at which steam is injected down wells 10 and 12 with the condensate in the fracture 34 being removed through the production wells 21, 22 and 23 of FIGURE 2. After the preheat period wells 10 and 12 can be converted to production wells.

In FIGURE 4 the steam input wells 4 and 8 and the oil production or output wells 24, 25 and 26 are shown as extending into a relatively permeable zone wherein the downward steam drive of the present method can be accomplished without the necessity of fracturing the formation.

In the present method of oil recovery the wells are preferably drilled in locations selected so that the wells are adapted to provide two overlapping injection-production patterns, such as five-spot patterns, at spacing suitable for steam injection and condensate withdrawal at pressures initially greater than the overburden pressure, and at somewhat reduced pressures later, if desired. Two series of alternately spaced wells are employed, with one series of wells being fractured horizontally near the top of the oil-producing formation while the other series of wells are fractured horizontally at a lower depth. In relatively thin reservoirs the fractures will be located near the top and the bottom of the reservoir. However, in relatively thick reservoirs it may be necessary to carry out the two-level preheat and steam drive method of the present invention at varying depths. In a relatively thick reservoir the upper level of heat supply might be placed part way down from the top of the reservoir and the lower level part way up from the bottom. Subsequently, heat which would normally be lost in a two-level heating process, due to loss above and below the heated central zone, would be useful in improving the mobility of oil in the upper and lower sections of the reservoir.

In the heating stage, the formation interval between the horizontally-directed fractures is simultaneously heated along horizontally extensive planes. In each fracture the rate of steam injection and condensate withdrawal is preferably controlled to maintain condensation all along the fracture. The preheating stage of the present method provides a unique and advantageous type of heated reservoir zone in which to conduct a steam drive. The heated zone is generally discshaped and is hottest along the top and bottom and coolest in the middle. The arrangement of the heated zone is such that steam is applied at substantially equal pressure along the entire area of the top of the zone. After the preheat period, and after the steam has been shut off to the lower fracture, steam injected into the upper fracture pushes the oil bank, in which the cooler and more viscous portions are located near the center of the reservoir formation through which the oil bank is driven. As the steam drive moves the oil bank, the cooler portion of the oil bank is heated primarily by contact with the hotter reservoir formation section around the lower fracture into which the oil bank is pushed. The elevated temperature of the portion of the oil-bearing formation adjacent the upper fracture is maintained by heat from the steam.

When the formation between the vertically-displaced fractures has been heated the desired amount, the injection of steam into the lower fracture is terminated and the steam pressure reduced, causing an in situ regeneration of steam in a manner enhancing the downward displacement of the heated reservoir oil. As the pressure in the lower fracture is reduced, formation water, as well as condensed steam which permeated the roof of the lower fracture, will be vaporized and will displace oil toward wells opening into the region of the lower fracture, i.e., the production wells. If part of the oil-bearing formation lies below the lower fracture, part of its oil should be produced by this mechanism. After the vertically downward displacement from upper level to lower level is concluded, release of pressure at the upper level would tend to produce some of the heated oil above the central zone by vaporization of water within that region. Thus, the overall economy of the process would be enhanced. In most cases the use of fracture propping agents is not necessary as during the heating stage the fractures can be held open by steam pressure. By the end of the preheating stage, the sand in the vicinity of the fractures is generally stripped free of enough oil to provide zones of high fluid permeability around the fractures in the wells. In some cases it may be desirable to employ propping agents in the fractures, especially when the overburden pressure is too great for the fractures to be held open with steam pressure.

I claim as my invention:

1. A method of recovering oil from an underground oil-bearing formation which is penetrated by a plurality of alternately-disposed wells which may be divided into steam-input wells, condensate-removal wells and oil-output wells, said method comprising establishing communication between both the input wells and the condensate removal wells with the oil-bearing formation at one level thereof, establishing communication between the oil output wells and the oil-bearing formation at a level substantially below that of the other wells, horizontally fracturing the oil-bearing formation from said input and condensate removal wells at one level of the oil-producing formation and in a manner such that the fractures are in open communication with each other, horizontally fracturing the oil-bearing formation from oil outlet wells at a lower level than said first fracture and in a manner such that the lower horizontal fractures are in open communication with each other, continuously injecting steam through said input wells while continuously removing condensate from the condensate removal wells and injecting steam through some of the oil outlet wells while removing condensate from other of the oil outlet wells for a time sufficient to preheat the zone of said oil-bearing formation between the upper and lower fractures, subsequently discontinuing the injection of steam into the oil output wells, injecting steam into the upper portion of said oil-bearing formation through said input wells to produce oil by a downward steam drive to said oil output wells, and recovering said produced oil from said oil output wells.

2. A method of recovering oil from an underground oil-bearing formation which is penetrated by a plurality of alternately-disposed wells which may be divided into steam-input wells, condensate-removal wells and oil-output wells, said method comprising establishing communication between both the input wells and the condensate removal wells with the oil-bearing formation at one level thereof, establishing communication between the oil output wells and the oil-bearing formation at a level substantially below that of the other wells, horizontally fracturing the oil-bearing formation from said input and condensate removal wells at one level of the oil-producing formation and in a manner such that the fractures are in open communication with each other, horizontally fracturing the oil-bearing formation from oil outlet wells at a lower level than said first fracture and in a manner such that the lower horizontal fractures are in open communication with each other, continuously injecting steam through said plurality of input wells while continuously removing condensate from the condensate removal wells and injecting steam through some of the oil outlet wells while removing condensate from the other of the oil outlet wells to preheat the lower zone of said oil-bearing formation between the upper and lower fractures, the wells having steam injected into them being spaced in the oil field so that the producing formation is preheated in alternate high and low overlappingg flood patterns extending from said plurality of wells having steam injected into them at the two frarcture levels, subsequently discontinuing the injection of steam into the oil output wells, injecting steam into the upper portion of said oil-bearing

formation through said input wells to produce oil by a downward steam drive to said oil output wells, and recovering said produced oil from said oil output wells.

3. A method of recovering oil from an underground oil-bearing formation which is penetrated by a plurality of alternately-disposed wells which may be divided into steam-input wells, condensate-removal wells and oil-output wells, said method comprising establishing communication between both the input wells and the condensate removal wells with the oil-bearing formation near the top thereof, establishing communication between the oil output wells and the oil-bearing formation at a level substantially below that of the other wells, horizontally fracturing the oil-bearing formation from said input and condensate removal wells at a level near the top of the oil-producing formation and in a manner such that the fractures are in open communication with each other, horizontally fracturing the oil-bearing formation from oil outlet wells at a lower level than said first fracture and in a manner such that the lower horizontal fractures are in open communication with each other, sealing off in the production wells any fractures which may extend from an input or condensate removal well, continuously injecting steam through said input wells while continuously removing condensate from the condensate removal wells and injecting steam through some of the oil outlet wells while removing condensate from other of the oil outlet wells to preheat the lower zone of said oil-bearing formation between the upper and lower fractures, subsequently discontinuing the injection of steam into the oil output wells, injecting steam into the upper portion of said oil-bearing formation through some of said input wells to produce oil by a downward steam drive to said oil output wells, and recovering said produced oil from said oil output wells.



4. The method of claim 3 including the step of propping the fractures open.

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