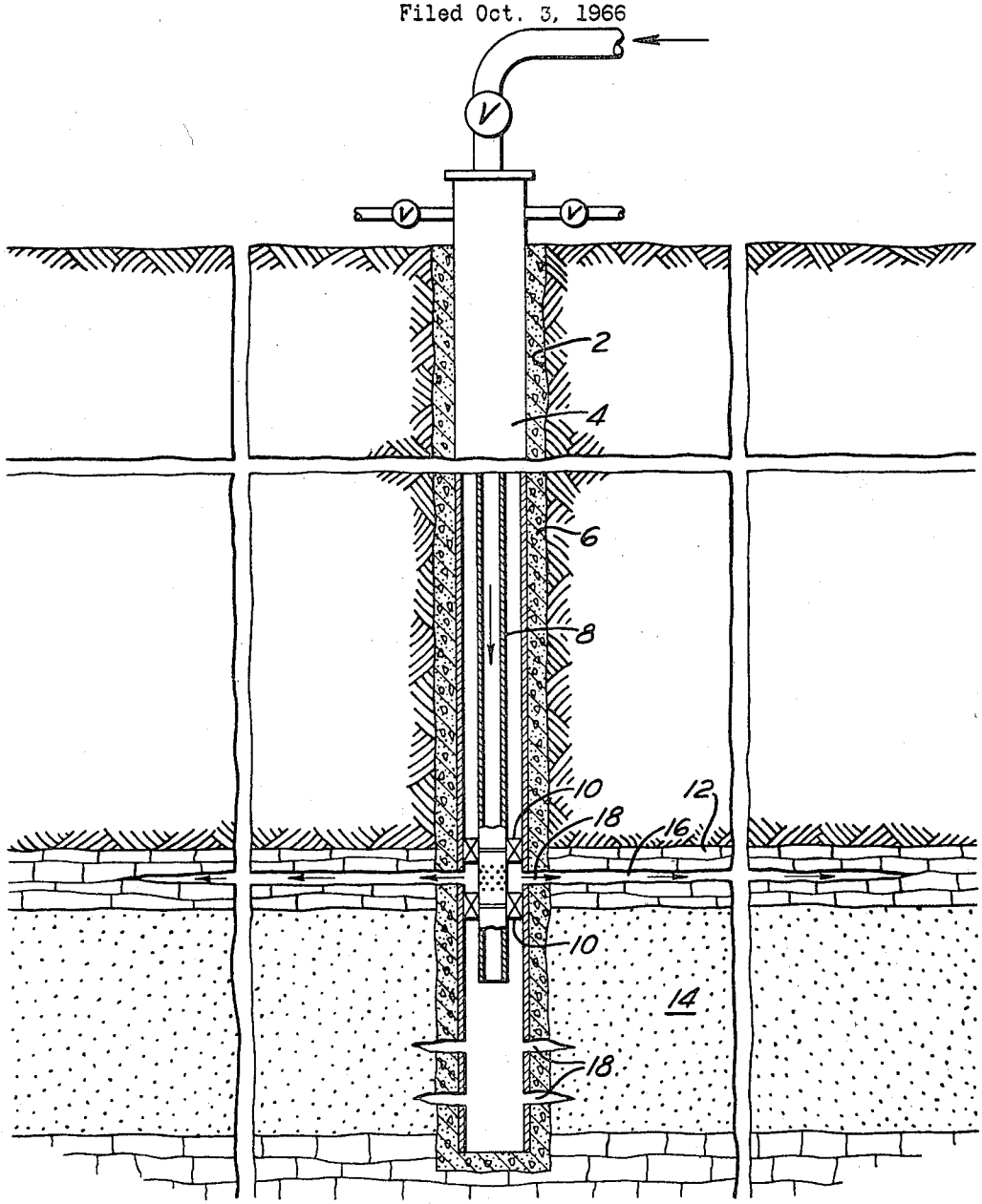
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CONDUCTION HEATING OF FORMATIONS

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CONDUCTION HEATING OF FORMATIONS

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ABSTRACT OF THE DISCLOSURE

A method for producing oil from a subterranean formation containing a viscous oil adjacent an impermeable formation in which steam is injected down the well and into a fracture extending from the well outwardly into the impermeable formation while flow of steam into the oil-bearing formation is blocked. After injecting steam for a period to accomplish the desired heating, by conduction of the oil, flow from the impermeable formation is blocked, and the well placed in communication with the oil-bearing formation to produce oil from the well.

This invention relates to a method of producing viscous hydrocarbon fluids from a hydrocarbon-containing formation which is adjacent an impermeable formation.

A considerable number of reservoirs presently being produced in the United States are characterized as containing viscous crude. When reservoirs are found to possess heavy viscous fluids the operator is faced with the problem of choosing a well stimulation means which will yield high ultimate recoveries without subjecting the well to adverse conditions.

One method of producing oil from formations containing heavy viscous crudes is to initiate in situ combustion within the hydrocarbon-containing formation to heat the in-place oil and thereby increase its fluidity. This method requires careful control by the operator, utilizes expensive equipment and consumes a considerable amount of the in-place oil. In situ combustion also produces large amounts of heat and high temperatures which coke part of the oil in the formation. The presence of coke in the formation will lower the productivity of the well. Coking of the oil will also utilize a portion of the reservoir oil and make it unavailable for recovery.

Another method of heating subterranean formations to increase the fluidity of in-place viscous crudes is to burn injected gases within formations adjacent the reservoir or within the hydrocarbon-containing reservoir itself. These methods likewise have disadvantages owing to the high temperatures created, the amount of supervision required and the formation of coke which will lower the efficiency of the operation.

In certain areas a permeable sand is separated from the viscous hydrocarbon-containing formation by a thin impermeable stratum such as shale. Attempts have been made in the past to heat these upper or lower sands and thereby heat the remote hydrocarbon-containing formations by conduction. Such attempts are inefficient because of the heat losses suffered in conducting the heat through two reservoir stratums. Fluids contained in the heated adjacent permeable stratum will also absorb large amounts of the heat thereby further decreasing the efficiency of heating the hydrocarbon-containing stratum.

This invention resides in an improved method for thermally stimulating production of viscous oils utilizing a single well. Steam is injected down the well and outwardly from the well through a fracture in an impermeable formation adjacent the formation containing the viscous oil to be produced. Flow of steam into the oil-bearing formation is blocked. Injection of steam into the fracture is continued until the desired heating of the viscous oil by conduction from the fracture through the intervening impermeable formation is accomplished. The fracture is then isolated from the well bore, the oil-bearing formation is placed in communication with the well bore, and the pressure in the well bore is reduced to cause flow of oil into the well.

Injection of the steam through the impermeable formation is accomplished by creating a fracture through this stratum by pumping a fluid down the well bore and into the impermeable stratum at a rate which will produce a pressure greater than the overburden pressure on the formation. Owing to the impermeable properties of the stratum there will be no contamination or commingling within the hydrocarbon-containing formation. The utilization of steam for the heating medium of this invention will allow greater temperature control and will enable the operator to supply large quantities of heat to the adjacent hydrocarbon-containing formation while injecting only a small volume of heating medium into the well. Obtaining high heat delivery from low volumes of heating medium is a necessity of this invention owing to the limited space provided for the heating medium.

In the drawing:

The drawing is a diagrammatic view partially in section representing a well bore and the equipment used for the operation of this invention.

In the drawing, numeral 2 indicates a well bore in which casing 4 has been installed with cement 6 placed in the annulus between the well bore 2 and the casing 4. Tubing 8 extends from the surface and is set opposite the hydrocarbon-containing formation 14. A straddle packer 10 is run on the tubing and set in a position to isolate perforations 18 opposite a fracture 16, as preferred in this invention, created through an impermeable stratum 12. Other perforations 18, located below the straddle packer 10, provide a path for the fluid to flow from the hydrocarbon-containing formation 14 into the well.

In the operation of this invention, as indicated in the drawing, the straddle packers are set in an open position which permits steam to be delivered down the tubing and into the fracture. The hydrocarbon-containing formation below the packers is sealed by the valve arrangement of the straddle packers. Steam is delivered down the tubing and into the fracture which extends through the impermeable stratum. Injection of the steam will continue until the portion of the fracture desired to be treated is heated to at least 400° F. for a desired duration. Injection is terminated and the tubing, as preferred in this invention, is rotated to seal the interval between the straddle packers and open the tubing to communicate with the lower zone. The pressure inside the well bore is then lowered and fluid entering the well bore below the straddle packers is produced.

Injecting steam through the impermeable formation will heat to high temperatures the adjacent hydrocarbon-containing formation. Owing to the limited space provided for the heating medium, steam or steam with relatively small amounts of gas is the injection fluid that must be utilized for this invention. The use of steam or steam and gas mixtures as the heating medium of this invention will permit sufficient heat to be delivered to the adjacent formation while injecting only a small volume of heating fluid into the well.

Owing to the dense impermeable properties of the fracture zone, the condensed liquids from the injected steam cannot escape into the hydrocarbon-containing formation. It will therefore be possible to heat the hydrocarbon-containing formation without commingling the injecting fluids with the formation oil.

Most impermeable strata, such as shale, have parallel

bedding planes. A fracture may therefore be created through thin sections of this stratum without breaking the fluid seal formed by these impermeable layers between adjacent formations and the hydrocarbon-containing formation.

In the injection of steam of this invention, the impermeable formation fracture may be initiated or extended by injecting the steam at a rate which will produce a pressure exceeding the overburden pressure on the formation. This will not produce detrimental effects because these shale formations will fracture along their bedding planes and not into an upper or lower formation. A greater radial treatment depth may thus be accomplished by extending the fracture to distances more remote from the well bore.

Owing to the injection pressures that may be generated during injection of the steam, the fracture does not need to be propped in an open position in order to perform subsequent heating treatments. It also follows that the initial fracture through the formation may be created by the injection of this steam.

In this invention it is preferred that injection of steam should continue until the fracture is heated to a temperature in the range of 400° F. to 700° F. The duration of this treatment is a variable dependent upon the radial extent to which the operator desires to heat the hydrocarbon-containing formation and the thickness of this oil-bearing formation. In formation conditions wherein the pay zone is thin it may be advisable for the operator to inject into the impermeable formation over long periods of time. However, in thick pay formations, it may be advantageous to extend the heat to relatively short radial distances from the well bore, preferably 100 to 150 feet, cease injection and produce through the same well. As the formation cools and production diminishes the fracture may again be heated. It is recommended however that in each subsequent reheating the radial distance heated to above 400° F. should be extended.

Owing to the ease of operation and equipment involved, it is an important advantage of this invention to use steam as the heat transferring material. The utilization of steam permits the operator to effectively heat the reservoir without subjecting the oil-bearing sands to the excessive temperatures that may be produced by in situ heating methods. Steam heating techniques will also allow the operator to supply large amounts of heat while injecting only a small volume of fluid into the impermeable stratum because of the larger amount of heat that is delivered to the adjacent formation as the steam condenses into water.

It has been found that a more advantageous and more efficient heating operation is conducted if small amounts of a gas, such as natural gas or air, is mixed with the steam. Where such a mixture is injected into the impermeable strata the partial vapor pressure of the steam can be lower thereby keeping the mixture in a vapor state for longer intervals of time as injection continues. This allows the hot injected fluid to be extended to greater radial distances from the well bore before condensation occurs with its resultant rapid heat release.

Heating a hydrocarbon-containing formation by this method can thereby be efficiently accomplished under controlled temperature conditions without subjecting the in-place reservoir fluids to contamination or waste.

The use of steam as the heating medium allows the operator to deliver large amounts of heat to the adjacent formation while injecting only a small volume of heating material into the limited space provided.

I claim:

1. An intermittent producing method for recovery of oil through a single well penetrating a subterranean oil-bearing formation and an adjacent impermeable formation, the impermeable formation having a fracture therein spaced from the oil-bearing formation and extending outwardly from the well, comprising isolating the oil-bearing formation from the upper part of the well, injecting steam into the well and displacing the steam down the well and into the fracture, continuing injection of the steam until the portion of the fracture desired to be heated is heated for a desired duration, terminating injection of the steam into the well, isolating the fracture from the upper part of the well and placing the oil-bearing formation in communication with the upper part of the well, lowering the pressure inside the well, and producing fluids which enter the well.

2. A method as set forth in claim 1 in which the fracture is heated to a temperature in the range of 400° F. to 700° F.

3. A method as set forth in claim 1 in which the fracture is heated to at least 400° F. for a distance of 100 to 150 feet from the well bore.

4. A method as set forth in claim 1 in which the injected fluid is a mixture of a permanent gas and steam.

5. A single well method of producing hydrocarbons from a subterranean hydrocarbon-containing formation adjacent an impermeable formation, said formations penetrated by a well bore extending downward from the surface of the earth comprising isolating the hydrocarbon-containing formation from the upper part of the well, injecting steam down the well bore and into contact with the impermeable formation, increasing the pressure on the steam in contact with the formation to create a fracture through the impermeable formation with the steam, continuing injection of the steam until the portion of the fracture desired to be treated is heated to at least 400° F. for a desired duration, terminating injection of the steam, isolating the fracture from the upper part of the well bore and placing the oil-bearing formation in communication with the upper part of the well bore, lowering the pressure inside the well bore and producing fluids which enter the well bore.

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