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[54] **SECONDARY RECOVERY FOR STEEPLY DIPPING RESERVOIRS: COMBINED CELLAR AND ATTIC FLOODING**

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[52] **U.S. Cl.** **166/272,** 166/303

[51] **Int. Cl.** **E21b 43/00,** E21b 43/20

[58] **Field of Search** 166/266, 272, 279, 303, 166/309

[56] **References Cited**

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[57] **ABSTRACT**

A method of producing oil from a steeply dipping reservoir wherein a hot aqueous fluid is injected into the reservoir which liberates gas from the oil in the reservoir. This gas then travels to the top of the reservoir where it displaces the oil at the top of the reservoir and forces it down to a production well located down dip of the top of the reservoir. The fluid travels to the bottom of the reservoir where it displaces oil upward.

3 Claims, 2 Drawing Figures

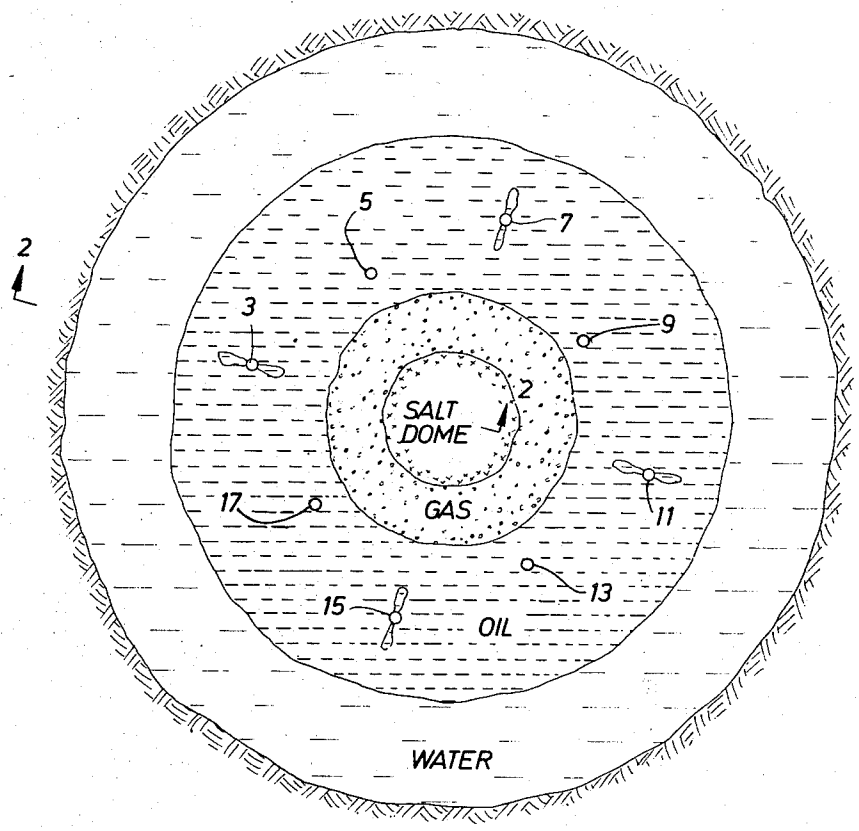
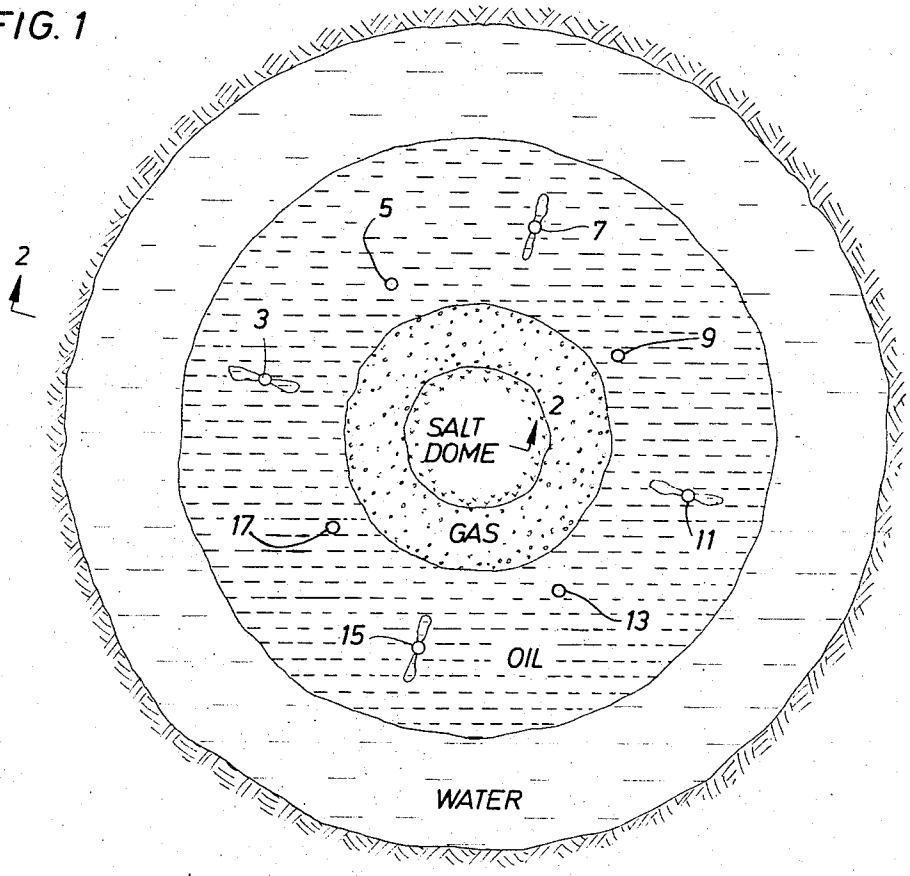


FIG. 1


2
5
7
3
9
SALT
DOME
2
17
GAS
11
13
15
OIL
WATER

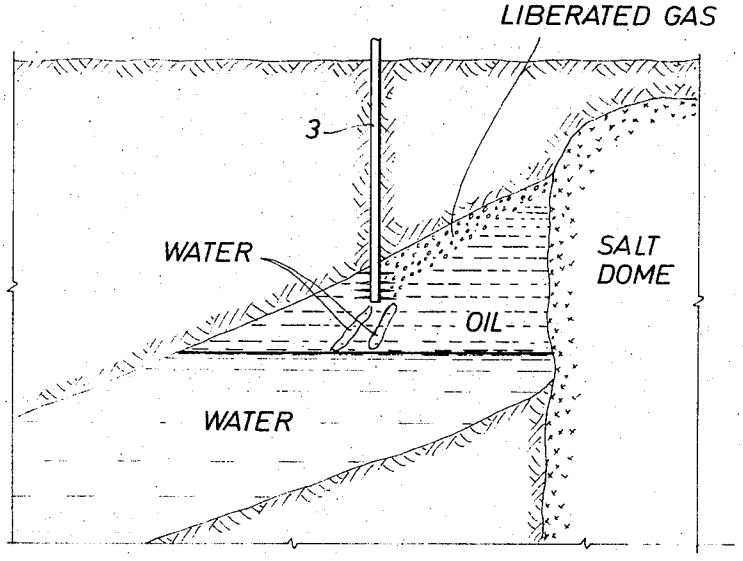

LIBERATED GAS
3
WATER
SALT
DOME
OIL
WATER

FIG. 2

SECONDARY RECOVERY FOR STEEPLY DIPPING RESERVOIRS: COMBINED CELLAR AND ATTIC FLOODING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention pertains to the field of secondary recovery of oil from subterranean reservoirs.

2. Discussion of the Prior Art

Subterranean oil bearing reservoirs are discovered which lie at a steep angle from the horizontal. If a well is not completed at the apex of such a reservoir, and there is no gas cap to drive the oil down to production wells some oil will necessarily be forever trapped in the portion of the reservoir above the highest producing well since the wells will not drain the area above them. One way to recover this attic oil, as it is called, is to inject gas into the formation through wells near the apex of the reservoir. This gas will travel updip in the formation and displace the oil in the apex forcing it down to wells located lower in the structure. This is called attic flooding. The procedure has a major drawback, however. It depends on a ready supply of gas being available for injection. The demand and market price of natural gas, methane and mixtures of methane and light hydrocarbons, has precluded its use for this purpose in some instances. In other instances the supply of natural gas is not available in the field at all. Inert gas injection has been resorted to where it is not feasible to use natural gas; but since solution gas, the gas dissolved in oil, is composed of hydrocarbons the solution gas vaporizes into the inert gas phase even though the pressure and temperature remain constant. Thus, inert gas causes adverse shrinkage and viscosity increase of the reservoir oil, both of which contribute to inefficient recovery.

It is an object of this invention to provide a method of attic flooding which introduces free solution gas into the oil reservoir without the need for a supply of natural gas on the surface.

It is a further object of this invention to achieve attic flooding and simultaneously introduce water into the reservoir which will travel downdip and displace oil upward, which is called cellar flooding.

Briefly, the objects of this invention are accomplished by injecting into the oil reservoir a hot aqueous fluid which is of high enough temperature to liberate solution gas from the reservoir oil. This liberated gas will travel updip to the apex of the reservoir while the injected water travels downdip in the formation.

SUMMARY OF THE INVENTION

The invention is a method whereby oil is produced from a steeply dipping reservoir which is penetrated by at least one well which is not completed at the very top of the reservoir, wherein a hot aqueous fluid above the bubble point temperature of the reservoir fluids is injected into the reservoir through the well which causes the oil in the reservoir to liberate gas, which gas travels to the top of the steeply dipping reservoir while the injected aqueous fluid travels to the bottom of the reservoir. The liberated gas then forces the oil out of the topmost segment of the reservoir and down to a well or wells used for production, while the injected aqueous fluid forces the oil upward to a well or wells used for production.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a planned sketch of an oil reservoir terminating at the center against a salt dome.

FIG. **2** is a crossectional view of this same reservoir showing only well **3.**

DESCRIPTION OF THE PREFERRED EMBODIMENT

The method of my invention is applicable to reservoirs having certain characteristics. First, the reservoir must be steeply dipping, that is it must be at an angle such that gas and water will migrate updip and downdip respectively in the reservoir. Next, the reservoir must have a very small gas cap or no gas cap at all since the object of this invention is to provide a method of displacing oil from high in a reservoir where there is no natural method displacing the oil from the apex of the reservoir. Also, the reservoir must have solution gas present in sufficient concentrations in the oil so that it may be liberated rapidly by the hot injected water. The precise concentration of solution gas needed in a particular reservoir to accomplish the objects of this invention will be dependent on the physical properties of the reservoir including the size and shape of the attic area above the highest production wells.

The hot aqueous fluid injected into the reservoir in the method of my invention may be fresh water, brine, or steam for example. The fluid must be of such temperature that it will liberate solution gas from the reservoir oil rapidly. It must, of course, be above the bubble point of the reservoir fluids so that gas evolution from the oil will take place.

The method of my invention is applicable to situations where the injection well for the hot aqueous fluid is the same as the production well or to situations where the injection and production wells are separated. In the first case the hot aqueous fluid is injected into the reservoir and the gas is liberated in the reservoir. After a time injection is stopped and a period of time is allowed for the liberated gas to travel upward in the reservoir and for the aqueous fluid to travel downward in the reservoir. When the gas and aqueous fluid have cleared the well bore sufficiently, production is resumed from that well and then the cycle is repeated again.

In cases where the production and injection wells are separated the method of my invention may be continuous such that the hot aqueous fluid is injected into the injection well at the same time that oil is produced from the production wells.

The attached figures depict a typical embodiment of my invention. FIG. **1** depicts wells situated around a salt dome. Wells **3, 7, 11** and **15** are injection wells and wells **5, 9, 13** and **17** are production wells. FIG. **2** depicts a crossection of the reservoir through injection well **3.** Hot water above the bubble point of the oil in the reservoir is injected into the reservoir through well **3** and enters the reservoir through openings in the well. Gas is liberated which travels to the apex or the reservoir where it forms a secondary gas cap. The water travels downward to the bottom of the reservoir. The generated gas cap and the water force the oil to the production wells where it is produced.

EXAMPLE

The following example is an illustration of the tech-

nique of my invention but is not meant to limit the scope of the invention. FIG. 1 is a planned sketch of an oil reservoir terminating in the center against a salt dome. FIG. 2 is a crossectional view of this same reservoir showing only well 3. This is a steeply dipping reservoir as is contemplated by this invention. A well arrangement is shown in FIG. 1 for preventing migrating fluids from each well mixing with migrating fluids from other wells. Typical conditions prior to and after hot water injection are listed below in the Table.

	Injection Before	After
Pressure (PSI)	4,000	4,000
Temperature (°F)	200	260
Oil Gravity (°API)	35	35
Gas Gravity	0.7	0.7
G/O (Ft. ^{3}/bbl)	950	820
Formation Volume	1.5	0.12 Gas 1.48 Liquid
Total		1.60 Total

Typical saturations prior to and after water displacement are:

	% of Pure Volume Prior	After	Oil Recovery (%)
Gas	0	0	
Oil	80	40	50
Water	20	60	

The effect of establishing a free gas saturation by injection of water above the bubble point temperature of the reservoir fluids is shown by the Table below of saturations prior to and after water invasion.

	% of Pure Volume Prior	After	Oil Recovery (%)
Gas (0.8/1.6×.12)=	6	6	
Oil (0.8/1.6×1.48)=	74	34	57
Water	20	60	

The 6 percent gas saturation established by heat will not be produced. It will gravitate to the attic and/or remain as trapped gas behind the water invasion. The oil recovery is increased from 50 to 57 percent.

I claim:

1. In a method whereby oil is produced from an oil column in a steeply dipping hydrocarbon reservoir which is penetrated by at least one injection well located downdip of at least one production well both located downdip of the very top of the reservoir but in the oil column which comprises liberating gas from the oil in the reservoir by injecting a hot fluid into the reservoir through the injection wells and withdrawing oil from the reservoir through the production wells, the improvement which comprises

liberating gas from the oil in the reservoir by injecting the hot fluid above the bubble point temperature of the reservoir fluids through the injection wells, which gas travels to the top of the steeply dipping reservoir forcing the oil out of the topmost segment of the reservoir and down to the production wells while the injected fluid travels to the bottom of the reservoir forcing the oil upward to the production wells.

2. A method as in claim **1** wherein the hot aqueous fluid is water.

3. A method as in claim **1** wherein the hot aqueous fluid is steam.

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