Jan. 15, 1963 A. F. BERTUZZI 3,073,386

METHOD OF OIL PRODUCTION BY VERTICAL GAS DRIVE

Filed July 27, 1956

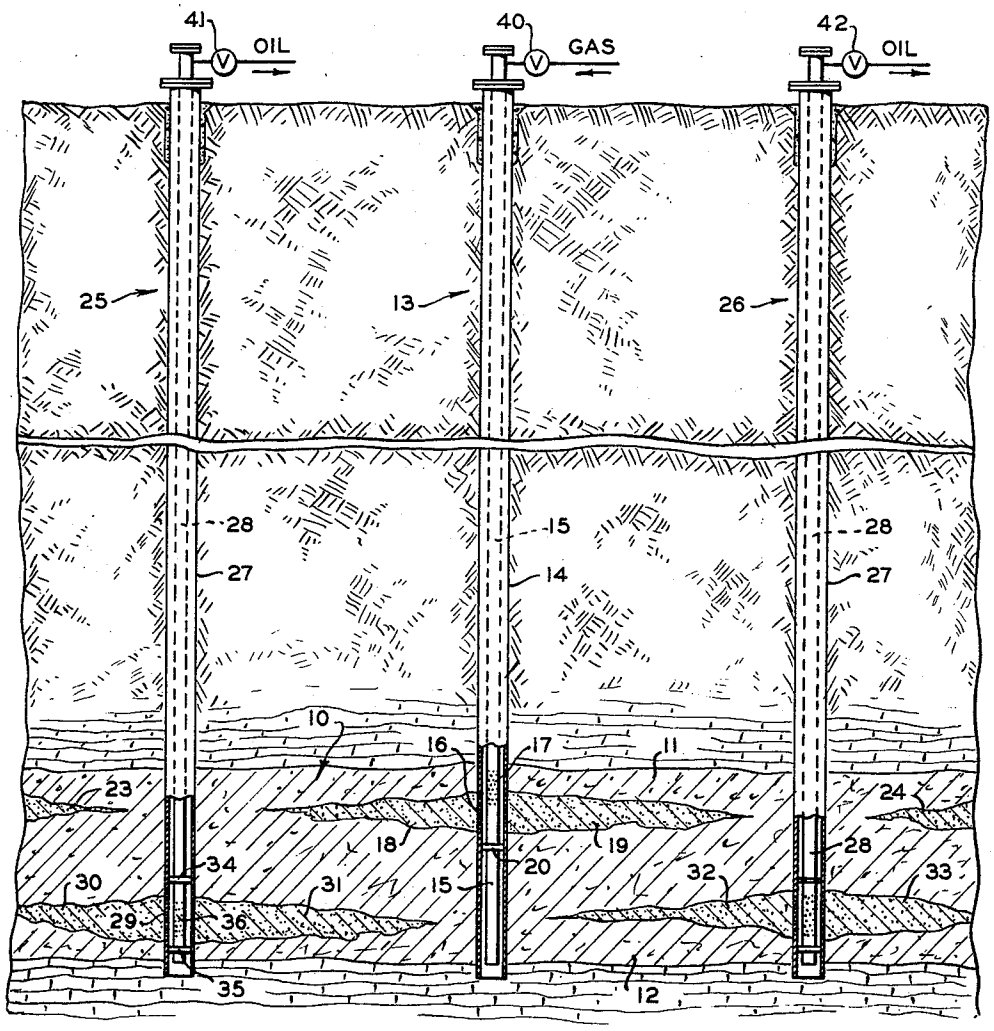


FIG. 1.

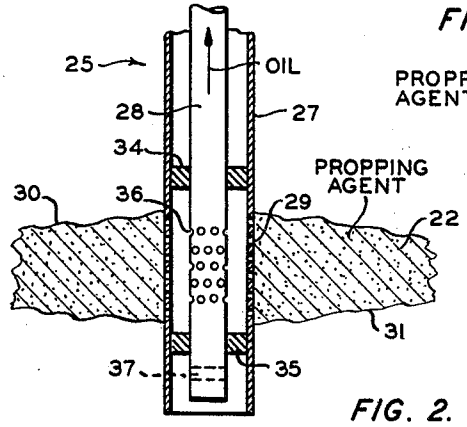


FIG. 2.

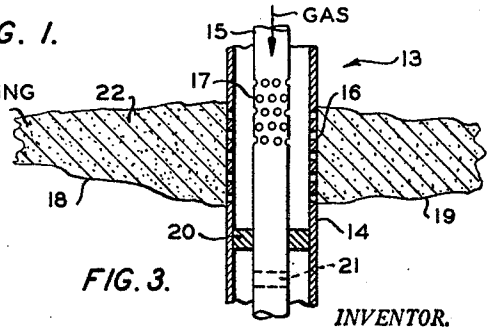


FIG. 3.

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3,073,386
Patented Jan. 15, 1963

3,073,386

METHOD OF OIL PRODUCTION BY VERTICAL GAS DRIVE

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Filed July 27, 1956, Ser. No. 600,610
3 Claims. (Cl. 166—9)

This invention relates to a system for producing oil, and a method therefor.

In accordance with this invention, the production of oil from an oil-bearing formation is increased by introducing gas through a number of horizontal fissures along a substantial area in the upper part of an oil-bearing formation. The gas thus introduced either pushes or drags the oil downwardly through the formation to a series of horizontal fissures extending along the lower part of the formation and underlying the fissures through which the gas is introduced.

According to one feature of the invention, the upper fissures extend from a different well or series of wells than the fissures through which the oil is withdrawn, thus preventing channeling of the gas along the casing of a single well. By practice of the invention, a gas cap is provided at the top of the porous oil-bearing formation, resulting in increased recovery of the oil, and furnishing a particularly useful method of oil production from relatively thick reservoirs which have little or no dip. After completion of the fissures, it is desirable that a propping agent, such as sand or gravel, be introduced to prevent caving in of the fissures after the pressure utilized to form them is released.

Accordingly, it is an object of the invention to provide an improved method of oil recovery.

It is a further object to provide a system of oil recovery particularly suitable for relatively thick formations of little or no dip.

It is a still further object to provide a method and apparatus for removing maximum quantities of oil from a reservoir at the lowest possible cost.

Various other objects, advantages and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanyings, in which:

FIGURE 1 is a schematic view illustrating the arrangement of wells and fissures in the underground formation;

FIGURE 2 is an enlarged view of the lower portion of an oil-producing well; and

FIGURE 3 is an enlarged view of the lower portion of a gas injection well.

Referring now to the drawings in detail, I have shown an oil-bearing porous formation **10**, the upper part **11** of which can be designated a gas zone, and the lower portion **12** of which can be designated an oil zone.

A gas input well **13** has a casing string **14** and a tubing string **15** which extend downwardly to the formation **10**, the tubing and casing being perforated at **16** and **17**, respectively, adjacent a set of horizontal fissures or fractures **18**, **19** which extend along a substantial area in the upper part of the gas zone **11**. The casing has a packer **20** below the fissures **18**, **19** and the tubing has a plug **21** below the perforations **17**.

Although the invention can be practiced with fissures of any length, as long as they occupy a substantial area in the upper part of the formation, it is desired that they extend to a region close to the adjacent oil-producing wells. In general, the length of the fissures will vary from 100 to 625 feet, and the oil-producing wells are generally 50 to 100 feet away from the ends of the fissures.

It will be noted that the fissures **18**, **19** are filled with a propping agent **22**, such as sand or gravel, so that they

will not collapse upon release of the pressure utilized in forming them.

Preferably and advantageously, the gas injection wells are interlaced, and several of each are provided. To illustrate this, I have shown fissures **23** and **24** extending toward the oil production wells from adjacent gas injection wells, these fissures being at substantially the same level as the fissures **18**, **19**.

I have also shown in FIGURE 1 a pair of oil-producing wells **25** and **26**, each of which is provided with a casing string **27**, and a tubing string **28**. The casing string is perforated at **29** adjacent a set of fractures or fissures **30** and **31** adjacent the well **25** and a set of fractures **32** and **33** adjacent the well **26**. Each casing **27** has packers **34**, **35**, located, respectively, above and below the associated fissures **30**, **31** or **32**, **33**. Further, each tubing **28** has perforations **36** effecting communication between the tubing and the region between the packers **34** and **35**, with a plug **37** disposed below the perforations **36**.

The two sets of fissures **30**, **31** and **32**, **33** extend along a substantial area in the lower part or oil zone of the formation, and they normally extend to within 50 or 100 feet of the gas injection wells associated therewith. Each of these sets of fissures is advantageously filled with propping agent **22**.

In operation, gas is introduced through a valve **40** to one or more of the gas injection wells. This gas passes through perforations **16** and the fissures **18**, **19** to the formation. Thence, the gas moves downwardly through the formation pushing oil ahead of it, or carrying the oil along with it to the lower fissures **30**, **31** and **32**, **33**. The oil passes through the perforations **29**, **36** and up the tubing to the surface of the earth whence it is recovered through valved lines **41** and **42**. This provides a very efficient and economical method of recovering small amounts of oil from the formation **10**. It will be evident that the particular arrangement shown, wherein the gas is introduced through wells other than the oil-producing wells, is quite advantageous in that it prevents channeling of the flow of gas. In particular, if the fractures in the upper and lower portions were formed from the same well, gas could readily channel along the outside of the tubing and reach the production zone without pushing any oil ahead of it.

As previously indicated, the method of the invention is particularly applicable to relatively thick formations of little or no dip. These may be defined as formations having a thickness of 30 to 1000 feet, certain California formations of a thickness of 400 to 500 feet being particularly suitable for practice of the invention. To obtain maximum recovery, the fractures **18**, **19**, **23** and **24** should be as close as possible to the top of the formation, but care should be taken that they not enter the overburden. Usually, accordingly, the fissures **18**, **19**, **23** and **24** are formed 10 to 30 feet below the top of the formation. Similarly, the fissures **30** to **33** should be as close as possible to the bottom of the formation but should be sufficiently far above the water table, if one is present, as to preclude the encroachment of undesirable water. Ordinarily, the fissures **30** to **33** are 5 to 10 feet above the bottom of the formation. It will be evident that a formation of little or no dip permits the gas cap to form uniformly and produces an even well-distributed flow of oil from the top fissures to the bottom fissures.

The gas can be introduced continuously or intermittently. The pressure, of course, should be higher than the formation pressure and sufficient to permit the gas to drive or carry the oil downwardly to the lower fissures. Normally, the gas pressure varies between 200 and 1800 pounds per square inch where the permeability of the formation varies between 0.004 and 40.0 millidarcys.

For a given well spacing and reservoir permeability,

the fractures should be as long as possible and yet effect the vertical linear drive. Obviously, there should not be direct communication of a given fracture with a production and injection well. This can be controlled by method of completing the wells with perforations and packers, or by stopping the fracture short of the offset well so that the resistance of the reservoir between fracture and offset is greater than the resistance between the upper and lower fracture.

From the foregoing, it will be evident that the oil production system of the invention has a number of important advantages in the recovery of oil by gas injection in that a very uniform sweeping action of the gas is obtained which is well distributed along a substantial horizontal area of the formation.

While the invention has been described in connection with a present, preferred embodiment thereof, it is to be understood that this description is illustrative only and is not intended to limit the invention.

I claim:

1. The method of producing oil which comprises forming horizontal fissures along a substantial area in the upper part of an oil bearing formation, said fissures radiating from a common location, forming horizontal fissures along a substantial area in the lower part of said formation underlying the upper fissures, said lower fissures radiating from a location which is horizontally offset from said first-mentioned location a distance greater than the length of said fissures, introducing gas by way of a passageway into the upper fissures at a pressure sufficient to drive or carry the oil downwardly, and producing oil by way of a passageway from the lower fissures.

2. The process of claim 1 wherein there are a plurality of sets of upper fissures and a plurality of sets of lower fissures all offset from each other a distance greater than the length of said fissures and radiating from a plurality of said locations.

3. The process of claim 1 wherein the fissures have a length of 100 to 625 feet, the formation has a thickness of 30 to 1000 feet, and the gas is introduced at a pressure of 200 to 1800 pounds per square inch gage.

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