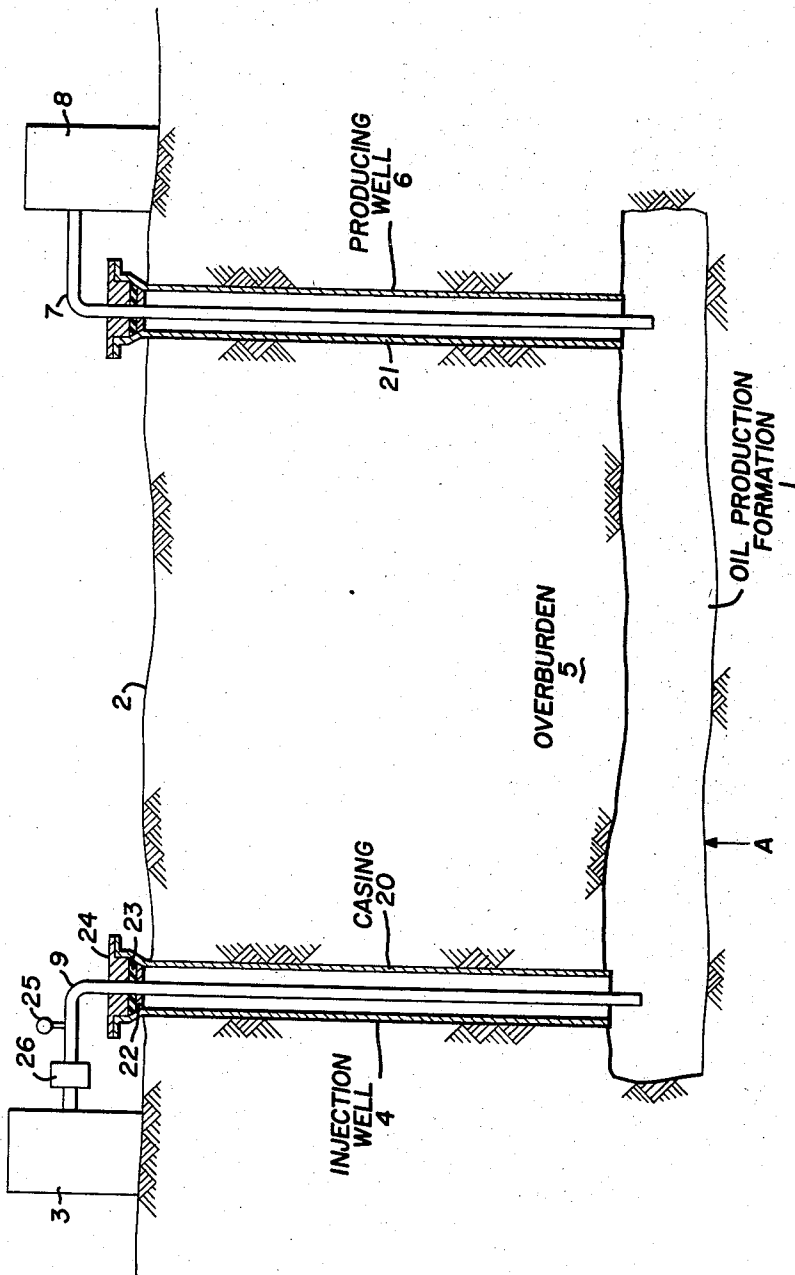


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SECONDARY RECOVERY PROCESS

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1 Claim. (Cl. 166—11)

The present invention is broadly concerned with an improved process for increasing the recovery of crude petroleum oil from oil bearing sub-surface formations. The invention is more particularly concerned with a secondary recovery operation wherein high pressure steam is used in a particular manner to secure the recovery of additional quantities of oil from an oil-bearing formation. In accordance with the present process, sufficient steam pressure is used in the formation to create fissures which extend through the formation, preferably, from the injection well to a producing well or wells. In accordance with the technique of the present operation, a minimum amount of steam is used for a maximum production of oil and excessive losses of heat to adjacent non-productive strata is prevented.

It has long been realized by the petroleum industry that only a relatively small proportion of the oil in a subterranean reservoir is removed from the reservoir during the primary production stage. Specifically, it has been found that most reservoirs still generally contain from about 40% up to as much as 85% of their original oil when primary production has ceased. This retention of desired oil in the productive formation is the result of the approach of equilibrium between the expulsive and the retentive forces acting on the oil. Therefore, to obtain further production of oil, a change of the physical or chemical relation between the retained oil and the formation is needed.

Accordingly, the petroleum industry has employed a great number of methods or processes for secondary oil recovery. In general, these methods call for the introduction of a fluid within one or more injection wells in a reservoir and for the subsequent withdrawal of oil from spaced production wells. Fluids that have been suggested or employed for this purpose include water, flue gas, carbon dioxide, methane, propane, butane, and the like.

One of the most widely employed methods for the secondary recovery of oil has been the waterflooding procedure in which water is injected and employed as the driving medium. This procedure has been successful in recovering from about 10 to 50% of the initial oil from most reservoirs. Unfortunately, however, this waterflooding procedure still leaves from about 35 to 65% of the oil in the reservoirs. Furthermore, a waterflooded reservoir is not readily adapted to other additional secondary recovery techniques since the water tends to decrease the transmissibility of oil in a reservoir to an extent such that the other commonly employed secondary recovery drive media are unable to function properly or efficiently.

Also, the use of steam to increase oil recovery in a secondary operation has been proposed. However, heretofore, the method for the use of steam as a secondary recovery medium has been to use it in a manner similar to a gas or water drive wherein the oil is driven ahead of the injected steam as a bank of flowing oil. By this method the water of condensation acts as a driv-

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ing medium of the oil toward producing wells and thus further the recovery of oil.

One difficulty in this method of utilizing steam is that there occurs large, and sometimes prohibitive, heat losses to adjacent non-oil-containing formations. These heat losses increase rapidly with time, and thus, it is essential that the process go fairly rapidly if these excessive and prohibitive heat losses are to be avoided. However, the process or operation cannot be speeded up without limit, since with bank movements of fluids, it is not possible to achieve production rates above a certain figure due to the porosity and geological nature of the oil-bearing strata. This is particularly the case in reservoirs wherein there exist high oil viscosities and wherein the formations have relatively low permeabilities and also are of relatively shallow depths.

In accordance with the present invention, these difficulties are overcome by the use of steam of sufficient pressure so as to cause fracture of the reservoir rock and to lift the overburden. When these fractures occur, steam and condensed water will flow through the formed fissures from the injection well toward the producing well. Under these conditions, the temperature of the reservoir will rise rapidly as heat flows from the fissure to the surrounding oil-bearing strata by diffusion. By operating in this manner, a limitation otherwise present in the use of steam is removed, namely: the relatively low rate of transfer of heat to the reservoir. By the present method of operation, any rate of heat transfer which can be supported by boiler capacity and condensate lifting facilities can be achieved. In operation, in accordance with the present invention, it is not desirable that live steam in any substantial quantity reach the producing well, since it is desirable that the latent heat or heat of condensation of the injected steam be utilized to heat the oil-bearing formations about the fissures.

As the steam condenses in the fissures this will tend to restrict flow of fluid through them. This in turn will cause the steam and water to flow through larger and larger areas adjacent the fissures, thus further rapidly heating up the reservoir by diffusion. Furthermore, in accordance with the present invention, as the adjacent areas near the reservoir heat up, the pressure gradients as existing along the fissures will begin to move oil under steam and water drive toward the producing wells. Thus, by the time the bulk of the reservoir is well heated, the steam and condensate water will have removed substantial quantities of oil from the reservoir. Thus, the process of utilizing steam in a secondary recovery method will be efficiently accomplished without prohibitive losses of heat to adjacent non-productive strata.

The process of the present invention may be more fully understood by reference to the drawing illustrating embodiments of the same.

An oil-producing formation 1 is shown positioned below the earth's surface 2. A borehole 4 and borehole 6 extend from the earth's surface to the oil production formation. These boreholes are lined with suitable casing 20 and 21, respectively. In accordance with the present invention, steam under high pressure is generated in facilities 3. This steam is passed through injection well 4 by means of a conduit of sufficient strength 9. Suitable auxiliary equipment is utilized, such as a support 22, packing 23 and well head equipment 24 as well as pressure recording gauges 25 and metering equipment 26. The high pressure steam is injected into oil-containing formation 1 in sufficient pressure to lift the overburden 5 and to cause fissures to form in oil-containing formation 1, preferably, extending from the injection well 4 to a producing well or wells 6. Thus, in operation, the injected high pressure

steam will flow through these fissures and will be substantially completely condensed prior to reaching producing well 6. The fluids are removed through conduit 7 in well 6 and passed to facilities 8 wherein a segregation between the water and produced oil is made.

As pointed out heretofore, the present process of creating fissures by the use of high pressure steam overcomes the difficulties previously encountered in using steam as a driving medium. Heretofore, due to the inherent nature of oil-containing formations, the drive had to proceed at a relatively low rate of production. Thus, the steam bank may have proceeded to a particular point at which time not only was the portion of the oil-producing reservoir between the injection well and particular point heated, but in addition, vast areas of the non-producing overburden also heated. Heat is also lost to the area of non-oil-containing strata existing below the oil-bearing formation. In accordance with the present invention, the injected steam will flow through the produced fissures and will reach the producing well before heat will be lost in significant amounts to the non-oil-bearing strata existing above and below the oil-bearing formation. While the present invention may be used with respect to any type of formation in a secondary recovery method, it is particularly adapted to fairly shallow fields. The fissuring process may tend to produce a somewhat erratic and unpredictable initial pattern of heat input fissures. Thus, it is desirable that there exist a fairly close well spacing. Also, in order that lateral and vertical heat diffusion occur in a reasonable time, it is also desirable that the flow channels enlarge themselves from the original fissures in a reasonable time so as to prevent prohibitive losses of heat to adjacent non-producing strata. Furthermore the shallow fields will require less pressure to secure the required fissures from the injection well to the producing wells.

The pressure requirement for the production of fissures in a formation, is roughly equivalent in pounds per square inch to the depth of the formation in feet. It has been found in the art of formation fracturing this pressure, commonly referred to as the "formation breakdown pressure" is equal to the pressure required to overcome the rock-binding strength and the pressure to lift the effective overburden. Due to both change in the

character and the subterranean configurations of the formation, the formation breakdown pressure varies from place to place. However, as a general rule, this pressure in pounds per square inch divided by the formation depth in feet, is reasonably constant from about .6 to about .9 p. s. i. per foot of depth or 60 to 90 pounds per square inch per hundred feet of depth.

This invention teaches that it is necessary to apply pressures to the formation equal to the formation breakdown pressure, a pressure which is readily recognized. As a fluid is injected or pumped into a formation, the pressure increases until a maximum pressure is reached whereby increased injection of fluid does not materially effect this pressure. This pressure is readily discernible at the well head by noting both the fluid injection rates and pressures.

While it is desirable that the fissures extend throughout the formation, this is not essential. Furthermore, the fissure pattern may change with time. The extent and degree of fissuring necessary as well as the precise fissure pattern must be of such a nature as to permit the introduction of sufficient steam at a rate adapted to give heat to the reservoir so that the operation can be carried out before prohibitive amounts of heat are lost to non-oil-containing adjacent strata.

What is claimed is:

In a process for the recovery of oil from a subterranean oil formation, which is penetrated by an injection well and a producing well spaced from said injection well, including the steps of injecting steam into said formation through said injection well and recovering fluid from the formation through said producing well, the improvement which comprises applying the steam within the injection well against the formation at a pressure sufficient to fracture the formation, whereby heat is rapidly dissipated through the formation and fluid including oil and water flows through said fractures to said producing well.

References Cited in the file of this patent

UNITED STATES PATENTS

1,237,139	Yeomans	Aug. 14, 1917
2,734,578	Walter	Feb. 14, 1956