

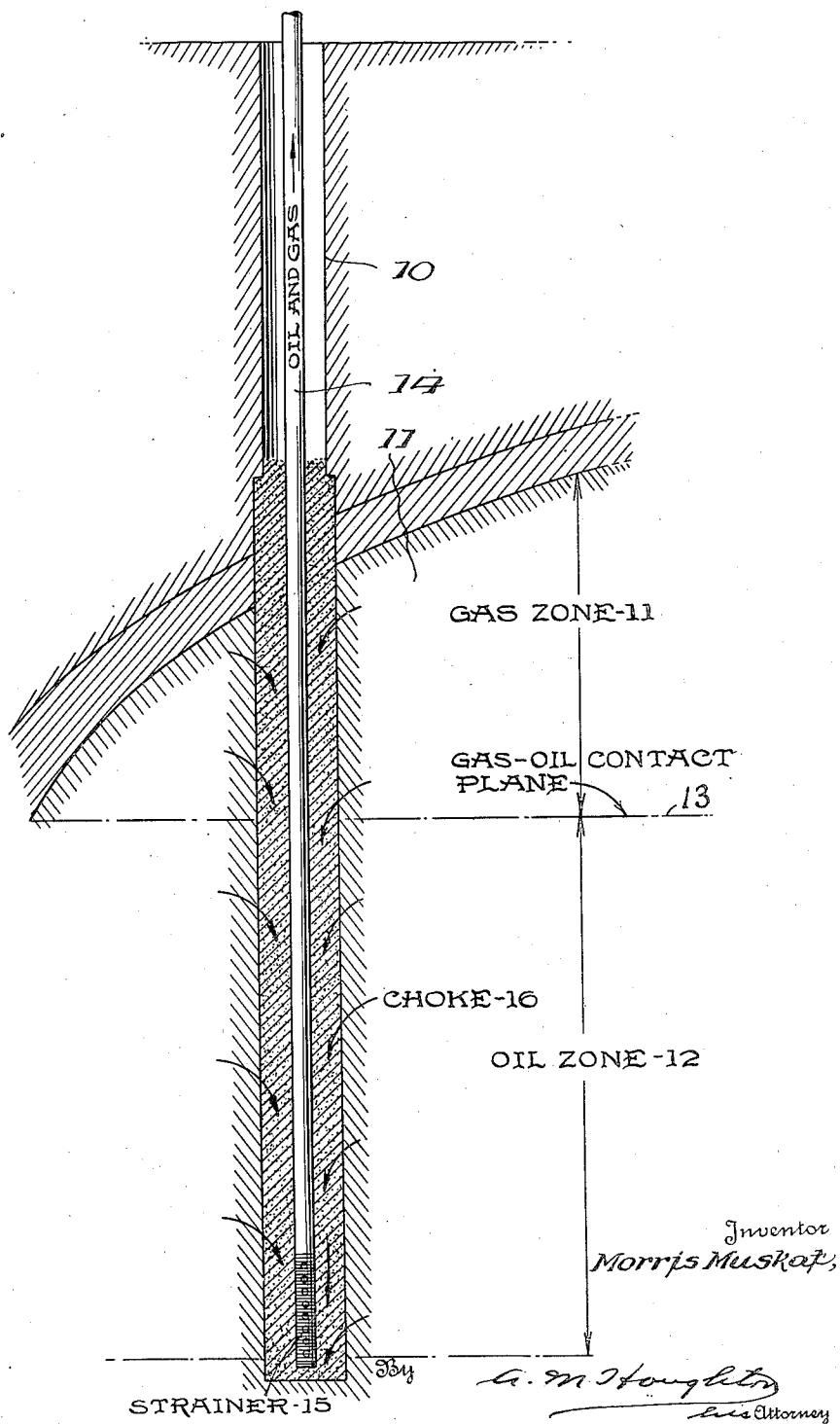
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RECOVERY OF OIL FROM OIL FIELDS

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RECOVERY OF OIL FROM OIL FIELDS

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4 Claims. (Cl. 166—1)

This invention relates to improving recovery of oil from oil fields.

In producing oil fields, the force that drives oil from the permeable reservoir rock containing it to the wells is pressure exerted on the oil in the rock by some fluid other than oil. Without such extraneous drive fluid the oil, which saturates the rock in the manner of a sponge, remains stagnant. The drive fluid may be compressed natural gas occurring naturally in association with the oil, or gas or air artificially injected under pressure. Or it may be water under hydrostatic pressure, the water being either naturally present or artificially introduced. To produce oil it is essential that such extraneous fluid pressure be maintained. The amount of oil that can be recovered from a producing formation depends directly upon the degree to which the gas associated with the oil within the oil bearing strata or contiguous strata is conserved. That is, the lower the average volume of gas which is produced with each barrel of oil the higher will be the cumulative recovery of oil from the producing formation.

In the best modern oil field development technique gas pressure is maintained as long as possible by various expedients. Sometimes gas produced with oil is separated and fed back into adjacent wells under pressure. And, when an oil field has become "exhausted" by reason of loss of gas, oil can still be produced by injecting gas, or air, in suitable ways, to replace the lost formation pressure.

The great difficulty in maintaining the required gas driving pressure on the oil is that the gas which flows much more readily through rock than oil does anyway, tends to short circuit the oil beds and escape. That is, gas under pressure instead of performing its duty of squeezing oil out of an adjacent oil sand takes the path of least resistance and leaks away through the most permeable bed it can find.

Probably the greatest problem in operating an oil field is that of keeping down the ratio of extraneous fluid, to oil, in the fluid mixture produced from the wells.

Ordinarily the gas-bearing stratum overlies the oil strata, or at least overlies the main ones. This is especially true in oil deposits of the gas-cap type, where the reservoir may be visualized as an impervious-roofed dome, partly filled with oil and overlain by a body of compressed gas at pressure equal to the hydrostatic pressure of the oil. As the oil production proceeds, the body of gas usually expands and travel outwards and

downwards toward the flanks of the structure, increasing the original thickness of free gas horizons at any one place, and creating new gas cap extensions into parts of the strata which originally may have been fully saturated with oil. A similar situation obtains even in fields which do not originally possess gas cap zones, but in which during the course of production of oil and gas the upper parts of the pay become greatly depleted of the oil and entrap the upward migrating gas phase, thus creating free gas zones which are essentially equivalent to those occurring in normal gas caps.

In conventional oil production practice, the only expedient of much practical use for keeping down gas influx has been to carry the tubing to the very bottom of the well, so that gas from the overlying gas formation has to take as long a passage as possible before reaching the tubing intake. This is not very effective.

Other methods have been devised with the accomplishment of that end in view, involving mechanically isolating the productive strata while shutting off the overlying gas strata. These known methods are satisfactory provided the levels of the several strata, and certain other important conditions, are accurately known. But often such knowledge is impossible of attainment.

The main object of the invention is the provision of a means for lowering the production ratio of gas to oil in recovering oil from subterranean deposits; without requiring an accurate knowledge of subsurface stratigraphy or indeed of several other conditions, information as to which has hitherto been essential.

The invention is based on the discovery that a special kind of choke can be provided in wells in a manner such that in effect it throttles down the gas flow to a marked degree and at the same time has but little throttling effect on the oil flow. In the simplest embodiment the choke takes the form of an annular body of longitudinally and laterally permeable character, so disposed with respect to the well tubing and to the productive and gas-bearing strata faces that the gas has to take a much longer obstructed path than the oil from or to a well. The result is a sort of selective choking action which brings about a remarkable reduction in gas-oil ratio.

The invention is applicable to both input wells and output wells. For the sake of concreteness it will be described primarily in connection with output wells.

The mode of practicing the invention will be clear from a consideration of the accompanying

drawing which is a schematic view in vertical section of the invention embodied in an output well, for the purpose of conserving natural formation pressure.

As shown, a well 10 penetrates a gas cap or stratum 11, and extends down to an oil-producing stratum 12. The gas-oil contact plane is shown at 13. A tubing 14, with a strainer-protected inlet 15 at its bottom, extends to the bottom of the oil stratum. Oil is produced through the tubing by pump, gas-lift or other means not shown.

Assuming the hydrostatic head of oil in the tubing to be less than the formation pressure in stratum 11, gas tends to escape down the annular space between tubing and well, to the tubing inlet, and to be produced along with the oil. In ordinary practice inordinate amounts of gas may be produced along with the oil. It would seem easy to shut off the gas stratum in some way, and thus solve the problem, but in practice this is difficult or impossible. Things are not so clear-cut as appears in a pictorial representation. Even by the most careful rock coring, or use of electric logging methods, it is often impossible to locate the gas strata with any certainty.

According to the invention an annular permeable choke 16 is provided in the space between the tubing and the well, extending throughout the height of the formations which produce oil or are believed to produce oil. This choke can take many forms. It can be a monolithic mass such as permeable cement, or, more conveniently, a mass of non-consolidated particles such as sand.

In use the choke imposes very little restriction on oil flow, as only a short passage of oil through the choke is required. But the throttling effect on the gas flow, which may have to course through many yards of the choke, is considerable.

If the producing pressure differential over the oil formation be kept less than the fluid head between the top of the perforations in the tubing and the gas-oil contact plane the escape of gas from the free gas zone will be completely eliminated. And if the producing pressure differential exceeds this fluid head the escape of gas from the free gas zone is severely limited and reduced in quantity. As a matter of fact, from the mechanics of the flow of petroleum fluids through porous media it is apparent that a restricted column of porous material such as that which is disposed between the tubing and the exposed face of the producing strata in the present invention will increase the resistance to flow from a gas-producing formation by an amount that is quite comparable to the total resistance of the reservoir sand itself.

It will be seen that in so positioning the choke with respect to the oil and gas-producing formations and to the inlet of the production tubing it is not necessary to predetermine the position of the gas-oil contact. The method automatically restricts the escape of gas from the free gas zone regardless of the position of the gas-oil contact provided only that the choke be extended to the plane of gas-oil contact. Preferably, it can extend to the very top of the gas bearing strata.

While the presence of the choke will have some tendency to increase the resistance to the flow of the oil from the oil bearing zone to the tubing, this effect is quite negligible unless the permeability of the choke material be very low as

compared to the permeability of the main body of the producing formation. In order to minimize even this small increased resistance to the flow of the oil, my invention encompasses the setting of the choke in such a way that gravel rather than sand is placed opposite the oil bearing strata and that sand be set on top of the gravel and opposite the gas bearing strata. This or any other combination of sand and gravel or either separately may be used to effect the purpose of this invention.

Placement of the choke is usually simple. Using sand for the choke, the sand can be deposited with the aid of the apparatus shown in Chenault Patent 2,140,072. If a consolidated (monolithic) choke is desired, it is convenient to employ Portland cement containing enough gas generating agents (advantageously hydrogen generating agents) to give to the mass the required permeability under the conditions in which the mass sets. Such a cement choke is set by methods already known for making permeable cement filter packs.

In installing the tubing and choke, the tubing, with its end initially closed or provided with a valve, is set to the very bottom of the well bore, and the choke deposited around it. If desired, the lower end of the tubing can be replaced by a suitable liner, screen or strainer.

In employing the invention in conjunction with gas repressuring, the same arrangement is employed as shown in the drawing, but repressuring gas is forced down the tubing and thence into the rock. The ratio of the gas entering the oil-bearing stratum to that entering the bypassing stratum is increased. A similar arrangement can be provided in the output wells, to effect still further improvement in gas-oil ratio.

In practice, the annular opening between well bore 10 and tubing 14 is closed off somewhere above choke 16 in a conventional manner (not shown), thus limiting flow of fluids in the well to that entering or leaving through tubing 14. For this purpose, a packer may be set anywhere between the well head and the top of choke 16, but I often find it more advantageous to run the tubing through a stuffing box at the well head.

What I claim is:

1. In a well extending through a gas-containing formation into a lower, oil-bearing stratum, a fluid conduit extending into the well and communicating therewith at a point near the bottom within the horizons of the oil-bearing stratum, and an elongated tubular choke made of a permeable medium enclosing the lower end of said fluid conduit and extending upwardly therefrom over the exposed face of said oil-bearing stratum and therebeyond at least to the plane of gas-oil contact.

2. In a well extending through an upper gas-bearing stratum and a lower oil-bearing stratum: tubing extending down to, and opening adjacent, the bottom of said oil bearing stratum, and an elongate annular choke made of a medium permeable in all directions, filling the space between the tubing and the exposed strata faces, whereby an obstructed fluid path is provided between the gas stratum and the tubing opening, relatively longer than the path between the oil-bearing stratum and the tubing opening.

3. In a producing well extending through an upper gas-bearing stratum and a lower oil-bearing stratum: tubing extending down to, and opening adjacent, the bottom of said oil bearing stratum, and an elongate annular choke made

of a medium permeable in all directions, filling the space between the tubing and the exposed strata faces, whereby an obstructed fluid path is provided between the gas stratum and the tubing opening, relatively longer than the path between the oil-bearing stratum and the tubing opening.

4. In a gas-repressuring input well extending through an upper gas-bypassing stratum and a lower oil-bearing stratum: gas input tubing ex-

tending down to, and opening adjacent, the oil bearing stratum, and an elongate annular choke made of a medium permeable in all directions, filling the space between the tubing and the exposed strata faces, whereby an obstructed fluid path is provided between the gas stratum and the tubing opening, relatively longer than the path between the oil-bearing stratum and the tubing opening.

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