

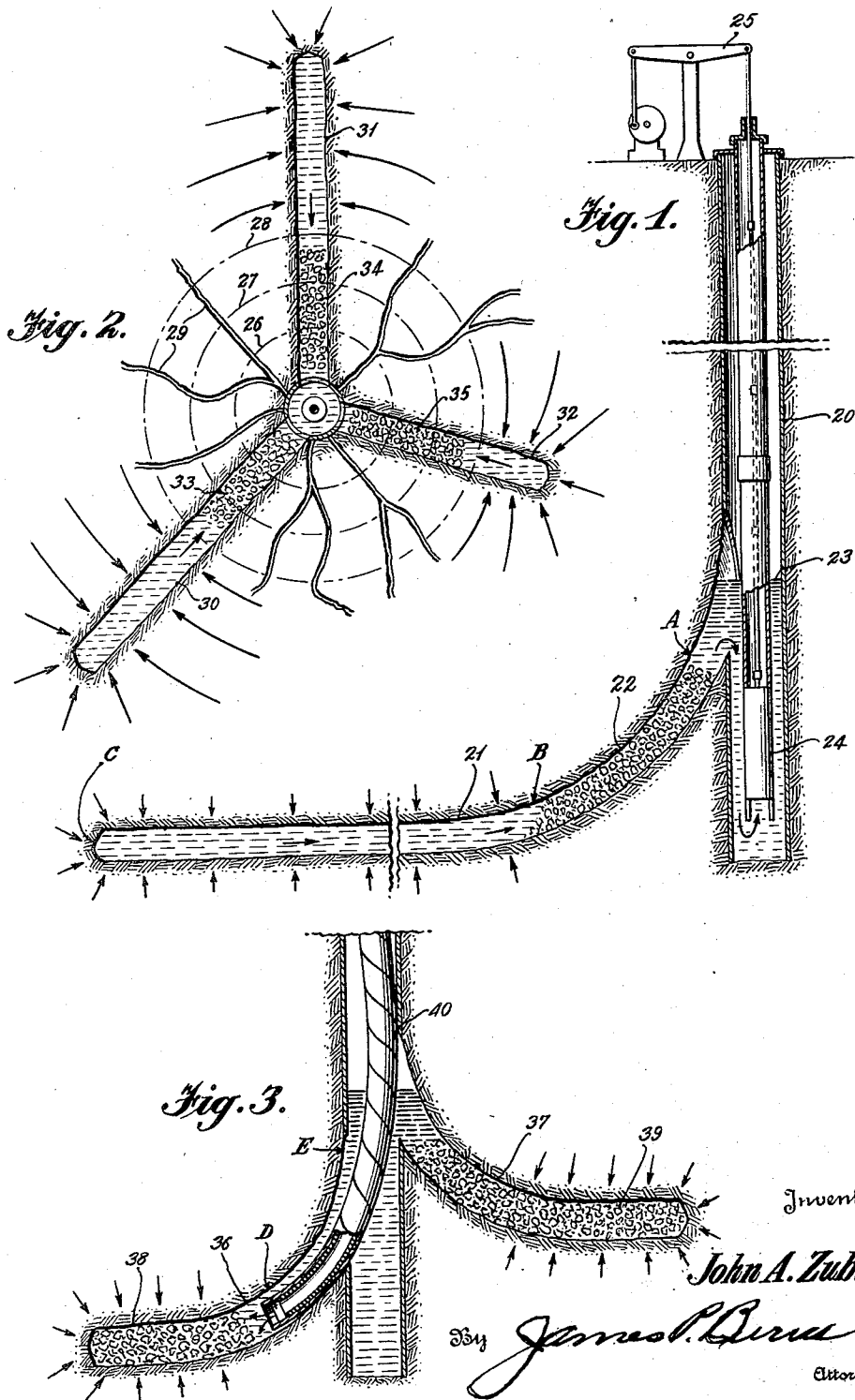
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METHOD OF PRODUCING OIL

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METHOD OF PRODUCING OIL

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This invention relates to a method of producing oil. More specifically, the invention contemplates a novel method for producing oil from formations which contain large amounts of fine sand, silt, or colloidal-like matter.

In many oil fields, the oil producing formation contains in addition to coarse sand, substantial amounts of very fine sand or silt-like material which is readily carried by the flowing oil toward the producing well. To avoid difficulties encountered as a result of the carrying of this fine material into the well, various forms of screen pipe having extremely small openings have been employed in an effort to keep the fine sand and silt from entering the well. In practice, these small openings quickly become clogged and materially retard the flow of the oil from the formation into the well. When larger openings are provided in the screen pipe, the silt and fine sand enter the well along with the oil and result in the packing of such silt and fine sand around the tubing and pumping equipment, making frequent removal thereof necessary. The cleaning out of such materials from the well is a costly operation and represents a substantial economic loss due to the time consumed and the interruption in the production of the well.

When an oil well is drilled into a given oil producing formation, the natural channels for the flow of oil to such well are left entirely to chance. When certain areas around the well become clogged by sand, silt, and colloidal-like matter, carried with the oil fewer channels remain open to ensure continuing producing from the well. Under the action of a pump in maintaining a low liquid level in a given well, there is kept up a constant pressure differential between the well and the formation near the well. As the channels for oil flow become fewer, less oil enters the well, resulting in a lowering of the liquid level in the well and the creation of a greater pressure differential, which in turn causes the oil to flow with increased pressure through the remaining channels. Under such circumstances, even greater amounts of silt, fine sand, and colloidal-like material will be carried by the oil into the well, resulting in the clogging of the well and the freezing of the pumping equipment. In many instances, where perforated pipe with fine slots has been employed in an effort to prevent the fine sand from entering the well, the screen pipe has lasted only a few days, after which it has been found to be destroyed under the impact of the velocity of the sharp sand and silt carried in the oil.

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It has also been suggested to introduce a so-called "gravel-pack" into the well, the gravel thereof to act as a filter bed through which the oil is forced to flow before entering the pump.

5 Such a gravel pack has been found to slow up somewhat the deposit of fine sand and silt in the well, and to allow the pumping equipment to operate for a considerably longer period of time than when no such expedient as the gravel pack is resorted to.

10 The gravel pack method is, however, open to objection since the vertical well does not provide adequate space to accommodate an effective filter bed. It will be appreciated that oil wells with small production naturally operate with a low fluid level. The pumps to be effective must be sufficiently submerged within the oil and, therefore, must be installed below the lowest fluid level. Gravel packing that fills the bore of the well can, of course, be installed only below the pumping equipment, and is necessarily reduced in extent to the amount of space between the lower end of the pump and the bottom of the well. Where gravel packs fill the annular space between the vertical bore and a perforated casing, there is provided only a very thin filter of but several inches in thickness even in an underreamed hole. Such gravel packs are inadequate to effectively eliminate the difficulties incident to the carrying of fine sand, silt, and colloidal-like material into the well.

It is, of course, appreciated that the permeability of an oil sand, as well as the viscosity of the oil content thereof, constitute the main factors which determine the resistance to flow of the oil from the formation to the well. Thus far, little has been done in an economic way to change the viscosity of the oil in the formation. Furthermore, the permeability or the porosity of the oil sand cannot be changed. I have, however, heretofore determined that the flow of oil from a formation into a vertical producing well can be materially facilitated by drilling deviating bores from a vertical well bore which extend into the formation. These deviating bores may be drilled in accordance with the teachings contained in my prior Patents Nos. 2,336,338 and 2,344,277. Through the medium of such deviating drain holes, it is possible to perforate the oil sand of the formation with wide, open, smooth, low pressure channels. Through these, the oil can flow with but a small fraction of the energy required to cause flow for the same distance through an oil sand with only its limited natural permeability. Due to the low friction of the open channel

connection with the vertical producing well, the deviating drain holes have substantially the same low pressure as prevails in the vertical well itself.

I have now discovered that it is entirely feasible and advantageous to install a gravel pack of substantial extent in that curved portion of each deviating drain hole adjacent to the vertical well. In this way, a part of the pressure differentials that exist between the drain holes and surrounding formation can be absorbed by the friction created by the filter material through which the oil must flow in reaching the vertical well. By proper correlation of the extent of the gravel pack with the formation pressure, a sufficient pressure differential can be maintained to cause oil to flow into the drain holes. It will be appreciated that the differential pressure reduces gradually in the direction of the vertical well, reaching its lowest value at that point of the drain hole where the filter pack ends. In this way, the greatest differential in pressure between the drain holes and the formation exists at the farthest distances from the vertical well. In this way, the oil from the formation flows into the drain holes and thence upwardly through the filter material into the vertical well. At intermediate points along the deviating bores, while there is less differential pressure than at the extremities thereof, there will nevertheless be substantial oil flow from the formation into the deviating bores due to their large area of contact with the formation. For average production of oil from the entire formation surrounding the deviating bore, and as a result there exists no zones of agitation that act to stir up and suspend in the oil any excessive amounts of fine sand and silt. In this way, oil can be produced with substantially less sand and silt therein than through the employment of prior methods of production because very substantial amounts of the silt, fine sand, and colloidal-like material, which would normally reach the well, are deposited in the drain holes and the gravel packs contained therein.

It will be appreciated, of course, that it is possible to gravel pack deviating drain holes extending from the producing well throughout their entire length, and this expedient may be resorted to where the deviating drain holes are relatively short, but this is not ordinarily necessary.

One significant advantage of the present invention resides in the fact that it makes it possible to control the velocity of drainage of the oil from the formation into the drain holes and the producing well by regulating the pressure differential between the formation and the well, which can be in large part accomplished by controlling the liquid level within the well and the extent of the gravel packs provided in the deviating bores. The liquid level may be controlled from the top of the well in any conventional manner.

It will be appreciated that several deviating drain holes may be drilled around one vertical producing well, and that while gravel packs are convenient and desirable, other forms of filter material may be used. Since the gravel packs are disposed away from the vertical producing well in which the pumping equipment is installed, the fine sand and silt that deposits within such filter packs never acts to disturb the well itself. Furthermore, when one or more deviating bores becomes objectionably clogged, it can be abandoned and a new deviating bore drilled with-

out the destruction of the producing well. In view of the foregoing discussion of the problems and nature of the invention, it can be appreciated that one object of this invention relates to the control of the velocity of the oil flow from its original deposit in the formation into the producing well through the provision of deviating drain holes provided with appropriate filters. It is a further object of the invention to provide for the flow of oil from the formation through deviating drain holes provided with filters in such manner as to deposit fine sand, silt, and colloidal-like material within the deviating drain holes and away from the vertical producing well within which the pumping equipment is installed.

It is a further object of the invention to provide for the maintenance of the controlled differential pressure between the oil producing formation and the vertical producing well to minimize the deposit of fine sand, silt, and colloidal-like material in the well.

For purposes of exemplification of the invention, a drawing accompanies this specification and forms a part thereof, in which:

Fig. 1 is a diagrammatic view, partly in section, of an oil well from which has been drilled a laterally extending deviating bore;

Fig. 2 is a diagrammatic plan view partly in section showing the location of a series of deviating bores in a partially depleted oil sand surrounding an oil well; and

Fig. 3 is a view similar to Fig. 1, but illustrating two relatively short curved bores deviating from a vertical well.

Referring to Fig. 1, the vertical bore 20 is shown as having a deviating bore 21 drilled downwardly and laterally therefrom. The deviating bore 21 is illustrated as filled with a filtering material in the form of a gravel pack 22 extending between points A and B in the upwardly curved portion of the deviating bore 21. Oil entering the deviating bore 21 from the surrounding formation between the point B and the end C of the deviating bore 21, tends to fill the deviating drain hole. The oil under hydraulic pressure, gas pressure or water pressure, is forced to flow upwardly through the filter material 22 from the point B to the point A, and thence into the vertical bore 20, in which a liquid level as indicated at 23 may be maintained through the action of the pump 24 actuated from the surface of the well as, for example, by a conventional walking beam 25.

By maintaining the permeability of the filter material 22 between the points A and B greater than the permeability of the surrounding formation, the oil will pass through the filter material 23 leaving any fine sand, silt, and colloidal-like material in the deviating bore and preclude passage of any substantial amount of such objectionable materials into the vertical well.

In the disclosure of Fig. 1, the open drain hole extending from point B to point C is of considerable length and exposes a substantial drainage area to the surrounding formation which, it will be appreciated, is much greater than the drainage area provided by the vertical bore 20. If the vertical well 20 has been producing oil for a number of years before the deviating bore 21 is drilled, it will usually be found that the formation surrounding the vertical bore has been clogged to a substantial extent with fine sand, silt, and the like, deposited therein. Accordingly, new life is imparted to the well through the medium of the deviating bore.

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In Fig. 2 there is illustrated a more or less ideal underground plan, wherein the concentric rings 26, 27 and 28 are intended to illustrate how the floating sand, normally carried in the oil, will pack around a vertical well bore more or less concentrically under the assumption that the oil sand is of equal structure and has even permeability surrounding the well, and that the flow of oil is substantially equal from all radial directions toward the vertical well.

The ring 26 indicates the zone of greatest clogging of the formation by the fine sand, silt, and the like. The larger ring 27 indicates a zone of somewhat lesser clogging, and the ring 28 indicates a zone where only partial clogging of the formation has occurred. After the formation has been clogged, experience shows that fissures, such as indicated generally at 29, often break through the formation due to the pressure differential. The irregularities of fissures of this kind reduce the over-all flow of oil but cause the oil that does reach the well to move at a velocity adequate to carry substantial amounts of sand and silt into the pumping apparatus in the well. The three drain holes indicated in Fig. 2 at 30, 31 and 32 are shown as having been drilled so as to extend clearly beyond the clogged zones of the oil producing formation. It will be additionally observed that, compared with the fissures that usually occur, the deviating drain bores are of substantial size. They are relatively straight, of uniform diameter, and smooth walled. They thus allow the oil to flow through them with very little friction. They are also shown as provided with the gravel packs 33, 34 and 35, located relatively close to the vertical well. The arrows in Fig. 2 show generally how the oil in the formation beyond the clogged zone flows to the outer ends of the deviating drain holes which, because of their direct connection with the vertical well, create the requisite pressure differential to ensure flow of oil from the formation thereinto. In accordance with the plan diagrammatically illustrated in Fig. 2, an existing vertical well that has become substantially completely clogged off from the formation may be made to yield very substantial additional quantities of oil, and this may be accomplished without encountering the extreme difficulties incident to carrying into the vertical well the fine sand, silt, and colloidal-like material that originally occasioned the clogging off of the vertical well from the formation.

In Fig. 3 there are disclosed a plurality of relatively short deviating bores 36 and 37, and in this case the gravel packs 38 and 39 extend substantially throughout the length of the respective deviating bores 36 and 37. In some instances, it may be desirable to treat the walls of the deviating bores intermediate the gravel pack and the vertical well, for example the zone between D and E of the deviating bore 36 in Fig. 3, in a manner to reduce the porosity of the formation at this point so as to ensure the passage of the oil from the formation through the gravel pack.

It will be appreciated that by packing the deviating bores throughout their lengths, the necessity of casing these bores can be avoided since the gravel pack will preclude deleterious cave-ins of the formation, which is, in certain types of formation, a desirable feature.

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In Fig. 3, there is also shown a flexible tube 40 of the general character described in my prior Patent No. 2,336,338, which can be employed as a conduit for feeding gravel or similar filter material downwardly through the vertical well and into the downwardly deviating bore. The flexible tubular pipe 40 can be gradually withdrawn from the deviating bore as the filter material is discharged thereinto. In this way, the filter material may be positioned at any suitable point in the deviating bore or throughout the length thereof as desired. It will be appreciated that in operations such as disclosed in Figs. 1 and 2, the introduction of the gravel pack is proceeded with cautiously until a pack of the gravel material is established adequate to sustain the remainder of the gravel pack.

While for purposes of illustration I have shown the invention as applied to a well provided with a pump, it will be understood that the same principle of oil production can be applied to wells operating by gas lift, or to flowing wells flowing under gas pressure in primary or secondary recovery. It will be additionally appreciated that, while the description has largely proceeded on the basis of the drilling of deviating bores from a pre-existing well, the invention may be applied to a new well as well as to an old well.

The foregoing description has been given by way of exemplification and not in limitation of the invention, which is defined by the subjoined claim.

I claim as my invention:

A method for separating oil from sand, colloidal matter, and the like while the oil is being produced from a vertical well, comprising drilling a downwardly and sidewardly deviating drain hole from a vertical well, filling at least the downwardly curved section of said drain hole with a gravel-like filter medium, flowing the oil through said laterally deviating drain hole and upwardly through the filter medium in the downwardly curved portion thereof to the mouth of said deviating drain hole and thence into the vertical well at a point above the bottom thereof, and separating by gravity and collecting at the bottom of the vertical well additional entrained materials before the oil is delivered to the surface at the top of the well.

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