June 27, 1939. A. L. ARMENTROUT ET AL 2,164,266

METHOD AND APPARATUS FOR PRODUCING FLUID FROM WELLS

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Fig. 1.

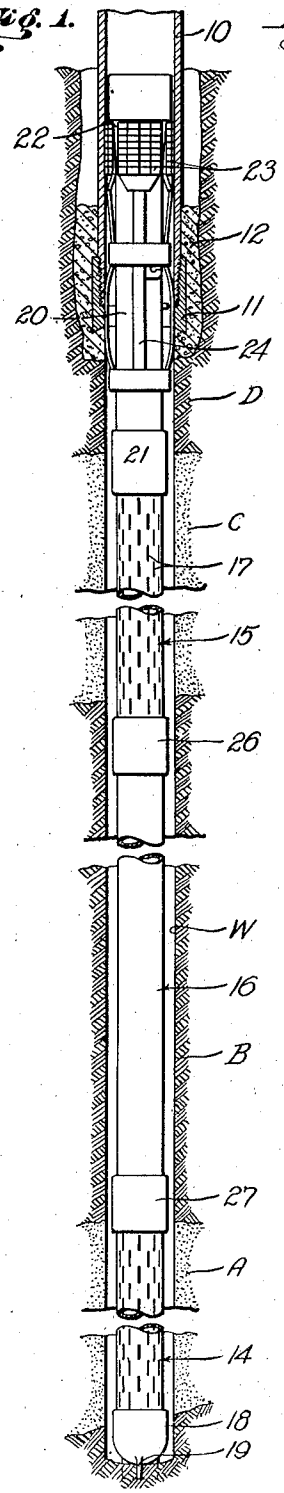


Fig. 2.

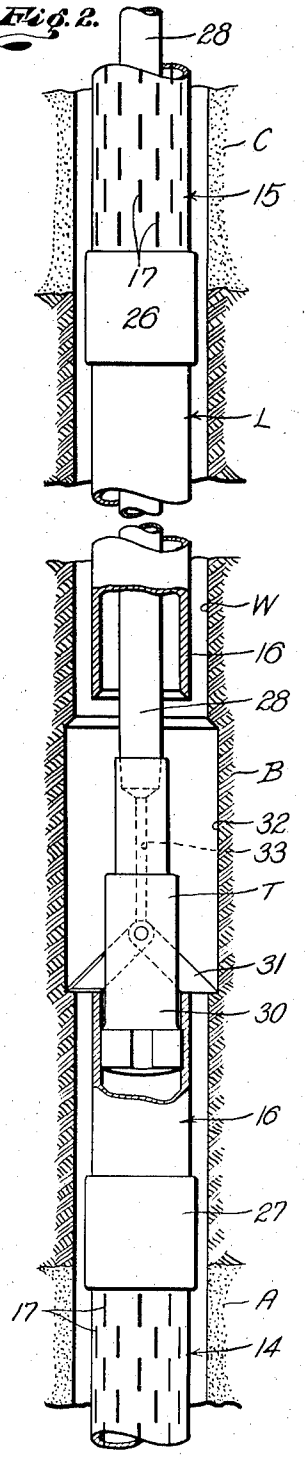
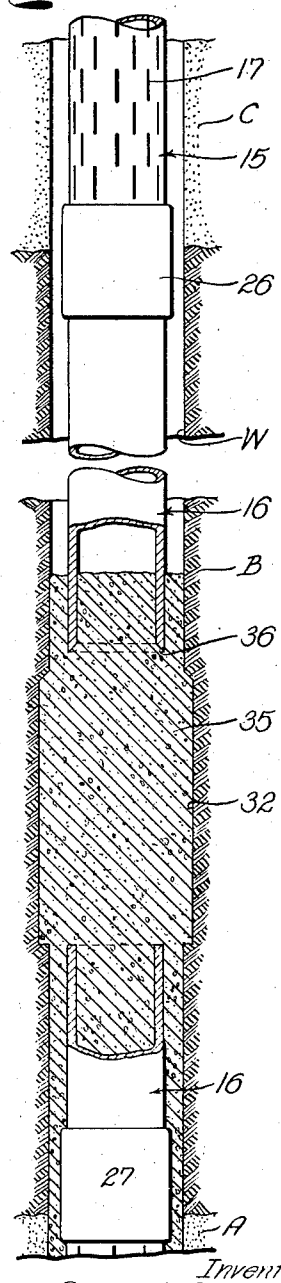


Fig. 3.



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METHOD AND APPARATUS FOR PRODUCING FLUID FROM WELLS

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8 Claims. (Cl. 166—1)

This invention relates to the recovery of fluid from wells and relates more particularly to a method and apparatus for producing fluid from wells such as oil wells and gas wells.

In the production of oil and gas from deep wells water often flows into the wells after the prolonged production of the oil and gas. Very often when an oil sand is depleted of its oil content, it becomes waterlogged and admits water to the well. This water intrusion from one stratum has a marked influence on the rate at which oil may enter the well from another stratum. Oil flows into the well by virtue of the gas pressure action or hydrostatic pressure action and when this action is opposed by water accumulating in the well and admitted by another stratum, the rate of oil production is materially lessened and in some instances is stopped. Furthermore, water in the well produced by a depleted oil sand sometimes enters an active or producing stratum driving the oil away from the well and tending to prevent the yield of oil from the sands.

An object of this invention is to provide a method for producing fluids from wells by means of which an unwanted fluid produced by one stratum may be fully shut off and excluded without shutting off or restricting the flow of wanted fluid from another stratum.

Another object of this invention is to provide a method for easily, quickly and inexpensively shutting off a portion of a well that is admitting or producing water or other unwanted fluid, leaving the remainder of the well in a condition to produce the desired fluid.

Another object of this invention is to provide a method for dependably and completely sealing off a portion of a well that is producing water or unwanted fluid without the necessity of removing the liner from the well and without shutting down the well for any substantial period.

Another object of this invention is to provide a well liner constructed so that a portion thereof may be readily removed to permit plugging or sealing off of the well bore at the open section thus formed without removing the remainder of the liner from the well.

Another object of this invention is to provide a well liner having a drillable portion located or occurring between producing sands or strata that may be drilled out or removed by a drilling tool to permit the plugging or sealing off of the well at the open section thus formed without the withdrawal of the liner from the well.

A further object of this invention is to provide a well liner of the character mentioned that is economical to manufacture, easy to install and that materially facilitates sealing off or cementing off the well to exclude undesired fluid from certain strata.

Other objects and features of our invention will be better and more fully understood from the following detailed description of a typical form and application of the apparatus and a typical manner of carrying out the method of the invention throughout which description reference may be had to the accompanying drawing in which:

Fig. 1 is a longitudinal sectional view of the lower portion of a typical oil or gas well illustrating the liner of the invention in position therein. Fig. 2 is an enlarged fragmentary vertical sectional view of the liner shown in Fig. 1 illustrating the manner in which a tool may drill away the drillable portion of the liner and Fig. 3 is a view similar to Fig. 2 showing a body of cement shutting off the lower portion of the well.

It is believed that the method of the invention will be best understood following a detailed description of a typical preferred form of the apparatus as employed in a typical producing well such as an oil well. It is to be understood that the apparatus of the invention may be varied considerably to adapt it for use in different installations and that the invention is not to be construed as restricted to the specific form or application of the apparatus illustrated.

The portion of the typical well W illustrated in the drawing penetrates or passes through a lower producing zone or stratum A, a non-producing zone or stratum B above the stratum A and an upper producing zone or stratum C above the stratum B. A non-producing zone or stratum D overlies the upper producing stratum C. It will be considered that the well W is an oil well and that the strata A and C are oil sands producing oil. A casing 10 extends downwardly in the well W from the ground surface and its lower end is set or cemented in the stratum D. In accordance with the usual practice, a shoe 11 is provided on the lower end of the casing 10 and the lower portion of the casing and its shoe 11 are imbedded in a body of cement 12 occupying a portion of the well passing through the stratum D.

The apparatus of the present invention is in the nature of a liner L comprising, generally, sections 14 and 15 arranged in or extending through the producing strata A and C respectively, and a

drillable section 16 interposed between the perforate sections 14 and 15.

The liner L is an elongate tubular structure constructed to extend through the lower portion of the well W. In practice the liner L may be of sufficient length to extend from a point above the lower end of the casing 10 to a point below the lower producing stratum A. The liner L is preferably proportioned to extend through the open lower portion of the well W with considerable clearance so that an annular space is left about it. It is to be understood that the liner L may be made up of any required number of sections or lengths of tubular stock and that the invention is not to be considered as limited to the particular number of lengths or sections illustrated.

Where the well W has two spaced producing strata A and C, the liner L embodies the two perforate sections 14 and 15. The perforate portions or sections 14 and 15 of the liner L may be formed of steel or other suitable material. While we have shown the sections 14 and 15 each comprising a single length of tubular stock, it is to be understood that they may be made up of any required number of connected pieces or lengths and that the lengths of the sections 14 and 15 depend upon the vertical extent of the producing strata A and C. The sections 14 and 15 may be provided with multiplicities of openings, ports or slots 17 for admitting the produced fluids to the interior of the liner. In the particular case illustrated there are multiplicities of vertically extending slots 17 provided in the sections 14 and 15 in vertically and circumferentially spaced relation. The slots 17 are such that the sections 14 and 15 serve to screen out the sand and other solid matter and allow the entrance of the fluid produced by the strata A and C respectively, to the interior of the liner L. It is preferred to proportion the sections 14 and 15 so that they extend entirely through the producing strata A and C respectively. In the case where the section 14 constitutes the lowermost perforate portion of the liner L a suitable shoe 18 may be secured to its lower end. The shoe 18 may be provided with blades 19 for cooperating with the bottom of the well W.

The invention preferably includes means for sustaining or retaining the liner L in the well. In practice this means may constitute a suitable liner hanger connected with the upper end of the liner L and cooperating with the set casing 10. The particular liner hanger illustrated in the drawing includes a tubular body 20 connected with the liner L by a suitable coupling 21. A cone 22 is provided on the body 20 and a set of slips 23 is expansible by the cone 22 to grip the interior of the casing 10. A tailpiece 24 is connected with the slips 23 and yieldingly or frictionally cooperates with the interior of the casing 10 to control the slips 23. The slips 23 gripping the interior of the casing 10 and engaged by the cone 22 dependably support or suspend the liner 11 from the casing 10. It is to be understood that in certain applications or instances the liner hanger may not be required and the liner L may be supported through its engagement with the bottom of the well bore.

The portion or section 16 of the liner L is an important feature of the invention. The section 16 is a tubular member or structure and is preferably integral or formed of a single length of tubular stock, although it may be constructed of a plurality of connected tubular sections, if desired. In accordance with the invention the section 16 is located or positioned so that it occurs in the part of the well W extending through the non-producing stratum B. A suitable coupling 26 connects the upper end of the section 16 with the perforate section 15 and a similar coupling 27 connects the lower end of the section 16 with the perforate section 14. The couplings 26 and 27 may be formed of steel or of the same material as the sections 14 and 15.

In accordance with the invention the liner section 16 is formed of a material that may be cut out or drilled up by a tool T operated on a well drilling string 28. It is preferred to form the section 16 of aluminum or its alloys that may be readily milled or drilled up by a drilling tool, wall scraper, or other drilling device that may be operated in the well W. The section 16 may be formed also of other readily drillable material such as "Bakelite", hard rubber compositions, cement, glass, or soft metals or other materials that are readily drillable.

In the event that the well W has more than two spaced producing zones or strata the liner L may be provided with spaced drillable sections similar to the section 16 related so that a drillable section is provided in the liner between each pair of adjacent producing strata. It is to be observed that the liner L is constructed of steel or other conventional material except for the provision of the drillable section 16.

In carrying out the method of the invention with the typical apparatus described above, the depths or positions of the various strata A, B, C and D are first determined. These positions may be determined by suitable surveying instruments well known to those skilled in the art. Following the location of the various strata of the well, the liner L is made up or constructed so that the perforate section 14 is positioned in the part of the well penetrating the stratum A, the section 16 is positioned in the part of the well penetrating the non-productive stratum B and the perforate section 15 is positioned in the part of the well penetrating the stratum C when the liner L is hung or set in the well. The liner L may be run into the well W in the usual manner and suspended from the casing C through the medium of the slips 23 expanded by the cone 22. The well W is then allowed to produce or is pumped in the manner well known to those well skilled in the art.

The fluids produced by the strata A and C are free to flow into the liner L through the slots 17 to flow up or to be pumped up through the liner. After prolonged production, the lower zone or stratum A may become exhausted or substantially exhausted of its oil or other desired fluid and may produce or admit water or other undesirable fluid to the well. If this occurs it may become desirable or necessary to close off or seal off the startum A from the well W so that the unwanted water or fluid will not lessen or destroy the productivity of the upper producing stratum C.

When it becomes desirable or necessary to close off or seal off the stratum A from the well W, a suitable tool is run into the well to cut out or drill up the drillable section 16. In Fig. 2 of the drawing we have illustrated the tool T carried by the string 28 and acting on or drilling away a part of the drillable section 16. The tool T shown in the drawing is in the nature of an expansible wall scraper or underreaming tool, having a body 30 whose lower portion fits in the

liner L and having expansible cutting blades 31. The present invention is not concerned with the details of the tool T, or with the means for expanding the cutting blades 31 and these details have been omitted from the drawing. It is desirable to employ a tool T that is operable to act on the earth formation at the wall of the well W to enlarge the well as at 32, as it cuts away or drills up the section 16. The tool T is lowered into the well W on the string 28 to a position within the drillable section 16 and is then manipulated or controlled so that its blades 31 expand into cutting contact with the said section. The string 28 is then rotated and fed longitudinally so that the blades 31 cut away the wall of the section 16 and enlarge the well W as at 32. The particular tool T illustrated in the drawing is operable by rotation and downward feeding of the string 28 to drill up the section 16 and enlarge the well bore. It will be understood, however, that a type of cutting tool may be employed that operates by rotation and upward feeding of the string 28, if this procedure is preferred. The slips 23 assisted by the blades 19 serve to hold the liner L against rotation during the above described operation of the tool T. The teeth of the slips 23 may have vertical grooves 9 cut in them to better resist turning of the liner L. In practice sand and silt accumulates about the liner L and may assist in holding the liner against turning. Although we have herein illustrated and made reference to a rotary type tool for drilling up or cutting away the section 16, the invention also contemplates the employment of a cable tool for performing this function.

The tool T is preferably operated to drill up or cut away a portion of the section 16 of substantial length. In practice the drilling operation may be terminated before the blades 31 come in contact with the collar or coupling 27; however, if the drilling continues until this occurs, the resistance to cutting offered by the steel coupling 27 will indicate to the operator that the section 16 has been cut away or drilled up down to the coupling 27 and that the drilling operation cannot be continued. The tool T is preferably such that it breaks or drills the metal of the drillable section 16 into relatively small pieces or fragments.

Where a rotary tool is employed as illustrated in the drawing, the invention contemplates the washing or flushing of the cuttings or fragments of the section 16 from the well by circulation fluid. The tool T has a suitable circulation passage 33 and the circulation fluid or water, is pumped down through the string 28 and through the passage 33 to discharge at the blades 31 throughout the drilling operation. This circulation fluid under pressure after leaving the tool T flows upwardly through the upper portion of the liner L and the casing 10 to the ground surface. As described above, the drillable section 16 is preferably formed of a material having a low specific gravity and the returning circulation fluid carries with it the cuttings or fragments of the drilled away portion of the section 16 and thus removes them from the well. The flushing of the cuttings or fragments of the section 16 from the well while highly preferred is not absolutely essential and the cuttings may be permitted to settle in the well, if desired. When the drilling away or drilling up of a substantial portion of the section 16 has been completed, the drilling string 28 is pulled from the well to withdraw the tool T.

The next phase or step of the method of the invention is the cementing off of the stratum A bearing the water or unwanted fluid. A quantity or body of Portland cement slurry 35 is passed down through the casing 10 and the remaining upper portion of the liner L to the lower part of the well W. This operation may be performed in any of the manners well known to those skilled in the art. It is preferred to deliver sufficient cement slurry to the lower portion of the well to completely occupy it from its lower wall to a point at or above the upper plane 36 of the cutting or drilling operation of the tool T. As illustrated in Fig. 3 of the drawing the body of the cement slurry 35 may extend upwardly beyond the plane 36 defined by the lower end of the upper remaining portion of the section 16. It will be understood, of course, that the body of the cement slurry 35 occupies that portion of the well W extending into or penetrating the stratum A. Owing to the fact that the tool T has cut away a substantial length or portion of the drillable section 16 the cement slurry 35 is free to flow downwardly around the remaining lower portion of the liner L and to completely occupy that part of the well underreamed by the tool T and indicated at 32. Thus the cement slurry 35 forms a solid body or plug in the well below the producing stratum C. The tool T in reaming or enlarging the bore at 32 cleans the wall of the well, removing all accumulations of mud, wax, etc. therefrom. The cement slurry 35 dependably bonds with the cleaned wall of the well and directly engages the earth formation.

Following the introduction and setting of the cement slurry 35, the well may be produced from the stratum C and the other exposed producing strata, if any. The set or hardened cement slurry 35 dependably and completely closes off the stratum A preventing water or other unwanted fluid therefrom from interfering with the production of wanted fluid or oil from the stratum C. It will be observed that it is unnecessary to pull or remove the liner L from the well to seal off the stratum A. This is important as considerable difficulty is often encountered in attempting to withdraw a liner from a well following a substantial period of production. The present invention provides a simpe, inexpensive apparatus and a practical method for fully sealing off unwanted fluid from one or more strata of a well to allow wanted fluid to be produced from the remaining strata. The method may be readily performed with the usual cementing equipment, etc. The apparatus or liner L may be fabricated to permit the carrying out of the method under practically any condition.

Only a typical preferred form of apparatus and a typical preferred manner of carrying out the method of our invention having been described herein, we do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to ourselves any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described our invention, we claim:

1. A liner for use in a well having producing strata separated by a non-producing stratum comprising perforate tubular liner sections for arrangement in the portions of the well penetrating said producing strata, and a readily drillable liner section between the first mentioned sections

for arrangement in the portion of the well penetrating said non-producing stratum.

2. A liner for use in a well having a producing stratum and a non-producing stratum including a tubular body for arrangement in the well and including a perforate portion of steel to be located in the producing stratum and a drillable portion of aluminum to be located in the non-producing stratum.

3. A liner for use in a well having a producing stratum and a non-producing stratum including a tubular body for arrangement in the well and including a perforate portion to be located in the part of the well extending through the producing stratum and an imperforate portion to be positioned in the part of the well passing through the non-producing stratum formed of a material having a low shear strength to be readily drilled up in the well.

4. A liner for use in a well having producing strata separated by a non-producing stratum comprising a tubular body adapted for arrangement in the well, the body including portions of steel in the parts of the well penetrating said producing strata, said portions being adapted to be perforated for the admission of the produced fluid, and an imperforate portion connected between the first mentioned portions formed of a material having a low shear strength to be drillable.

5. The method of operating a well having spaced productive zones comprising the positioning of a tubular liner in the well having perforate portions to receive the fluid from said zones, subsequently drilling up a part of said liner between said perforate portions to leave an open section in the well, and then introducing cement into the open section thus formed to seal off the last mentioned zone.

6. The method of producing a well having spaced upper and lower productive zones, which method comprises positioning a tubular liner in the well having perforate portions at said zones for receiving the fluid therefrom and a drillable part between said perforate portions, allowing the well fluids to enter through said liner, and subsequently closing off said lower zone by first drilling up said drillable part of the liner to form an open section in the well and then sealing off said lower zone by introducing cement into said open section and into or around the remaining portion of the liner therebelow.

7. The method of producing a well having spaced upper and lower productive zones, which method comprises positioning a tubular liner in the well having perforate portions at said zones for receiving the fluid therefrom and having a drillable part between said perforate portions, allowing the well to produce from said zones and subsequently shutting off said lower zone by operating a drilling tool in the liner to drill up out through said drillable portion and to ream the wall of the well, and introducing plastic cement to the well to close the well where said part was cut and the well was reamed.

8. The method of producing a well having spaced upper and lower productive zones, which method comprises suspending a tubular liner in the well having perforate portions at said zones for receiving the fluid therefrom and having a drillable part between said perforate portions, allowing the well to produce from said zones and subsequently shutting off said lower zone by operating a drilling tool in the liner to drill said drillable part into fragments and leave an open section in the well, flushing said fragments from the well with fluid and then introducing cement slurry in the well to flow down around and within the liner from said open section.

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