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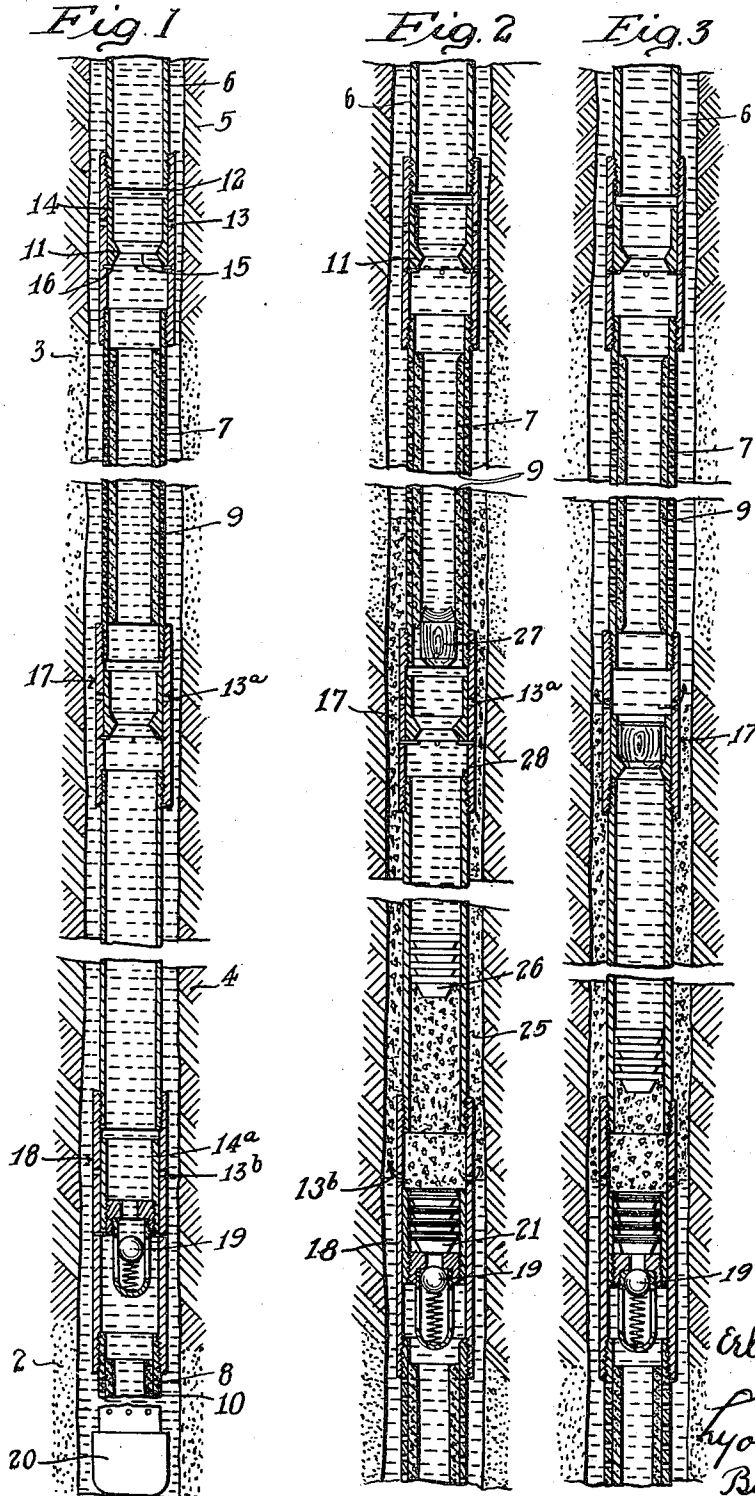
E. P. HALLIBURTON

2,004,606

PROCESS OF CEMENTING WELLS

Filed May 5, 1934

2 Sheets-Sheet 1



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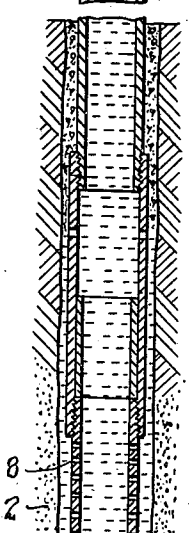
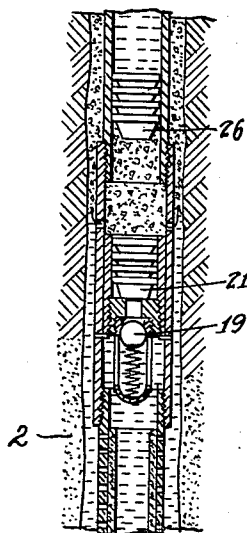
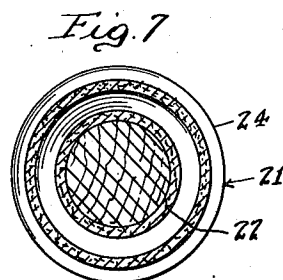
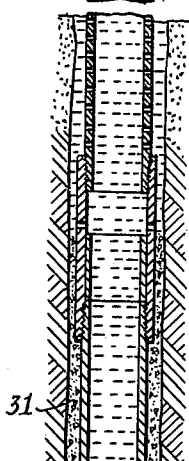
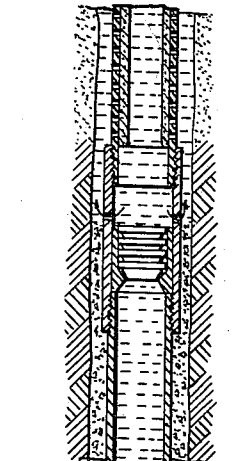
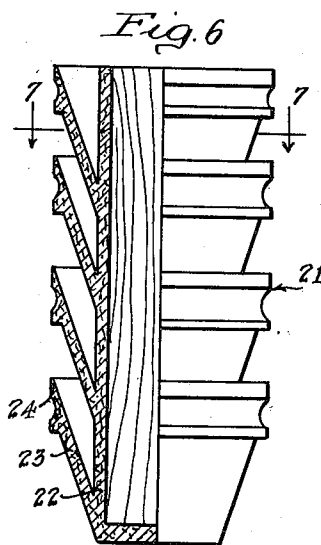
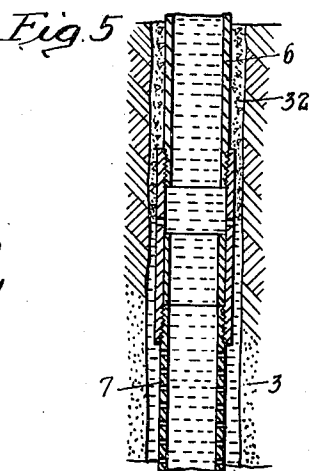
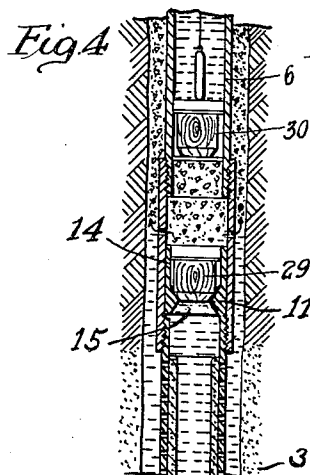
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UNITED STATES PATENT OFFICE

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PROCESS OF CEMENTING WELLS

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5 Claims. (Cl. 166—21)

This invention relates to a process of cementing wells, such as oil wells, and refers particularly to a process of cementing a well in which there have been located two or more spaced apart oil producing sands.

In the production of oil from oil producing sands, it has been generally found necessary to cement off the formations above the oil producing sand to prevent the entrance of water from the upper strata. In the ordinary operations of producing oil from an oil sand, a string of casing or tubing is lowered approximately to the producing formation. Then fluid cement is forced into position between the outside of the casing and the walls of the well hole and there permitted to harden so as to close off all the well above the oil producing formation from communication with the producing string. With this process, it is obviously impossible for the well to produce for no more than one oil producing sand, as all of the upper oil producing sands are cemented off from the well.

It is the general object of the present invention to provide a method of cementing oil wells by which production may be secured from a plurality of oil producing sands in the oil well, while at the same time all non-producing formations are cemented off from communication with the well-hole so as to inhibit the entrance of water from water sands into any of the oil producing sands.

A further object of the present invention is to provide apparatus, by means of which the process may be carried out.

More particularly, the principal object of the present invention is to provide a process of cementing oil wells, by which that portion of the well between any two oil producing sands can be cemented tightly to the oil producing string without cementing off either of the oil producing formations, leaving both in condition so that they may produce through the producing string at the option of the operator.

Various further and additional objects and advantages of the present invention will be apparent from the description of a preferred form or example of a process and apparatus for cementing oil wells having multiple sands, which process and apparatus embody the present invention. For this purpose, I have hereinafter described a preferred form or example of process and apparatus embodying the invention, the description being given with reference to the accompanying drawings, in which

Figure 1 is an elevation in vertical section showing the apparatus in position in the well hole during the first step of the process, wherein the

space back of the casing is cleared of detritus by circulating mud fluid down the producing pipe and up around the exterior of the same.

Figure 2 is a similar view showing following steps of the process and apparatus wherein the formations between the lower two producing sands are cemented from each other.

Figure 3 is a similar view of the apparatus during further steps of the process wherein cement around the upper oil producing formation is removed.

Figure 4 is a similar view showing the cementing of formations above the second oil producing sand.

Figure 5 is a similar view showing the well hole and apparatus after the completion of the operations.

Figure 6 is an enlarged elevation in quarter section of a preferred form of collapsible plug used in the process and apparatus.

Figure 7 is a section of the plug on the line 7—7 in Figure 6.

Referring, first, to Figure 1 of the drawings, the apparatus is illustrated in position in the well hole, in which 2 is a lower oil producing formation, 3 an upper oil producing formation, 4 a non-productive formation between the two producing formations 2 and 3, and 5 an upper non-productive formation above the formation 3. The first step of cementing such an oil well is to lower in place the apparatus, exhibited in Figure 1. This apparatus comprises a string of tubing or casing 6 provided with a screen pipe 7 and a further screen pipe 8, spaced apart so that the screen pipes 7 and 8 may be respectively positioned in the well opposite the oil producing formations 3 and 2. Each of these screen pipe sections when they are lowered into the well are initially closed by interior lining 9 and 10, which may be formed, for example, of hardened cement. Above the screen pipe 7 the apparatus is provided with a cementing valve 11, which includes a collar 12 provided with a number of discharge ports 13 which are normally closed by an inner sleeve 14. The sleeve 14 is provided with a restricted throat 15, formed preferably of soft metal so that it may be drilled from the apparatus at the completion of the operation. The sleeve 14 is held in position closing the ports 13 by pins 16, which are preferably of fragile metal so that they may be sheared off, and the sleeve 14 lowered as more particularly described hereinafter.

A similar cementing valve 17 is provided just below the screen pipe 7.

Immediately above the screen pipe 8 a further cementing valve 18 is provided, generally similar

to the valve 11 except that its sleeve 14a is made to support a back-pressure valve 19 adapted to permit the passage of fluid downwardly through the apparatus but capable of closing against the return flow of fluid. This back-pressure valve is preferably of the ball type.

In operation of the apparatus and in performing the process of the invention, after the apparatus, as shown in Figure 1, has been lowered into place with the two screen linings 7 and 8 opposite the two producing formations, the first step of the process is then to insure that the space between the apparatus and the walls of the well is clear. For this purpose, fluid is pumped down the apparatus passing through the back pressure valve 19 and out of the guide-shoe 20 on the lower end of the screen 8, and returning to the surface of the well through the space between the well-hole and the apparatus, thereby washing out all detritus from this space.

Now, referring to Figure 2, the succeeding steps of the process are illustrated, by means of which cement is deposited in that portion of the space between the apparatus and walls of the well existing between the two oil producing formations. The first step is to introduce into the apparatus a plug 21. This plug 21 is preferably of the type illustrated in Figures 6 and 7, although various other collapsible plugs may be utilized in place thereof. In Figure 6 the plug 21 is indicated as preferably comprising a rubber tube 22 having upwardly and outwardly tapering flanges 23 culminating in the wiping rims 24. The upward and outward flanges of the plug are adapted to yield to permit the plug to pass through restrictions in the apparatus when it is pumped down the well, while at the same time hydraulic pressure from above is capable of expanding the plug to force the same into tight-fitting relationship with the apparatus when the plug is in its bottom position.

After the plug 21 is placed into the tubing 6 there is introduced into the tubing fluid cement in quantities sufficient to seal off the formations between the two producing formations 2 and 3 of the apparatus, preferably a slight excess of cement for this purpose being employed to insure an adequate supply in the process. This cement is indicated at 25 in the drawings in the position it occupies after the plug 21 has reached the back-pressure valve 19. After the cement 25 has been placed in the tubing, there is a second plug 26 placed on the top of such cement. This second plug is also of a collapsible type and may be similar in construction to the plug 21.

After the introduction of the second plug 26 there is introduced into the tubing 6 a measured quantity of fluid, preferably drilling fluid or mud fluid, and on the top of this mud fluid there is placed a third plug 27. After the third plug 27 has been inserted, there is pumped upon the top of plug 27 drilling fluid until the drilling fluid is noticed to be again pumped to the surface of the well around the apparatus.

The measured quantity of drilling fluid placed between the two plugs 26 and 27 is sufficient so that the plug 27 will strike the restriction of the cementing valve 17 before the plug 26 strikes the plug 21; the object being to introduce just sufficient drilling fluid between plugs 26 and 27 so that the plug 27 reaches its lowermost position while the plug 26 is still slightly above plug 21.

The plug 27 is made of a diameter to pass through the restriction of the upper cementing valve 11, but to be caught by the restriction of the cementing valve 17 and forcing the sleeve

thereof downward until the same strikes the shoulder 28 at the top of the tubing threaded to the lower end of the valve. This motion of the sleeve is sufficient to uncover the ports 13^a of the valve 17 and permit the drilling fluid or mud which is pumped into the tubing 6 to pass out of such ports 13^a and return to the surface of the well. In the meantime, the cement between valves 21 and 26 has been forced out of the lower end of the apparatus and up to a point somewhat above the ports 13^a of valve 17. That portion of the cement which is thus forced above the ports 13^a is washed away by the continued circulation of fluid. When the operator at the top of the well sees that the cement has been adequately washed away, the circulation is stopped. At this stage of the process, there has been deposited between the ports 13^b of the lower cementing valve 18 and the ports 13^a of the intermediate cementing valve 17 neat fluid cement to cement off all formations between these two points, while the cement has been kept away from the oil producing formations.

There is then inserted a fourth plug 29 into the tubing 6 of a diameter adapted to be caught by the restriction 15 of the lining of the upper cementing valve 11. This plug, as shown in Figure 4, when it reaches the cementing valve 11, pushes the sleeve 14 of that valve down to uncover the ports 13 and is then stopped with the sleeve by the shoulder on the upper end of the screen 7. After the plug 29 has been placed in the tubing, there is introduced into the tubing on the top of the plug sufficient further fluid cement to fill that portion of the hole around the apparatus between the ports 13 of the upper cementing valve 11 and any desired point—for example, the top of the well. In case there are only two oil producing formations in the well, sufficient cement is introduced to reach generally to the top of the well, whereas if there is a further or third higher oil producing formation, sufficient cement is introduced to extend just to or somewhat above this formation, the process and apparatus of this invention being adapted for suitably cementing any number of formations in like manner.

After the specified amount of cement has been introduced into the top of the plug 29, a further plug 30 is inserted and this plug then pumped down to or approximately to the plug 29 by the introduction of drilling fluid above the plug 30. This causes the cement introduced between the plugs 29 and 30 to be forced out of the ports 13, where it rises upwardly sealing off the formations above the ports 13 from the oil producing strata 3 therebelow. When the plug 30 has reached the desired position, it is held stationary by closing the valve at the top of the well so as to maintain the pressure on the apparatus until the two portions of cement have hardened, i. e. that portion between the valves 18 and 17 and that above the valve 11.

After the completion of the setting, the plugs 21, 26, 27, 29 and 30 are drilled out of the apparatus, and at the same time the linings 9 and 10 drilled away from the screen pipe sections 7 and 8, thus leaving the apparatus in the position shown in Figure 5. In Figure 5, the screen pipes 7 and 8, respectively, are indicated as open for the passage of oil from formations 3 and 2, respectively, into the apparatus, whereas the well-hole between these formations is indicated as solidly cemented off by the cement 31 and the formations above the oil producing formation 75

3 indicated as closed off by the cement 32. Simultaneous production of oil from both formations 2 and 3 into the oil spring thus may be permitted, if desired, without danger of any seepage of water in either formation.

While the particular form of the process and apparatus herein described is well adapted to carry out the objects of this invention, various modifications and changes may be made without departing from the scope of the invention, as set forth in the accompanying claims.

I claim:

1. An apparatus for cementing an oil-well having a plurality of spaced apart oil producing sands, which apparatus comprises a casing having oil screens therein at spaced apart points corresponding to the distances between the oil producing sands, means for temporarily closing the openings of said oil screens, cement introducing valves above said oil screens and a valve below the upper oil screen, said valves having various-sized restrictions so that they may be operated by introducing various-sized plugs into the well casing.

2. An apparatus for cementing oil-wells comprising a casing having a lower screen section with a valve thereabove, an upper screen section with valves above and below the same, each of said screen sections having means for temporarily closing the same, and each of said valves being provided with restrictions for cooperation with different-sized plugs.

3. A process of cementing an oil-well having a plurality of spaced apart oil producing sands, which comprises introducing into the oil-well a casing having screen sections at points spaced apart distances corresponding to the distances between the oil producing sands, the casing being lowered until said screen sections are opposite the oil producing sands, then circulating a non-hardening fluid through the casing and up to the surface of the well, thereafter introducing a closure means adapted to open communication through the sides of the casing at a point above and adjacent to the lowermost oil sand, thereafter introducing cement through the casing and into the well-hole at said point above and adjacent to the lowermost oil producing sand and forcing the same to rise upwardly, thereafter introducing a second closure means on top of said cement, thereafter introducing a non-hardening fluid and a third closure means adapted to open communication through the sides of the casing at the point of the next oil producing sand, thereafter introducing a non-hardening fluid at the next higher oil sand and forcing the same to rise upwardly so as to remove cement, if any, opposite said second higher oil sand, thereafter introducing a fourth closure means on top of said non-hardening fluid adapted to open communication through the sides of the casing at a point near the top of said second higher sand, and then introducing fluid cement through the casing and forcing the same to enter the well at said point near the top of the second higher sand and forcing

such cement to rise upwardly in the well-hole.

4. A process of cementing an oil-well having two vertically spaced apart oil producing sands and a well casing therein, comprising the steps of washing the well with non-hardening fluid, introducing a closure means adapted to seal the bottom of the casing and to open communication through the side of the casing at a point above and adjacent to the lower oil sand, introducing on top of said closure means a quantity of fluid cement sufficient to fill the annular space between the casing and the well-holes from said point upward to a point above the bottom of a higher oil sand, introducing a second closure means adapted to ride down the casing on top of said cement, introducing non-hardening fluid on top of said second closure means sufficient to drive said cement into said annular space, introducing a third closure means on top of said last named non-hardening fluid, adapted to open communication through the sides of the casing at the point of said higher oil sand, introducing non-hardening fluid on top of said third closure means to wash said cement from said higher oil sand, introducing a fourth closure means on top of said last named non-hardening fluid adapted to open communication through the sides of the casing at a point immediately above said higher oil sand, and introducing on top of said fourth closure means fluid cement through said communication sufficient to fill the annular space between the well-walls of the casing upward to any desired height.

5. A process of cementing oil-wells having two vertically spaced apart oil producing sands and a well casing therein, comprising the steps of introducing into the casing at the top of the well in consecutive order non-hardening fluid to wash the well, a closure means adapted to seal the bottom of the casing and to open communication through the side of the casing at the point above and adjacent to the lower oil sand, a quantity of fluid cement on top of said closure means sufficient to fill the annular space between the casing and the well-walls from said point upward to a point above the bottom of a higher oil sand, a second closure means adapted to ride down the casing on top of said fluid cement, non-hardening fluid on top of said second closure means sufficient to drive said cement into said annular space, a third closure means on top of said last named non-hardening fluid adapted to open communication through the sides of the casing at the point of said lower oil sand, non-hardening fluid on top of said third closure means to wash said cement from said higher oil sand, a fourth closure means on top of said last named non-hardening fluid adapted to open communication through the sides of the casing at a point immediately above said lower oil sand, and fluid cement on top of said fourth closure means sufficient to fill the annular space between the well-walls and the casing upward from said last named communication to any desired height.

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