DRILLING AND LINING OF DRAIN HOLES

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Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

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DRILLING AND LINING OF DRAIN HOLES

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This invention relates to improved apparatus and methods of drilling and lining oil well drain holes, that is, auxiliary holes or bores extending laterally into the producing formation from a main bore location.

After a drain hole has been drilled from a main well bore, it is frequently desirable to advance a liner into the drain hole, for supporting the walls of the hole against collapse. The present invention is in certain respects particularly concerned with improvements in the manipulation of constructing and handling these liners. Especially contemplated is a new way of assuring a very direct and positive connection of the inner end of the drain hole liner to the main liner in the main bore of the well. Whereas in many prior arrangements the drain hole liner has not been directly attached to the main liner at all, with the result that the earth formation was not properly retained against collapse into the well at the juncture between the two liners, the present invention is particularly concerned with a unique manner of forming between these two liners a very direct and yet easily made connection, which acts to effectively retain the formation against such collapse at that location.

In accordance with the invention, the main liner is preferably preformed, before being lowered into the well, to have one or more wall apertures positioned at the desired drain hole locations. The liner is then lowered into the well, and drain holes are drilled at the locations of these preformed liner apertures. After drilling a particular drain hole, a specially formed flexible liner is advanced thereinto. This liner preferably has an upper portion which is a tight or forced fit within the aperture of the main liner, so that the desired positive joint between the two liners is formed by merely forcing the drain hole liner through the aperture.

As the drain hole liner is advanced through the aperture, the liner may be retained against rotation from a predetermined proper position by means of interengaging guide means on the liner and an engaging whipstock which is utilized for directing the liner. These guide means may include a lug positioned in an upper tubular portion of the whipstock unit, and a guide recess formed on the drain hole liner and adapted to slide over the lug. Such positioning of the drain hole liner is desirable in order that an upper angularly cutoff portion of the drain hole liner may properly connect into the main liner.

An additional feature of the invention resides in a unique manner of supporting the whipstock in the main liner during the drilling and other operations. For this purpose, there may be specially designed means on the main liner and whipstock, which are engageable to support the whipstock at a proper location for deflecting the drill bit or drain hole liner laterally through the aperture in the main liner. These supporting means may include a lug or block attached to the main liner, and receivable in a mating recess in the whipstock. This block may be attached to the main liner by a shear pin, so that it may be sheared off of the inner wall of the liner after completion of one drain hole, to permit drilling of another drain hole, or to entirely open the bore in preparation for other operations.

The above and other features and objects of the present invention will be better understood from the following detailed description of the typical embodiment illustrated in the accompanying drawings, in which:

Fig. 1 is a view showing in a well a main liner having preformed apertures or windows into which are connectable a number of liners for laterally extending drain holes;

Fig. 2 is an enlarged view partly in section of a portion of the Fig. 1 main liner;

Fig. 3 is a vertical section through the liner, with a whipstock and drill string positioned therein;

Fig. 4 is an enlarged horizontal section taken on line 4—4 of Fig. 3;

Fig. 5 is a fragmentary view of the lower portion of the whipstock, and showing the recess by which the whipstock is supported in the liner;

Fig. 6 is a view showing one of the drain hole liners as it is being lowered into position in a well;

Fig. 7 is a view corresponding to Fig. 6, but showing the drain hole liner after being advanced to its ultimate position in the well;

Fig. 8 is a horizontal section taken on line 8—8 of Fig. 6; and

Fig. 9 is a view taken during the drilling of the final drain hole.

Referring first to Fig. 1, we have shown at 10 the main bore of a well, into which is lowered a main liner 11 having the usual perforations 12 through which oil flows into the liner for delivery upwardly to the surface of the earth. Liner 11 is connected in any suitable manner to the lower end of the usual well casing 13. Liner 11 is conventional in construction, except that its side wall contains a number of preformed drain hole openings or windows 14, for placing the main liner in communication with a number of drain holes to be drilled along laterally extending courses designated at 15. Before lowering liner 11 into the well, it is determined exactly where the drain holes are to be drilled, and openings 14 are then formed in the liner at the desired locations. With these openings thus preformed, liner 11 is lowered to the Fig. 1 position, and the drain holes are then drilled.

The drain holes are formed by a flexible drilling string 16, which is directed laterally through liner openings 14 by a conventional whipstock 17. After a particular drain hole has been drilled, a flexible liner 18 is advanced into the hole to the position of Fig. 9, following which the next successive hole is drilled and lined.

Whipstock 17 may be of essentially conventional construction, having an upper tubular or sheath portion 19 through which drill string 16 or liner 18 are advanceable downwardly, and having an inclined deflecting face 20 for deflecting the drill string or drain hole liner laterally through one of the main liner openings 14 and into the surrounding formation 21. Liner 18 may be of such design that whipstock 17 has the usual side window 21, through which a deflected string or liner may advance laterally out of the whipstock. The whipstock may be removably supported in the well by a number of support lugs or blocks 22, which is directed laterally through liner openings 14. For coaction with blocks 22, whipstock 17 may contain a vertically extending recess 24 of a width equal to the width of blocks 22, so that the whipstock may be supported on any of the blocks in the position of Fig. 3. The upper ends of the lugs 22 and recess 24 may be inclined upwardly and toward the center of the whipstock and main liner, to provide a pair of engageable inclined shoulders for effecting the desired support of the whipstock, and at the same time preventing the whipstock from slipping off of the lug by virtue of the inclination of...
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The lever end of recess 34 may open and flare downwardly at 26, as seen in Fig. 5, so that the whipstock may be easily advanced downwardly to a position of support by one of the lugs 22. For a reason that will appear later, studs 23 are specially formed to be sheared or broken by downward force exerted against the corresponding block 22.

The drill string 16 for drilling drain holes 15 is longitudinally flexible, and may typically be of the type described more specifically in application Ser. No. 279,557, filed March 31, 1952 on "Flexible well Drill Collar," now U.S. Patent 2,712,436, issued July 5, 1955. This string may be formed from a pipe, whose wall is cut at longitudinally spaced locations along waving lines 27, to divide the pipe into a number of artifically interconnected segments which are free for limited relative movement, thus giving the string as a unit the desired longitudinal flexibility. The waving cuts 27 preferably form on the successive string segments a number of interengaging lobs and recesses, which effectively retain the segments against longitudinal separation, while at the same time permitting their limited relative movement. The cuts 27 may be formed by a welding torch, the width of the cut being sufficiently great to allow looseness between successive segments.

Drill string 16 carries at its lower end the usual drilling bit 28, which assists to drill a drain hole 15 upon rotation of the string. Preferably, the whipstock 17 is adapted to be lowered into and removed from the well by means of drill string 16. While this support may be effected in any of different ways, I have typically and for simplicity illustrated the whipstock supporting connection as comprising an enlargement 29 formed on string 16 and adapted for engagement with a shoulder 30 extending inwardly from the upper tubular portion 19 of the whipstock. As will be understood, during lowering of string 16 and the whipstock into a well, enlargement 29 on the drill string is in engagement with the underside of whipstock shoulder 30, so that the string and whipstock are lowered as a unit. The string is then adapted to be advanced downwardly for drilling drain hole 15, and during such advancement, enlargement 29 of course advances downwardly away from its position of engagement with shoulder 30.

After a drain hole has been drilled the whipstock and drill string are removed from the well, following which the drain hole liner 18 is positioned in the upper tubular portion 19 of the whipstock and line 18 are then lowered downwardly into the well as a unit. The liner 18 is tubular and longitudinally flexible, and may typically be formed essentially the same as flexible drill string 16. That is, liner 18 may include a number of interconnected rigid segments 31 movably joined together by lobe and recess type connections at 22. The various segments 31 may contain wall apertures 33, through which fluid from the earth may flow into the drain hole liner 18 for delivery to main liner 11. The lower end of drain hole liner 18 may carry a rounded nose member 36, which may contain fluid passing apertures 37.

The upper end of flexible liner 18 carries a rigid tubular connector member 34, which is adapted to be tightly connected into one of the openings 14 in the main liner 11. This upper member 34 has a circular external surface 35, which enlarges slightly in diameter in an upward direction, and which is adapted to peripherally engage and fit tightly and closely within opening 14. When ultimately connected into the main liner 11, connector member 34 of the drain liner extends downwardly and outwardly from the main liner at an angle "a" to the main liner. This cylinder has a diameter which is very slightly smaller than the effective diameter of the portion of member 34 which is ultimately received in opening 14 in the Fig. 7 position (the difference between these diameters being typically about 1/8") so that member 34 is a forced fit in opening 14, and when forced downwardly to the Fig. 7 position is very tightly retained within the opening. The upper end of member 34 is cut off in an angularly extending cylindrical plane, of a diameter corresponding to the diameter of main liner 11, and disposed at such an angle to the upper end 38 of member 34 as to be substantially flush with the inner surface of the main liner in the ultimate Fig. 7 position.

Drain hole liner 18 is lowered into the well at the lower end of a tool string 39, which may be at least partially flexible, and which carries at its lower end a member 40 adapted to be removably threadedly connected at 41 into the upper end of connector member 34 of liner 18. Member 40 is attached to the tool string 39 by a conventional universal joint 42, which is adapted to allow universal movement of member 40 relative to the tool string, while at the same time transmitting rotary motion between these parts. During lowering of liner 18 and whipstock 17 into the well, the former is contained within the upper tubular portion 19 of the latter, and the whipstock is suitably suspended by engagement of an enlargement or shoulder 29a on the tool string with whipstock shoulder 30. After the whipstock has been again positioned on one of the support blocks 22, liner 18 may be advanced downwardly into the previously drilled drain hole 15. Before lowering of the liner 18 and whipstock 17 in the well a positioning block 43 is attached to the inner side of the upper tubular portion of the whipstock by a stud 44. This block is adapted to be received within a vertically extending slot 45 formed in the side of member 34, to prevent advancement of member 34 downwardly to the Fig. 7 position unless keying block 43 and slot 45 are in registerating relation. This block and recess thus assure proper positioning of member 34 in opening 14.

To now describe briefly a complete drain hole drilling and lining operation, as performed in accordance with the present invention, the first step after drilling of the main bore and positioning casing 13 therein is to perform the apertured production liner 11, with the various apertures 14 being formed in the liner prior to lowering. These apertures 14 are formed in the liner at predetermined positions, which are selected from a study of the characteristics of the producing formation having a sufficiently great vertical extent, liner 11 may be formed of a number of threadedly interconnected tubular sections or stands. The liner 11 containing preformed apertures 14 is then lowered into its illustrated Fig. 1 position within the main bore 10. As thus lowered, liner 11 contains one of the whipstock positioning block 22 at a location beneath the central portion of each of the various apertures 14. Following positioning of main liner 11 in the well, whipstock 17 and drill string 16 are lowered together as a unit into the well, with the lower portion of the drill string and bit entirely contained within the upper tubular portion 19 of the whipstock. In this position of the drill string, the whipstock is supported from the drill string by engagement of string shoulder 29 with the underside of whipstock shoulder 30. The string and whipstock are thus lowered through casing 13 and into liner 11, to the Fig. 3 position in which the uppermost support block 22, associated with the uppermost aperture 14, is received within slot 24 in the whipstock, to thus support the whipstock in the Fig. 3 position independently of any suspension of such whipstock by the drill string may then be simultaneously rotated and advanced downwardly, while circulating fluid is supplied to the bit 26 through the tubular string, with the result that the bit is deflected laterally by whipstock face 20, and acts to drill a first and upper one of the laterally extending drain holes 15.
After the first drain hole has been drilled, string 16 is retracted upwardly into its initial position within the tubular upper portion 19 of the whipstock, so that shoulders 29 and 30 again move into engagement, and the string and whipstock are then elevated as a unit upwardly out of the main bore. While at the surface, the entire whipstock is withdrawn from the whipstock, as may be permitted by detachment of the shoulder 30 from the whipstock by virtue of a threaded connection at 130. Locating block 43 is then connected into the whipstock, liner 18 is positioned within the upper tubular portion of the whipstock and connected to tool string 39, and the upper shoulder 18 is retracted to the whipstock. In this condition, the whipstock is supported by engagement shoulder 29a on the tool string with the underside of whipstock shoulder 30 of the whipstock, so that the liner and whipstock may be lowered together into the hole to the Fig. 6 position in which the whipstock is again supported on block 22.

With the whipstock thus supported, tool string 39 and liner 18 are advanced downwardly within the whipstock, the liner being deflected laterally through aperture 14 into the drain hole. As upper member 34 of the drain hole liner 14 is advanced, the lower member is rotated until slot 45 engages the circular position of guide block 43, and thus allows further downward and outward advancement of the drain hole liner. Block 43 and recess 45 effectively retain member 34 in the desired relative position during further downward advancement, so that member 34 is received within aperture 14 in the proper Fig. 7 position. This member is forced tightly into aperture 14, to make a very tight forced fit acting to positively retain the drain hole liner in the position of Figs. 7 and 9 relative to the main liner. Tool string 39 is then rotated in a counter clockwise direction to bring the threaded connection at 41 and permit the tool string to be pulled upwardly from the well leaving liner 18 in the drain hole.

The next step comprises withdrawing tool string 39 and the whipstock upwardly out of the hole, with the whipstock being suspended from the tool string by virtue of the interengagement of shoulders 29a and 30. It will of course be understood that, if desired, tool string 39 as utilized in connection with liner 18 may actually be a portion of the previously described drill string 16, in which case shoulder 29a of Fig. 6 may be the same shoulder as shown at 29 in Fig. 3. Following complete withdrawal of the whipstock and tool string from the hole, it is next desirable to shear the uppermost whipstock positioning block 22 off of main liner 11, as by forcing any suitable tool at the lower end of a tool string downwardly against that block. The downward force thus exerted against block 22 shears the preformed shear pins or studs 23, and may permit block 22 to fall to the bottom of the well. Such removal of the uppermost block 22 from liner 11 allows for lowering of the whipstock into a position of support on the next lower block 22, so that a second drain hole may be drilled and lined in the above described manner. All of the drain holes are successively drilled and lined in this manner, with the lowermost hole being the last to be formed (see Fig. 9). After this last hole has been formed and lined, the tools are all removed from the well, and the desired multiple drain hole arrangement is thus completed.

We claim:

1. Apparatus comprising a main liner to be lowered into the main bore of a well and having an aperture formed in its side wall, a flexible drain hole liner adapted to be advanced laterally through said aperture and into a drain hole and having an upper portion for forming a connection with said main liner, a whipstock to be lowered into said main liner and having a deflecting face adapted to deflect said drain hole liner laterally through the aperture, means for supporting the whipstock in the main liner at a location to deflect said drain hole liner through said aperture, and interengageable guide means on said whipstock and said drain hole liner acting to maintain said upper portion of the drain hole liner against rotation from a predetermined position as it is advanced through said aperture.

2. Apparatus as described in claim 1, in which said whipstock has a tubular portion through which said drain hole liner passes, said guide means comprising a lug projecting inwardly from said tubular portion and receivable in guiding relation with an axially extending guide recess formed in said upper portion of the drain hole liner.

3. Apparatus as described in claim 1, including a lowering string connectable to said drain hole liner for lowering it into the well, and a releasable connection between said string and said upper portion of the drain hole liner adapted to be released by movement of the former from the surface of the earth.

4. The method comprising lowering into the main bore of a well, a main liner having an aperture formed in its side wall prior to lowering, drilling a drain hole extending laterally from said aperture in the liner, and then advancing a flexible drain hole liner through said aperture.

5. The method as recited in claim 4, including forming a tight frictional connection between an upper end of said drain hole liner and said first mentioned liner.

6. The method comprising lowering into a well a liner having a preformed aperture in its side wall and having a whipstock positioning shoulder, lowering a whipstock into said liner to a position of support on said shoulder, and then drilling a drain hole extending laterally from said aperture by means of a bit deflected through the aperture by said whipstock.

7. The method comprising lowering into a well a liner having a preformed aperture in its side wall and having a whipstock positioning lug, lowering a whipstock into said liner to a position of support on said lug, then drilling a drain hole extending laterally from said aperture by means of a bit deflected through the aperture by said whipstock.

8. The method as recited in claim 7, in which said liner has a second of said apertures and a second of said lugs, said method including supporting the whipstock on the second of said lugs after shearing off the first lug, then drilling a second drain hole at the second aperture, removing the whipstock from the well, and shearing off the second lug.

9. Apparatus comprising a main liner to be lowered into the main bore of a well and having an aperture formed in its wall, a whipstock to be lowered into said main liner to a location adjacent said aperture and having an inclined face for deflecting a member through the aperture and into a laterally extending drain hole, an interengageable means on said liner and whipstock acting to support the latter at said location in the former, said last mentioned means comprising a lug projecting inwardly from said liner, and means forming a positioning recess on said whipstock for receiving said lug.

10. Apparatus comprising a main liner to be lowered into the main bore of a well and having an aperture formed in its wall, a whipstock to be lowered into said main liner to a location adjacent said aperture and having an inclined face for deflecting a member through the aperture and into a laterally extending drain hole, and interengageable means on said liner and whipstock acting to support the latter at said location in the former, said last mentioned means comprising a block carried by and projecting inwardly from the liner, a shear pin attaching said block to said liner, and a recess in said whipstock for receiving said block and having an upper wall engageable by the block to support the whipstock in the liner.

11. Apparatus comprising a main liner to be lowered
into the main bore of a well and having an aperture formed in its wall, a whipstock to be lowered into said main liner to a location adjacent said aperture and having an inclined face for deflecting a member through the aperture and into a laterally extending drain hole, interengageable means on said liner and whipstock acting to support the latter at said location in the former, a flexible rotatable drain hole liner adapted to be deflected laterally by said whipstock face through said aperture and into a drain hole, said drain hole liner including a connector portion at the upper end of said drain hole liner for forming a connection between the main liner and drain hole liner, and interengageable means on said whipstock and said drain hole liner acting to maintain said connector portion of the latter against rotation from a predetermined position relative to the main liner as the connector portion is advanced through said aperture.

12. Apparatus comprising a main liner to be lowered into the main bore of a well and having an aperture formed in its wall, a whipstock to be lowered into said main liner to a location adjacent said aperture and having an inclined face for deflecting a member through the aperture and into a laterally extending drain hole, interengageable means on said liner and whipstock acting to support the latter at said location in the former, said interengageable means comprising a block carried by and projecting inwardly from the liner, a shear pin attaching said block to said liner, and a recess in said whipstock for receiving said block and having an upper wall engageable by the block to support the whipstock in the liner, said apparatus including also a flexible drain hole liner adapted to be deflected laterally by said whipstock face through said aperture and into a drain hole, said whipstock having a tubular portion through which said drain hole liner passes, and a guide lug projecting inwardly from said tubular portion of the whipstock, said drain hole liner having an upper portion which is a forced fit in said aperture and contains a guide recess for movably receiving said lug thereby maintaining said drain hole liner against rotation from a predetermined position as the drain hole liner is advanced into a drain hole.

14. Apparatus as described in claim 13, in which said last mentioned means include means carried at the inside of the liner forming one of said shoulders adapted to engage and support the whipstock in the liner and performed to be sheared from the liner by downward force.

15. Apparatus as described in claim 13, including a flexible drain hole liner adapted to be deflected laterally by said whipstock face through said aperture and into a drain hole and having an upper portion which peripherally engages and is a forced fit within said aperture to form a tight frictional connection between said drain hole liner and said main liner at the aperture.

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CERTIFICATE OF CORRECTION

Patent No. 2,797,893

July 2, 1957

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 10, for "with an" read --within an--.

Signed and sealed this 17th day of September 1957.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents