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CEMENTING OF WELL PIPE IN STAGES

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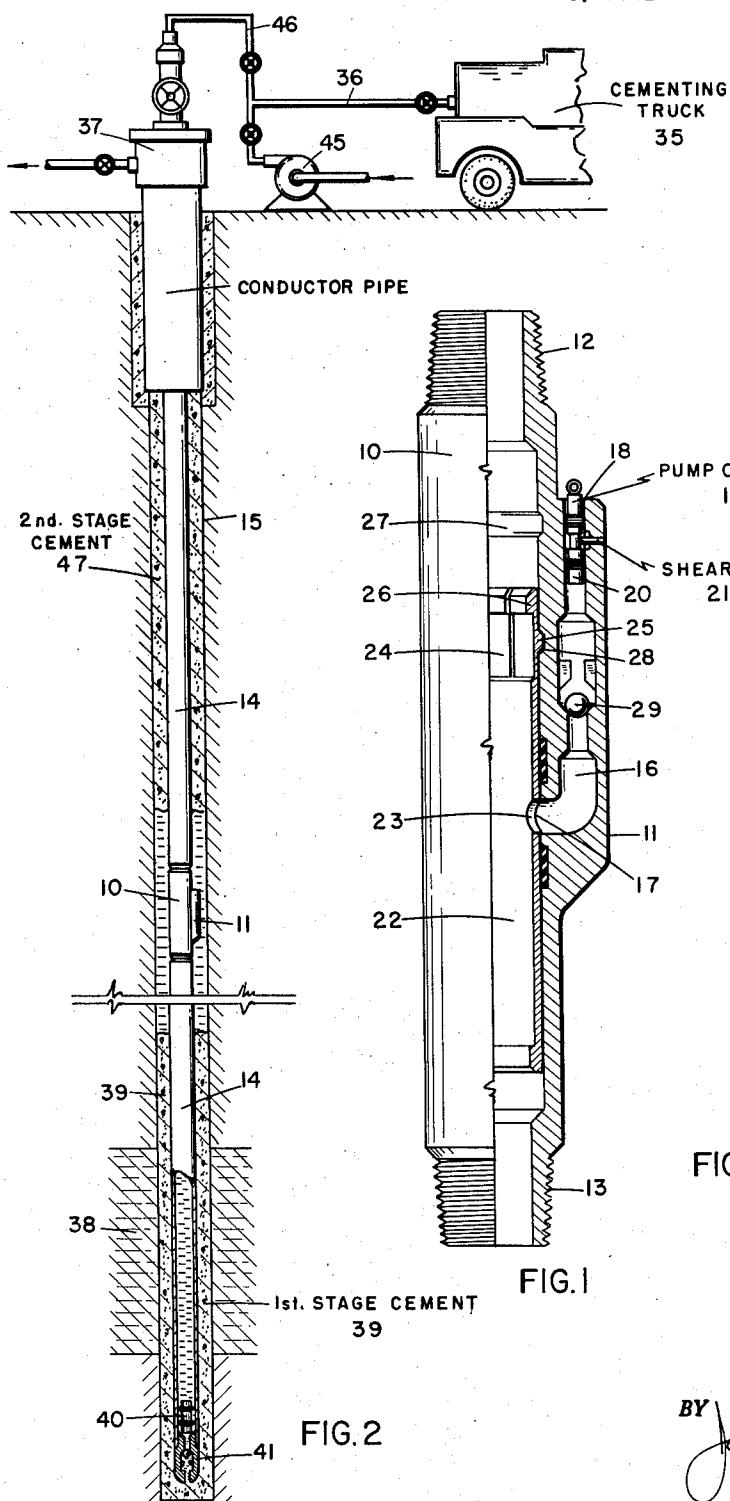
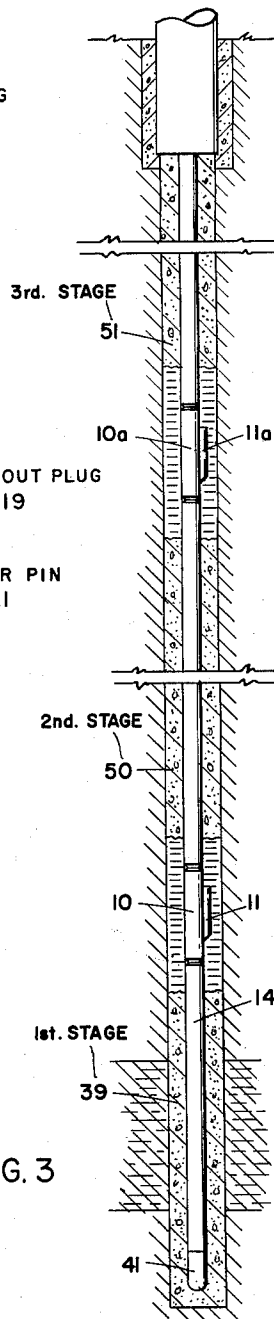


FIG. 3

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1

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CEMENTING OF WELL PIPE IN STAGES

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This invention concerns apparatus for use in technique for cementing well pipe in a borehole in two or more stages, and in particular it concerns a staging tool or tools arranged along the length of a well pipe in a manner to facilitate carrying out of the stage cementing operation.

Stage cementing of well pipe has important advantages over single-column cementing in many wells. It reduces the possibility of breaking down a weak formation with the high cementing pressures required to lift a long column of cement; it minimizes cement contamination during long column cementing; it reduces the quantity of cement required when it is desired to cement widely separated or spaced intervals; and it is useful in placing a cement sheath as a substitute for surface casing.

However, these advantages in operations are offset when presently-available staging techniques and tools are used, for in order to complete the well after stage cementing operations it is necessary to drill out cement and plugs left in the well pipe and stage tool or tools.

Thus, the staging tool of the invention overcomes disadvantages in the use of available tools by eliminating the necessity to drill out the tool and by leaving the well pipe full of displacing fluid instead of having a portion of the well pipe filled with cement. In the arrangement of the invention, the entire length of the well pipe is accessible for work-over operations. In known stage cementing techniques, also, the rubber plugs used to spot the stage cement remain in the well pipe and are difficult to drill out. In the technique of the invention, no plug is left in the well pipe and, consequently, drilling out of it prior to cementing in the later stages is eliminated.

The staging tool of the invention permits cementing of upper sands; cementing off of a water sand; and placing of cement as a substitute for surface casing.

Thus, a primary object of the present invention is to provide an improved stage cementing tool and a stage cementing technique for use therewith.

In brief, the cement staging tool comprises a hollow body member having an offset mandrel mounted thereon; said mandrel having a fluid passageway therethrough; a sleeve valve slidable in said body member between one position which opens fluid communication between the interior of said body member and said mandrel passageway and another position which closes fluid communication between the interior of said body member and said mandrel passageway; a check valve positioned in said mandrel passageway for permitting flow of fluid from the interior of said mandrel through said passageway, but preventing flow of fluid to the interior of said mandrel through said passageway; a fluid pressure releasable plug positioned in said passageway for preventing flow of fluid through said passageway; and means for locking said sleeve in its closed position.

The above object and other objects and advantages of the invention will be apparent from a more detailed description thereof when taken with the drawings wherein:

FIG. 1 is a vertical, partly sectional view of the staging tool of the invention;

FIG. 2 is a schematic illustration of one use of the staging tool of FIG. 1; and

FIG. 3 is a schematic illustration of the use of a plurality of staging tools.

For a more detailed description of the invention, reference now is made to the drawing. In FIG. 1 the staging

2

tool is shown, and it includes a hollow body member or mandrel 10 having an offset or side pocket mandrel 11 mounted thereon. Body 10 is provided with threaded end portions 12 and 13, which are used to threadedly connect body 10 in a well pipe 14, which in turn is supported in a borehole 15 from a wellhead 37 (see FIG. 2). One end of a passageway 16 in mandrel 11 terminates in an opening 17 leading to the interior of body 10. The other end of mandrel 11 terminates in an opening 18, which fluidly communicates with the annulus between the wall of borehole 15 and well pipe 14 when body 10 is in position in well pipe 14. A pump-out plug 19 is initially positioned in passageway 16 adjacent opening 18, and it includes a solid member 20 having sealing elements arranged thereon and connected to mandrel 11 by means of a shear pin 21. A sliding sleeve valve 22 having an opening 23 along the length thereof is arranged in body 10. The upper end of sleeve valve 22 is split to form a plurality of expansible fingers 24, which have formed thereon locking lugs 25 and latching shoulders 26. The interior wall of body 10 is provided with upper and lower locking slots 27 and 28. In its lowermost position, opening 23 in sleeve valve 22 is aligned with opening 17 in mandrel 11, and lug 25 is engaged with locking slot 28. In its uppermost position, opening 17 is not aligned with opening 23, and lug 25 is engaged with locking slot 27. Sleeve valve 22 is initially in its lower or open position and is movable to its upper closed position by means of a wire line tool (not shown) which engages shoulder 26 of the sleeve valve. A check valve 29 also arranged in passageway 16 permits flow through this passageway in a direction away from opening 17 but prevents back flow toward opening 17.

The operation of a two stage cementing technique utilizing one staging tool for a well containing only one long pipe string is illustrated in FIG. 2, and this operation will now be described. For cementing the first stage the well is conditioned as required and the first stage cement is pumped from cement truck 35 through conduits 36 and 46 into well pipe 14, which is provided with a conventional cement shoe 41. A volume of cement sufficient to cement off an interval 38 is pumped down well pipe 14 past the stage tool and through cement shoe 41 on the lower end of the pipe string and up the annulus between the wall of borehole 15 and well pipe 14, as indicated at 39, the predetermined volume of cement being followed by a cement top plug 40 and follow-up fluid pumped by pump 45 through conduit 46 until plug 40 is positioned atop cement shoe 41, as illustrated. Well fluid in the annulus between the well pipe and the borehole wall is displaced upwardly through the annulus to the earth's surface. During the first stage cementing, the stage tool is in the position shown in FIG. 1; that is, the sleeve valve is open and the pump-out plug closes the upper end of passageway 16.

The second stage cement slurry is now placed in the annulus by first pumping fluid by means of pump 45 into well pipe 14 via conduit 46, and additional pressure 1000 to 300 p.s.i. above the pressure used for the first-stage cementing job is applied to fracture shear pin 21 and flush pump-out plug 18 from the upper end of passageway 16. Then the second stage cement slurry from cement truck 35 is pumped through conduits 36 and 46 into well pipe 14 through openings 17, 23, and check valve 29 through the upper end opening 18 of mandrel 11 into the annulus between well pipe 14 and the wall of the borehole 15. The desired volume of cement for the second stage designated 47 is followed by displacing fluid pumped into well pipe 14 by means of pump 45. Then, pressure is released on the displacing fluid, and sleeve valve 22 is closed by lowering a wire line tool into sleeve valve 22 and engaging

shoulder 26 to move sleeve valve 22 upwardly until lug 25 engages locking slot 27.

The sliding sleeve valve can be locked in this position, since there will be no further need for opening this valve.

By the use of this technique the well pipe 14 is only left with cement-displacing fluid following the cementing operation. The well pipe is fully open. There are no plugs or tools or cement to drill out for additional cementing stages.

Although in the foregoing description of the invention, only the setting of a surface sheath of cement has been described, other second-stage cementing operations may be performed. Additionally, although only a two stage cementing operation using one well pipe and one staging tool was described to illustrate the invention, three or more cementing stages using additional staging tools may be performed. When more than one staging tool is used, as illustrated in FIG. 3, each tool is positioned adjacent the place the cement is to be spotted, and to prevent the upper tools from fracturing their shear pins 21 prematurely, the relative strengths of the shear pins of each tool may be increased from the lowermost to the uppermost tools or openings 17 of the upper tools may be closed by sleeves 22 until the tools are needed. Thus, referring to FIG. 3, the first and second stages of cement 39 and 50, respectively, are placed in the annulus in the same manner as described with reference to FIG. 2. After setting these stages, the third stage cement slurry is placed in the annulus by first pumping fluid by means of pump 45 into well pipe 14 via conduit 46, and additional pressure 1000 to 3000 p.s.i. above the pressure used for the second stage cementing job is applied to fracture the shear pin of the staging tool designated by the body member 10a and mandrel 11a and flush the pump-out plug from the upper end of the passageway of mandrel 11a. Then the third stage cement slurry from cement truck 35 is pumped through conduit 36 and 46 into well pipe 14 through openings 17, 23, and check valve 23 and the upper end of the mandrel 11a into the annulus between well pipe 14 and the wall of the borehole 15. The desired volume of cement for the third stage designated 51 is followed by displacing fluid pumped into well pipe 14 by means of pump 45. Then pressure is released on the displacing fluid and sleeve valve 22 in body member 10a is closed by lowering a wire line tool into sleeve valve 22 and engaging shoulder 26 to move sleeve valve 22 upwardly until lug 25 engages locking slot 27. Also, cementing operations may be carried out using the staging tools in multiple tubingless completions in which case one or more of the tools would be arranged in each of several strings of casing.

Having fully described the nature, operation, elements, and objects of my invention, I claim:

1. Apparatus for use in stage cementing of well pipe in a borehole comprising a hollow body member connected in said well pipe and in fluid communication therewith and having an offset mandrel mounted thereon; said

mandrel having a fluid passageway therethrough terminating in a lateral passage opening into said hollow body member; a sleeve valve slidable in said body member between one position which opens fluid communication between the interior of said body member and said mandrel passageway and another position which closes off fluid communication between the interior of said body member and said mandrel passageway; a check valve positioned in said mandrel passageway for permitting flow of fluid when said sleeve valve is in said one position from the interior of said body member through said passageway but preventing flow of fluid to the interior of said body member through said passageway; a fluid pressure releasable plug positioned in said passageway further from said sleeve valve than check valve and adapted to prevent flow of fluid through said passageway; and means for locking said sleeve valve in its other closed position.

2. Apparatus for use in stage cementing well pipes in a borehole comprising a plurality of staging tools arranged vertically spaced along the length of at least one of said well pipes; each of said staging tools comprising a hollow body member connected in said well pipe and in fluid communication therewith and having an offset mandrel mounted thereon; said mandrel having a fluid passageway therethrough terminating in a lateral passage opening into said hollow body member; a sleeve valve slidable in said body member between one position which opens fluid communication between the interior of said body member and said mandrel passageway and another position which closes off fluid communication between the interior of said body member and said mandrel passageway; a check valve positioned in said mandrel passageway for permitting flow of fluid when said sleeve valve is in said one position from the interior of said body member through said passageway but preventing flow of fluid to the interior of said body member through said passageway; a fluid pressure releasable plug positioned in said passageway further from said sleeve valve than said check valve and adapted to prevent flow of fluid through said passageway; and shear means for releasably securing said plug in said passageway; the shear means of said tools having increasing shear strengths from the lowermost tool to the uppermost tool; and means for locking said sleeve in its closed position.

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