METHOD AND MEANS OF COMPLETING A WELL

Theodore A. Huber, Houston, Tex., assignor, by mesne assignments, to Esso Research and Engineering Company, Elizabeth, N. J., a corporation of Delaware

Application October 31, 1951, Serial No. 254,116
22 Claims. (Cl. 166—21)

This invention relates to a method and a means for completing and/or recompleting a well.

The principal object of the present invention is to provide a method and means for altering the position of the lower end of the tubing, with respect to the walls of the borehole, without altering the setting of the tubing itself. A further object is to provide a method and means whereby the depth of tubing in a well may be effectively increased at will and later returned to its original length when desired by the operator.

The method of my invention may be briefly described as a method of increasing the effective depth of tubing in a well originally tubed so that the lower end of the tubing is above the bottom of the well. This increase in effective depth is accomplished by lowering by means of a wire line a tubular member open at the top and the bottom thereof through the tubing until the lower end of the tubular member projects below the lower end of the tubing, the upper end of the tubular member being positioned within the tubing. A sealing means is provided on the outside of the tubular member so that when the tubular member has been lowered to the desired depth the annular space between the tubular member and the tubing may be sealed to the passage of the fluid therethrough. The tubular member may be raised and lowered as desired and may be withdrawn from the tubing when desired. This method of increasing the effective length of the tubing permits a number of operations to be conducted more efficiently as will become apparent from the more detailed description given hereinafter.

The present invention is illustrated in the accompanying drawings in which:

Figs. 1a to g illustrate successive stages in the completion of a well equipped with tubing to a depth just above the uppermost formation from which it is expected to produce during the life of the well;

Fig. 2 is a view, partly in elevation and partly in section, showing the device of the present invention; and

Fig. 3 is a view of the device of Fig. 2 in a different stage of its use from that shown in Fig. 2.

Referring to Fig. 1, the numeral 10 designates casing which extends from the surface of the earth to the bottom 11 of borehole 12. Tubing 13 is shown as concentrically arranged within casing 10, the lower end 14 of tubing 13 being positioned above formation 15. Formation 15 is the uppermost of formations 15, 16, and 17 from which fluids will be produced during the life of the well. The lower end 14 of tubing 13 is positioned in this way so that tubing 13 need not be disturbed at any time during the life of the well irrespective of the formation produced. It will be noted that in Fig. 1a casing 10 and formation 17 are pierced by a plurality of perforations 18. The formation fluid contained by formation 17 flows through perforations 18 into borehole 12 and to the surface of the earth through tubing 13 as indicated by the arrows.

When it is desired to discontinue production from formation 17 and thereafter to produce from a formation located above formation 17, a tubing extension 19 is lowered down through tubing 13 by means of a wire line 20. The outside diameter of tubing extension 19 is less than the inside diameter of tubing 13 and, accordingly, tubing extension 19 is freely movable through tubing 13. A sealing means is provided adjacent the upper end of tubing extension 19 so as to close off the annular space between tubing 13 and tubing extension 19. Packers 21 and 22 are provided for this purpose. As shown in Fig. 1b the lower end 22 of tubing extension 19 is positioned near the bottom 11 of borehole 12. Fluid is then circulated downwardly in the well between casing 10 and tubing 13 so that accumulated debris is washed from the bottom of the well upwardly through tubing extension 19 and then through tubing 13 to the surface of the earth.

On completion of the washing operation illustrated in Fig. 1b, tubing extension 19 is raised up within tubing 13 by means of wire line 20 so that the lower end 22 of tubing extension 19 is just above the upper edge of formation 17 as shown in Fig. 1c. Cement is then pumped down through tubing 13 and through tubing extension 19 until sufficient cement has been introduced into borehole 12 to fill the borehole to a point just above formation 17. A fluid is then introduced into the annulus between casing 10 and tubing 13 and the pressure on cement plug 23 is increased so that cement is forced into perforations 18 as shown in Fig. 1d. The technique involved in cement squeezing is well-known and the details of such operation will not be discussed here. Following the squeeze operation, excess cement is washed from borehole 12 as illustrated in Fig. 1e by circulating fluid downwardly within the annulus formed by casing 10 and tubing 13 upwardly inside tubing extension 19 and tubing 13 as indicated by the arrows.

Fig. 1f shows borehole 12 with the tubing extension 19 removed therefrom by means of a wire line 20 and with a gun perforator 24 run through tubing 13 on a wire line 20 for perforating formation 16. After formation 16 has been perforated, perforating gun 24 is withdrawn from the borehole by means of wire line 20 and the well allowed to produce through tubing 13 as indicated by the arrows in Fig. 1g.

The method of my invention, while it has been illustrated in connection with cementing and backwashing, is not limited to cementing or backwashing but can be employed in any operation wherein it is necessary or desirable to increase the effective depth of tubing without altering the setting of the tubing.

In carrying out the method of my invention, I have found the apparatus shown in Fig. 2 to be particularly effective. Referring to Fig. 2, the numeral 40 designates a borehole lined with casing 41 down to the bottom 42 thereof. Borehole 40 has also been equipped with tubing 43, the lower end 44 of which is positioned above the uppermost formation from which it is expected to produce during the lifetime of the well. At least one and preferably a series of ports 45 extend through the walls of tubing 43 adjacent the lower end 44 thereof. A suitable packer 46 held in place by suitable means, such as slips 47, is positioned below ports 45 and effectively closes the annulus between casing 41 and tubing 43. Packers, such as packer 46, are well-known and will not be described here in detail. Tubing extension 48 having an open upper end 49 and an open lower end 50 carries its outer surface flush with its upper end 49 a suitable sealing means, such as packer 51, and carries below packer 51 another suitable sealing means, such as packer 52. Packers 51 and 52 are spaced apart so that ports 45 can be bridged thereby. Packers 51 and 52 seal off the annular space between tubular section 48 and tubing 43 when tubular extension 48 is so positioned that both these packers are located within tubing 43.
When it is desired to prevent fluids from flowing between the annular space formed by casing 41 and tubing 43 and the interior of tubing 43, tubular extension 45 is lowered into the position shown in Fig. 2 so that packer 52, positioned above ports 45. When it is desired to permit fluids to flow from the annular space formed by casing 41 and tubing 43 and out the lower end of tubing 43 or to flow upwardly through tubing 43 and through ports 45 into the annular space between casing 41 and tubing 43, tubular extension 45 is lowered until lower packer 52 clears the lower end 44 of tubing 43 as shown in Fig. 3. It will thus be seen that the flow of fluid from the annular space between casing 41 and tubing 43 through ports 45 may be controlled by either raising or lowering tubular extension 45 by means of wire line 53.

The invention has been described and illustrated in the drawing by reference to a cased well wherein the casing extends from top to bottom of the well. It is to be understood that the invention is applicable also to cased wells where the casing does not extend completely through the bottom of the well but extends a greater portion of the depth of the well with open hole below the casing. Such cased wells with casing extending only a part of the distance traversed by the well with open hole below the casing are conventional to the art such as that shown in Patent to Canon, U. S. 2,516,402.

While the device employed in the present invention may be secured with the upper end of the tubular member in the tubing by means of a line such as a wire line and the like, other securing means, well known to the art, such as landing nipples, latchng dogs, collars, pipe engaging members and the like, may also be used. Such securing means are conventional and may be illustrated by reference to the Composite Catalog of Oil Field and Pipeline Equipment, 19th edition, 1952-53, pages 944, 4049, and 4064 where examples of equipment of the nature referred to are described.

What I wish to claim as new and novel and to secure by Letters Patent is:

1. A method of introducing cement into a cased and tubed well without altering the setting of the tubing with respect to the well head, said well having been previously completed so that the lower end of the tubing was positioned above the bottom of the well which comprises lowering a tubular member open at both ends through said tubing until the lower end of said tubular member is positioned below the lower end of the tubing while the upper end of said tubular member is positioned within said tubing; securing the upper end of said tubular member in said tubing and sealing the annular space between the tubular member and the tubing so that fluid is unable to flow past said tubular member through said annular space; introducing cement slurry through said tubing and said tubular member until the desired quantity of cement slurry has been introduced into the well; washing out excess cement slurry by circulating fluid downwardly through the annular space between the tubing and the casing and upwardly through said tubular member and said tubing, and withdrawing cement slurry from said tubing.

2. A method of recompleting a cased and tubed well without altering the setting of the tubing with respect to the well head, said well having been previously completed so that the lower end of the tubing was positioned above the bottom of the well which comprises lowering a tubular member open at both ends through said tubing until the lower end of said tubular member is positioned below the lower end of the tubing while the upper end of said tubular member is positioned within said tubing; securing the upper end of said tubular member in said tubing and sealing the annular space between the tubular member and the tubing so that fluid is unable to flow past said tubular member through said annular space; introducing fluid into said well and circulating said fluid through said well for washing said well, discontinuing the introduction of said fluid when said well has been washed and introducing cement slurry through said tubing and said tubular member until the desired quantity of cement has been introduced into the well, washing out excess cement by circulating fluid downwardly through the annular space between the tubing and the casing and upwardly through said tubular member and said tubing, withdrawing cement slurry from said tubing and circulating said cement slurry through said tubing and said tubular member until said tubing and said casing are again at a point beneath said tubing to bring said well into production.

3. A method of introducing cement into a cased and tubed well without altering the setting of the tubing with respect to the well head, said well having been previously completed so that the lower end of the tubing was positioned above the bottom of the well in communication with the formation wall which comprises lowering a tubular member open at both ends through said tubing until the lower end of said tubular member is positioned below the lower end of the tubing while the upper end of said tubular member is positioned within said tubing; securing the upper end of said tubular member in said tubing and sealing the annular space between the tubular member and the tubing so that fluid is unable to flow past said tubular member through said annular space; introducing cement slurry through said tubing and said tubular member until the desired quantity of cement slurry has been introduced into the well; applying fluid pressure to said cement to squeeze said cement into the surrounding formation, washing out excess cement slurry by circulating fluid downwardly through the annular space between the tubing and the casing and upwardly through said tubular member and said tubing, and withdrawing said cement slurry from said tubing.

4. Apparatus comprising tubing open at the lower end suspended within a well lined with casing, said tubing being provided with at least one port adjacent its lower end, said port means comprising an annular channel between the tubing and said casing below said port and said annular space between said tubing and said casing, the said channel being capable of being lowered a sufficient distance to place the second sealing means below the tubing, with said first sealing means remaining positioned above said port to allow fluid communication between said port and the annular space between the tubing and the casing.

5. Apparatus comprising tubing open at the lower end suspended within a cased well, said tubing being provided with at least one port adjacent its lower end, a packer closing the annulus between said casing and said tubing and positioned below said port; a tubular member open at both ends movable within said tubing; spaced first and second sealing means mounted on said tubular member for sealing the annular space between said tubular member and said tubing, said first and second sealing means being spaced as to be capable of forming an annular channel between said tubing and said tubular member with the first sealing means positioned above said port and the second sealing means positioned below said port when said tubular member is lowered to a point adjacent the port, said tubular member being capable of being lowered a sufficient distance to place the second sealing means below the tubing, with said first sealing means remaining positioned above said port to allow fluid communication between said port and the annular space between the tubing and the casing.

6. Apparatus for use in connection with tubing open
at the lower end suspended in a well lined with casing comprising a tubular section having at least one port extending through the wall thereof, said tubular section being connected to said tubing to form a continuous tubing string; a packer mounted on said section below said port for closing the annulus between said casing and said tubing string below said port; a tubular member open at both ends movable within said tubing string by means of a line, spaced first and second packers mounted on said tubular member for sealing the annular space between said tubular member and said tubing string, said first and second packers being so spaced as to be capable of forming an annular chamber between said tubing and said tubular member with the first packer positioned above said port and the second packer positioned below said port when said tubular member is lowered to a point adjacent the port, said tubular member being capable of being lowered by said line a sufficient distance to place the second packer below the tubing, with said first packer remaining positioned above the port to allow fluid communication between said port and the annular space between the tubing and the casing.

7. A method of washing a cased and tubed well without altering the setting of the tubing with respect to the well head, said well having been previously completed with the lower end of the tubing positioned above the bottom of the well, which method includes lowering a tubular member open at both its ends through said tubing until the lower end of said tubular member is positioned below the lower end of the tubing while the upper end of said tubular member is positioned within said tubing to form a path of flow including said tubing and said tubular member extending from the lower end of the tubing to a lower level in the well to be washed; securing the upper end of said tubular member in said tubing and sealing the annular space between the tubular member and the tubing so that fluid is unable to flow past said tubular member annular space, washing the well below the open end of the tubing by introducing a washing fluid into said well through said tubing and tubular member, and circulating said washing fluid along said path of flow through said well to remove debris and the like from said well, said debris and said washing fluid being flowed upwardly in said well through the annular space between the tubing and the casing.

8. Apparatus for introducing fluid into a cased and tubed well without altering the setting of the tubing in which the lower open end of the tubing is arranged substantially above the bottom of the well which comprises tubular member means lowerable through the tubing for establishing a path of flow through said tubing from the open end of the tubing to a particular level in said well below the lower open end of the tubing with the upper end of the tubular means positioned within the lower end of the tubing; means carried by said tubular member for sealing between the tubular means and the tubing, and means attached to said tubular member for varying the effective length of said tubular member below the lower open end of the tubing while maintaining said seal between the tubular means and the tubing path of flow.

9. Apparatus for use in connection with tubing open at the lower end suspended in a well lined with casing comprising a tubular section having one port extending through the wall thereof, said tubular section being connected to said tubing to form a continuous tubing string, a packer mounted on said section below said port for closing the annulus between said casing and said tubing below said port, a tubular member open at both ends movable within said tubing string, and sealing means mounted on said tubular member for sealing the annular space between said tubular member and said tubing string, said tubular member being capable of being lowered a sufficient distance out of the tubing string to provide fluid communication between said port and the casing.
without altering the setting of the tubing in which the lower open end of the tubing is arranged substantially above the bottom of the well which comprises removable securing and sealing a tubular member open on its lower end to the lower open end of the tubing to establish a path of flow of variable length including said tubing and said tubular member extending from the lower end of the tubing sufficient to reach a particular level in said well below said tubing to be cemented, introducing fluid cement into said well by flowing said fluid cement to said particular level along said path of flow to deposit fluid cement in said well, and then removing excess fluid cement from said well along said path of flow of variable length.

18. A method in accordance with claim 17 in which the path of flow is varied in length prior to removing excess fluid cement.

19. A method for treating a cased and tubed well open to the formation without altering the setting of the tubing in which the lower open end of the tubing is arranged substantially above the bottom of the well above the uppermost of a plurality of formations which comprises removably securing and sealing a tubular member open on its lower end to the lower end of the tubing to establish a path of flow including said tubing and said tubular member of variable length and extending from the lower end of the tubing a sufficient distance to reach a particular level in said well below said tubing adjacent one of said formations, treating said well at said particular level by introducing a treating agent to said level along said path of flow, then varying the length of said path of flow while maintaining the setting of the tubing, and then introducing fluid into said well at a different level along said path of flow of varied length.

20. A method for completing a well penetrating a subsurface earth formation having a casing arranged therein open to the formation which comprises permanently setting a tubing in the well casing with its lower open end arranged substantially above the bottom of the well, removably securing and sealing a tubular member open on its lower end to the lower end of the tubing to establish a path of flow including said tubing and said tubular member extending from the lower end of the tubing a sufficient distance to reach a particular level in said well below said tubing, and introducing fluid into said well through said tubing to flow through said path of flow and discharge at said particular level.

21. A method in accordance with claim 20 in which the fluid is a washing liquid.

22. A method in accordance with claim 20 in which the fluid is cement.

References Cited in the file of this patent

UNITED STATES PATENTS

1,400,765 Pallette ................ Dec. 20, 1921
2,051,919 Church ........................ Oct. 8, 1935
2,064,536 Bates ......................... Dec. 15, 1936
2,087,297 Pew .......................... July 20, 1937
2,156,207 Terrill ........................ Apr. 25, 1939
2,316,402 Canon ........................ Apr. 13, 1943
2,347,746 McWilliams .................. May 2, 1944
2,376,878 Lehnard ...................... May 29, 1945
2,381,875 Bryant ........................ Aug. 14, 1945
2,416,842 O'Leary ........................ Mar. 4, 1947
2,436,525 O'Donnell .................... Feb. 24, 1948
2,543,814 Thompson et al. ............ Mar. 6, 1951