

Sept. 4, 1962

R. A. MALOTT

3,052,298

METHOD AND APPARATUS FOR CEMENTING WELLS

Filed March 22, 1960

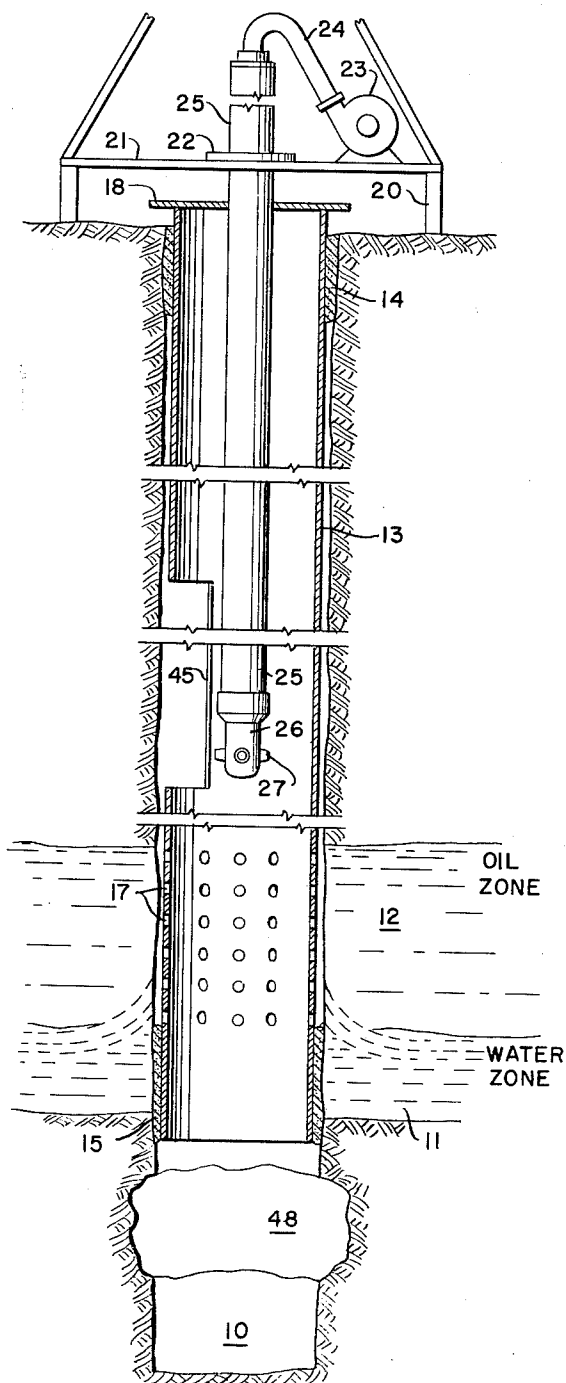


FIG. 1

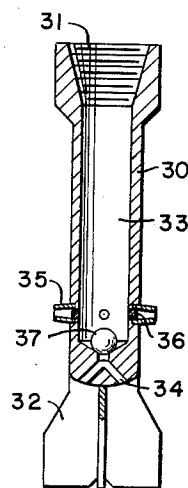


FIG. 2

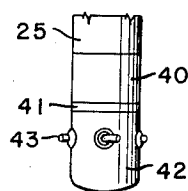


FIG. 3

INVENTOR:

R. A. MALOTT

BY: A. H. McCarthy
HIS AGENT

1

3,052,298

METHOD AND APPARATUS FOR CEMENTING WELLS

Raymond A. Malott, Fullerton, Calif., assignor to Shell Oil Company, New York, N.Y., a corporation of Delaware

Filed Mar. 22, 1960, Ser. No. 16,698

4 Claims. (Cl. 166—22)

This invention relates to a method and apparatus for cementing wells and pertains more particularly to a method and apparatus for forming a firm bond between cement and earth formation, eliminating the mud cake ring, channels and cavities.

In well drilling operations it is often necessary to place a quantity of cement outside a well casing so as to close certain holes, slots or apertures which have been cut or formed in the wall of the well casing. Thus, for example, it may be necessary to cut, as by milling, a longitudinal slot in the well casing for various purposes, such, for example, as for redrilling the well by side-tracking it to one side, etc. It is therefore an object of the present invention to provide a method and apparatus for plugging a window in a well casing prior to redrilling.

In redrilling a well by side-tracking, a window 30 feet or more in length may be cut in the side wall of the well casing to permit drilling through the well casing at an angle to the original well borehole. It is therefore another object of the present invention to provide a method and apparatus for forming a good bond between a cement seal or plug and the borehole formation to prevent the redrilling bit from following the mud ring of the old hole.

In carrying out either of the above-described operations, it is common to encounter a mud sheath on the wall of the borehole that was originally deposited there by the circulation of a drilling mud in the borehole during drilling operations and before a well casing was set. After a well casing has been positioned and sealed in a well, it is impossible to circulate fluid on the outside of the casing in order to wash the borehole wall. It is therefore another object of the present invention to provide a method and apparatus for hydraulically cleaning a mud sheath off a borehole wall prior to cementing operations (i.e., through a perforated section of liner or casing).

During the producing life of a well it is quite common for water from a lower water zone to cone upwardly around a well casing into the oil-producing zone so that large amounts of water are produced along with the oil. In order to eliminate some or all of the water coning, the lowermost perforations adjacent a producing zone may be sealed off. Under normal presently known cementing methods it is difficult to form a fluidtight seal between the well casing and the formation outside the perforations to be sealed. It is therefore a further object of the present invention to provide a method and apparatus for cementing through a perforated well casing or a well string to form an effective seal outside the well casing to prevent water from channeling past the seal.

Still another object of the present invention is to provide a method and apparatus whereby the normal wall scraping operation is eliminated and at the same time

2

establishing a firm bond between a cement plug and the formation.

These and other objects of the present invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a schematic view illustrating a well in longitudinal cross-section in which the method and apparatus of the present invention could be employed.

FIGURES 2 and 3 are additional alternative forms of a cementing tool to be used in cementing operations in the well of FIGURE 1.

Referring to FIGURE 1 of the drawing, an oil well 10 is illustrated as traversing a water zone 11 and an oil zone 12. A well casing 13 has been installed in the well 10 and sealed at the top as at 14 and at the bottom as at 15 by cement which originally sealed off the water producing zone 11. However, during the production of the well, water has started to cone, as at 16, from the water formation up into the oil-producing formation 12 so as to enter to bottom of the well casing 13 through the perforations 17. The perforations 17 may be formed in the bottom of the casing 13 in any suitable manner, as by shooting or cutting, or the perforated lower portion of the well casing 13 may originally consist of a well screen having slots of any suitable design and dimension therein.

The top 18 of the casing 13 may be open or closed, as desired, for carrying out cementing operations. Positioned above the well casing is a derrick 20 having an operating floor 21 on which normal well-drilling and cementing equipment, such, for example, as a rotary table 22 and a cement pump 23 may be placed. The discharge of the cement pump 23 is connected by means of a conduit 24 to a string of pipe 25 which extends down into the well casing 13. The pipe string 25 may be either a tubing string or, in some instances, may be the drill string which is employed during drilling operations. Fixedly secured to the bottom of the pipe string 25 is a cementing sub 26 from which a plurality of horizontally-directed cement discharge ports extend. It has been found that substantially horizontally-directed cement discharge or jetting ports are needed in order to have cement impinge on the formation with sufficient velocity and momentum to create a good bond between a cement plug or seal and the formation.

Another form of a cementing sub to be used in accordance with the present invention is shown in FIGURE 2. This cementing sub comprises a hollow body 30 threaded at the top, as at 31, for connection to the lower end of a drill string. Secured to the bottom of the sub body 30 are blades 32 forming a drag bit. Extending downward from the chamber 33 within the sub 30 are one or more drilling mud discharge ports 34 which may be directed at an angle so as to clean the blades 32, or which may be directed downwardly against the bottom of a well borehole so that the entire sub forms a jet-type drag bit. Extending horizontally through the wall of the sub body 30 are a plurality of cement discharge ports 35. These cement ports 35 are normally closed by pressure-fracturable discs 36 or a sleeve. If during drilling operations it is desired to cement through the drill string without pulling the string and bit 32 to the surface, a steel ball 37 may be dropped through the column of mud in the drill string connected to the top of the sub 30 with the ball 37 finally coming to rest at the bottom of the chamber 33 where

it closes the mud discharge ports 34. Closure of the ports causes an immediate buildup of pressure within the chamber 33 sufficient to fracture the discs 36 so as to open the cement ports 35. Cementing operations may then be carried out without pulling the drill string and bit to the surface.

In FIGURE 3, a cementing sub 40 is shown as being connected to a cementing string 25 with a swivel joint 41 being connected into the sub 40 so that the lower portion 42 is arranged to rotate on a vertical axis. A plurality of horizontally-directed jet cementing nozzles 43 are arranged on the periphery of the rotatable portion 42 of the sub 40 so that fluid jetting from the nozzle 43 causes the lower portion 42 of the sub 40 to spin on its vertical axis. All of the nozzles 43 are set at an angle to the radius in a horizontal plane to cause the lower portion 42 of the sub 40 to rotate.

In FIGURE 1, the well casing 13 is shown as having at a window 45 cut, as by milling or any other suitable method, in the side wall of the well casing 13. In such a situation it is desirable to form a hard consolidated cement plug on the surface of the borehole outside the window 45 in the casing 13 prior to re-drilling operations by side-tracking a bit. Since a mud sheath undoubtedly exists on the wall of the borehole opposite the window 45, a quantity of water is first pumped down through the pipe string 25 and out the jets 27 of the sub 26 to clean the wall of the borehole. The pipe string 25 would be rotated rapidly as the pipe string 25 and its sub 26 were raised and/or lowered one or more times opposite the window 45. If desired, a quantity of sand may be mixed with the water to give an abrasive effect to facilitate removing the mud sheath from the wall of the borehole.

After sufficient water was jetted against the borehole wall opposite the window 45 to clean the formation, a cement slurry would then be pumped by pump 23 through pipe string 25 and out the jet nozzles 27 so as to impinge against the formation and also cause turbulence. A jet velocity of at least 100 feet per second should be employed so as to provide a satisfactory bond between the cement and the formation. Also, where a permeable formation exists, the sand-cement slurry impinges on wall and removes any mud cake allowing the cement to be exposed to hydrostatic differential across the face of the sand, resulting in rapid dehydration of the cement slurry, a harder cement when set and a better bond. At the same time the pipe string 25 and its sub 26 would be rotated, say, at a speed of 100 revolutions per minute. Preferably, the cement is sprayed on the borehole wall in a single vertical pass of the sub 26 over the entire length of the window 45 as the sub is pulled from the bottom to the top of the window. However, in some situations it may be necessary to run the sub down the length of the window again while continuing the jetting action to stir up the cement and form a better bond against the wall of the borehole. Afterwards, the pipe string 25 and the sub 26 would be withdrawn from the well and the cement would be allowed to set up before resuming drilling operations.

The same procedure would be employed when it is desired to close the lower perforation 17 through which water from the water zone 11 is coning, as at 16. Thus, by running the pipe string 25 down into the well casing 13 until the jets 27 were opposite the lowermost perforation 17, cement could be pumped down through the pipe string 25 and jetted out through nozzles 27 through the lowermost perforations 17 to form a seal between the well casing and the borehole wall opposite the cone 16. It is only by jetting of a cement slurry that a suitable bond may be obtained in back of a perforated casing. Preferably in carrying out cementing operations in accordance with the present method the cement slurry contains from about 5-20% or more by weight of sand to furnish an abrasive action, directed velocity head, and turbulence to the ce-

menting operation. This eliminates the use of formation scratches which could not be used.

Alternatively, instead of rotating the pipe string 25 at relatively high speeds during the cementing operation, the pipe string 25 may be held stationary or substantially stationary if a rotatable cementing sub 40, as shown in FIGURE 3, is employed. In such a case the lower portion 42 of the cementing sub 40 would rotate, thus eliminating any necessity of rotating the cementing string 25.

In drilling wells it has been found that the borehole often enlarges, as at 48, to a diameter of a size so that it is impossible to set a packer. The apparatus of the present invention could be employed to set a plug of cement in this enlarged hole area by a spraying or jetting cement against the wall thereof at high velocities, say, 300 feet per second, in order to form a satisfactory bond. The plug would be allowed to set and drilled through so that a packer could be set at this level in the borehole. Additionally, if the well was drilled too deep, say, for example, into a water sand, an excellent water shut-off could be obtained by cementing the bottom of the borehole in accordance with the method of the present invention.

I claim as my invention:

1. Apparatus for drilling and cementing a well, said apparatus comprising a drag-type drill bit with a tubular body member having a chamber formed therein, connector means at the upper end of said body member for connecting said body member to the lower end of a pipe string in fluid communication therewith, said body member being of a diameter to pass longitudinally through a well casing on the lower end of a pipe string and being rotatable therewith, a plurality of cement jetting discharge ports extending horizontally and radially through the wall of said body member for jetting a cement slurry horizontally against a borehole wall, a pressure disc normally closing each of said horizontal discharge ports, normally open vertically-directed port means from said chamber located below said radially extending discharge ports for discharging a fluid downwardly out of said bit, said vertically-directed port means being adapted to be closed by an object dropped through a pipe string and into the body member of said bit.

2. A method of cementing the annular space outside a well casing at a point opposite at least one opening through the side wall of said casing, said method comprising lowering a fluid jetting tool on the end of a pipe string down through said casing to the opening in the casing wall, pumping a stream of well cementing fluid down said pipe string and jetting it horizontally at high velocity through said opening and against the previously cleaned borehole wall to establish an intimate fluidtight bond thereon, continually discharging said horizontally jetting stream of well cementing fluid while moving the pipe string and stream jetting therefrom over at least the entire opening in said well casing.

3. A method of cementing the annular space outside a well casing at a point opposite at least one opening through the side wall of said casing, said method comprising lowering a fluid jetting tool on the end of a pipe string down through said casing to the opening in the casing wall, pumping a nonsetting fluid down through said pipe string and jetting it horizontally through the opening in the casing wall and against the borehole wall at a velocity sufficient to wash a mud sheath from the borehole wall, moving said pipe string vertically and horizontally while jetting over at least the entire opening in said well casing, subsequently pumping a stream of well cementing fluid down said pipe string and jetting it horizontally at high velocity through said opening and against the previously cleaned borehole wall to establish an intimate fluid-tight bond thereon, continually discharging said horizontally jetting stream of well-cementing fluid while moving the pipe string and stream jetting therefrom over at least the entire opening in said well casing.

4. A method of cementing a well, said method comprising lowering a fluid jetting tool on the end of a pipe string down into a well to the level to be cemented, pumping a nonsetting and formation cleaning fluid down through said pipe string and jetting it horizontally against the borehole wall at a velocity sufficient to wash a mud sheath from the borehole wall, rotating said pipe string while moving said jetting tool of said pipe string vertically over at least the entire portion of the borehole to be cemented, subsequently pumping a stream of well-cementing fluid down said pipe string and jetting it horizontally at high velocity against the previously cleaned borehole wall to establish an intimate fluidtight bond thereon, continually discharging said horizontally jetting stream of well cementing fluid while moving the

5

10

15

pipe string and stream jetting therefrom over at least the entire area to be cemented.

References Cited in the file of this patent

UNITED STATES PATENTS

1,276,536	Jergins	Aug. 20, 1918
1,715,767	Le Flore	June 4, 1929
1,912,578	Halliburton	June 6, 1933
2,071,389	Crowell	Feb. 23, 1937
2,268,010	Baum	Dec. 30, 1941
2,315,496	Boynton	Apr. 6, 1943
2,329,157	Frack	Sept. 7, 1943
2,771,141	Lewis	Nov. 20, 1956
2,811,208	Eadie	Oct. 29, 1957