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WELL COMPLETION TOOL

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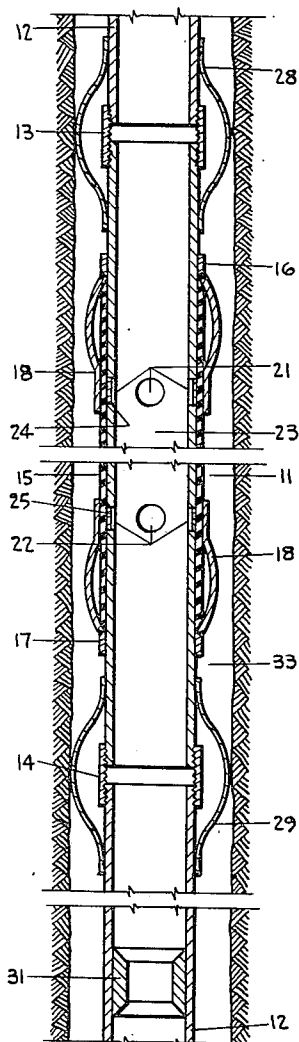


Fig. 1

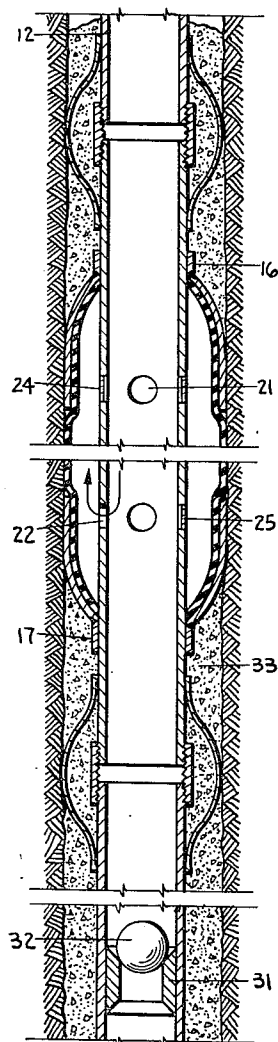


Fig. 2

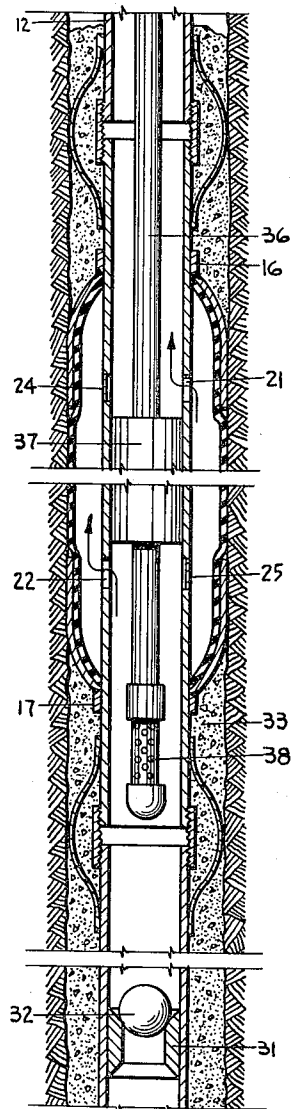


Fig. 3

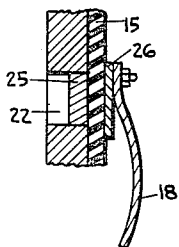


Fig. 4

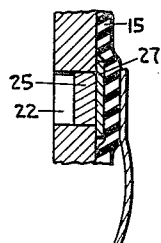


Fig. 5

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2,765,854

WELL COMPLETION TOOL

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5 Claims. (Cl. 166—187)

This invention relates to a device adapted to be used in completing oil and gas wells after they have been drilled, and pertains more particularly to a tool for cementing of well casing within a borehole while preventing the setting of a cement sheath adjacent the total producing zone of the well, or adjacent a small interval thereof.

During the completion of oil wells, especially during the cementing of a casing string in the borehole, it is often desirable to exclude cement from the portion of borehole adjacent the producing formations. This is normally accomplished by providing a pair of packers spaced on the casing string and adapted to be expanded to contact the borehole wall when they are positioned above and below the producing formation. The use of a pair of packers is undesirable, however, if it is desired to fill the annulus between the casing string and the borehole wall with cement above the upper packer as well as below the lower packer, as it is then necessary to provide the casing string with suitable valve means above the upper packer for flowing cement through the casing string and into the annulus above the upper packer.

It is a primary object of this invention to provide a method and apparatus for excluding cement and other liquids from the annular space between a casing string and the borehole wall adjacent the total producing section or adjacent to a small interval in that total section during cementing or well completion operations.

Another object of this invention is to provide a method and apparatus for cementing a well casing in a borehole and subsequently forcing the cement slurry from the annular space between the casing string and the borehole wall adjacent the producing formations or adjacent to a small interval in the total section of the well.

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

Figures 1, 2 and 3 are views, taken in vertical cross-section, of the present apparatus connected into a casing string and positioned in a well borehole during cementing operations.

Figures 4 and 5 are enlarged fragmentary views taken in cross-section of the protective plate means employed by the present tool.

Referring to Figure 1 of the drawing, the present well completion tool comprises a tubular body member 11 adapted to be connected at its upper and lower ends into a string of well casing 12 in any suitable manner, as by means of threaded collars 13 and 14. The diameter of the tubular body member 11 is substantially equal to that of the well casing 12 while the length of the body member 11 is equal to, greater than, or less than the thickness of the producing formation within the well, depending upon the amount of the producing formation that is to be opened to production. Thus, if the oil sand is 5 feet thick and it is desired to open it all to production, the tubular body member 11 should be 8 or 10 feet long. However, in another field having a 65

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foot oil sand with gas above and water below, only a 5 to 10 foot section is normally opened to production, the section being at least 15 feet below the gas-oil contact and 5 to 10 feet above the oil-water contact. In such a case, the body member 11 need be only slightly more than 10 feet long.

Surrounding the tubular body member 11 throughout a major portion of its length, is an expandable sleeve or diaphragm 15 which is fixedly secured at each end to the outside of the body member 11 in any suitable fluidtight manner, as by means of ring clamps 16 and 17.

The ring clamps 16 and 17 may also form the base to which a plurality of spring-like arms 18 may be attached. One or more fluid ports 21 and 22 are formed in the wall of the tubular body 11 preferably near the upper end and also near the lower end of said expandable sleeve 15 for admitting fluid from the bore 23 of the tubular body 11 into the space between the outer surface of body member 11 and the inner surface of the expandable sleeve 15. Preferably, a series of upper fluid ports 21 and a series of lower fluid ports 22 are employed. When the present completion tool is in its normal or inoperative position, the fluid ports 21 and 22 are closed in a fluidtight manner by differential pressure disks 24 and 25 which are fixedly secured in the fluid ports 21 and 22. The disks 24 and 25 may be made of any suitable material, such as metal, plastic, etc., with the thickness of the disks or the strength of the bonding material by which they are secured in the ports, selected so that the disks 24 and 25 may be forced out of the ports 21 and 22 or ruptured at a desired hydraulic pressure.

The expandable sleeve 15 may be made of rubber, synthetic rubber, plastic material, rubberized canvas, a canvas laminate, etc., the diaphragm material selected being subject to deterioration and destruction in the presence of a suitable acid or chemical solvent. If the sleeve 15 is made of rubber or any other elastic plastic material, the sleeve is designed with a size to fit the tubular body member 11 snugly in its inoperative position. However, if the sleeve 15 is made of canvas, rubberized canvas, or other substantially non-elastic plastic material, the sleeve is folded around the tubular body 11 while the tool is being run into a well.

The spring arms 18 which are secured to the ring clamps 16 and 17 extend over the portions of the sleeve 15 adjacent the clamps and serve to hold the sleeve against the tubular body member 11. While only two or four springs may be employed extending from each of the ring clamps 16 and 17, it is preferred that a plurality of leaf springs be secured to each of the spring clamps 16 and 17, so that they extend in an overlapping manner entirely around the circumference of the tubular body member and diaphragm 15 in a manner similar to that disclosed in U. S. Patent No. 2,602,514, to W. S. Althouse, Jr., issued July 8, 1952, and entitled "Cement Basket." The spring arms 18 protect the sleeve 15 by holding it against the body member 11 when the tool is run into the well. Preferably, the spring arms are of a length such that they extend from the ring clamps 16 and 17 to a point beyond the fluid ports 21 and 22. Thus, the ends of the spring arms 18, which cover the fluid ports 21 and 22 outside of the sleeve 15, serve as shields or guard devices for protecting the sleeve or diaphragm 15 when the differential pressure disks 24 and 25 are ruptured.

As shown in Figure 4 of the drawing, each spring arm 18 located outside of a fluid port 22 may have secured to the end thereof a circular plate 26 slightly larger in diameter than the diameter of the pressure disk 25. Upon rupture of the pressure disk 25, the plate 26 prevents the ruptured disk from being propelled through the dia-

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phragm or sleeve 15. Figure 5 of the drawing illustrates another form of the shield means provided outside the rupturable disk 25. In this form, the shield takes the form of a plate means 27 which has been secured to the inside surface of the sleeve 15 by any suitable means, as by cementing. The protective plate means 27 may be made of any suitable material such as metal or hard plastic which will not fracture when the pressure disk 25 is propelled against it.

Preferably, a set of centralizer springs 28 and 29 are secured to the outside of the tubular body member 11 above and below its expansible sleeve 15 so as to prevent injury of the sleeve by rubbing against the borehole wall as the apparatus is lowered into a well borehole. In order to use the present apparatus most effectively, the casing string, at some point below the completion tool, is provided with a valve seat 31 within its bore for receiving a ball valve or plug 32 (Figure 2) for a purpose which will be described hereinafter. This valve seat, if employed, will be of a size so as to permit passage of conventional cementing plugs.

The primary application of this tool is for the completion of a well drilled through a producing formation where a cement seal is desired both above and below the interval to be opened to production in the total oil or gas bearing interval. The tool of Figure 1 is connected into a string of casing 12 and is run into a well borehole until it is positioned opposite the producing section which would normally be opened to production by standard perforation methods through a cement seal. Conventional cementing techniques are employed and a cement slurry is pumped down the casing string 12 until it passes around the lower end of the well casing and rises in the annular space 33, between the borehole wall and the outer wall of the well casing 12, to a point somewhere above the present completion tool and above the producing formation. The use of suitable cementing apparatus, such as a float collar and float shoe or possibly a float shoe and a baffle collar on the casing shoe joint, is assumed. Since these elements are well known to the art of cementing wells and do not form part of this invention, they will not be further described herein.

It is sufficient to state that some sort of a valve seat 31 is positioned below the present completion shoe in the well casing string 12. As shown in Figure 2 of the drawing, when a ball valve or cementing plug 32, which has been pumped down into the well casing on top of the cement slurry, seats itself on the valve seat 31, the pressure within the well casing string 12 above the plug 32 increases slowly with continued pumping of a fluid, such as water, down the well casing until one or more than one of the differential pressure disks 21 and 22 are ruptured. Continued pumping of a hydraulic fluid down the well casing 12 causes it to flow through the fluid ports 22 and into the space between the sleeve 15 and the outer wall of the tubular member 11, thus expanding the sleeve 15 until it contacts the borehole wall. If no centralizer springs 28 and 29 are employed, the present apparatus will center itself and the casing string 12 within the borehole upon expansion of the sleeve 15. Expansion of the sleeve 15 causes the cement previously located between the sleeve and the borehole wall to be squeezed or forced upwardly or downwardly, as the case may be, thus resulting in the removal of the cement from the annular space 33 in the borehole adjacent the producing formation or any selected section thereof.

The spring arms 18 surrounding the sleeve 15 at either end thereof also expand against the borehole wall, but at the same time retain the diaphragm within its desired zone and prevent the hydraulic pressure from rupturing the ends of the diaphragm. A high differential fluid pressure is maintained in the well casing 12 and in the expanded sleeve 15 until the cement surrounding the well casing has taken a permanent set.

After the cement has set, the interior of the well

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casing 12 may be put in communication with the producing zone of the well in any manner well known to the art. For example, a gun perforator may be lowered into the well casing to a point opposite the diaphragm or sleeve 15 and fired so that both the casing and the expansible sleeve 15 are perforated. If the expansible sleeve 15 is made of natural rubber or an oil-soluble plastic material, the oil from the formation will disintegrate the remains of the sleeve and cause it to be washed to the surface. Preferably, however, the sleeve material may be removed more rapidly by the introduction into the well of an acid or a suitable solvent for dissolving or disintegrating the sleeve 15.

As illustrated in Figure 3 of the drawing, a tubing string 36 may be run through the well casing carrying a packer 37 which would be expanded against the inner walls of the well casing at a point between the upper and lower fluid ports 21 and 22, respectively, in the well casing. The acid or solvent could then be pumped down the tubing string 36 to be discharged out the lower perforated section 38 thereof, and be circulated up through the fluid ports 22 and 21 and then up the annular space between the tubing string 36 and the well casing 12 after the expansible sleeve 15 had disintegrated. If only one set of differential pressure disks 24 or 25 is ruptured during the initial operation of the present completion tool, sufficient fluid pressure may be applied through the tubing string 36 to rupture the unruptured disks that remain, if necessary, for circulation purposes. Destruction of this expansible sleeve then permits chemical treatment of the formation in any desired manner and is followed by conventional completion procedures.

I claim as my invention:

1. A well completion tool for cementing a string of casing in a well, said tool comprising a tubular body adapted to be connected at both ends into a string of casing and run into a well borehole, said tubular body being provided with first and second fluid port means through the wall thereof in axial spaced relationship, an expansible sleeve surrounding said body over a portion thereof which includes said first and second port means, means for securing the ends of said sleeve to said body in a fluid-tight manner, disk means removably secured to said tubular body for normally closing said port means, said disk means being adapted to be ruptured under a hydraulic pressure greater than that normally employed in cementing a well, and shield means fixedly positioned in register with said disk means and secured to said expansible sleeve for protecting said sleeve from injury when said disk means are ruptured.

2. A well completion tool for cementing a string of casing in a well, said tool comprising a tubular body adapted to be connected at both ends into a string of casing and run into a well borehole, said tubular body being provided with first and second fluid port means through the wall thereof in axial spaced relationship, an expansible sleeve surrounding said body over a portion thereof which includes said first and second port means, said sleeve adapted to be expanded radially into contact with the wall of said well borehole, clamp means for securing the ends of said sleeve to said body in a fluid-tight manner, disk means removably secured to said tubular body for normally closing said port means, said disk means being adapted to be ruptured under a hydraulic pressure greater than that normally employed in cementing a well, and shield means fixedly positioned outside said disk means in register therewith and secured to said expansible sleeve for protecting said sleeve from injury when said disk means are ruptured.

3. A well completion tool for cementing a string of casing in a well, said tool comprising a tubular body adapted to be connected at both ends into a string of casing and run into a well borehole, said tubular body being provided with first and second fluid port means through the wall thereof in axial spaced relationship, an

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expansible sleeve surrounding said body over a portion thereof which includes said first and second port means, clamp means for securing the ends of said sleeve to said body in a fluid tight manner, disk means removably secured to said tubular body for normally closing said port means, said disk means being adapted to be ruptured under a hydraulic pressure greater than that normally employed in cementing a well, a plurality of spring arms fixedly secured at one end to each of said clamp means with the other end extending over a portion of said expansible sleeve for normally retaining said sleeve against said tubular body, and shield means fixedly positioned outside said disk means in register therewith and secured to said spring arms for protecting said sleeve from injury when said disk means are ruptured.

4. A well completion tool for cementing a string of casing in a well, said tool comprising a tubular body adapted to be connected at both ends into a string of casing and run into a well borehole, said tubular body being provided with first and second fluid port means through the wall thereof in axial spaced relationship, an expansible rubber sleeve surrounding said body over a portion thereof which includes said first and second port means, a ring clamp surrounding each end of said sleeve for securing the end of said sleeve to said body in a fluidtight manner, a disk removably positioned in and normally closing each of said port means said disk being adapted to be ruptured under a hydraulic pressure greater than that normally employed in cementing a well, a plurality of spring arms fixedly secured at one end to each of said clamps with the other end extending over a portion of said expansible sleeve for normally retaining said sleeve against said tubular body, and shield means fixedly positioned outside said disk means in regis-

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ter therewith and secured to said expansible sleeve for protecting said sleeve from injury when said disk means are ruptured.

5. A well completion tool for cementing a string of casing in a well, said tool comprising a tubular body adapted to be connected at both ends into a string of casing and run into a well borehole, said tubular body being provided with first and second fluid ports through the wall thereof in axial spaced relationship, an expansible rubber sleeve surrounding said body over a portion thereof which includes said first and second port means, clamp means for securing the ends of said sleeve to said body in a fluidtight manner, a disk removably positioned in and normally closing each of said ports said disk being adapted to be ruptured under a hydraulic pressure greater than that normally employed in cementing a well, a plurality of spring arms fixedly secured at one end to each of said clamp means with the other end extending over a portion of said expansible sleeve for normally retaining said sleeve against said tubular body, and a shield positioned outside each of said disks in register therewith and fixedly secured to an adjacent spring arm, for protecting said sleeve from injury when said disk means are ruptured, each of said shields and spring arms being adapted to move radially away from said tubular body when a hydraulic pressure is applied to expand said rubber sleeve against the wall of said well borehole.

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