April 4, 1961 W. M. O'REILLY ET AL 2,978,029

PLUG FOR WELL BOREHOLES

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FIG. 1.

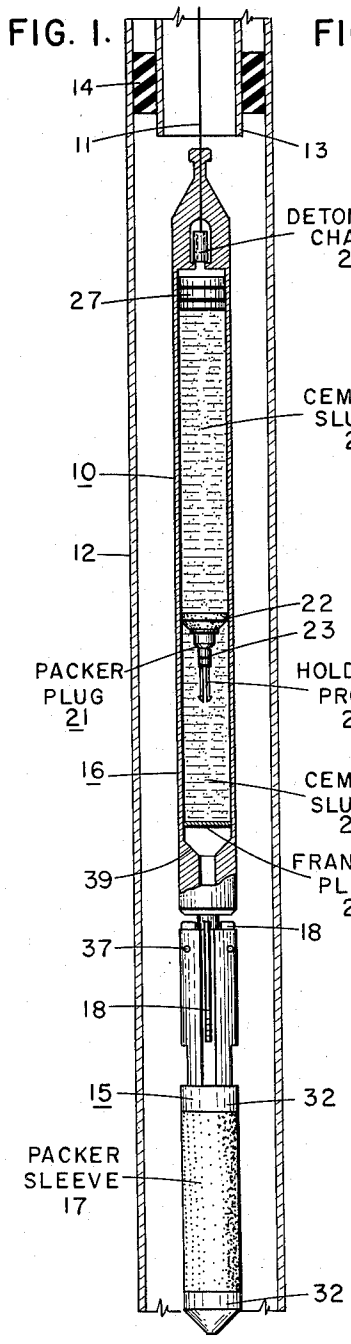

FIG. 2.

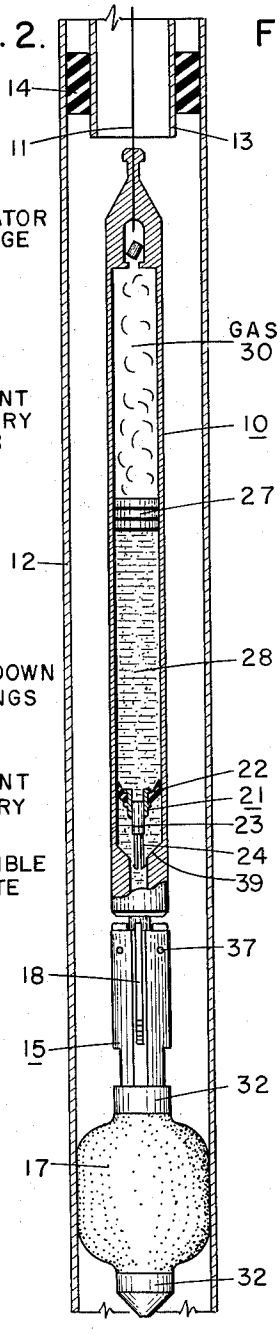

FIG. 3.

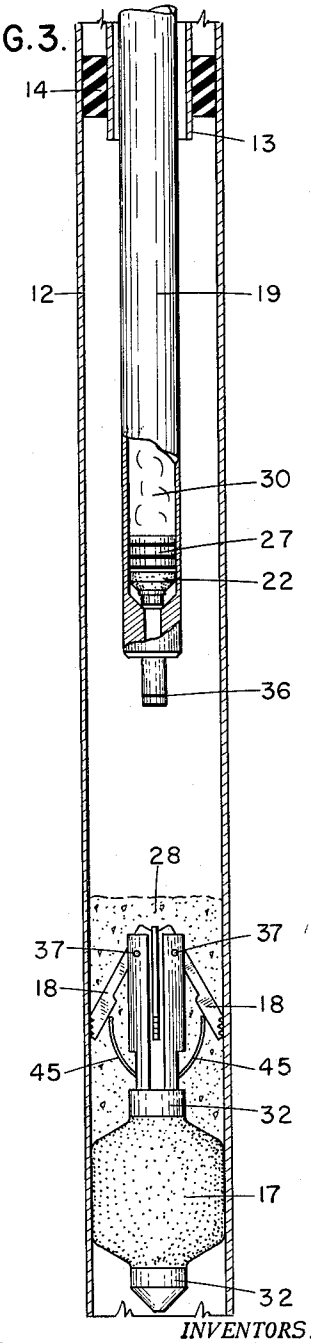

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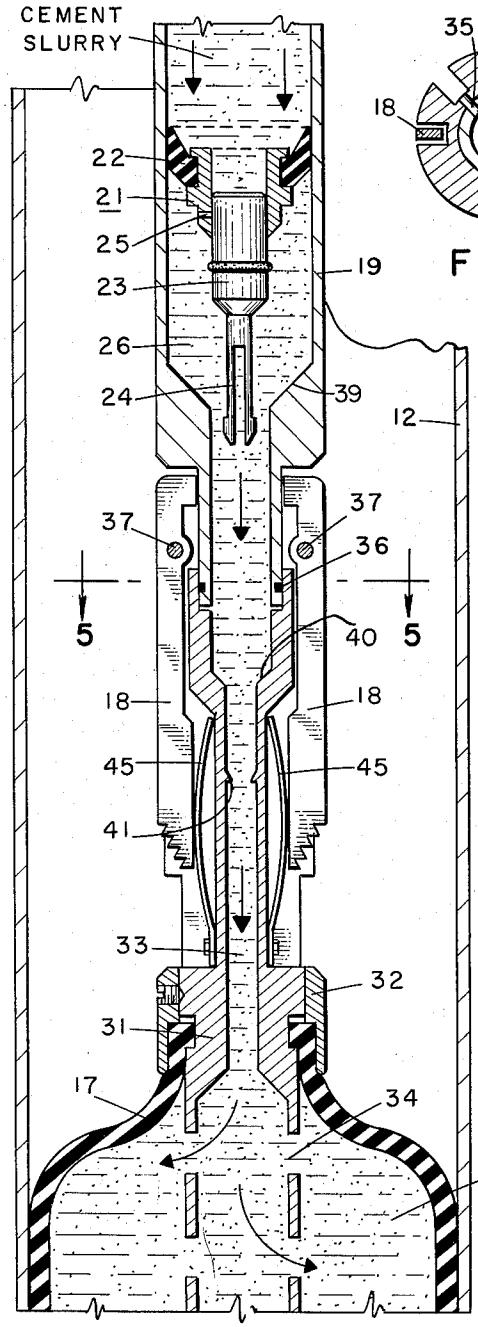
FIG. 4.



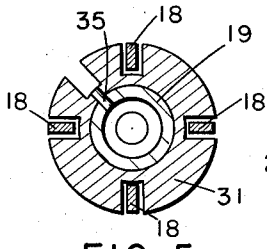


FIG. 5.

FIG. 6.

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United States Patent Office 2,978,029 Patented Apr. 4, 1961

2,978,029

PLUG FOR WELL BOREHOLES

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Filed May 11, 1959, Ser. No. 812,308

1 Claim. (Cl. 166—63)

This invention relates to a plug for a well borehole and, in particuluar, to an inflation packer for plugging the borehole and apparatus for inflating the packer.

When producing oil and gas wells, it is often desirable to plug the casing bore below the lower extremity of the production tubing without removing this tubing from the well bore. Currently it is possible to do this through the use of a vaned membrane type tool as, for example, an inverted umbrella which forms a relatively unreliable linear contact with the casing. Graded layers of gravel and sand usually are placed separately on the inverted umbrella to provide a base for the cement which forms the plug and which also is placed separately. Thus, a plug formed in this manner requires several operations, including the undesired one of pumping cement down the tubing into the casing, and is generally unreliable.

The present invention provides a borehole plug which overcomes disadvantages of currently available borehole plugs.

Briefly, the invention comprises a packer section including an inflatable packer and anchoring means adapted to engage the wall of the borehole to anchor the packer section in the borehole and a setting tool section releasably connected to the packer section, the setting tool section including cement for expanding the inflatable packer and for filling the space above the packer with cement and means for forcing the cement into position.

Thus, a primary object of the present invention is to provide an improved plug for boreholes which may be lowered through tubing and which does not require the pumping of cementitious materials through the tubing string.

This and other objects of the invention will be apparent from a description thereof taken in conjunction with the drawings wherein:

Fig. 1 is a cross-sectional view of a borehole showing the tool of the invention in running-in position;

Fig. 2 is a view similar to that of Fig. 1 showing the arrangement of the tool with the packer being filled with cement;

Fig. 3 is a view similar to that of Figs. 1 and 2 showing the packer filled with cement and the running apparatus disconnected from the packer section of the tool;

Fig. 4 is a vertical partly sectional view illustrating in greater detail the position of the slip arm actuating apparatus when the tool is in the position shown in Fig. 2.

Fig. 5 is a view taken on lines 5—5 of Fig. 4; and

Fig. 6 is a view similar to that of Fig. 4 showing arrangement of the apparatus after the running portion has been released from the packer section.

Referring to the drawings in greater detail and wherein identical numerals designate identical parts, in Figs. 1 to 3, the apparatus of the invention generally designated 10 is shown suspended on a wire line electrical conductor 11 in a casing 12 in which is arranged a tubing string 13; the annulus between the tubing string and the casing

is sealed off by means of a packer 14. As seen in Fig. 1, apparatus 10 includes a packer section 15 and a setting tool section 16. Packer section 15 includes an inflatable packer sleeve 17 and expansible slip arms 18. The setting tool section 16 includes a hollow housing 19 which contains initially a frangible disc or plate 20 positioned in the lower end theheof; a movable plug unit 21, which includes a cup packer 22 releasably connected by means of a shear pin 25 (see Fig. 4) to a packer plug or seal 23 having hold-down prongs 24 attached thereto spaced from frangible plate 20; a cement slurry 26 located between unit 21 and frangible plate 20; a piston 27 spaced from unit 21; a cement slurry 28 arranged between piston 27 and unit 21; and a detonator charge 29 located above piston 27. Conductor 11 may extend into the detonator charge 29 to facilitate firing thereof.

To expand packer sleeve 17 and set slip arms 18, the detonator charge 29 is fired which, as seen more clearly in Fig. 2, generates a gas 30 which in expanding moves piston 27 downwardly. This movement of piston 27 forces cement slurry 28, unit 21, and cement slurry 26 downwardly which causes fracture of frangible plate 20 and movement of cement slurry 26 into packer sleeve 17.

This action is seen more clearly in Figs. 4 and 5 to which reference is now made. Expansible sleeve 17 is secured to a packer mandrel 31 by means of collars 32 (only the upper one of which is shown in Fig. 4). Mandrel 31 is provided with a bore 33 and ports 34 which latter are enclosed by sleeve 17. The upper end of mandrel 31 is releasably connected to the lower end of housing 19 by means of a shear pin 35 (see Fig. 5). Bore 33 fluidly communicates with the interior lower end of housing 19 and an O-ring seal 36 is provided to seal off the connection between housing 19 and mandrel 31. Slip arms 18 are pivotally connected to mandrel 31 as at 37 and arranged in slots formed in mandrel 31 when retracted. Leaf springs 45 are secured to mandrel 31 and function to bias the lower free ends of slip arms 18, which are serrated for engaging the wall of the casing, outwardly. The upper ends of slip arms 18 bear against the outer surface of the lower end of housing 19. A shoulder 40 is formed on the inner surface of mandrel 31 along the passage of bore 33 to provide a seat for unit 21. Also, along bore 33 a latch surface 41 is provided to engage hold-down prong 24 when unit 21 is seated on shoulder 40, as shown in Fig. 6. In this figure, shear pin 35 has been severed; cement slurry 26 has expanded packer sleeve 17; springs 45 have biased outwardly the serrated ends of slip arms 18; and cement slurry 28 is being located atop the plug formed by expanded packer 17.

In operation, referring first to Fig. 1, tool 10 is lowered on wire line 11 (or it may be run on a pipe string if that type operation is desired) through tubing string 13 and out the lower end thereof to a desired depth in casing 12 (the tool may be run in an unrestricted casing instead). Then the detonator charge 29 is fired in the same manner as with conventional perforating devices. If the tool is run on a pipe string, a percussion type detonator actuated by a dropped "go-devil" may be employed. As seen in Fig. 2, the expanding gas 30 created by the detonation of the charge moves piston 27 downwardly to displace cement slurry 28, unit 21 and cement slurry 26 downwardly which movement fractures frangible plate or disc 20. Unit 21 is located in the cement slurry such that the quantity of cement slurry 26 is proportioned to the size of packer 17 which, in turn, is selected according to the size of the casing to be plugged. Sufficient cement is used to inflate packer 17 to form a tight contact with the wall of casing 12 without rupture of packer 17. As seen more clearly in Fig. 4, the cement slurry 26 is forced through the lower end of housing 19 into bore 33

and through perforations 34 into the interior of packer sleeve 17. When cup packer 22 engages shoulder 39, a sufficient amount of cement slurry 26 has filled packer sleeve 17 to plug the casing. Further expansion of gas 30 causes shearing of pin 25 and moves packer plug 23 to its seat on shoulder 40 to seal off bore 33 as shown in Fig. 6. In this position hold-down prongs 24 are engaged with latches 41 which locks packer seal 23 in the passage or bore 33. Seal 23 functions to retain the cement in sleeve 17 to insure that the packer sleeve will remain inflated. Continued expansion of the gas increases the internal pressure which causes shear pin 35 to shear with resultant separation of packer section 15 and setting tool section 16. When the lower portion of housing 19 is removed, slip arms 18 are moved outwardly by springs 45 to engage the wall of the casing. The remainder of the cement moves to form a column resting on the cement filled packer plug.

The device of the invention generally will be used in permanent type well completion installations; however, it also may be used to prevent formation contamination by well bore fluids when well tubing is removed for any reason.

Having fully described the nature, objects, elements and operation of our invention, we claim:

Apparatus for use in plugging a well bore comprising a packer mandrel provided with a passageway, an inflatable packer surrounding said mandrel, said mandrel passageway fluidly communicating with the interior of said packer, a hollow housing releasably connected to said mandrel and provided with a passageway fluidly communicating the interior of said housing and said packer-mandrel passageway, slip arms pivotally arranged on said mandrel, the inner ends of said slip arms initially engaging said housing to maintain said slip arms retracted, means engaging said slip arms adapted to bias said slip arms outwardly, sealing means for sealing off said passageways from fluids exterior thereof when said housing and mandrel are interconnected, a frangible disc arranged in the lower portion of said housing, a first body of cementitious material arranged in said housing above said disc, a cup packer arranged above said first body of cementitious material and having means releasably connected thereto adapted to move through said housing passageway to plug off said mandrel passageway, a second body of cementitious material arranged in said housing above said cup packer, a piston member arranged above said second body of cementitious material, and a detonator arranged above said piston member whereby detonation of said detonator moves said piston member, said second body of cementitious material, said cup packer, and said first body of cementitious material downwardly to fracture said frangible disc and force said first body of cementitious material into said packer to inflate said packer, said plug means engaging said packer mandrel passageway and the connection between said housing and said mandrel severing whereby said slips are moved outwardly to engage the wall of said borehole and said second body of cementitious material depositing in said well bore atop said inflated packer.

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