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CEMENTING PLUG

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Fig. 1.

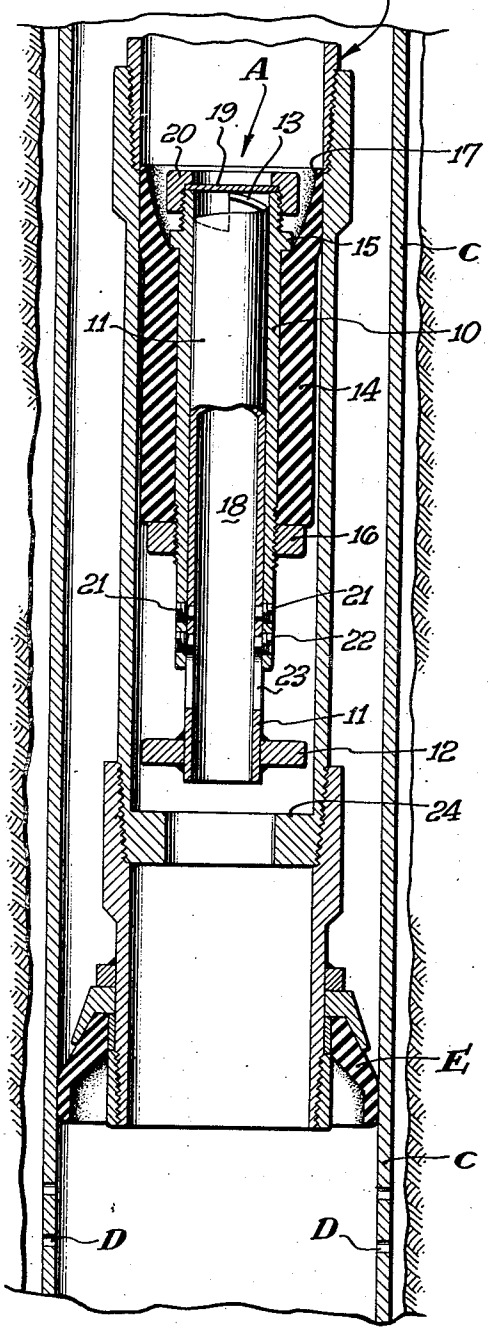
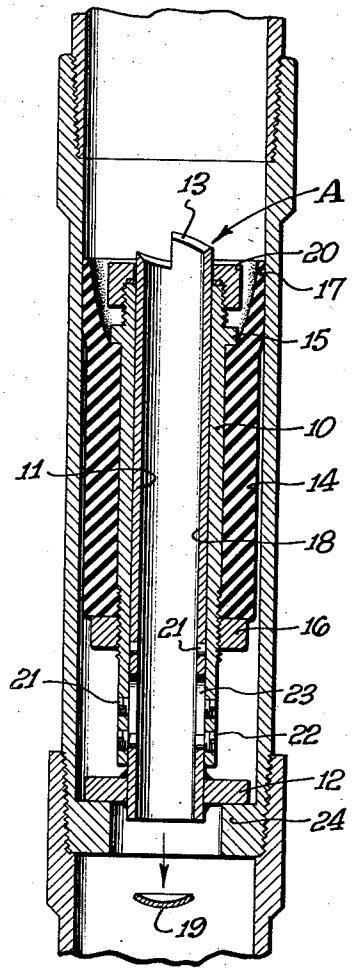


Fig. 2.



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CEMENTING PLUG

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8 Claims. (Cl. 166—1)

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This invention relates to a plug device adapted to be pumped down well tubing, casing and similar conduits, and more particularly to a bottom or top cementing plug capable of preventing contamination between a charge of cementitious material and the fluid which precedes or follows it in its downward passage through the well conduit.

Certain types of cementing plugs have a longitudinal passage which is initially closed by a member that is subsequently disrupted hydraulically by the pressure of the fluid in the well casing or tubing above the plug. There are several limitations and disadvantages to prior devices of this type. The disruption of the closing member may produce only partial opening of the passage, resulting in impeded fluid flow through the plug. Moreover, since only a relatively small area is acted upon by the fluid, the effects of minor errors in dimensions of the closure member and variations in its physical characteristics are magnified, producing its shearing or other mode of removal from the passage at unit pressures differing considerably from the supposed predetermined pressure at which passage opening is to occur. The relatively small area of the closure member on which the fluid pressure acts also necessitates removal of such member from the passage by relatively small total hydraulic forces, if abnormally high unit hydraulic pressures are to be avoided, to which the entire casing or tubing string containing the plug would be subjected. The closure member must, therefore, be held across the passage by a retaining device of relatively low strength.

It is an object of the present invention to provide a well plug having a passage initially closed by a member which is positively sheared and completely removed from the passage upon application of a predetermined degree of pressure to the fluid in the well conduit above the plug.

Another object of the invention is to provide a well plug having a passage closed by a member which is removed hydraulically by fluid pressure acting over an area which is substantially greater than the area of the passage itself.

Still another object of the invention is to provide a plug adapted to be pumped down a well conduit and having a passage closed by a member which can be removed from the passage by the pressure of the fluid in the conduit acting over substantially its entire cross-sectional area.

Yet a further object of the invention is to provide a well plug having a passage closed initially by a diaphragm member whose removal from the

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passage is independent of the hydraulic pressure acting directly upon it.

A further object of the invention is to provide a well plug having a passage closed by a member which can be retained in passage closing position by means having a greater strength than the corresponding unit pressure required to effect removal of the member from the passage.

Another object of the invention is to provide a well cementing plug whose initially closed central passage can be opened hydraulically at a predetermined pressure with greater accuracy than heretofore obtainable.

This invention has other objects that will become apparent from a consideration of the embodiment shown in the drawings accompanying and forming part of the present specification. This form will now be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Figure 1 is a longitudinal section through a plug device, disclosed as descending through a tubular string contained within a casing position in a well bore; and

Figure 2 is a longitudinal sectional view of the plug device at rest within the tubular string and its central passage open to the flow of fluids.

As disclosed in the drawings, a cementing plug A may be pumped down a conduit, such as a tubing string B, extending within a well bore to the desired depth. The tubing string may be used as an agency for conveying cementitious material from the top of the well bore, and for discharging such material behind well casing C through its side ports D. A casing engaging packing in the form of a swab cup E can be secured to the lower end of the tubing string to prevent upward passage of the cementitious material through the casing-tubing annulus, and to insure its outward flow through the ports D.

The plug includes a tubular body or mandrel 10 telescoped over an inner tubular member 11 having a stop or bumper flange 12 secured at its lower end and a circular knife or blade 13 at its upper end. A packing sleeve 14 is secured to the body by being clamped between its upper shoulder 15 and a nut 16 threaded on its lower end. The upper end of the packing sleeve has an outwardly flaring lip 17 for slidable sealing engagement against the wall of the well conduit B through which it may be pumped.

The plug has a central passage 18 throughout its entire length provided within the tubular body 10 and member 11. This passage is closed initially by a plate or diaphragm closure 19 extending across the upper end of the body, to which it is clamped by a suitable open nut 20 threaded on the body. The diaphragm 19 may be made from any suitable material, such as lead, tin, steel or aluminum.

The tubular member 11 is secured to the body 10 by frangible means, such as one or more shear pins 21, which hold the two parts in such longitudinal relationship with respect to one another as to position the shearing knife 13 immediately below the diaphragm 19. Assuming that downward movement of the tubular member 11 is prevented, the subjecting of the fluid above the plug A to sufficient pressure causes such fluid to act on the packing 14, body 10 and diaphragm closure 19, exerting sufficient force thereon to shear the screws 21 and move the body and diaphragm downwardly with respect to the tubular member 11, pressing the diaphragm against the circular knife 13, which will pierce and shear it completely from the passage 18. The sheared diaphragm disc portion is forced hydraulically through the central passage in the tubular member completely out of the lower end of the plug.

The extent of telescopic movement of the body 10 over the tubular member 11 is limited by a suitable stop, which, as shown in the drawings, may consist of a set screw 22 in the body 10 slidable within a longitudinal slot 23 in the member 11. The extent of travel of the body, as determined by the length of the slot, need only be sufficient to insure complete cutting out or shearing of the plate 19 by the knife 13.

In the actual use of the plug A within a well bore, it is pumped down through a well conduit, such as the tubing string B, with the shear screws 21 in place and the diaphragm 19 intact and clamped securely to the body 10 across the plug passageway 18. The plug proceeds downwardly until its tubular member 11 engages a shoulder 24 in the lower end of the tubing string B, which stops further movement of the plug. The operator is advised of the fact that the plug has been arrested by a pressure rise, as indicated on a suitable gage (not shown) at the top of the well bore. Thereupon, the pressure of the fluid in the tubing string above the plug A is increased until it reaches the predetermined amount required to act across the entire area of the plug and shear its screws 21, forcing the body 10 with its attached packing sleeve 14 and closure diaphragm 19 downwardly over the tubular member 11. This movement presses the diaphragm 19 against the circular knife 13, which pierces and completely severs it from the body, allowing the fluid in the tubing string to blow it through the tubular member 11 and out of the passage 18. Any fluid in the tubing string B above the plug A may now be pumped through the plug or discharged through the lower end of the tubing string.

The diaphragm 19 can be made of any suitable material and in any thickness or number of layers, to withstand the pressure imposed on the plug. The dimensions and characteristics of the diaphragm are such as to preclude its shearing and disengagement from the body 10 by the direct application of hydraulic pressure alone to its upper surface. It is severed from the body by the cutting action of the knife 13, which can become effective only after the screws 21 have been sheared. The shear screws 21 are disruptable and the diaphragm 19 severed from the body 10 by lower unit hydraulic pressures imposed on the plug than would be required to shear the diaphragm by direct action upon it. The shearing force on the pins 21 and on the cutting edge of the circular knife 13 is provided by the fluid under pressure acting over substantially the entire area of the plug, allowing larger shear pins to be employed for the same unit hydraulic pressure, and a relatively rigid closure member to be secured across the passage 18. As a result, greater accuracy in removing the diaphragm at a predetermined pressure is assured, since the ability to use greater dimensional shear screws and diaphragms for the same unit hydraulic shearing pressure minimizes the effect of minute variations in their dimensions and the characteristics of their materials.

The circular shearing blade 13 completely severs and allows removal of the diaphragm 19 from the passage 18, leaving no portions extending into it as obstructions to the free passage of fluids. The relatively small area available for the central passage 18 makes it highly desirable that it be completely open after its closure member has been pierced, to prevent restrictions to the flow of fluids through the plug.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. A well plug including a tubular body having a passage therethrough, a packing surrounding said body and movable therewith, said packing being adapted for slidable sealing engagement with a well conduit, breakable means secured to said body across its passage to close the same, whereby the packing, the body and the breakable means are subjectable to the pressure of fluid in the well conduit thereabove, a member telescoped within said body below said breakable means and having means at its upper end for disrupting said breakable means, said member being adapted to be held stationary to provide for relative movement between said body and member.

2. A well plug including a tubular body having a passage therethrough, a packing surrounding said body and movable therewith, said packing being adapted for slidable sealing engagement with a well conduit, breakable means secured to said body across its passage to close the same, whereby the packing, the body and the breakable means are subjectable to the pressure of fluid in the well conduit thereabove, a member telescoped within said body below said breakable means and having a circular knife at its upper end for cutting said breakable means, said member being adapted to be held stationary to provide for relative movement between said body and member.

3. A well plug including a tubular body having a passage therethrough, a packing surrounding said body and movable therewith, said packing being adapted for slidable sealing engagement with a well conduit, a diaphragm secured to said body across its passage to close the same, whereby the packing, the body and the diaphragm are subjectable to the pressure of fluid in the well conduit thereabove, a member telescoped within said body below said disphragm and having means at its upper end for piercing said diaphragm, said member being adapted to be held stationary to provide for relative movement between said body and member.

4. A well plug including a tubular body having a passage therethrough, a packing surrounding said body and movable therewith, said packing being adapted for slidable sealing engagement

with a well conduit, a diaphragm secured to said body across its passage to close the same, whereby the packing, the body and the diaphragm are subjectable to the pressure of fluid in the well conduit thereabove, a tubular member telescoped within said body below said diaphragm and having a circular knife at its upper end for severing said diaphragm, said member being adapted to be held stationary to provide for relative movement between said body and member.

5. A well plug including a tubular body having a passage therethrough, a packing surrounding said body and movable therewith, said packing being adapted for slidable sealing engagement with a well conduit, breakable means secured to said body across its passage to close the same, whereby the packing, the body and the breakable means are subjectable to the pressure of fluid in the well conduit thereabove, a member telescoped within said body below said breakable means and having means at its upper end for disrupting said breakable means, said member being adapted to be held stationary to provide for relative movement between said body and member, and frangible means initially securing said member to said body.

6. In combination, a well conduit having a stop shoulder, a well plug including a tubular body having a passage therethrough, a packing on said body adapted for slidable sealing engagement with said conduit, a diaphragm secured to said body across its passage to close the same, a tubular member having a cutting edge at its upper end for cutting said diaphragm and telescoped within said body below said diaphragm, said tubular member being engageable with said stop shoulder, and stop means for limiting the extent of downward movement of said body along said tubular member.

7. In combination, a well conduit having a stop shoulder, a well plug including a tubular body having a passage therethrough, a packing surrounding said body and movable therewith, said packing being adapted for slidable sealing engagement with said well conduit, breakable means secured to said body across its passage to close the same, whereby the packing, the body and the breakable means are subjectable to the pressure of fluid in the well conduit thereabove, a member telescoped within said body below said breakable means and having means at its upper end for disrupting said breakable means, said member being held stationary by engagement with said stop shoulder to provide for relative movement between said body and member to effect disruption of said breakable means by said means at the upper end of said member.

8. In combination, a well conduit having a stop shoulder, a well plug including a tubular body having a passage therethrough, a packing on said body adapted for slidable sealing engagement with said conduit, a diaphragm secured to said body across its passage to close the same, a tubular member having a cutting edge at its upper end for cutting said diaphragm and telescoped within said body below said diaphragm, said tubular member being engageable with said stop shoulder, frangible means initially securing said member to said body to prevent downward movement of said body along said member and disruption of said diaphragm by said cutting edge, and stop means for limiting the extent of downward movement of said body along said tubular member.

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