

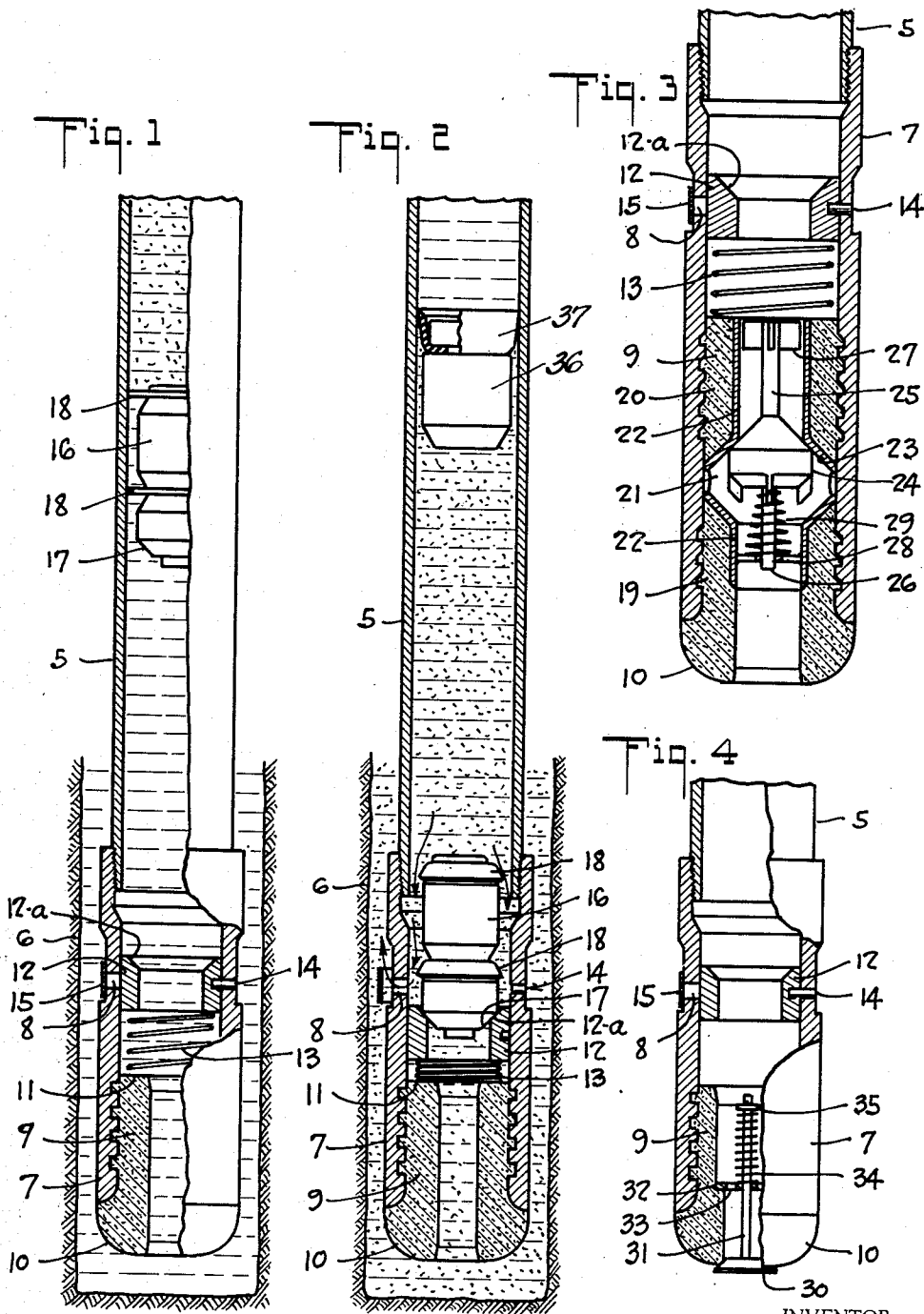
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APPARATUS FOR CEMENTING WELLS

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## APPARATUS FOR CEMENTING WELLS

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This invention relates generally to apparatus for cementing casing in wells and is particularly adapted for use in sealing the annular area of the well bore around the lower end of a water string, without requiring the passage of the sealing fluid through the lower end of the casing or through the obstructions of a float valve; and accordingly, comprises an improvement of the subject-matter of my co-pending applications, S. N. 27,041, filed June 17, 1935, now Patent No. 2,120,694, granted June 14, 1938, and S. N. 119,986, filed January 11, 1937, respectively, of which the present invention is a continuation-in-part.

It is a general object of this invention to provide a shoe for the lower end of the casing string to be cemented in a well bore, comprising a drillable body having its bottom turned inwardly to form a guide to centralize the casing in the well bore while it is being lowered; which shoe may be equipped with a valve to enable the sustentation of part of the weight of the casing by closure of its lower end to pressure in the well.

The provision of a valve in the lower bore of the casing also serves to prevent clogging of the casing by debris carried therein by well fluid into which the casing is lowered. Due to the tendency of clogging detritus to accumulate in the lower end of the casing adjacent the float valve it is usually desirable to cement through lateral ports located in or above the casing shoe.

An important object of this invention is to provide lateral ports in or adjacent the shoe which are normally closed to pressure therein by a valve supported on and operatively associated with the lapideous body of the shoe, which ports may be communicated with the casing thereabove, when desired, by a barrier plug actuated by fluid pressure introduced and controlled at the well surface.

Another object is to provide a unitary structure for the lower end of the casing having a lateral port comprising a hollow shoe for guiding and floating the casing to position, in combination with means for normally maintaining the ports closed to insure effective initial circulation of hydraulic fluid through the bottom of the shoe, and fluid-operated means adapted to simultaneously open the ports and by closing the bore through the shoe to deflect cementitious fluid moved downwardly through the casing by pump pressure, to deflect the cement outwardly through the ports, and thereby insure an even distribution of cement around the casing.

It is a further object to provide in combination with the apparatus hereinabove noted, packing means carried by the barrier plug and adapted to

slidably fit the casing to convey fluid pressure thereabove to the plug and expedite movement of the same through the casing, which packing means are collapsible to permit the plug to bypass fluid to the ports; and an indicator plug adapted to discontinue the flow of pressure fluid downwardly thereby at the conclusion of the ejection of the cement from the casing, by its abutment on said barrier plug.

Another object is to provide outwardly opening back pressure valves on lateral ports located in or adjacent a casing shoe adapted to open by pressure within the casing to permit the ejection of hydraulic and cementitious fluid therefrom but to close against back flow of cement through the ports at the conclusion of the cementing discharge.

Other objects and salient features of my invention will be obvious to those of skill in this art upon an examination of the following description read in the light of the accompanying drawing, in which:

Fig. 1 is a sectional view of the lower end of the casing string with the apparatus of my invention operatively associated therewith, illustrating a step in the use thereof;

Fig. 2 is a sectional view similar to Fig. 1 depicting the present apparatus as employed in a step of its operation subsequent to that shown in Fig. 1;

Figs. 3 and 4 are sectional views of modified forms of the casing shoe.

Referring to the drawing in detail, the numerals of which indicate similar parts throughout the several views, 5 designates a casing string located in a well bore 6 in position for cementing. A casing shoe 7, threaded to the lower end of casing 5, is provided with a plurality of lateral ports 8 through its upper wall. Ports 8 may be disposed diametrically at any angle with respect to the casing or on a chord of the casing periphery, as is most conducive to effective distribution of the cement to be ejected therefrom. The lower inner wall of shoe 7 is corrugated in any suitable manner to facilitate retention of a lapideous hollow body 9 cast therein with its lower end protruding from the lower end of the shoe. The portion of the body below the shoe is enlarged in diameter to equal the diameter of the shoe and is turned inwardly and downwardly to form a guiding end 10 for the casing. The difference in inside diameter of body 9 and shoe 7 forms an upwardly directed shoulder 11 on the upper edge of the body on which a sleeve valve 12, slidable with the casing wall, is resiliently sup-

ported, normally in a position closing ports 8, by a spring 13. The upper edge of sleeve valve 12 is inwardly bevelled to form an annular valve seat 12a for a travelling plug later referred to.

5 The sleeve valve is held in position over ports 8 by a series of shear pins 14 extending into the casing and driven into valve 12 at points around its periphery in horizontal alignment with the ports to prevent premature vertical displacement of the valve by either the urge of spring 13 or fluid pressure.

10 A series of spring valves 15, secured by any well known means as by rivets on the outside of shoe 7 over the ports 8, are individually operable 15 to normally maintain closure of the ports to pressure around the casing but may be opened by a balance of pressure in the casing. When it is desired to open the ports for discharge of either hydraulic or cementitious fluid and close the bore through the lower end of the shoe, a barrier plug 16 having a valve at its lower end comprising a bevelled surface 17 corresponding to the angle of valve seat 12a of the sleeve valve, is inserted into the casing and moved downwardly therethrough by fluid pressure. The diameter of plug 16 is less than that of the casing but greater than the diameter of the central opening through sleeve valve 12. Plug 16 carries one or more flexible packers 18 which are slidable with the casing wall to receive the downward impulse of fluid pumped into the casing on top of the plug, but which are adapted, upon an increase in fluid pressure thereon, incident to seating of plug 16 on valve seat 12a, to collapse, and by-pass fluid downwardly as will hereinafter be more in detail described.

In a modification of my invention as illustrated in Fig. 3, the lapideous body in the lower end of the shoe is divided into two annular sections 19 and 20 between which a valve chamber 21 is formed. The bore of both sections of the body and the chamber 21 are provided with a liner 22 which at the upper end of chamber 21 is inwardly bevelled to correspond with the shape of the lower edge of the upper body section 19 to form a valve seat 23. A float valve having its upper edge bevelled at an angle corresponding to valve seat 23 is disposed in valve chamber 21. Upper and lower valve guides 25 and 26 concentrically extend from opposite sides of float valve 24 into sections 19 and 20, respectively. Wings 27 on upper guide 25 slidably engage the portion of liner 22 in body section 20; and the lower valve guide 26 slidably extends through a hole in a spider 28 carried by the lower end of the liner, thus maintaining centralization of the valve in chamber 21. A helical spring 29, encircling guide 26 between spider 28 and the valve 24, resiliently urges the valve against seat 23, but permits its displacement downwardly by fluid pressure in the casing. It will be observed that the float valve completely closes the lower end of the casing to facilitate lowering of the casing into the well and by preventing the admittance of debris, insures freedom of circulation downwardly through the string to the lateral ports, yet being within the casing, is protected by the shoe and guide 10 from injury which might otherwise result from abutment of the casing on the well bottom or sides of the hole.

Referring to the modification of my invention illustrated in Fig. 4, a float valve 30 is provided to seat on the outer end of the shoe guide 10. A valve stem 31 rigidly connected to the valve 30 extends upwardly into the bore of the lapideous

body 9 and through a central opening of a spider 32 carried on a shoulder 33 formed by an enlargement of the upper bore of body 9. Helical spring 34 encircles stem 31 between the spider and an abutment 35 at the upper end of the stem to resiliently retain valve 30 in a position closing the shoe to pressure outside thereof.

Spring 13 for the resilient support of the sleeve valve may be omitted in any of the embodiments as is indicated in Fig. 4.

The operation of my invention is briefly described as follows: The casing is lowered in the well bore and, if provided with a float valve as depicted in Figs. 3 and 4, is floated to position. Any tendency of the casing to hang up in the hole will ordinarily be obviated by the guiding end 10 of the shoe which serves to centralize the lower end of the casing in the well and obviates any tendency of the shoe to shear the sides of the hole. Where necessary, however, hydraulic fluid may be circulated through the lower end of the casing string in a manner well known to those of skill in the art. After placement of the casing in the well, freedom of circulation is established by the introduction of hydraulic fluid therein which is pumped through the sleeve valve and shoe guide, displacing the float valve where employed, and thence passes upwardly around the casing to the well surface, removing debris which might otherwise block the opening of valves 15 on ports 8, or restrict the passage of cement subsequently pumped therethrough.

Barrier plug 16 is then inserted into the casing and a volume of cement is pumped on top of the plug. The quantity of cement, being determined by the specific purpose to be achieved, may be equal in volume to that required to fill the entire annular area of the well bore around the casing to the well surface, or any lesser amount, such, for example, as a volume sufficient to fill the bore from the bottom of the well upwardly to a second series of ports (not shown), located between the ends of the casing. On top of the cement an indicator plug 36 carrying an upwardly turned calathiform packer 37 adapted to slidably engage the casing and prevent the passage of fluid thereby, is placed and the two plugs 16 and 36 with the cement slug therebetween are pumped through the casing by hydraulic fluid. Upon reaching the casing shoe, the plug 16 seats on sleeve valve 12, closing the casing bore. Increased pressure of the fluid thereabove causes the compression of spring 13 and/or the shearing of pins 14, followed by the lowering of valve 12, which communicates the lateral ports with the casing bore. The release of pressure through the ports 8 results in the collapse of packing 18 and the passage of cement from above the plug through the ports. When all cement between the plugs has been ejected from the casing through the lateral ports, the indicator plug 36 will seat on plug 16, closing the bore of the casing above the ports, which will be immediately indicated to the operator by an increase in pressure in the casing.

With pressure in and around the casing at the ports substantially equalized by the closure of the casing above the ports, the back pressure valves 15 will close, preventing return flow of cement. It is usually desirable to augment valves 15 by maintaining sufficient pressure in the casing above plug 36 to preserve the cement in a state of quiescence until it has set sufficiently to hold its position, after which the plug, valves, and

shoe guide body are drilled out to the diameter of the casing for further development of the well.

Circulation of hydraulic fluid through the ports may be established before the introduction of cement into the casing by the insertion of plug 16 between two volumes of hydraulic fluid; the fluid immediately above the plug being expelled through the ports upon closure of the bore therebelow, as above described. In such modifications of the method of the apparatus disclosed, the cement may be pumped directly on top of the hydraulic fluid or another plug (not shown) having collapsible packing means similar to that of plug 16, and adapted to by-pass fluid downwardly, may be employed to separate the hydraulic fluid and the cement.

While I have described several preferred embodiments of my invention, it will be obvious that the valve chamber 21 in the shoe of Fig. 3 may be enlarged to insure a wide passage around the valve for the preliminary circulation of hydraulic fluid through the lower end of the casing; a single valve in the bore of the casing adapted to control both the lateral ports and the bore of the casing therebelow, may be substituted for the separate sleeve and float valves shown; and numerous changes may be made in design, size, relative proportion and number of the various parts without departing from the spirit of my invention as defined in the appended claims.

What I claim and desire to secure by Letters Patent is:

1. A device for cementing the lower end of a string of well casing comprising an outer ported member and an inner sleeve valve tending normally to maintain closure of said ports and forming a valve seat, a plug of lapideous material secured within the lower end of said member tapered inwardly and downwardly to form a guiding end, a passageway formed centrally and longitudinally through said plug, and a barrier plug having a valve at the base thereof actuated by pressure fluid to open said ports and by contact with said valve seat close the bore of said passageway to pressure thereabove.

2. A device for cementing the lower end of a string of well casing comprising an outer ported member and an inner sleeve valve tending normally to maintain closure of said ports and forming a valve seat, a plug of lapideous material secured within the lower end of said member

tapered inwardly and downwardly to form a guiding end, a passageway formed centrally and longitudinally through said plug, a float valve closing the bore of said passageway to pressure therebelow, and a barrier plug having a valve at the base thereof actuated by pressure fluid to open said ports and by contact with said valve seat close the bore of said passageway to pressure thereabove.

3. A floating and guiding shoe adapted to be connected to the lower end of a string of well casing comprising an outer tubular member; ports in said tubular member; an inner sleeve valve in said tubular member forming a valve seat; means for releasably holding said sleeve valve over said ports; a plug of lapideous material secured within the lower end of said tubular member; a portion of said plug projecting beyond the lower end of said tubular member, said projecting portion being tapered inwardly and downwardly to form a guiding end, a passageway formed through said plug, a float valve closing the bore of said passageway to pressure therebelow, and a plug having a valve at the base thereof actuated by pressure fluid for opening the ports and by contact with said valve seat closing the bore of said passageway to pressure thereabove.

4. Well casing having a series of ports, valvular means inside said casing tending normally to maintain closure of said ports, said means being longitudinally slidable in said casing to open said ports and forming a valve seat for a plug, and a plug having a valve at the base thereof to contact said valve seat adapted to be driven downwardly through said casing by pressure fluid but capable of downwardly by-passing said fluid within the casing to said valve seat when anchored thereon for opening the ports and closing the bore of the casing below the ports.

5. In a device for cementing the lower end of well casing in a well, a ported member tapered inwardly and downwardly to form a guiding end, a sleeve valve within said member to normally maintain the closure of said port, said valve forming an annular valve seat, valve means movable through the casing against said seat to successively open said port and close the bore through said member.

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