

June 24, 1969

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3,451,476

MULTIPLE STAGE CEMENTING

Filed Nov. 3, 1967

Sheet 1 of 2

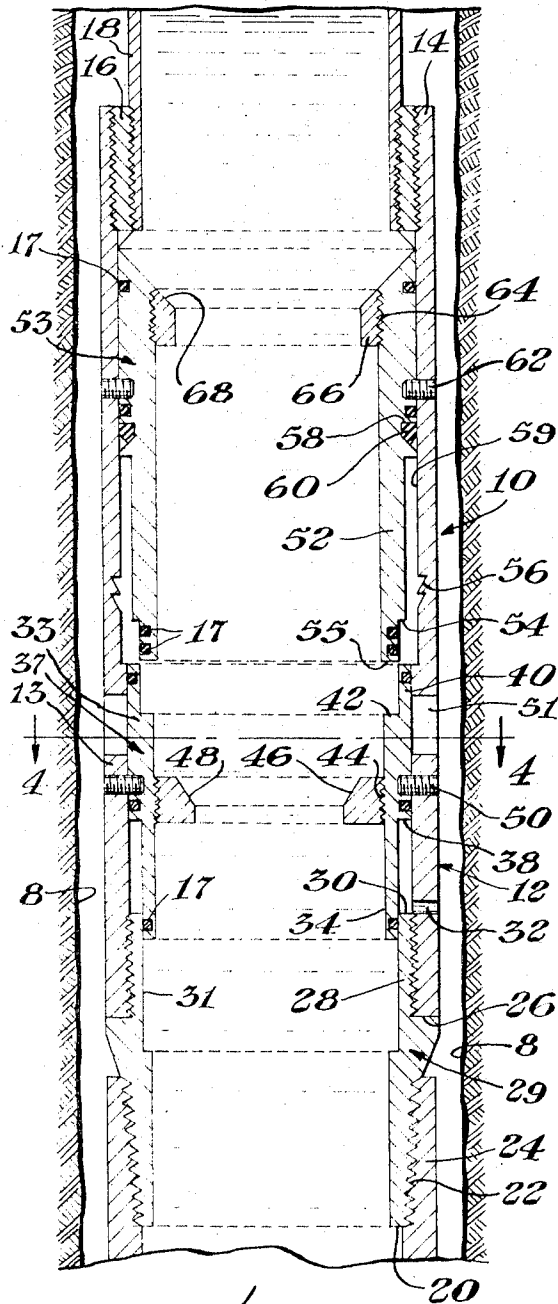


Fig. 1

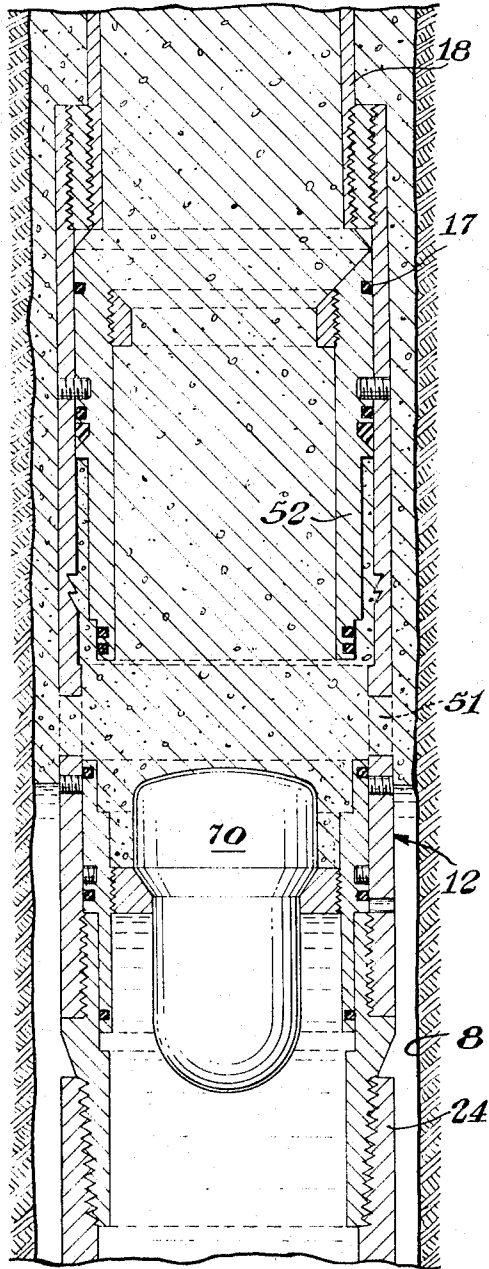


Fig. 2

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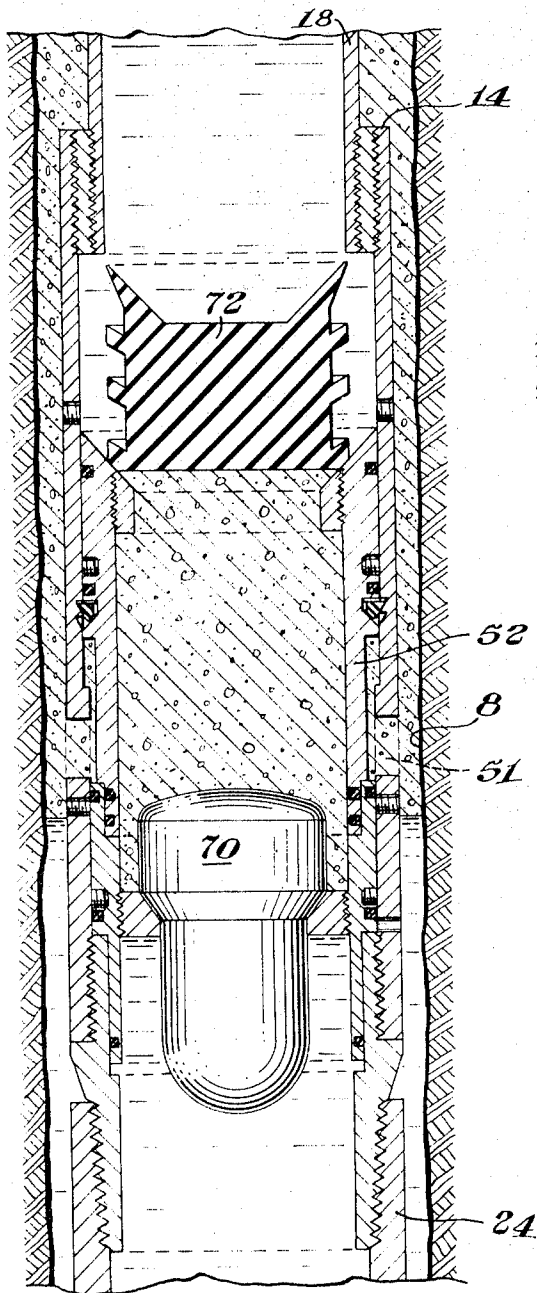


Fig. 3

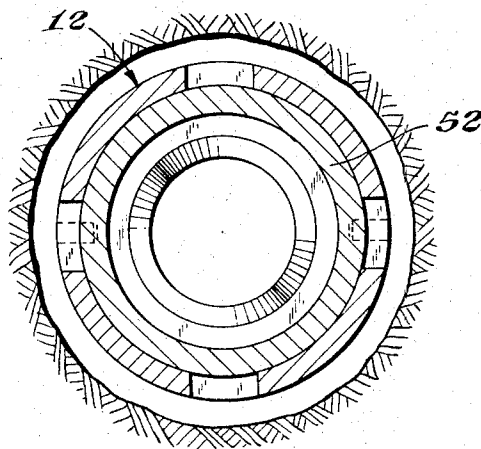


Fig. 4

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MULTIPLE STAGE CEMENTING

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4 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to multiple stage well cementing apparatus in which sleeve valves are operated by differential pressure across the apparatus. Means are provided for relieving pressure caused by moving the first sleeve valve downward to uncover side ports.

This invention relates to the cementing of oil wells and more particularly to an arrangement for cementing long strings of casing in stages so that the cement which fills the annular space around the casing may be supplied thereto without all of its passing around the bottom of the casing. The multiple stage cementing of wells is now well known to those skilled in the art. Methods and apparatus for accomplishing this are disclosed in the United States patent to C. A. Pitts, No. 2,435,016, granted June 5, 1944.

In the multiple stage cementing of wells, a valve structure, usually called the multiple stage unit, is made up with the casing. The arrangement is such that, at the proper time, the valve in the unit is opened so that cement can flow around the casing. This valve may be a sleeve, for example, and the sleeve may be moved downwardly to its open position by means of one of the cementing plugs used in the cementing operation.

It is very important in carrying on multiple stage cementing operations to provide some means for sealing the ports in the multiple stage unit after the cement is discharged therethrough. One type of valve, spring actuated, is disclosed in the patent to Owsley et al., No. 2,201,299, granted May 21, 1940. The use of springs for actuating poppet valves or other valves on the outside of the multiple stage unit is not entirely satisfactory. There is danger that the springs may be broken or the valves damaged as the casing is lowered into the well, and there is danger that some obstruction may lodge in the ports and prevent the valves seating properly. If the valves do not seat properly, after the well is completed water may seep along the cement and enter the casing through the ports of the multiple stage unit. Some operators prefer to pump the cement around the entire string of casing rather than use the multiple stage cementing process because of the dangers mentioned above.

It is an object of the present invention to provide an improved multiple stage cementing unit in which sleeve valves are provided both for opening and for closing the ports through which the cement is discharged and in which the sleeves are positively actuated by the cementing plugs used in carrying out the multiple stage cementing operation.

Another object of this invention is to provide an improved multiple stage cementing unit having sleeve valve means for relieving pressure as a first sleeve valve element moves downwardly to uncover the ports used in the second stage of cementing.

In accordance with this invention there is provided apparatus especially useful in multiple stage well cementing operations. The apparatus is adapted to be coupled to a string of casing intermediate of the ends of the casing. The apparatus comprises an outer body shell

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which is coupled to the casing and a pair of sleeve elements which are movable downwardly on the breaking of holding elements after a ball or plug seats across each sleeve element.

The downward movement of the first or lower sleeve forces liquid out through the ball and seat (or plug and seat) because a port adjacent to the sleeve in the wall of the device causes a pressure reduction on the lower end of the sleeve.

The upper or second sleeve may be broken away and moved downwardly to mate with the lower sleeve and close off the larger port or ports.

Both sleeves are actuated by fluid pressure after a suitable plug or ball device is dispatched down the casing to seat against a valve which is part of each sleeve element.

The invention, as well as additional objects and advantages thereof, will best be understood when the following detailed description is read in connection with the accompanying drawings, in which:

FIG. 1 is a sectional view showing apparatus in accordance with this invention;

FIG. 2 is a sectional view of the apparatus showing the lower sleeve valve in its lowered position;

FIG. 3 is a sectional view showing the apparatus with both the upper and lower sleeve valves in their lowered position; and

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3.

Referring to the drawing, there is shown, in a well bore 8, a string of casing comprising an upper section 18 and a lower section 24, joined by multiple stage cementing apparatus, indicated generally by the numeral 10.

The apparatus 10 comprises an elongated collar section, indicated generally by the numeral 12, which is internally threaded at its upper end 14 and coupled through bushing 16 to the upper section 18 of the casing. The lower end 20 of the collar 12 contains threads 22 by which it is coupled to the lower section 24 of the well casing.

The collar 12 is conveniently made in two pieces. The upper or main part 13 is coupled at its lower end 26 to a coupling section 29 (which joins the casing section 24 as described above). The coupling section has a thinned section 28 which threadedly engages the main part 13.

The internal wall part 31 of the coupling section is slightly counterbored and is adapted to have part of the lower sleeve valve 37 fit closely but slidably within it.

The lower sleeve valve 37 has an upper wall part 33 whose outer diameter fits closely but slidably within the part 13 of the collar 12 and a lower part 34 of lesser internal diameter (by the thickness of the thinned section 28 of the coupling section 29) which is adapted, as mentioned above, to telescope within the internal wall part 31 of the coupling section.

The upper end part 40 of the upper wall part 33 is counterbored on its inner diameter, the counterbore terminating at a shoulder 42.

A drillable valve seat element 46 is threadedly coupled as at 44 to the inner wall part of the sleeve valve 37. The element 46 contains a seat 48 on its upper side.

The sleeve valve 37 is retained in position by shear pins 50 extending between the collar and the sleeve valve.

The collar contains ports 51 through which cement slurry or other pumpable material will flow in the second stage of the well cementing operation.

When the sleeve valve 31 is retained in position by the pins 50, the ports 51 are covered and closed off by the upper wall part 33 of the valve 37.

A small port or bore 32 extends through the wall of the collar section 13 just above the upper end 30 of the coupling section 29.

An upper sleeve valve, indicated generally by the numeral 53 is disposed above the sleeve valve 37 within the part 13 of the collar 12.

The inner wall 59 of the part of the section 13 of the collar which lies above the valve 37 in its pin retained position is slightly counterbored and contains serrations 56 slightly above the upper end of valve 37 (in its pin retained position).

The upper part of the sleeve valve 53 has an outer diameter which fits closely but slidably in the counter bored inner wall part 59. The lower part 52 of the sleeve valve 53 is of slightly lesser outer diameter and is adapted to fit closely but slidably against the inner wall of the collar section when the upper valve is moved downwardly after its retaining pin(s) 62 are broken during cementing operations.

The lower end 55 of the sleeve valve 53 has a reduced outer diameter part adapted to the telescope into the upper end part 40 of the sleeve valve 37 when the two valves 37, 53 are in their final positions in the cementing operation.

A grooved circumferential channel 58 extends around the upper part of the sleeve valve 53 and contains a compressed ring-like locking element 60.

A drillable valve seat element 66 engages and is coupled to threads 64 on the inner diameter of the sleeve valve 53 at its upper end part. The element 66 has a seat 68 on its upper side which is adapted to mate with a ball or cementing plug (72 in FIG. 3).

In operation, as shown in FIG. 1, the casing and cementing apparatus 10 are filled with fluid or other pumpable material as is well known in the art. A ball or plug 70 (see FIG. 2) is then injected down the casing, seating against the seat 48 of valve seat element 46 of the lower sleeve valve 37.

Pressure exerted from the surface through the casing 18 forces the sleeve valve 37 downwardly and shears the pins 50.

The bore or small port 32, prevents undue expansion of the casing or excessive compression of the fluid below as the valve sleeve 37 moves downwardly after the ball or plug 70 seats; because of the lower pressure in the well annulus and the fact that the surface 38 is subject to the lower pressure in the annulus (via port 32), the sleeve 37 has more pressure exerted on its upper surfaces than on its lower surfaces. Thus, as the sleeve 37 moves downwardly, the ball or plug 70 unseats temporarily and permits liquid in the casing below the ball or plug 70 to pass through the valve 46. As the sleeve reaches its lowered position the port 51 is fully opened, the port 32 is covered by the wall of part 34, and the ball or plug 70 settles into place.

As shown in FIG. 2 in its lowered position the shoulder 38 of the valve 37 seats against top 30 of the coupling section and the outer diameter of the thinned section 34 fits closely but slidably against the walls of the part 28 of the coupling section 29.

The ports 51 are open and cement is then force down the casing 18, through the ports 51 and into the well bore annulus as is well known in the well cementing art.

When the appropriate amount of cement has been injected into the casing 18, a second ball or plug 72 is inserted and forced down the casing 18, seating against the seat 68 of seat element 66 in the upper sleeve valve 53.

The pressure exerted above the valve 53 breaks the shear pin(s) 62 and forces the sleeve valve 53 downwardly to the position shown in FIG. 3. As may be seen in FIGS. 3 and 4, the lower end 55 of the valve 53 bears against the shoulder 42 as the reduced outer diam-

eter part of the end 55 telescopes into the upper end part 40 of the sleeve valve 37.

In this position the locking element in the channel 58 in valve 53 is caught in the serrations 56 in the inner wall of the section 13 of the collar 12, holding the valve 53 in its downward position.

In its downward position, the walls of the sleeve valve 53 seal off the ports 51.

It should be noted that the sleeve valves 37, 53 are provided with O-ring type seal elements 17 at various points in order to assure fluid tight seals as the sleeves move within the collar 12 or telescope within each other.

The drillable valve seats may be made of any suitable material, such as aluminum or phenol-formaldehyde plastic, for example.

What is claimed is:

1. In multiple stage cementing apparatus wherein a pair of sleeve valves each having an internal valve seat are disposed one above the other in a collar assembly adapted to be coupled intermediate the ends of a string of casing, said sleeve valves being retained in predetermined position by shear type holding means until a first sleeve valve is lowered following the seating of a valve element in said valve seat to expose liquid flow ports in said collar assembly and seat with respect to said collar assembly, and later the second sleeve valve is lowered following the seating of a valve element in its valve seat to seal off said fluid exit ports in said collar, the improvement comprising a means for communicating pressure existing in the interior of the collar assembly to substantially all of one end surface area of said first sleeve valve and a means for communicating the pressure existing exterior of the collar assembly to substantially less than all of the other end surface area of said first sleeve valve whereby a difference in the interior and exterior pressure exerts a longitudinal force on said sleeve.

2. An apparatus in accordance with claim 1 wherein the end surface of said first sleeve valve is disposed in the interior of the collar assembly whereby such end surface is in communication with pressure existing in said interior and an enclosed flow channel between said collar assembly and a substantial part of the other end surface of said first sleeve and including a bore extending through the collar assembly disposed substantially where said first sleeve valve seats with respect to said collar assembly whereby such other end surface is in communication with the exterior of said collar assembly until said first sleeve valve is at least almost in its lower position.

3. Apparatus in accordance with claim 1, wherein the side walls of said enclosed flow channel are a thinned wall part of said first sleeve valve and a wall part of said collar, with the end parts of said enclosed flow channel being a shoulder surface of said first sleeve valve and a shoulder surface of said collar assembly.

4. Apparatus in accordance with claim 1, wherein said enclosed flow channel has an upward facing part having an area which is at least as large as the area of the end surface of said sleeve valve which lies below said enclosed flow channel.

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