Jan. 27, 1948. C. A. PITTS 2,435,016

MULTIPLE STAGE CEMENTING

Filed June 5, 1944 2 Sheets-Sheet 1

Fig. 1

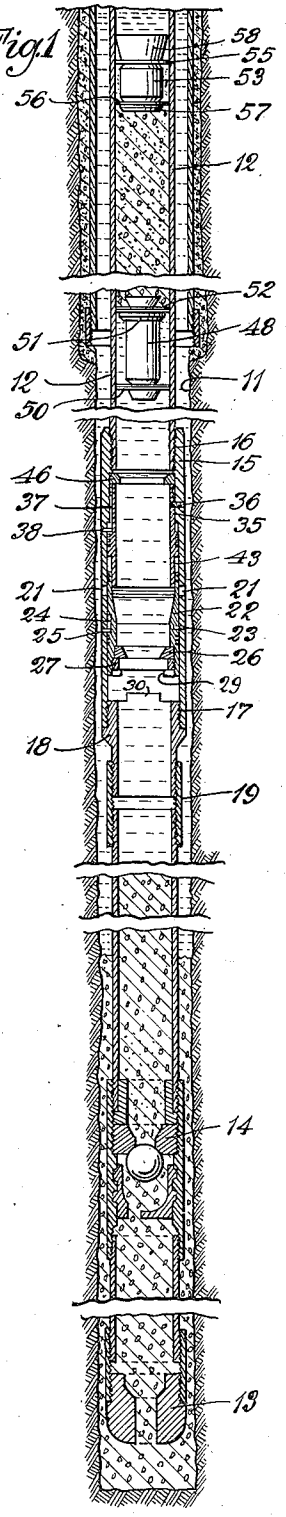


Fig. 2

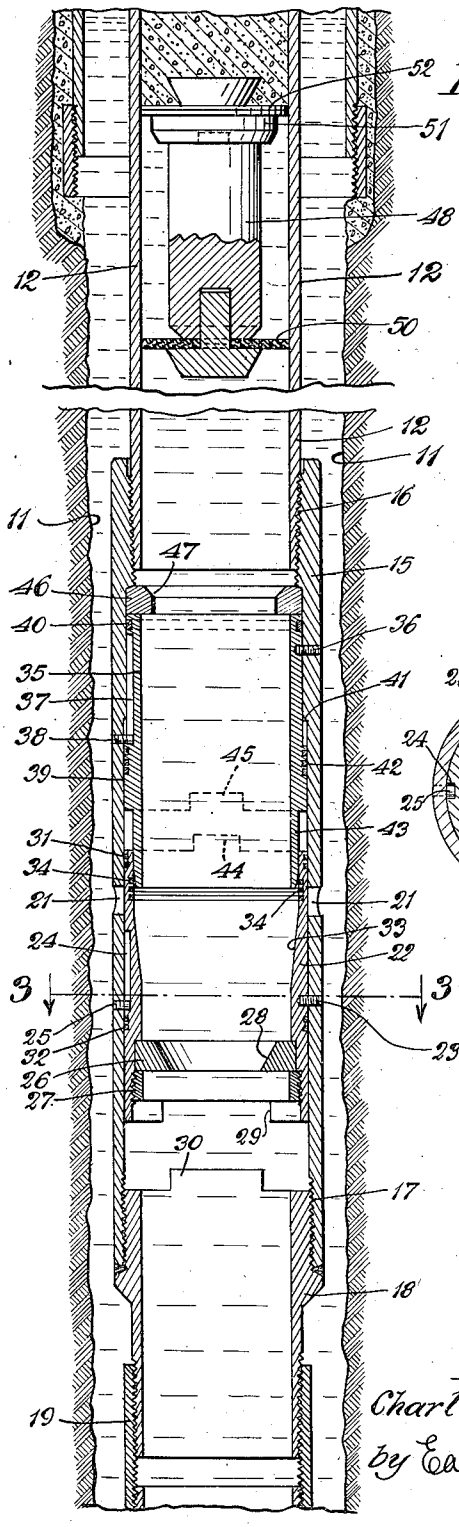
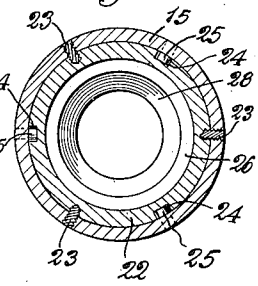


Fig. 3



Inventor
Charles A. Pitts
by Earl Babcock
Attorney

Jan. 27, 1948. C. A. PITTS 2,435,016

MULTIPLE STAGE CEMENTING

Filed June 5, 1944 2 Sheets-Sheet 2

Fig. 4

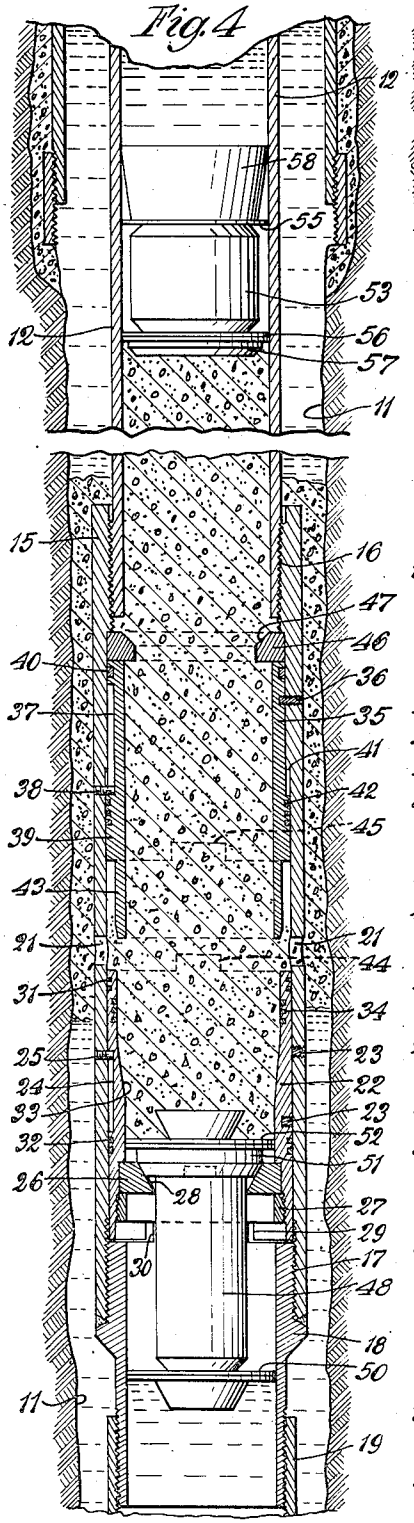
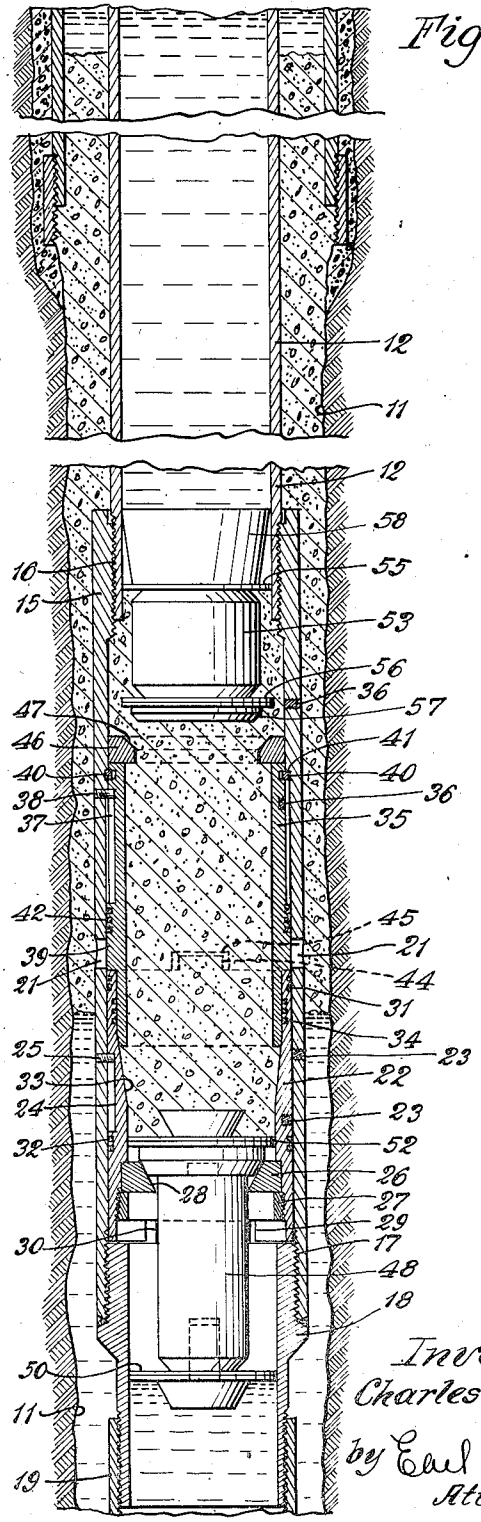


Fig. 5



Inventor
Charles A. Pitts
by Earl Babcock
Attorney

Patented Jan. 27, 1948

2,435,016

UNITED STATES PATENT OFFICE

2,435,016

MULTIPLE STAGE CEMENTING

Charles A. Pitts, Duncan, Okla., assignor to Halliburton Oil Well Cementing Company, Duncan, Okla.

Application June 5, 1944, Serial No. 538,848

3 Claims. (Cl. 166—1)

1

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 it 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 Halliburton, Reissue No. 19,570, granted May 14, 1935.

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 outwardly therethrough into the annular space around the casing. The valve may be a sleeve valve, as it is in the above mentioned reissue patent to Halliburton, and the sleeve may be moved to open position by 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. In the reissue patent to Halliburton cited above, poppet valves actuated by leaf springs are provided on the outside of the unit to accomplish this purpose. Another type of valve, also 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 a 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

2

carrying on the multiple stage cementing operation.

Other objects and advantages reside in certain novel features of the arrangement and construction of parts, as will be apparent from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a vertical cross-sectional view of an oil well with casing therein, the casing being provided with a multiple stage cementing unit constructed in accordance with the principles of the invention, the view also showing a body of cement being pumped into the casing with two cementing plugs capable of cooperating with the multiple stage cementing unit to actuate the same;

Figure 2 is an enlarged vertical cross-sectional view of the multiple stage cementing unit of Figure 1 and illustrating the position of the parts before either of the plugs enters the multiple stage unit;

Figure 3 is a transverse cross-sectional view of the multiple stage unit taken on the line 3—3 of Figure 2;

Figure 4 is a vertical cross-sectional view of the multiple stage unit of Figure 2, showing the position of the parts after the first or lower cementing plug has performed its function in the multiple stage unit but prior to the time that the second or upper cementing plug has reached the unit, this view illustrating the position of the parts as cement is being discharged through the ports of the multiple stage unit; and

Figure 5 is a vertical cross-sectional view of the multiple stage unit of Figures 2 and 4 and illustrating the position of the parts after both cementing plugs have performed their function in the multiple stage unit and showing the position of the parts as they exist after the cement has been discharged from the multiple stage unit.

Referring to the drawings in detail, and first to the arrangement of Figure 1, it will be seen that a bore hole is there illustrated at 11. Within the hole there is a casing 12 in which is incorporated a multiple stage unit constructed in accordance with the principles of the present invention, together with a guide shoe 13, and a float valve 14.

The multiple stage unit is shown in detail in Figures 2 to 5. It includes an elongated collar 15, internally threaded at its upper end, as illustrated at 16, to make connection with the casing, and internally threaded at its lower end, as illustrated at 17, to make connection with a short coupling 18, which is screw threaded into one of the regular collars 19 of the casing. It will be

seen that in the arrangement illustrated the internal diameter of the coupling 18 is the same as the internal diameter of the casing, and that the outer diameter of the elongated collar 15 of the multiple stage unit is somewhat greater than the outer diameter of the regular casing collars 19.

The elongated collar 15 is provided with cement discharge ports 21. Sleeves are provided on the interior of the collar 15 for controlling the passage of the fluid through these ports. The lower of these sleeves is designated 22, and when the device is made up with the casing and lowered into the well this sleeve covers the ports and prevents the passage of fluid therethrough. The sleeve 22 may be held in the position shown in Figure 2 by three shear pins 23 in the collar 15 as illustrated in Figure 3. It may also be provided with three vertically extended guide slots 24 to cooperate with the guide pins 25 in the collar 15. At its lower end the sleeve 22 is provided with a ring 26 made of drillable material such as "Bakelite," this being positively secured to the sleeve 22 by an annular nut 27. The inner surface of the ring 26 is tapered to provide a seat as illustrated at 28. The bottom edge of the sleeve 22 is provided with a slot 29 while the top edge of the coupling 18 is provided with a lug 30 so that when the sleeve 29 is moved downwardly to the position shown in Figures 4 and 5, the sleeve 22 cannot then be rotated with respect to the casing even though the guide pins 25 should shear. It will be seen that the outer surface of the sleeve 20 is cylindrical and that it fits snugly within the collar 15. Two packing glands are provided on the outside of the sleeve 22, those near the top being designated 31 and the lower ones being designated 32. Thus, when the sleeve 22 is in the position shown in Figure 2, an effective seal is maintained to prevent the passage of fluid through the ports 21, and when the sleeve 22 is in the position shown in Figure 5, there can be no flow of fluid between the sleeve 22 and the collar 15 at a point beneath the ports 21.

The interior of the sleeve 22 may be provided with a tapered surface as illustrated at 33. Above the taper additional packing is provided as illustrated at 34, for the purpose of effecting a seal with the skirt of the upper sleeve 35 of the multiple stage unit.

The upper sleeve 35 is held in the position shown in Figure 2, while the multiple stage unit is made up with the casing and lowered into the well, by means of one or more shear pins 36. This sleeve may be provided with a guide slot 37 cooperating with a guide pin 38 fixed to the collar 15. The main portion 39 of the upper sleeve 35 is of the same outside diameter as that of the lower sleeve 22. At its upper portion, however, the sleeve 35 is of reduced outside diameter and is provided at its upper end with a split latch ring 40. It will be seen that the collar 15 has two diameters. As shown in Figure 2, the upper portion of the collar 15 has an internal diameter the same size as the outside diameter of the upper portion of the sleeve 35, but from a point just above the pin 38 on down, the inside diameter of the collar 15 is slightly larger. This provides a shoulder 41 inside the collar 15. When the sleeve 35 is moved downwardly to the position shown in Figure 5 the latch ring 40 expands beneath the shoulder 41 and prevents upward movement of both sleeves 22 and 35.

The portion 39 of the upper sleeve 35 is provided with packing 42, which effects a seal with the interior of the collar 15. This seal is of no importance when the sleeve is in the position shown in Figure 2, but when the sleeve 35 is moved to the position shown in Figure 5 the packing 42 then functions to prevent flow of fluid through the ports 21, and upwardly between the sleeve 35 and the interior of the collar 15.

The lower portion of the sleeve 35 is provided with a skirt 43 of reduced outside diameter. The lower edge of the skirt may be slightly tapered as illustrated, the angle of the taper being about the same as that on the surface 33 of the lower sleeve 22. It is desirable that the upper edge of the lower ring 22 be provided with a lug shown in dotted lines at 44, and that the lower edge of the portion 39 of the sleeve 35, outside of and above the skirt 43, be provided with a recess as shown in dotted lines at 45 to cooperate with the lug 44 to prevent rotation of the sleeves 22 and 35 relative to each other after they have been telescoped together as illustrated in Figure 5. If such an arrangement is provided when the parts are in the position shown in Figure 5, neither sleeve 22 nor sleeve 35 can be rotated with respect to the casing. The purpose in providing means for preventing rotation of the sleeves 22 and 35, is to prevent damage thereto, or to the packing around and between them, when cement is being drilled out of the interior of the multiple stage unit. It will be observed that the internal diameter of the sleeve 35 is the same as the internal diameter of the casing 12. Likewise the internal diameter of the sleeve 22 at the thickest portion thereof is the same as the internal diameter of the casing. Hence these sleeves are not drilled out after the cementing operations are completed.

To provide means for shearing the pins 36 and for forcing the upper sleeve downwardly at the desired time, a ring 46, made of drillable material such as "Bakelite" is provided in the multiple stage unit. In the arrangement shown, this ring rests loosely upon the upper edge of the sleeve 35. Ring 46 is provided with a seat 47 adapted to receive and form a tight seal with the lower portion of the second or upper cementing plug.

The cementing plugs used in connection with the multiple stage unit of the present invention need not differ materially from those heretofore used in carrying out multiple stage cementing operations, except that care must be exercised in the selection of the proper dimensions to cause the first or lower cementing plug to pass through the ring 46 to seat and maintain a seal on the lower ring 26, while the second or upper cementing plug must seat and maintain a seal on the upper ring 46.

The first or lower cementing plug is illustrated in the drawing at 48. As shown, it is constructed of a cylinder of wood to which is attached at the lower end one or more flexible disks of belting or the like, as shown at 50, while at the top a tapered valve portion 51 is provided to maintain a seal with the seat 28 of the ring 26. Above the valve portion 51 additional belting 52 may be secured.

The second or upper cementing plug is shown in the drawing at 53. It also may be constructed of a cylindrical body of wood with disks of belting at the top and bottom as shown at 55 and 56. In this case the tapered valve portion 57 which maintains a seal with the cooperating ring

46, is mounted beneath the plug. Above the upper flexible disk 55 of the plug 53, a flexible cup 58 may be provided.

The operation of the multiple stage unit illustrated is as follows:

With the parts in the position shown in Figure 2, the multiple stage unit is made up with the casing 12 and lowered into the well. In accordance with the usual practice mud is then circulated downwardly through the casing 12 and upwardly through the annular space. The first stage of cement slurry is then mixed and pumped into the well, this body of slurry flowing downwardly through the shoe 13 of the casing and up around the lower portion thereof. This first stage of slurry is followed by a measured quantity of mud or water. The second stage of slurry is then pumped into the well behind the first or lower plug 48. This second stage is followed by the second or upper plug 53. As the plugs 48 and 53 with the body of cement slurry therebetween pass downwardly into the well the first or lower plug enters the multiple stage unit and seats upon the ring 26. The pump pressure then shears the pins 23 and the lower ring 22 passes downwardly until it rests upon the top of the coupling 18. The parts are then in the position shown in Figure 4. With the parts in this position, the second stage of cement flows outwardly through the ports 21 of the multiple stage unit.

After most of the cement slurry has discharged through the ports 21 the second or upper cementing plug 53 comes to rest upon the ring 46. This causes the pins 36 to shear and the upper sleeve 35 to move downwardly. The parts then take the position shown in Figure 5. It will be seen that in Figure 5 the skirt 43 of sleeve 35 has telescoped into the lower sleeve 22 and that the latch ring 40 has expanded beneath the shoulder 41. The ports 21 are permanently sealed because the latch ring 40 prevents upward movement of either sleeve 22 or 35, and the various packing preventing leakage. After the cement has hardened the plugs 48 and 53 together with the rings 26 and 46 and the small body of cement within the multiple stage unit remaining between the plugs 48 and 53, is drilled out, leaving the interior of the multiple stage unit clear and unobstructed.

In constructing a multiple stage unit in accordance with the principles of the present invention, care must be exercised to provide for the escape of fluid from certain portions of the apparatus to permit the desired telescopic action of the sleeves 22 and 35.

Attention is called to the fact that after the pins 23 have sheared the lower sleeve 22 which is then in the position shown in Figure 4, takes such a position that the upper edge of the sleeve is flush with or just beneath the ports 21. Thus no fluid is trapped in the small annular space outside the skirt 43 and within the collar 15 as the sleeve 35 moves down to its final position shown in Figure 5.

When the upper cementing plug 53 comes into engagement with the ring 46, the fluid pressure shears the pins 36 and forces the upper sleeve 35 downwardly a short distance, i. e. the distance necessary to cause the skirt 43 of this sleeve just to enter the upper portion of the lower sleeve 22, and effect a seal with the packing 34 on the interior of the sleeve 22. This completes the function of the plug 53, but at this instant the telescoping action of the sleeves 22 and 35 is not completed. As soon as the initial seal

is effected the cement slurry can no longer flow around the skirt 43 from the space within the sleeves, and since the slurry is substantially incompressible the plug 53 can not move downwardly any further. (Note that in Figure 5, the plug 53 is not resting on the ring 46.) The sleeves 22 and 35 are so constructed and arranged with respect to the ports 21 that such relative fluid pressures are developed as to cause the sleeve 35 to move on downwardly to the final position shown in Figure 5, once the pressure on the plug 53 has caused the skirt 46 to effect a seal with the sleeve 22 as described above. It will be seen that when the plugs are in the position shown in Figure 4, except for variations due to flow, the fluid pressure above the plug 53 is the same as that below the plug 53, and the same as that outside of the multiple stage unit. When the skirt 43 effects its initial seal with the lower sleeve 22, a difference in fluid pressures is then set up between the interior and exterior of the multiple stage unit. From that point on, fluid can not flow through the ports 21 and the exterior of the casing is not subjected to pump pressure. The fluid pressure beneath the plug 53 then becomes equal to that above it and the plug 53 stops moving. However, due to the particular construction of the sleeves 22 and 35, the difference in fluid pressure between the inside and outside of the collar 15 causes the sleeve 35 to move on down to its final position. A downward force equal to the difference in the fluid pressure inside and outside the collar 15, times the area of the annular space equal to the area of the upper edge of the sleeve 22 is exerted upon the sleeve 35 at this time. This force added to the momentum imparted to the sleeve 35 upon the shearing of the pins 36 drives the sleeve 35 into tight wedging engagement with the tapered portion 33 of sleeve 22.

From this description it will be clear to those skilled in the art that the sleeves 22 and 35 provide what may be referred to as a differential valve. That is, these sleeves function to cover or uncover the discharge ports in the collar in response to fluid pressure conditions existing in the collar or to the differential pressure existing at times between the interior and exterior of the collar.

The differential pressure between the interior and exterior of the collar at the time when the skirt of the upper sleeve is just beginning its telescopic movement into the lower sleeve is instrumental in causing the upper sleeve 35 to move on down farther and effect a permanent seal between a point above the ports and the lower sleeve 22. Since the lower sleeve is then below the ports, the ports are permanently covered.

It will be apparent to those skilled in the art that the principles of the present invention may be carried out in a variety of ways. Devices other than the sleeves may be used to cover and uncover the ports. Various means other than the shear pins may be used for holding the sleeves temporarily against sliding movement so that they may be successively released to perform the intended action of controlling the flow of fluid through the ports. In lieu of the cementing plugs shown and described herein for actuating the sleeves, other objects such as balls may be caused to pass down through the casing. Furthermore, it will be apparent that the invention is not confined to the use with cement but may be employed in any case where it is desired to limit the amount of fluid which is to

flow through the ports by passing two objects successively down the casing. Packing rings of various kinds may be used instead of those particularly illustrated in the drawing. In the appended claims where the words "normally" or "normal position" are employed in connection with the position of the sleeves or other devices which cover and uncover the ports, it will be understood that this has reference to the position of the parts as the multiple stage unit is being lowered into the well.

Thus, while only one embodiment of the invention has been shown and described herein, it is obvious that various changes may be made without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. Apparatus for use in the multiple stage cementing of casing in wells comprising an elongated collar adapted to be made up with the casing and having one or more ports therein for the discharge of cement slurry therethrough, a differential valve arrangement mounted in said collar and consisting of two sleeves mounted one above the other for sliding movement within said collar for controlling the flow of fluid through said ports, means for holding, temporarily, each of said sleeves against sliding movement in said collar with one of said sleeves covering said ports, and means operable by the passage of objects successively down through the casing for releasing successively the means holding said sleeves against sliding movement and for causing said sleeves to uncover said ports and subsequently again cover said ports, the upper of said sleeves having a portion of the same outer diameter as the lower of said sleeves, and another portion adapted to telescope snugly within the lower of said sleeves thereby providing areas on said sleeves subjected to different total fluid pressures tending to cause said sleeves to telescope.

2. Apparatus for use in the multiple stage cementing of casing in wells comprising an elongated collar adapted to be made up with the casing and having one or more ports therein for the discharge of cement slurry therethrough, a differential valve arrangement mounted in said collar and consisting of two sleeves mounted one above the other for sliding movement within said collar for controlling the flow of fluid through said ports, the upper of said sleeves having a portion of the same outer diameter as the lower of said sleeves and a depending skirt adapted to telescope snugly within the lower

of said sleeves, means for holding, temporarily, each of said sleeves against sliding movement in said collar with the lower of said sleeves covering said ports, and means operable by the passage of objects successively down through the casing for releasing successively the means holding said sleeves against sliding movement and for causing a sequence of operation in which the lower sleeve moves down to uncover said ports to permit the flow of fluid therethrough and then the upper sleeve moves down to cause the skirt thereof to telescope within and maintain a seal with said lower sleeve thus covering said ports and preventing the flow of fluid therethrough.

3. Apparatus for use in the multiple stage cementing of casing in wells comprising an elongated collar adapted to be made up with the casing and having one or more ports therein for the discharge of cement slurry therethrough, a differential valve arrangement for controlling the flow of fluid through said ports first to prevent such flow, then permit a limited amount of fluid to flow and then to prevent such flow permanently in response to the passage of objects successively down through the casing, said differential valve arrangement including a lower sleeve and an upper sleeve slidably mounted within said collar, said lower sleeve normally covering said ports, said lower sleeve having two packing rings on the outside thereof, one above and one below said ports when said lower sleeve is in its normal position, said lower sleeve also having a packing ring on the inside thereof near its upper edge, said upper sleeve having a portion of the same outside diameter as said lower sleeve, said portion having a packing ring on the outside thereof and said upper sleeve having a skirt depending from said portion and adapted to telescope snugly within said lower sleeve to effect a seal in the packing inside said lower sleeve.

CHARLES A. PITTS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,941,406	Manning	Dec. 26, 1933
1,941,443	Manning	Jan. 23, 1934
2,155,609	McClendon et al.	Apr. 25, 1939
2,315,931	Burt et al.	Apr. 6, 1943
2,379,079	Hayward	June 26, 1945