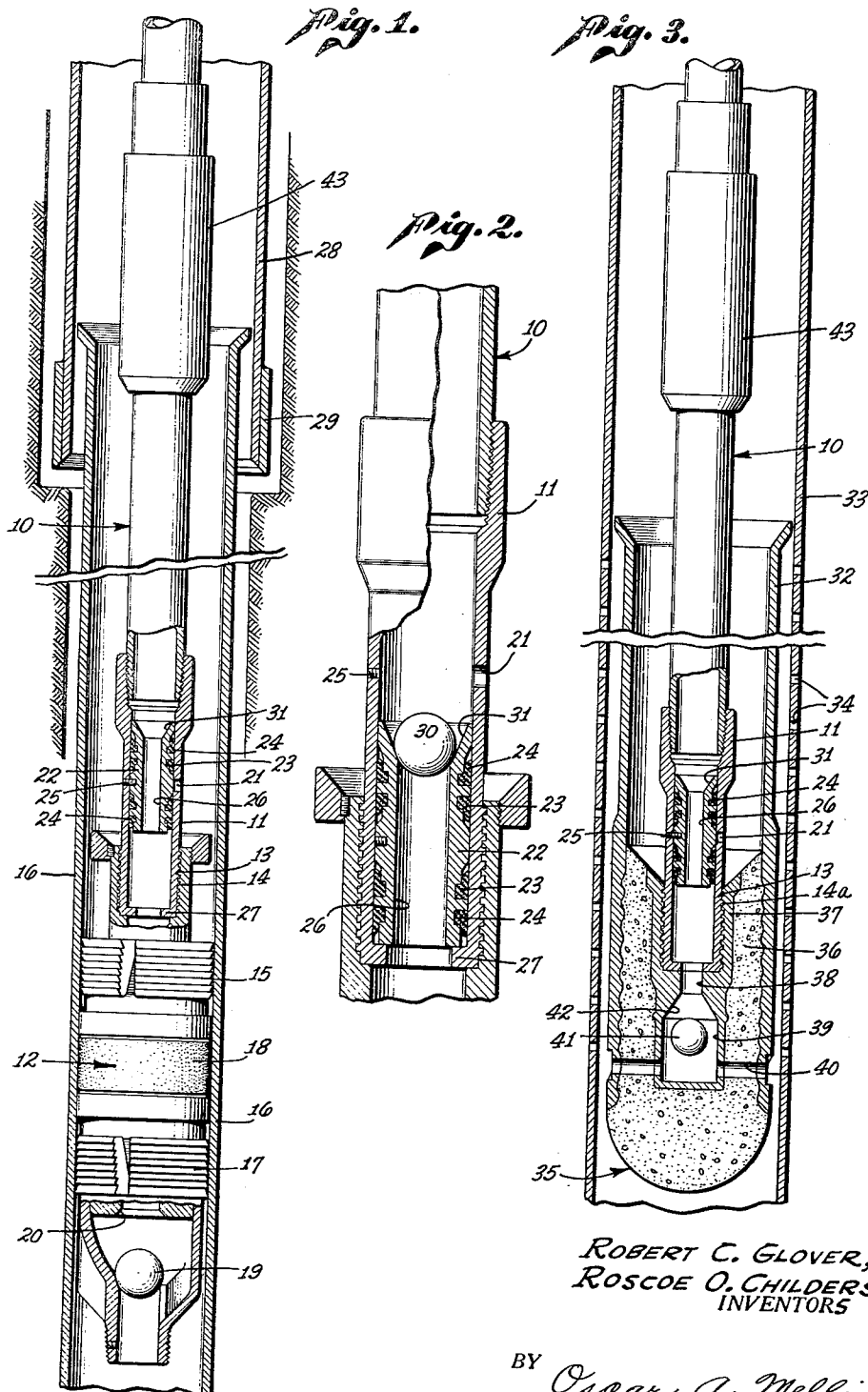


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 APPARATUS FOR SUPPORTING AND CEMENTING
 LINERS OR CASINGS IN WELL BORES
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APPARATUS FOR SUPPORTING AND CEMENTING LINERS OR CASINGS IN WELL BORES

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The present invention relates to the cementing of liners or similar conduits in well bores. An object of the invention is to provide an apparatus capable of supporting the weight of a liner from the surface of a well bore during the deposition of cement slurry around it, while excess slurry is being circulated from the liner, and until the cement has set sufficiently to assume the burden of holding the liner in place, after which the apparatus may be removed from the well bore.

A further object of the invention is to provide an apparatus which enables a liner to be supported off the bottom of a well bore and cemented in place without resort to other additional expedients, such as liner hangers.

Still another object of the invention is to provide an apparatus which can be run in a well bore and coupled to a liner or casing section therein for the purpose of supporting it in position while it is being cemented in place.

This invention has other objects which will become apparent from a consideration of the embodiments shown in the drawing accompanying and forming part of the present specification. These embodiments 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 drawing:

Figure 1 is a longitudinal section through a well bore showing one form of the apparatus supporting a liner or casing section in the well bore;

Figure 2 is a longitudinal section of part of the apparatus disclosed in Figure 1, with certain elements disclosed in another operative position; and

Figure 3 is a view similar to Figure 1 of another embodiment of the invention.

In its general aspects, the invention contemplates supporting a liner or casing section in a well bore by means of apparatus through which cement slurry can be pumped for passage into the annular space between the casing or liner section and the wall of the well bore or wall of any other surrounding enclosure. The particular apparatus employed is always carrying the weight of the liner or casing section while the cement is being deposited behind it, and until such time as the cement has set and hardened sufficiently to be able to assume the burden of supporting the liner or casing section. Despite the requirement that the apparatus continue the sustaining the liner or casing section at the desired

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position in the well bore, excess cement slurry may be readily flushed from the interior of the liner while this supporting action is still occurring, thereby obviating the cementing of the entire apparatus in the well bore, which would ordinarily prevent its removal therefrom without difficulty.

As illustrated in Figures 1 and 2, the apparatus consists of a tubular string or conduit 10 having a sub 11 at its lower end by means of which the tubing string or conduit is suitably secured to a cement retainer 12 through the mating left hand threads 13, 14 provided, respectively, on the sub and retainer. The cement retainer 12 may assume many forms, in the present instance being of the type specifically described in United States Patents Nos. 2,121,051 and 2,204,648. According to the disclosure of those patents, an upper set of slips 15 is provided for anchoring the cement retainer to a casing, liner or conduit 16 against movement therein in an upward direction. A lower set of segmental slips 17 is provided for anchoring the retainer against movement in a downward direction. An intervening packing 18 is mounted on the retainer body to effect a seal between it and the wall of the liner or casing in order to prevent passage of fluids in either direction therebetween.

Fluids may be pumped from the tubular string 10 and completely through the cement retainer 12 for passage into the casing or liner therebelow, from which point it may flow around the lower end of the liner or casing, or through suitable lateral openings (not shown) therein, for upward passage through the annular space between the casing or liner and the wall of the confining well bore. Reverse or return flow of this fluid back into the retainer and tubing string is prevented by a back-pressure ball 19 capable of upward movement to contact its cooperable seat 20. Complete details of the particular cement retainer shown in Figure 1 may be found in the patents referred to, but it is to be realized that the retainer or well packer employed may assume various other specific forms.

The lower end of the tubular string or conduit 10 is provided with control means for permitting passage of fluids between its interior and exterior. Lateral ports or openings 21 in the sub 11 are normally closed by positioning a valve sleeve 22 in the interior of the sub across its ports. Suitable seals between the sleeve and the inner wall of the sub prevent leakage of fluid therebetween and its passage through the ports. In the present instance, such seals consist of op-

posed inner cup-like members 23, 23 disposed on opposite sides of the ports 21 and facing toward each other to prevent passage of fluid from the exterior of the tubing string to its interior, and opposed outer cup-like packing members, 24, 24 facing away from each other to prevent passage of fluids from the interior of the tubing string to its exterior. The valve sleeve 22 is initially held in position across the ports by one or more shear screws 25 or any other frangible device, which may be disrupted hydraulically upon closing of the central passage 26 through the sleeve to permit pressure to be built up within the string 10 to shear the screws 25 and slide the sleeve 22 downwardly within the sub 11 until it contacts the shoulder 27 at the bottom end of the sub. When in this position, the sleeve is clear of the ports 21 and circulation in either direction between the interior and exterior of the tubing string can occur.

As disclosed in Figure 1, it is desired to lower a liner 16 through a water string 28 and cement the same in position in the well bore formed below its casing shoe 29. The cement retainer 12 is suitably tripped and anchored in the liner or conduit 16 at the surface of the well bore and lowered through the casing 28 on the end of the tubing string 10 until the liner has been positioned at the specified location in the well bore where it is to be anchored in place. When this position is reached, cement slurry is pumped down through the tubing string 10 for passage through the cement retainer 12 and around the lower end of the liner for upward passage through the annular space between the liner and the well bore to preferably completely fill the same with cement. As a precautionary measure, usually an excess of cement slurry is pumped through the cement retainer, the additional quantity flowing over the top of the liner and settling downwardly therein toward the cement retainer.

It is highly desirable that this excess slurry be flushed from the bore while it is still in a fluid or plastic state; and it is also a requirement that the tubing string continue to support the liner in place until the cement slurry deposited around it has set and hardened. The tubing string can continue to effect such support and all excess slurry pumped from the liner by providing the above-described circulation device or control means at the end of the tubing string.

When excess slurry is to be flushed from the interior of the liner 16, a ball 30 is lowered or pumped down the tubing string to seat upon the upper end 31 of the sleeve 22 in order to close its central longitudinal passage 26 and enable pressure to be built up in the fluid above the sleeve for exerting a downward force sufficient to shear the screws 25 and shift the sleeve downwardly in the sub until it clears the ports 21.

After the ports are open, circulating fluid pumped down the tubing string 10 issues through the sub ports 21 for upward passage through the annular spaces between the tubing string 10 and the liner 16 and water string 28 to the surface of the bore. It is apparent that this circulating fluid carries all excess cement in the liner to the surface of the bore. If desired, circulation may be continued in this manner for a period of several hours, or until the cement around the liner has set and hardened sufficiently to sustain the load of the liner; whereupon the strain may be taken from the tubing string 10 to permit its ready rotation to the

right for effecting disconnection between the left hand threads 13 of the sub and the corresponding threads 14 at the upper end of the cement retainer. Following such disconnection, the entire tubular string 10 with its sub 11, sleeve valve 22 and ball 30 attached thereto may be removed to the surface of the bore. If desired, the cement retainer 12, which is usually made of drillable material, can be drilled up by the use of a suitable drilling tool or bit after the cement has completely hardened around the liner 16.

The apparatus described also finds use in connection with liner or casing sections which have parted or been separated, and which are to be pulled up into a desired location within the well bore or rejoined in abutting relation with an upper adjoining section, the parted liner section then being cemented in the well bore for the purpose of holding it in such abutting position.

The cement retainer 12 is run in the well bore on the tubing string 10 shown in Figure 1, until it is positioned inside the parted or separated liner section, preferably near its lower end. The retainer is then set in packed off condition in the liner, in a well known manner, in order to couple the liner to the tubing string. The tubing string may then be elevated to raise the liner section in the well bore to the location in which it is to be cemented in place. The required amount of cement slurry is then pumped down through the retainer, passing upwardly and around the whole length of the liner, and overflowing thereinto over its upper end. The tripping ball 30 is lowered in the tubing string for seating on the sleeve 22, and the latter forced downwardly in the sub 11 to open the ports 21 and allow excess cement slurry to be flushed from the liner, in the same manner as was described above. After the cement has set and hardened, the tubing string 10 may be removed from the bore, following unscrewing of the sub 11 from the cement retainer 12.

Another embodiment of the invention is disclosed in Figure 3, in which it is desired to cement a scab liner 32 in a casing 33 for the purpose of closing lateral ports or perforations 34 in the latter member. The lower end of the liner 32 includes a guide shoe 35 having a cement plug 36 anchored to the shoe and holding a threaded sleeve 37 therein, which has a central passage 38 leading into a valve chamber 39 from which lateral ports 40 extend to the exterior of the shoe and liner. Return flow of fluids from the exterior of the liner back into the shoe is prevented by a float ball valve 41 member adapted to seat upwardly against a valve seat 42 for the purpose of closing the central passage 38 through the shoe.

The same tubing string 10 and sub arrangement as was described in connection with Figures 1 and 2 may be employed, the left hand threads 13 of the sub being screwed into the corresponding left hand threads 14a in the inner sleeve, thereby effecting a connection between the tubing string 10 and the liner 32. The liner is run into the casing on the end of this tubing string until it is located at the proper point adjacent the casing perforations 34. As was described in connection with the Figure 1 embodiment of the invention, cement slurry is pumped through the tubular string 10 and sub 11 for passage through the lateral ports 40 of the shoe and upward movement through the an-

nular space between the liner 32 and wall of the casing 33. Excess slurry overflows into the liner, and this may be flushed from the liner and casing after the ports 21 have been opened by lowering the tripping ball 30 to its sleeve seat 31 and lowering the sleeve hydraulically in the sub to a position clear of the ports. With the ports 21 open, circulation may be established down through the tubing string 10 and through the sub ports 21 for upward passage between the tubing string or conduit and the liner 32 and casing 33, to thoroughly wash this region and prevent any cement from remaining around the tubing string.

As was described in connection with the other form of the invention, this circulation may be continued until the cement around the liner 32 has set and hardened sufficiently to bond it in place to the casing 33. When this condition has occurred, circulation may be discontinued and the tubing string 10 turned to the right to effect its disconnection from the shoe 35, the string then being elevated to the surface of the bore. Following complete hardening of the cement and plugging of the perforations, the interior of the float shoe may be drilled out to establish intercommunication through the liner 32 between the casing portions both above and below the liner.

For the purpose of aiding removal of the tubing string 10 from the cement retainer 12 or shoe 35, it can include a telescopic expansion joint 43, which will permit unrestrained elevation of the sub 11 as it is being unscrewed from the retainer or shoe.

We claim:

1. Apparatus of the character described, including a liner, a tubular string, means for coupling said liner to said tubular string in leak-proof relation with respect thereto independently of longitudinal movement of said tubular string to enable said tubular string to support said liner, said tubular string having a lateral outlet at its lower end, and a sleeve valve in said string for normally closing said outlet, said sleeve valve being shiftable to a position opening said outlets to allow passage of fluid therethrough while said tubular string is in tension sustaining the weight of said liner.

2. Apparatus of the character described, including a conduit, an initially imperforate tubular string, means for coupling said conduit to said tubular string in leak-proof relation with respect thereto to enable said tubular string to support said conduit, said tubular string having a lateral outlet at its lower end always communicable with the annular space around said tubular string, a sleeve valve in said string for normally closing said outlet, frangible means securing said sleeve valve in position across said lateral outlet, and means cooperable with said sleeve valve to enable fluid pressure to be built up in said tubular string for disrupting said frangible means and for shifting said sleeve to a position opening said outlet to allow circulation therethrough while said tubular string is in tension sustaining the weight of said conduit.

3. Apparatus of the character described including a conduit, an initially imperforate tubular string having a lateral outlet at its lower end, means for coupling said conduit to said tubular string in leak-proof relation with respect thereto to enable said tubular string to support said conduit for running said conduit to a desired position in a well bore, a sleeve valve in said string

for normally closing said outlet, frangible means for securing said sleeve valve in position across said outlet, and means adapted to be sent down said tubular string for closing the passage through said sleeve valve to enable the building up of fluid pressure thereabove to disrupt said frangible means and shift said sleeve to a position opening said outlet and allowing circulation therethrough while said string is in tension sustaining the weight of said conduit.

4. Apparatus of the character described including a conduit, a tubular string having a lateral outlet at its lower end, a packer connected to said tubular string and anchored to said conduit against movement in both longitudinal directions to enable said conduit to be supported substantially entirely by said tubular string, a sleeve valve normally closing said lateral outlet, and means cooperable with said sleeve valve for enabling it to be shifted hydraulically to a position opening said outlet to permit circulation therethrough while said tubular string is in tension sustaining the weight of said conduit.

5. Apparatus of the character described, including a conduit to be positioned in a well bore, a packer adapted to be anchored to said conduit in leakproof relation against movement with respect thereto in both longitudinal directions, a tubular string detachably secured to said packer and having a lateral outlet at its lower end, a sleeve valve normally closing said lateral outlet, and means movable downwardly through said tubular string into cooperation with said sleeve valve for enabling its hydraulic shifting to a position opening said outlet to permit circulation therethrough while said tubular string is in tension sustaining the weight of said conduit.

6. Apparatus of the character described, including a conduit adapted to be positioned in a well bore, a packer adapted to be anchored in said conduit in leakproof relation with respect thereto, a tubular string detachably secured to said packer and having a lateral outlet at its lower end always communicable with the annular space around said tubular string, a sleeve valve having a central bore and normally closing said lateral outlet to permit fluid passage through said tubular string and packer, frangible means for maintaining said sleeve valve in such closed position, and means movable downwardly through said tubular string into cooperation with said sleeve valve to close the bore therethrough for enabling said frangible means to be disrupted and hydraulic shifting of said sleeve to a position opening said outlet to permit circulation therethrough between the interior and exterior of said tubular string while the latter is in tension sustaining the weight of said conduit.

7. Apparatus of the character described, including a conduit adapted to be cemented in a well bore, a tubular string having a lateral outlet at its lower end, means including a cementitious plug for coupling said conduit to said tubular string in leak-proof relation with respect thereto to enable said conduit to be supported substantially entirely by said tubular string, a sleeve valve normally closing said lateral outlet, and means cooperable with said sleeve valve for enabling it to be shifted hydraulically to a position opening said outlet to permit circulation therethrough while said tubular string is in tension sustaining the weight of said conduit.

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