March 10, 1959 C. F. WARNER 2,876,844

APPARATUS FOR CEMENTING A LINER IN A WELL BORE

Filed June 14, 1954

3 Sheets-Sheet 1

Fig. 1

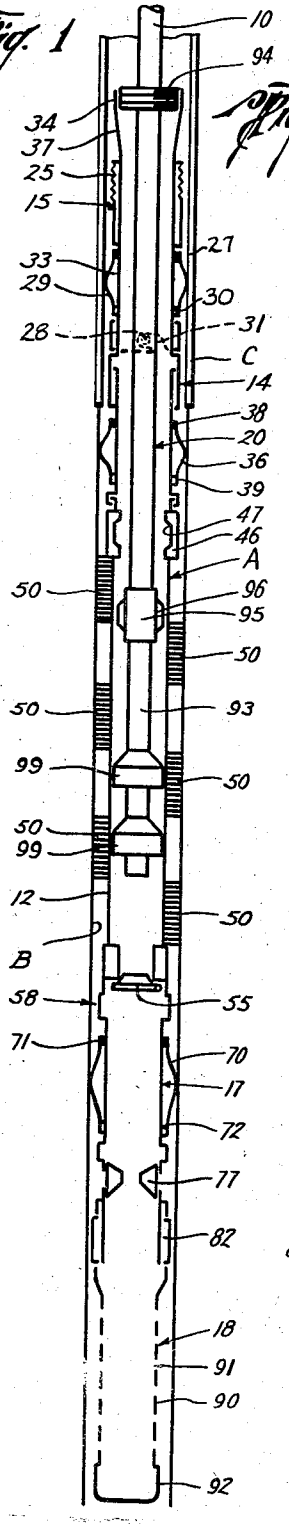


Fig. 2

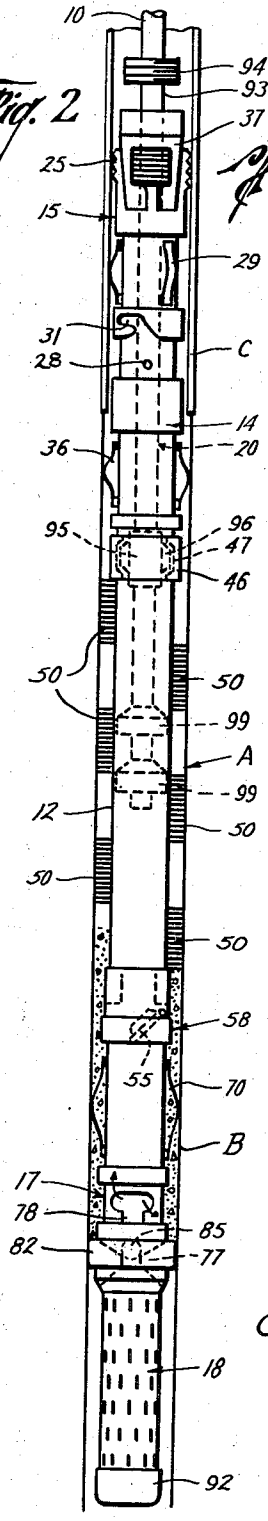
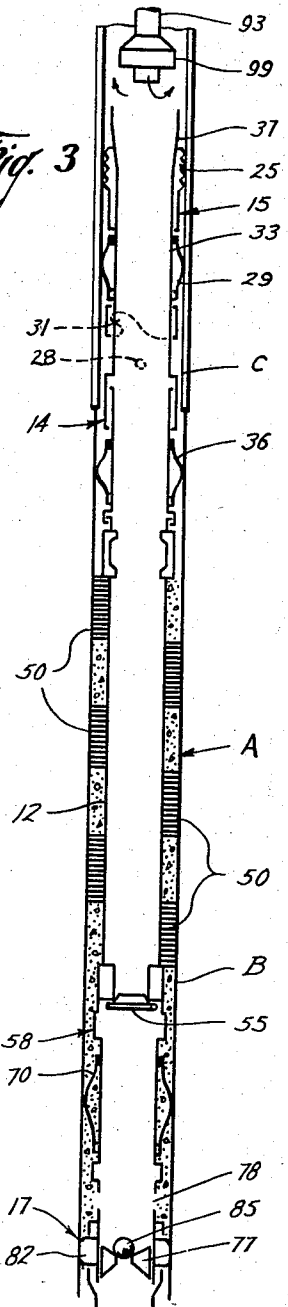


Fig. 3



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3 Sheets-Sheet 2

Fig. 4

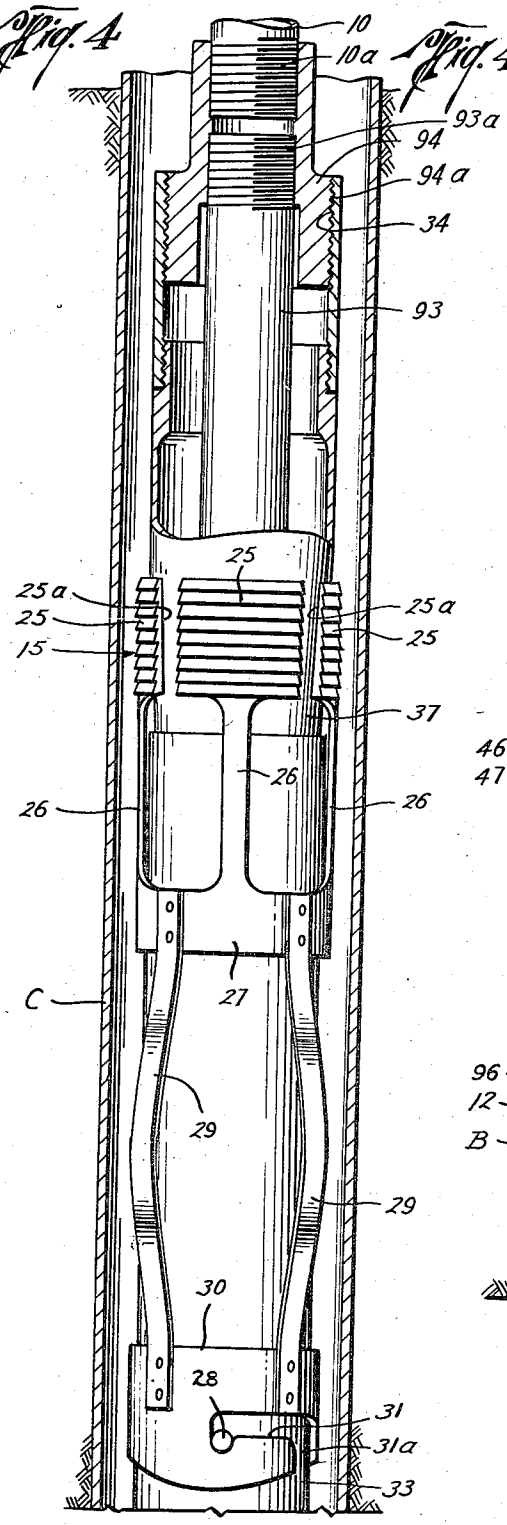
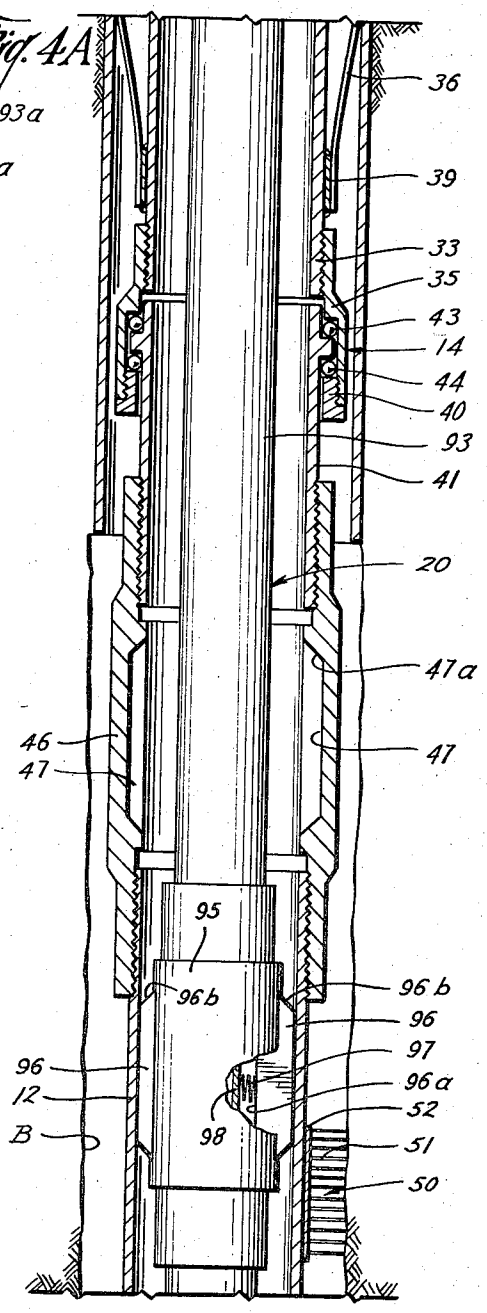


Fig. 4A



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3 Sheets-Sheet 3

Fig. 4B

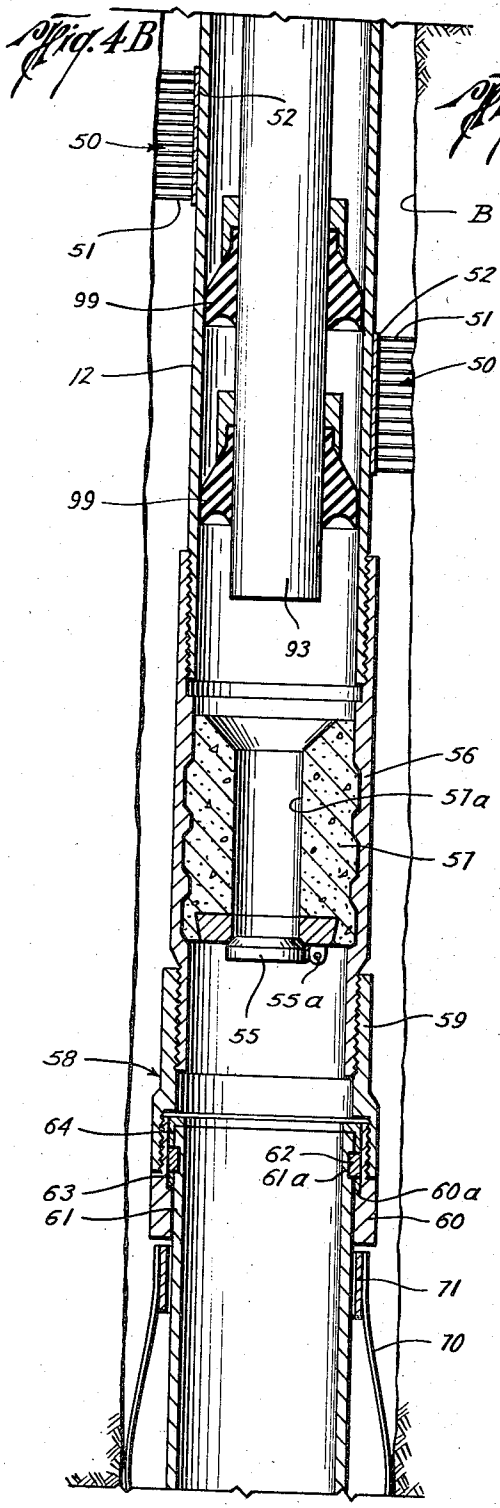
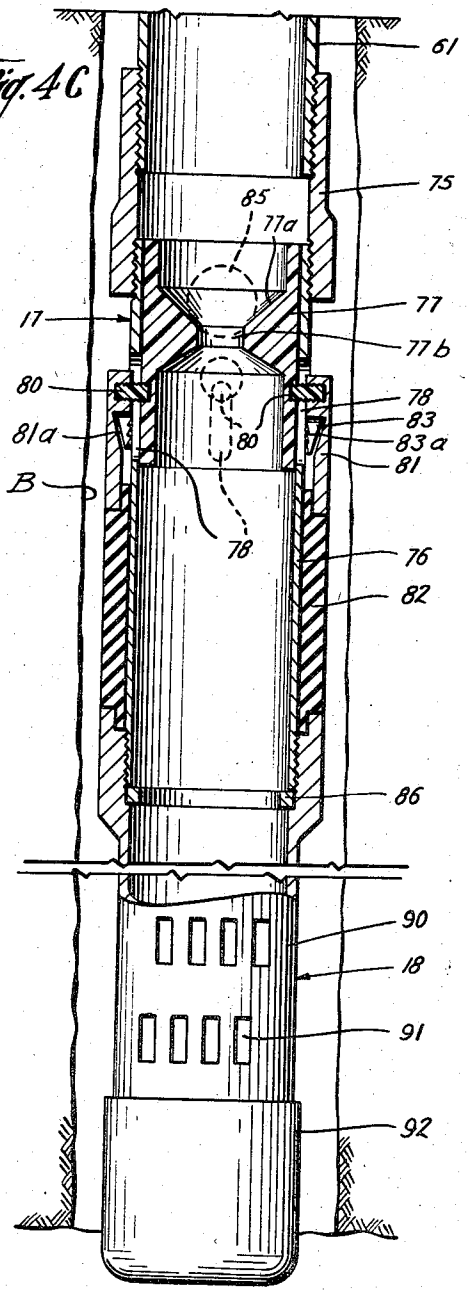


Fig. 4C



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2,876,844

APPARATUS FOR CEMENTING A LINER IN A WELL BORE

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Application June 14, 1954, Serial No. 436,538

8 Claims. (Cl. 166—184)

This invention relates to new and useful improvements in apparatus for cementing a liner in a well bore.

An object of this invention is to provide a new and improved apparatus for cementing a liner in a well bore at the lower end of the well casing, wherein the liner is rotated during the cementing operation to provide an improved bond between the liner and the well bore.

An important object of this invention is to provide a new and improved apparatus for cementing a liner in a well bore at the lower end of a well casing, wherein the liner has scratcher members thereon and the liner is adapted to be rotated to cause the scratchers to scratch the walls of the well bore to remove mud and provide a roughened surface on the walls of the well bore whereby cement which is pumped into the annular space between the liner and the well bore firmly bonds the liner to the well bore.

Another object of this invention is to provide a new and improved apparatus for rotating a liner during the cementing thereof in the well bore, wherein the liner has a means thereon for scraping the well bore during such cementing operation to improve the bond between the liner and the well bore, the means for rotating the liner during the cementing operation being removable from the liner after the cement has been pumped into position between the liner and the well bore.

The construction designed to carry out the invention will be hereinafter described together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, illustrating the improved apparatus of this invention as it is lowered into the well bore.

Figure 2 is a view similar to Figure 1, but illustrating the apparatus during the rotation thereof and during the introduction of cement into the annular space between the linear and the well bore.

Figure 3 is a view similar to Figure 2, but illustrating the liner after it has been cemented in position in the well bore below the well casing and during the washing operation.

Figures 4, 4A, 4B and 4C are views, partly in section and partly in elevation, illustrating the complete apparatus of this invention in detail with the parts being in the position for lowering into the well bore.

In the drawings, the letter A designates generally the apparatus of this invention which is adapted to be lowered into a well bore B below a well casing C on a tubing string or support pipe 10. The apparatus A includes a liner 12 which is suspended from a swivel 14 connected to a liner hanger 15 which is adapted to be set in the well casing C. Thus, when the liner hanger 15 is set in the casing C, the liner 12 is suspended therefrom and is

adapted to be rotated relative thereto through the swivel connection 14. A cement control structure or cement shoe 17 is mounted at the lower end of the liner 12 and a perforated liner 18 is connected below the cement shoe 17 whereby after the liner 12 is cemented in position in the well bore B, fluid may flow upwardly through the perforated liner 18 into the bore of the liner 12 for flow to the surface of the well through the casing C. The setting of the liner hanger 15 at the upper end of the liner 12 and the rotation of the liner 12 after the hanger 15 has been set and during the introduction of cement into the well bore B is accomplished by a control rod device 20, as will be explained. The control rod device 20 is adapted to be removed from the apparatus A after the liner has been cemented in position in the well bore B to thereby leave the bore of the liner open for the conducting of the fluid from the well bore through the perforated liner 18.

The details of the apparatus A of this invention are shown in Figures 4, 4A, 4B and 4C which illustrate the tool from its upper to its lower end, respectively. As best seen in Figure 4, the liner hanger 15 includes a plurality of gripping members or slips 25 which are adapted to engage the inner surface or wall of the well pipe or casing C to support the liner 12 in the casing C. The slips 25 are supported on resilient or flexible arms 26, all of which are formed integrally or are otherwise connected to an annular band 27. The band 27 is connected to a plurality of friction members or springs 29 which are bowed outwardly for constant engagement with the inside of the well pipe or casing C. The lower ends of the friction springs 29 are connected to an annular locking ring 30 which has a J-slot 31 therein. The locking ring 30 surrounds a tubular support section 33 which extends from a threaded box 34 at its upper end to a swivel housing 35 at its lower end. When the tool is lowered into the well, the liner hanger 15 is locked to the tubular support section 33 by a pin 28 on the section 33 which extends into the J-slot 31 (Figure 4). When it is desired to disconnect the locking ring 30 from the tubular support section 33, the section 33 is rotated or turned to the left or counter-clockwise (as viewed from the top of Figure 4) so as to cause the pin 28 to move to a position just above the longitudinal portion 31*a* of the J-slot 31. Thereafter, upon a downward movement of the section 33 relative to the locking ring 30, the section 33 is free to move without carrying therewith the locking ring 30 or the portions attached thereto.

The tubular support section 33 includes a slip expander or cone 37 which has its outer surface tapered or inclined downwardly and inwardly at an angle similar to the inclination of the inner surfaces 25*a* of each of the slips 25, whereby upon downward movement of the slip expander 37 with the tubular support section 33 the slips 25 are urged laterally or radially outwardly into gripping engagement with the well casing C. It will be understood of course that the friction springs 29 are constantly in engagement with the well casing C and they prevent the slips 25 from moving downwardly upon the downward movement of the slip expander 37 and the tubular support 33 relative to the slips 25. It will be evident that the connection of the pin 28 in the slot 31 holds the slips 25 in a lowered position with respect to the slip expander 37 when the tool is being lowered into the casing or well bore so as to prevent the premature setting of the slips 25. When the slips 25 are set in the casing C, the tubular section 33 is thereafter prevented from moving downwardly relative to the slips 25. An upper centralizer is mounted on the tubular section 33 which has bowed friction springs 36 connected by an upper band 38 and a lower band 39 (Figure 1) with the

lower band being welded or otherwise connected to the section 33 so that the centralizer functions to hold the section 33 and other parts above the swivel 14 against rotation after the slips 25 are set. This upper centralizer is very desirable although it could be omitted if desired.

The swivel 14 (Figure 4A) may be formed in numerous ways, but as shown in the drawings, the swivel housing 35 has an annular retaining plug 40 threaded into its lower end. A tubular swivel section or pipe 41 extends upwardly into the swivel housing 35 and has an annular flange 42 thereon which extends laterally into housing 35 above the annular plug 40. A plurality of circumferentially arranged ball bearings 43 are positioned above the flange 42 and a plurality of circumferentially arranged ball bearings 44 are disposed below the flange 42 so that a double race bearing is provided in the swivel 14, whereby the section or pipe 41 is free to rotate relative to the swivel housing 35 and the tubular support section 33 connected thereto.

The lower end of the swivel pipe 41 is connected to a collar 46 which has longitudinal recesses or keyways 47 formed on the inner surface thereof, the purpose of which will be hereinafter explained. The lower end of the collar 46 is connected to the liner 12 which has secured on its external surface a plurality of scratcher members 50 which are suitably positioned so that substantially the entire wall of the well bore B is scratched or scraped upon a rotation of the liner 12. Each of the scratcher members 50 includes a plurality of laterally or radially extending scratchers or wires 51 which are mounted on a plate 52 which in turn is welded or otherwise secured to the external surface of the liner 12. Thus, as the liner 12 is rotated, the walls of the well bore B are scratched or scraped to remove mud or other material which would interfere with proper cementing action when cement is pumped into the annular space between the exterior of the liner 12 and the walls of the well bore B.

It is desirable to locate a back check valve below the liner 12 to close fluid flow upwardly into the liner 12 during the lowering operation. A valve housing 56 is connected to the lower end of the liner 12 and has an inner sleeve 57 therein with a bore 57*a* therethrough which is closed by the check valve 55. The sleeve 57 is formed of concrete or other drillable material. The valve 55 is normally held in a closed position (Figure 4B) by a suitable spring (not shown) mounted at the hinge of 55*a* of the valve 55. The valve 55 is of course adapted to be swung or pivoted downwardly to an open position when the pressure thereabove exceeds by a predetermined amount the pressure therebelow, whereby the valve 55 serves as a back check safety valve.

A swivel 58 is provided below the liner 12 and the valve housing 56 by a swivel adapter 59 which has a threaded connection with the lower end of the valve housing 56. A swivel collar 60 is connected to the swivel adapter 59 and such collar 60 has an inwardly extending radial shoulder 60*a*. A tube or pipe 61 which forms a continuation of the liner 12 is supported in the swivel 58 by a lock ring 62 which fits into an annular groove 61*a* in the exterior of the pipe 61 and which serves to retain the pipe 61 against longitudinal movement relative to the swivel 58. Bearings 63 and 64 are also provided in the swivel 58 to facilitate the swivel action thereof. A centralizer which includes a plurality of bowed spring members 70, all of which are connected to an annular band 71 at their upper ends and a similar band 72 (Figure 1) at their lower ends, serves to maintain the apparatus centrally positioned as it is lowered into the well bore. The upper band 71 is free to move longitudinally relative to the pipe 61, but the lower band 72 is welded or otherwise affixed to the pipe 61, so that as the centralizer frictionally engages the well bore B, it also serves to prevent rotation of the pipe 61 and other parts below the swivel 58.

The cement shoe 17 is connected below the lower end of the pipe 61 and is essentially the same as that shown in U. S. Patent No. 2,488,819 issued to J. J. Larkin. An adapter 75 connects the lower end of the pipe 61 with the sleeve 76, which sleeve 76 is in turn threaded or otherwise connected to the perforated liner 18. Disposed within the upper end of the sleeve 76 is a slidable valve 77 formed of Bakelite, an aluminum alloy, or any other similar drillable material. When the valve 77 is in its upper position (Figure 4C), it closes flow ports 78 which are formed in the wall of the sleeve 76. The valve 77 is retained in its upper or closed position by means of shear pins 80 which are also preferably formed of a plastic such as Bakelite and which extend from the valve 77 into an annular collar 81. The collar 81 rests on or abuts the upper end of a resilient or elastic packing sleeve 82 which surrounds the sleeve or body 76. A plurality of wedges 83 are positioned within a tapered groove 81*a* of the collar 81 and each preferably has upperly directed teeth 83*a* on their inner surfaces for engaging the exterior of the body or sleeve 76. The wedges 83 are adapted to permit downward movement of the collar 81 but upon upward movement of the collar 81, the teeth 83*a* engage the external surface of the body 76 to prevent such upward movement. When it is desired to move the valve 77 downwardly to open the ports 78 to permit the flow of cement to the well bore for cementing the liner into position, a ball 85 is dropped downwardly through the apparatus for seating on an annular seat 77*a* so as to close the bore 77*b* of the valve 77. Thereafter, the valve 77 is pumped downwardly by the fluid pressure or the pressure of the cement thereabove so as to move the valve 77 downwardly with respect to the sleeve or body 76. Such downward movement causes the collar 81 to also move downwardly and thereby the annular packing element 82 is compressed or expanded into sealing the engagement with the walls of the well bore B. When the packing element 82 has been fully expanded into a set position in the well bore B, further downward movement of the collar 81 is prevented, but the pressure still acts on the valve 77 to urge it downwardly with the result that the shear pins 80 are severed or sheared to permit the valve 77 to continue its downward movement. The downward movement of the valve 77 continues until it is stopped by an annular stop ring 86 mounted at the lower end of the body or sleeve 76 and it will be apparent that as soon as the upper end of the valve 77 has passed below the ports 78, such ports 78 will be opened and cement or other fluid will be directed through the ports 78 into the well bore above the annular packing element 82. The wedges 83 prevent the release of the packing element 82 after the pins 80 have been sheared.

The perforated liner 18 is of conventional construction and includes the sleeve 90 having openings 91 therein to permit the well fluid to flow therethrough. The usual bull plug or nose plug 92 is mounted on the lower end of the perforated liner 18.

The control rod assembly 20 for manipulating the apparatus for the setting of the liner hanger 15 and for rotating the liner 12 during the admission of cement into the well bore, includes a control pipe 93 (Figures 4, 4A and 4B) which has its upper end threaded into an annular nut 94. The threads 93*a* on the upper end of the control rod 93 and the threads 10*a* on the lower end of the tubing string or support pipe 10 are right hand threads whereas the external threads on the nut 94 are left hand threads 94*a*. The nut 94 is thus releasable from the thread 34 upon a rotation of the tubing string 10 to the right or in a clockwise direction (as viewed from above in Figure 4).

The control rod 93 has mounted thereon a clutch member housing 95 (Figure 4A) which has a plurality of longitudinal slots therethrough through which extend a plurality of clutch members or keys 96 which are resiliently urged outwardly by springs 97 or any other similar resilient means disposed between the rear surface 96*a* of the

clutch members 96 and a retaining plate 98 in the housing 95. When the apparatus is lowered into the well bore, and the nut 94 is connected to the left hand threads 34, the clutch housing 95 and the parts connected therewith are positioned below the clutch collar 46. After the hanger 15 is set in the casing C, the nut 94 is released by a rotation to the right or in a clockwise direction and then the control rod 93 is raised upwardly to permit the clutch members 96 to be urged into the keyways or longitudinal grooves 47, whereby a rotative connection between the control rod 93 and the liner is established. Thereafter, upon rotation of the tubing string or support pipe 10, such rotation is imparted to the liner 12 to cause the scratcher members 50 to scratch the inside surface of the well bore B. During such rotation cement is pumped downwardly through the tubing string 10 and through the control rod 93 discharging from the lower end of rod 93. To prevent the cement and other fluid from passing upwardly into the liner 12, one or more inverted casing swab cups 99 are mounted on rod 93. These cups 99 make a substantial sealing engagement with the bore of liner 12 under pressure from below.

The operation of the apparatus and the method of this invention is best illustrated by referring to Figures 1–3. In Figure 1, the apparatus is shown with the parts in the relative position they assume as the apparatus is lowered into the well bore. The nut 94 is connected to the threads 34 so that there is a direct connection between the tubing string 10 and the sleeve 33. During such lowering operation, the pin 28 is positioned in the slot 31 so that the liner hanger 15 is carried downwardly with the apparatus as it is lowered into the well bore. When the apparatus has been lowered to a position wherein the hanger 15 is positioned at the lower end of the casing C with the rest of the apparatus extending down into the open well bore B (Figure 1), the tubing string 10 is turned to the left or counter-clockwise to move the pin 28 into the open portion 31*a* of the slot 31 (Figure 4) at which time a lowering of the tubing string 10 will release the sleeve 33 from the slip hanger 15. The liner hanger 15 is prevented from moving downwardly after the pin 28 has been released from the slot 31 by reason of the friction or drag springs 29 on the inside of the casing C. As the sleeve 33 is then lowered with the lowering of the tubing string 10, the slip expander or cone 37 moves downwardly to coact with the slips 25 to move same radially outwardly into firm gripping engagement with the casing C (Figure 2). Thereafter, the tubing 10 is rotated to the right or clockwise to disconnect the nut 94 from the threads 34 (Figure 4) whereby the tubing 10 can be raised upwardly relative to the liner 12. This, of course, moves the control rod assembly 20 upwardly and moves the clutch members 96 into the keyways or clutch grooves 47 in the housing 46 whereby a direct rotative connection is established between the tubing string 10 and the liner 12 (Figure 2). Thereafter, rotation is imparted to the liner 12 by rotating the tubing string or support pipe 10. During such rotation, cement is pumped downwardly through the tubing string 10 and the control rod 93 for discharge from the lower end thereof. The cement pressure urges the safety back check valve 55 to an open position (Figure 2) and the pressure is then exerted on the valve 77, the ball 85 having been previously dropped prior to the admission of the cement. Thus, the cement pressure acts to urge the valve member 77 downwardly, and as previously explained the downward movement of the valve member 77 serves to expand the annular packing element 82 into sealing engagement with the well bore B and also moves the valve 77 to a position below the lateral ports 78, whereby the cement is discharged through the ports 78 but is prevented from flowing into the well bore area below the annular packing element 82. By reason of the rotation of the scratchers 50 during the admission of the cement into the well bore B, the walls of the well bore are substantially free from mud and other impurities which might otherwise prevent a firm bond between the liner 12 and the well bore B with the cement. Also, the movement of the scratcher members 50 tends to agitate the cement as it flows into the annular space between the liner 12 and the well bore C to assure a uniform distribution of the cement in such annular space.

After the cement has been pumped downwardly in a sufficient quantity to fill the annular space between the liner 12 and the well bore B, the entire control assembly 20 is removed from the liner and the liner hanger by lifting upwardly on the tubing 10. Due to the upper inclined or sloped edges 96*a* of the clutch members 96 and similarly inclined or sloped edges 47*a* in the grooves 47, the upward movement of the tubing string 10 is sufficient to cause the clutch members 96 to retract and thereby permit the release of the clutch members 96 from the grooves 47 so that the entire control assembly 20 can be removed from the apparatus. As shown in Figure 3, a washing action can be performed after the cement step in order to clear out any excess mud or cement remaining in the casing C above the liner hanger 15. Thus, with the lower end of the control rod 93 positioned above the liner hanger 15, a washing fluid is pumped downwardly through the tubing string and the control rod 93 for discharge from the lower end thereof whereby a circulation is set up in the casing to remove mud and cement from inside the liner 12 and thereabove. After the washing operation, the entire control rod assembly 20 is removed from the well and the usual drilling apparatus (not shown) is lowered into the liner 12 to drill out the check valve sleeve 57, check valve 55, and the portions of the cement shoe 17 within the sleeve or body 76 such as the valve member 77, as well as any cement in the liner which has not been washed out during the washing step. Thus, the bore of the liner is completely open from the screen 18 upwardly. Thereafter, production from the well formation will be obtained by the well fluid flowing into the liner 12 through the ports or perforations 91 in the perforated liner 18 and thence upwardly through the casing C to the surface of the well.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed is:

1. In an apparatus for cementing a liner in a well bore below a well casing in the well bore, a liner, a liner hanger above the liner for gripping the casing to support said liner in the well bore and below said casing, a swivel connection between said liner hanger and said liner for permitting rotation of said liner relative to said liner hanger, scratcher members on said liner for scratching the walls of the well bore upon a rotation of the liner, and means for rotating said liner in the well bore to effect the rotation of said scratcher members.

2. An apparatus for cementing a liner in a well bore comprising, a hanger for suspending the apparatus in a well, a cement shoe having a resilient packing element thereon, valve controlled port means in the wall of the cement shoe above the packing element, means for expanding the packing element into contact with the wall of the well by fluid pressure and for opening said port after the packer is expanded, a rotatable liner swivelled to and interconnecting the hanger and cement shoe, and scratcher members on the rotatable liner.

3. An apparatus for cementing a liner in a well bore below a well casing, comprising a liner, a liner hanger above said liner for gripping the casing to support said liner in the well bore below the casing, a tubular member swivelly connected to said liner, scratcher members on said liner for scratching the walls of the well bore upon

a rotation of the liner, means for rotating said liner in the well bore to effect the rotation of said scratcher members, said liner hanger including casing gripping slips adapted to engage said well casing in gripping contact therewith, said tubular member extending through said liner hanger and having a slip expander member thereon, a swivel connection between said liner and said tubular member whereby said liner is rotatable relative to said liner hanger after said liner hanger is set in gripping contact with said well casing.

4. An apparatus for cementing a liner in a well bore below a well casing, comprising a liner, a liner hanger above said liner for gripping the casing to support said liner in the well bore below said casing, scratcher members on said liner for scratching the walls of the well bore upon a rotation of said liner, means for rotating said liner in the well bore to effect the rotation of said scratcher members, said liner hanger including a tubular body swivelly connected to said liner to permit rotation of the liner relative to the tubular body, casing gripping slips surrounding said tubular body and adapted to move laterally into gripping engagement with the well casing, a slip expander on said tubular body for urging said slips radially into the gripping engagement with the well casing, a releasable connection between said slips and said tubular body, and means to release said releasable connection to permit longitudinal movement of said tubular body relative to said slips to effect a longitudinal movement of said slip expander relative to said slips for urging said slips into gripping engagement with the well casing.

5. An apparatus for cementing a liner in a well bore, comprising a first liner, scratcher members on said first liner for scratching the walls of the well bore upon a rotation of said first liner, means for rotating said first liner in the well bore to effect the rotation of said scratcher members, a means for introducing cement through the first liner and into the well bore during the rotation of said first liner, a cement shoe on the lower end of said first liner, a perforated liner positioned below said cement shoe, and a swivel connection between said cement shoe and said first liner whereby said first liner is rotated without rotating said cement shoe and said perforated liner.

6. An apparatus for cementing a liner in a well bore comprising, a first liner, scratcher members on said first liner for scratching the walls of the well bore upon a rotation of said first liner, means for rotating said first liner in the well bore to effect the rotation of said scratcher members, a cement shoe swivelly connected

on the lower end of said first liner, a perforated liner depending from said cement shoe, said cement shoe having a valve sleeve member therein adapted to be moved longitudinally upon the application of fluid pressure thereagainst, said cement shoe also having a resilient packing element thereon adapted to be expanded into sealing engagement with the well bore by said valve member as it is moved downwardly in the cement shoe by fluid pressure, said shoe also having a lateral port therethrough above said packing element which is uncovered by the valve member when the packer is expanded for permitting fluid to flow from said first liner into the well bore above said packing element and said perforated liner.

7. An apparatus adapted to be lowered into a well bore on a support pipe for cementing a liner in a well bore, comprising a liner, scratcher members on said liner for scratching the walls of said well bore upon a rotation of said liner, means for rotating said liner in the well bore to effect the rotation of said scratcher members, means for introducing cement through the liner and into the well bore during the rotation of said liner, said means for rotating said liner including a control rod supported by said support pipe, a clutch member on said control rod having laterally movable clutch projections thereon, and a clutch adapter sleeve on said liner having longitudinal grooves therein for receiving said clutch projections to thereby establish a rotative connection between said liner and said control rod whereby rotation of said control rod imparts a rotation to said liner.

8. The structure set forth in claim 7, including a releasable threaded connection between said liner and said control rod for preventing relative longitudinal movement of said control rod with respect to said liner during the lowering of said apparatus into the well bore, said releasable connection being released to permit longitudinal movement of the control rod with respect to the liner for effecting the engagement of said projections with said grooves in said clutch adapter sleeve.

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