

April 6, 1943.

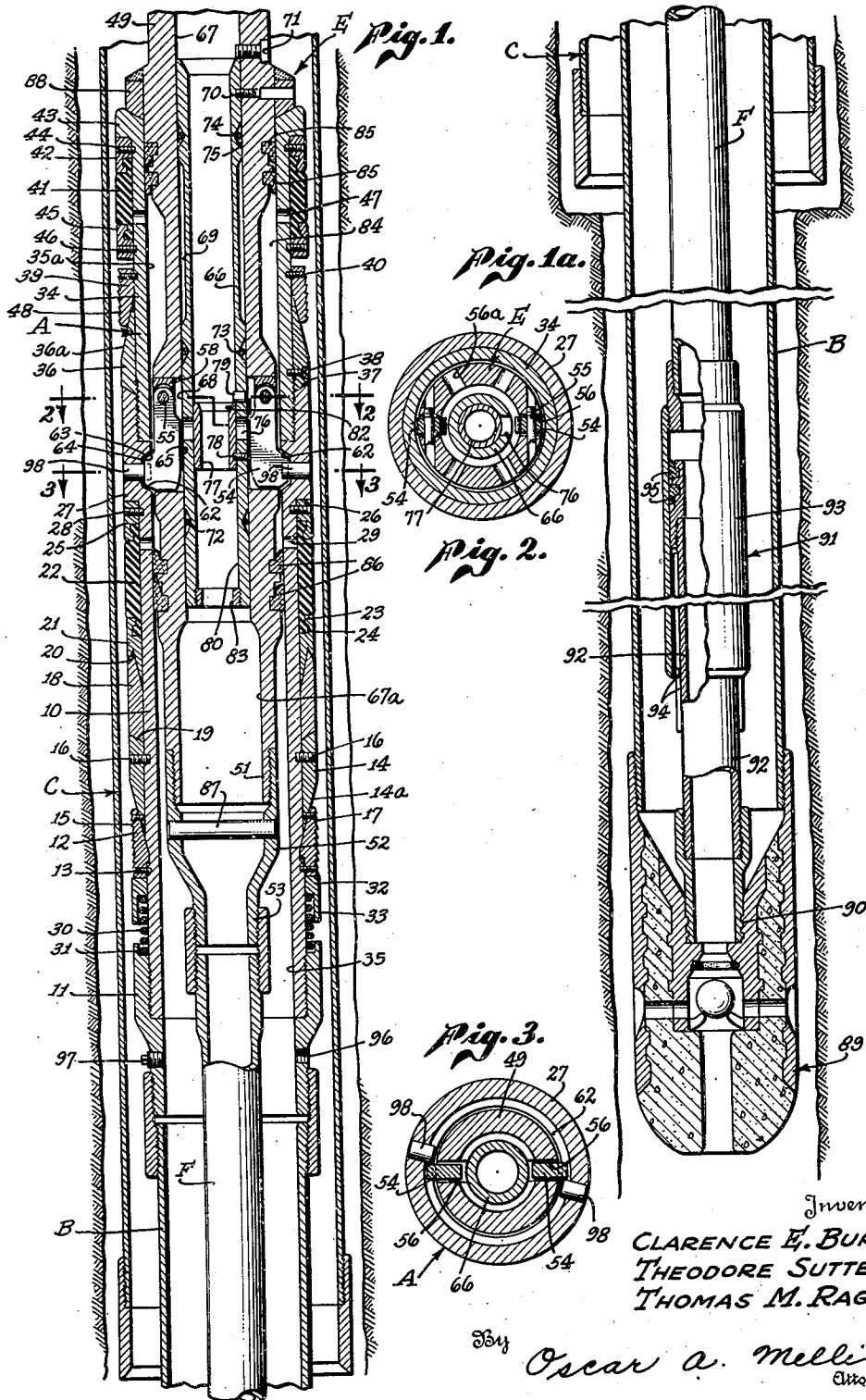
C. E. BURT ET AL

2,315,931

LINER HANGER APPARATUS

Filed June 17, 1940

3 Sheets-Sheet 1



April 6, 1943.

C. E. BURT ET AL
LINER HANGER APPARATUS

2,315,931

Filed June 17, 1940

3 Sheets-Sheet 2

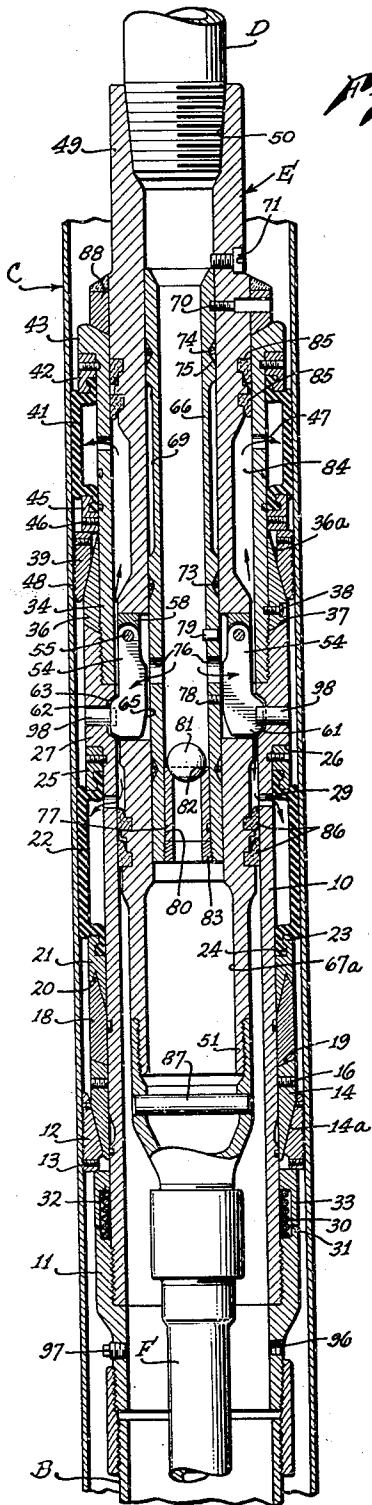


Fig. 4.

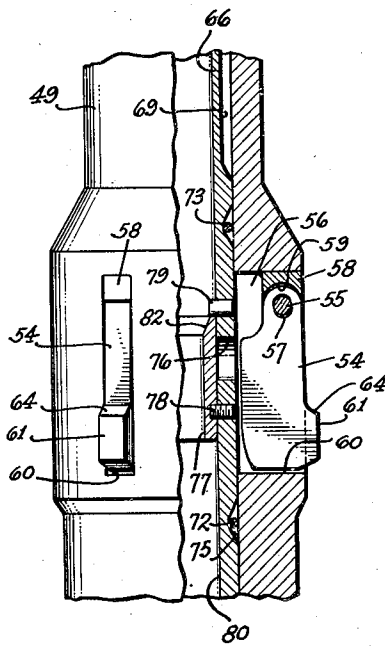


Fig. 5.

Inventors
CLARENCE E. BURT,
THEODORE SUTTER,
THOMAS M. RAGAN,

By *Oscar A. Mellin*
Attorney

April 6, 1943.

C. E. BURT ET AL

2,315,931

LINER HANGER APPARATUS

Filed June 17, 1940

3 Sheets-Sheet 3

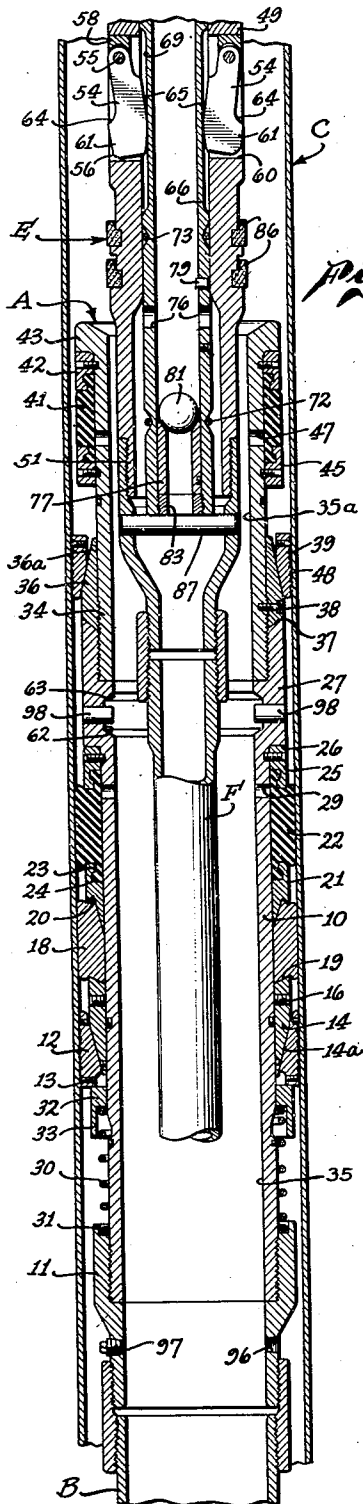
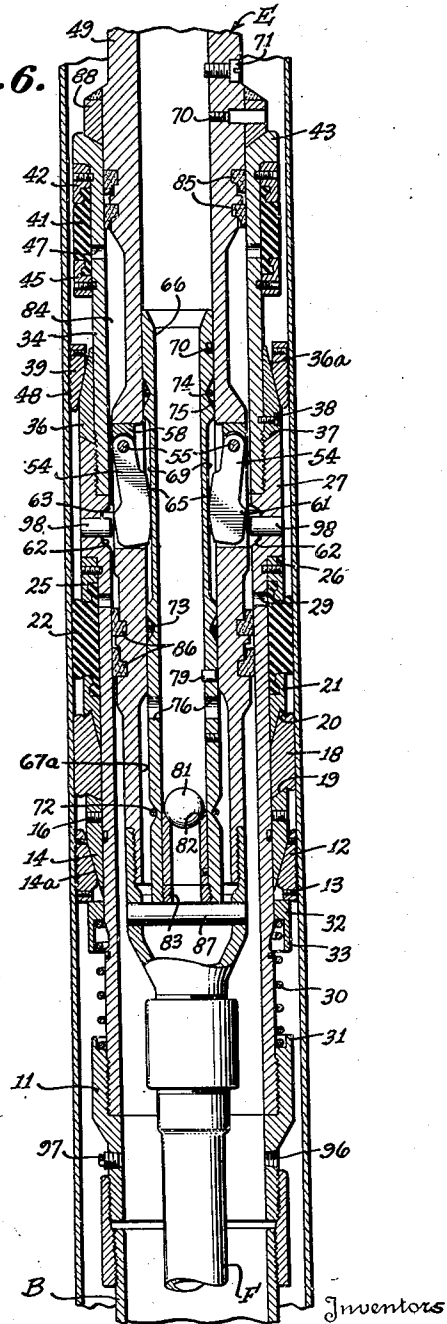


Fig. 6.

Fig. 7.



Inventors
CLARENCE E. BURT,
THEODORE SUTTER,
THOMAS M. RAGAN,

By Oscar A. Mellin
Attorney

UNITED STATES PATENT OFFICE

2,315,931

LINER HANGER APPARATUS

Clarence E. Burt, Los Angeles, Theodore Sutter, Huntington Park, and Thomas M. Ragan, Downey, Calif., assignors to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

Application June 17, 1940, Serial No. 340,984

37 Claims. (Cl. 166—1)

This invention relates to well packers, and more particularly to liner hangers and the associated mechanisms for producing their setting in a well casing.

A liner hanger of the retrievable type is restrained against downward movement in a well casing by the weight of a depending liner holding its anchoring elements firmly engaged with the wall of the casing. The requirement of retrievability has resulted in the omission of any provision for preventing displacement of the liner hanger in an upward direction. As a result, pressures and other forces acting from below tend to elevate the hanger and its depending liner in the casing, limiting the extent of operations that can be performed successfully with such equipment. The performance of high pressure squeeze cementing operations around the liner and its connected hanger, or their subjection to high production pressures, has often resulted in the pumping or forcing of the apparatus up the casing away from their initial location therewithin.

It is an object of the present invention to provide an improved retrievable well packer, especially adapted for use as a liner hanger, which can be anchored against displacement in both an upward and downward direction.

A further object of the invention is to provide an improved liner hanger apparatus capable of being set in packed-off condition within a well casing prior to the introduction of circulation through and behind a depending liner, for the purpose of washing the hole and conditioning the mud therein, enabling the proper performance of a displacement or squeeze cementing operation to take place. In this connection, cement slurry can be deposited behind the liner after the hanger has been packed-off in the casing, the displaced cement slurry then being subjected to a squeeze or pressure through the use of the liner hanger setting mechanism.

Still a further object of the invention involves an improved well packer and tool for hydraulically setting the packer in a well casing, the setting tool being hydraulically releasable from the set packer for removal from the casing.

Another object of the invention is to provide an improved method for cementing a liner in a well bore.

This invention has other objects that will become apparent from a consideration of the embodiment shown in the drawings accompanying and forming part of the present specification. This form will now be described in detail, 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 appended claims.

Referring to the drawings:

5 Figures 1 and 1a constitute a two part, longitudinal section through a well casing, showing the liner hanger, its setting tool, and associated apparatus in running-in position within a well casing;

10 Figure 2 is a transverse section taken along the line 2—2 in Figure 1;

Figure 3 is a transverse section taken along the line 3—3 in Figure 1;

15 Figure 4 is a view similar to Figure 1, disclosing the hydraulic actuation of the slips to casing engaging position;

Figure 5 is a longitudinal sectional and elevational view of part of the setting tool;

20 Figure 6 is a longitudinal section illustrating the liner hanger set in packed-off condition in the casing, with its setting tool released therefrom; and

Figure 7 is a view similar to Figure 3, with the setting tool removed from the liner hanger.

25 As shown in the drawings, the liner hanger A consists of a tubular main body 10 of steel or other suitable material having a sub 11 threaded on its lower end, to which is attached a depending liner B. The body carries a plurality of segmental down-pressure slips 12 normally held in retracted position by shear screws 13 extending through each slip into the body. The slips are engageable with a lower expander cone 14 whose downwardly converging tapered surface 14a is adapted to slide along the companion tapered surfaces on the slips 12 to shift them radially into contact with the casing C and to hold them wedged thereagainst with their wickers 15 digging into the casing wall. This expander cone 14 is slidable on the main body 10 of the packer and is initially held thereon in retracted position by one or more shear screws 16. A third set of shear screws 17 connects the cone with the upper ends of the slips. The screws 16 holding the cone expander to the body have a lower shear strength than the screws 13 fastening the slips to the body, and the latter screws have a lower shear value than the screws 17 securing the cone and slips together.

50 A sleeve 18 of lead or any other suitable packing material surrounds the body with its lower end engaging the upper end of the expander cone 14. This engagement occurs along a downwardly and inwardly inclined surface 19 to confine the bottom end of the lead seal packing against in-

advertent displacement, while the upper end is received within a V-shaped groove 20 formed in the lower portion of a retainer thrust ring 21 slidable on the packer body. This thrust ring is secured to an elastic or rubber packing sleeve 22 by the respective interlocking flanges 23, 24, the upper end of the sleeve 22 being similarly coupled to an upper retainer ring 25 abutting a shoulder 26 on an enlarged portion 27 of the body 10. The upper ring 25 is held against downward movement by a screw 28 extending through the ring into the body.

When the well packer A is to be set in the casing, fluid under pressure will enter the rubber packing sleeve 22 through the ports or openings 29 in the body, to expand the sleeve against the casing C and produce its elongation in a downward direction (see Figure 4). As the sleeve is stretched downwardly, it moves the retainer thrust ring 21, lead seal packing 18, expander cone 14 and segmental slips 12 in the same direction, the lead seal packing 18 acting as a fairly rigid load transmitting member between the rubber packing 22 and cone 14. The downwardly exerted hydraulic force will shear the cone screws 16 and then the slip screws 13, the third set of screws 17 remaining intact to hold the cone and slips together for downward movement in unison against the action of a helical spring 30 encompassing the packer body. The lower end of the spring bears against the sub 11, which has an upstanding lip 31 confining the spring against outward displacement. The upper end of the spring 30 engages a ring 32 which abuts the slips and has a depending skirt 33 confining and protecting the spring.

The skirt 33 and lip 31 are initially spaced apart, enabling downward movement in unison of the cone and slips to occur against the force exerted by the spring 30. After the skirt and lip abut, the exertion of sufficient force by the fluid within the expansible rubber packing 22 will shear the screws 17 holding the cone and slips together, permitting the cone 14 to move down within the slips 12 and the compressed spring 30 to expand and slide the slips 12 along the face 14a of the cone into engagement with the casing C.

After the slips contact the casing, weight imposed downwardly on the main body 10 of the packer will compress the rubber and lead packings 22, 18 between the body and casing, in addition to wedging the expander cone 14 firmly in the slips 12, causing their downwardly directed wickers 15 to be embedded securely in the wall of the casing. The packer or liner hanger A is now set in packed-off condition within the well casing C, supporting the weight of the liner B through the cone 14 and slips 12, with leakage between the body 10 and casing C prevented by both the rubber sleeve 22 and lead sleeve 18.

The general arrangement of parts described above forms the subject matter of an invention filed December 23, 1939, by one of the present joint inventors, Clarence E. Burt, for "Retrievable well packers," Serial No. 310,810, now Patent No. 2,290,142 granted July 14, 1942.

The liner hanger A just described cannot be displaced in a downward direction due to the disposition of its expander cone 14 and slips 12. However, forces acting in the other direction may tend to shift it upwardly. To guard against this occurrence, the main body 10 of the packer is extended upwardly by threading an additional tubular body sleeve 34 into the thickened upper portion 27 of the main body. The interior passage 35a of

this additional body forms a continuation of the central cylindrical passage 35 through the lower packer body. In effect, the two body parts function as one.

A second expander cone 36, whose outer surface 36a converges upwardly, is mounted on the upper body portion 34 and rests upon the end 37 of the lower body portion, its upward movement being prevented by a screw 38 extending into the upper body. A plurality of segmental up-pressure slips 39 is initially held in retracted position on the upper body by a plurality of shear screws 40. The inner surfaces of these slips are companion to and engageable with the outer surface 36a of the cone expander, so that downward movement of the slips 39 over the cone surface will result in their radial displacement into engagement with the wall of the casing C.

The slips 39 are released from their retracted position by means of an elastic or rubber sleeve 41 encompassing the upper body, with its upper end secured to a retainer ring 42 abutting a shoulder or flange 43 on the secondary body 34. Downward movement of this ring is prevented by one or more screws 44 securing it to the body. The lower end of the expansible sleeve 41 is secured to a lower ring 45, and this ring is initially held in position spaced from the upper ends of the retracted slips by one or more shear screws 46 threaded into the body.

Fluid under pressure passes through one or more ports 17 in the upper body and into the rubber sleeve 41 to expand it into engagement with the casing C and then produce its elongation downwardly (see Figure 4). The elongation of the upper packing sleeve 41 will shear the screws 46 holding the lower ring 45 in its initial position and move it downwardly into engagement with the upper slips 39, disrupting their retaining screws 40 and permitting them to move along the cone 36 into engagement with the casing, either under the hydraulic action of the fluid within the rubber packing 41 or solely under the action of gravity. Upon release of the pressure within the upper packing sleeve 41, it will tend to assume its normal position retracted from engagement with the wall of the casing, with its lower retainer ring 45 removed from engagement with the slips 39 (see Figures 6 and 7).

As was described above, the lower slips 12 and cone 14 prevent displacement of the liner hanger or packer A in a downward direction. Any upwardly directed thrusts are incapable of shifting the packer up the casing since the upper cone 36 would be wedged more securely in the slips 39 and force their upwardly facing wickers 48 more securely in the wall of the casing. Thus, it will be seen that displacement of the packer in either direction cannot occur once it has been anchored in the casing.

In the event that it is desired to make the well packer or liner hanger A retrievable, its parts above the main body portion 27 are made of some readily drillable material, such as cast iron, aluminum alloy, or the like. The upper body portion 34, retainer rings 42, 45 and cone 36 could be made of either cast iron or an aluminum alloy, while it is preferred that the slips 39 be made of cast iron in view of its greater hardness properties. Whatever specific drillable material or materials are used, if it is desired to retrieve the liner hanger A and depending liner B, all that need be done is to run a suitable drilling tool in the well casing to disintegrate the drillable upper body 34, expansible sleeve 41, retainer rings 42, 45, slips 39

and cone 36. The drilled particles are removable to the surface of the well bore by the circulating fluid used in the drilling operations. Upon removal of this upper section, the liner will still remain in its initial set position suspended from the casing by the lower slips 12. A suitable fishing tool can then be lowered in the casing for the purpose of grasping the remaining portions of the liner hanger A and removing it together with its depending liner B as a unit from the well casing C.

The above-described hanger A with its depending liner B is lowered in the casing on the end of a tubular string D threaded to the body 49 of a setting tool E coupled to the main body 10 of the liner hanger. This setting tool not only serves to couple the liner hanger to the tubular string, but also governs the passage of fluid under pressure into the upper and lower expansible packing members 22, 41 to produce their elongation and the setting of the slips 12, 29.

The body 49 of the setting tool is provided with an upper threaded box 50 for attachment to the end of the tubular string D, and with a lower male end 51 on which is threaded a sub 52 having a bottom end 53 of reduced diameter adapted to be coupled to a string of tubing F, for a purpose which will be described later. The main body 49 carries a plurality of latches 54 pivotally mounted on hinge pins 55 within radial slots 56 extending completely through the wall of the body (see Figure 5). In order to relieve the pins of the load imposed upon the latches, the pivot opening 57 through each latch is elongated, allowing bodily displacement of the latches 54 to a limited degree in both longitudinal directions. Upwardly directed thrusts on the latches are not transmitted to the hinge pins themselves but to blocks 58 welded or otherwise secured in the upper ends of the slots 56, having curved seats 59 adapted to receive companion portions formed at the upper ends of each latch. Similarly, downwardly directed forces imposed on the latches will engage their bottom ends with the bottoms 60 of the slots, transmitting the loads to the body 49 without their imposition on the hinge pins 55 themselves. In short, the hinge pins 55 serve merely as fulcrums for the latches, with very little if any load being imposed upon them. One of the latches 54 and slots 56 have been disclosed in Figure 5 as displaced from the position shown in the other figures solely for purposes of illustration and clarity. It is apparent that the number of latches and cooperable slots can be varied without departing from the invention.

Each latch 54 has a locking dog 61 adapted to extend outwardly from its confining slot 56 for reception within an internal circumferential groove 62 formed in the main body. The cooperation between the inwardly diverging sides 63 of this groove and the corresponding ends 64 of the locking dogs serves to couple the setting tool E to the packer body 10.

Displacement of the dogs from their locking position within the packer body is prevented by the engagement of the inner surfaces 65 of the latches with the exterior of a sleeve 66 slidable within the central passage 67 through the body. When the larger cylindrical surface 68 of the sleeve is positioned across the body slots 56, the latches 54 and their dogs 61 are held within the body groove 62, but when the reduced cylindrical portion 69 of the sleeve is positioned adjacent these slots, the latches 54 may pivot on their

hinge pins 55 inwardly to free their dogs 61 from the confines of the groove 62.

The sleeve 66 is retained in its uppermost position to hold the locking dogs within the groove by means of a shear screw 70 extending through the setting tool body 49 into the upper end of the sleeve. This position is determined by the abutting of the upper terminus of the sleeve with a cap screw 71 extending through the body into its passage 67. The shear screw 70 is adapted to be fractured by hydraulic pressure to shift the sleeve 66 downwardly until its reduced diameter portion 69 is opposite the slots 56, whereupon the latches 54 may be retracted from the body groove. A common or mutual arrangement is employed for shifting the sleeve 66 downwardly, and for controlling the passage of fluid under pressure to the expansible packings 22, 41 for setting the slips 12, 39 in engagement with the casing C.

The hydraulic tripping mechanism includes the aforementioned sleeve 66 slidable within the setting tool body 49. This sleeve is provided with spaced packing rings 72, 73, 74 forced outwardly into slidable sealing engagement with the cylindrical interior 67 of the body by being confined within V-shaped grooves 75 in the exterior of the sleeve. The uppermost and intermediate rings 74, 73 are on opposite sides of the reduced sleeve portion 69, with the intermediate and lowermost rings 73, 72 positioned on opposite sides of one or more ports or openings 76 extending completely through the wall of the sleeve 66. These ports 76 are initially closed by a slide valve 77 held across their entrance openings by a shear screw 78 extending through the sleeve into the valve. The closed position of this valve 77 is determined by its abutting a stop pin 79 extending through the sleeve slightly into its passage 80.

With the setting tool E assembled in the packer A, the complete apparatus is lowered to its proper position within a well casing. A tripping ball 81 is lowered, pumped, or allowed to gravitate down through the tubular string until it engages the tripping ball seat 82 at the upper end of the slide valve 77. Such engagement will prevent further passage of fluid through the tubular string and body, enabling sufficient fluid pressure to be built up therein to shear the screw 78 and force the valve 77 downwardly clear of the ports 76 through the tripping sleeve, until it is arrested by a stop ring 83 threaded into the lower end of the tripping sleeve. Pressure of a higher degree than is necessary to shear the valve screw 78 can now be imposed upon the fluid within the tubular string and setting tool, this fluid passing through the tripping sleeve ports 76 and through the slots 56 or body ports 56a, from where it can pass through the annular space 84 between the exterior of the setting tool body 49 and the wall of the packer body 10, 34, through the packer body ports 29, 47 and into the expansible sleeves 22, 41. These sleeves will first be expanded into engagement with the casing and then elongated downwardly to shear the various screws and move the slips into anchoring engagement with the wall of the casing, in the manner described above and as shown in Figure 4.

The fluid is confined for passage through the space 84 between the setting tool body and the packer body by the opposed packing seals 85, 86, the upper ones 85 being positioned above the upper ports 47, and the lower ones 86 below the lower ports 29 through the packer body. These packings 85, 86 prevent leakage between the

setting tool body 49 and the packer body 10, 34, while the round packing seals 72, 73, 74 carried by the sleeve on opposite sides of the latch slots 56 and reduced sleeve portion 69 prevent fluid leakage between the tripping sleeve and the setting tool body.

After the slips 12, 39 have been engaged with the casing, weight can be imposed upon the well packer body 10 by setting down on the tubular string D to compress the lower rubber packing sleeve 22 and lead sleeve 18 into engagement with the casing C. Following this operation, the setting tool E is releasable from the body by building up sufficient pressure within the tripping sleeve 66 to shear the screw 70 holding it to the setting tool body 49. This latter screw has a greater shear value than the slide valve screw 78 in order that setting of the packer can be accomplished before the latches 54 are released. As soon as the tripping sleeve shear screw 70 has been disrupted, the sleeve will be moved downwardly by the fluid under pressure to an extent limited by the stop pin 87 extending across the bottom sub 52, to position its reduced cylindrical portion 69 opposite the latches 54. An upward strain then taken on the tubular string D will cause the inclined upper ends of the locking dogs 64 to engage the upper inclined side 63 of the body groove to move the latches inwardly completely out of the groove 62. The setting tool E may now be elevated and removed from the well packer A.

In assembling the setting tool E within the well packer A prior to its being run in the hole, the valve sleeve 77 is first inserted within the tripping sleeve 66 through its bottom end until it abuts the stop pin 79 extending inwardly from the sleeve. The shear screw 78 is then inserted in place and the stop ring 83 threaded in the bottom end of the sleeve. This assembled tripping sleeve 66 with its seals 72, 73, 74 in position is next placed within the setting tool body 49 with its lower end resting on the stop pin 87 in the sub 52, in order to position its reduced diameter 69 opposite the latch slots 56. The latches 54 and their dogs 61 can accordingly be retracted inwardly, allowing insertion of the setting tool within the packer body until its upper collar 88 engages the upper end 43 of the packer body. Such engagement will locate the locking dogs 61 opposite the internal groove 62 in the body 10. The cap screw 71 or other stop element is then threaded into the setting tool body, and a hook or other suitable tool inserted within the tripping sleeve 66 for pulling it upwardly into engagement with this stop 71. In moving upwardly, the larger cylindrical diameter 68 of the sleeve is positioned opposite the latch slots 56 to move the locking dogs 61 into the body groove 62 and hold them in this position until the sleeve 66 is lowered hydraulically, in the manner described above. The shear screw 70 is then inserted through the collar and setting tool body into the tripping sleeve 66. The well packer A and the setting tool E are now properly assembled for running into the hole and for the setting of the tool in packed-off condition at the desired point in the casing.

The arrangement described can be employed for the performance of other operations than the mere setting of a liner hanger in the casing. Another example of its utility is disclosed in the drawings, wherein a float shoe 89 is connected to the bottom end of the liner B. A tubular string F extends between the setting tool body and shoe, being threaded to the setting tool sub 52 at one

end, with its other end attached to the float shoe 89 by means of a left hand thread connection 90. An expansion joint 91, consisting of an inner mandrel 92 slidably splined to and telescoped within an outer cylinder 93 by means of splines 94 is included in this tubular string F, to permit movement of the setting tool E in and out of the packer body 10, 34. Suitable seals 95 are mounted on the upper end of the mandrel 92 for slidable engagement with the cylinder 93 to prevent leakage between the exterior and interior of the joint 91.

For the purpose of allowing the hole to be washed and the mud conditioned after the liner hanger A has been set in packed-off condition in the casing, one or more holes 96 are provided in the packer sub 11 to permit fluid to pass through the setting tool E, its depending tubular string F, and out through the whirler shoe 89, for upward passage around the liner B, through the openings 96 in the sub and the body passage 35, 35a to the surface of the bore hole. Fluid may pass through the tubing F below the setting tool after its sleeve 66 has been tripped, since it will be noted that the ports 76 through the tripping sleeve are then positioned within the enlarged lower passage 67a in the setting tool body, with its tripping sleeve resting on its associated stop pin 87 (see Figures 6 and 7). After the packer has been set and the latches 54 released, the setting tool E may be elevated from the packer body, as shown in Figure 7, allowing circulation to occur in the manner described, with the fluid passing around the setting tool E and upper tubular string D, after moving through the packer body passage 35, 35a.

When the sleeve 66 is in its tripped position, fluid is incapable of passing through the latch slots 56 due to the provision of the upper seal 74 in the sleeve, which in conjunction with the intermediate sealing ring 73 is disposed on opposite sides of the slots 56 to prevent fluid passage through them in both directions. Due to this disposition of packing members, the fluid is confined for movement down through both tubular strings D, F and the shoe 89, being prevented from exiting at any other point.

After the washing and conditioning operation has occurred, the proper quantity of cement slurry can be pumped down the tubular strings D, F and intermediate setting tool E for passage through the shoe 89 and for movement around the liner B toward the liner hanger A. This displacement operation will occur with the setting tool elevated from the packer body (see Figure 7). After sufficient cement slurry has been disposed behind the liner B, the setting tool E can again be lowered into the packer body 10, 34 to its initial position, as determined by the abutting of its collar 88 with the upper end 43 of the packer body, and the cement slurry subjected to a squeeze or pressure imposed through the fluid within the tubular strings D, F. With the sub holes 96 open, the extent of unit squeeze pressure will be limited approximately to a value equaling the weight of the running in string D, E, F divided by the inside area of the liner hanger A.

If it is desired to perform a high pressure squeeze operation on the cement placed behind the liner B, the well packer A is lowered in the hole with tapered or other plugs 97 closing the holes 96 in the liner sub. After the liner hanger has been set in the casing in packed-off condition, any amount of squeeze pressure can be ap-

plied to the fluid or cement slurry behind the liner, particularly since upward movement of the liner B is prevented by the upper set of slips 39 and its cooperable cone 36.

Upon completion of the displacement or squeeze cementing operation, the setting tool E can be elevated from the set well packer (see Figure 7), and the entire tubular string D, E, F rotated to the right a sufficient number of turns to unscrew the threaded end 90 of the tubular string F from the cooperable left hand threads in the shoe 89. The entire string and setting tool D, E, F may then be elevated to the surface of the well bore.

It is also preferred to weld or otherwise secure one or more pins 98 at spaced intervals around the packer body groove 62. These pins extend into the groove and cooperate with the sides of the latches 54, so that the tubular string D, E, F, liner hanger A, its depending liner B and shoe 89 can be rotated together prior to the setting of the liner hanger in the casing, in the event that such operation becomes desirable in lowering the assembled apparatus into the hole or in washing the hole before the packer has been tripped. If the groove pins 98 were not provided, the tubular string D, E, F might rotate with respect to the liner hanger A, liner B and shoe 89, and result in the unscrewing of the lower end 90 of the string from the shoe.

While the setting tool has been described in connection with a well packer having both upper and lower slips, it is to be understood that it will function properly in connection with a well packer embodying the lower slips only. Moreover, although specifically described as a liner hanger, the tool is capable of use for other well packer purposes, such as a production packer or cement retainer.

We claim:

1. An apparatus of the character described including a body adapted to be lowered in a well casing, means for anchoring said body to said casing against movement in an upward direction, means for anchoring said body to said casing against movement in a downward direction, said body consisting of readily drillable material adjacent said first-mentioned anchoring means and difficultly drillable material adjacent said second-mentioned anchoring means.

2. An apparatus of the character described including a body adapted to be lowered in a well casing, means cooperable with the upper portion of said body for anchoring it to said casing against movement in an upward direction, means cooperable with the lower portion of said body for anchoring it to said casing against movement in a downward direction, the upper portion of said body consisting of readily drillable material and its lower portion of difficultly drillable material.

3. An apparatus of the character described including a body adapted to be lowered in a well casing, cooperable slip and expander means carried by the upper portion of said body for anchoring it to said casing against movement in an upward direction, cooperable slip and expander means carried by the lower portion of said body for anchoring it to said casing against movement in a downward direction, the upper portion of said body and first-mentioned expander means consisting of readily drillable material, and the lower portion of said body consisting of difficultly drillable material.

4. An apparatus of the character described in-

cluding a composite body adapted to be lowered in a well casing and consisting of an upper readily drillable portion and a lower difficultly drillable portion, a readily drillable conical expander mounted on said upper body portion, slips cooperable with said conical expander for anchoring said body to said casing against movement in an upward direction, a second conical expander mounted on said lower body portion, and slips cooperable with said second conical expander for anchoring said body to said casing against movement in a downward direction.

5. An apparatus of the character described including a composite body adapted to be lowered in a well casing and consisting of an upper readily drillable portion and a lower difficultly drillable portion, a readily drillable expander having an upwardly converging outer surface mounted on said upper body portion, slips having upwardly directed wickers cooperable with said expander for anchoring said body to said casing against movement in an upward direction, a second expander having a downwardly converging outer surface mounted on said lower body portion, and slips having downwardly directed wickers cooperable with said second expander for anchoring said body to said casing against movement in a downward direction.

6. An apparatus of the character described including a body adapted to be lowered in a well casing, means for anchoring said body to said casing against movement in an upward direction, means for anchoring said body to said casing against movement in a downward direction, said body consisting of readily drillable material adjacent one of said anchoring means and difficultly drillable material adjacent the other of said anchoring means.

7. An apparatus of the character described including a composite tubular body adapted to be lowered in a well casing and consisting of an upper readily drillable portion secured to a lower steel portion, a readily drillable expander mounted on said upper body portion, slips cooperable with said expander for anchoring said body to said casing against movement in an upward direction, a second expander mounted on said steel body portion, and slips cooperable with said second expander for anchoring said body to said casing against movement in a downward direction.

8. An apparatus of the character described including a body adapted to be lowered in a well casing, normally retracted means for anchoring said body to said casing against movement in an upward direction, normally retracted means for anchoring said body to said casing against movement in a downward direction, means capable of elongation by fluid under pressure within said body for impelling said first-mentioned anchoring means into engagement with said casing, and separate means capable of elongation by fluid under pressure within said body for impelling said second-mentioned anchoring means into engagement with said casing.

9. An apparatus of the character described including a body adapted to be lowered in a well casing, cooperable slip and expander means for anchoring said body to said casing against movement in an upward direction, cooperable slip and expander means for anchoring said body to said casing against movement in a downward direction, fluid operated means for moving one of said slip means and its cooperable expander means with respect to each other to impel said slip

means into engagement with said casing, and means capable of elongation by fluid under pressure within said body for moving the other of said slip means and its cooperable expander means with respect to each other to impel said other slip means into engagement with said casing.

10. An apparatus defined in claim 9, said last-mentioned means comprising a packing sleeve adapted to effect a seal between said body and casing.

11. An apparatus of the character described including a body adapted to be lowered in a well casing, a conical expander mounted on said body, slips cooperable with said conical expander for anchoring said body to said casing against movement in an upward direction, a second conical expander mounted on said body, slips cooperable with said second conical expander for anchoring said body to said casing against movement in a downward direction, fluid operated means acting directly on said first-mentioned slips for impelling them along their cooperable expander into engagement with said casing, and separate fluid operated means for moving said second conical expander along its cooperable slips to impel them into engagement with said casing.

12. An apparatus of the character described including a body adapted to be lowered in a well casing, an expander having an upwardly converging outer surface mounted on said body, slips movable along the outer surface of said expander into engagement with said casing, a second expander having a downwardly converging outer surface mounted on said body, slips movable along the outer surface of said second expander into engagement with said casing, fluid operated means for impelling said first-mentioned slips downwardly along their cooperable expander to casing engaging position, and separate fluid operated means for moving said second expander downwardly along its cooperable slips to impel them into engagement with said casing.

13. An apparatus of the character described including a body adapted to be lowered in a well casing, a conical expander mounted on said body, slips cooperable with said expander for anchoring said body to said casing against movement in an upward direction, a second conical expander mounted on said body, slips cooperable with said second expander for anchoring said body to said casing against movement in a downward direction, fluid operated means for impelling said first-mentioned slips along their cooperable expander into engagement with said casing, and means comprising a packing sleeve on said body for moving said second conical expander along its cooperable slips to impel them into engagement with said casing.

14. An apparatus of the character described including a body adapted to be lowered in a well casing, an upper conical expander mounted on said body, an upper set of normally retracted slips cooperable with said expander for anchoring said body to said casing against movement in an upward direction, a lower conical expander mounted on said body, a lower set of normally retracted slips cooperable with said lower expander for anchoring said body to said casing against movement in a downward direction, a sleeve on said body capable of elongation by fluid under pressure within said body for impelling said upper slips along their cooperable expander into engagement with the casing, and

means comprising a packing sleeve on said body capable of elongation by fluid under pressure within said body for moving said lower expander along said lower slips to impel them into engagement with the casing.

15. An apparatus of the character described including a body adapted to be lowered in a well casing, an expander mounted on said body, slips cooperable with said expander to anchor said body to said casing, and means for moving said expander and slips with respect to each other to impel the latter into engagement with said casing comprising a sleeve capable of inflation by fluid under pressure within said body and a pliable, inelastic annulus connected to said sleeve and adapted to engage both said body and casing to effect a seal therebetween.

16. An apparatus of the character described including a body adapted to be lowered in a well casing, an expander mounted on said body, slips cooperable with said expander to anchor said body to said casing, and means for moving said expander and slips with respect to each other to impel the latter into engagement with said casing comprising instrumentalities operable by fluid under pressure within said body and a pliable, inelastic annulus connected to said instrumentalities and adapted to engage both said body and casing to effect a seal therebetween.

17. An apparatus of the character described including a body adapted to be lowered in a well casing, a generally conical expander mounted on said body, normally retracted slips cooperable with said expander for anchoring said body to said casing, a sleeve capable of elongation by fluid under pressure within said body, and a pliant, inelastic annulus connecting said sleeve and expander and adapted to effect a seal between said body and casing.

18. An apparatus of the character described including a tubular body adapted to be lowered in a well casing, a generally conical expander mounted on said body, normally retracted slips cooperable with said expander for anchoring said body to said casing, a sleeve capable of elongation by fluid under pressure within said body and fixed at one end to said body, a pliant, inelastic annulus connected to the other end of said sleeve and to said expander, said sleeve and annulus adapted to effect a seal between said body and casing, said body having a port through its wall opening into said sleeve.

19. An apparatus of the character described including a body adapted to be lowered in a well casing, means for anchoring said body to said casing against movement in an upward direction, means for anchoring said body to said casing against movement in a downward direction, fluid operated means for impelling said first-mentioned anchoring means into engagement with said casing, separate fluid operated means for impelling said second-mentioned anchoring means into engagement with said casing, and means for conducting fluid under pressure simultaneously to said respective fluid operated means to produce their actuation.

20. An apparatus of the character described including a tubular well packer body, means for anchoring said body to a well casing against movement in an upward direction, means for anchoring said body to said casing against movement in a downward direction, fluid operated means for impelling said first-mentioned anchoring means into engagement with said casing, separate fluid operated means for impelling said

second-mentioned anchoring means into engagement with said casing, a tubular member within said body having means for conducting fluid from the interior of said member to said respective fluid operated means, and means movable within said tubular member for controlling the passage of fluid through said conducting means.

21. An apparatus of the character described including a tubular well packer body, means for anchoring said body to a well casing, fluid operated means for impelling said anchoring means into engagement with said casing, a tubular member within said body having ported means for conducting fluid from the interior of said member to said fluid operated means, and valve means within said member normally closing said ported means and adapted for slidable movement therewithin to open said ported means.

22. An apparatus of the character described including a well packer, a member within said packer forming the lower end of a running-in string by which said packer is movable through a well casing, means for coupling said member to said packer, means within said member for retaining said coupling means in its coupled position, said last-mentioned means being movable by the pressure of fluid within said member to a position permitting inward movement of said coupling means to effect release of said member from said well packer.

23. An apparatus of the character described including a well packer having a tubular body, a tubular member within said body forming part of a tubular string by which said packer is movable through a well casing, coupling means, a sleeve within said member for holding said coupling means in an outer position to couple said member to said tubular body, and means enabling said sleeve to be shifted by fluid under pressure within said member to a position permitting said coupling means to move inwardly and uncouple said member from said body.

24. An apparatus of the character described including a well packer having a body, a member within said body forming part of a run-in string by which said packer is movable through a well bore, coupling means, means within said member for holding said coupling means in position to couple said member and body together, and means enabling said holding means to be shifted by fluid under pressure within said member to allow said coupling means to occupy a position uncoupling said member and body.

25. An apparatus of the character described including a well packer having a body, a member within said body forming part of a run-in string by which said packer is movable through a well bore, coupling means carried by said member, means within said member for holding said coupling means in an outer position to couple said member to said body, said holding means having a recessed portion, and means for shifting said holding means within said member to position its recessed portion adjacent said coupling means and permit withdrawal of the latter inwardly from said body.

26. An apparatus of the character described including a well packer having a tubular body, a tubular member within said body forming part of a tubular string by which said packer is movable through a well bore, coupling means carried by said member, a sleeve within said member for holding said coupling means in an outer position to couple said member to said body, said sleeve having a recessed portion, and means enabling

fluid pressure to be built up in said tubular member to shift said sleeve and position its recessed portion adjacent said coupling means, permitting withdrawal of the latter inwardly from the body.

27. An apparatus of the character described including a well packer having a tubular body, a tubular member within said body forming part of a tubular string by which said packer is movable through a well bore, latches pivotally carried by said member and receivable within a groove in said body, a sleeve within said member for holding said latches in said groove to couple said member to said body, said sleeve having a portion of reduced diameter, and means for closing the passage through said sleeve to enable fluid under pressure to be built up within said tubular string and shift said sleeve downwardly to position its reduced diameter portion opposite said latches, permitting their inward withdrawal from said body groove.

28. An apparatus of the character described including a body adapted to be lowered in a well casing, normally retracted means carried by said body, fluid operated means for impelling said normally retracted means into engagement with said casing, a member within said body forming part of a run-in string by which said body is movable through said casing, releasable means for coupling said member to said body, and means within said member for controlling the passage of fluid to said fluid operated means and release of said releasable means to allow uncoupling of said member and body from each other.

29. An apparatus of the character described including a body adapted to be lowered in a well casing, normally retracted slips carried by said body, fluid operated means for impelling said slips into engagement with said casing, a tubular member within said body forming part of a tubular string by which said body is movable through said casing, releasable means for coupling said member to said body, means having ports therein for conducting fluid from the interior of said tubular member to said fluid operated means, said ported means holding said releasable means in coupling position, and means within said ported means normally closing its ports, but adapted for sliding movement therewithin to open said ports and move said ported means within said tubular member to a position allowing release of said releasable means and uncoupling of said member and body from each other.

30. An apparatus of the character described including a well packer body, a tubular member within said body forming part of a tubular string by which said body is movable through a well casing, normally retracted slips carried by said body, fluid operated means for impelling said slips into engagement with said casing, releasable means for coupling said member to said body, a sleeve having ports within said member, said sleeve holding said releasable means in coupling position, a valve within said sleeve normally closing said ports to prevent passage of fluid to said fluid operated means, and means cooperable with said valve to open said ports and shift said sleeve in said member to a position allowing release of said releasable means and uncoupling of said member and body from each other.

31. In combination, a liner, a liner hanger for selectively positioning and suspending said liner in a well pipe, and having a passage there-through, a setting tool having means detachably engageable with said hanger and extending into the passage thereof, said tool also having

a fluid channel therein and means for closing off the space between the same and the hanger when engaged therein, and a wash pipe depending within the liner from said tool.

32. In combination, a liner hanger for selected, retrievable setting in a well pipe, having a lengthwise passage, a liner suspended from said hanger, a setting tool engageable with, and disengageable from, said hanger for setting the latter and having a hollow body telescoping within the passage of the hanger when engaged therewith and closing the same, and a wash pipe carried by said tool body in communication with the hollow body thereof and depending, in said engaged position of the tool, within the liner substantially below the lower end of the hanger.

33. A well packer having external means for engagement with a well pipe in which the packer is to be set, fluid pressure actuated means for moving said external means into engagement with said well pipe, a setting tool within said packer having conducting means to feed fluid under pressure to and actuate said fluid pressure actuated means, and fluid pressure controlled valve means in said setting tool initially maintaining said conducting means closed to flow of fluid to said fluid pressure actuated means to prevent movement of said external means into engagement with said pipe prior to the time when it is desired to set said packer in said pipe, said valve means being operable when desired.

34. An apparatus of the character described including a well packer body, means for anchoring said body to a well casing, fluid operated means for impelling said anchoring means into engagement with said casing, a tubular member within said body having ported means for conducting fluid from the interior of said member to said fluid operated means, and valve means for closing said ported means prior to engagement of said anchoring means with said casing.

35. An apparatus of the character described including a well packer body, means for anchor-

ing said body to a well casing, fluid operated means for impelling said anchoring means into engagement with said casing, a setting tool detachably connected with said body and having a tubular member within said body provided with a port for conducting fluid from the interior of said setting tool to said fluid operated means, a sleeve valve normally closing said port, and means for closing the bore of said sleeve valve to enable its hydraulic shifting to a position in which said port is open.

36. An apparatus of the character described including a well packer body, slips for anchoring said body to a well casing, fluid operated means for shifting said slips into engagement with said casing, a tubular setting tool member within said body having a port for establishing communication between the interior of said member and said fluid operated means, a sleeve valve within said member for closing said port, and means movable downwardly in said member to close the bore through said sleeve valve and enable its hydraulic shifting to port opening position.

37. An apparatus of the character described including a well packer body, retracted means carried by said body, fluid operated means for impelling said retracted means into engagement with a well casing, a tubular member within said body having ported means for conducting fluid from the interior of said member to said fluid operated means, valve means having a bore adapted to be positioned within said member to allow fluid passage through said ported means, and means for closing the bore of said valve means to enable fluid pressure to be built up in said tubular member to actuate said fluid operated means and to shift said valve means within said tubular member to a position allowing passage of fluid through said member after closing of said bore.

CLARENCE E. BURT.
THEODORE SUTTER.
THOMAS M. RAGAN.