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REMOVABLE WELL PACKER

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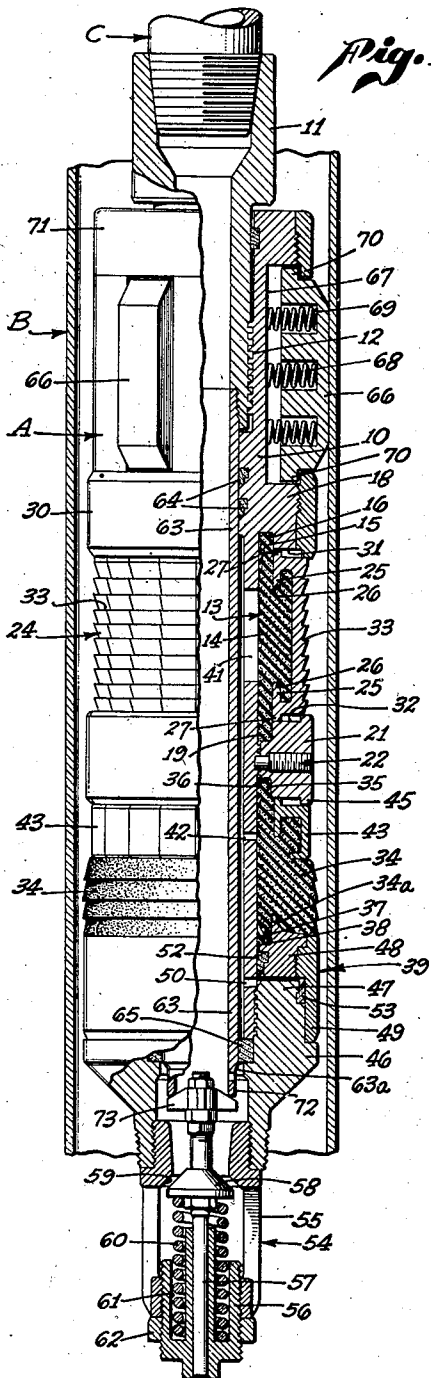


Fig. 1.

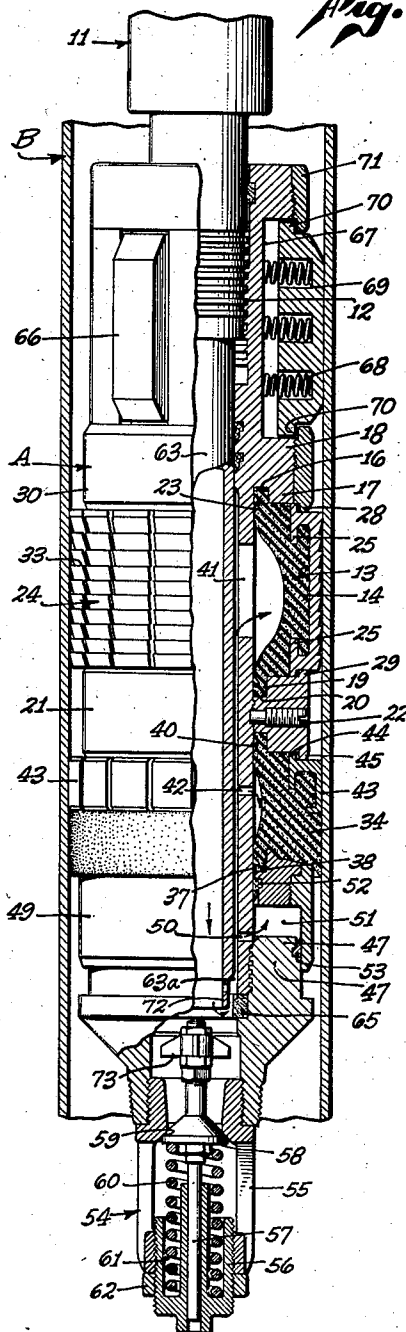


Fig. 2.

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REMOVABLE WELL PACKER

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11 Claims. (Cl. 166—12)

This invention relates to well devices, and more particularly to well packers capable of being set in packed off condition in well bores.

It is sometimes desirable to employ well packers of the bodily removable type in the performance of squeeze cementing, acidizing, testing, or other operations within the well bore, to obviate the necessity for drilling out the particular packer after the well operation has been completed. An object of the present invention is to provide an improved packer of the character indicated having separate casing gripping and packing members normally held in retracted position during movement of the tool through the casing, but adapted to be actuated directly by hydraulic pressure to expand and hold them against the casing.

Still a further object of the invention is to provide a selective control mechanism for determining the application of pressure to the gripping members and packing elements of a well packer, which control is obtainable through rotation of the tubular string to which the tool is attached.

Another object of the invention is to force the packing element of a well packer against the wall of the casing by hydraulically loading one of its ends.

This invention has other objects that will become apparent from a consideration of the embodiment shown in the drawing accompanying and forming part of the present specification. This form 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 view through a well casing, illustrating the well packer with its casing engaging elements in retracted position; and

Figure 2 is a view similar to Figure 1, with the packer anchored in packed off condition against the casing.

The well packer A disclosed in the drawing is designed to be run in a well casing B on the lower end of a tubular string C of tubing or drill pipe. The main tubular body 10 of the packer is supported from the tubular string through a sub 11 attached to the upper portion of the body by means of interengaging left hand threads 12, so as to permit disconnection of the tubing string C from the entire well packer A, if such action becomes necessary or desirable.

The tubular body 10 has a rubber or other elastic or flexible actuator sleeve 13 encircling its exterior. This elongate actuator consists of a main body portion 14 having an upward extension 15 received within an annular groove 16 formed between the cylindrical exterior of the body 10 and a ring 17 depending from a flange 18 extending outwardly from the body. The actuator 13 also includes a depending extension 19 received within a groove 20 defined between the cylindrical exterior of the body and a retainer ring 21 threaded on the body and prevented from rotating thereon by a set screw 22. The extensions 15, 19 are formed with oppositely facing annular lip seals 23, 23 engaging the exterior of the body 10 so as to prevent leakage of fluid along the body from the interior of the elastic actuating member 13.

A plurality of relatively narrow casing gripping segments or members 24 extends lengthwise of the elastic actuator 13, being positioned closely adjacent one another when in retracted position so as to substantially completely encompass the full exterior of the actuating member. These gripping segments 24 are held in assembled position on the actuator 13 by opposed inwardly extending arms 25, 25 received within companion annular grooves 26, 26 in the ends of the actuating member. It is to be noted that this construction in effect embeds the arms 25 of the segments in the elastic actuator, so that upon retraction of the latter the segments 24 will correspondingly be moved to an inward, retracted position. In this connection, outward movement of the segments upon inflation or expansion of the rubber actuator 13 is limited by engagement of the terminal ears 27, 27 on the segments with circumferential stop members 28, 29 extending, respectively, from a lower runner ring 30 threaded on the intermediate body flange 18 and from the retainer ring 21. Radial movement of the gripping segments 24 to and from the casing is guided by the upper and under surfaces 31, 32 of the intermediate body flange 18 and retainer ring 21, while the external face of each segment is provided with upwardly facing teeth or wickers 33 designed to grip the casing and anchor the packer thereto by preventing its upward movement. The actuator 13 and segments or members 24 together comprise a casing gripping means for anchoring the packer to the well casing.

The well packer is also provided with a packing member 34 for effecting a seal between the tubular body 10 and the wall of the casing B. This

member encompasses the body below the gripper segments 24 and is provided with an upper extension 35 seated within an annular groove 36 formed between the body and the retainer ring 21, and a lower extension 37 seated within an annular groove 38 formed between a packing expander 39 and the body portion 10. As was described in connection with the actuating member 13 for the gripper segments, the extensions have opposed lip seals 40, 40 engaging the exterior of the body to prevent leakage of fluids from within the packing 34 along the body.

Both the gripper segment actuator 13 and the packing 34 are expansible by the direct application of fluid under pressure to their interiors. To achieve this purpose, ports 41 are formed through the body 10 for conducting fluid from its interior into the actuating member 13 to expand the latter and produce corresponding bodily movement of the gripping segments 24 radially into engagement with the casing. The body also has a second set of ports 42 establishing communication between its interior and the interior of the packing member 34, to conduct fluid under pressure into the packing to inflate it and engage its exterior surface with the wall of the casing. This packing is preferably provided with a plurality of segments 43 embedded therein at its upper end which are movable into engagement with the casing to form an annular bridge between the retainer ring 21 and the casing B, so as to prevent plastic or cold flowing of the packing material, as described and claimed in my co-pending application entitled "Packing devices," filed January 15, 1941, Serial No. 374,471, now Patent No. 2,295,770. As described in this application, the extent of outward movement of the segments 43 is limited by engagement of their ears 44 with a stop 45 depending from the retainer ring 21.

A guide 46 is threaded on the lower end of the body, its upper end functioning as a piston 47, above which a cylinder head 48 is disposed for sliding movement along the exterior of the main body 10 of the packer. A skirt 49 is secured to and depends from this cylinder head 48 for sliding movement along the exterior of the piston. This piston and cylinder device constitute the packing expander 39 for additionally securing the packing 34 in engagement with the wall of the casing. This result is obtained by directing fluid under pressure through a third set of ports 50 in the body into the cylinder space 51 between the cylinder head and piston, the fluid under pressure moving this cylinder 48, 49 upwardly to slide the lower end 37 of the packing along the body 10 and also force the packing 34 radially outwardly against the casing. This outward movement is assisted by tapering the end 34a of the packing downwardly and outwardly and correspondingly tapering the cylinder head 48, so as to provide a lateral thrust component, which, upon upward movement of the cylinder, urges the packing outwardly against the casing. For the purpose of confining the fluid to the cylinder space 51 between the cylinder head 48 and piston 47, a seal ring 52 is placed in the cylinder head for slidable engagement with the body 10, and a piston ring 53 is mounted on the exterior of the piston for slidable sealing engagement with the interior of the cylinder skirt 49.

The elastic actuating member 13 and packing member 34 inherently tend to assume retracted positions against the packer body, in spaced rela-

tion with the wall of the casing B. Upon reaching the desired setting point in the casing, fluid under pressure is pumped down the tubular string C for passage through the body 10 and the various ports 41, 42, 50 to expand the actuating member 13 outwardly and urge the segments 24 into gripping engagement with the wall of the casing, to expand the packing 34 into sealing engagement with the casing due to its inflation by the direct application of fluid pressure to its interior, and to further hold the packing against the casing by upward movement of the cylinder 48, 49 along the body 10 and piston portion 47 of the guide 46. With the parts in these positions, any forces tending to shift the packer A upwardly in the casing are resisted by the embedding of the wickers 33 in the casing, such forces being transmitted from the guide 46, body 10 and packing expander 39 through the retainer ring 21 and segments 24 directly to the casing. When the fluid pressure is released, the inherent retracting forces of the elastic actuator 13 and packing member 34 automatically produce their withdrawal from the casing, the actuator carrying the segments 24 to their initial retracted position, and the packing member automatically carrying the flow preventing segments 43 inwardly from the casing and forcing the packing expander 39 downwardly to its initial position.

From the combination of elements described, it is apparent that pressure internally of the tool body expands the gripping segments 24 and packing 34 into engagement with the casing, while a relieving of this pressure permits their automatic retraction to occur. For the purpose of obtaining a greater pressure within the tool body over that externally thereof, various expedients may be employed. In the present instance, a back-pressure valve 54 is disclosed, which can maintain a greater pressure within the tool than externally thereof, to ensure the holding of the gripping segments 24 and packing 34 in engagement with the casing during performance of an operation within the well bore.

This back-pressure valve 54 consists of a spider-like cage 55 screwed in the lower end of the guide 46, and carrying at its lower end a guide 56 for a valve stem 57, to which is affixed a valve head 58 adapted to engage a seat 59 provided on the cage itself. The valve head 58 is urged to closed position against its seat 59 by a helical spring 60 received within an annular groove 61 formed in the valve guide 56 and engaging the head 58 to move it upwardly into contact with the seat 59. When the pressure inside the tool overcomes the force of the spring 60, the valve opens by forcing the head from its seat against the action of the spring. The tension in this latter element is adjustable by threading the stem guide 56 in the cage 55 and holding it in any position of adjustment by a lock nut 62. This adjustment is preferably made to such a degree as to ensure that the gripping segments 24 and the packing member 34 are in engagement with the casing before the valve 54 opens. Because of this fact, assurance is had that the pressure within the tool body is always greater than that externally thereof, in order to keep the expansible members 24, 34 engaged with the casing. The back-pressure valve 54 also serves the further purpose of preventing return flow of fluids back into the well packer A and tubular string C.

The passage of fluids through the various ports in the packer body is controlled by a tubular valve

sleeve 63 therewithin. This sleeve is secured to the sub 11 for rotation with it, and is adapted to have slidable sealing engagement with upper and lower sealing rings 64, 65 disposed on opposite sides of the sets of ports 41, 42, 50. When the sleeve 63 is in its lower position with its external surface engaging both the upper and lower rings 64, 65, fluid is incapable of passing between the interior of the tubing string C and the interiors of the elastic actuator 13, packing member 34 and cylinder space 51. However, upon elevation of the tubular sleeve 63 so that its lower end 63a is positioned above the lower sealing ring 65, fluid may pass from the tubular string around the bottom end of the sleeve into the space between the sleeve 63 and body 10, and through the ports 41, 42, 50 of the latter into the actuating member 13, packing 34 and cylinder space 51, to move the gripping segments 24 and packing 34 into engagement with the casing B. Movement of the valve sleeve 63 to open and closed positions is accomplished through rotation of the tubular string C from the surface of the well bore.

The tubular body 10 is prevented from rotating by a friction device, which in the present instance consists of friction runners 66 disposed in spaced longitudinal slots 67 formed in the body 10. These runners are urged outwardly into frictional engagement with the casing by a plurality of coil springs 68 received within sockets 69 in the runners and bearing upon the bottoms of the slots 67. The extend of outward movement of these friction runners 66 is limited by engagement of the runner terminals 70 with an upper stop ring 71 threaded on the body and the lower ring 30 previously described. Although these friction runners 66 resist rotation of the packer body 10, they do not prevent its longitudinal movement through the casing in either direction, since they can merely slide along the inner surface of the casing.

As was stated above, the sub 11 is connected to the body by means of the left hand threads 12. Since rotation of the body is resisted by the friction runners 66, turning of the tubular string C the desired number of revolutions to the right results in elevation of the sub 11 and the tubular valve sleeve 63 attached thereto with respect to the body 10 until the lower end 63a of the sleeve has been positioned above the lower seal ring 65. Conversely, rotation of the tubular string C to the left produces lowering of the sub 11 and tubular valve sleeve 63 with respect to the body 10 to engage the latter with the seal ring 65 and close the ports 41, 42, 50.

While running the tool in the well bore, it is preferred that the tubing string C be permitted to fill up with fluid. To accomplish this purpose, the back-pressure valve head 58 is held off its seat 59 by an extension 72 on the valve sleeve 63 having a substantially lesser diameter than the lower seal ring 65, so as not to seal or engage therewith upon elevation of the valve sleeve. This extension 72 contacts a winged spider 73 secured to the upper end of the valve stem 57 when the valve sleeve 63 is in its lowermost position to hold the valve head 58 off its seat 59 against the action of the valve spring 60. Not only does this allow fluid to move into the tubing string C as the well packer A is being lowered in the casing, but this position of the valve sleeve also closes the various ports 41, 42, 50, so as to permit the building up of fluid pressure within the sleeve 63 without effecting expansion of the packing 34 and gripping members 24 from their retracted positions. Because of this fact, circulation can be

established through the tubing string for upward passage around the tool without fear of setting the packer elements against the casing, nor can any pressure built up within the sleeve 63 and tubing string C during running of the tool in the casing effect premature and inadvertent setting of the tool.

After the desired setting point in the casing has been reached, the tubing string C is rotated to the right, as described above, to elevate the valve sleeve 63 and move its lower end 63a from engagement with the lower seal ring 65, as well as its extension 72 from the spider 73. This will allow the valve spring 60 to close the valve, and permit fluid under pressure to pass around the sleeve 63 and through the body ports 41, 42, 50 into the elastic actuator 13, packing 34 and cylinder space 51, to expand the packing and gripping segments 24 into engagement with the casing. So long as pressure is maintained within the tool, these members will be held in contact with the casing.

If it is desired to relieve the pressure within the tubular string and still hold the tool in anchored and packed off condition within the casing, the tubular string C is rotated to the left while maintaining pressure therewithin, to reengage the lower seal 65 with the tubular valve sleeve 63 and thus trap fluid under pressure within the segment actuator 13, packing 34, and cylinder space 51.

With the tubular sleeve in elevated position (as in Figure 2), and after performance of the desired well operation at the particular point at which the tool was set, the pressure can be bled off to allow the casing engaging members 24, 34 to retract to their initial positions, whereupon the tubing string C may be rotated to the left to lower the tubular valve sleeve 63 to a position in which its extension 72 engages the spider 73 and holds the valve head 58 from its seat 59. The well packer A may now be moved within the well casing B to another setting point or it can be removed entirely to the surface of the well bore, as desired. During upward movement of the tool, the holding of the valve head 58 in open position enables the fluid to automatically drain from the tubular string C, thereby preventing the undesired flooding of fluids on the rig floor.

The holding of the valve 54 open after the particular well operation has been performed also permits a further operation to take place, namely, the reverse circulation of excess cement from the well bore after a cementing operation has been performed. That is, fluid forced downwardly through the annular space between the tubular string C and casing B can pass down around the well packer A and upwardly through the valve 54, tool body 10, and tubular string C to the surface of the well bore.

Reference is herewith made to my application for "Retrievable well packers," Serial No. 407,430, filed August 19, 1941, in which is claimed the broader aspects of the invention hereinabove described.

I claim:

1. A well packer, including a body adapted for lowering in a well casing on a tubular string, an elastic sleeve surrounding said body with its ends secured thereto, a plurality of narrow circumferentially juxtaposed segmental casing gripping members completely encircling said sleeve and extending longitudinally thereof substantially parallel to the axis of said well packer, a casing engaging packing separate from said elastic sleeve mounted on said body below said casing gripping members, and means for directing

fluid under pressure from the interior of said body into said sleeve to expand it and bodily translate said casing gripping members radially into engagement with said casing.

2. A well packer, including a body adapted for lowering in a well casing on a tubular string, an elastic sleeve surrounding said body with its ends secured thereto, a plurality of narrow circumferentially juxtaposed segmental casing gripping members completely encircling said sleeve and extending longitudinally thereof substantially parallel to the axis of said well packer, a separate normally retracted packing mounted on said body below said casing gripping means, and means for directing fluid under pressure from the interior of said body into said sleeve and packing to expand said sleeve and bodily translate said casing gripping members radially into engagement with said casing and also engage said packing with said casing.

3. A well packer, including a body adapted for lowering in a well casing on a tubular string, a normally retracted packing carried by said body for effecting a seal with said casing, cylinder and piston means on said body engageable with an end of said packing to compress it and move it radially into engagement with said casing, means for directing fluid from the interior of said body to said cylinder and piston means, and valve means operable by manipulation of said tubular string for controlling said directing means to selectively permit or prevent return flow of fluid from said cylinder and piston means to the interior of said body.

4. A well packer, including a body adapted for lowering in a well casing on a tubular string, a normally retracted packing sleeve carried by said body for effecting a seal with said casing, cylinder and piston means on said body engageable with an end of said packing to move it into engagement with said casing, means for directing fluid from the interior of said body into said packing and cylinder and piston means, whereby to force said packing hydraulically into engagement with said casing, and means for selectively controlling passage of fluid in both directions through said directing means to permit selective expansion or retraction of said packing sleeve.

5. A well packer, including a body adapted for lowering in a well casing on a tubular string, a normally retracted packing carried by said body for effecting a seal with said casing, a piston secured to said body, a cylinder movable on said piston and engageable with said packing to move it into engagement with said casing, and means for directing fluid from the interior of said body into said cylinder to actuate the same.

6. A well packer, including a body adapted for lowering in a well casing on a tubular string, casing gripping means carried by said body, a normally retracted packing mounted on said body, hydraulically operable means engaging said packing for moving it into engagement with said casing, means for directing fluid from the interior of said body to said casing gripping means and to said hydraulically operable means for actuating said casing gripping means and hydraulically operable means, and valve means attached to and extending within said body, said valve means being connectible to said tubular string to be rotated by said tubular string for selectively opening and closing said directing means.

7. A well packer, including a body adapted for lowering in a well casing on a tubular string, casing gripping means carried by said body, a normally retracted packing mounted on said body, hydraulically operable means engaging said packing for moving it into engagement with said casing, means for directing fluid from the interior of said body to said casing gripping means, to said packing and to said hydraulically operable means for actuating said casing gripping means, packing and hydraulically operable means, and a sleeve valve attached to and extending within said body, said sleeve valve being connectible to said tubular string to be rotated by said tubular string for selectively opening and closing said directing means.

8. A well packer, including a body adapted for lowering in a well casing on a tubular string, normally retracted means carried by said body for engagement with said casing, hydraulically operated means for moving said normally retracted means into engagement with said casing, valve means attached to and extending within said body, said valve means being connectible to said tubular string to be rotated by said tubular string for controlling the passage of fluid into said hydraulically operated means.

9. A well packer, including a body adapted for lowering in a well casing on a tubular string, casing anchoring means carried by said body, means for directing fluid between the interior of said body and said casing anchoring means to bodily translate said anchoring means radially into engagement with said casing, valve means attached to and extending into said body and connectible to said tubular string to be rotated by said tubular string for selectively opening and closing said directing means, and means on said body engageable with said casing for resisting movement of said body therewithin to permit said valve means to be rotated by said tubular string while said casing anchoring means is in retracted position.

10. A well packer, including a body adapted for lowering in a well casing on a tubular string, a flexible sleeve mounted on said body, a plurality of circumferential juxtaposed casing gripping members disposed around said sleeve and extending longitudinally thereof substantially parallel to the axis of said well packer, a packing separate from said flexible sleeve mounted on said body, and means for directing fluid pressure from the interior of said body into said sleeve and packing to expand said sleeve and bodily translate said casing gripping members radially into engagement with said casing and also engage said packing with said casing.

11. A well packer, including a body adapted for lowering in a well casing on a tubular string, normally retracted means carried by said body for engagement with said casing, hydraulically operated means for moving said normally retracted means into engagement with said casing, and means threadedly attached to said body and adapted to be secured to said tubular string, comprising a sleeve valve extending into said body and movable by rotation of said tubular string for controlling the passage of fluid into said hydraulically operated means.

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