WELL PACKER AND TUBING STRING COUPLING THEREFOR

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4 Claims. (Cl. 166—201)

The present invention relates to subsurface well tools, and more particularly to well packer apparatus adapted to be introduced in a well bore.

This application is a division of our application for "Wire Line Packer and Tubing String Combination," Serial No. 178,212, filed August 8, 1950, now Patent No. 2,713,907.

An object of the invention is to provide a well packer having a packing element that resists buckling, especially when expanded outward to large extents.

Another object of the invention is to provide a well packer having a packing element that has a large extent of outward expansion, and which is capable of providing a plurality of seals against the wall of a well bore, or other confining enclosure.

A further object of the invention is to provide a well packer through which fluid can flow and having a comparatively long tubular body extension above its packing structure to enable cementitious material to be deposited around the body without plugging the body passage.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figures 1 and 1a constitute a sectional view through a well apparatus disposed in an open well bore. Fig. 1a constituting a lower continuation of Fig. 1; Fig. 2 is a cross-section taken along the line 2—2 on Fig. 1; Fig. 3 is a cross-section taken along the line 3—3 on Fig. 1a; Fig. 4 is a view similar to Fig. 1a, illustrating the well packer set in the well bore and cementitious material being deposited upon it; Fig. 5 is a view similar to Figs. 1a and 4, disclosing a tubing string in leakproof relation to the well packer; Fig. 6 is a cross-section taken along the line 6—6 on Fig. 5; Fig. 7 is a cross-section taken along the line 7—7 on Fig. 5.

As disclosed in the drawings, the apparatus includes a well packer A adapted to be expanded to a substantial extent into leakproof engagement with the wall of an open well bore B. After having been set in the well bore B by means of a setting tool C, the latter is released from the packer and cementitious material D, contained in the dump bailer portion E, of the setting tool dumped upon and around the set packer.

The cementitious material D sets and hardens in the well bore B to form a supplemental plug therein, which can also anchor the packer A in the well bore and hold its main body portion 10 centered with respect to the well bore, in order that the subsequent leakproof association of a tubing string F with the packer can be facilitated. The well packer has a passage 11 therethrough which will communicate with the tubing string, to allow fluid to pass in both directions between the well bore B below the well packer A and the interior of the tubing string.

The well packer and setting tool combination are preferably run in the well bore on a wire line running-in string G, and after the packer has been set and the cementitious material D dumped thereupon, the setting tool C may be retrieved to the top of the well bore through elevation of the wire line.

The packer A disclosed in the drawings includes the tubular body portion 10, which has a lower abutment and guide 12 threadedly secured on its lower end. A packing element or structure 13 surrounds the body, with its lower end resting upon the guide 12, and with its upper end supporting an upper abutment 14 slidably mounted upon the packer body 10. The packing element or structure 13 preferably includes a plurality of packing sleeves 15 which are separated by an intervening washer or disc 16. Moreover, to limit the extent of outward expansion of the packing element, a tubular stop sleeve 17 is disposed therewithin, which is slidable relative to the tubular body 10. Originally, this stop sleeve has a substantially shorter length than the distance between the upper and lower abutments 14, 12.

A the packing element 13 is expanded outwardly into engagement with the wall of the confining well bore B by moving the abutments 14, 12 toward one another, thereby shortening the packing sleeves 15 and causing the latter to bulge outwardly toward the formation.

As explained hereinafter, a downward force is imposed upon the upper abutment 14 and an upward force on the tubular body 10 for the purpose of shifting the abutments toward one another. The extent of approach of the abutments is limited by their engagement with the upper and lower ends of the tubular stop sleeve 17, which determines the maximum amount of outward expansion of the rubber packing sleeves 15 into engagement with the bore hole.

The abutments 12, 14 are precluded from moving away from each other, thereby possibly allowing retraction of the packing sleeves 15, by a one-way lock device of any suitable form. As disclosed, this lock device is mounted within the upper abutment 14, consisting of a split sleeve 18 adapted to frictionally engage the exterior of the packer body 10. This sleeve has outer downwardly inclined surfaces 19 engageable with companion inner surfaces 20 in the upper abutment 14. It is apparent that downward movement of the upper abutment 14 along the body 10, or relative upward movement of the tubular body within the upper abutment, is permitted by the sleeve 18. However, movement of these parts in a reverse direction is precluded, since it effectively shifts the lock sleeve or ring 18 in a downward direction with respect to the upper abutment 14 and causes the coengaging cam faces 19, 20 to wedge the sleeve more firmly into engagement with the packer body 10.

The packing element or structure 13 has a comparatively long over-all initial length; so as to provide sufficient packing material for outward expansion to a substantial extent into engagement with the wall of the confining enclosure or well bore B. The making of this element as a single rubber sleeve, for example, might tend to cause its buckling during outward expansion to large extents, and an improper and inadequate pack-off against the wall of the well bore might result. Such single packing element might also become torn or ripped during the outward expansion.
It has been found that the aforenamed difficulties are minimized, if not entirely eliminated, by making the
packing element 13 of the plurality of sleeves 15 separated
by a spacer member 16, such as the washer or disc.

The outward expansion occurs through forced insertion of each sleeve and bulging it outwardly.

The shorter sleeves tend to be anchored at each abutment 14, 12 by frictionally engaging the latter, and their other ends also tend to be anchored by their frictional engagement
against the spacer or separating washer 16. As a result, it is the intermediate portions of each sleeve
which moves outwardly, and, in view of the much shorter length of each sleeve, the buckling tendency is overcome and the sleeves expand outwardly uniformly around their circumferences.

In addition to preventing buckling, the plurality of bulges that are formed effectively provides individual
drives of each rubber sleeve 15 against the formation wall.

The plurality of seals thus provide appear to have a much greater anchoring effect against the wall of the formation, as well as a much greater sealing effectiveness, than a single rubber sleeve would have.

The packer A is of the type that will allow fluid to flow through it after it has been set in the well bore.

For this reason, the body 10 is made tubular and it
preferably extends to a considerable extent above the upper abutment 14. As a matter of fact, the tubular body may be made of sections secured together through the agency of intervening couplings 21. Such upward extension of the tubular body 10 is desired, since cementitious material D may be deposited upon the set packer and around its upwardly extending body portion.

This cementitious material, upon hardening, will form a supplemental plug in the well bore. In fact, it may well have a greater effectiveness as a plug in resisting the well pressures than the rubber plug 15. In addition, it will serve to secure the packer body 10 firmly in the well bore by anchoring the coupling collars 21 to the cement D.

The packer A may be set and the cement D dumped upon the set packer in a single trip of the equipment in the well bore. This is accomplished by securing a combination setting tool and dump bailer C to the packer A.

The lower portion of the setting tool, in effect, constitutes a dump bailer E.

The setting tool includes a power cylinder 22 consisting of a sleeve 23 threaded onto an upper cylinder head 24, and also onto a lower cylinder 25. The lower is slidable mounted in the cylinder and has a rod 27 secured to it, which extends downwardly through the lower head 25.

In the operation of the equipment, a downward pressure is imposed upon the piston 26, tending to move it downwardly in the cylinder 22, and reactively, the cylinder head 25 is moved upwardly.

Since the packer A is set by moving the upper abutment 14 downwardly and the packer body 10 relatively upwardly, it is desired to transfer the upward force of the cylinder 22 to the packer body 10 and the downward force and movement of the piston 26 to the upper abutment 14.

The transfer of the upward force of the cylinder occurs by connecting the lower cylinder head 25 to a tubular mandrel 28, whose lower end is secured onto a tension mandrel 29 threaded onto a tension stud 30. The lower end of the stud is threaded into a plug 31 screwed into the upper end of the packer body 10.

This piston 27 has a cross-piece or anvil 32 extending transversely through it, and also through a pair of opposed elongate slots 33 in the tension mandrel into a setting ring 34. A setting sleeve 35 is threaded onto this ring and extends downwardly along the tubular mandrel 28 and tension mandrel 29, its lower end being threaded into an adapter collar 36 drilled to receive both the upper end of a barrel or container 37 which actually constitutes the dump bailer portion B of the setting tool C. The lower end of the container 37 bears upon the upper abutment 14, leakage between the latter two parts being prevented by a suitable side seal 38 on the upper abutment engaging the inner wall of the container. The flue cementitious material D may be introduced into the barrel 37, and around the packer body 10, through an upper window or opening 39 provided in the barrel.

For the purposes that will appear below, the upper end of the packer body has one or more side ports 40, preferably disposed above the window or opening 39, so as to prevent the cementitious material D from entering the interior of the packer body 10, and possibly plugging it. It is also to be noted that the plug 31 carries one or more side seal rings 41 engaging the inner wall of the body 10, to prevent leakage therealong, and that the stud 30 has an intermediate weakened section 38a, to enable disruption of the stud when sufficient tension is placed upon it, thereby automatically disconnecting the setting tool C from the packer A.

The piston 26 is moved downwardly within the cylinder 22 and the cylinder urged in a relative upward direction by developing a gaseous pressure in the upper portion of the cylinder. A power charge or a combination of gas and explosive as disposed in a combustion chamber 46 formed in the upper cylinder head 24, this power charge being ignited by firing a cartridge 47 contained in a gun barrel 48 clamped between the upper head 24 and a cable head 49, to which the lower end of the wire line G is secured. This latter member has a conductive core or wire 50 having an electrical connection with a heating filament 51 in the cartridge.

When current is caused to pass through the heating filament 51, the cartridge 47 is fired; the flame issuing therefrom in a downward direction igniting the upper end of the power charge 45 and instigating its combustion.

This power charge contains its own source of oxygen, and, as it burns, gas is evolved at a gradually increasing pressure. This gas under pressure forces the piston 26 downwardly in the cylinder 22, the downward movement being transmitted through the piston rod 27, anvil 32, setting ring 34, setting sleeve 35, adapter collar 36 and container 37 to the upper packer abutment 14. At the same time, the cylinder 22 is being urged in an upward direction, such upward movement being transmitted through the tubular mandrel 28, tension mandrel 29, tension stud 30 and plug 31 to the packer body 10, which moves the lower body abutment 12 upwardly. A piston rod 27 in this manner moves the upper and lower abutments 14, 12 are shifted toward one another to bulge and expand the packing structure 13 in a lateral outward direction. Such expansion occurs progressively as the pressure in the cylinder 22 increases, due to the continued combustion of the power charge 45. Eventually, expansion of the packing structure 13 can occur no longer because of engagement of the abutments 12, 14 with the stop sleeve 17. However, the gas pressure in the cylinder is continuing to increase, until the ultimate strength of the weakened section 38a of the tension stud 30 is exceeded, which results in a pulling apart of the tension stud and the detachment of the setting tool C from the well packer A. Following such detachment, the setting tool C can be elevated, preferably in a gradual manner, by elevating the wire line G, the lower end of the container 37 being moved upwardly off the upper abutment 14, allowing the flue cementitious material D to be contained in the container to drop out upon the packer A and around the packer body 10. Inasmuch as the body ports 40 are above the container window or opening 39, no cementitious material will pass through these ports during the dumping operation.

When all the cementitious material D has been emptied from the bailer E, the setting tool C can be removed from the well bore B.

The cementitious material D will set and harden in the well bore around the tubular packer body 10 and also
against the wall of the open hole.

Upon hardening, an annular cement plug is formed in the well bore of extended extent, which is effectively anchored to the formation, in view of the irregularities present in the latter (Fig. 5). In addition, the coupling collars 21 in the body 10 are locked in the hardened cement, which prevents longitudinal displacement of the body in both directions. Deposit of the cement around the body 10, particularly along an extended length of the latter, tends to stabilize the body centered in the well bore, and results in subsequent tilting or inclination.

After the cementing material D is hardened, it is desired to relate a tubing string F to the set packer; so that any well production from below the packer A can be conducted to the top of the well bore through the tubing string. Instead of conducting well production, it is also possible to force or pump fluid down the tubing string F and through the packer body 10 to a point in the well bore below the latter.

The tubing string F has a sealing adapter structure 60 forming a part of its lower end, which is capable of being sealed off against the upper portion of the body 10 to conduct fluid between the interior 11 of the body and the interior of the tubing string F. The adapter consists of an upper head 61 threaded onto the lower end of a joint of tubing F, this upper head merging into a neck portion 62 from which an inner skirt 63 depends. This skirt has one or more side seals 64 adapted to seal off against the periphery of the tubular body 10 above its ports 40.

The sealing adapter 60 also includes an outer sleeve 65 threaded onto the upper head 61 and extending downwardly along the neck portion 62 and inner skirt 63 to a substantial extent below the lower end of the latter. This outer sleeve has a lower head 66 provided with one or more side seals 67 adapted to engage the periphery of the tubular body below the ports 40.

Leakage between the neck portion 62 and the outer sleeve 65 is prevented by one or more seals 68 in the former engaging the inner wall of the latter. These seals prevent leakage in both directions and they prevent the fluid in the annulus around the tubing string F from entering the tubing string. This fluid is allowed to enter the adapter 60, in view of the provision of a bleeder hole 69 in the outer sleeve 65 above the seals 68, which communicates with the interior of the inner skirt 63 through a bleeder port 70 in the neck portion 62 of the tubular device.

The inner skirt 63 is spaced from the outer sleeve 65, forming an annular passage 71 therebetween through which well fluid can pass. The well production can flow upwardly through the tubular body 10, thence laterally through the body ports 40 into the outer sleeve 65, from where it will flow upwardly through the annular passage 71 between the outer sleeve 65 and skirt 63, and thence through a fluid port 72 in the neck portion of the device, and on into the tubing string F.

The sealing adapter 60 is lowered in the well bore B on the lower end of the tubing string F. A tapered guide 73 is formed in the lower head 66, which engages the upper tapered portion 74 of the packer body 10, and is centered with respect to the packer body. Such centering action properly relates the adapter 60 with the body 10, and allows it to be moved thereover to the extent determined by engagement of a stop shoulder 75 in the outer skirt 63 with the upper end 74 of the packer body. When these shoulder 75, 74 engage, the skirt seals 64 engage the packer body 10 above the body ports 40, and the lower head seals 67 engage the packer body 10 below the body ports 40. While the skirt seals 64 are being moved downwardly along the body 10, the fluid that would otherwise be trapped between the packer plug 31 and the neck portion 62 is allowed to escape through the bleeder port 70 and the bleeder hole 69 to the exterior of the apparatus.

The sealing adapter 60 is hydraulically balanced, in order that fluid pressure within the well packer A, adapter 60 and tubing string F will not tend to shift the tubing string longitudinally with respect to the packer. It is to be noted that the fluid in the annulus between the packer body 10 and the inner surface of the outer sleeve 65 can act downwardly on the lower head 66 over the annular area R (Fig. 5). This same fluid under pressure can act in an upward direction on the adapter across the annular area S between the periphery of the packer body 10 and the inner surface of the outer sleeve. These two areas are equal; so that there is no tendency for the fluid within the apparatus to shift the adapter in either direction.

In addition, it is to be noted that the fluid under pressure within the tubing string F can act downwardly upon the neck portion 62 of the apparatus over the cross-sectional area T. But this same fluid is acting in an upward direction over the same cross-sectional area of tubing at the top of the well bore.

The foregoing comments show quite clearly that the internal pressure within the apparatus can have no tendency to shift the apparatus in either direction. As a result, there are no fluid loads due to internal pressure upon either acting in an upward direction, which might tend to kink the tubing string F, or acting in a downward direction, that might tend to place an excessive strain on the tubing string or upon the packer itself. Moreover, in view of the hydraulically balanced condition, the tubing string F and adapter 60 can be moved easily over the packer body 10 when the equipment is being related to one another, and the adapter can be easily elevated from the packer body 10 in the event it is desired to withdraw the tubing string F.

Accordingly, subsurface well equipment has been provided which enables the well packer to be expanded to a substantial extent and anchored firmly in an open hole in such manner as to resist high pressures, and yet allow production to be had through the well packer A itself. The tubing string F can be readily placed in leakproof relation to the well packer merely by disposing its lower portion 60 along the packer.

The inventors claim:

1. In a well packer: a body; a packing structure including a plurality of elastic sleeves on said body; a stop member within said sleeves slidable on said body; a spacer member on said stop member and engaging the adjacent ends of said sleeves; upper and lower abutments on said body engaging the upper and lower ends of said packing structure; and means for exerting an upward pull on said body and a downward push on said upper abutment to longitudinally compress said sleeves and expand said sleeves laterally outward.

2. In a well packer: a body; a packing structure including a plurality of rubber sleeves on said body; a tubular stop sleeve within said rubber sleeves and slidable on said body; a rigid flat spacer disc surrounding and movable with respect to said stop sleeve and engaging the confronting ends of said rubber sleeves, said disc being moveable longitudinally relative to said body; upper and lower abutments on said body engaged with the upper and lower ends of said packing structure; and means for exerting an upward pull on said body and a downward push on said upper abutment to longitudinally compress said rubber sleeves and bulge said rubber sleeves laterally outward.

3. In a well packer: a body; a packing structure on said body sealed against said body; means for longitudinally compressing said packing structure to expand said packing structure outwardly; a plug rigidly secured to and closing the upper end of said body; said body extending a substantial distance above said packing structure and having an open lower end and a side port adjacent and below said plug to allow fluid to flow through said tubular body between a region below said packing
structure and a region externally of said body above said packing structure.

4. In a well packer: a tubular body; a packing structure on said body sealed against said body; means for expanding said packing structure outwardly of said body; a plug rigidly secured to and closing the upper end of said body; said body extending a substantial distance above said packing structure and having an open lower end and a side port adjacent and below said plug to allow fluid to flow through said tubular body between a region below said packing structure and a region externally of said body above said packing structure.

References Cited in the file of this patent

UNITED STATES PATENTS

1,956,694 Parrish ---------------- May 1, 1934
2,227,972 Pranger ---------------- Jan. 7, 1941
2,618,339 Glover ---------------- Nov. 18, 1952