MULTIPLE-TUBING WELL PACKER

INVENTOR

JOHN P. MOORE

BY J. H. M. CROCKET

HIS AGENT
MULTIPLE-TUBING WELL PACKER
John P. Moore, Metairie, La., assignor to Shell Oil Com-
pany, New York, N.Y., a corporation of Delaware
Filed Sept. 16, 1963, Ser. No. 309,071
4 Claims. (Cl. 166—119)

This invention relates to apparatus for use in wells drilled in the earth, and pertains more particularly to a packer assembly adapted to seal off at least one predetermined interval of a well.

It is often desirable to be able to seal off a selected interval of a well positioned adjacent and in communication with a particular formation traversed by the well in order to treat or make use of the particular formation. For example, it may be desired to produce the particular formation or to exclude it together with other formations traversed by the well. Alternatively, the particular formation adjacent the isolated portion of the well may be employed as a water injection well either to dispose of water or for purposes of flooding the formation with water. Further, in addition to injecting water into the particular formation adjacent the sealed off portion of the well, it may be desirable to simultaneously inject another fluid into an adjacent formation. This is particularly true in carrying out a focused acid treatment of a portion of an oil production zone wherein it is desirable to isolate a relatively small interval of the formation to be treated and inject acid therein while simultaneously injecting oil into the formation above and below the packed-off interval. Likewise, it is known to be able to form a relatively thin plastic disc structure in a well between, say, a water zone and an oil-bearing zone by injecting a plastic into the formation so that it extends radially a substantial distance from the well.

In many wells, the setting of dual or spaced packers is carried out in a conventional manner by running first one packer into the well to a selected position and setting it, withdrawing the setting tool and then subsequently running a second packer and setting it in the well at a higher level. This operation is time consuming in that two trips into the well have to be made. Additionally, the structure of presently known single packers is such that it is difficult to set them close together in order to isolate a relatively small interval of the well. This is especially true where the packers are provided to be used with two or more strings of tubing.

It is therefore a primary object of the present invention to provide a multiple-tubing well packer having at least two sealing elements which may be positioned relatively close together in order to isolate a relatively small vertical interval of a well and/or well casing.

Another object of the present invention is to provide a dual seal well packer for use with multiple strings of tubing wherein the seals on the packer may be set in one operation without the necessity of making two trips into the well to set two individual seals or packer elements.

A further object of the present invention is to provide a multiple-tubing dual packer assembly which may be permanently set within a well casing.

Still another object of the present invention is to provide a multiple-tubing well packer assembly having multiple packing elements which may be set in an operative manner by use of an interconnecting tubing or mandrel extending between the individual packing elements, the tubing or mandrel being engageable by suitable means extending from the surface down to the desired level in the well at which the packer is to be set.

A still further object of the present invention is to provide a multiple tubing wire line packer assembly adapted to be set by a conventional wire line setting device.

It is also an object of the present invention to provide a multiple-tubing dual packer assembly for use in a well to permit the production of two zones of a well simultaneously.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a diagrammatic view taken in longitudinal cross section of one form of a multiple tubing, multiple seal, well packing assembly in accordance with the present invention;

FIGURE 2 is a diagrammatic view of a well in longitudinal cross section wherein a multiple tubing, multiple seal, well packer assembly of the present invention is illustrated as being secured to the lower end of a setting tool which in turn depends from a hoist and actuating line extending to the surface; and

FIGURE 3 is a longitudinal cross-sectional view of a well wherein a multiple tubing, multiple seal, well packer assembly of the present invention is fastened to the well casing with the strings of tubing extending to a production wellhead at the surface.

Referring to FIGURE 1 of the drawing, one form of a multiple tube, multiple seal, well packer assembly in accordance with the present invention is illustrated as comprising a body member 10 which includes a downwardly extending elongated tubular mandrel or conduit 11 with upper and lower bracket means 12 and 13, respectively, integrally formed on or fixedly secured to the mandrel or conduit 11. Thus, the lower bracket means 13 is fixedly secured to the lower end of the conduit 11, as by screws 14. A bore 15 extends through the bracket means 12 and 13. A second tubular mandrel or conduit 16 is mounted for limited sliding movement within the bore 15 in a direction parallel to the fixed mandrel or conduit 11. The upper end of the conduit may be of enlarged diameter, as at 17, so as to seat on a shoulder or other stop means 18 formed within the bore 15 to prevent the movable conduit 16 from falling out of the bore 15.

The packer assembly of the present invention is provided with upper and lower packer elements 20 and 21, respectively, which surround both tubular conduits 11 and 16 and are adapted to be expanded radially outwardly against the inner wall of the well or well casing 22 in which they are positioned and to be expanded radially inwardly against the tubular conduits. The packer elements 20 and 21 may be of any suitable type and are illustrated in one form as comprising an annular rubber member positioned between expander rings which are adapted to be moved towards each other so as to squeeze the annular rubber packer element and cause it to expand. Thus, the upper packer element is carried between an expander ring 24 secured to fixed conduit 11 and an expander ring 25 fixedly secured, as by screw threads 26, to the movable or slidable conduit 16. In a like manner, the lower packer element 21 is secured for movement between the expander ring 27 secured to the fixed conduit 11 and the expander ring 28 carried by the movable conduit 16.

One of the conduits, in this case conduit 11, is provided with a series of perforations or fluid flow passages 30 through the wall thereof so that the interior of the conduit 11 is in communication with the interior of the well casing 22 between the packer element 20 and 21. At the same time the lower end of the conduit 11 is closed, as at 31, at any suitable point below the lowermost perforation 30. The slidable conduit 16 on the other hand is in communication with the casing at all points below the lowermost packer element 21 of the packer assembly. It is immaterial which of the two conduits 11 and 16 are in communication with the space below the packer assembly. Thus, instead of conduit 16 having an open lower end and conduit 11
having a closed lower end with perforations 30 above the packer element 21, the structure of the two conduits 11 and 16 could be reversed so that the fixed conduit 11 did not have perforations and was opened in its lower end while the movable conduit 16 has a closed lower end with perforations above the packer element 21. The packer assembly of the present invention would be used in a well casing 22 which was provided with perforations 32 through the well thereof at a level between the two packer elements 10 and 21 while the lower end of the casing 22 would be open or additional perforations 33 would be provided through the wall of the casing 22 below the lowermost packer element 21.

In order to anchor the present packer assembly securely in a well casing 22, the packer assembly is provided with suitable anchoring means which prevent the packer assembly from dropping down the well or from being forced out of the well under pressure. In one form of anchoring means as shown in FIGURE 1, the well packer of the assembly of the present invention is provided with two sets of slips for anchoring the packer, one positioned above the upper packer 20 and the other positioned below the lower packer 21. The upper anchoring means comprises a series of slip elements 35 having an actuator ring 36 which in turn is mounted within an annular recess 37 formed on the outer wall of the body member 10 to be understood in its inoperative position is held at the top of the recess 37 by any suitable means, as by a friction fit or by a shear pin 38. Thus, the slips 35 are held in a retracted position so that they do not engage the inner wall of the casing 22 as the packer assembly is lowered into the well. The expander ring 44 above the packer 20 is tapered downwardly and outwardly, as at 40, in a manner illustrated to serve as a cooperating slip cone, adapted to engage the lower sloping surfaces of the slips 35 and force them outwardly against the inner wall of the casing 22. It is to be noted that the actuator ring 36 is of larger diameter than the body member 10 so as to extend beyond the outer surface of the body member 10 where it can be engaged by the lower sleeve 41 of the actuating tool 43 (FIGURE 2). The slips 35 to be moved laterally and outwardly when engaged by the slip cone 40. Thus, a dove-tailed key 43 may be radially engaged on the top of each slip and mounted in a keyway 44 of similar shape extending radially across the lower face of the actuator ring 36.

A similar anchoring device is provided below the lowermost packer 21. The lower anchoring means comprises a plurality of slips 45 positioned above and secured to an actuator ring 46, as by a dove-tailed key and keyway as described with regard to slips 35. While the serrated faces or teeth 47 of the upper slip elements 35 are angled in a manner so to form what is commonly known as a "hold-down" slip assembly which prevents packer assembly from being forced out of the well, the teeth 48 of the lower slips 45 are angled in the opposite direction so as to form what may be called a "hold-up" slip assembly.

The lower expander ring 28 has a downwardly and inwardly tapered face 50 forming a slip cone engageable by the sloping faces of the slips 45 so that the slips 45 are forced outwardly against the inner wall of the well casing 22. Preferably, the expander ring 28, which is slidably mounted around conduits 11 and 16 below packer 21, is also temporarily held above the slips 45 in any suitable manner, as by shear pins 51. The bore 52 of the slidable conduit 16 and the bore 53 of the fixed conduit 11 are also preferably provided with landing surfaces or seating shoulders, 54 and 55 respectively, for receiving and seating therein the lower end 60 of a tubular rod or tube 58 of the actuating tool 42. One form of connector means are screw threads 60. The connector means 60 is preferably of a type that may be readily disconnected by upward axial movement of the actuator rod 58 after the packer assembly of the present invention has been fixedly anchored in place in the well. Thus, if only one or two threads 60 are employed a convenient upward pull on the actuator rod will cause the threads to be stripped off allowing removal of the actuator rod 58 and the subsequent installation of the lower end of a tubing string on the landing surface 54 within the open end of the slidable conduit 16. However, in the event that a substantial number of threads 60 are employed, the wall of the slidable conduit 16 below the thread 60 and above the landing surface 54 may be reduced in cross section substantially, as by cutting a recess 61 therein, so as to form a tension sleeve which can be ruptured and pulled away from the top of the slidable conduit 16 by an upwardly pulling force being applied from the actuator rod 58.

The actuator tool 42 used to set the well packer assembly of the present invention is secured to the well packer assembly only by means of the threads 60. The lower sleeve 41 of the actuating tool 42 is only in contact with the outer surface of the body member 10 of the packer assembly while being adapted to engage the actuator ring 36 of the upper slip assembly 35. The actuator tool 42 is also shown as being provided with a tubular member 44 connectable into the top of the bore 54 of the fixed conduit 11, but it is to be understood that this nipple 62 may be dispensed with, if desired.

The multiple-tubing, multiple-seal, well packer assembly of the present invention is designed to be set within a well by employing any of the suitable wire line actuating tools 42 well known to the art. One such satisfactory tool is known as the Baker Wire Line Pressure Setting Assembly manufactured by Baker Oil Tool and described in the 1962–63 Composite Catalog of Oil Field Equipment and Services, published by World Oil, page 202, product No. 457–02 (K–183). This tool, schematically shown as element 42 in FIGURE 2, is lowered by means of a wire line 63 into the well on a wire line 63 coming from a suitable hoist mechanism (not shown). When the tool 42 and the attached packer assembly have been lowered to desired level within the well, an explosive charge carried within the actuating tool 42 is fired to create a volume of expended gas which provides two sequential motions. First, the lower sleeve 41 (FIGURE 1) is forced downwardly relative to the actuating rod 58 and when this motion has stopped the actuating rod 58 is subsequently pulled upwardly to the actuating sleeve 41.

Thus, in actuating the packer assembly of the present invention a downward movement by the actuating sleeve 41 causes the actuator ring 36 of the upper slip assembly to be forced downwardly, forcing slips 35 downwardly against these slip cones 40 and outwardly against the inner wall of the well casing. Since further downward movement of the sleeve 41 and slips 35 is impossible, continued expansion of gas within the actuating tool 42 results in an upward movement of its actuating rod 58 and the slidable conduit 16 secured to the lower end thereof. This upward pull on the slidable conduit 16 causes the flange 64 at the lower end thereof to pull the slips 45 up against the tapered face of the slip cone 50 and causes pin 51 to shear. Continued pull on the movable conduit 16 pulls the expander rings 28 and 25 upwardly against the packer elements 20 and 21 respectively, to compress the packer elements and force them outwardly into sealing engagement into the inner wall of the well casing 22.

A snap ring assembly, 56 and 57, located at the outer end of the tubing 58, which is a tempered cylindrical split metal band, is fitted into a recess in the movable conduit 16 at a position on said conduit immediately above the actuator ring 46. During the setting sequences described, the snap ring performs no function, however, after a packer is securely anchored, any relaxation of
the sealing elements or downward motion of the slideable conduit 16 is prevented since the snap ring 68 will not pass the actuator ring 46.

When the packer elements 20 and 21 have been set within the well casing, upward pull on the actuating rod 58 is continued until a predetermined stress, say 40,000 pounds, causes the tension sleeve 61 below the threads 62 to part and release the actuating tool 42. The actuating tool is then pulled out of the well and tubing strings 56 and 57 are lowered into the packer assembly as shown in FIGURE 3. The top of the well may then be closed in a conventional manner. Thus, with the multiple-tubing, multiple-seal, well packer assembly of the present invention set in place as shown in FIGURE 3, one tubing string 56 is in communication through the slideable conduit 16 and through both packer assemblies 20 and 21 with the well casing interior below the lower packer 21 which in turn communicates with one formation interval 66 through perforations 33. A second formation interval 67 is positioned between the packer elements 20 and 21 and is in communication through perforations 32 in the well casing 22, and through perforations 30 in the fixed conduit 11 with the well tubing string 57. It is quite apparent that the spacing between the packers 20 and 21 depends upon the vertical dimension of the formation interval to be isolated. Thus, as the formation interval 67 is of substantial vertical dimension the length of the conduit 11 and 16 may be increased to a length at least slightly less than the depth of the formation interval.

I claim as my invention:
1. A permanent packer assembly for use in well casing traversing closely spaced upper and lower formations, said casing being perforated opposite said upper and lower formations, said assembly comprising:
a pair of vertical tubular conduits arranged in a side-by-side relationship,
bracket means fixedly secured to one of said conduits and extending transversely to engage said other conduit, said other conduit being axially movable through said bracket means in a direction parallel to said one conduit,
one of said conduits having fluid port means through the wall thereof intermediate the ends thereof and said conduit being closed below said port means, first and second expandable packer means arranged in speed relationship and surrounding both of said conduits above and below the port means through the wall of said conduit,
the other of said conduits having fluid port means in communication between the bore thereof and the space below the second packer means, and anchoring means carried outwardsly on each of said packer means and adapted to be expanded outwardsly against the inner surface of a well casing to anchor the packer assembly therein.
2. The apparatus of claim 1 wherein said anchoring means includes first and second anchors carried jointly by said conduits, one of said anchors being a hold-down anchor for one of said packer means and the other anchor being a hold-up anchor for the other packer means.
3. The apparatus of claim 2 wherein one of said anchors is carried by and is mechanically operatively connected to one of said conduits and, the other anchor is carried by and is mechanically operatively connected to the other of said conduits.
4. The apparatus of claim 3 wherein said anchors are mounted above and below said spaced packer means.
5. The apparatus of claim 4 wherein both of said packer means and said lower anchor operatively engage said movable conduit and are adapted to be set by axial movement of said conduit.
6. The apparatus of claim 1 including an expander ring element carried by one of said conduits above each of said packer means and expander ring elements carried by the other of said conduits below each of said packer means.

References Cited by the Examiner

UNITED STATES PATENTS

3,054,456 9/1962 Hammaker 166--45

CHARLES E. O'CONNELL, Primary Examiner.

J. A. LEPPINK, Assistant Examiner.