United States Patent

Cobbs

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[54] MULTI-ELEMENT PACKER

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[52] **U.S. Cl.** **166/120,** 166/191

[51] **Int. Cl.** **E21b 23/00**

[58] **Field of Search** 166/120, 185, 191

[56] **References Cited**

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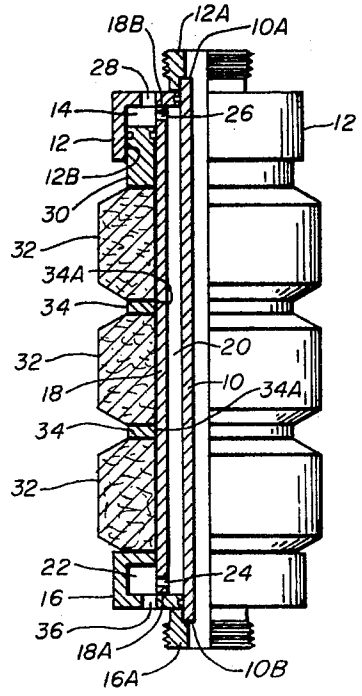
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[57] **ABSTRACT**

A multi-element packer for closing a borehole including a tubular inner mandrel, a cylindrical member at one end of the mandrel and a coupling plate at the other end, an outer mandrel coaxially positioned over the inner mandrel providing an annular passageway between the two, an annular piston positioned in the cylinder member displaced by fluid pressure applied to the cylinder member, and a plurality of tubular elastomer elements positioned on the outer mandrel between the piston and the coupling plate, the elastomer elements being expanded by force of the piston.

5 Claims, 4 Drawing Figures



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2 Sheets-Sheet 1

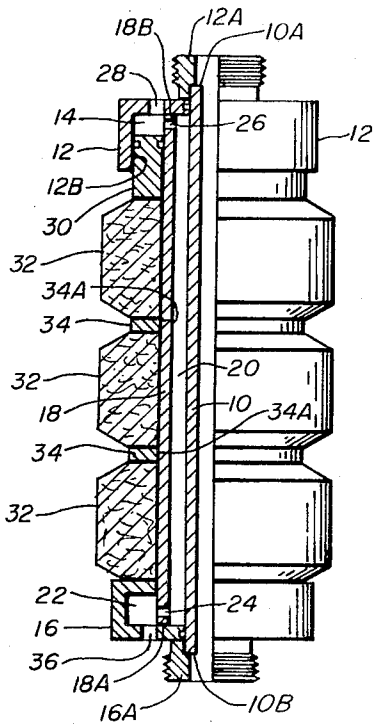


Fig. 1.

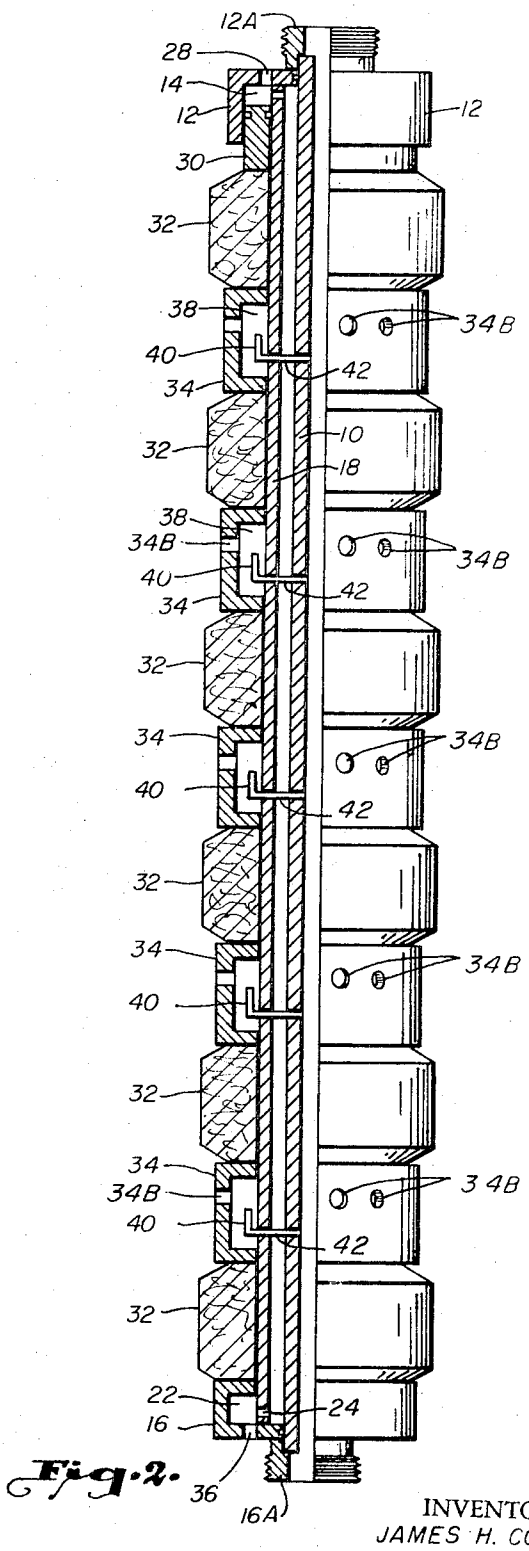


Fig. 2.

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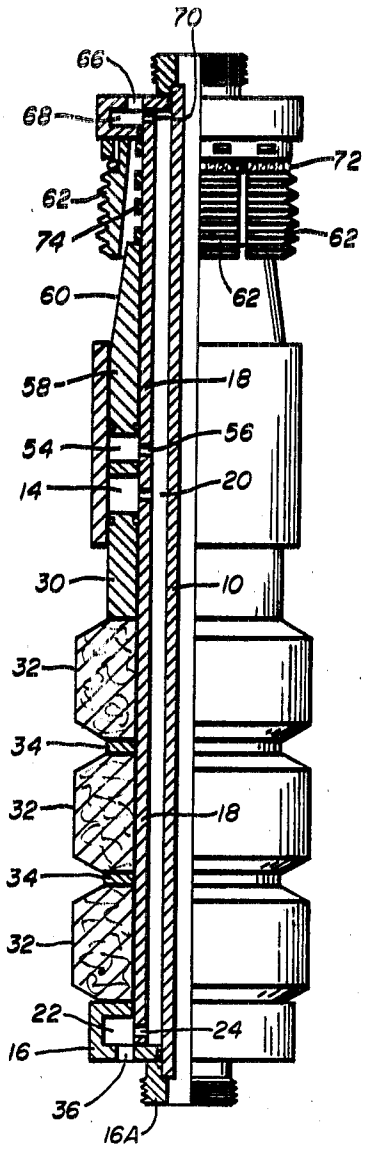


Fig. 3.

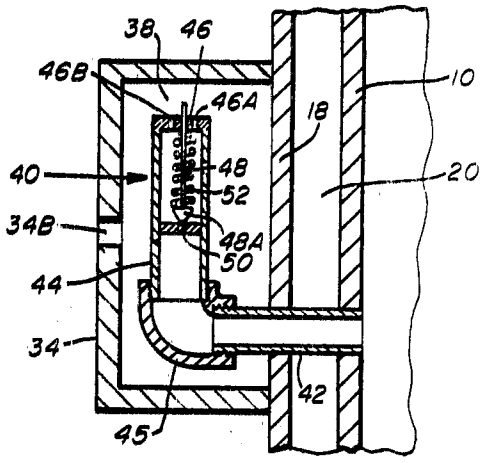


Fig. 4.

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MULTI-ELEMENT PACKER

BACKGROUND, SUMMARY AND OBJECTS OF THE INVENTION

Packer devices are well known for use to close off boreholes in the completion, treating, testing and operation of oil, water and gas wells. This invention provides a multi-unit packer having as one of its advantages the provision wherein a combination of elastomers can be used to achieve the desired results. As one example, hard elastomers may be used at the ends of a plurality of elastomers for strength and resistance to cold flow while soft elastomers are used in the middle portion for their improved sealing properties. The packer of this invention may be used for testing between packers (that is, as a straddle packer) or in a multi-packer application or as a single packer, and in each case multiple elastomers are utilized which may be of different durometer or cold flow characteristics. Another advantage of the packer of this invention is that contact pressure can be very closely controlled by means of a small tubing extending from the packer to the earth's surface by means of which hydraulic pressure is applied to the packer.

It is therefore an object of this invention to provide an improved multi-element packer.

More particularly, an object of this invention is to provide a multi-element packer including the utilization of a sequence of elastomers which may have different characteristics, including different cold flow patterns, when subjected to pressure, to achieve the results required of the specific application to which the packer is put.

Another particular object of the invention is to provide a multi-unit packer including means whereby a series of such multi-unit packers may be easily assembled to achieve the desired pressure retaining characteristics for varying applications.

Another object of this invention is to provide a multi-unit packer including a simple and effective slip set arrangement for securing the packer in position in a borehole wherein the slips are set simultaneously with the expansion of elastomers and utilizing a single hydraulic pressure source.

Another object of this invention is to provide a packer of the multi-unit type including means of selectably controlling the differential pressure across each elastomer element.

These and other objects of the invention will be fulfilled by the apparatus to now be described in the following specifications and claims, taken in conjunction with the attached drawings.

DESCRIPTION OF VIEWS

FIG. 1 is an elevational view, shown partially in cross-section, of a simple embodiment of the multi-unit packer of this invention.

FIG. 2 is an elevational view, shown partially in cross-section, showing an alternate embodiment of the multi-unit packer of this invention including means of controlling the differential pressure across each elastomer element.

FIG. 3 is an elevational view of an additional alternate embodiment of the invention, shown partially in cross-section, providing a slip actuation mechanism as an integral portion of the packer for more effectively contacting the borehole in which the packer is positioned to prevent the displacement of the packer in the borehole.

FIG. 4 is an enlarged cross-sectional view of the differential pressure valve element as used in the embodiment of FIG. 2.

DETAILED DESCRIPTION

Referring now to the drawings and first to FIG. 1, a simple embodiment of the multi-element packer of this invention is shown. The packer includes an inner tubular mandrel **10** having an upper end **10A** and a lower end **10B**. Affixed to the upper end **10A** is a cylinder member **12** which is opened at one end and partially closed at the other, with the partially closed end having affixed thereto a tubular extension **12A** which receives the upper end **10A** of the inner mandrel. Tubular extension **12A** is threaded on the exterior as an example of one means whereby the packer may be secured to tubing or to an adjacent packer or other type of tool. The cylinder member **12** has an enlarged interior portion **12B** providing a cylinder chamber **14**.

At the lower end of the inner mandrel **10** is a coupling plate **16** having a tubular extension **16A** affixed thereto. The tubular extension **16A** receives the lower end **10B** of the inner mandrel. The outer periphery of tubular extension **16A** is threaded to enable a subsequent packer element, tool or tubing to be affixed.

Coaxially received about the inner mandrel **10** is a tubular outer mandrel **18** which extends sealably between the cylinder member **12** and the coupling plate **16**. The exterior diameter of inner mandrel **10** is smaller than the interior diameter of outer mandrel **18**, providing an annulus or annular passageway **20** therebetween. Coupling plate **16** is secured to the lower end **18A** of outer mandrel and configured to provide a passageway **22** there around. A first fluid port **24** is provided in mandrel **18** adjacent the lower end **18A** which communicates the coupling plate passageway **22** with the annular passageway **20**. At the upper end **18B** of outer mandrel **18A** a second fluid port **26** is provided communicating the cylinder chamber **14** with the annular passageway **20**. Cylinder member **12** includes a fluid inlet port **28** which communicates the cylinder chamber **14** with the upper exterior end of the packer.

Slidably received on the exterior of outer mandrel **18** is an annular piston **30** which is displaced by fluid pressure within cylinder chamber **14**.

Positioned between the piston **30** and coupling plate **16** on the exterior of outer mandrel **18** are a plurality (three in FIG. 1) of elastomer elements **32**. The elastomer elements are of ring configuration and are of resilient material which cold flows under pressure and, when piston **30** moves downwardly towards coupling plate **16**, the elastomer elements **32** expand outwardly to engage the walls of the borehole in which the packer is placed.

Positioned between each adjacent elastomer element **32** is a spacer plate **34** each having an opening **34A** therein slidably receiving outer mandrel **18**.

The packer of FIG. **1** is typically lowered into a borehole on the end of a tubing string. When it is desired to set the packer in a borehole fluid pressure, either pneumatic or hydraulic, is applied to fluid inlet port **28**. Such fluid may be applied by means of a small diameter high pressure flexible tubing, such as nylon tubing, extending from port **28** to the earth's surface. As pressure builds in cylinder chamber **14** piston **30** is moved downwardly in the direction towards the coupling plate **16**, expanding the elastomer elements **32** outwardly. Formed in the coupling plate **16** is an outlet port **36**. If only one multi-unit packer element is utilized, such as shown in FIG. **1**, then outlet port **36** is closed. This invention provides means whereby a sequence of multi-unit packers may be utilized such as by attachment of a second packer element to the threaded lower tubular portion **16A**. In such event, the outlet port **36** is connected to the subsequent inlet port of the subsequent packer by means of a small tubing or the like so that the fluid pressure applied to actuate the packer is transmitted sequentially from one packer to another and thus to as many as are placed in series.

As previously stated, one of the advantages of this invention is the provision of means whereby the elastomer elements **30** may be of different characteristics, and particularly of different cold flow characteristics usually determined principally by the hardness or durometer of the material of which the elastomers are composed. For instance, the top and bottom elastomers in FIG. **1** may be of relatively hard material to serve to physically support the packer in the borehole against displacement forces, while the intermediate elastomer element may be of a softer material for improved effectiveness of seal against the borehole wall to prevent the passage of fluid or gas.

Referring to FIGS. 2 and 4, an alternate embodiment of the invention is shown. The packer element of FIG. 2 is the same as that of FIG. 1 with two basic differences. First, in the arrangement of FIG. 2 each spacer plate 34 is configured to provide an annular area 38 therein. Second, positioned in the annular area of each of the spacer plates is a pressure release valve 40, each of which communicates with the interior of inner mandrel 10 by means of tubing 42 which extends through outer mandrel 18. The spacer plates 34 of the configuration of FIG. 2 are provided with openings 34B.

Referring to FIG. 4 an exemplary arrangement of the pressure release valve is shown. The valve includes a tubular portion 44 attached to tubing 42 by means of an ell fitting 45. Within tubing 44 is a plate 46 having apertures 46A therein and a central opening 46B. Slidably received in opening 46B is a valve plunger 48 having an enlarged end portion 48A. The outer end of tubular valve body 44 is closed except for a small valve opening 50 which is normally closed by the outer end 48A of the valve plunger. A spring 52 normally urges the plunger to closed position in which the end portion 48A closes opening 40 and prevents flow of fluid therethrough. When the fluid pressure builds beyond that at which the resilient force of spring 52 is overcome, plunger 48 is displaced and allows fluid to flow through opening 50 and tubing 42 into the annular space between adjacent elastomer sealing elements.

The arrangement of FIGS. 2 and 4 permit, as previously indicated, the selection of the maximum differential pressure which will be applied across any one elastomer element 32 of the packer. For purposes of illustration, assume that it is desired to hold a differential pressure across each of the elastomer elements 32 in the embodiment of FIG. 2 at no more than 200 psi. Further, assume that the total maximum pressure encountered in the borehole is 1,200 psi. Each differential pressure valve 40 can then be set to open in 200 psi increments. That is, the valve 48 closest to the bottom of the packer would be set to open at 200 psi; the valve 40 second from the bottom of the packer would be set to open at 400 psi; the valve 40 third from the bottom of the packer would be set to open at 600 psi; and so forth. With 1,200 psi beneath the packer the pressure between the two lowermost elastomer elements 32 would be 1,000 psi; between the next above two adjacent elastomer elements the pressure would be 800 psi; and so forth. With a 1,200 psi pressure and six elastomer elements 32 as shown in FIG. 2, each of the pressure release valves 40 would be opened to permit flow of fluid therethrough. If the pressure were less than 1,200 psi below the packer then one or more of the pressure release valves 40 would not open.

A further obvious embodiment would include the provision of check valves (not shown) installed along with the differential pressure valves 40 to permit the venting of gas trapped between elastomers through inner mandrel 10 without the necessity of releasing the setting pressure to vent the gas out of the borehole.

Referring to FIG. 3, an additional alternate design of this invention is shown. In this arrangement, the cylinder member 12 provides, in addition to the lower cylinder chamber 14, an upper cylinder chamber 54. A port 56 communicates chamber 54 with the annular passageway 20 so that setting pressure applied in the annular passageway imparts force both to annular piston 30 and to an annular slip setting piston 58. The slip setting piston 58 is slidably received on the exterior of outer mandrel 18 and has affixed to it at the upper end a cone portion 60 having inclined exterior surfaces. Received about the cone portion 60 are a plurality of segmented slips 62. The slip segments 62 have deep cut wickers in the exterior surface thereof to dig into the borehole in which the packer is positioned.

At the upper end of the inner and outer mandrels is an upper coupling plate 64 having essentially the same configuration and use as the lower coupling plate 16 previously described. An inlet port 66 provides means wherein setting pressure may be applied to the packer, such setting pressure entering the upper coupling plate annular passageway 68 and flowing through the port 70 in the wall of the outer mandrel 18 adjacent the upper end thereof, into annular passageway 20.

To retain the slips segments 62 in withdrawn position a spring 72 encompasses the segments so that when piston 58 is withdrawn the segments collapse to release their engagement with the borehole. A spring 74 received around outer mandrel 18 urges piston 58 towards the non-actuated position in which the slip segments 62 are collapsed.

It can be seen that the multi-element packer of FIG. 3 provides means whereby the slip segments 62 are forced outwardly into engagement with the walls of the borehole concurrently with the expansion of the elastomer elements 32 to effect leakproof seal with the borehole. The embodiment of the packer of FIG. 3 may be used alone or with a sequence of other multi-unit packers such as shown in FIG. 1 or 2. It can further be seen that each of the embodiments may include the use of elastomers of various characteristics which can be combined to achieve the maximum effectiveness of the packer according to various pressures, borehole conditions, and so forth.

While the invention has been described with a certain degree of particularity, it is manifest that many changes may be made in the details of construction and the arrangement of components without departing from the spirit and the scope of this disclosure. It is understood that the invention is not limited to the exemplified embodiments set forth herein for purposes of illustration, but is to be limited only by the scope of the attached claim or claims, including the full range of equivalency to which each element thereof is entitled.

What is claimed:

1. A multi-element packer for closing a borehole comprising:

a tubular inner mandrel having an upper end and a lower end each including means for affixing to a tubing or an adjacent packer;

a cylinder member being open at one end and partially closed at the other, the partially closed end having an axial opening therein, and coaxially receiving said inner mandrel at the upper end thereof;

a coupling plate having an axial opening therein sealably and coaxially receiving the said inner mandrel at the lower end thereof;

an outer mandrel coaxially positioned over said inner mandrel and extending from said cylinder member to said coupling plate, providing an annulus area between the interior circumference of said outer mandrel and the outer circumference of said inner mandrel, said coupling plate being affixed to said outer mandrel and providing an annular passageway there around, the inner diameter of said cylinder member being larger than the outer diameter of said outer mandrel providing an annular cylinder chamber, said cylinder member having a fluid inlet opening therein communicating with said cylinder chamber, and said outer mandrel having a first opening therein communicating said cylinder chamber with said annulus between said inner and outer mandrels, said outer mandrel having a second opening communicating said coupling plate annular passageway and a fluid outlet opening communicating the annular passageway with the exterior of said coupling plate;

an annular piston slidably received on the exterior of said outer mandrel and within said cylinder member, the piston being displaceable by fluid pressure within said cylinder chamber; and

a plurality of tubular elastomer elements received coaxially on said outer mandrel between said annular piston and said coupling plate.

2. A multi-element packer for closing a borehole according to claim 1 including a spacer plate between adjacent elastomer elements, each spacer plate having an axial opening therein slidably receiving said outer mandrel.

3. A multi-element packer for closing a borehole according to claim 1 including:

a slip drive cylinder member being open at one end and partially closed at the other, the partially closed end receiving said outer mandrel and providing an annular slip drive cylinder chamber around said outer mandrel;

an annular slip piston slidably received on said outer mandrel and within said cylinder chamber, said outer mandrel having a fluid opening communicating said slip drive cylinder chamber with said annulus area between said inner and outer mandrels;

a slip cone portion slidably received on the exterior of said outer mandrel and affixed to said slip piston;

a plurality of slip segments supported on the exterior of said slip cone, each having an inclined surface engaging the said slip cone portion whereby the movement of said slip cone portion towards said slip segments expands said slip segments outwardly, said slip segments having roughened outer configurations to engage the walls of a borehole when expanded outwardly and to thereby retard the movement of said packer in a borehole; and

spring means resiliently urging said slip segments towards said outer mandrel.

4. A multi-element packer for closing a borehole according to claim 2 including:

a pressure relief tube communicating between the interior of said inner mandrel and the exterior of said outer mandrel in each of said spacer plates; and

a pressure relief valve in each of said pressure relief tubes permitting the flow of fluid from the interior of the inner mandrel to the annular space between adjacent elastomer sealing elements when the pressure exceeds a preselected level.

5. A multi-element packer for closing a borehole according to claim 4 wherein each said spacer plate is in the form of a hollow cylinder having aligned openings in the upper and lower ends thereof coaxially receiving said outer mandrel and providing an annular chamber around the outer mandrel, the circumferential wall of said cylinder having at least one opening therein, and said pressure relief valve being within said annular chamber.

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