

July 8, 1969

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3,454,087

PRESSURE BALANCED PACKER

Filed Nov. 15, 1967

Sheet 1 of 3

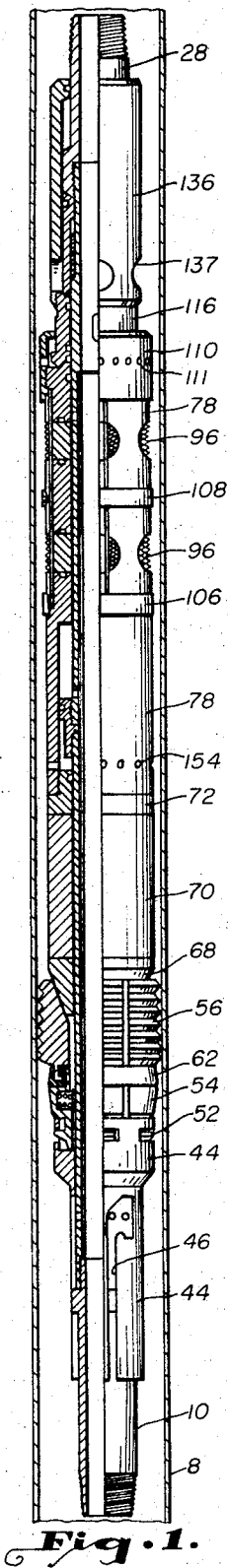


Fig. 1.

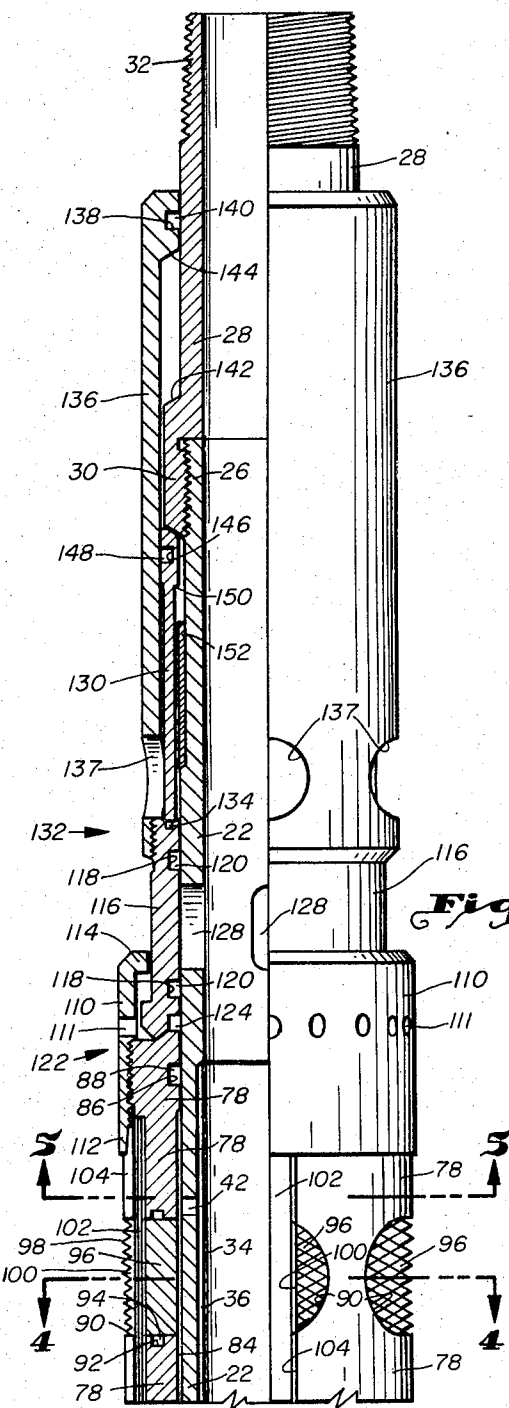


Fig. 2A.

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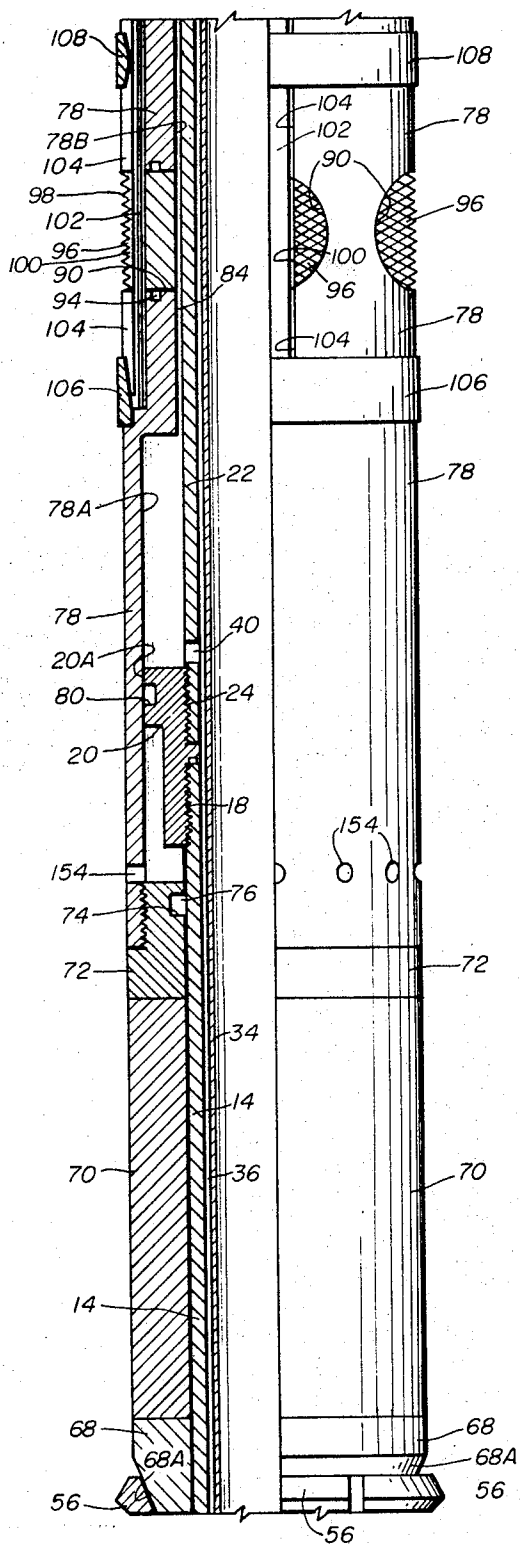


Fig. 2B.

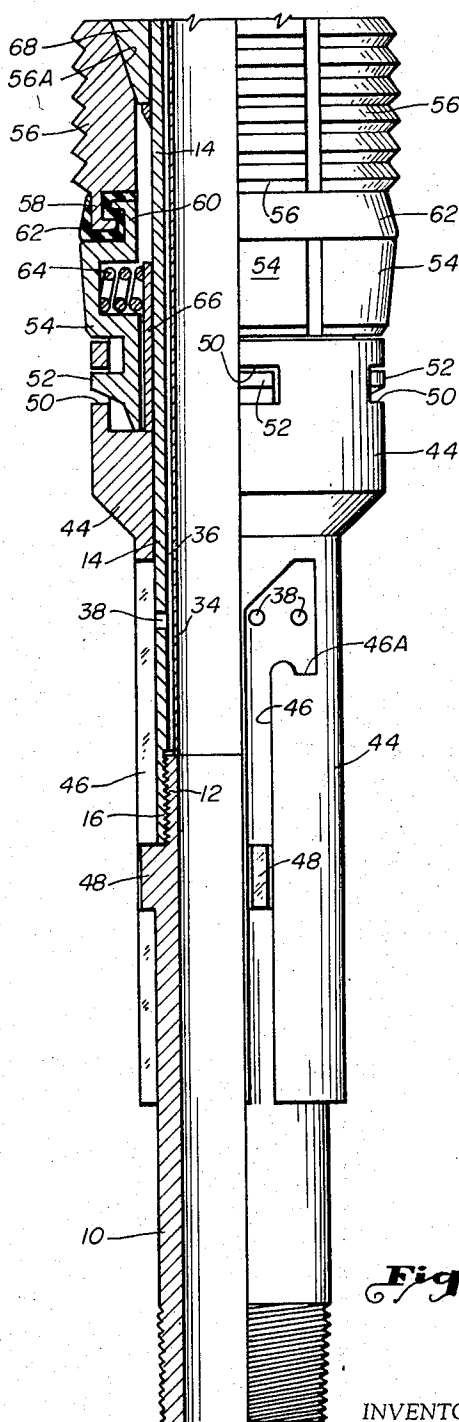


Fig. 2C

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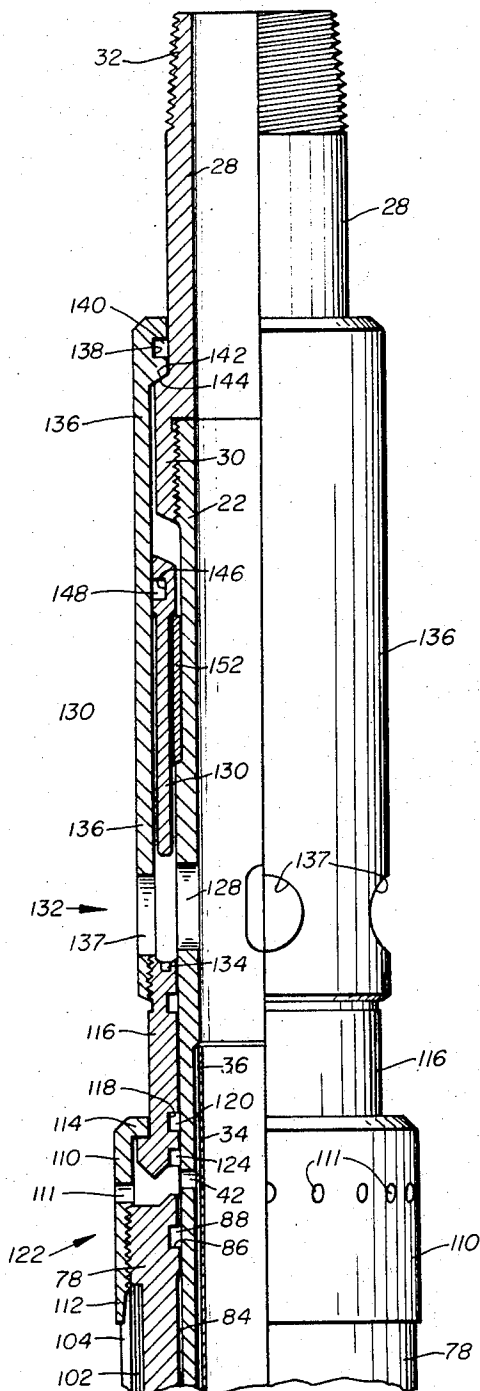


Fig. 3.

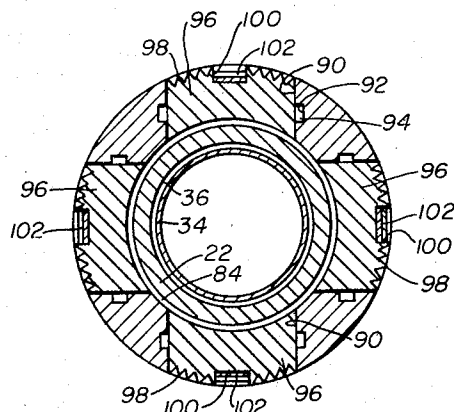


Fig. 4.

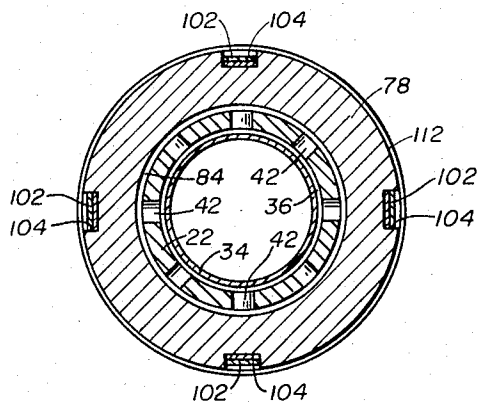


Fig. 5.

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3,454,087

PRESSURE BALANCED PACKER

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Int. Cl. E21b 33/128

U.S. Cl. 166—120

4 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a pressure balanced packer for mounting on the lower end of a tubing string for sealably closing a well casing, the packer being removable by non-rotated upward pull on the tubing string. More particularly, the invention relates to a packer for mounting on a tubing string to sealably close a well casing, the packer including an elongated tubular mandrel affixed at the upper end to the lower end of the tubing string, a tubular elastomer packing element received on the exterior of the mandrel intermediate the length thereof, the packing element being of normal exterior diameter less than the interior diameter of the casing and expandable by the application of compressive force against the ends thereof to sealably engage the interior of the casing, slips provided on the exterior of the mandrel below the packing element, the slips being outwardly expandable to engage and lock against the interior of the casing when the mandrel is in a set position, a tubular inner sleeve within the mandrel providing an annular fluid passageway therein including an opening in the mandrel below the packing element whereby fluid pressure exterior of the mandrel below the packing element is communicated to the fluid passageway, a tubular cylinder member carried by the exterior of the mandrel and having an enlarged internal diameter portion, an enlarged diameter piston member on the mandrel slidably received in the cylinder member, the mandrel having an opening communicating the cylinder member above the piston with the fluid passageway whereby the hydraulic pressure in the fluid passageway is communicated above the piston to force it down against the packing element to thereby cause the packing element to be expanded to proportion to the hydraulic fluid pressure below the packing element, and a valve sleeve slidably positioned on the mandrel above the packing element closing a vent in the mandrel communicating with the annular passageway, the valve sleeve being arranged so that an upward pull on the mandrel slides the valve sleeve to expose the vent and release the pressure in the fluid passageway thereby releasing the hydraulic force applied by the piston against the packing element. The invention, in addition, includes a slidable valve port actuated by upward pull on the mandrel to expose large diameter fluid bypass openings providing free fluid flow between the upper exterior portion of the packer and the interior of the mandrel. In addition, the invention includes improved hold down buttons actuated by hydraulic fluid pressure in the above described annular passageway.

Cross-reference

This application is not related to any pending United States or foreign patent application.

Summary of the invention

The use of packers in the oil industry is well known. Packers are typically utilized in a well casing to divide the interior of the casing into two zones, that is, a zone below the packer and a zone above the packer. Packers are run into well casings on the lower end of a string of tubing. When the packer has been lowered to the desired position

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in the well casing, means is provided for setting the packer, that is, fixing it into position and expanding a packing element to seal the interior of the casing to divide the casing into the two mentioned zones.

The packer of this invention functions in basically the same way as other known devices but includes substantial improvements over such other known packer devices. After a packer has been set in position in a casing to perform a certain function, such as squeezing cement into a formation below the packer, the packer must be removed. Known types of packers include arrangements wherein the tubing string must be rotated in one direction or another in combination with upward or downward motions for release of the packer. This rather complex release arrangement occasionally fails and results in the packer locking in position. One of the important advantages of the packer of this invention is that it can always be released by a direct upward non-rotated pull on the tubing string.

Another disadvantage of known packing devices which is overcome by this invention is that known packer devices are frequently locked into place by hydraulic fluid pressures either interiorly or exteriorly of the packer. The packer of this invention is completely pressure balanced which means that it can be released by an upward pull on the tubing string regardless of the hydraulic pressures to which the packer is subjected. The packer of this invention is arranged such that double seals are provided against all pressure closing ports and valves.

The packer of this invention includes other improvements including novel means of retaining hold down buttons in position and includes the further advantage that the tool is subject to a compact design such that the overall length thereof is substantially less than other known packers intended to accomplish a comparable purpose.

Description of the views

FIGURE 1 is a side view of the packer of this invention as assembled for mounting on a tubing and shown positioned in a well casing, the view being shown partially in cross-section.

FIGURES 2A, 2B and 2C are enlarged sectional views of the side elevation of the packer each shown partially in cross-section.

FIGURE 3 is an enlarged side elevational view shown partially in cross-section showing the relation of the elements of the upper portion of the packer as it is released by upward pull.

FIGURE 4 is a cross-sectional view taken along the line 4—4 of FIGURE 2A.

FIGURE 5 is a cross-sectional view taken along the line 5—5 of FIGURE 2A.

Detailed description

Referring to the drawings and first to FIGURE 1, the packer of this invention is shown in partial cross-sectional view as positioned in a well casing 8. Referring particularly to FIGURES 2A, 2B and 2C, it is seen that the packer is assembled about a tubular mandrel made up of a lower mandrel 10 having a threaded portion 12 at the top thereof; a center mandrel 14 having a threaded portion 16 at the lower end thereof engaging the threaded portion 12 of the lower mandrel 10, and a threaded portion 18 at the top thereof; an internally threaded piston member 20 receiving the upper threaded portion 18 of center mandrel 14; and upper mandrel 22 having a threaded portion 24 at the lower end thereof threadably engaging the piston member 20, and a threaded portion 26 at the upper end thereof; and a top mandrel 28 having a lower threaded portion 30 which engages the threaded portion 26 of the upper mandrel 22. The top mandrel 28 has an upper threaded portion 32 which is adapted to

receive connection to the lower end of a tubing string whereby the packer may be positioned into and withdrawn from a well casing.

All the portions of the packer of this invention enumerated to this point are affixed to each other to provide a continuous mandrel extending throughout the length of the packer. Beginning at the top of the lower mandrel 10 and extending up to approximately the center of upper mandrel 22 is a thin walled inner sleeve 34 which provides an annular passageway 36 between its exterior and the interior surface of the mandrel elements 14, 20, and the lower portion of upper mandrel 22. Ports 38 formed in the center mandrel 14 provide communication between the annular passageway 36 and the exterior of the lower end of the packer. Middle ports 40 formed in upper mandrel 22 communicate the annular passageway 36 with a cylinder area to be described subsequently, and ports 42 in upper mandrel 22 communicate the annular passageway 36 with a second annular passageway to be described subsequently.

Carried about the lower end of the mandrel assembly is a tubular slip base member 44 having one or more slots 46 formed therein in the form of an inverted J. Integrally affixed to and extending rigidly from lower mandrel 10 is a lug 48 extending into each of the J-slots 46, the function of which will be described subsequently.

Formed in the upper end of the slip base member 44 are spaced openings 50 each of which pivotally receives a boss portion 42 of a slip drag link 54. A plurality of slip segments 56 are provided about the mandrel assembly in paralleled space relationship, each of the slips having an exterior configuration adapted to engage and hold against the interior of a casing when the slips are expanded. Each of the slips at the lower end thereof has an L-shaped connector portion 58 which mates with a similar and complementary L-shaped connector portion 60 integrally affixed to each drag link 54. The space between the L-shaped connector portions 58 and 60 is filled with and the exterior is surrounded by an elastomer 62. Thus each of the slip segments 56 is pivotally affixed by means of the elastomer to a slip drag link 54 which in turn is pivotally supported to the slip base member 44, there being a slip drag linkage port 50 for each slip segment. Compression springs 64 resiliently urge each of the slip drag links 54 outwardly, the compression springs being positioned between the drag links and a tubular member 66. Slidably positioned about the center mandrel 14 is an upper slip cone 68 having a tapered surface 68A which engages the complementary tapered surface 56A of the slip segments. As the slip cone 68 is forced downwardly against the slip segments 56 they are moved outwardly to engage the interior of the casing in which the packer is positioned.

Affixed to the upper end of the slip cone 68 is an elastomer expandable packing element 70 which, when compressive pressure is applied against the ends thereof, expands outwardly and sealably against the interior of the casing in which the packer is positioned. Slidably received on the exterior of the center mandrel 14 is a tubular upper packing sleeve 72 which is fixed to the upper end of the packing element 70. A gasket groove 74 is provided in the upper packing sleeve 72 retaining a gasket 76 which sealably engages the exterior of the center mandrel.

The upper end of the upper packing sleeve 72 threadably receives the lower portion of a tubular cylinder member 78. The enlarged internal diameter interior surface 78A of the cylinder member slidably receives the exterior cylindrical surface 20A of piston member 20. Formed in the exterior cylindrical surface 20A of piston member 20 is a gasket groove 80 which receives the gasket 82. The interior diameter of the upper end of the cylinder member 78 is reduced (identified by numeral 78B) compared to the cylindrical surface 78. However, the reduced internal diameter portion 78B is nevertheless of a diameter exceeding the external diameter of the

upper mandrel 22 so that an annular passageway 84 is provided therebetween. Port 42 formed in the upper mandrel 22 communicates the annular passageway 36 formed on the interior of center mandrel 22 with the annular passageway 84 formed on the exterior of the center mandrel 22. A gasket groove 86 is formed in the interior of the upper end of the cylinder member 78 and has a gasket member 88 therein which provides a seal against the exterior surface on the center mandrel 22.

Formed in the upper position of the cylinder member 78 are two spaced apart levels of hold down button openings 90 (see FIGURES 2A, 2B and 4). Two layers of four buttons each are shown although obviously any arrangement having one or more buttons in each of any number of layers would be within the purview of the invention. Each of the button openings 90 has a gasket groove 92 and a gasket 94 therein. Slidably positioned in each of the button openings 90 is a hold down button 96 having a non-slip configured exterior surface. Each of the hold down buttons 96 is expandable by hydraulic action against the interior of the casing in which the packer is positioned, in a manner to be described subsequently, to assist in holding the packer in preselected positions in a casing. Formed in the face 98 of each of the hold down buttons 96 is a slot 100 which receives an elongated flat spring 102. A slot 104 is likewise provided in the exterior surface of the cylinder member 78. A lower retaining ring 106 positioned around the cylinder member 78 receives the lower end of each of the springs 102. In like manner a center retaining ring 108 is positioned around the springs 102 between the two rows of hold down buttons 96. Threadably affixed to the upper end of the cylinder members 78 is a cage member 110 which has an extending lower lip 12 which retains the upper end of the springs 102. Thus, the hold down buttons 96 are supported in recessed position by means of springs 102 and are slidably advanced outwardly by the application of hydraulic pressure in the annular space 84.

Cage member 110 is provided with ports 111 and a reduced internal diameter upper portion 114 forming an internal shoulder.

Slidably received about the upper end of upper mandrel is a valve sleeve 116 having, on the interior surface thereof, upper and lower gasket grooves 118, each with gaskets 120 therein. The lower end of the valve sleeve 116 seats against the upper end of the cylinder member 38 forming a pressure release valve generally indicated by the numeral 122. A seal 124 is provided in the lower end of the valve sleeve 116 to insure complete seal of valve 122 when the sleeve 116 is forced against the upper end of cylinder member 78.

Large flow passageway ports 128 are provided in upper mandrel 22 and when the packer is in set position as shown in FIGURE 2A, the ports 128 are sealed by gaskets 120 in the valve sleeve 116.

Slidably received above the upper end of upper mandrel 22 is an upper valve sleeve 130. The lower end of upper valve sleeve 130 engages the upper end of lower valve sleeve 116 and forms a flow bypass valve generally indicated by the numeral 132. A gasket 134 is provided in the upper end of the lower valve sleeve 116 to insure complete liquid tight closure of the valve 132 when the upper sleeve 130 is forced against the lower sleeve 116.

A tubular upper cage member 136 is slidably received on the exterior surface of the top mandrel 28. The cage member 136 threadably engages, at the lower end thereof, the upper end of lower valve sleeve 116. The upper end of the upper cage member 136 has a reduced diameter portion having gasket groove 138 and gasket 140 therein sealably and slidably engaging the exterior surface of the top mandrel 28.

The lower threaded portion 30 of the top mandrel 28 is of enlarged exterior diameter providing a seating surface 142 which engages a complementary seating surface 144 on upper cage member 136 when the mandrel is pulled

upwardly as the packer is retrieved in a manner to be described subsequently.

Formed in the exterior surface of the upper end of upper valve sleeve 130 is a gasket groove 146 containing gasket 148 which sealably engages the interior surface of upper cage member 136.

The upper end of upper valve sleeve 130 is of reduced internal diameter providing an internal shoulder 150. Positioned around the upper mandrel 22 is a seat ring 152 formed of hardened material, the upper end of which engages the seating surface 150 of upper slip ring 130 to move it upwardly as the mandrel is lifted when the packer is being withdrawn.

Operation

The packer is used by affixing threaded portion 32 of top mandrel 28 to the end of a tubing string. Preparatory to lowering the packer into a well casing the slip base member 44 is positioned so that each of the lugs 48 extending from lower mandrel 10 are positioned in the upper portion 46A of a slot 46. This serves to separate the slip segments 56 from the slip cone 68 so that the slips are maintained in a retracted non-engaging position. When the depth in the casing at which it is desired to set the packer is reached the tubing string to which the packer is suspended is pulled slightly upwardly and then rotated as the tubing is gradually lowered. This moves the lugs 48 out of the upper portion 46A of notches 46 and as the tubing is further lowered, allows the lugs 48 to pass downwardly in the longitudinal vertical portions of slots 46. Springs 64 force the slip drag links 54 outwardly with sufficient pressure so that frictional engagement with the interior of the casing is had to the extent that while the packer can be moved up and down freely within the casing sufficient force is nevertheless inserted on the slip drag links to hold them when the tubing is being rotated so as to permit the alignment of lugs 48 with the longitudinal portions of slots 46.

With lugs 48 in the longitudinal portion of slots 46 further downward movement of the packer causes the slip segments 56 to contact slip cone 68 and to be thereby forced outwardly into engagement with the casing 8. FIGURES 1 and 2 show the slips as positioned for engagement with the casing. As additional weight of the tubing string is settled upon the packer the slips 56 are forced outwardly with proportionally greater pressure into non-slip engagement with the interior of the casing in which the packer is positioned.

The setting of the slips having taken place, further downward force applied by the weight of tubing above the packer results in the additional steps of closing valves 122 and 132 and, in addition, compressive force is applied against packing element 70 causing it to bulge outwardly into sealed engagement with the interior of the casing. In the drawings the packing element 70 is shown in the collapsed or non-sealing position.

When the packer has been set and the packing element 70 has been expanded into sealed engagement with the interior of the casing, the casing is divided into two zones, that is, a zone below the packing element and a zone above the packing element. Fluid can now be pumped down the interior of the tubing and the packer mandrel into the casing below the packing element. As fluid is thus pumped into the casing below the packing element fluid pressure passes through port 38 in center mandrel 14 and into annular passageway 36. Fluid pressure passes upwardly in the passageway 36 and out through port 40 in upper mandrel 22 into the cylinder 78 above piston member 20. Fluid pressure in the cylinder 78 above the piston 20 forces the piston downwardly into engagement with upper packing sleeve 72 to further exert a force on packing element 70 to cause it to bulge outwardly with greater sealing pressure against the interior of the casing. Thus, the greater the fluid pressure exerted below the packing element 70 the greater is the pressure applied to force the packing element 70 against the interior of the casing. Piston 20

is free to move downwardly since ports 154 in the lower end of the cylinder member 78 prevent trapping the fluid below the piston.

The fluid pressure in the annular passageway 36 passes upwardly and through port 42 (see FIGURE 2A) into annular passageway 84. The pressure in the passageway 84 is applied to the rearward surface of the hold down buttons 96 to force the buttons outwardly into engagement with the interior of the casing. The buttons thereby engage the casing to augment the holding effect of slips 56 in the arrangement wherein the higher the fluid pressure applied the greater is the force of the hold down buttons against the casing to hold the packer in position.

When it is desired to remove the packer, the tubing is lifted upwardly in a non-rotated manner. The mandrel assembly is thereby moved upwardly relative to the exterior portions of the packer and the seating surface 142 of top mandrel lower threaded portion 30 engages the seating surface 144 of the upper cage member 136. In addition, the upward movement of the mandrel assembly results in seating ring 152 engaging the seating shoulder 150 of upper valve sleeve 30. Further upward movement of the mandrel assembly raises valve sleeves 116 and 130. This results in the opening of valves 122 and 132 as shown in FIGURE 3. The opening of valve 122 results in equalization of the pressure within fluid passageway 36 by permitting fluid flow through ports 42 and 111. With the pressure in fluid passageways 36 and 84 equalized with the pressure exterior of the packer, the hold down buttons 96 are withdrawn by springs 102 and pressure applied against packing element 70 by piston 20 is removed.

The opening of flow bypass valve 132 permits fluid to flow freely from the interior of the mandrel assembly through ports 128 in the upper mandrel 22 and ports 137 in upper cage member 136.

Further upward motion of the tubing affixed to the mandrel assembly moves lugs 48 into the upper portion 46A of slot 46. The packer can then be raised or lowered in the casing and reset at a new position by repeating the same steps heretofore described.

As the packer is moved by upward motion of the tubing attached to it fluid is free to pass from the exterior of the packer through ports 137 and 128 (see FIGURE 3) and down through the exterior of the mandrel assembly so that no swabbing action occurs. The same flow path is available as the packer is lowered into the hole permitting fluid to flow upwardly in the mandrel and outwardly through ports 128 and 137.

A most important feature of the invention is that the packer can always be released by a straight upward pull without rotation. Hydraulic forces on the packer are always balanced so that regardless of the amount of internal or external fluid pressure the packer can be released by upward pull on the tubing without any other type of unlocking action necessary.

The invention has been described with a certain degree of particularity and is manifest that many changes may be made in the details of construction and the arrangement of components without departing from the spirit and scope of this disclosure. It is understood that the invention is not limited to the abstract herein, nor the summary of the invention, nor the exemplified embodiment presented to illustrate an example of the invention, but the invention is to be limited only by the appended claim or claims, including the full range of equivalency to which each element thereof is entitled.

What is claimed:

1. A packer for mounting on the lower end of a tubing string for sealably closing a casing and being removable by upward pull on the tubing string, the packer comprising:

an elongated tubular mandrel affixed at the upper end to the lower end of said tubing string;
a tubular elastomer packing element received on the

exterior of said mandrel intermediate the length thereof, said packing element being of normal exterior diameter less than the interior diameter of said casing and expandable by the application of compressive force against the ends thereof to sealably engage the interior of said casing;

slip means supported on the exterior of said mandrel below said packing element, said slip means being outwardly expandable to engage and lock against the interior of said casing when said mandrel is lowered to a set position relative to said slip means;

a tubular inner sleeve affixed to the interior of said mandrel having an outside diameter less than the inside diameter of said mandrel and providing an annular fluid passageway therebetween, said passageway being closed at each end, said mandrel having a port opening therein below said packing element communicating the exterior of said mandrel with said annular passageway;

a tubular cylinder member carried on the exterior of said mandrel and having the lower end thereof affixed to the upper end of said packing element, a portion of said cylinder member having an enlarged inner diameter relative to the exterior diameter of said mandrel providing an annular pressure cavity;

an enlarged diameter piston member carried by said mandrel in said annular pressure cavity, the outside diameter of said piston member slidably and sealably engaging the enlarged interior diameter of said cylinder member, said mandrel having a port opening therein above said piston member communicating said annular passageway with said pressure cavity whereby fluid pressure in said pressure cavity forces said piston member against said packing element to increase the compressive force on said packing element in proportion to the pressure of fluid in said annular passageway; and

a valve sleeve slidably positioned on said mandrel above said cylinder member, the mandrel having an upper port therein spaced from the upper end of said cylinder communicating with said annular passageway, said valve sleeve closing said upper port when said mandrel is in the set position and being slidable upwardly as said mandrel is pulled upwardly to open said upper port and vent the fluid pressure in said fluid passageway through said upper port to thereby relieve the hydraulic pressure on said piston member tending to expand said packing element.

2. A packer according to claim 1 wherein said mandrel includes a bypass port therein above said tubular inner sleeve, and including:

an upper valve sleeve slidably positioned on said mandrel, said upper valve sleeve closing said bypass port when said mandrel is in the set position; and means of slidably positioning said upper valve sleeve to open said bypass port when said mandrel is raised upwardly whereby the fluid pressure above and below said packing element may equalize.

3. A packer according to claim 1 including:

an enlarged diameter tubular member of outside diameter slightly less than the inside diameter of said casing, said enlarged diameter member being carried coaxially on said mandrel, said tubular member having at least one cylindrical opening therein, the axis of said opening being perpendicular the tubular member tubular axis, and said tubular member having a groove in the external surface thereof in the plane of the tubular axis and the axis of said cylindrical opening;

a cylindrical hold down button member having a forward and rearward face, said button member being slidably and sealably positioned in said cylindrical opening in said tubular member, said button having an outer face configured to provide toothed projections which engage the interior of said casing when the button member is slidably radially outwardly advanced relative to said tubular member, said button member having a diametrical groove in the outer face thereof, said groove being aligned with said groove in said tubular member;

an elongated spring member received and retained in said groove in said tubular member and said button member normally urging said button member inwardly; and

means communicating hydraulic fluid pressure from said annular passageway, to the rearward surface of said hold down button member.

4. A packer according to claim 3 including a pair of tubular retainer rings receiving said tubular body member and spaced to either side of said button member, said retainer rings serving to retain said spring member in said groove in said body member.

References Cited

UNITED STATES PATENTS

3,211,227	10/1965	Mott	166—120
3,233,675	2/1966	Tamplen et al.	166—120
3,311,169	3/1967	Hefley et al.	166—120

50 JAMES A. LEPPINK, *Primary Examiner*.

U.S. Cl. X.R.

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PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,454,087

Dated July 8, 1969

Inventor(s) Charles A. Pitts

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 42, cancel beginning with "received about the upper end" and insert -- positioned on the exterior --; after "mandrel" insert -- 22 --; Column 5, line 25, for "reached" read -- reacted --; Column 6, line 45, for "exterior" read -- interior --.

SIGNED AND
SEALED

SEP 30 1969

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents