

Sept. 5, 1967

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3,339,637

WELL PACKERS

Filed Oct. 14, 1965

3 Sheets-Sheet 1

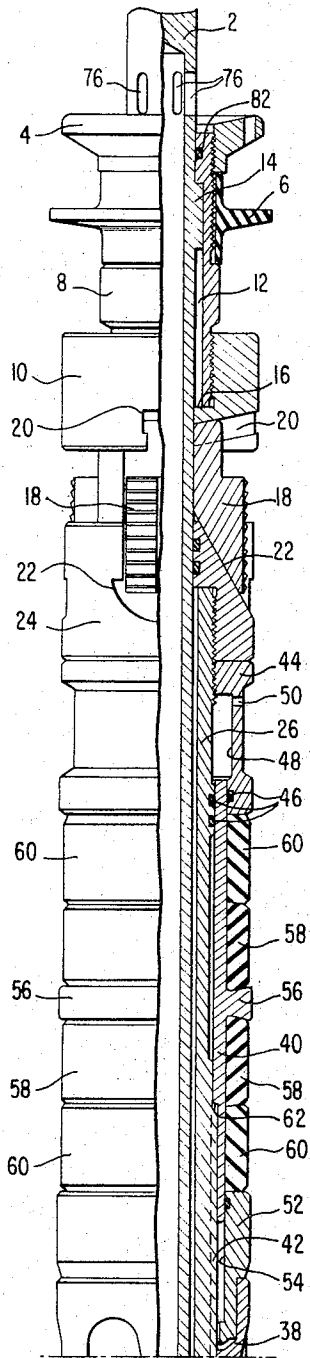


FIG. 1A

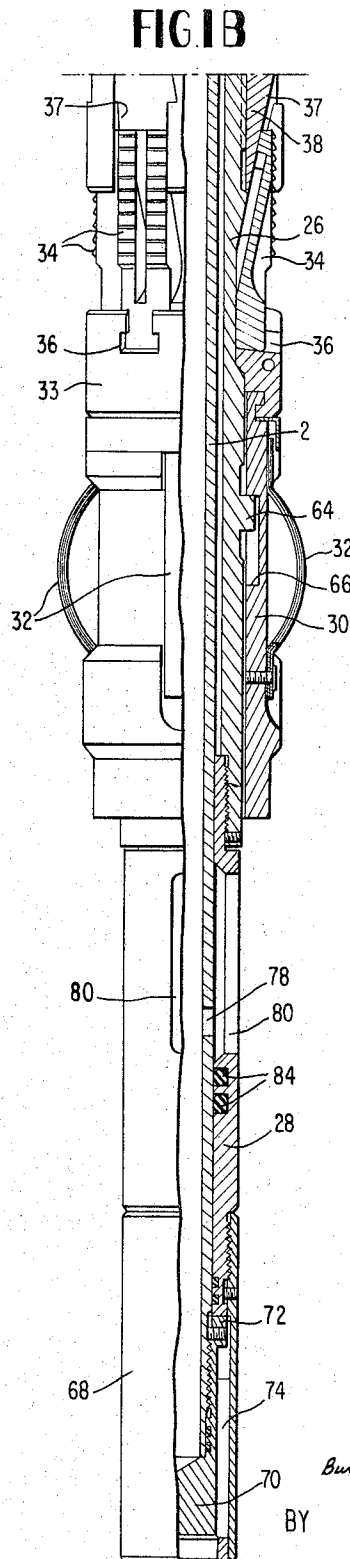


FIG. 1B

FIG. 2

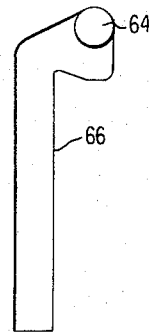
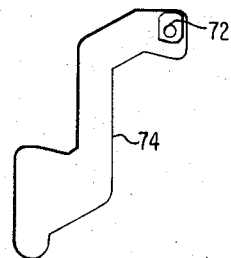


FIG. 3



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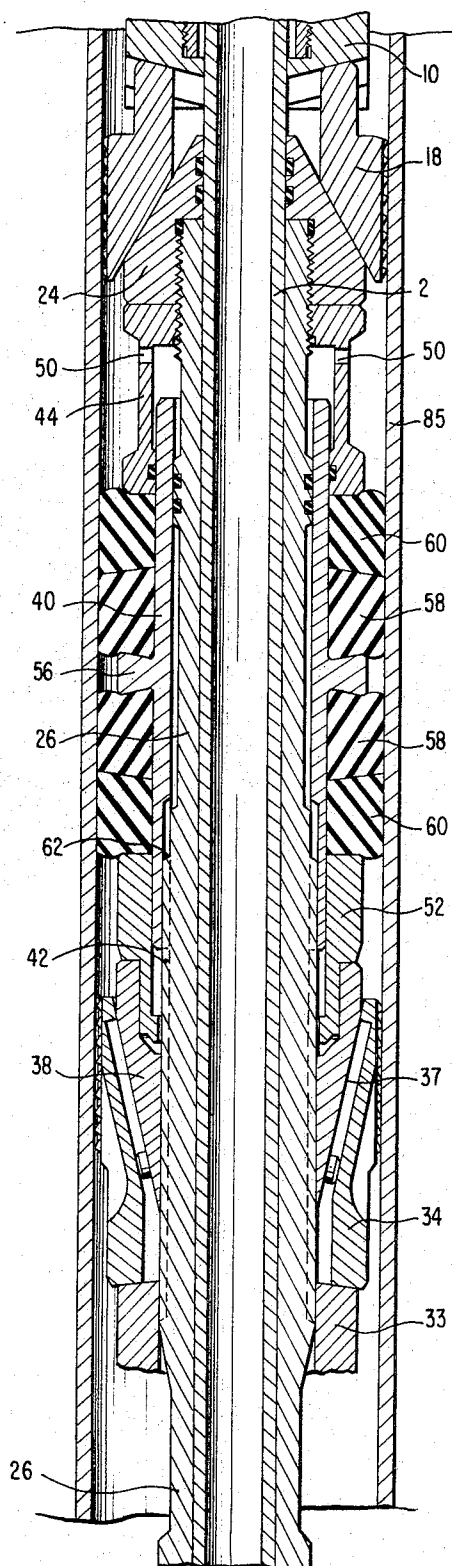


FIG.4

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FIG 5

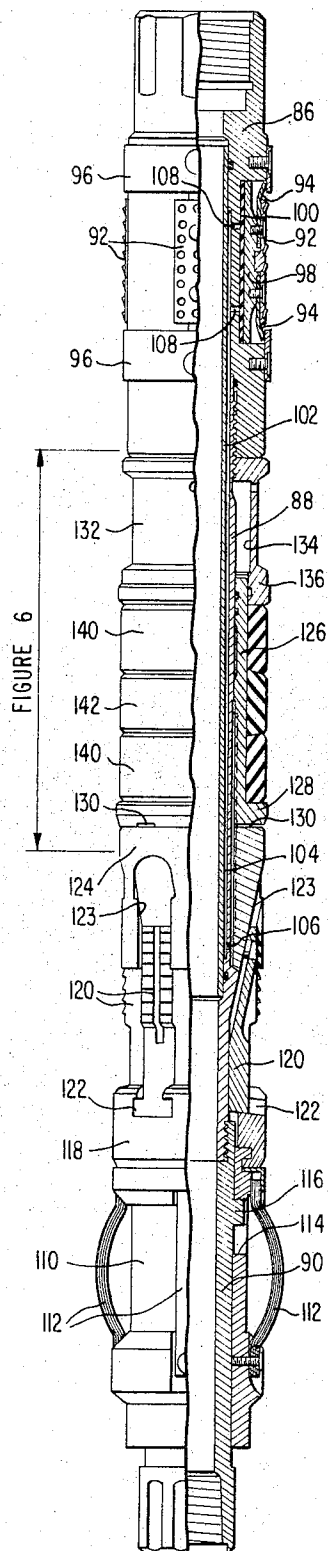
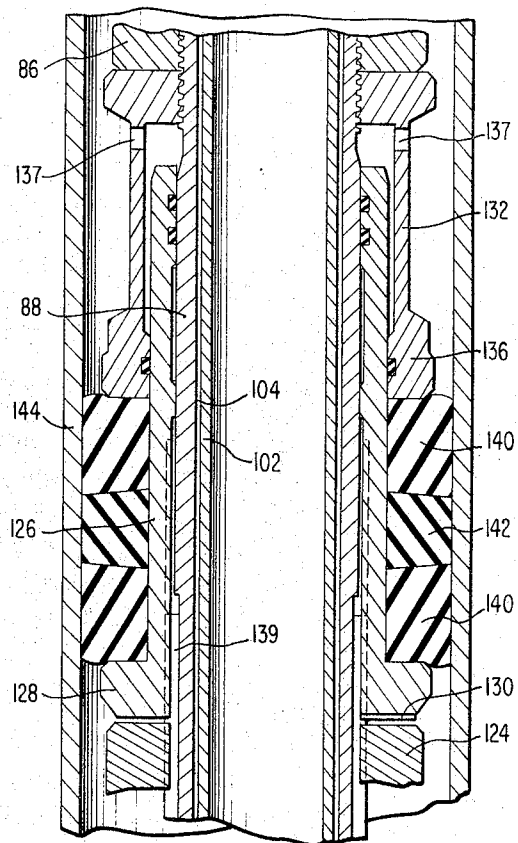


FIG 6



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WELL PACKERS

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Filed Oct. 14, 1965, Ser. No. 496,039
12 Claims. (Cl. 166-128)

This invention relates to packers used in well operations, and more particularly to mechanically set packers.

A conventional packer includes a ring of elastically deformable material mounted on a mandrel, with shoes on the mandrel at opposite ends of the elastic ring. An axial force is applied mechanically to cause the shoes to move toward each other, thereby compressing the elastic ring axially and causing the center portion of the ring to expand radially outward against the casing. The effectiveness of the seal between the casing wall and the packer ring depends upon the magnitude of the axial force exerted on the packer ring by the shoes. Occasionally, well conditions are such that the mechanical force on the packer ring is insufficient to maintain a fluid-tight seal between the packer ring and the casing. If there is an extremely high differential pressure across the packer ring, after it has been set, the packer ring may collapse or leakage may occur between the packer ring and the casing.

Accordingly, it is an object of this invention to provide a mechanically set packer which resists collapse due to a fluid pressure differential across the packer ring.

It is a further object of this invention to provide a mechanically set packer which forms a tight seal against a casing.

A still further object of this invention is to provide a mechanically set packer which may be operated easily and reliably.

These objects are accomplished in accordance with the preferred embodiment of the invention by a packer having a floating packer mandrel on which the packer element or ring is mounted. The floating packer mandrel is mounted in telescoping relation on an inner mandrel, with top and bottom shoes also mounted on the inner mandrel. The floating packer mandrel has a flange engaging one end of the cylindrical packer element and one of the packer shoes engages the opposite end of the packer element. The floating mandrel is in the form of a piston, with one end in fluid communication with the exterior of the packer below the packer element and the opposite end of the floating mandrel in fluid communication with the exterior of the packer above the packer element.

Conventional slips also are provided above and below the packer element. By manipulating the inner mandrel and applying an axial force, the slips are displaced outwardly against the wall of the casing and the shoes displaced longitudinally toward each other. The displacement of the shoes axially compresses the packer element, causing the center portion of the packer element to expand outwardly against the casing. This forms an initial seal between the packer element and the casing. Any fluid pressure differential across the packer element is applied to the floating packer mandrel, causing the mandrel to be displaced toward one of the packer shoes, thereby further axially compressing the packer element and forming a tighter seal against the wall of the casing. Preferably, a plurality of packer elements is provided and one of the packer elements is more easily deformed than the other, in order to provide a more effective seal.

This preferred embodiment is illustrated in the accompanying drawings in which:

FIG. 1A is a cross sectional view of the upper portion of the packer of this invention;

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FIG. 1B is a cross sectional view of the lower portion of the packer;

FIG. 2 is a schematic view of the J-slot in the drag spring sleeve;

FIG. 3 is a schematic view of the J-slot in the bypass body;

FIG. 4 is a cross sectional view of the central portion of the packer showing the packer elements expanded against the wall of a casing;

FIG. 5 is a cross sectional view of a modified form of a packer of this invention; and

FIG. 6 is a cross sectional view of the central portion of the modified form of the packer, with the packer elements expanded against the wall of a casing.

Referring to FIGS. 1A and 1B, the packer of this invention is secured to the lower end of a tubing string by a conventional overshot or other suitable device, not shown. The packer includes a central mandrel 2 which is adapted to be connected to the tubing string. A junk catcher 4 and a resilient cup 6 are mounted on a slip control body 8, which in turn is mounted in telescoping relation on the mandrel 2. An upper slip retainer 10 is threadedly secured to the lower end of the slip control body 8. The slip control body 8 has an internal cylindrical recess 12 to accommodate a flange 14 on the mandrel 2. Upon axial movement of the mandrel through the recess 12, the flange 14 engages an internal shoulder 16 in the upper slip retainer 10.

A plurality of slips 18 are mounted in T-slots 20 in the upper slip retainer 10. The opposite end of each slip 18 is received in a sloping T-slot 22 formed in an upper mechanical slip body 24. An intermediate mandrel 26 is threadedly secured at its upper end to the mechanical slip body 24 and at its lower end, the mandrel 26 is threadedly secured to a bypass body 28. A drag spring sleeve 30 is mounted over the intermediate mandrel 26 and drag springs 32 on the sleeve 30 extend outwardly to engage the interior surface of a casing. A split ring collar 33 is secured to the end of the sleeve 30 for receiving the lower end of slips 34, which are mounted in T-slots 36 in the collar 33. The opposite end of each slip 34 is received in a sloping T-slot 37 formed in a lower mechanical slip body 38.

A floating mandrel 40 is mounted over the intermediate mandrel 26. The outer surface of the mandrel 26 has a spline 42 which is received in a corresponding groove in the floating mandrel 40. The spline 42 prevents the floating mandrel 40 from rotating relative to the intermediate mandrel 26. A top shoe 44 is threadedly secured at one end to the intermediate mandrel 26. The opposite end of the shoe 44 is spaced from the mandrel 26 and the floating mandrel 40 extends into the annular space between the shoe 44 and the mandrel 26. O-rings 46 on opposite sides of the mandrel 40 prevent the leakage of fluid around the mandrel. The central portion of the shoe 44 has a cylindrical recess 48 for receiving the end of the mandrel 40 upon longitudinal movement of the mandrel relative to the shoe 44. A radial port 50 in the shoe 44 provides fluid communication between the outside of the shoe and the upper end of the mandrel 40. A bottom shoe 52 is mounted in sliding relation on the mandrel 26. The shoe 52 has an internal recess 54 for receiving the end of the mandrel 40 upon longitudinal movement of the shoe relative to the mandrel 40.

The floating mandrel 40 has a radial flange 56 and a pair of cylindrical packer elements 58 and 60 are mounted in the space between the flange 56 and the top and bottom shoes. The inner packer elements 58 are softer than the outer packer elements 60. Preferably, the outer packer elements have a hardness of about 95, while the

inner packer elements have a hardness of approximately 85 on the durometer scale. The adjacent edges of the packer elements are slightly tapered, as shown in FIG. 1A to resist axial displacement of the softer elements 58 when the elements are expanded against the casing. Normally, the flange 56 is centered between the top and bottom shoes. Downward longitudinal displacement of the mandrel 40 is limited by a shoulder 62 on the end of the spline 42 which engages the inner end of the corresponding recess in the mandrel 40. Upward movement of the mandrel 40 is restricted only by engagement of the end of the mandrel with the upper end of the cylindrical recess 48 in the top shoe 44.

At the lower end of the intermediate mandrel 26, there is a lug 64 which engages a J-slot 66 in the drag spring sleeve 30. The shape of the J-slot 66 is shown schematically in FIG. 2. Below the intermediate mandrel 26, the bypass body 28 is threadably secured to a J-slot body 68. The lower end of the central mandrel 2 is closed by a threaded cap 70. The cap 70 has a lug 72 which is spaced from the end of the mandrel 2 and engages in a J-slot 74 in the J-slot body 68. The J-slot 74 is shown schematically in FIG. 3. The cap 70 closes the end of the mandrel 2. The lower end of the J-slot body 68 has an opening that is sufficiently large to allow the cap 70 to pass through the opening when the central mandrel 2 is displaced downwardly relative to the J-slot body 68. The J-slot 74, however, limits the extent of axial movement of mandrel 2.

The central mandrel 2 has a plurality of upper bypass ports 76 and lower bypass ports 78. The lower bypass ports communicate with the exterior of the packer through openings 80 in the bypass body 28, when the mandrel 2 is in the position shown in FIG. 1. An upper sealing ring 82 in the slip control body 6 and lower seal rings 84 in the bypass body 28 prevent the leakage of fluid into the interior of the mandrel 2 when the mandrel is displaced downwardly a sufficient distance for the bypass ports 76 and 78 to be positioned below the respective seal rings 82 and 84.

In operation, the packer is run in a casing 85 on the end of a tubing string with its components in the positions shown in FIG. 1. The upper end of the mandrel 2 is coupled to a tubing string by an overshot or other conventional coupling device. When the desired elevation is reached, the mandrel 2 is rotated in a right-hand direction to move the lug 72 into the elongated portion of the J-slot 74. When the lug 72 is in the straight portion of the J-slot 74, right-hand rotation is transmitted to the intermediate mandrel 26, and continued right-hand rotation of the mandrel causes the lug 64 on the intermediate mandrel 26 to move into the elongated portion of the J-slot 66 in the drag spring sleeve. A downward force is applied to the mandrel 2 to cause the lug 72 to move into the recess in the bottom of the J-slot 74, which then imposes a downward force on the intermediate mandrel 26 to cause the lug 64 to move downwardly through the J-slot 66.

Downward movement of the mandrel 2 relative to the intermediate mandrel 26 causes the flange 14 to move through the recess 12 and to engage the shoulder 16 in the slip retaining sleeve 10. Since the drag springs 32 resist longitudinal displacement of the sleeve 30 relative to the casing 85, downward movement of the mandrels 2 and 26 relative to the sleeve 30 causes the upper slips 18 to be wedged outwardly against the casing by the mechanical slip body 24 and the lower slips 34 to be wedged outwardly against the casing by the lower mechanical slip body 38. The teeth on the slips are inclined in a direction facing away from the packer elements 58 and 60, so that the slips may slide along the casing 85 toward the packer elements, but resist movement longitudinally away from the packer elements. The downward force on the mandrel 2 causes the packer elements 58 and

60 to be compressed between the top shoe 44 and the bottom shoe 52. The floating mandrel flange 56 is clamped between the packer elements 58, and as the mandrel 26 moves downwardly, the shoulder 62 on the spline 42 is displaced downwardly relative to the packer mandrel 40, and the mandrel 40 is free to adjust its position downwardly as the packer elements 58 and 60 are axially compressed.

Since the inner packer elements 58 are softer than the outer packer elements 60, they tend to be deformed to a greater extent. The hard packer elements 60 resist axial deformation of the softer elements 58 as a result of fluid pressure acting on the elements 58. The combination of separate, soft and hard packer elements thus provides an effective seal against the wall of the casing.

When the packer elements are expanded against the wall of the casing 85, as shown in FIG. 4, there is no fluid communication between the annular space above and below the packer elements, and accordingly, a fluid pressure differential may exist across the packer elements. Fluid pressure above the packer elements is applied to one end of the floating mandrel 40 through the ports 50 in the top shoe 44. Fluid pressure from below the packer elements is applied to the opposite end of the floating mandrel 40 through the space between the lower end of the slip body 38 and the outer surface of the mandrel 26, as shown in FIG. 4. The resultant force on the floating mandrel 40, due to the pressure differential acting at opposite ends of the mandrel 40, causes the mandrel to be displaced upwardly or downwardly relative to the intermediate mandrel 26, depending on the direction of the resultant force. This movement of the mandrel 40 imposes an additional compressive force on one of the sets of packer elements 58 and 60. Thus, as the pressure differential across the packer elements increases, the compressive forces tending to maintain the packer elements expanded against the casing also increase and maintain a tight seal.

When it is desired to collapse the packer, the tubing string which is coupled to the mandrel 2 is picked up and given a left-hand rotation to move the lug 72 into the elongated portion of the J-slot 74. Upward displacement of the mandrel 2 causes the upper and lower bypass ports 76 and 78 to move past the seals 82 and 84 until the interior of the mandrel 2 is in communication with the annular space above and below the packer elements 58 and 60. At the same time, upward movement of the mandrel 2 causes the ring 14 to engage the upper end of the cylindrical recess 12, thereby imposing an upward axial force on the slip control body 10 to draw the slips 18 away from the casing 85. As soon as the upper slips are separated from the casing, the packer elements 58 and 60 expand longitudinally to displace the top and bottom shoes 44 and 52 away from each other. Continued upward movement of the mandrel 26 causes the T-slots 37 to draw the lower slips 34 away from the casing. The mandrel 2 is then given a left-hand rotation to move the lug 64 into the offset portion of the J-slot 66, thereby locking the intermediate mandrel 26 to the drag spring sleeve 30. The packer then can be moved through the casing.

A modified form of the invention is illustrated in FIGS. 5 and 6. The packer includes a hydraulic slip body 86, an upper mandrel 88 and a lower mandrel 90 which are secured together by screw threads. The slip body 86 has internal threads at its upper end for securing the packer to the lower end of a tubing string. The upper slip body 86 has slip inserts 92 which are biased toward a retracted position by springs 94. The springs 94 are retained in the slip body 86 by a pair of retainer bands 96. The slip inserts 92 are spaced around the circumference of the slip body 86 and under each of the slip inserts 92 there is a shoe 98 and a resilient slip pad 100 which forms an expandable fluid chamber between the pad 100 and the bottom of the recess in which the shoe 98 is received.

A tube 102 extends through the slip body 86 and is secured at its lower end in the upper mandrel 88 to form a fluid passage 104. A radial port 106 is formed in the upper mandrel 88 for fluid communication with the passage 104. Fluid pressure in the passage 104 communicates with the chamber under the pad 100 by means of radial ports 108 in the slip body 86.

A drag spring sleeve 110 is mounted on the lower mandrel 90 and a plurality of drag springs 112 project outwardly from the sleeve to engage the casing. A J-slot 114, having substantially the shape shown in FIG. 2, is provided in the drag spring sleeve 110 and a lug 116 on the lower mandrel 90 extends into the J-slot 114. A split ring collar 118 is connected to the upper end of the drag spring sleeve 110 for retaining one end of each of the lower slips 120 in T-slots 122. The opposite end of each slip is mounted in a sloping T-slot 123 formed in a mechanical slip body 124.

A packer mandrel 126 is mounted in telescoping relation on the upper mandrel 88. One end of the packer mandrel 126 has a radial flange 128 which abuts against the mechanical slip body 124. A plurality of radial slots 130 in the packer mandrel 126 permit fluid communication between the packer mandrel 126 and the mechanical slip body 124. A top shoe 132 having a cylindrical recess 134 is threadedly secured at one end to the upper mandrel 88, and a ring 136 is formed on the opposite end of the shoe 132. The axial surface of the ring 136 is spaced from the exterior surface of the upper mandrel 88 to form a hollow cylinder for receiving the upper end of the packer mandrel 126. Ports 137 in the shoe communicate with the interior of the shoe 132. Seal rings 138 prevent the leakage of fluid around the end of the mandrel 126. As shown in FIG. 6, there is a spline 139 on the mandrel 88 which is received in a groove in the mandrel 126 for preventing rotation of one mandrel relative to the other.

Packer elements 140 and 142 are mounted between the flange 128 on the packer mandrel and the ring 136 on the top shoe. The center packer element 142 is softer than the outer packer element 140. Therefore, the center packer element 142 is expanded to a greater extent radially than the harder elements 140. As shown in FIG. 5, the adjacent edges of the packer elements 140 and 142 preferably have a slight taper which tends to confine the center element 142 and prevent axial extrusion.

In operation, the packer is lowered in a casing 144 on the end of a tubing string, with its various components in the positions shown in FIG. 5. At the desired depth, the tubing string is rotated in a right-hand direction to cause the lug 116 to move into the elongated portion of the J-slot 114. The drag springs 112 engage the walls of the casing 144 and prevent the sleeve 110 from rotating with the lower mandrel 90. The drag spring sleeve 110 remains stationary and the slips 120 are displaced outwardly against the casing by the mechanical slip body 124 as the upper mandrel 88 and the lower mandrel 90 move downwardly relative to the sleeve 110.

When the slips 120 are in engagement with the casing 144, the mechanical slip body 124 is restricted by the slips 120 from moving downwardly. Therefore, further downward movement of the mandrel 88 causes the top shoe 132 to move toward the flange 128 on the packer mandrel, thereby compressing the packer elements 140 and 142 in an axial direction and causing them to expand radially outward against the casing. The center packer element 142 is softer than the outer packer elements 140, and accordingly, the center element deforms axially to a greater extent to form a tight seal against the casing.

The packer mandrel 128 is exposed at its lower end to the fluid pressure below the packer elements and at its upper end to the fluid pressure above the packer elements. Ordinarily, when this form of the packer is used, higher fluid pressure occurs below the packer elements. The fluid is applied to the packer mandrel 126 through the slots 130 between the flange 128 and the mechanical slip

body 124. The fluid pressure acting on the packer mandrel 126 causes the mandrel to be displaced toward the top shoe 132 and imposes a supplemental axial force tending to expand the packer elements 140 and 142. The fluid pressure below the packer elements is also applied through the port 106 and the passage 104 to the slip pad 100 of each slip assembly to expand the upper slips 92. The packer in its set condition is shown in FIG. 6.

The packer may be collapsed by relieving the pressure below the packer elements 140 and 142 by any suitable means, such as by conventional relief ports. When the pressure below the packer elements is reduced, the upper slips 92 are retracted by the springs 94 and picking up the weight of the tubing string permits the packer elements to expand axially and return to the position shown in FIG. 5. A shoulder 144 on the upper mandrel 88 engages the lower end of the mechanical slip body 124 for displacing the body upwardly and retracting the slips 120. When the slips have been retracted, a left-hand rotation is imparted to the lower mandrel 90 to move the lug 116 into the short portion of the J-slot 114. The packer components are then in the position shown in FIG. 5, and the packer may be moved through the casing.

The packer of this invention utilizes mechanical means for expanding the packer elements and, in addition, imposes an auxiliary force in response to fluid pressure in the well for expanding the packer elements and maintaining a tight seal against the casing. In certain installations, it is not possible to impose sufficient mechanical force on the packer elements to withstand the high fluid pressure differentials acting on the packer elements. The packers of this invention take advantage of this pressure differential to apply an additional axial force to the packer elements, thereby more effectively resisting the collapse of the packer elements.

Furthermore, by providing packer elements having different hardnesses, the softer packer element is deformed to a greater extent, while the harder packer elements resist a tendency for the softer elements to be displaced by high pressure differentials.

While this invention has been illustrated and described in several embodiments, it is recognized that various changes may be made therein without departing from the invention as set forth in the claims.

I claim:

1. Packer apparatus comprising:

- (a) a first mandrel;
- (b) a packer mandrel mounted in telescoping relation over said first mandrel, said packer mandrel being movable longitudinally relative to said first mandrel;
- (c) a deformable packer element, said element being in the form of a ring and being mounted on the exterior of said packer mandrel;
- (d) means forming shoes at opposite ends of said packer element, said packer mandrel having a flange engaging said packer element, piston means on opposite ends of said packer mandrel, one of said piston means being exposed to fluid pressure at one end of said packer element and the other of said piston means being exposed to fluid pressure at the opposite end of said packer element;
- (e) means for selectively anchoring one of said shoe forming means against a casing upon axial movement of said first mandrel, and means for moving the other of said shoe forming means toward said one shoe forming means to expand said packer element;
- (f) said packer element including a plurality of sub-elements, one of said sub-elements being substantially softer than other sub-elements, whereby an effective casing seal may be formed.

2. Packer apparatus according to claim 1 including: means for restricting rotation of said packer mandrel relative to said first mandrel.

3. Packer apparatus according to claim 1 wherein said anchoring means includes a plurality of slips, said slips

being positioned below said packer element and having teeth projecting away from said packer element, and cam means on said first mandrel, said cam means urging said slips outwardly against the casing upon downward movement of said first mandrel, whereby the packer element may be expanded by movement of the mandrel and said packer mandrel imposes an auxiliary force on the packer element in response to a pressure differential across said packer element.

4. In packer apparatus, a mandrel, a pair of shoes mounted for axial movement on said mandrel, a plurality of packer rings on said mandrel between said shoes, said rings being in substantially end to end abutting relation, one of said rings being substantially softer than other of said rings, whereby an effective casing seal may be formed upon axial movement of said shoes toward each other.

5. In packer apparatus according to claim 4, said packer rings having adjacent edges tapered for retaining said softer ring.

6. Packer apparatus comprising:

- (a) a first mandrel;
- (b) a packer mandrel mounted in telescoping relation over said first mandrel, said packer mandrel being movable longitudinally relative to said first mandrel;
- (c) a deformable packer element, said element being mounted on the exterior of said packer mandrel;
- (d) means forming shoes at opposite ends of said packer element, said packer element including a plurality of rings arranged in end to end abutting relation, said packer mandrel having a flange extending between said rings, piston means on opposite ends of said packer mandrel, one of said piston means being exposed to fluid pressure at one end of said packer element and the other of said piston means being exposed to fluid pressure at the other end of said packer element;
- (e) means for selectively anchoring one of said shoe forming means against a casing upon axial movement of said first mandrel, and means for moving the other of said shoe forming means toward said one shoe means to expand said packer element, whereby the packer mandrel flange compresses said rings in response to fluid pressure on said piston means.

7. Packer apparatus according to claim 6 wherein a plurality of said packer rings are disposed on opposite sides of said packer mandrel flange, at least one of said packer rings on each side of said flange being substantially softer than other rings on the same side of the flange.

8. Packer apparatus according to claim 1 including means for selectively bypassing fluid around said packer element when it is expanded.

9. Packer apparatus according to claim 6, wherein said selective anchoring and moving means includes:

- (a) a second mandrel mounted in said first mandrel in telescoping relation, said second mandrel having ports therein above and below said packer element, means on said first mandrel for closing said ports upon downward axial movement of said second mandrel, first J-slot means controlling relative axial movement between said first mandrel and said second mandrel,
- (b) said anchoring means including slips on said first mandrel below said packer element, slips on said second mandrel above said packer element, and second J-slot means controlling movement of said first and second mandrels relative to said lower slips, said slips having teeth facing away from said packer element for gripping said casing to resist collapse of said packer element.

10. Packer apparatus according to claim 6 wherein the interior surface of each of said shoes is spaced from the outer surface of said first mandrel and forming a hollow annular space for receiving said packer mandrel, seal means for preventing the leakage for fluid from one end to the other of said packer mandrel, and a spline on one of said packer mandrels and said first mandrel and a groove on the other of said mandrels.

11. Packer apparatus according to claim 1 wherein said sub-elements are in the form of rings arranged in end to end abutting relation, with one of said rings being softer than other of said rings, said softer ring being on the opposite side of said other rings from both of said shoe forming means, whereby said other harder rings are positioned between said softer ring and said shoe forming means.

12. Packer apparatus according to claim 10 wherein said packer element has three rings and said softer ring being the center ring.

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