WELL PACKER

This invention relates to a well packer for forming a fluid barrier between the interior of a casing string and the exterior of a tubing string.

Well packers for directing formation fluid flow through a tubing string have been used for many years in the oil and gas industry. Well packers have been designed to accommodate one, two or more tubing strings. Examples of prior dual string well packers are shown in U.S. Patent 3,167,127 to P.S. Sizer; U.S.Patent3,381,752 to T.L. Elliston; and U.S. Patent 3,391,741 to T.L. Elliston. These patents are incorporated by reference for all purposes within this application.

One object of the present invention is to provide a dual string packer which does not require

relative movement between its primary string mandrel and secondary string mandrel while setting the packer.

Another object of the present invention is to provide a well packer, either single or dual string, which can be released from its downhole set position by cutting the mandrel means below the packing elements.

A further object of the present invention is to provide a dual string well packer which is hydraulically set and has opposing slips on opposite ends of the packing element(s).

An additional object of the present invention is to provide a dual string hydraulically set packer which does not require moving seals on either the primary or secondary mandrel while setting the packer with the exception of the setting piston.

A still further object of the present invention is to provide a dual string well packer which has

a continuous primary spring mandrel and secondary string mandrel extending through the packing elements.

Another object of the present invention is to provide a dual string well packer which when set will resist both tension and compression forces within the tubing strings.

A further object of the present invention is to provide a dual string well packer which has the operational characteristics of a permanently set packer but can be removed from the well bore without having to mill or grind up the packer.

With these objects in view, the present invention provides a well packer comprising a pair of parallel mandrel means, each having a passageway extending therethrough; upper and lower body means carried on the exterior of the mandrel means and slidable longitudinally with respect to each other over the mandrel means; anchoring means carried by each body means and

radially expandable relative to each body means between a retracted position and an expanded position whereby each anchoring means is engageable with the interior of a casing string to prevent longitudinal movement of its associated body means relative to the casing string; packing means carried on the exterior of the mandrel means between the upper and lower body means; piston means, carried by said mandrel means, for moving the body means longitudinally toward each other in response to fluid pressure in one of said passageways; the longitudinal movement of the body means causing compression of the packing means and radial expansion thereof to form a fluid barrier between the exterior of the mandrel means and the interior of the casing string; the same longitudinal movement causing radial expansion of the anchoring means; means for locking each body means to the mandrel means after completion of the longitudinal movement whereby the packing means are maintained compressed and the anchoring means are maintained radially expanded; each anchoring means comprising a plurality of slip elements; each body means further comprising a slip carrier and a

slip expander which are movable longitudinally towards each other to radially expand the associated slip elements; means for releasing the mandrel means from the locking means of the lower body means; and means for moving the slip expander of the upper body means longitudinally away from its associated slip carrier to allow retraction of the slip elements carried by the upper body means after the locking means for the lower body means has been released.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a longitudinal schematic view partially in section and elevation showing two parallel upper strings of production tubing coupled with two parallel lower strings of production tubing supported from a well packer set in a casing string;

Figs. 2A, B, C and D are drawings in elevation with portions broken away showing the exterior

of a well packer incorporating the present invention;

Figs. 3A, B, C, D, E and F are drawings partially in section and elevation with portions broken away showing the well packer of Figs. 2A-D incorporating one embodiment of the present invention;

Figs. 4A, B, C and D are drawings, partially in longitudinal section and elevation with portions broken away, of the packer shown in Figs. 3A-F. The longitudinal section is generally shown rotated 90 degrees from the longitudinal section shown in Figs. 3A-F. However, an irregular section is shown in the vicinity of the upper and lower external slips and the hydraulic piston's connecting tube. Fig. 25 demonstrates how the irregular section was taken at these three locations.

Fig. 5 is a fragmentary drawing in section taken generally along line 5-5 of Fig. 3B;

Fig. 6 is a drawing in section along line 6-6 of Figs. 3E and 4C;

Fig. 7 is a plan view of the retaining cylinder which blocks the first and second cylinders of the upper body means from telescoping relative to each other;

Fig. 8 is an enlarged fragmentary view in section showing the threads on the exterior of the retaining cylinder which releasably engage matching threads on the interior of the second cylinder;

Fig. 9 is a drawing in section taken along line 9-9 of Figs. 3C and 4A;

Fig. 10 is a drawing partially in section and elevation of the locking sleeve used in the upper body means;

Fig. 11 is a drawing in longitudinal section of the slip expander of the lower body means;

Fig. 12 is a drawing in section taken along line 12-12 of Fig. 11;

Fig. 13 is a drawing in longitudinal section of the portion of the mandrel means which can be cut to release the lower body means;

Fig. 14 is a drawing in longitudinal section of the lower body means adapter sub;

Fig. 15 is a plan view of the lower body means adapter sub shown in Fig. 14;

Fig.16 is a schematic drawing partially in section with portions broken away showing a well packer similar to the packer of Figs. 3A-F being lowered through a casing string;

Fig. 17 is a schematic drawing partially in section with portions broken away showing the well packer of Fig. 16 set within the casing string;

Fig. 18 is a schematic drawing partially in section with portions broken away showing the

well packer of Fig. 16 after the mandrel means has been cut to release the lower body means;

Fig. 19 is a schematic drawing partially in section with portions broken away showing the well packer of Fig. 16 after the mandrel means has been raised to shift the locking sleeve or cylinder of the upper body means;

Fig. 20 is a schematic drawing partially in section with portions broken away showing the well packer of Fig. 16 after the mandrel means has been lowered to disengage the retaining cylinder;

Fig. 21 is a schematic drawing partially in section with portions broken away showing the well packer of Fig. 16 being removed from the casing string;

Figs. 22A, B, C and D are drawings in section with portions broken away showing a well packer incorporating the present invention with an

alternative embodiment for releasing the lower body means from its locked or set position;

Fig. 23 is a schematic drawing partially in section with portions broken away showing the lower body means of the well packer of Figs. 22A-D being released from its locked position;

Fig. 24 is a schematic drawing partially in section with portions broken away showing the well packer of Fig. 23 being removed from the casing string; and

Fig. 25 is a drawing in radial section taken along line 25-25 of Fig. 4A.

In Fig. 1 a well completion is shown using dual production tubing strings 40 and 41. A production packer 60 is set to seal with the interior of a casing 42 and to direct formation fluid flow through the tubing strings 40 and 41 to the well surface (not shown). The lower portions of the tubing strings 40 and 41 are suspended from the packer 60. The upper portions of the tubing

strings 40 and 41 are attached to an orienting head assembly 43. An orienting body 44 is attached to the packer 60. The orienting head assembly 43 and the orienting body 44 provide a system for releasably coupling the upper portions of the tubing strings 40 and 41 to the packer 60. This coupling system is fully described in U.S. patent 4,236,734 by Mansour Ahangarzadeh. Alternatively, the upper portions of the tubing strings 40 and 41 could be directly attached to the packer 60 by suitable threaded connections. However, the use of the orienting head assembly 43 and the orienting body 44 provides for greater flexibility in operating the well.

The packer 60 is built around a pair of parallel mandrel means 61 and 62 which have passageways 63 and 64 extending respectively therethrough. The mandrel means 61 and 62 include several sections of hollow tubing which are attached to each other by matching threads 143. O-rings 144 are used to prevent fluid leaks through threaded connections 143. Other sections of the mandrel

means 61 and 62 are designated as 61a, 61b, 61c, 62a, 62b, 62c and 62d respectively. The orienting head assembly 43 and the orienting body 44 have parallel longitudinal bores 45 and 46 which extend therethrough and communicate with the passageways 63 and 64 respectively. A locator recess or profile 47 is provided in each bore 45 and 46 for use in releasing the packer 60 from its set position. The recesses 47 may also be used for other well control purposes. Threads 50 are provided within the bores 45 and 46 to connect the orienting head assembly 43 with the upper portion of the respective tubing strings 40 and 41.

Upper body means 65 is releasably secured to and surrounds the exterior of the mandrel means 61 and 62. The upper body means 65 includes several subassemblies which are generally cylindrical and slidable with respect to each other and the mandrel means 61 and 62. An upper slip carrier 66 is formed by the portion of upper body means 65 immediately adjacent to the orienting body 44. Co-acting threads 48 are provided on the extreme end of the mandrel

means 61 and 62 and within the bores 45 and 46 to attach the orienting body 44 to the packer 60. If desired, suitable threads could be placed on the extreme end of the mandrel means 61 and 62 to allow direct attachment to the tubing strings 40 and 41 respectively. An adapter sub or collar could be used in place of the orienting body 44 to provide a suitable shoulder to abut the slip carrier 66.

The slip carrier 66 has a plurality of external slip elements 67 attached thereto by conventional T-handles 68 and dove-tailed slots 69. A plurality of screw holes 70 is provided through the exterior of the slip carrier 66 to allow insertion of shear screws 71 therein. Suitable annular grooves 72 are provided in the exterior of both mandrel means 61 and 62 adjacent to screw holes 70 to receive the extreme end of shear screws 71. As shown in Fig. 5, the shear screws 71 releasably secure the upper slip carrier 66 th the mandrel means 61 and 62. The threads 48 and the orienting body 44 prevent longitudinal movement of

the mandrel means 61 and 62 with respect to each other in the embodiment of the present invention shown in Fig. 3B. If the orienting body 44 is not used, the upper slip carrier 66 and the shear screws 71 will also prevent longitudinal movement of the mandrel means 61 and 62 with respect to each other until after the screws 71 have been sheared.

The upper slip carrier 66 also carries an internal slip ring or c-ring 73 adjacent to each mandrel means 61 and 62. Beveled cam surfaces are provided on the interior of the slip carrier 66 to activate the internal slip rings 73 causing them to ride against or contact the adjacent mandrel means 61 or 62. Teeth 74 are formed on each slip ring 73 to engage the exterior of the adjacent mandrel means 61 or 62 allowing longitudinal movement of the mandrel means in only one direction with respect to the internal slip rings 73. As will be explained later, the internal slip rings 73 perform an important function in the release of the upper body means 65 from its set position.

A slip expander 75 is releasably secured by shear screws 76 to the exterior of the mandrel means 61 and 62 spaced longitudinally from the slip carrier 66. As shown in Figs. 3B, 3C and 4A, this defines the first or retracted position for the anchoring means of the upper body means 65. The slip expander 75 has tapered surfaces 77 adjacent to each slip element 67. When sufficient force is applied to the slip expander 75, the screws 76 will shear allowing the slip expander 75 to move longitudinally towards the slip carrier 66. The tapered surfaces 77 cause the slip elements 67 to radially expand during the longitudinal movement and to engage the interior of the casing string 42 as shown in Fig. 17. The slip elements 67, the slip carrier 66 and the slip expander 75 cooperate to provide an anchoring means carried by the upper body means 65 which is engageable with the interior of the casing string 42 to prevent longitudinal movement of the body means 65 relative thereto. Bolts 78 are provided for use during assembly of the packer 60 and to define the maximum longitudinal distance the slip

expander 75 can move away from the slip carrier 66. The bolts 78 also assist with the removal of the packer 60 after it has been released from its set position. Beveled cam surfaces 50 are provided on the interior of the slip expander 75 adjacent to each mandrel means 61 and 62. The surfaces 50 are sized to receive the internal slip ring 73. The slip carrier 66 and the c-ring configuration of the slip rings 73 hold the internal slip rings 73 in contact with the mandrel means 61 and 62 while the packer 60 is lowered into the casing string 42 and set at a desired downhole location. The slip expander 75 via the surfaces 50 holds the internal slip rings 73 in contact with the mandrel means 61 and 62 during the release of the packer 60 from its set position if downward force must be applied to the slip expander 75.

A first cylinder 80 surrounds the mandrel means 61 and 62 and abuts the slip expander 75. A flange 82 is formed on the exterior of the first cylinder 80 to provide a shoulder for the slip

expander 75 to rest on. A second cylinder 81 surrounds the mandrel means 61 and 62 adjacent to the first cylinder 80. The outside diameter of the first cylinder 80 is sized to telescope within the inside diameter of the second cylinder 81. A retainer plate 83 is provided at the end of the second cylinder 81 opposite the first cylinder 80. The retainer plate 83 is basically a solid disc with two openings 85 and 86 for the mandrel means 61 and 62 to respectively slide through. A circumferential rim 84 is provided on the exterior of the plate 83 to receive the end of the second cylinder 81.

Teeth or grooves 87 are formed on the inside diameter of the second cylinder 81 near the end which receives the first cylinder 80. A retaining cylinder 88 is disposed within the second cylinder 81 and has matching teeth or grooves 89 to engage the teeth 87. A portion of the retaining cylinder 88 is cut away as best shown in Fig. 7 which allows the cylinder 88 to function in a manner similar to a snap ring or c-ring. Also, the pitch of the

teeth 87 and 89, as best shown in Fig. 8, is selected so that when force is applied to end 90 of the cylinder 88, the teeth 87 and 89 will ratchet over each other if the cylinder 88 can flex inwardly.

Normally, a locking sleeve 91 is positioned between the mandrel means 61 and 62 and the retaining cylinder 88 to prevent inward flexing of the cylinder 88. Shear pins 92 are provided to releasably secure the locking sleeve 91 to the first cylinder 80 and to maintain the locking sleeve 91 positioned bethind the retaining cylinder 88. As best shown in Fig. 3C, the retaining cylinder 88 prevents the first cylinder 80 from telescoping relative to the second cylinder 81 as long as the teeth 87 and 89 are engaged.

Snap rings 93 are secured to the exterior of each mandrel means 61 and 62 in appropriately sized grooves adjacent to the locking sleeve 91. Shoulders 94 are provided on the interior of the locking sleeve 91 adjacent to the snap rings 93.

As will be explained later, the snap rings 93 engage the shoulders 94 to lift or remove the locking sleeve 91 from behind the retaining cylinder 88. The first cylinder 80 and the second cylinder 81 cooperate to provide a support for the slip expander 75 and prevent the slip expander 75 from moving longitudinally away from the slip carrier 66 until after the retaining cylinder 88 has been released from the teeth 87.

Packing means 97 are carried on the exterior of the mandrel means 61 and 62 between the upper body means 65 and lower body means 110. The packing means 97 are preferably molded from elastomeric material. When the upper body means 65 and the lower body means 110 are moved longitudinally towards each other, this longitudinal movement causes compression and radial expansion of the packing means 97 to form a fluid barrier with the interior of the casing string 42 as shown in Fig. 1. For the packer 60, the packing means 97 consists of three separate elastomeric elements. However,

other configurations of packing means 97 can be readily used.

The lower body means 110 is carried on the exterior of the mandrel means 61 and 62 and is releasably secured thereto. The lower body means 110 includes several subassemblies which are generally cylindrical and slidable with respect to each other and the mandrel means 61 and 62. Various components of the lower body means 110 are interchangeable with components of the upper body means 65 and have the same reference numerals, e.g. slip elements 67.

A lower slip expander 111 is formed by the portion of the lower body means 110 immediately adjacent to the packing means 97. Parallel bores 113 and 114 extend longitudinally through the slip expander 111 to receive mandrel means 61 and 62 respectively therein. A shoulder or rim 112 is formed on the interior of each bore 113 and 114 near the end adjacent to the packing means 97. Shoulders 112 are used to support the weight of

the lower body means 110 and the lower portions of the tubing strings 40 and 41 while removing the packer 60 from the casing 42.

As best shown in Fig. 12, surface 77 on the lower slip expander 111 actually consists of two parallel tapered surfaces 77a and 77b. Channels 98 are formed between surfaces 77a and 77b to guide the slip element 67 and to retain close contact between the slip elements 67 and the lower expander 111 while the packer 60 is being both set and released. The surface 77 on the upper slip expander 75 has a similar configuration.

Teeth 101 are formed on the exterior of each slip element 67 to engage the inner wall of the casing 42. The pitch or angle of the teeth 101 is selected such that the slip elements 67 carried by the lower body means 111 will prevent the packer 60 from moving downwardly (one direction) relative to the casing 42. The slip elements 67 of the upper body means 65 are carried with their teeth

101 oriented to prevent the packer 60 from moving upwardly (the other direction) relative to the casing 42 when the upper slip elements are expanded.

A slip carrier 117 has a plurality of external slip elements 67 attached thereto by conventional T-handles 68 and dove-tailed slots 69. Separation cylinders 119 and 120 are disposed around the mandrel means 61 and 62 respectively between the slip expander 111 and the slip carrier 117 to prevent undesired longitudinal movement of the expander 111 toward the carrier 117. The cylinders 119 and 120 are sized to be received respectively within the bores 113 and 114 of the expander 111.

A plurality of screw holes 121 is provided through the exterior of the slip expander 111 into each bore 113 and 114 to allow insertion of shear screws 122 therein. Suitable annular grooves 123 are provided in the exterior of each separation cylinder 119 and 120 to receive the extreme end of the shear screws 122. As shown in Fig. 3D, the

shear screws 122 releasably secure the cylinders 119 and 120 to the slip expander 111. The cylinders 119 and 120 prevent longitudinal movement of the slip expander 111 and the slip carrier 117 towards each other until after the screws 122 have been sheared.

The separation cylinders 119 and 120 are also releasably secured to their respective mandrel means 61 and 62 by shear screws 124. Snap rings 125 and 126 are carried on the exterior of the mandrel means 61 and 62 respectively to provide shoulders 127 and 128. Opposing shoulders 129 and 130 are formed on the interior of the cylinders 119 and 120 respectively. Opposing shoulder 127 contacts shoulder 129 and opposing shoulder 128 contacts shoulder 130 when the packer 60 is removed from the casing 42.

When sufficient force is applied to the slip carrier 117, the screws 122 will shear allowing the cylinders 119 and 120 to slide within their respective bores 113 and 114. The slip carrier 117 can then move longitudinally towards the

slip expander 111 to radially expand the slip elements 67. The slip expander 111, the slip elements 67, and the slip carrier 117 cooperate to provide an anchoring means carried by the lower body means 110 which is engageable with the interior of the casing string 42 to prevent longitudinal movement of the body means 110 relative thereto. The first or retracted position for the anchoring means of the lower body means 110 is shown in Figs. 3D and 4B. The bolts 78 are used for the same function within the lower body means 110 as in the upper body means 65.

An adapter sub 133 is used to connect the lower slip carrier 117 to a release support cylinder 140. The adapter sub 133 is formed from a relatively short solid cylinder by machining parallel bores 135 and 136 therethrough. The mandrel means 61 and 62 are slidably disposed within the respective bores 135 and 136. A counter bore 134 is machined in one end of the adapter sub 133 to receive a portion of the slip carrier 117 therein. Holes

137 extend through the exterior of the adapter sub 133 and communicate with the counter bore 134. Shear screws 138 are positioned within each hole 137 to secure the attachment of the expander 117 to the adapter sub 133.

Matching threads 141 on the exterior of the adapter sub 133 and the interior of a release support cylinder 140 are used to attach these two components to each other. The cylinder 140 is a relatively long hollow sleeve with a single bore 142 therethrough. The inside diameter of the bore 142 is larger than the sum of the outside diameters of the mandrel means 61 and 62. A fluid dampening plate 131 is secured by snap rings 132 to the mandrel means 61 and 62 between the adapter sub 133 and mandrel sections 61a and 62a. The outside diameter of a dampening plate 131 is slightly less than the inside diameter of the bore 142. Therefore, the dampening plate 131 restricts fluid flow within the bore 142 whenever the mandrel means 61 and 62 move longitudinally relative to the release support

cylinder 140.

The mandrel sections 61a and 62a are disposed within the release support cylinder 140 and are critical components for releasing the packer 60 from the casing string 42. A stop plate 145 is positioned within the release support cylinder 140 and rests on an internal flange 146. The plate 145 has bores 147 and 148 with the mandrel sections 61b and 62b slidably disposed therethrough. Shoulders 149 and 150 are formed by the upsets at threaded connections 143 between the mandrel sections 61a and 61b and the mandrel sections 62a and 62b respectively. The bores 147 and 148 are sized to prevent the shoulders 149 and 150 from sliding therethrough. Shoulders 151 and 152 are formed on the exterior of the mandrel means 61 and 62 by the upsets at the threaded connections 143 between the mandrel sections 61 and 61a and the mandrel sections 62 and 62a. The shoulders 149, 150, 151 and 152 are important components for releasing the packer 60 from the casing 42.

A lower internal slip housing 154 surrounds

the mandrel means 61 and 62 adjacent to the release support cylinder 140. A plurality of internal slip segments 173 is carried within the housing 154 adjacent to each mandrel means 61 and 62. Beveled cam surfaces 172 provided on the interior of the housing 154 activate the internal slips 173 causing them to ride against or contact the adjacent mandrel means 61 or 62. Teeth 174 are formed on each slip 173 at an angle which allows movement of the mandrel means 61 and 62 in only one direction relative to the slips 173.

A lower spring housing 155 surrounds the mandrel means 61 and 62 adjacent to the slip housing 154. Springs 156 are disposed therein and surround each mandrel means 61 and 62. The springs 156 contact the slip segments 173 and bias them against the cam surfaces 172. Windows 157, as shown in Figs. 2C and 4C, are machined partially through the exterior of the spring housing 155. Bolts 158 are inserted through the windows 157 to secure the spring housing 155 to a piston 159.

The piston 159 and its piston housing 160 are carried on the mandrel means 61 and 62 and cooperate to provide a piston means for moving the lower body means 110 longitudinally towards the upper body means 65 in response to fluid pressure in the passageway 64. This longitudinal movement causes radial expansion of the slips 67 and compression of the packing means 97. The internal slips 173, the springs 156 and the slip housing 154 provide means for locking the lower body means 110 to the mandrel means 61 and 62 after completion of the longitudinal movement whereby the packing means 97 are maintained compressed and the slips 67 on both the upper body means 65 and the lower body means 110 are maintained radially expanded.

Ports 161 extend radially through the mandrel section 62c and a sleeve 162 which surrounds the exterior of the mandrel section 62c. The sleeve 162 is secured to the section 62c by the engagement between the sections 62c and 62d. A boss 163 is

attached to the exterior of the sleeve 162 to communicate fluid between ports 161 and a connecting tube or conduit 164. The connecting tube 164 is formed from two hollow tubes 164a and 164b which can telescope within each other. The tube 164a is attached to the piston housing 160. The tube 164b is attached to the boss 163. Knockout plugs 165 are threadedly engaged with each port 161 to prevent fluid flow therethrough until after a knockout sleeve 166 has been shifted. Various well tools are readily available which can engage the sleeve 166 to shear the end of the plugs 165 to open fluid communication between the ports 161 and the piston 159.

Bolts 168 which extend through the spring housing 155, the slip housing 154, the support cylinder 140 and the stop plate 145 securely abut these components to each other. The bolts 158 and 168 cooperate to transfer longitudinal movement of the piston 159 to the lower body means 110.

Threads 169 are provided on the extreme end of the mandrel sections 61c and 62d to connect the lower portions of the tubing strings 41 and 40 thereto.

Figs. 16 through 21 show the operating sequence of the various components within the packer 60 as it is lowered through the casing 42, set or anchored at a desired downhole location, and then released from the casing 42. The components shown in Figs. 16 through 21 are in schematic form only. The same numerical designations are used to allow correlation between the schematic representation of a component and its more detailed construction shown in the other figures. Only the mandrel means 62 and its associated components will be discussed. Figs. 16 through 21 demonstrate that the present invention could be used with a packer having a single mandrel means as well as a packer having dual mandrel means.

In Fig. 16, the components of the packer 60 are shown as they would appear while the packer 60

was lowered through the bore of the casing string 42. A suitable running tool (not shown) would be attached to the orienting body 44. The shear screws 71 and 76 releasably secure the upper slip carrier 66 and the slip expander 75 an the exterior of the mandrel means 62 spaced longitudinally from each other with the slip elements 67 retracted. The locking sleeve 91 is releasably positioned behind the retaining cylinder 88 by the shear pins 92. The retaining cylinder 88 in turn prevents the first cylinder 80 from telescoping within the second cylinder 81. The packing means 97 are relaxed.

The lower slip carrier 117 is releasably spaced from the lower slip expander 111 by the separation cylinder 120 to maintain the slip elements 67 retracted. The shear screws 122 secure the cylinder 120 to the slip expander 111, and the shear screws 124 secure the cylinder 120 to the mandrel means 62. The shear screws 124 provide a first releasable means for securing the lower body means 110 to the mandrel means 62. The adapter sub 133

and the release support cylinder 140 (shown as a single component in Figs. 16-21) are attached to the lower slip carrier 117 by the shear screws 138.

After the packer 60 has been lowered to the desired downhole location, a suitable wireline tool can be used to shift the sleeve 166, thereby opening a fluid communication path from the passageway 64 to the piston means 159 via the ports 161. Fluid pressure within the passageway 64 can then be increased to apply force to the lower body means 110 by the piston 159. The shear screws 124 are selected to release the lower body means 110 from the mandrel means 62 when fluid pressure acting upon the piston 159 exceeds a first preselected value. After the screws 124 are sheared, the force generated by the piston means 159 is transmitted to the packing means 97 and the upper body means 65 via the lower body means 110 and the packing means 97. The shear screws 76 can be selected to have a shear value greater than

the shear value of the shear screws 124. Thus, force generated by the piston 159 will shear the screws 76 to release the upper slip expander 75 from the mandrel means 62 after the screws 124 have been sheared. This same force causes the slip expander 75 to move longitudinally towards the slip carrier 66 and radially expand the slip elements 67 until they engage the casing string 42. During this radial expansion of the slip elements 67, the slip carrier 66 is firmly abutted against the orienting body 44 which is threadedly engaged with the mandrel means 62.

Prior to the slip elements 67 on the upper body means 65 being engaged with the interior of the casing string 42, fluid pressure acting on the piston 159 tends to compress and radially expand the packing means 97 between the upper body means 65 and the lower body means 110. The shear value of the shear screws 122 is selected to allow the fluid acting on the piston 159 to exceed a second preselected value prior to shearing the screws 122. This second preselected fluid pressure

corresponds to the force required to compress the packing means 97 to form a fluid tight barrier between the exterior of the mandrel means 62 and the interior of the casing string 42. After the screws 122 have been sheared, the lower slip carrier 117 can slide longitudinally towards the lower slip expander 111 to radially expand the slip elements 67 and engage them with the interior of the casing string 42 as shown in Fig. 17. Thus, the lower body means 110 is anchored to the casing string 42 to hold the packing means 97 compressed and radially expanded. In the alternative, the lower body means 110 can be anchored to the casing string 42 prior to the upper body means 65 or concurrent therewith. If fluid pressure within the passageway 64 continues to increase above this second preselected value, the additional force generated by the piston means 159 causes the slip elements 67 of the lower body means 110 to more securely engage the casing string 42. When the packer 60 is anchored to the interior of the casing string 42 as shown in Fig. 17, the packer 60 will resist both tension and compression forces

from the tubing strings 40 and 41. The packing means 97 will also seal against differences in fluid pressure in either direction within the casing 42. The packer 60 can remain in this position indefinitely.

As the well conditions change, it may be necessary to remove the packer 60 from its downhole location. A standard wireline locking mandrel or well tool with a tubing cutting tool attached (not shown) can be lowered through the tubing string 40 and secured within the locator recess or profiles 47 of the orienting head assembly 43. A locking mandrel satisfactory for engagement with the profiles 47 is shown in Composite Catalogue of Oil Field Equipment and Services 34th Revision (1980-81) Volume 4 page 5972. Various types of tubing cutting tools are shown in this same catalogue on page 6085. The lengths of the locking mandrel and the tubing cutting tool is selected such that the cutting tool will be disposed within the mandrel section 62a between the shoulders 152 and 150 when

the locking mandrel is positioned within the profiles 47. Various mechanical, chemical, and explosive tubing cutters are commercially available for use with the present invention. The profiles 47 and the mandrel sections 61a and 62a cooperate to provide means for releasing the mandrel means 61 and 62 from the internal slips 173.

When the mandrel section 62a is cut, the lower portions of the tubing strings 40 and 41 drop, causing the shoulders 150 and 145 to contact each other. This transfers the weight of the lower portion of the tubing strings 40 and 41 to the screws 138 which are designed to shear, allowing the lower slip carrier 117 to separate from the adapter sub 133. The lower portion of the tubing strings 40 and 41 will then drop further until the adapter sub 133 contacts the shoulder 152 on the mandrel means 62. To slow down or cushion the impact of the adapter sub 133 with the shoulder 152, the dampening plate 131 restricts fluid flow within the support cylinder 140.

The configuration of the packer 60 after cutting

the mandrel section 62a is shown in Fig. 18. Prior to this, the internal slips 173 prevent the mandrel means 62 from moving upwards with respect to the other components of the packer 60. After the mandrel section 62a has been cut (mandrel section 61a would also have to be cut in a similar manner), upward tension can be applied to the tubing strings 40 and 41 to lift the orienting body 44 and the portion of the mandrel means 62 attached thereto. This upward tension will shear the screws 71 and 92 allowing the mandrel means 62 to move longitudinally upward with respect to the packing means 97. The teeth 74 on the internal slip 73 allow longitudinal movement of the mandrel means 62 in this direction. The snap ring 93 provides a shoulder on the mandrel means 62 whereby this longitudinal movement of the mandrel means 62 lifts the locking sleeve 91 from behind the retaining cylinder 88. This position for the locking sleeve 91 is shown in Fig. 19. After the locking sleeve 91 is lifted, the retaining cylinder 88 can flex inwardly allowing disengagement of the teeth 87 and 89.

The upward movement of the mandrel means 62 results in the internal slips 73 engaging the exterior of the mandrel means 62 at a new location. By next lowering the mandrel means 62, the internal slips 73 contact the beveled cam surfaces 50 of the slip expander 75. Continued lowering of the mandrel means 62a transmits force via the internal slips 73 to the slip expander 75 to remove the slip expander 75 from behind the upper slip elements 67. The internal slips 73 and the camming surface 50 cooperate to provide means for moving the slip expander 75 longitudinally away from the slip carrier 66. The channels 98 on the expander 75 cause the slips 67 to retract and thus disengage the upper body means 65 from its anchored position with the interior of the casing string 42. This same engagement between the mandrel means 62, the internal slips 73, and the camming surfaces 50 causes the slip expander 75 to abut the first cylinder 80 which in turn contacts the end 90 of the retaining cylinder 88 and disengages the retaining cylinder 88 from the teeth 89 of the second cylinder 81. Thus, the first cylinder 80 can now telescope within the second cylinder 81 and

remove all support for the slip expander 75. The above described position for the packer 60 is shown in Fig. 20. In this configuration, the upper body means 65 has been released from its anchored position, and the packing means 97 is no longer held in compression.

Following release of the upper body means 65, upward tension is next applied to the mandrel means 62 via the orienting body 44. The mandrel means 62 is now free to move upward. This upward movement causes the internal slip elements 73 to re-engage the slip carrier 66 lifting it upwards. The slip ring 126 on the mandrel means 62 will contact the separation cylinder 120 which in turn contacts the lower slip expander 111. Thus, lifting the mandrel means 62 will result in removing the lower slip expander 111 from behind the slip elements 67. The channels 98 cause the slip elements 67 to retract which disengages the lower body means 110 from its anchored position with the interior of the casing string 42. The

packer 60 can now be withdrawn from the casing string 42. The weight of the lower portion of the tubing strings 40 and 41 is carried by the shoulders 150 and 152 and the release support cylinder 140. The configuration of the various components of the packer 60 as it is withdrawn from the casing string 42 is shown in Fig. 21.

In summary, the packer 60 is hydraulically set at a downhole location by applying fluid pressure to the piston 159. The packer 60 is released from its set position by the cutting mandrel section 62a. The mandrel means 62 is first lifted to free the cylinder 88 from the locking sleeve 91. The mandrel means 62 is next lowered to telescope the first cylinder 80 into the second cylinder 81 and to disengage the upper body means 65 from the interior of the casing string 42. Finally, the mandrel means 62a is raised to move the slip expander 111 upward and to retract the lower slip elements 67. The mandrel means 62a can continue moving

upwards to withdraw the packer 60 from the casing string 42.

A portion of a well packer 200 incorporating an alternative embodiment of the present invention is shown in Figs. 22A-D. Some components are interchangeable between the packer 60 and the packer 200. These components have the same numerical designation. Other components of the packer 200, which function in a similar manner to components within the packer 60 but are slightly different in design, have the same numerical designation followed by a prime (').

The packer 200 uses the same upper body means 65 as previously described for the packer 60. Therefore, only lowef body means 201 is shown in Figs. 22A-D. The major difference between the well packer 200 and the well packer 60 is that fluid pressure within the passageway 64' can be used to release the locking means for the lower body means 201 rather than the cutting mandrel means 62'.

The packing means 97 are carried on the exterior of the mandrel means 61' and 62' between the upper body means 65 and the lower body means 201. When the upper body means 65 and the lower body means 201 are moved longitudinally towards each other, this longitudinal movement causes compression and radial expansion of the packing means 97 to form a fluid barrier with the interior of the casing string 42 as shown in Fig. 22A. For the packer 200, the packing means 97 consists of three separate elastomeric elements. However, other configurations for the packing means 97 can be readily used.

The lower body means 201 is carried on the exterior of the mandrel means 61' and 62' and is releasably secured thereto. The lower body means 201 includes several subassemblies which are generally cylindrical and slidable with respect to each other and the mandrel means 61' and 62'. Various components of the lower body means 201 are interchangeable with components of the lower body means 110 and have the same number, e.g. slip elements 67.

The lower slip expander 111 is the portion of the lower body means 201 immediately adjacent to the packing means 97. Parallel bores 113 and 114 extend longitudinally through the slip expander 111 to receive the mandrel means 61' and 62' respectively therein. A shoulder or rim 112 is formed on the interior of each bore 113 and 114 near the end adjacent to the packing means 97. The shoulders 112 are used to support the weight of the lower body means 201 and the lower portions of the tubing string (not shown) while removing the packer 200 from the casing 42. As previously explained, the channels 98 are formed on the lower slip expander 111 to retain close contact with the slip elements 67 while the packer 200 is both being set and released.

The slip carrier 117 has a plurality of external slip elements 67 attached thereto by the conventional T-handles 68 and dove-tailed slots 69. The separation cylinders 119 and 120 are disposed around the mandrel means 61' and 62' respectively

between the slip expander 111 and the slip carrier 117 to prevent undesired longitudinal movement of the expander 111 towards the carrier 117. The cylinders 119 and 120 are sized to be received respectively within the bores 113 and 114 of the expander 111.

A plurality of screw holes 121 is provided through the exterior of the slip expander 111 into each bore 113 and 114 to allow insertion of the shear screws 122 therein. Suitable annular grooves 123 are provided in the exterior of each separation cylinder 119 and 120 to receive the extreme end of shear screws 122. The shear screws 122 releasably secure the cylinders 119 and 120 to the slip expander 111. The cylinders 119 and 120 prevent longitudinal movement of the slip expander 111 and the slip carrier 117 towards each other until after the screws 122 have been sheared.

The separation cylinders 119 and 12o are also releasably secured to their respective mandrel means 61' and 62' by the shear screws 124. The snap rings 125 and 126 are carried on the exterior of

mandrel means 61' and 62' respectively to provide shoulders 127 and 128. Opposing shoulders 129 and 130 are formed on the interior of the cylinders 119 and 120 respectively. Opposing shoulder 127 contacts shoulder 129 and opposing shoulder 128 contacts shoulder 130 when the packer 200 is removed from the casing 42.

When sufficient force is applied to the slip carrier 117, the pins 122 will shear, allowing the cylinders 119 and 120 to slide within their respective bores 113 and 114. The slip carrier 117 can then move longitudinally towards the slip expander 111 to radially expand the slip elements 67 as shown in Figs. 22A and 23. The slip expander 111, the slip elements 67, and the slip carrier 117 cooperate to provide an anchoring means carried by the lower body means 201 which is engageable with the interior of the casing string 42 to prevent longitudinal movement of the body means 201 relative thereto.

A support plate 202 is positioned next to and abuts the lower slip carrier 117. The support

plate 202 has bores 203 and 204 with mandrel sections 61' and 62' slidably disposed therethrough. For ease of assembly, the support plate 202 is a separate component. In Figs. 23 and 24 the slip carrier 117 and the support plate 202 are shown as a single component. A piston 205 and the piston housing 206 are carried on the exterior of mandrel means 61' and 62' adjacent to the support plate 202. One end of the piston 205 is slidably disposed within the housing 206. The other end of the piston 205 abuts the support plate 202. Ports 207 as shown in Figs. 23 and 24 extend radially through mandrel means 62' to communicate with a passageway 208 through the piston housing 206. The ports 207 and the passageway 208 cooperate to communicate fluid pressure from passageway 64' to act upon the piston 205. The piston 205 and the piston housing 206 cooperate to provide a piston means for moving the lower body means 201 longitudinally towards the upper body means 65 in response to fluid pressure in the

passageway 64'. This longitudinal movement causes radial expansion of the slips 67 and compression of the packing means 97. Internal slips 173', springs 240, and slip housing 209 provide a portion of the means for locking the lower body means 201 to the mandrel means 61' and 62' after completion of the longitudinal movement of the lower body means 201 towards the upper body means 65.

The lower internal slip housing 209 surrounds the piston 205 and is a continuation of the piston housing 206. The cross section of the packer 200 used in Figs. 22A-C does not show the internal slips 173'. A plurality of slip segments 173' is carried within the housing 209 adjacent to the piston 205 as shown in Figs. 23 and 24. Beveled cam surfaces and the springs 240 activate the slips 173'. Teeth are formed on each slip 173' at an angle which allows longitudinal movement of the piston 205 in only one direction relative to the mandrel means 61' and 62'.

The piston housing 206 rests upon a support cylinder 206a. In Figs. 23 and 24, the piston housing 206 and the support cylinder 206a are shown as a single unit. For ease of manufacture and assembly, they are two separate components as shown in Fig. 22B. The support cylinder 206a is releasably secured to the mandrel means 61' and 62' by a snap ring 210. The mandrel means 61' and 62' include several sections of hollow tubing which are threadedly attached to each other. Sections 61a' and 62a' have exterior grooves 211 to receive the snap ring 210. A backup ring 212 surrounds the snap ring 210 and holds it engaged with the grooves 211. The snap ring 210 traps a flange 213 of the support cylinder 206a against shoulders 215 and 216 on the exterior of the mandrel sections 61a' and 62a' respectively. When the flange 213 is so trapped, the support cylinder 206a and thus the piston housing 206 cannot move longitudinally relative to mandrel means 61' and 62'. The snap ring 210, the grooves 211, the shoulders 215 and 216 and the backup ring 212 provide another

portion of the means for releasably locking the lower body means 201 to the exterior of the mandrel means 61' and 62'.

A sliding sleeve 220 is attached to the backup ring 212 by threads 221 and surrounds the exterior of mandrel section 62a' below the ring 212. The sleeve 220 consists of two sections designated 220a and 220b. Seal rings 217 and 218 are disposed between the exterior of the mandrel sections 62a' and the interior of the sliding sleeve section 220a. First ports 219 extend through the wall of the mandrel section6 62a' and communicate fluid pressure from the passageway 64' to a variable volume chamber 230 formed between seal rings 217 and 218. Second ports 221 extend through the wall of the mandrel section 62a' and communicate fluid pressure from the passageway 64' to the side of the seal ring 218 opposite the first ports 219. When both first ports 219 and second ports 221 are open and the passageway 64' is not blocked therebetween, fluid pressure on opposite sides of the seal ring 218 is equalized. A shoulder 222 is provided on the

exterior of the mandrel section 61a' to provide a stop for the seal ring 217. Therefore, when fluid pressure is increased within the variable volume chamber 130, the shoulder 222 limits the longitudinal movement of the seal ring 217 away from the first ports 219.

A guide sleeve 223 is disposed around the exterior of the mandrel section 62a' adjacent to the sliding sleeve section 220b. The outside diameter of the guide sleeve 223 is sized to telescope within the inside diameter of the sliding sleeve section 220b. Shear screws 224 releasably attach the sleeve section 220b and the guide sleeve 223 to each other in their extended position. A seal ring 225 is provided on the exterior of mandrel section 62a' abutting the extreme end of the guide sleeve 223 within the sliding sleeve section 220b. The seal ring 225 prevents fluid communication between the second ports 221 and the exterior of the sliding sleeve 220. The guide sleeve 223 is supported by a collar 226 on the exterior of the mandrel section 62a'. The mandrel means 62' includes an adapter

sub 62b' and a landing nipple 62c' attached by threads 231 to the mandrel section 62a'. The landing nipple 62c' has internal locator recess or profile 232 for securing various well tools therein. Well tools (not shown) can be landed or locked into the nipple 62c' for use in setting the packer 200 at a desired downhole location and for use in releasing the packer 200 from the downhole location. The landing nipple 62c' can be considered as either a part of the mandrel means 62' or as part of the lower tubing string which would be attached to the mandrel means 62' below the packer 200.

Figs. 23 and 24 show the operating sequence of the various components within the packer 200 as it is set or anchored at a downhole location within the casing 42, and then released from the casing 42. The components shown in Figs. 23 and 24 are in schematic form only. The same numerical designations are used to allow correlation between the schematic representation of a component and

its more detailed construction shown in the other figs. Only the mandrel means 62' and its associated components will be discussed. Figs. 23 and 24 demonstrate that the present invention could be used with a packer having a single mandrel means as well as a packer having dual mandrel means.

After the packer 200 has been lowered to the desired downhole location, a suitable wireline tool can be locked into the nipple 62c' to block the passageway 64'. An example of such a tool is shown in Otis Wireline Subsurface Flow Controls & Related Service Equipment Catalogue (OEC 5121C) page 17. Fluid pressure within the passageway 64' can then be increased via the port 207 and the passageway 208 to apply force to the lower body means 201 by the piston 205. During this time the same fluid pressure is present at both the first ports 219 and the second ports 221. The shear screws 124 are selected to release the lower body means 201 from the mandrel means 62' when fluid pressure acting upon the piston 205 exceeds a first preselected value. After the screws 124 are sheared, the force generated by

the piston 205 is transmitted to the upper body means 201. The shear screws 76 are selected to have a shear value less than the shear value of the shear screws 92 or 122. Thus, force generated by the piston 205 will shear the screws 76 to release the upper slip expander 75 from the mandrel means 62' after the screws 124 have been sheared. This same force causes the slip expander 75 to move longitudinally towards the slip carrier 66 and radially expand the slip elements 67 until they engage the casing string 42. During this radial expansion of the slip elements 67, the slip carrier 66 is firmly abutted against the orienting body 44 which is threadedly engaged with the mandrel means 62'.

After the slip elements 67 on the upper body means 65 have engaged the interior of the casing string 42, fluid pressure action on the piston 205 can be increased further to compress and radially expand the packing means 97 between the upper body means 65 and the lower body means 201. The shear value of the shear screws 122 is selected to allow

the fluid acting on the piston 205 to exceed a second preselected value prior to shearing the screws 122. This second preselected fluid pressure corresponds to the force required to compress the packing means 97 to form a fluid tight barrier between the exterior of the mandrel means 62' and the interior of the casing string 42. After the screws 122 have been sheared, the lower slip carrier 117 can slide longitudinally towards the lower slip expander 111 to radially expand the slip elements 67 and engage them with the interior of the casing string 42 as shown in Fig. 23. Thus, the lower body means 201 is anchored to the casing string 42 to hold the packing means 97 compressed and radially expanded. The internal slips 173' engage the exterior of the piston 205 to hold the piston 205 extended from the piston housing 206. When fluid pressure within the passageway 64' decreases, the slips 173' prevent the piston 205 from returning to its initial position. As long as the piston housing 206 is anchored to the exterior of mandrel means 62' via the snap ring 210, the internal slips 173' and the snap ring 210 can lock the lower

body means 201 to the exterior of the mandrel means 62'. When the packer 200 is anchored to the interior of the casing spring 42 as shown in Fig. 23, the packer 200 will resist both tension and compression forces from the tubing strings 40 and 41. The packing means 97 will also seal against differences in fluid pressure in either direction within the casing 42. The packer 200 can remain in this position indefinitely.

As the well conditions change, it may be necessary to remove the packer 200 from its downhole location. A standard wireline locking mandrel or well tool with a tubing packoff tool attached (not shown) can be lowered through the tubing string 40 and secured within the locator recess or profiles 232 of the nipple 62c'. The length of the locking mandrel and tubing packoff tool extending thereabove is selected such that the packoff tool will be disposed within the mandrel section 62a' between the ports 219 and 221 when the locking mandrel is positioned within the profiles 232. Various packoff

tools are commercially available for use with the present invention. Examples of such tools are shown in Otis Wireline Subsurface Flow Controls & Related Service Equipment Catalogue (OBC 5121C) pages 14, 25 and 119. The profiles 232 and the mandrel section 62a' cooperate to provide means for releasing the locking means for the lower body means 201 from the mandrel means 61' and 62'.

With the packoff positioned between the first ports 219 and the second ports 221, fluid pressure can be increased within the variable volume chamber 230 creating a difference in pressure across the seal ring 218. When this pressure difference reaches a preselected value, the screws 224 will shear allowing the sliding sleeve 220 to telescope downwardly over the exterior of the guide tube 223. This movement removes the backup ring 212 from holding the snap ring 210 engaged with the grooves 211 as shown in Fig. 23. Dotted lines show the locked position for the backup ring 212 in Fig. 23.

After the backup ring 212 has been removed

from the supporting snap ring 210, the mandrel means 62' can slide longitudinally relative to the upper housing means 65 and the lower housing means 201. Prior to this, the slips 173' retained the piston 205 locked relative to the piston housing 206 which was in turn locked to the mandrel means 62' by engagement of the snap ring 210 with the grooves 211. Upward tension can now be applied to lift the orienting body 44 and the mandrel means 62' attached thereto. This upward tension will shear the screws 71 and 92 allowing the mandrel means 62' to move longitudinally upward with respect to the packing means 97. The mandrel means 62' is manipulated in the same manner as previously described for the packer 60 to release the upper body means 65 from the casing 42.

Following release of the upper body means 65, upward tension is next applied to the mandrel means 62' via the orienting body 44. The mandrel means 62 is now free to move upward. This upward movement causes the internal slip elements 73 to re-engage the slip carrier 66 lifting it upwards. The snap

ring 126 on the mandrel means 62' will contact the separation cylinder 120 which in turn contacts the lower slip expander 111. Thus, lifting the mandrel means 62' will result in removing the lower slip expander 111 from behind the slip elements 67. The channels 98 cause the slip elements 67 to retract which disengages the lower body means 201 from its anchored position with the interior of the casing string 42. The packer 200 can now be withdrawn from the casing string 42. The configuration of the various components of the packer 200 as it is withdrawn from the casing string 42 is shown in Fig. 24.

In summary, the packer 200 is hydraulically set at a downhole location by applying fluid pressure to the piston 205. The packer 200 is released from its set position by pressurizing the variable volume chamber 230 and releasing the snap ring 210. The mandrel means 62' is first lifted to free the cylinder 88 from the locking sleeve 91. The mandrel means 62 is next lowered to telescope the first cylinder 80 into the second cylinder 81 and to disengage the upper body means 65 from the interior of the casing string 42.

Finally, the mandrel means 62' is raised to move the slip expander 111 upward and to release the lower slips 67 from the casing 42.

The previous descriptions of the packers 60 and 200 are representative of only two embodiments of the present invention. Those skilled in the art will readily see other alternative changes and modifications without departing from the scope of the invention which is defined in the claims.

CLAIMS

1. A well packer comprising:

a. a pair of parallel mandrel means, each having a passageway extending therethrough;

b. upper and lower body means carried on the exterior of the mandrel means and slidable longitudinally with respect to each other over the mandrel means;

c. anchoring means carried by each body means and radially expandable relative to each body means between a retracted position and an expanded position whereby each anchoring means is engageable with the interior of a casing string to prevent longitudinal movement of its associated body means relative to the casing string;

d. packing means carried on the exterior of the mandrel means between the upper and lower body means;

e. piston means, carried by said mandrel means, for moving the body means longitudinally toward each other in response to fluid pressure in one of the passageways;

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f. the longitudinal movement of the body means causing compression of the packing means and radial expansion thereof to form a fluid barrier between the exterior of the mandrel means and the interior of the casing string;

g. the same longitudinal movement causing radial expansion of the anchoring means;

h. means for locking each body means to the mandrel means after completion of the longitudinal movement whereby the packing means are maintained compressed and the anchoring means are maintained radially expanded;

i. each anchoring means comprising a plurality of slip elements;

j. each body means further comprising a slip carrier and a slip expander which are movable longitudinally towards each other to radially expand the associated slip elements;

k. means for releasing the mandrel means from the locking means of the lower body means; and

l. means for moving the slip expander of the upper body means longitudinally away from its associated slip carrier to allow retraction of

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the slip elements carried by the upper body means after the locking means for the lower body means has been released.

2. A well packer as claimed in claim 1, further comprising:

a. releasable means for securing the lower body means to the mandrel means until fluid pressure within the piston means exceeds a first preselected value;

b. releasable means for preventing longitudinal movement of the slip expander of the upper body means relative to its associated slip carrier until fluid pressure within the piston means exceeds the first preselected value; and

c. releasable means for preventing longitudinal movement of the slip expander of the lower body means relative to its associated slip carrier until fluid pressure within the piston means exceeds a second, higher preselected value.

3. A well packer as claimed in claim 1 or 2 wherein the locking means further comprises:

a. slip segments disposed between the exterior of the mandrel means and the interior of the lower body means;

b. teeth projecting from each slip segment at an angle relative to the mandrel means whereby the slip segments allow longitudinal movement of the lower body means towards the upper body means and prevent longitudinal movement of the body means away from each other; and

c. a camming surface formed on the interior of the lower body means to project the slip segments adjacent thereto into contact with the mandrel means.

4. A well packer as claimed in claim 1, 2 or 3 wherein the upper body means further comprises:

a. first and second concentric cylinders surrounding the mandrel means between the slip expander for the upper body means and the packing means;

b. the outside diameter of the first cylinder selected to telescope within the inside diameter of the second cylinder;

c. a retaining cylinder releasably disposed

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between the exterior of the mandrel means and the inside diameter of the second cylinder;

d. the retaining cylinder abutting the first cylinder and thereby blocking the first and second cylinders from telescoping relative to each other;

e. a locking sleeve disposed between the mandrel means and the retaining cylinder; and

f. a shoulder carried on the exterior of the mandrel means within the second cylinder adjacent to the locking sleeve whereby longitudinal movement of the mandrel means in one direction relative to the second cylinder will cause the shoulder to contact the locking sleeve and release the engagement between the mandrel means, locking sleeve, retaining cylinder and second cylinder allowing the first and second cylinders to telescope relative to each other.

5. A well packer as defined in claim 4, wherein the first and second cylinders prevent the slip

expander of the upper body means from moving longitudinally away from its associated slip carrier until after the retaining cylinder has been released.

6. A well packer as claimed in any preceding claim, wherein the releasing means for the locking means of the lower body means further comprises:

a. a locator recess in either the passageway of one of the mandrel means or the tubing string attached to the mandrel means;

b. a well tool releasably engageable with the locator recess;

c. a tubing cutting tool attached to the well tool and extending longitudinally therefrom; and

d. the distance between the cutting tool and the well tool selected to equal the distance from the locator recess to a preselected location within the mandrel means.

7. A well packer as claimed in any preceding claim, further comprising:

a. a port extending radially through one of the mandrel means;

b. a conduit for communicating fluid from the port to the piston means; and

c. the piston means secured to the exterior of the mandrel means adjacent to and abutting the lower body means.

8. A well packer as claimed in any preceding claim, wherein

a. the piston means includes a piston slidably disposed within a piston housing;

b. slip segments are disposed between the piston and the piston housing;

c. teeth project from each slip segment at an angle relative to the piston whereby the slip segments allow fluid pressure to extend the piston from the piston housing and prevent the piston from returning to its initial position; and

d. a snap ring releasably secures the piston housing to the mandrel means.

9. A well packer as claimed in any preceding claim, further comprising an orienting body disposed above the upper body means and each mandrel means securely engaged with the orienting body preventing relative movement between the mandrel means.

10. A well packer which can be attached to a tubing string for the purpose of forming a fluid barrier within a casing string, comprising:

a. mandrel means having a passageway extending therethrough;

b. upper and lower body means carried on the exterior of the mandrel means and slidable longitudinally with respect to each other over the mandrel means;

c. anchoring means carried by each body means and movable relative to each body means between a retracted position and an expanded position whereby each anchoring means is engageable with the interior of the casing string to prevent longitudinal movement of its associated body means relative to the casing string;

d. packing means carried on the exterior of the mandrel means between the upper and lower body means;

e. piston means, carried by the mandrel means,

for moving the body means longitudinally toward each other in response to fluid pressure in the passageway;

f. longitudinal movement of the lower body means towards the upper body means causing compression of the packing means and radial expansion thereof to form the fluid barrier;

g. the same longitudinal movement causing expansion of the anchoring means;

h. means for locking the lower body means to the mandrel means;

i. means for releasing the mandrel means from the locking means of the lower body means;

j. means for moving the slip expander of the upper body means longitudinally away from its associated slip carrier to retract the slip elements carried by the upper body means after the locking means for the lower body means has been released;

k. releasable means securing the lower body means to the mandrel means until fluid pressure within the piston means exceeds a first preselected value;

l. releasable means preventing longitudinal movement of the slip expander of the upper body means relative to its associated slip carrier until fluid pressure within the piston means exceeds the first preselected value; and

m. releasable means preventing longitudinal movement of the slip expander of the lower body means relative to its associated slip carrier until fluid pressure within the piston means exceeds a second preselected value.

11. A well packer as claimed in claim 2 or 10, further comprising:

a. the change in fluid pressure within the piston means between the first and second preselected value compressing the packing means; and

b. the locking means for the lower body means maintaining the packing means compressed without regard to fluid pressure in the piston means.

12. A well packer as claimed in claim 1 or 10, wherein the means for releasing the lower body means comprises:

a. a first and a second shoulder formed on the

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exterior of the mandrel means between the slip carrier of the lower body means and its associated locking means;

b. the shoulders spaced longitudinally from each other;

c. first and second shoulders carried by the lower body means;

d. the first and second shoulders of the lower body means spaced longitudinally from each other;

e. the shoulders of the mandrel means positioned between the shoulders of the lower body means; and

f. the shoulders of the mandrel means sized to engage the shoulders of the lower body means.

13. A well packer, carried by a tubing string, for forming a fluid barrier within a casing string, comprising:

a. a mandrel means having a passageway extending longitudinally therethrough and each end of the mandrel means engageable with the tubing string;

b. upper and lower body means carried on the exterior of the mandrel means and slidable longitudinally over the exterior of the mandrel means;

c. anchoring means carried by each body means and movable relative to the respective body means between a retracted position and an expanded position whereby each anchoring means is engageable with the interior of the casing string to prevent longitudinal movement of its associated body means relative thereto;

d. packing means carried on the exterior of the mandrel means between the upper and lower body means;

e. piston means, carried by the mandrel means, for moving the body means longitudinally toward each other in response to fluid pressure in the passageway;

f. longitudinal movement of the body means toward each other causing compression of the packing means and radial expansion thereof to form a fluid barrier between the exterior of the mandrel means and the interior of the casing string;

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g. the same longitudinal movement casing radial expansion of the anchoring means;

h. means for locking the lower body means to the exterior of the mandrel means after completion of the longitudinal movement whereby the packing means are maintained compressed and the anchoring means are maintained radially expanded;

i. each anchoring means comprising a plurality of slip elements;

j. each body means further comprising a slip carrier and a slip expander which are movable longitudinally towards each other to radially expand the slip elements;

k. a first and a second shoulder formed on the exterior of the mandrel means between the slip carrier of the lower body means and its associated looking means;

l. the shoulders spaced longitudinally from each other;

m. first and second shoulders carried by the lower body means projecting radially inward toward the mandrel means;

n. the first and second shoulders of the lower body means spaced longitudinally from each other;

o. the shoulders of the mandrel means positioned between the shoulders of the lower body means; and.

p. the shoulders of the mandrel means sized to engage the shoulders of the lower body means.

14. A well packer as claimed in claim 13, wherein means for releasing the locking means of the lower body means comprises:

a. a profile in either the passageway of the mandrel means or the tubing string attached to the mandrel means;

b. a well tool releasably engageable with the profile;

c. a tubing cutting tool attached to the well tool and extending longitudinally therefrom; and

d. the distance between the cutting tool and the well tool selected to equal the distance from the profile to a preselected location intermediate the first and second shoulders of the mandrel means.

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15. A well packer as claimed in claim 13, wherein the mandrel means comprises:

a. a pair of parallel mandrels, each having a passageway extending longitudinally therethrough;

b. a port extending radially through one of the mandrel means;

c. a conduit for communicating fluid from the port to the piston means; and

d. the piston means secured to the exterior of the mandrel means adjacent to and abutting the lower body means.

16. A well packer as claimed in claim 1 or 10, wherein the means for releasing the locking means of the lower body means further comprises:

a. a snap ring releasably secured to the exterior of the mandrel means below the piston means;

b. a backup ring which normally maintains the snap ring secured to the mandrel means;

c. the snap ring and a shoulder on the exterior of the mandrel means cooperating to lock the lower body means to the mandrel means;

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d. a hydraulically actuated sliding sleeve surrounding the mandrel means and attached to the backup ring; and

e. means for communicating fluid pressure from the passageway to the sliding sleeve whereby fluid pressure above a preselected value will move the sliding sleeve longitudinally to release the snap ring from the mandrel means.

17. A well packer substantially as hereinbefore described with reference to and as illustrated in Figs. 3 to 21 and 25 or in Figs. 22 to 24 of the accompanying drawings.

