

[54] **WELL PACKER APPARATUS**
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[51] Int. Cl. **E21b 33/12**
[58] Field of Search.....166/129, 183, 188, 196

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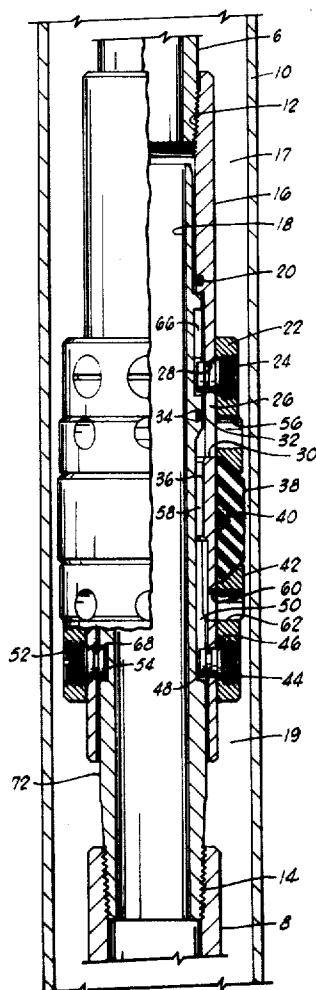
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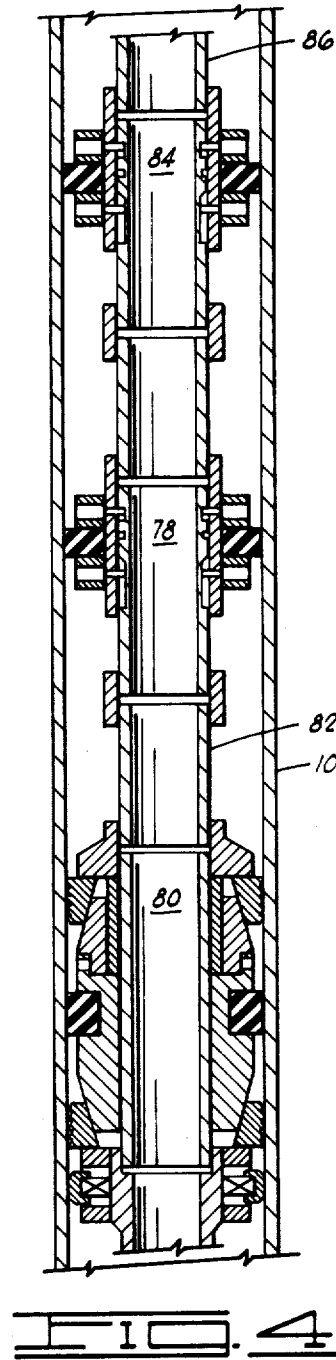
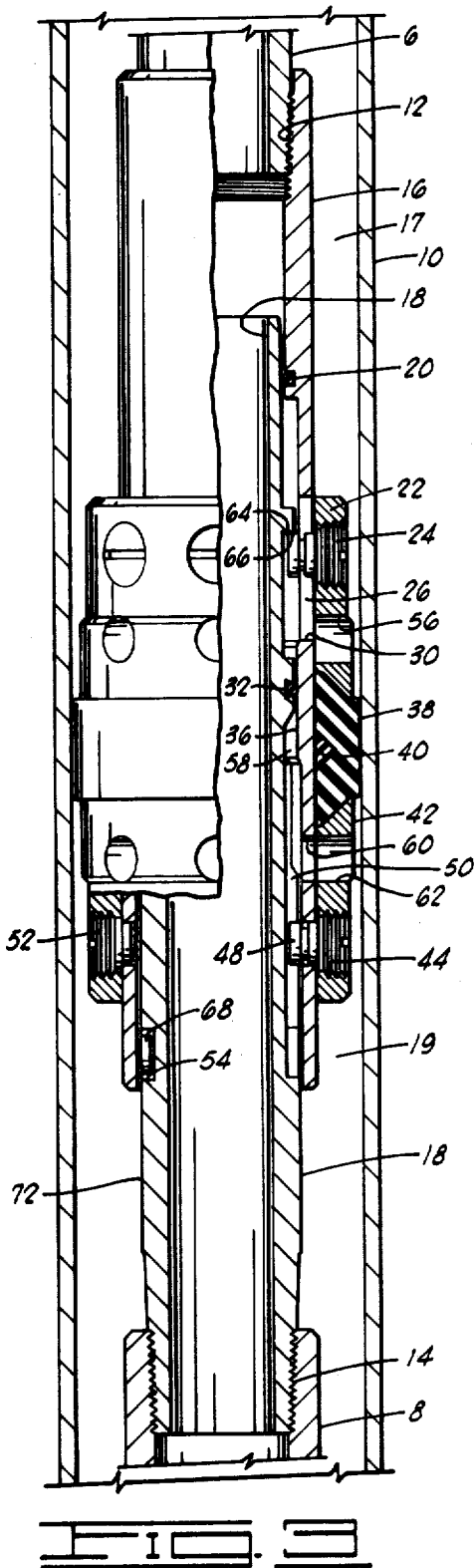
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[57] **ABSTRACT**

A packer is provided, one or more of which may be used to seal between a well casing and a tubing string placed inside the well casing. The well packer is provided with a bypass valve to permit flow of fluid through the packer inside the packing element to facilitate lowering the packer into the well and to facilitate lifting the packer out of the well. The pipe below the packer must be anchored to withstand upstrain exerted in tubing above the packer to cause setting of the packer, closing of the bypass valve and holding force to hold the packer in position in the casing after setting. The packer may be held in a retracted position, while lowering into the well, by screws or pins which shear when the setting upstrain is applied to the packer. A latch is provided to lock the packer in retracted position to hold the bypass valve open while the packer is being lifted from the well.

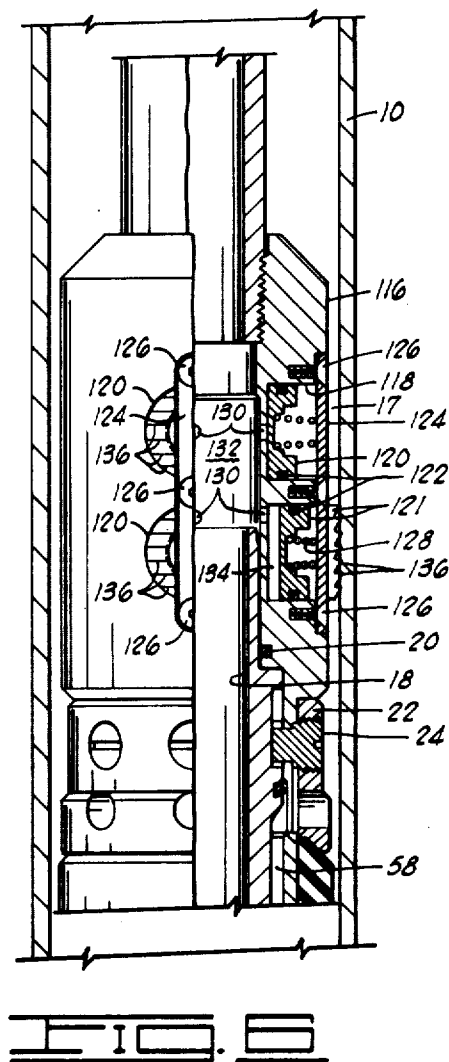
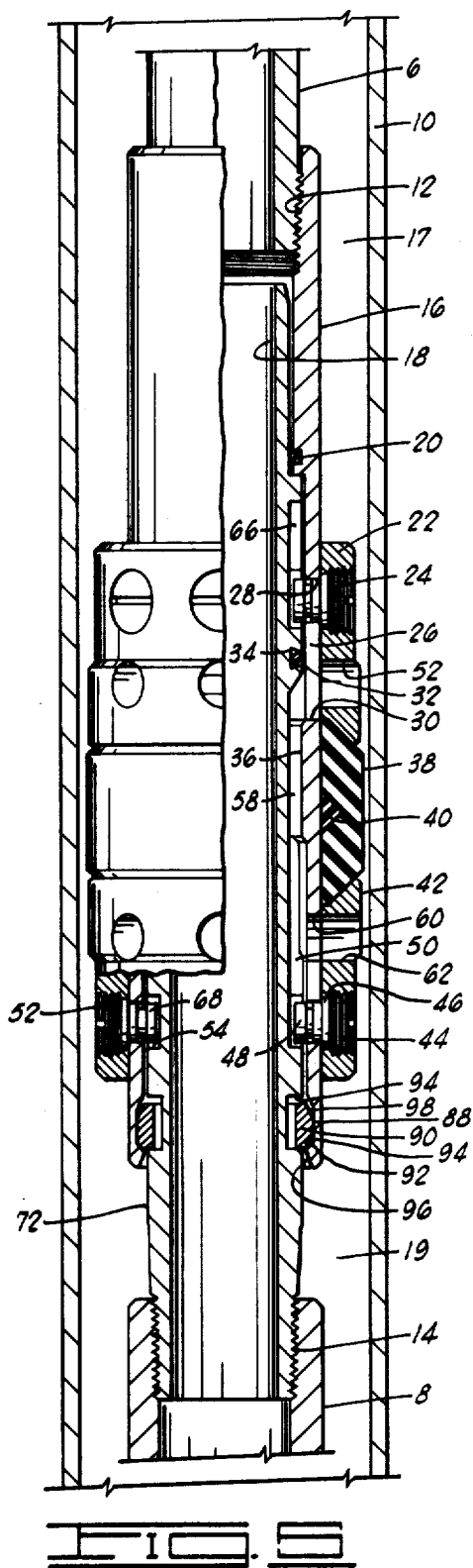
15 Claims, 6 Drawing Figures





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WELL PACKER APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to well packers and more particularly to tension set packers to seal between one or more levels in a well. Some well completions require that several levels of interest be sealed from each other by a packing arrangement between the well casing and tubing string. It may be desired to selectively produce fluid from or inject fluid into various levels in the well either simultaneously or in some sequence. In relatively low pressure applications, these packing devices may be entirely supported by the tubing string. In some cases, when higher pressures are involved, a hydraulic anchor may be utilized for greater pressure holding capabilities.

Prior art devices have not provided a tension-set packer of the none-hookwall variety with a bypass valve. A packer which grips the inside of the casing with a mechanical anchor is often referred to as a hook-wall packer. Most such prior art devices have provided a mechanical anchor between the packer and well casing to support the setting load and pressure from one direction. A mechanical anchor ordinarily limits the number of packers on a tubing string to one. Wells are ordinarily filled with water, oil or a mud so that the hydrostatic pressure of this column of liquid will overcome the pressure in each formation communicating with the well bore at the depth of each formation. When a packer is lowered into a well bore, it must pass through the liquid standing in the well bore. When the packer is being lowered, the liquid must pass upwardly with respect to the packer. The packing element on most packers achieves a seal by being compressed longitudinally to cause lateral expansion with sufficient pressure to seal against the well bore. After having been in this compressed condition for a long period of time, a packing element may not return to its original shape. In fact, it may stay in the sealing condition after the setting force has been removed from the packing element. When the valve is opened, it serves to equalized any pressure differential across the packer and permit the packer to be moved vertically in the well bore. Fluid standing in the well bore must pass down past the packer while the packer is being lifted from the well bore. If the packing element partially or completely seals the annulus around the packer, it is desirable to have a bypass passageway in the packer which will allow fluid to pass by the packing element, not restricted by the packing element.

Therefore, it is a primary object of this invention to provide an improved tension-set well packer with a bypass valve.

It is a further object of this invention to provide an improved tension-set well packer wherein more than one may be used in a tubing string.

SUMMARY OF THE INVENTION

These and other objects of the invention are provided generally with a new and improved tension-set well packer wherein bypass means are provided inside the packer to allow liquid to flow inside the tool past the packing element. The bypass means are held open while lowering the tool and are closed when the packer is set. As an additional feature, means are provided to hold the valve open while the packer is being lifted from the well.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view partially in cross section and partially in elevation of a packer according to the invention in retracted position positioned in well casing.

FIG. 2 is a partial elevation view of the mandrel of the packer according to FIG. 1 showing the external features thereof.

FIG. 3 is a view partially in cross section and partially in elevation showing the packer according to the invention in the set position in sealing engagement with the casing.

FIG. 4 is a schematic partially in elevation and partially in cross section showing two packers of this invention along with an anchoring well tool required for the use of these packers.

FIG. 5 is a drawing partly in elevation and partly in cross section showing an alternative latch arrangement according to the invention.

FIG. 6 is a drawing partially in elevation and partially in cross section showing an alternative body for packer according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1 a packer of the instant invention is illustrated in a retracted position so that it may be lowered to the proper level in the well. An upper thread connection 12 is threadedly engaged to a tubing string 6 so the packer may be lowered to the proper level in the well. The lower thread connection 14 is threadedly engaged to tubing 8 below the packer which is in turn engaged to an anchoring well tool which will be illustrated hereinafter. A tubular body 16 forms a major structural component of the packer. A tubular mandrel 18 forms another major structural component of the packer. The body 16 and mandrel 18 are positioned in a telescoping arrangement. A seal 20 is positioned in sealing engagement between the body 16 and mandrel 18 to seal pressure in the interior of body 16 and mandrel 18 from pressure in passageway 58 and annulus areas 17 and 19. An upper abutment 22 positioned in slidable and encircling arrangement with the body 16. The movement of upper abutment 22 with respect to body 16 is restricted to longitudinal movement without rotation by pin 24 which operates in a longitudinal slot 26 in body 16. The upper end 28 of slot 26 in body 16 limits the upward movement of pin 24 and upper abutment 22. A seal ring 32 which may be an O-ring is positioned in groove 34 of the mandrel 18 and is positioned to be moved into sealing engagement with seal bore 36 in body 16. Packing means in the form of a packing element 38 is positioned in encircling relationship to body 16 against upper abutment 22. A resilient ring 40 is used in a mating groove in packing element 38. The triangular-shaped cross section of ring 40 as illustrated creates a thin section at the center of packing element 38. Longitudinal compression of packing element 38 causes nodding of packing element 38 at its longitudinal midsection and effects an initial seal with less longitudinal force than would be required of a unitary packing element.

Lower abutment 42 is locked to body 16 by gudgeon pin 44 in abutting position to packing element 38. Pilot diameter 46 on gudgeon pin 44 matingly engages a counterbored hole in body 16 to lock lower abutment

42 to body 16. Diameter 48 on gudgeon pin 44 acts as a j-latch pin cooperating with j-latch 50, a portion of which is illustrated in this cross section. Shear pin 52 is positioned in threaded engagement with lower abutment 42 and body 16 and shear pin hole 54 in mandrel 18.

Port 56 in upper abutment 22 is aligned with slot 26 in body 16 to form a flow path for liquid to pass between the annulus 17 above the packer through port 56 through slot 26 into annular passageway 58 between body 16 and mandrel 18, and through hole 60 in body 16 and port 62 in lower abutment 42, communicating with annulus 19 below the packer.

FIG. 2 is an external partial elevation view showing the outside configuration of mandrel 18. Circle 64 illustrates the position of pin 24 in axial alignment with slot 66 in mandrel 16, when the packer is in retracted or running position. O-ring 32 is shown in position in groove 34. Circle 68 shows this diameter on shear pin 52 positioned in hole 54 which is cut into mandrel 16. Shear pin 52 thereby establishes axial and rotational alignment between body 16 and mandrel 18 when the packer is in the retracted position for lowering into the well. Circle 48 illustrates the position of the end of gudgeon pin 44 in j-slot 50.

SETTING THE PACKER

Thus it can be seen, that when relative upward movement of body 16 with respect to mandrel 18 is effected, end 68 will be sheared from pin 52 by engagement of end 68 in hole 54. Pin ends 64 and 48 will then move upwardly with respect to mandrel 18. Pin 48 will move up the straight section 70 of j-slot 50. Pin end 64 will move upwardly to engage the end of slot 66 which acts as shoulder means to halt further motion of upper abutment 22 and pin 24 with respect to mandrel 18 for a purpose that will be hereinafter explained.

Referring to FIG. 3 the packer is illustrated in set and sealing engagement with casing 10. Mandrel 18 is restrained from upward movement by tubing 8 below the packer connected to thread 14 on mandrel 18. With mandrel 18 held in place against upward movement, body 16 is moved upwardly by the upper tubing section 6 which extends to the surface and is threadedly engaged with thread 12 on body 16.

To effect setting and sealing of the packer, upstrain is applied to the body 16 by the upper tubing section 6 causing shear stress on pin 52 illustrated in FIG. 1 along a surface coincident with outside diameter 72 of mandrel 18. Shear pins 52 are sized so that shear action will take place at a desired upstrain. Relative longitudinal motion will then take place with body 16 moving upwardly with respect to mandrel 18. Pin end 64 will move upwardly to the end of slot 66 and further relative motion between mandrel 18, pin 24 and upper abutment 22 will be prevented so that no further upward movement of these parts can take place due to the restraint on mandrel 18 by tubing 8 below the packer. Continued upward movement of tubing 6 and body 16 will cause slot 26 to move upward with respect to pin 24, since pin 24 engages the shoulder in the end of slot 66. Lower abutment 42, being rigidly attached to body 16, will also move upwardly compressing packing element 38 between upper abutment 22 and lower abutment 42. Sufficient upstrain on body 16 is exerted to ef-

fect a seal by the packing means between body 16 and casing 10. The packing means is made up of packing element 38 and initial seal ring 40. The relative upward movement of body 16 with respect to mandrel 18 positions seal bore 36 in sealing engagement with O-ring 32, preventing communication of fluids through bypass passageway 58.

RELEASING THE PACKER

Release of the packer may be effected by downward movement of the upper tubing string 6 effecting downward movement of body 16 relative to mandrel 18. Such relative downward movement will restore the retracted position as illustrated in FIG. 1. Since the releasable connection, for example shear pins 52, between body 16 and mandrel 18, is broken when the packer is set, another means is used to lock the packer into retracted position for release of the lower tubing used to anchor mandrel 18 to effect setting of the packer. Downward relative motion of body 16 relative to mandrel 18 to the position shown in FIG. 1 will place gudgeon pin 44 in the position illustrated by circle 48 in FIG. 2 and then allow rotational movement of this pin by right-hand rotation of body 16 with respect to mandrel 18 into a latching position as illustrated by circle 74 in FIG. 2. Gudgeon pin 44 can then move up to engage surface 76 in j-slot 50 to hold body 16 and mandrel 18 in retracted position so that the bypass 58 is held open and the packing element 38 is given a full length to relax between upper abutment 22 and lower abutment 42.

Engagement of gudgeon pin 44 with the hook 76 in j-slot 50 carries upstrain from body 16 to mandrel 18 and provides ability to rotate and pull upward on tubing 8 which may be connected to tools below the packer.

Referring to FIG. 4 a packer of the instant invention is illustrated generally at 78. A well tool is illustrated at 80. Such well tool 80 is used for restraining lower tubing string 82 from upward movement. The well tool 80 may be a tension set mechanical packer of the variety which grips inside casing 10 or it may be a so-called permanent or drillable packer which provides a releasable connection to tubing 82 above such well tool. Well tool 80 may also be a tubing anchor which will withstand upstrain on tubing 82 or it may be one of another type of well tool which will hold against upstrain on tubing 82.

Since the requirement for setting a packer according to this invention is restraining the tubing below the packer and applying upstrain and upward movement to the tubing above the packer, it is apparent that more than one such tension set packer may be utilized in a well. FIG. 4 illustrates two such packers. Another packer may be run as illustrated generally at 84. It will be apparent to those with skill in the art that more than two such packers may be used in a well up to the number of zones desired to be isolated. The setting procedure is generally the same for setting a number of these tools; the only difference is that a greater upward travel of the tubing at the surface of the well will be experienced as approximately the same force will be transmitted to compress the packing element on each packer. The procedure for release of a number of these packers is generally the same as for the release of one packer in that set down force of the tubing is exerted

against the packers. The reactive longitudinal force and torque is restrained by tubing 82 immediately against the well tool 80 below the bottom tension packer. Right-hand rotation of the tubing 86 at the surface will be transmitted to each packer and latch each packer into the retracted position for removal from the well.

It should be understood that the packer according to this invention could be inverted from the position described hereinbefore and still fulfill all of the objects of this invention.

ALTERNATIVE EMBODIMENTS

Referring to FIG. 5 an alternative latch arrangement is shown when snap ring 88 is a spring-type with a slot removed leaving a surface 90 at the break in the ring 88. Such a spring-type ring has a surface 92 which engages a conical surface 94 in body 16. In this embodiment, upstrain on body 16 causes surface 94 to exert an upward and inward force on surface 92 of ring 88. Ring 88 is then forced upward to engage surface 94 in mandrel 18. Continued upstrain on body 16 exerts sufficient compressive stress on ring 88 to cause spring ring 88 to deform radially to a smaller diameter and allow body 16 to move upward into the set position as illustrated in FIG. 3. This embodiment features a releasable connection which is re-engageable. Set down force on body 16 causes surface 96 to engage surface 98 on spring ring 88 enough to allow body 16 to move down over spring ring 88 into its retracted position again as illustrated in FIG. 5. At least one shear pin 52 could still be used to maintain axial alignment of gudgeon pin 44 with straight portion 70 of j-slot 50 when the packer is being lowered to the level in the well in which the packer will be set.

FIG. 6 illustrates an alternative embodiment of a packer according to this invention incorporating a hydraulic holddown anchor. It is often desirable in completing wells to inject water into various formations in the well bore to dispose of excess saltwater and/or to maintain pressure in the formation by replacing produced oil or gas with injected water. In such an application, there is often a higher pressure in the tubing and in the zone below the packer than in the zone above the packer. This situation occurs due to the use of flow control valves which only permit a predetermined flow of injected water from the tubing into each zone and the variations in porosity and permeability of different zones. In the case of a pressure in a zone being much higher than the pressure in the next zone above the packer, the sealed cross section area of the packer has the pressure differential operating against this area and can cause a large force upward on the packer which must be restrained by the tubing. Packers according to this invention do not have mechanical means to grip the casing. In such a case, it is possible to incorporate a hydraulic anchor into the packer to grip the casing and anchor the packer against a large upthrust. Such a hydraulic anchor is shown in FIG. 6. The hydraulic anchor body 116 is used in place of the body 16 as illustrated in FIG. 1. The conventional mandrel 18 and upper abutment or upper thimble 22, pin 24, seal ring 20, may be used. Bores 118 are formed in the body 116 to accept piston slips 120 which have seal rings 122 of the O-ring or other type to seal between the body 116 and the piston slip 120. Piston slip 121 is

illustrated in position to grip the inside surface of the casing 10. The piston slips are retained in the body by retainer bars 124 held in place by screws 126; springs 128 urge the piston slips to the retracted position. Ports 130 communicate between the inside diameter 132 of the body and the piston area 134 of the piston slips. Pressure inside the body bore 132 is admitted to act on the piston area 134 and when a sufficient pressure differential is present between bore 132 and annulus 17, the piston slips move radially outwardly so that teeth 136 engage the internal diameter of the casing 10. The diameter of and number of piston slips 120 is sized so that the force due to a pressure differential thrusting upwardly on the area of the packer can be anchored by the piston slips being actuated by the same differential pressure thrusting the piston slips against the inside surface of the casing.

The above-described tool is applicable to production or injection wells wherein the tubing pressure exceeds or is substantially equal to the pressure in annulus 19. There are applications wherein the pressure in annulus 19 would exceed the pressure in annulus 17 and also in the tubing, such as in sealing off a zone below the packer as shown in FIG. 6. In such a case, it would be possible to vent pressure from annulus 19 through passageway 58 to the back of piston slips 120 and 121 by an alternate vent path (not shown). In such an arrangement, the same pressure causing an upward force on the packer would be actuating the piston slips 120 and 121 to anchor against this upward force.

It should be understood that the packer with hold-down according to this invention could be inverted to provide a hold-up anchor and still fulfill all the objects of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A tension-set well packer comprising:
 - a mandrel;
 - Shoulder means on said mandrel;
 - a body having a wall and encircling said mandrel and forming a passageway therebetween;
 - releasable means connecting said mandrel to said body;
 - sealing means encircling said body;
 - an upper thimble encircling said body above and abutable with said sealing means and engageable with said shoulder means on said mandrel;
 - a lower thimble on said body below and abutable with said sealing means;
 - selectively operable valve means for controlling flow through said passageway;
 - a seal between said body and said mandrel; and
 - port means through the wall of said body, said port means located between said seal means and said seal providing communication from said passageway to the exterior of said body.
2. The packer according to claim 1 wherein said body has at least one additional port communicating with said passageway, said sealing means being located between said additional port and said seal.
3. The packer according to claim 1 wherein said upper thimble has at least one port communicating with said port means.

4. The packer according to claim 1 wherein said releasable means for connecting said mandrel and said body comprises:

- a jay-latch in one of said mandrel or said body; and
- a cooperating jay-latch pin in the other of said mandrel or said body.

5. The packer according to claim 4 wherein said releasable means further includes shear means between said mandrel and said body.

6. The packer according to claim 4 wherein said releasable means further includes spring loaded means releasably connecting said body to said mandrel, said spring loaded releasable means being releasable by longitudinal thrust between said body and said mandrel.

7. The packer according to claim 1 wherein:

- said valve means is open when said body and said mandrel are in a first position; and
- said valve means is closed when said body is moved longitudinally with respect to said mandrel to a second position.

8. The packer according to claim 6 wherein:

- said releasable means hold said body and said mandrel in said first position when said releasable means is connected; and
- said releasable means permits said body and said mandrel to move to said second position when said releasable means is released.

9. The packer according to claim 8 wherein said valve means comprises:

- a seal surface formed inside said body; and
- a seal ring mounted on said mandrel and adapted to be sealingly engaged with said seal surface, when said body and said mandrel are in said second position.

10. The packer according to claim 1 further comprising:

- said body having a plurality of cylindrical bores therein opening to the interior of said body; and
- gripping members in said bores expandable against the well casing in response to fluid pressure within said body and bores.

11. A tension-set well packer adapted to be set in well casing comprising:

- a mandrel;
- shoulder means on said mandrel;
- a body having a wall exterior to said mandrel and forming a passageway therebetween;
- releasable means connecting said mandrel to said body;
- sealing means having first and second ends encircling said body;
- a first thimble exterior to said body abutable with said first end of said sealing means and engageable with said shoulder means on said mandrel;
- a second thimble on said body and abutable with said second end of said sealing means;
- selectively operable valve means for controlling flow through said passageway;
- a seal between said body and said mandrel; and
- port means through the wall of said body, said port means located between said seal means and said seal providing communication from said passageway to the exterior of said body.

12. The packer according to claim 11 further com-

prising:

- said body having at least one cylindrical bore therein opening to the interior of said body; and
- at least one gripping member in said bore expandable against the well casing in response to fluid pressure within said body and bore.

13. The packer according to claim 10 further comprising:

- said mandrel having at least one cylindrical bore therein opening to the interior of said mandrel; and
- at least one gripping member in said bore expandable against the well casing in response to fluid pressure within said body and bore.

14. A tension-set well packer adapted to be set in a well bore having pipe therein connectable to the packer and restrained against upward movement below the packer, and having pipe connectable to the top of the packer and extending to the surface of the well bore, said packer comprising:

- a mandrel connectable to the pipe below the packer;
- shoulder means on said mandrel;
- a body connectable to the lower end of the pipe extending to the surface of the well bore;
- said body having a wall and encircling said mandrel and forming an annular passageway therebetween;
- releasable means connecting said mandrel to said body;
- sealing means encircling said body;
- an upper thimble encircling and slidable on said body above and abutable with said sealing means and engageable with said shoulder means on said mandrel;
- a lower thimble on said body below and abutable with said sealing means;
- selectively operable valve means for controlling flow through said passageway;
- a seal between said body and said mandrel; and
- port means through the wall of said body, said port means located between said sealing means and said seal providing communication between said passageway to the exterior of said body.

15. A tension-set well packer adapted to be set in well casing comprising:

- a mandrel;
- shoulder means on said mandrel;
- a body having a wall exterior to said mandrel and forming a passageway therebetween;
- releasable means connecting said mandrel to said body;
- sealing means encircling said body;
- a first thimble exterior to said body abutable with said sealing means and engageable with said shoulder means on said mandrel;
- a second thimble on said body and abutable with said sealing means;
- selectively operable valve means for controlling flow through said passageway;
- a seal between said body and said mandrel; and
- port means through the wall of said body, said port means located between said seal means and said seal providing communication from said passageway to the exterior of said body.

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