

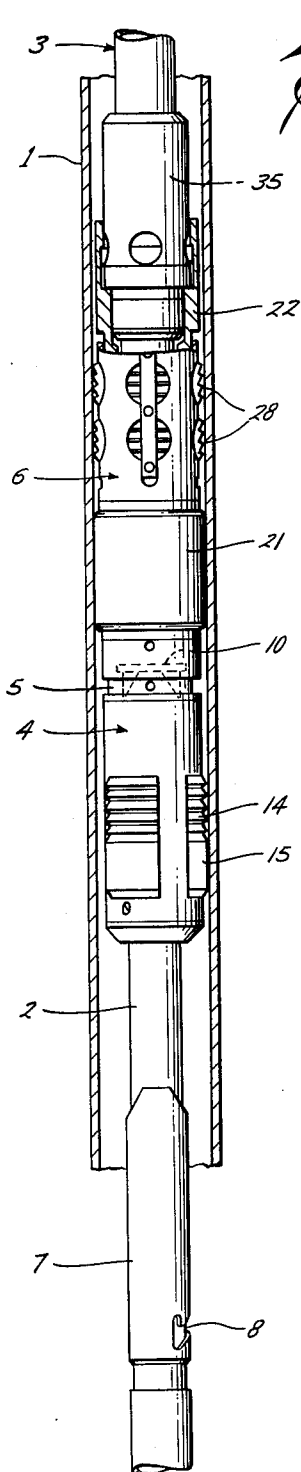
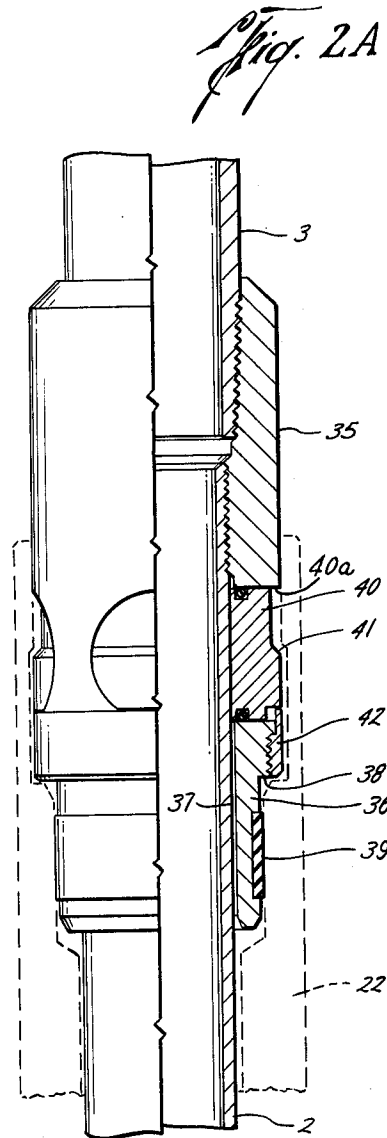
May 3, 1966

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HIGH PRESSURE WELL PACKER

3,249,149

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2 Sheets-Sheet 1



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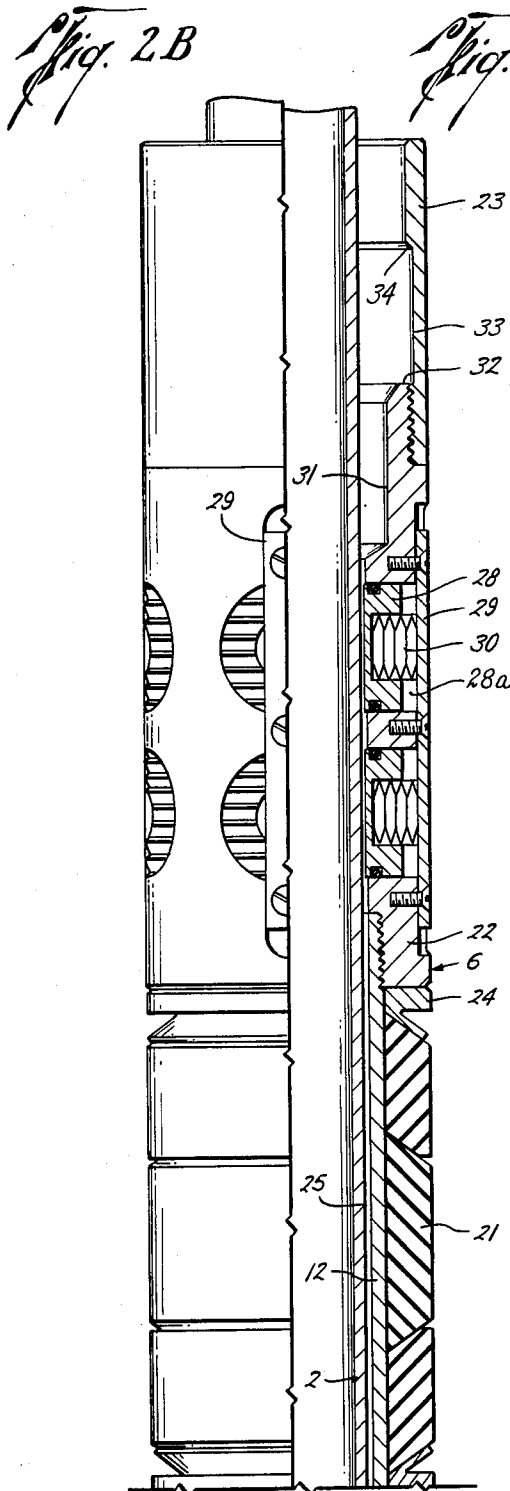
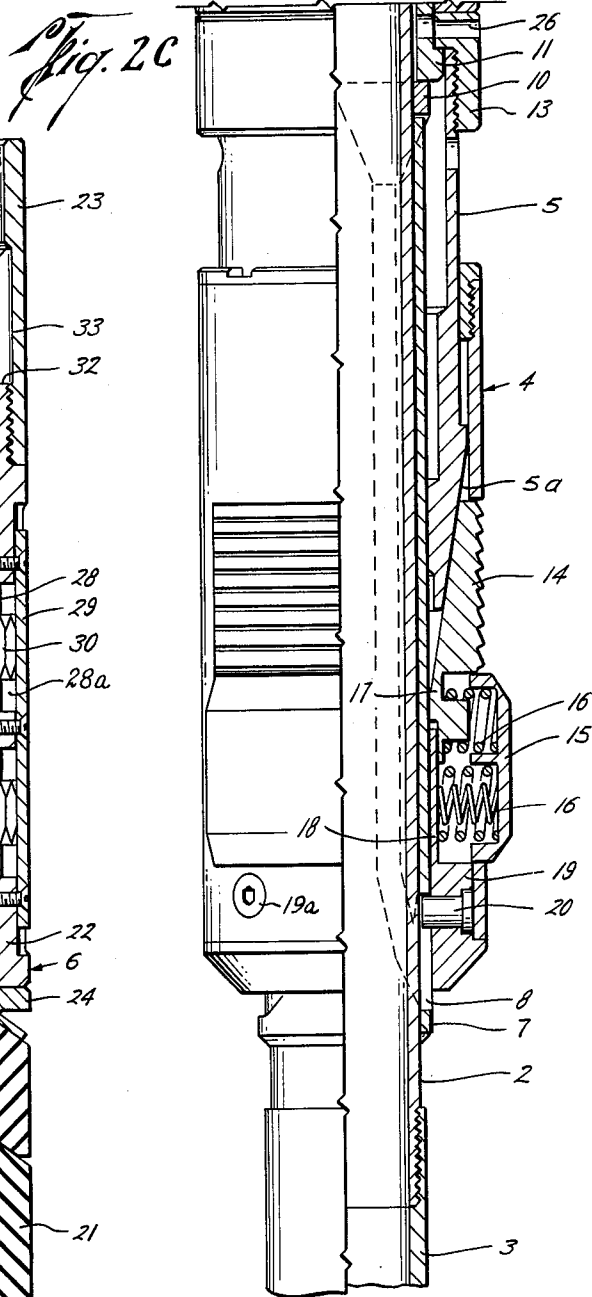
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HIGH PRESSURE WELL PACKER

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7 Claims. (Cl. 166-120)

This invention relates to well packers for incorporation in a production tubing string for lowering within a well bore to a given down-hole position at which the packing seal is deformed to bear on the bore wall or its casing liner so as to fill and block the adjacent annular space exteriorly of the tubing string and thereby close off from one another the annular space above and the annular space below the packer seal. More particularly, the invention relates to an improved interlock joining packer components to securely resist displacement from packer setting relationship.

An object of the invention is to provide a hydraulically actuated latch which comes into play automatically and secures the set packer assembly against unintentional release.

A further object is to combine a releasable latch element with other components of the packer assembly whose parts are retracted and ineffective initially and during tubing run-in travel through the well hole and until the tubing string is properly manipulated to condition the parts for and to effect the packer setting operation and coincidentally therewith to harness well fluid pressure differential across the packer for both actuating hold-down slips into clutching engagement with the casing and for projecting latch dogs for interlocking parts of the packer assembly against release.

Another object is to provide a fluid passageway inside the packer assembly and across the packing collar seal through which pressures are equalized prior to packer release and which passageway at its upper end is initially open and can be closed at the start of a packer setting operation so that fluid pressure below the set packer in excess of fluid pressure above the packer will project and maintain in locking projection a suitable latching dog.

A preferred but not necessarily the only embodiment of the invention is illustrated in the accompanying drawings wherein

FIG. 1 is an elevation partly in section of the improved packer assembly in set position within a well casing; and

FIGS. 2A, 2B and 2C are enlarged companion views partly in vertical section and partly in elevation of the packer assembly in the initial running-in relationship.

In the drawing, a well casing 1 is shown as having fitted thereto a packer assembly including an elongated mandrel 2 surrounding a full open bore and arranged for coupling connection at opposite ends with adjacent sections of a well tubing string 3 so as to constitute a part of the tubing string. In sleeved embracement on the lower part of the mandrel 2 and in end to end succession are tubular packing components comprising a bottom slip retainer cage 4, a slip expander 5 and a packing collar mandrel or body assembly 6.

Near its lower end the mandrel 2 is thickened by fitting and welding thereto an external tube 7 having a pair of diametrically opposite J-slots 8 of which the longer legs extend upwardly and terminate in V-shaped mouths at the top edge of the tube 7. Fitted within the V-shaped mouths are similarly shaped bearing teeth depending from a pressure thrust distributing ring 10, as best seen in FIG. 2C. This ring 10 is for abutment with the underside of a pick-up shoulder or laterally projecting annular rib 11 at the lower terminal of a tubular sleeve 12 which is part of the packing collar mandrel 6. In

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turn, the rib 11 is for pickup and seating suspension of an internal ledge of a stop abutment ring 13 fixedly threaded on the upper end of the tubular slip expander 5.

The tubular expander 5 extends inside the cage 4 and terminates downwardly in a tapered or conical outer face 5a for wedge bearing on mating tapered faces of a set of segmental slips 14 having downwardly facing wickers exteriorly thereof and being laterally projectable through cage windows and retained therein by the usual marginal lips (not shown) which underlie adjacent edges of the cage wall. Similar retaining lips locate casing engageable drag shoes or friction blocks 15 within the cage window. Each block is biased outwardly by a set of upper and lower coil springs 16-16 and the upper coil spring seats inwardly against a dependent tail or tab 17 on the adjoining slip 14 and resiliently urges the slip inwardly. Both the slip tail 17 and the lower spring 16 bear on an up-standing tubular wall 18 of a retainer ring 19 which is inserted within and closes the bottom of the outer wall of the cage 4 and is secured thereto by one or more screws 19a. Thus the springs 16-16 exert no force on the mandrel 2 which has a free sliding fit on the retainer ring 19. Inwardly projecting and outwardly headed slip clutch pins 20 are fitted to counterbored openings of the ring 19 and are held by an overlapping wall portion of the cage 4.

Bearing downwardly on the abutment ring 13 of the expander 5 is a packer collar 21 of rubber or other suitable elastic deforming material snugly embraced on the sleeve 12 of the mandrel 6 which, for convenience of manufacture and assembly, also includes a tubular body 22 and a terminal extension tube 23 threaded together in end to end succession. The wall thickness of the body 22 and of the unstressed packing collar 21, as seen in FIG. 2B, are substantially the same and the bottom end face of the body 22 is for downward force transmission abutment with the packer collar, preferably through a deformable metal washer 24. Internal diameters of the packer mandrel sections comprising the sleeve 12 and the body 22 somewhat exceed the outside diameter of the tubing mandrel 2 and the intervening clearance constitutes an internal fluid passageway 25 across the packer collar and has its opposite ends open to the exterior of the packer assembly when the packer collar is not in packing position. The lower passageway opening is through one or more radially aligned holes 26 in the bottom portion of the sleeve 12 and the surrounding abutment ring 13 of the expander tube. The upper opening is through the top of the body extension tube 23.

Drilled through the wall of the body 22 is a group of radial openings providing slide piston receiving chambers 28a for inward communication with the internal passageway 25. Peripherally sealed pistons, constituting casing engageable hold-down slips 28, are retained within the chambers by narrow straps 29 secured within vertical peripheral slots in the body 22 in bridging relation with the outer faces of the pistons which are grooved to straddle the retainer straps 29 and carry upwardly facing wickers for clutched engagement with the well casing. Belleville springs 30 interposed between the retainer straps 29 and the pistons resiliently urge the pistons inwardly in the absence of differential pressures on oppositely facing piston surfaces.

Above the hold-down piston chambers, the internal diameter of the body 22 is stepped outwardly and is machined to a smooth cylindrical sealing surface 31. This cylindrical surface terminates upwardly in a beveled guiding edge and a flat abutment shoulder 32. Above the shoulder 32, the body extension 23 is formed with an internal keeper groove 33 which terminates upwardly in an inwardly inclined shoulder 34. These internal surface formations at the top of the body 22, and as better indi-

cated by their dotted line showing in FIG. 2A, are for reception and mating co-operation with complementary surface formations carried by the head or coupling collar 35 at the upper end of the tubing string mandrel 2. Below its internally threaded upper coupling portion, the collar or head 35 has a dependent skirt 36 in annular clearance fitment with the mandrel 2 to afford a fluid passageway 37. Externally, the skirt 36 is of stepped diameter and a downwardly facing shoulder 38 separates the lower diameter portion from the larger upper diameter portion. Below the shoulder 38, the smaller diameter portion of the skirt is machined true to fit closely to the machined cylindrical surface 31 of the body 22 for interfitted valving co-operation in sealing the upper end of the passageway 25 when the tubing string is telescoped downwardly into the body 22. Insurance against leakage is afforded by interposing a seal, such as a pliable rubber gasket ring 39, between the surfaces and pocketing the same within a peripheral groove in the skirt 36.

Through the upper wall portion of the skirt 36 are one or more lateral openings or chambers 40a communicating inwardly with the internal clearance passage 27 and slidably receiving peripherally sealed pistons 40. In its outer face, each piston has a horizontally disposed and upwardly and inwardly inclined shoulder 41 between vertically offset outer face portions. The piston provides a projectable latch dog for projection into the keeper groove 33 and the shoulder 41 is for seating engagement with the internal shoulder 34. At its outer lower corner, each latch dog or piston 40 has a re-entrant groove and fits an upward extension into the piston opening of a retainer ring 42 sleeved on the skirt 36. This interfitted fit retains the latch dog piston 40 against rotation for retaining the shoulder 41 in horizontal position and also prevents drop-out of the latch dog piston.

When a packer assembly as described is to be set within a well bore, the packer will be incorporated in a production tubing string and lowered to a desired downhole location. Packer external diameter can be only slightly less than the liner casing internal diameter since all packer components except the friction blocks 15 will be initially contracted and centered by the friction blocks out of wear contact with the casing wall. During downward travel, the lower clutch pins 20 located within the short legs of the J-slots, transmit the travel force and pull down the slip cage with the friction blocks 15 dragging along on the casing wall. When the packer is to be set, descent of the tubing string is interrupted and the tubing string is elevated and rotated slightly through an angular distance to swing the J-slots 8 relative to the clutch pins 20 for aligning the long reaches of the J-slots with the pin. Upon such alignment and with the frictional contact against the casing wall of the friction blocks 15 for resisting movement of the cage 4, the tubing string can be lowered with the mandrel sliding freely through the external packer component to effect entrance of the mandrel head or collar 35 into the socket formation of the body 22. After the shoulder 38 of the tubing mandrel is seated on the shoulder 32 of the packer body 22, further downward force is transmitted from the tubing string to set the lower slips 14 and then expand the packer collar 21 into pack-off relation with the annular space surrounding the tubing string. At the same time, the internal passage is closed at its upper end at the valving surfaces 31 and 39. Increase of fluid pressure below the expanded packer as can be controlled by regulation of pressure within the bottom opening tubing string, will become active through the passageways 25 and 37 and within the piston chambers 28a and 40a behind the hold-down slips 28 and the latching pistons 40 for their outward projection. Such pressure maintains the hold-down slips in tight clutching contact with the casing to resist displacement forces and also, by reason of latching piston and keeper interengagement, maintains the parts against displacement to packer release relationship.

Should packer release be desired at some later time, then a short upward jar or pull transmitted through the tubing string, with or without regulating control of downhole pressure, will bring the inclined surfaces of the shoulders 41 and 34 on the latch piston 40 and keeper groove into a camming relationship for forced piston retraction and release of the safety interlock between the tubing mandrel 2 and the body 22 of the packer mandrel 6. Additional tubing string elevation then opens the top of the internal passage 25 for equilization of pressures across the packing, and whereupon the hold-down slips 28 will be spring retracted and permit elastic recovery of the packing collar 21. As soon as tubing string elevation brings the flared mouths at the top of the J-grooves 8 into engagement with the complementary teeth of the bearing ring 10, the bearing ring 10 will make pickup engagement with the bottom rib 11 of the packer mandrel 12 and raise the rib 11 into abutment with the ring 13 of the expander tube 5 for pulling the latter away from wedging relation with the bottom slip 14, which then moves to retracted position under the force of the spring 16. Thereafter, the bottoms of the J-slots will pick up the pins 20 and transmit upward travel of the tubing string to the cage and friction block 15. At this time the parts of the packer assembly will be in their positions of initial relationship and the packer can be reset in any desired position within the well casing or can be completely withdrawn to the surface and removed from the well.

While the foregoing description has been limited to a single embodiment, it is to be understood that the invention is capable of various modifications as come within the scope of the appended claims.

What is claimed is:

1. In a well packer assembly, a deformable packing collar, a lower collar stop abutment and slip unit, an upper collar abutment and slip unit having a tubular sleeve surrounded by the collar and terminated above the collar in an internal valve seat and a latch dog receiving internal groove, a fluid passage extending through said valve seat and the tubular sleeve to a point below the packer collar, a tubing string mandrel projected through the tubular sleeve and reciprocable relative thereto and provided with an upper annular enlargement for movement with mandrel movement into and out of the internal valve seat and groove, a bearing surface carried by the enlargement and movable into sealing engagement with said valve seat for blocking the upper end of said fluid passage, a hydraulically actuated and laterally projectable latch dog carried by the enlargement for alignment and reception within said internal groove and means active when the upper end of the fluid passage is blocked for communicating said fluid passage with and for projection of said latch dog.

2. In a well packer assembly having a lower slip sub-assembly, a tubing string mandrel slidably projected through the slip subassembly, a packing collar mandrel sleeved on the tubing string mandrel above said slip sub-assembly for relative mandrel reciprocation, a fluid passageway through the packing collar mandrel, mating sealing surfaces on said mandrels arranged to be brought into seating contact one with the other at one limit of relative mandrel reciprocation for thereby closing the upper end of said fluid passageway, a latch dog keeper formation on one of said mandrels, a hydraulically actuated and laterally projectable latch dog positioned by the other mandrel for alignment with said keeper formation at said last mentioned limit of mandrel reciprocation and means to direct actuating fluid from said passageway into latch dog projecting relation when said upper end of the passageway is closed by seating contact of said sealing surfaces.

3. In a well packer assembly as in claim 2, said packing collar mandrel also having hydraulically actuated hold-down slip means in the upper portion thereof comprising chamber means communicating inwardly with said

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passageway and slip means slidably fitted to and outwardly closing the chamber means for displacement laterally in response to differential fluid pressures thereon.

4. In a well packer assembly as in claim 2, one of said sealing surfaces and the keeper formation being in juxtaposed axially spaced apart relation internally of the upper end of said packing collar mandrel and the other of said sealing surfaces and the latch dog being carried externally of the tubing string mandrel and being positionable with relative mandrel travel into and out of nested relation with said upper end of the packing collar mandrel.

5. In a well packer assembly having a lower slip subassembly, a tubular mandrel slidably projected through the slip subassembly and adapted for connection in and as a part of a tubing string, a collar on said mandrel having a radially disposed chamber, a laterally projectable latch dog slidably fitted to the chamber and closing its outer end, a downwardly opening fluid passageway leading upwardly through said collar and communicating with the inner end of the chamber, a downwardly facing shoulder on the collar separating the portion thereof containing said chamber from a lower and smaller outside diameter portion, a peripheral sealing surface on said lower and smaller diameter portion, a packing collar supporting mandrel interposed between said shoulder and said slip subassembly and sleeved on said tubular mandrel for the relative mandrel reciprocation, said collar supporting mandrel terminating upwardly in a socket for nested reception of the collar on said tubular mandrel, an upwardly facing internal shoulder within the socket, a latch dog keeper within the socket above said shoulder, a sealing surface below the shoulder of an internal diameter to provide sealing contact with said sealing surface on the collar and a fluid passageway extending through the collar supporting mandrel and communicating the exterior thereof below its supported collar with said socket at the upper end thereof.

6. In a well packer, a tubular mandrel for coupled connection in a tubular string, a packer subassembly slidably sleeved on the mandrel and comprised of a deformable packing collar, casing engageable slip mechanism having an upwardly facing collar abutment stop, a downwardly facing pressure applying collar abutment having upwardly and downwardly extending tubular portions embracing and radially spaced from the mandrel to provide

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fluid flow clearance between opposite ends of the collar, chambers in the upwardly extending tubular portion communicating with the flow clearance, projectable pistons in the chambers having outer clutching faces for casing retention engagement, and an internal socket formation at the upper end of said upward extension providing an annular sealing surface and a latch keeper groove above the sealing surface, said tubular mandrel having a peripheral head above the packer subassembly for movement therewith into and out of nested relation with said socket, a peripheral sealing surface on said head to bear on the internal sealing surface of the socket, a chamber in the head above its sealing surface, an outwardly projectable piston in the chamber to provide a latch dog engageable with said keeper groove and a fluid passageway in the head communicating said chamber with the flow clearance within the socket when the head is nested therein.

7. In a well packer, a tubular mandrel adapted for connection with a tubing string and provided with a head thereon, a lower slip and stop unit surrounding the mandrel, a packer collar subassembly sleeved on said mandrel and provided with a deformable packing collar engageable downwardly with said unit and an upwardly opening socket above the collar to receive said head upon relative downward travel of the mandrel in a packer setting operation, a fluid passageway including said socket and extending through said subassembly for communicating the exterior thereof beyond opposite ends of the collar, interfitting sealing surfaces on the head and said socket active to close the upper end of said passageway from the exterior of the subassembly about the collar when the head is received within the socket, a latch dog keeper internally of the socket, a keeper engageable latch dog laterally projectably mounted in the head and means in the head for transmitting to said latch dog the fluid pressure within the upwardly sealed passageway.

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