

March 26, 1968

J. S. PAGE ET AL

3,374,837

RETRIEVABLE PACKER

Filed Oct. 18, 1965

3 Sheets-Sheet 1

FIG. 1a.

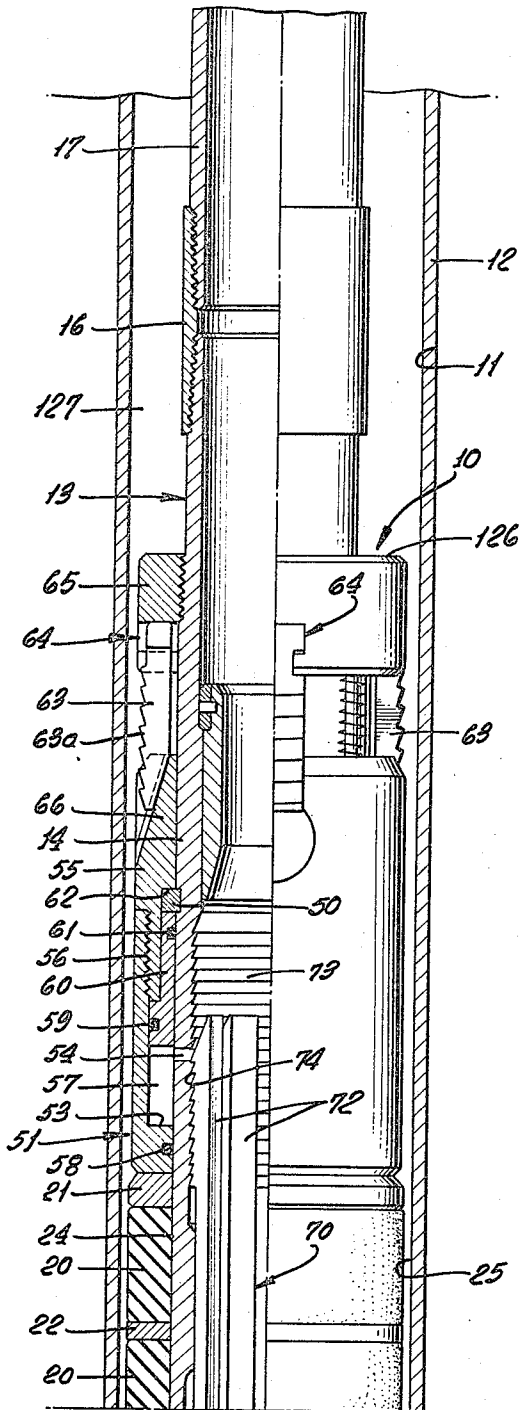
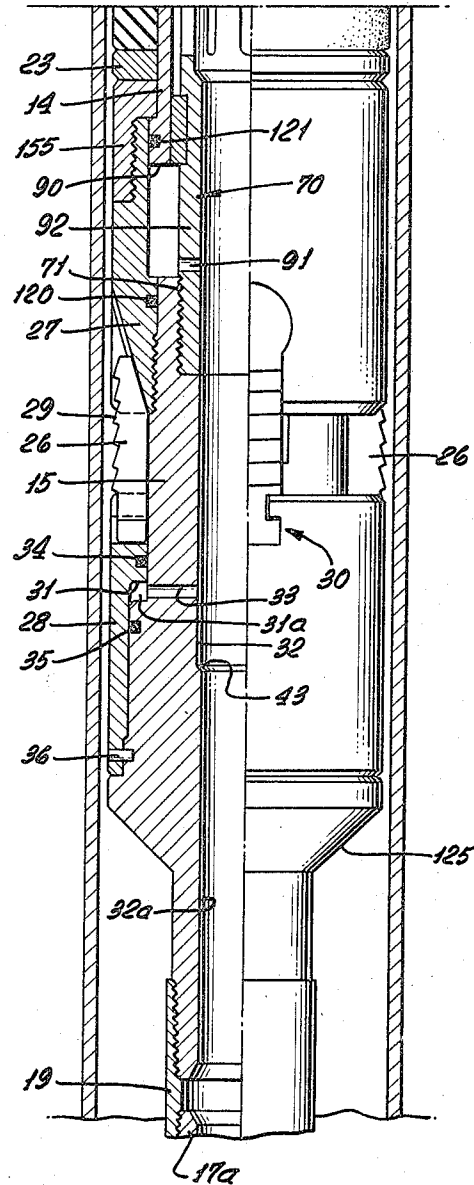


FIG. 1b.



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FIG. 2a.

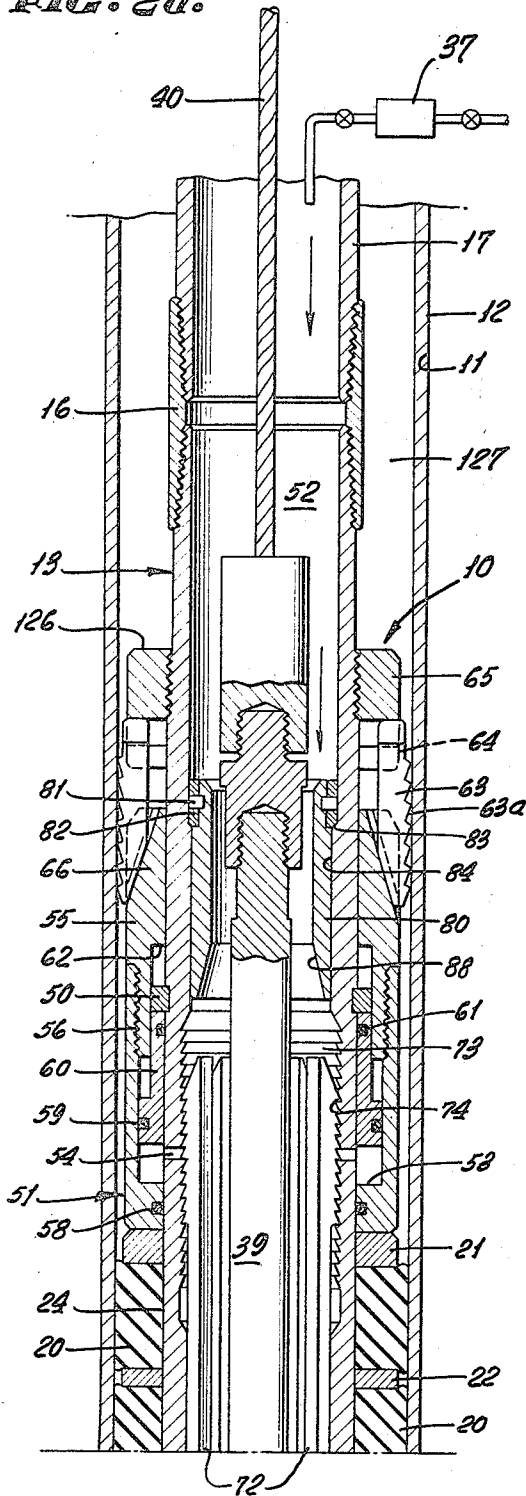
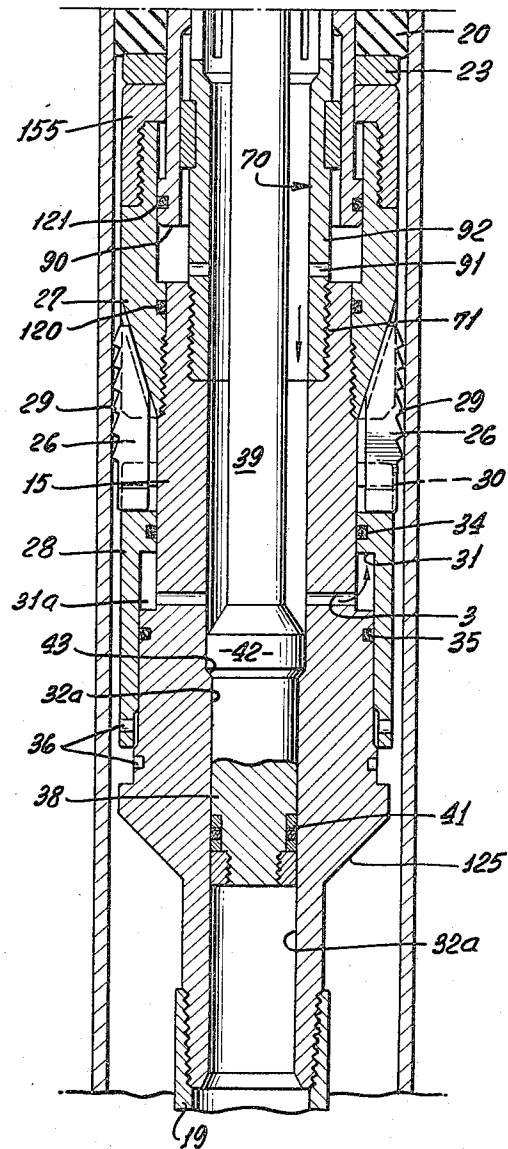


FIG. 2b.



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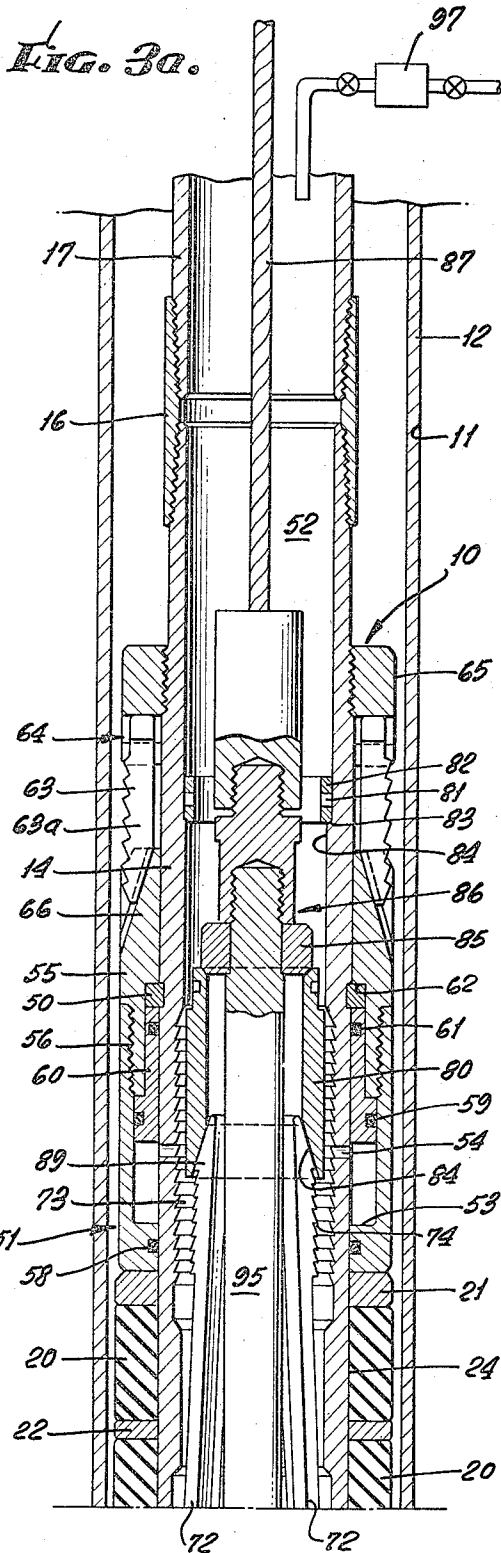
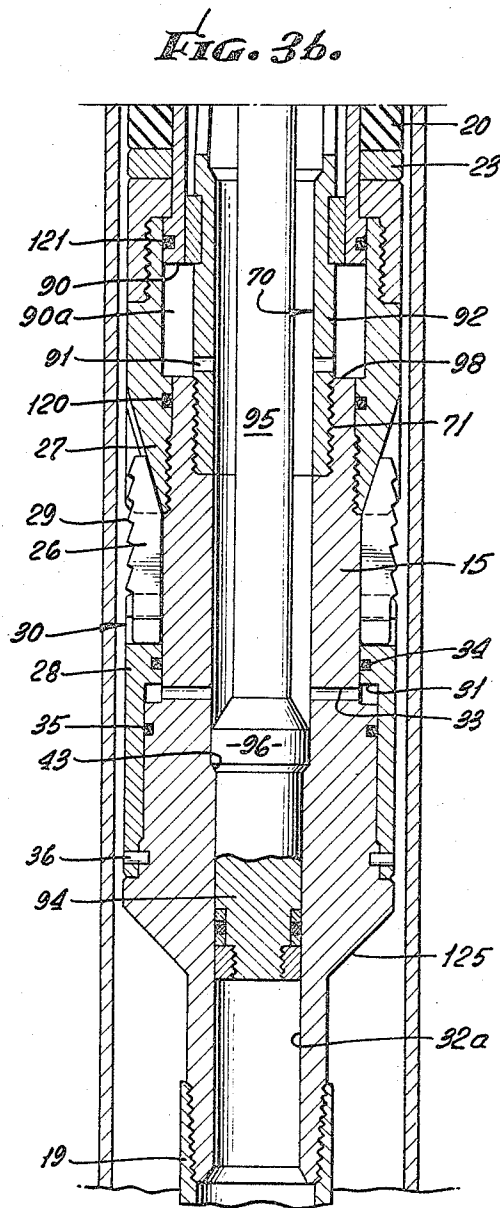
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RETRIEVABLE PACKER

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ABSTRACT OF THE DISCLOSURE

The invention provides for setting of a packer in a well by means of pressurization of fluid in a tubing string in relation to vertical manipulation of the string, the packer being carried on the string and typically being locked in set position; the invention also provides for release of the packer in response to pressurization of fluid in the string and vertical manipulation of the string.

This invention relates generally to well packers, and more particularly concerns improvements in the setting and releasing of well packers on tools run in wells on tubing strings.

In the past, it has been common to set a packer in a well with slips set above the packer to block fluid pressure induced upward displacement of the tool. One disadvantage with this approach has been lack of provision for surface controlled release of the slips and packer, so that it has been necessary to run auxiliary equipment into the well to drill out the slips and packer at such time that release was desired. Toward overcoming this problem it has been proposed that surface controlled release of the upper slips be effected by rotating the tubing string to unthread a down hole release connection; however, such an expedient is less than desirable since down hole threads are subjected to corrosion and binding, leading to malfunction of the release operation.

Summary of the invention

It is a major object of the present invention to overcome these and other problems peculiar to the setting of packers in oil wells, through the provision of a surprisingly effective tool including a well packer which can be easily set, and also released without requiring drill out or being dependent upon string rotation to secure release.

It is also an important object of the invention to provide an unusually effective method of packer setting and release that requires only vertical manipulation of the string in controllable relation to pressurization of fluid in the string, as well as a tool with a corresponding mode of operation. Also, a releasing tool may be run into the string to aid the release.

Basically, the new tool comprises vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, a well packer on the body structure, and means responsive to application of fluid pressure and to relative vertical displacement of the sections for attaching one of the sections to the well bore and for deforming the packer to seal off between the body structure and the well bore. Typically, first means on the body structure is made responsive to application of fluid pressure communicated from within the body structure to attach the lower section to the well bore, and second means including ram structure on the body structure is made responsive to application of fluid pressure communicated from within the body structure and to surface controlled string lowering of the upper section relative to the lower section for deforming the packer to seal off between the body structure and the well bore and for attaching the upper section to the well bore. Regarding release of the tool, the latter may be

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considered to include means on the body for attaching one of the upper and lower sections to the well bore and also for releasing said attachment in response to relative vertical displacement of the sections. Typically, locking means is provided to block raising of the upper section relative to the lower section when the packer is in deformed condition to seal the well bore, the locking means being releasable to enable raising of the upper section relative to the lower section so that the packer may release from sealing relation to the well bore.

In its method aspects, the invention includes the steps of running the tool in a well on tubing string, pressurizing fluid in the string to set lower slips, lowering the upper string to set the packer and upper slips, and producing the well; to release the tool the well fluid is pressurized, the tool body sections are forced apart, and the upper string may be lifted to aid the release and to pull the tool.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following detailed description of the drawings in which:

FIGS. 1a and 1b show one preferred embodiment of the tool as it is run into the well on a tubing string;

FIGS. 2a and 2b show the FIG. 1 tool in set condition in the well; and

FIGS. 3a and 3b show the manner in which the FIG. 1 tool may be released from FIG. 2 set condition.

Reference is first made to FIGS. 1a and 1b showing the tool 10 in running in position in a well 11 cased at 12. The tool includes vertically elongated tubular body structure 13 with upper and lower sections 14 and 15 adapted for relative vertical and axial displacement, as for example telescopic displacement. Upper section 14 has collar connection at 16 with the tubing string 17, whereas lower section 15 has collar connection at 19 with the string 17a. Accordingly, the sections 14 and 15 may pass well fluid vertically through the tool.

The tool also includes a well packer on the body structure 13 to seal off between the body and the well bore. In the specific example illustrated, the packer includes dual elastomer elements 20 extending annularly about the body section 14, and metal spacer rings 21, 22 and 23 are located above, between and below the elements for transferring axial loading to the elements to deform them as seen in FIGS. 2a and 2b. In that view, the elements seal off between the body annular surface 24 and the casing bore 25.

Further in accordance with the invention, means is provided to be responsive to application of fluid pressure and to relative vertical displacement of the body sections for attaching one of the sections to the well bore and for deforming the packer to seal off between the body structure and the well bore. Such means may also perform the additional function of attaching the other of the body sections to the well bore.

Typically, the above means may include slips 26 and tapered actuator structure such as downwardly tapered cone 27 on the lower section 15, as well as fluid pressure responsive driver 28 to transmit force effecting outward movement of the slips on the cone for attachment of the slip wickers 29 to the bore 25 as the slips are moved upwardly in contact with the cone surface. The slips typically have T-slot connection to the driver sleeve, as seen at 30 in FIG. 1b, allowing inward and outward shifting of the slips. The driver sleeve has a downward facing piston surface 31 in setting chamber 31a in communication with the body bore 32 via port 33 in section 15, and annular seals 34 and 35 seal off between the driver and body section 15 above and below piston surface 31.

A shear pin 36 prevents inadvertent setting of the slips until predetermined fluid pressure is exerted upwardly on the piston surface 31. Such pressure may be developed by

surface means indicated at 37 in FIG. 2a, following dropping and landing in the tool of means to plug the body bore 32a below the level of port 33, the surface means 37 acting to fluid pressurize the string interior. The bore plugging means may for example comprise the plunger 38 carried on a mandrel 39 run into the string by wireline 40, the plunger carrying a seal ring 41 to seal off against bore 32a. A tapered flange 42 on the mandrel 39 lands on the internal bore shoulder 43 of the tool.

Once the lower body section 15 is attached to the well bore, or set, the packer is then deformed to pack off against the well bore in response to relative vertical movement of sections 14 and 15. Typically, the means affording this function includes a stop element, such as ring 50 on section 14, to unblock fluid pressure application induced deformation of the packer as section 14 is lowered relative to section 15, such deformation resulting from unblocked downward travel of annular ram 51. In the illustrated embodiment, pressure from within the tool interior 52 is typically communicated to the upward facing piston surface 53 of the ram via port 54 in the section 14, to drive the ram downwardly for compressing the packer element 20, the downward thrust being transmitted via spacer 155 to actuator 27 and to the slips 26.

Prior to downward travel of the ram on section 14 to compress the packer, the ram is held in an upper position by the stop ring 50, and one particularly advantageous way to accomplish this is to locate the ring 50 to block downward travel of an upper actuator 55 to which the ram is attached as by thread 56, FIG. 1a illustrating this blocked condition with actuator shoulder 62 engaging the ring 50. FIG. 2a on the other hand shows the ring 50 and section 14 lowered, as by lowering of the upper string 17, allowing fluid pressure from within the tool interior 52 to urge the ram 51 and actuator 55 downwardly, as by pressure exertion on piston surface 53. In this regard annular seal 58 seals off between ram 51 and surface 24 of section 14, annular seal 59 seals off between ram 51 and sleeve 60 and seal 61 seals off between sleeve 60 and surface 24 of section 14, thereby to prevent fluid leakage from the pressure chamber 57 above the piston surface 53. Upwardly directed fluid pressure exerted on sleeve 60 is transmitted to the ring 50. The weight of the lowered string is sufficient to drive sleeve 60 downwardly toward piston surface 53, overcoming the fluid pressure exerted upwardly on the sleeve 60 and that fluid pressure may be reduced if necessary to allow lowering of the string.

The actuator 55 along with slips 63 provide one form of means located to attach the upper section 14 of the body to the well bore in response to relative vertical displacement of the sections 14 and 15. Since the slips 63 have T-slot connection at 64 to a flange 65 threaded on upper section 14 and since the actuator 55 is connected to ram 51, slip attachment to the well bore occurs in response to downward movement of the section 14 relative to the ram 51. In this regard, the actuator 55 may have a cone 66 tapering upwardly to urge the slips outwardly for anchoring engagement of the slip wickers 63a with the well casing bore, thereby locking the packer in radially deformed condition sealing off between the body section 14 and the casing. As the slips are moved downwardly by flange 65 and wedged between the cone 66 and casing bore 25, they transmit downward loading to the packer via the actuator 55 and ram 51, aiding compressive deformation of the packer. Upper slip wickers 63a are angled to resist upward movement during their forcible engagement with bore 25, whereas lower slip wickers 29 are angled to resist downward movement during their forcible engagement with bore 25.

An added aspect of the invention has to do with releasable locking means to positively lock the sections 14 and 15 against relative displacement when the packer is in deformed condition. In the illustrated embodiment, such locking means takes the form of a collet 70 carried on the lower section 15, as by threading 71, the collet having

fingers 72 projecting axially upwardly and interiorly of the upper section 14; further, the upper section and the collet fingers have ratchet interengagement shoulders 73 and 74 respectively to lock the sections 14 and 15 against relative axial displacement tending to separate them when the packer is in deformed condition.

Reference to FIGS. 2 and 3 will show the manner in which the locked-up tool may be released to release the packer and slips. A collet releasing sleeve 80 is normally retained in the upper section 14, as by a shear pin 81 connecting the sleeve to a collar 82. The latter normally seats at body bore step shoulder 83, blocking downward displacement of the sleeve within bore 84. FIG. 3a shows the sleeve 80 driven downwardly by a flange 85 on releasing tool 86 lowered by wireline 87. During this operation, the lower flared surface 88 of the sleeve 80 collapses inwardly the upper terminals 89 of the collet spring fingers 72 releasing the ratchet interengagement of shoulders 74 and 73, and thereby unlocking the sections 14 and 15 to permit their separation as by lifting of the string.

Following release of collet 70, axial separation of sections 14 and 15 is aided by the jacking action of fluid pressure responsive piston means transmitting force acting to relatively separate the sections. In the illustrated embodiment, the piston surface 90 at the lower terminal of the upper section receives application of fluid pressure communicated from within the body structure, as via port 91 in the collet cylinder 92, so as to transmit force acting upwardly to lift the upper section 14 relative to the lower section 15. At the same time, fluid pressure acts downwardly on section 15 at shoulder 98. Also, the upper string is elevated to aid release of the upper slips when upper section 14 is elevated. After the slips are disengaged and after ring 50 is lifted sufficiently to engage and lift actuator shoulder 62, actuator 55 and ram 51 are elevated to relieve the compressive force exerted on the packer. The jacking action helps relieve the downward loading on the upper slips 63 exerted by the string weight, so that those slips disengage from attachment to the bore 25. As the tool 10 is lifted by the string, the lower cone 27 is lifted from the lower slips 26, releasing their attachment to bore 25.

Fluid pressure communicated to piston surface 90 at releasing chamber 90a may be developed by surface pressurization of the column of fluid in the string after the lower section 15 is plugged at 94. For this purpose, the releasing tool 86 may include a rod 95 suspending the bore plug 94, and a flange 96 on the rod landing at shoulder 43 to limit downward movement of the releasing tool 86 in the body sections 14 and 15, as illustrated. Such surface pressurization is indicated schematically by the equipment 97 in FIG. 3a.

To review the operation, the tool 10 is run into a well on the string to pack-off depth; plunger 38 is then run into the well and pressurization of fluid in the string from the surface is effected to set the lower slips 29 by pressure application to chamber 31a. That pressure applied to releasing chamber 90a tends to keep the upper slips 63 from setting on upper cone 65, and the fluid pressure applied to packer setting chamber 57 keeps the cone 55 and sleeve 60 locked up against opposite sides of split stop ring 50.

The upper tubing string is then lowered, its weight overcoming the fluid pressure in setting chamber 57, so that the packer 20 is deformed to seal against bore 25, and so that the upper slips 63 are set on the cone 65. At the same time, collet 70 locks the upper and lower sections 14 and 15 to positively lock the packer in compressed condition, with the upper and lower slips anchored to the well bore 25.

To release the tool, the plug 94 is lowered as by wireline, and sleeve 80 displaced downward to release the collet 70. The fluid in the string above the plug is then pressurized for application to piston 90 at releasing chamber 90a and against sleeve 60 in the setting chamber,

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jacking the upper section 14 upwardly relative to lower section 15. The string can also be pulled upwardly, to assist in the release, and to pull the tool from the well.

While the well is being produced with the packer set, slips 63 engaging bore 25 in FIG. 2a resist upward displacement of the tool in response to upward pressure of fluid exerted against the lower end 125 of the body in FIG. 2b. Lower slips 26 resist downward displacement of the tool in response to downward pressure of fluid exerted against the upper end 126 of the tool, that fluid for example flowing into the upper annulus 127 from an upper zone of the formation. Well fluid from a lower zone is produced up the tubing 17.

Chamber 90a is sealed at 120 and 121. Compression springs 130 between flange 65 and actuator 55 transmit force tending to urge the actuator 55 downwardly relative to flange 65. Thus in FIG. 2a, those springs transmit force helping to urge ram 51 downwardly to compress and deform the packer.

We claim:

1. In combination with a string of tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, a well packer on the body structure, means at the well head for pressurizing hydraulic fluid within the string above said sections, and means responsive to application of said fluid pressure and to vertical displacement of the string above said sections acting to effect relative vertical displacement of said sections for attaching one of said sections to the well bore and for deforming the packer to seal off between the body structure and the well bore.

2. For combination with a string of tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, a well packer on the body structure, and means responsive to application of fluid pressure and to relative vertical displacement of said sections for attaching one of said sections to the well bore, for deforming the packer to seal off between the body structure and the well bore and for attaching the other of said sections to the well bore, said means including ram structure carried for travel on and relative to the other section and exposed to said application of fluid pressure, and an element on the other section operable to block said relative travel of the ram structure, said element being relatively movable with said other section in response to relative vertical displacement of said sections to unblock said relative travel of the ram structure, thereby to enable fluid pressure application induced travel of the ram structure for effecting said packer deformation, said element remaining in the path of relative vertical travel of the ram structure for effecting retraction of the ram structure to relieve deformation of the packer in response to reverse relative vertical displacement of said sections.

3. The combination of claim 1 including releasable locking means to lock said sections against relative displacement when the packer is in deformed condition.

4. The combination of claim 2 in which said means includes slip and actuator structure located to attach said other section to the well bore in response to relative vertical displacement of said other section and the ram structure.

5. In combination with a string of tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, an annular packer on the body structure to seal off between the body structure and the casing bore, means at the well head for pressurizing hydraulic fluid within the string above said sections and within said body structure, first means in the body structure and responsive to application of said fluid pressure communicated from within the body structure to attach the lower section to the well bore, and second means including ram structure on the body structure and responsive to applica-

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tion of said fluid pressure communicated from within the body structure and to lowering of the upper section relative to the lower section for deforming the packer to seal off between the body structure and the well bore and for attaching the upper section to the well bore, said upper section being attached to the string above said sections.

6. The combination of claim 5 in which said second means includes a stop carried by the upper section to unblock fluid pressure application induced travel of the ram structure to deform the packer in response to relative vertical displacement of said sections.

7. For combination with a string tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, an annular packer on the body structure to seal off between the body structure and the casing bore, first means in the body structure and responsive to application of fluid pressure communicated from within the body structure to attach the lower section to the well bore, and second means including ram structure on the body structure and responsive to application of fluid pressure communicated from within the body structure and to lowering of the upper section relative to the lower section for deforming the packer to seal off between the body structure and the well bore and for attaching the upper section to the well bore, and including a collet on one of said sections projecting axially and interiorly of the other section, the other section and said collet having ratchet interengagement shoulders to lock the sections against relative axial displacement tending to separate them when the packer is in deformed condition.

8. The combination of claim 7 including a fluid pressure responsive piston integral with the other of said sections to receive application of fluid pressure communicated from within said body structure and to transmit pressure developed force acting to relatively separate said sections in response to release of said ratchet interengagement shoulders.

9. The combination of claim 8 in which the collet has spring fingers carrying said collet shoulders, and including a sleeve located in the upper section for downward travel into collapsing relation with the collet spring fingers to release said ratchet interengagement shoulders to allow said relative separation of the sections.

10. For combination with a string of tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, a well packer on the body structure, means responsive to application of fluid pressure and to relative vertical displacement of said sections for attaching one of said sections to the well bore and for deforming the packer to seal off between the body structure and the well bore, releasable locking means to lock said sections against relative displacement when the packer is in deformed condition, and fluid pressure responsive piston means to transmit force acting to relatively displace said sections in response to release of said locking means.

11. For combination with a string of tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, an annular packer on the body structure to seal off between the body structure and the casing bore, first means in the body structure and responsive to application of fluid pressure communicated from within the body structure to attach the lower section to the well bore, and second means including ram structure on the body structure and responsive to application of fluid pressure communicated from within the body structure and to lowering of the upper section relative to the lower section for deforming the packer to seal off between the body structure and the well bore and for attaching the upper section to the well bore, said second means including a stop carried by the upper section to unblock fluid pressure application induced travel of the ram structure to

deform the packer in response to relative vertical displacement of said sections, said second means also including slip and tapered actuator structure on the upper section, with the actuator structure integral with the ram structure to urge the slip structure outwardly into attachment with the well bore in response to relative vertical displacement of the upper section and ram structure.

12. For combination with a string of tubing in a well, vertically elongated tubular body structure including upper and lower sections adapted for relative vertical displacement, an annular packer on the body structure to seal off between the body structure and the casing bore, first means in the body structure and responsive to application of fluid pressure communicated from within the body structure to attach the lower section to the well bore, and second means including ram structure on the body structure and responsive to application of fluid pressure communicated from within the body structure and to lowering of the upper section relative to the lower section for deforming the packer to seal off between the body

structure and the well bore and for attaching the upper section to the well bore, said second means including a stop carried by the upper section to unblock fluid pressure application induced travel of the ram structure to deform the packer in response to relative vertical displacement of said sections, said first means including slip and tapered actuator structure on the lower section, and a fluid pressure responsive driver to transmit force effecting outward movement of the slip structure on the tapered actuator for attachment to the well bore.

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