June 15, 1965 J. F. DE ROCHEMONT 3,189,095

HYDRAULICALLY SET WELL PACKERS

Filed Nov. 5, 1962 6 Sheets-Sheet 1

FIG. 1a.

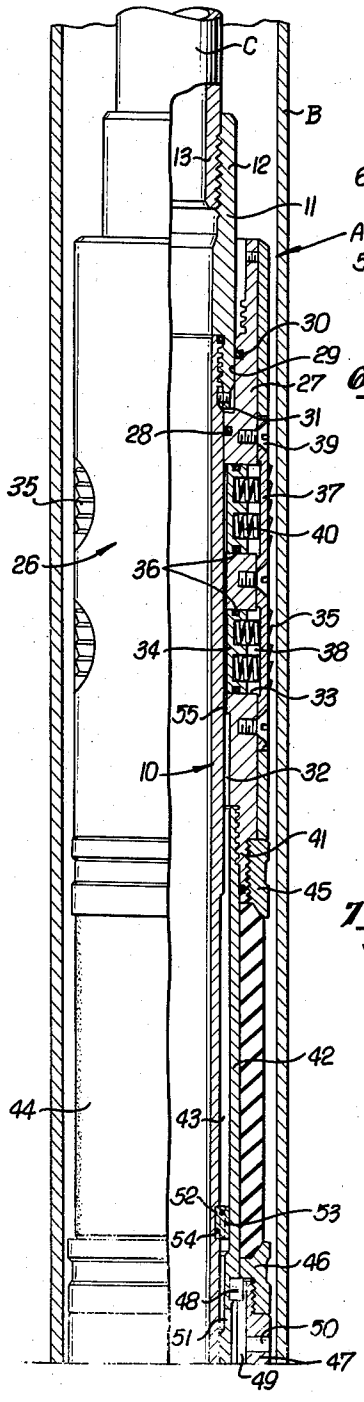


FIG. 1b.

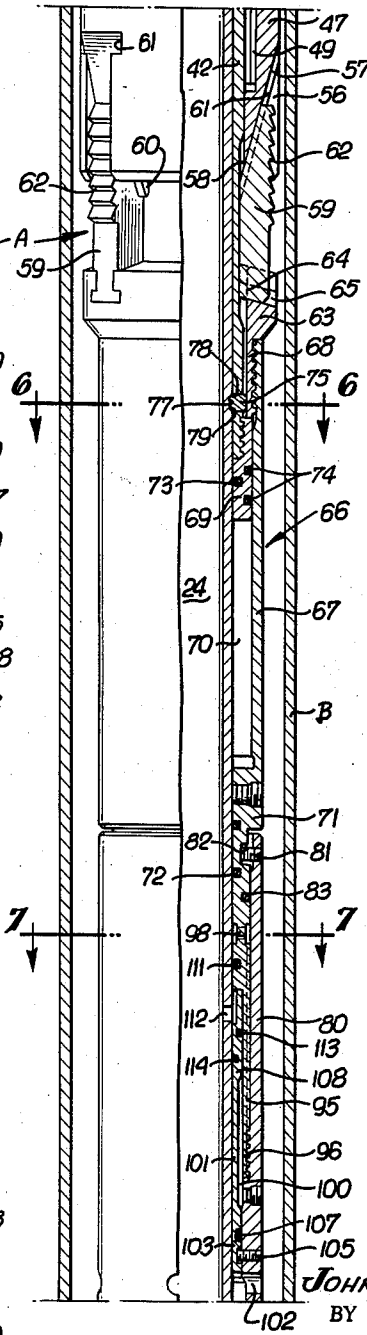
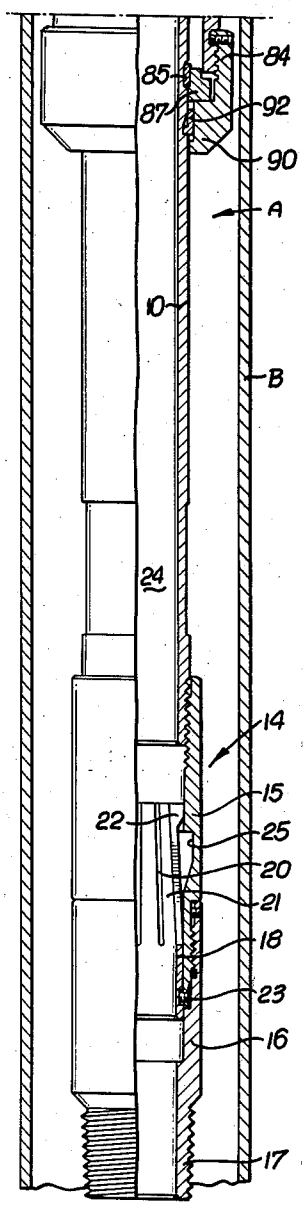


FIG. 1c.



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Filed Nov. 5, 1962 6 Sheets-Sheet 2

FIG. 2a.

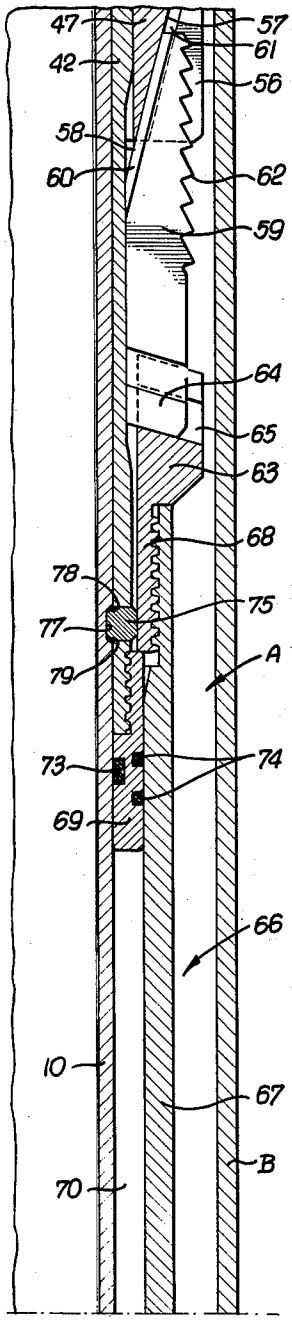


FIG. 2b.

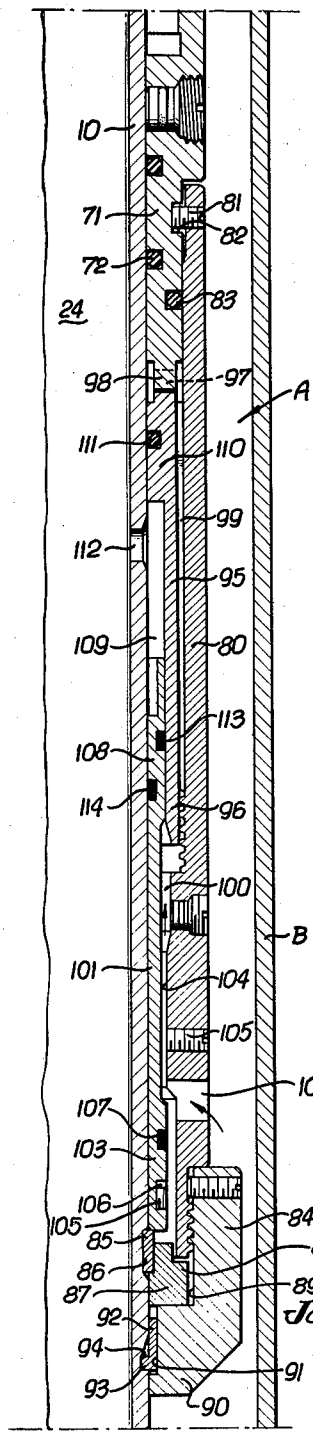
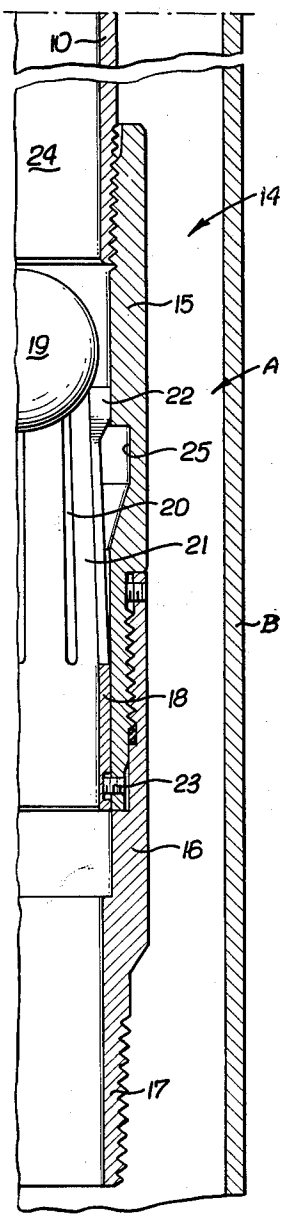


FIG. 2c.



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Filed Nov. 5, 1962 6 Sheets-Sheet 3

FIG. 3a.

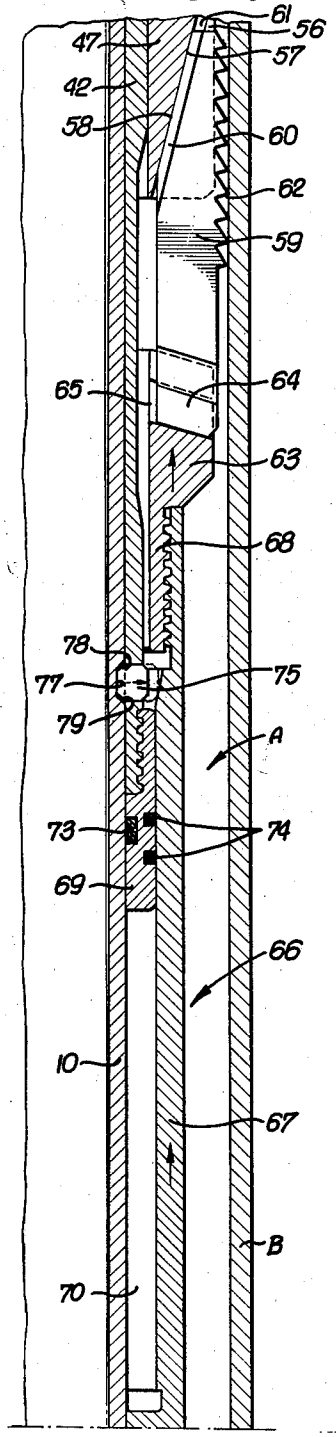


FIG. 3b.

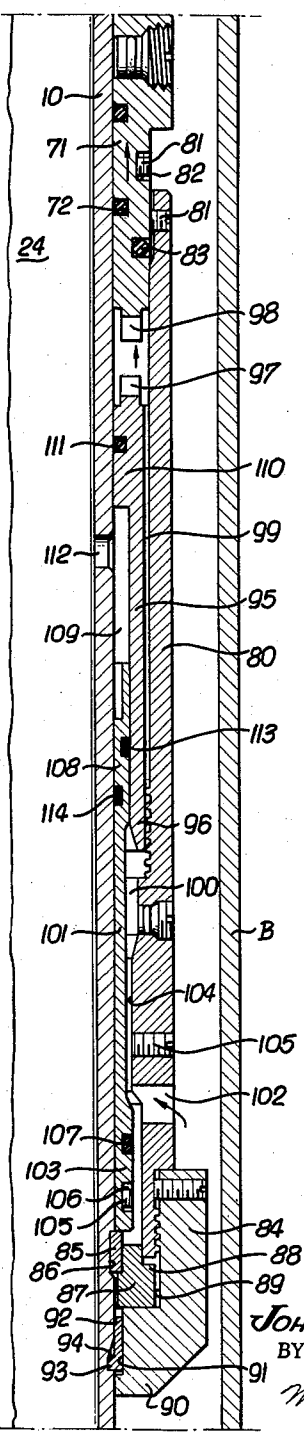
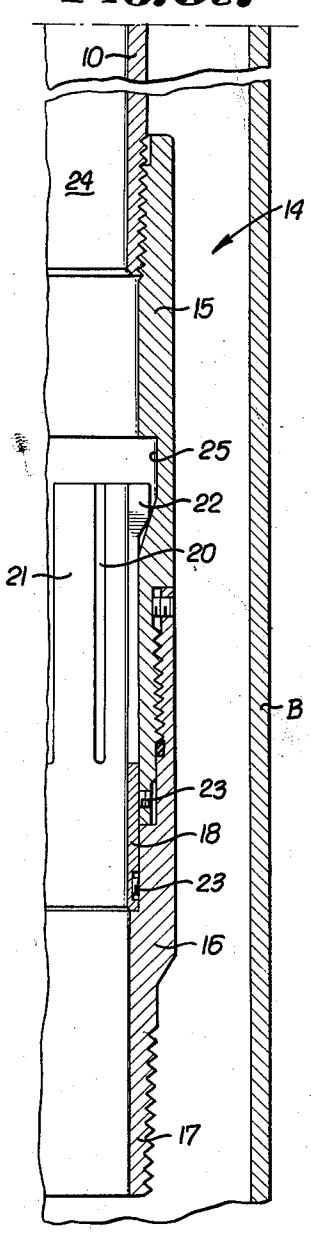


FIG. 3c.



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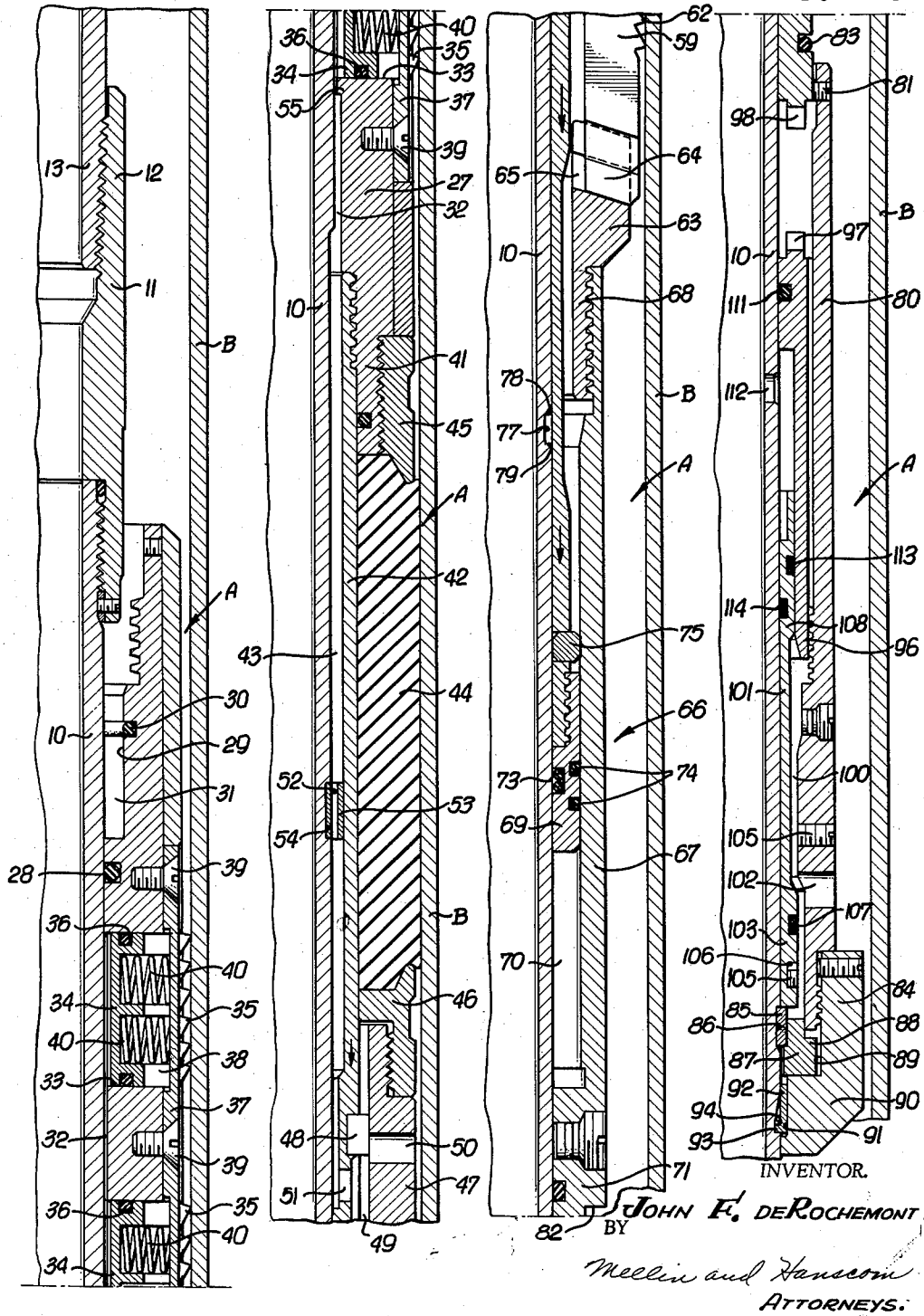
June 15, 1965 J. F. DE ROCHEMONT 3,189,095

HYDRAULICALLY SET WELL PACKERS

Filed Nov. 5, 1962 6 Sheets-Sheet 4

FIG. 4a. FIG. 4b. FIG. 4c. FIG. 4d.



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HYDRAULICALLY SET WELL PACKERS

Filed Nov. 5, 1962 6 Sheets-Sheet 5

FIG. 5a.

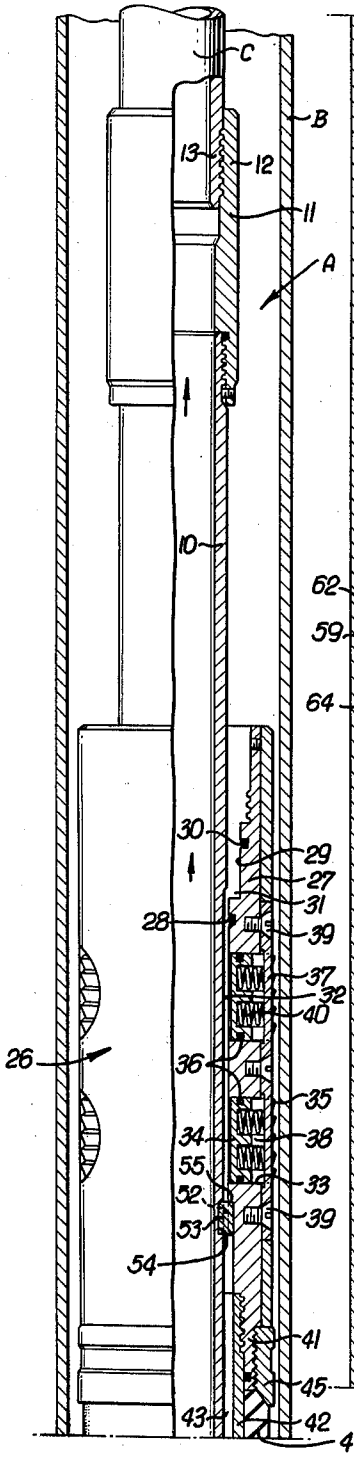


FIG. 5b.

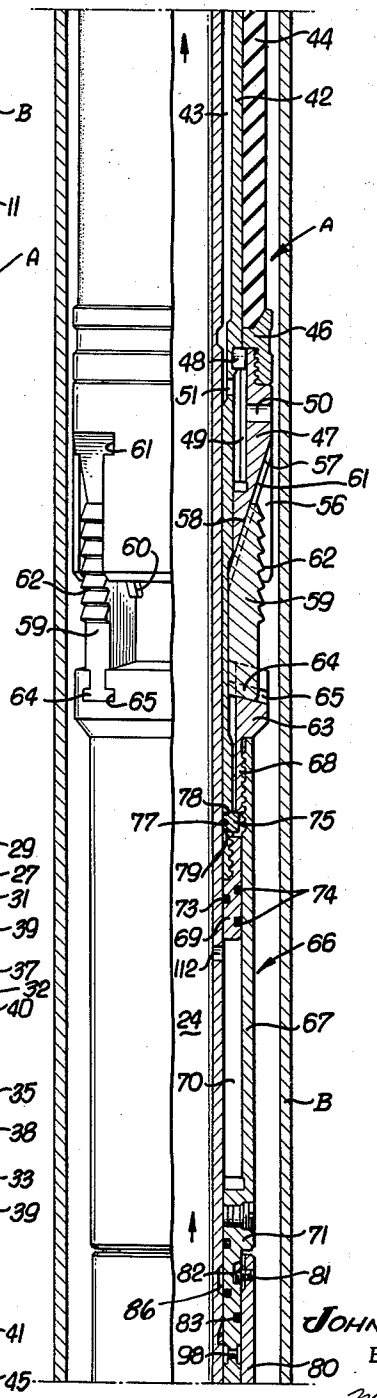
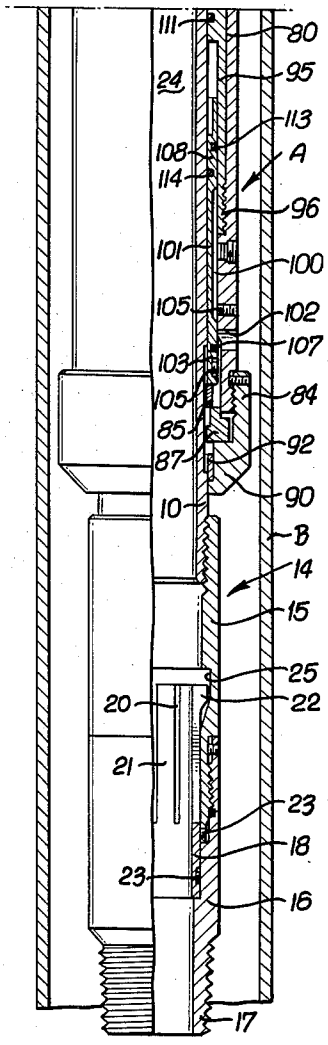


FIG. 5c.



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HYDRAULICALLY SET WELL PACKERS

Filed Nov. 5, 1962 6 Sheets-Sheet 6

FIG. 6.

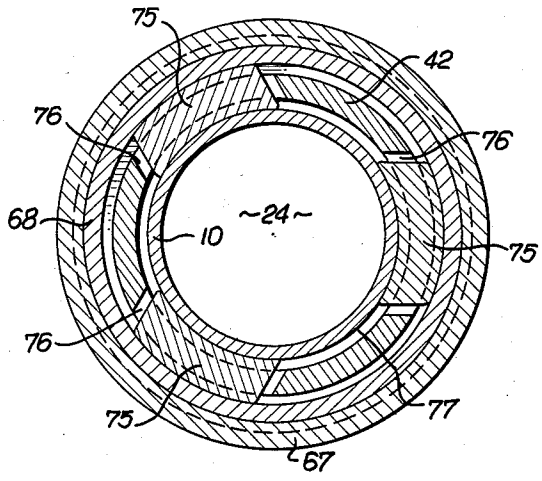
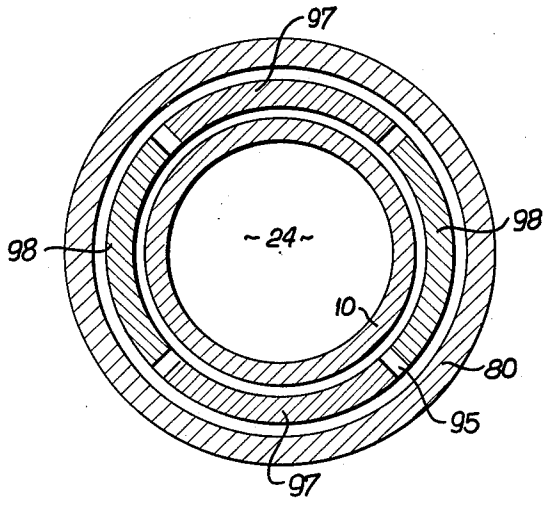


FIG. 7.



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United States Patent Office 3,189,095 Patented June 15, 1965

3,189,095

HYDRAULICALLY SET WELL PACKERS

John F. de Rochemont, Downey, Calif., assignor to Baker Oil Tools, Inc., Los Angeles, Calif., a corporation of California

Filed Nov. 5, 1962, Ser. No. 235,227
16 Claims. (Cl. 166—120)

The present invention relates to subsurface well bore equipment, and more particularly to subsurface well tools, such as well packers, adapted to be set hydraulically in well bores.

An object of the present invention is to provide a well tool adapted to be lowered in and set hydraulically in a well bore, in which the well tool can be made in comparatively small diameter sizes so as to be capable of operation in small diameter conduit strings, such as well casing, disposed in the well bore.

Another object of the invention is to provide a well tool adapted to be lowered in and set hydraulically in a well bore, the well tool parts being prevented by a lock device from outward expansion during running of the tool in the well bore, the hydrostatic head of fluid in the well bore being incapable of substantially loading the lock device, and thereby interfering with its release when setting of the tool is desired.

A further object of the invention is to provide a well tool adapted to be lowered in and set hydraulically, as by the hydrostatic head of fluid in a well bore, which is relatively simple in design and construction, comparatively economical to manufacture, and easier to assemble.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIGURES 1*a*, 1*b* and 1*c* together constitute a combined side elevational view and longitudinal section through a well packer disposed in a well casing, with its parts in their initial retracted position, FIGS. 1*b* and 1*c* constituting lower continuations of FIGS. 1*a* and 1*b*, respectively;

FIGS. 2*a*, 2*b* and 2*c* together constitute a quarter longitudinal section through a portion of the apparatus illustrated in FIGS. 1*b* and 1*c*, on an enlarged scale, illustrating the shifting of a valve to a position initiating hydrostatic setting of the well packer, FIGS. 2*b* and 2*c* constituting lower continations of FIGS. 2*a* and 2*b*, respectively;

FIGS. 3*a*, 3*b* and 3*c* are views corresponding to FIGS. 2*a*, 2*b* and 2*c* showing the parts in still another relative position, FIGS. 3*b* and 3*c* being lower continuations of FIGS. 3*a* and 3*b*, respectively;

FIGS. 4*a*, 4*b*, 4*c* and 4*d* are views corresponding to FIGS. 1*a*, 1*b* and 1*c*, but on an enlarged scale, illustrating the well packer anchored in packed-off condition in the well casing, FIGS. 4*b*, 4*c* and 4*d* being lowered continuations of FIGS. 4*a*, 4*b* and 4*c*, respectively;

FIGS. 5*a*, 5*b* and 5*c* are views corresponding to FIGS. 1*a*, 1*b* and 1*c* showing the parts in their position after releasing the well packer from its set condition in the well casing, FIGS. 5*b* and 5*c* being a lower continuation of FIGS. 5*a* and 5*b*, respectively;

FIG. 6 is a cross-section, on an enlarged scale, taken along the line 6—6 on FIG. 1*b*;

FIG. 7 is a cross-section, on an enlarged scale, taken along the line 7—7 on FIG. 1*b*.

The well tool A illustrated in the drawings is a well packer adapted to be lowered in a well casing B, or similar conduit string, on a tubular running-in string C, such as tubing or drill pipe, to a desired point at which the tool is to be anchored in packed-off condition in the well casing. After being set in the well casing, the tool can be released and removed entirely therefrom.

The tool A includes a central tubular body or mandrel **10** having an upper head **11** provided with a threaded box **12** for attachment to the lower end **13** of the tubular running-in string C. The lower end of the mandrel is threadedly attached to a hydraulic pressure device **14**, including an upper sub **15** threadedly secured to a lower sub **16** having a suitable threaded connection **17** for attachment to a string of tubing, or other device, (not shown) that might be disposed in the well casing. A seat **18** for a valve element **19**, such as a ball, is disposed in the subs **15**, **16**. It includes a sleeve **18** provided with a plurality of circumferentially spaced slots **20** to form spring-like arms **21** terminating in upper fingers **22**. Shear screws **23** initially locate the fingers **22** in the upper sub **15** so that they project inwardly partly across the central passage **24** through the tubular mandrel **10**, having an effective internal diameter that is less than the external diameter of the ball element **19** which is to engage it. When the ball element, engages these fingers, suitable fluid pressure can be built up in the tubular string C and mandrel **10** for the purpose of shearing the screws **23** and shifting the sleeve **18** downwardly to a position in which the fingers **22** come opposite an enlarged recess **25** in the upper sub **15**, whereupon the fingers spring outwardly into such recess and allow the ball **19** to be pumped downwardly through and out of the sub **16**, leaving an unrestricted passage therethrough.

The upper portion of the well tool A includes a hydraulic anchoring device **26** for preventing upward movement of the well packer in the well casing under the influence of well pressure therebelow. This anchoring device includes an annular body **27** having an upper seal ring **28** engaging the periphery of the tubular body or mandrel **10**. The body **27** has a counterbore **29** adapted to receive the upper body head **11**, there being a seal ring **30** mounted on the anchor body **27** and engaging the periphery of the head **11**, providing with the other seal ring **28** a confined space or atmospheric chamber **31** between the mandrel **10**, **11** and the anchor body **27** into which the well bore fluid or external fluid pressure cannot enter.

Below the seal **28** engaging the inner mandrel **10**, the anchor body **27** is enlarged in internal diameter to provide an annular passage **32** through which fluid under pressure can enter the anchor body, the pressure passing into a plurality of generally radial cylinders or bores **33** in the body, each of which accommodates a piston-like gripping element **34** having external wickers or teeth **35** adapted to engage and being embedded in the wall of the well casing B when the gripping members **34** are expanded outwardly by fluid pressure. Each gripping member has a suitable seal ring **36** (FIG. 4*a*) for sealing against the wall of the cylinder and is maintained in proper oriented position, so that its external wickers or teeth **35** are disposed in transverse position, by a retainer bar **37** extending longitudinally of the annular body **27** and within external longitudinal slots **38** in the gripping members to prevent the latter from turning. These retainer bars **37** are attached to the body by screws **39**, or the like, and also serve as seats for compression retractor springs **40** bearing against the inner surfaces of the bars **37** and also against the gripping members **34** for the purpose of urging the latter inwardly to a retracted position. When

an adequate fluid pressure differential is present in the annular space 32 between the body 27 and mandrel 10, the pistons 34 are urged outwardly against the force of the springs 40 to embed their teeth 35 in the wall of the well casing B. The greater the hydraulic force acting outwardly on the pistons 34, the greater will be the gripping action of their teeth against the casing wall.

The lower portion of the anchor body 27 serves as an upper abutment 41 threadedly attached to the upper end of an upper setting sleeve 42 spaced from the inner mandrel or body 10 to provide an annular space 43 therebetween through which fluid pressure can pass upwardly into the passage 32 for action on the piston gripping members 34. A suitable packing structure 44, such as a pliant, elastic, inherently retractable packing sleeve, made of rubber or rubber-like material, encompasses the setting sleeve 42, with its upper end bearing against the upper abutment 41 and also against an upper gauge ring 45 threaded on the upper abutment an actually constituting a part thereof. The lower end of the packing sleeve 44 bears against a lower abutment 46 slidable on the setting sleeve 42. This lower abutment 46 may constitute part of a slip expander device, being threadedly attached to the main portion 47 of such expander. Downward movement of the lower abutment and expander 46, 47 relative to the setting sleeve 42 is limited by engagement of the abutment with a key 48 suitably secured to the setting sleeve 42 and received within an internal keyway 49 in the expander to prevent relative turning between the sleeve and expander.

Fluid pressure from the exterior of the apparatus A and below the packing sleeve 44, when the latter is expanded against the well casing B, can pass through ports 50, 51 in the lower expander 47 and setting sleeve to the annular space 43 between the setting sleeve and tubular mandrel 10, such fluid passing upwardly through longitudinal holes 52 in a stop ring 53 mounted in a peripheral groove 54 in the mandrel 10 and adapted to engage a downwardly facing shoulder 55 in the anchor body when the tool A is to be released from the well casing B, as described hereinbelow.

The expander 47 has circumferentially spaced slots 56 therein, the inner wall 57 of each of which tapers in a downward and inward direction, coacting with a companion inner tapered surface 58 of a slip 59 slidably splined to the expander by inclined tongues 60 on the sides of each slip slidably received in companion inclined grooves 61 in the sides of the slot 56 adjacent to its tapered expander surface 57. The slips have wickers or teeth 62 adapted to embed in the wall of the well casing upon outward expansion of the slips, resulting from relative longitudinal movement between the expander 47 and slips 59 in a direction toward each other. Relative separating movement between the expander and slips causes the tongue and groove interconnections 60, 61 to shift the slips 59 from the expanded position to retracted position.

The slips 59 are all movable longitudinally together by having their lower portions slidably coupled to a slip ring 63 encompassing the upper setting sleeve 42. The lower end of each slip is formed as a T-shaped head 64 receivable in a companion-shaped radial slot 65 in the upper portion of the slip ring 63, thereby coupling the slips 59 for joint longitudinal movement with the slip ring, but permitting lateral movement of the slips into and out of engagement with the wall of the well casing.

The slip ring 63 is connected to the hydraulic setting portion 66 of the apparatus. As shown, a lower setting sleeve or cylinder 67 is threadedly attached to a depending skirt portion 68 of the slip ring 63 and is slidable along an annular piston 69 threadedly secured to the lower end of the upper setting sleeve 42. The elongate cylindrical portion of the lower setting sleeve or cylinder 67 is spaced from the inner mandrel 10, forming a cylindrical space or atmospheric chamber 70 therein, the lower end of which is closed by a lower cylinder head or piston 71 slidable along the inner mandrel or body 10, and the upper end of which is closed by the annular piston 69. Leakage of fluid between the cylinder head 71 and the inner body or mandrel 10 is prevented by a side seal 72 on the head slidably and sealingly engaging a periphery of the inner body 10; whereas, leakage of fluid between the annular piston 69 and the inner body 10 is prevented by one or more side seals 73 on the piston engaging the periphery of the body 10, and between the annular piston 69 and the lower setting sleeve 67 by one or more seal rings 74 mounted on the peripheral portion of the piston and slidably and sealingly engaging the inner wall of the setting sleeve 67.

The slips 59 and packing 44 are expanded outwardly as a result of the hydrostatic head of fluid acting downwardly on the annular piston 69 and upwardly on the annular head or piston 71. Initially, however, the hydrostatic head of fluid cannot effect expansion of the slips and packing. Downward movement of the annular piston 69 and of the upper setting sleeve 42 secured thereto along the inner body 10 is prevented by a lock device, including coupling dogs or keys 75 mounted in radial slots 76 (FIG. 6) in the setting sleeve 42 and received within a peripheral groove 77 in the body 10 having diverging upper and lower sides 78, 79. The keys 75 are held in such groove 77 by the inner wall of the slip ring skirt 68, as disclosed in FIGS. 1*b* and 2*a*. However, when the lower setting sleeve or cylinder 67 is shifted upwardly along the keys 75, the skirt 68 is shifted above the keys and the setting sleeve 67 of larger internal diameter than the internal diameter of the slip ring skirt 68 is positioned opposite the keys or dogs, permitting the latter to shift out of the groove 77, thereby freeing the mandrel 10 from the upper setting sleeve 42.

Upward movement of the lower setting sleeve or cylinder 67 along the inner body or mandrel 10 is prevented initially by a hydraulically released holding device, which also initially prevents the hydrostatic head of fluid from shifting the lower setting sleeve or cylinder 67 upwardly. As shown, a cylinder 80 encompasses the piston 71, being releasably secured thereto by one or more shear screws 81 extending through the upper portion of the cylinder 80 and into a groove 82 in the cylinder head. Leakage of fluid between the cylinder head 71 and the lower retaining cylinder 80 is prevented by a suitable seal ring 83 on the head engaging the inner wall of the retaining cylinder.

The lower end of the cylinder 80 is threadedly secured to a guide 84, the cylinder 80 and this guide being releasably attached to the inner mandrel or body 10 of the tool. As shown, an expansible, split thrust ring 85 is releasably secured within a peripheral groove 86 in the lower portion of the mandrel 10, the lower end of this thrust ring engaging an encompassing second thrust ring 87 bearing against the guide 84 and having an outer portion 88 received within a groove 89 formed between the lower flange 90 of the guide and the lower end of the cylinder 80 thereabove. Mounted in a counterbore 91 in the guide 84 below the thrust ring 87 is a shear ring or sleeve 92 having an inwardly directed leg or flange 93 received within a peripheral groove 94 in the inner mandrel or body 10 of the tool. It is evident that downward movement of the mandrel 10 is transmitted through the inner and outer thrust rings 85, 87 to the guide 84, without such movement or thrust being imposed upon the shear ring 92, such downward movement being transmitted from the guide 84 through the cylinder 80 and its shear screws 81 to the atmospheric cylinder 67, which is threadedly secured to the slip ring 63. Thus, downward movement of the tubular string C and mandrel 10 is transmitted through the keys 77 to the upper setting sleeve 42, and through the thrust rings 85, 87, guide 84, retaining cylinder 80, atmospheric cylinder 67 and slip ring 63 to the slips 59, thereby preventing any relative

longitudinal movement from taking place between the upper abutment 41 and the slip ring 63, which is essential to securing outward expansion of the packing assembly 44 and of the slips 59.

As stated above, the hydrostatic head of fluid is prevented from acting over the cross-sectional area of the cylinder head 71 within the retaining cylinder 80, and it cannot, therefore, shear the screws 81 holding the retaining cylinder to the cylinder head 71, which is essential to setting of the tool A in the well casing. The hydrostatic head of fluid can, however, act upon the cylinder head for the purpose of shifting it upwardly upon opening of a passage thereto within the cylinder 80. As shown, a by-pass sleeve 95 is disposed in the cylinder space between the cylinder 80 and the inner body 10 of the tool, its lower portion 96 being threadedly secured to the cylinder 80. This by-pass sleeve has upper coupling dogs 97 adapted to be engaged by companion lower dogs 98 (FIG. 7) on the cylinder head 71 to facilitate the threading of the by-pass sleeve 95 with the cylinder 80. It has longitudinal by-pass grooves 99 on its exterior extending through its threads 96, the upper end of which communicates with the cylinder space below the cylinder head or piston 71, and the lower end of which communicates with an annular passage 100 between a hydraulically shiftable valve sleeve 101 and the inner wall of the holding or retaining cylinder 80. This by-pass passage 100, when open, communicates with the fluid in the surrounding well bore through one or a plurality of side ports 102 in the cylinder 80. However, the passage 100 is closen initially by a lower valve head 103 of the hydraulically shiftable sleeve 101 being disposed above the ports 102 and sealingly engaging the inner wall 104 of the cylinder and being held in such position by one or more shear screws 105 threaded through the cylinder and disposed in a peripheral groove 106 in the valve head 103. A suitable side seal 107 on the valve head 103 sealingly engages the cylindrical seat 104 of the cylinder 80.

The upper end of the valve sleeve 101 is constituted as an annular piston 108 slidable in the annular space 109 between the by-pass sleeve 95 and the main body 10 of the tool. This piston 108 is initially disposed below the by-pass sleeve head 110 which is sealed against the periphery of the body 10 by a side seal ring 111 mounted in the head. Fluid under pressure from within the main body passage 24 can pass through a side port 112 therein into a cylinder space between the by-pass sleeve head 110 and the piston 108 therebelow, leakage of this fluid downwardly along the piston being prevented by one or more seal rings 113 on the piston engaging the inner wall of the by-pass sleeve 95 and by one or more seal rings 114 on the piston engaging the periphery of the body 10.

The well packer A is run in the well casing B on a tubular running-in string C, with its parts occupying the relative positions illustrated in FIGS. 1*a*, 1*b* and 1*c*. With the parts in such positions, the by-pass grooves 99 in the by-pass sleeve 95 are closed by virtue of the valve head 103 being disposed above the lower cylinder ports 102, the valve sleeve 101 being held in this position by the shear screw or screws 105. At this time, also, the dogs or keys 75 are held in the mandrel groove 77 by the slip ring skirt 68. To prevent the hydrostatic head of fluid from exerting a large downward force on the keys 75 as a result of downward action on the annular piston 69, the upper atmospheric chamber 31 is provided initially, so that there is an offsetting, opposite area on the upper sleeve 42 and anchor body 27 over which the hydrostatic head of fluid is acting upwardly. The cross-sectional area of the annular atmospheric chamber 31 is made slightly smaller than the effective area of the annular piston 69 over which the hydrostatic head of fluid can act in a downward direction, so that there is a net downward thrust on the upper setting sleeve 42 and anchor body 27 which is transmitted through the dogs 75 to the body 10 of the tool. Such downward thrust on the dogs is relatively small, but is still sufficient to slide the seal 30 off the sub 11 to secure setting of the apparatus.

When the location in the well casing is reached at which the tool is to be set, appropriate surface connections to the tubular running-in string C can be made at the top of the well bore. This tubular running-in string need not be moved longitudinally thereafter, remaining "flanged-up" at the top of the well bore. Circulating fluid can now be pumped down through the tubular running-in string C, passing through the inner body or mandrel 10 and through the tripping ball sleeve or seat 18, discharging from the lower sub 16. The circulating fluid will then pass upwardly around the tool A and the tubular running-in string C to the top of the well bore, carrying the drilling mud, or other undesirable well bore fluid, ahead of it to the top of the well bore.

After the hole has been properly conditioned, a tripping ball 19 can be lowered or pumped down through the tubular running-in string C, passing through the mandrel passage 24 and coming to rest upon the inwardly projecting fingers 22. The pressure of the fluid in the tubular running-in string and mandrel can now be increased, this fluid pressure passing through the mandrel port 112 into the by-pass sleeve 95 and acting downwardly on the piston 108. The shear screws 105 have a substantially lesser shear strength than the screws 23 holding the ball seat 18 to its sub 15. Accordingly, when the pressure has been increased sufficiently, the shear screws 105 are disrupted and the piston 108 and its sleeve 101 shifted downwardly to a position in which the valve head 103 is disposed below its companion cylindrical seat 104, establishing communication between the ports 102 and the by-pass passage 100 around the sleeve 101, the hydrostatic head of fluid then being capable of passing upwardly through the by-pass grooves 99 and acting upwardly on the lower cylinder head or piston 71 (FIGS. 2*a*, 2*b*, 2*c*). The hydrostatic head of fluid in the well bore is sufficient to overcome the shear strength of the screws 81, shifting the head 71 and its lower cylinder or sleeve 67 upwardly along the mandrel 10 and along the upper piston 69 and upper setting sleeve 42. Such upward shifting will shift the slip ring skirt 68 upwardly above the lock dogs 75, allowing the hydrostatic head of fluid to act downwardly on the piston 69 for the purpose of shifting the upper sleeve 42 and the anchor body 27 downwardly with it (FIGS. 3*a*, 3*b*).

When the annular piston 69 moves downwardly, it shifts the annular anchor body 27 downwardly with it and lowers the upper seal ring 30 of the annular body below the inner body head 11, opening the atmospheric chamber 31 so that the hydrostatic head of fluid can act over the area of the anchor body 27 between the seal ring 28 and internal diameter of the packing unit 44, and also over the piston 69 for the purpose of shifting the anchor body and its lower abutment portion 41 toward the slip ring 63. Initially, the packing assembly 44 and expander 47 move downwardly as a unit until the expander has moved within and shifted the slips 59 radially outwardly into engagement with the wall of the well casing. Thereafter, the upper abutment 41 moves toward the expander 47 to shorten the packing structure 44 and expand it outwardly against the wall of the well casing B.

In the manner just described, the well packer A will have been anchored in packed-off condition in the well casing. The hydrostatic head of fluid is constantly acting on the lower cylinder head 71 and the upper piston 69, tending to maintain the slips 59 and packing 44 expanded firmly against the wall of the well casing.

The pressure of the fluid in the tubular string and inner body of the tool can now be increased sufficiently to overcome the shear strength of the screws 23 holding the ball seat 18 to the sub 15, disrupting such screws and shifting the sleeve 18 downwardly until its lower end engages a shoulder 120 in the lower sub, at which time the fingers

22 are opposite the enlarged sub recess 25, the fingers inherently expanding outwardly into such recess and freeing the ball 19 for downward movement through the sleeve 18 and out of the sub 16, the ball dropping harmlessly into the well casing B and to the bottom of the hole.

With the packing 44 sealed off against the wall of the well casing B, any pressure below the well tool will pass through the ports 50, 51 and through the stop ring holes 52 and annular space 43 into the annular space 32 between the anchor body 27 and the tubular body or mandrel 10, acting on the inner ends of the gripping members 34 and urging them outwardly against the force of their retracting springs 40 into anchoring engagement with the wall of the well casing B. It is evident that any fluid pressure in the well casing tending to shift the tool A upwardly therewithin is prevented from doing so by the hydraulic anchoring of the gripping members 34 against the wall of the well casing B.

The fully set condition of the well packer is illustrated in FIGS. 4*a* to 4*d*. When in this condition, the lower cylinder head 71 has preferably shifted upwardly out of the confining retainer cylinder 80, allowing the hydrostatic head of fluid to act upon the lower end of the cylinder head 71 without the necessity for passing through the lower by-pass passage 102, 100, 99. The hydrostatic head of fluid is constantly acting upwardly on the lower cylinder head 71 and downwardly on the piston 69, maintaing the packing 44 and slips 59 set firmly against the wall of the well casing. If the packing material tends to extrude around the upper or lower gauge rings 45, 46, the hydrostatic head of fluid automatically compensates for such movement by moving the cylinder head 71 and piston 69 closer to each other, thereby maintaining the packing sleeve sealed against the wall of the well casing and the slips anchored against the wall of the well casing.

In the event it is desired to release the well packer A from the well casing and remove it therefrom, an upward pull is taken on the tubular running-in string C and on the inner mandrel or body 10 connected thereto. This upward pull is transmitted from the mandrel 10 to the shear sleeve 92, which engages the outer thrust ring member 87, which, in turn, engages the cylinder 80. The parts surrounding the mandrel 10 below the cylinder head 71 will all move upwardly with the mandrel until the upper end of the by-pass sleeve 95 engages the lower end of the cylinder head 71, further movement being prevented. Accordingly, the taking of a sufficient upward pull on the tubular running-in string C and on the mandrel 10 connected thereto will now shear the inner portion 93 of the shear ring 92 from its outer portion, freeing the mandrel so that it can move upwardly within the parts that surround it, the inner thrust ring 85 moving upwardly with the mandrel out of the outer thrust ring 87 until it is positioned thereabove. The thrust ring 85 is split and inherently expansible. Accordingly, upon being located above the outer thrust ring 87, it expands outwardly inherently out of the mandrel groove 86. If it does not expand sufficiently from the mandrel groove, the lower tapered side 86*a* of the groove will engage the ring and insure its outward expansion into the annular space between the lower end of the valve head 103 and the upper end of the outer thrust ring 87.

The mandrel 10 is now free to move upwardly within the parts that surround it until its port or ports 112 are disposed above the cylinder head 71 and in communication with the atmospheric chamber 70 (FIG. 5*b*), allowing the hydrostatic head of fluid to pass into the atmospheric chamber and equalize the pressure internally and externally thereof. The mandrel 10 moves upwardly until its stop ring 43 engages the shoulder 55 of the anchor body. At this time, an upper enlarged diameter portion 10*a* of the mandrel will have been disposed above the lower end of the anchor body chamber 31, such as shown in FIG. 5*a*, opening the annular passage 32 communicating with the gripping member cylinders 33, and allowing the fluid pressure acting internally and externally on the gripping members 34 to equalize, whereupon the retracting springs 40 will shift the gripping members inwardly from the wall of the well casing and to their initial retracted position.

Because of the engagement of the stop ring 53 with the ancher body shoulder 55, upward movement of the tubular string C and mandrel 10 carries the anchor body 27 upwardly with it, shifting its abutment portion 41 away from the expander 47 and allowing the packing sleeve 44 to retract from the wall of the well casing. Upward movement of the upper setting sleeve 42 with the anchor body 27 will cause its key 48 to engage the lower gauge ring 46, shifting the expander 47 upwardly with respect to the slips 59 and effecting retraction of the slips because of their tongue and groove interconnection 60, 61 with the expander. All of the parts have now been retracted from the well casing B, allowing the packer to be elevated in the well casing on the tubular string C and removed entirely therefrom.

I claim:

1. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means for preventing relative shifting between said body means and one of said actuating means and held in locked position preventing such shifting by the other of said actuating means; means interconnecting said body means and said other of said actuating means for preventing relative shifting therebetween; and means for shifting said other of said actuating means from holding relation to said lock means to release said lock means.

2. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging an upper portion of said normally retracted means and comprising an upper setting sleeve: lower actuating means engaging a lower portion of said normally retracted means and comprising a lower setting sleeve; hydraulically operable means on said sleeves for shifting said upper and lower actuating means relative to each other to expand said normally retracted means; releasable lock means interconnecting said body means and one of said actuating means and held in locked position by the other of said actuating means to prevent relative shifting between said body means and said one of said actuating means; releasable means interconnecting said body means and said other of said actuating means for preventing relative shifting therebetween; and means for shifting said other of said actuating means from holding relation to said lock means to release said lock means.

3. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means for preventing relative shifting between said body means and one of said actuating means and held in locked position preventing such shifting by

the other of said actuating means; port means for conducting the pressure of fluid externally of said body means to said other of said actuating means to shift said other of said actuating means relative to said one actuating means and release said lock means; and means closing said port conducting means and shiftable to open position in response to fluid pressure in said body means.

4. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means for preventing relative shifting between said body means and one of said actuating means and held in locked position preventing such shifting by the other of said actuating means; port means for conducting the pressure of fluid externally of said body means to said other of said actuating means to shift said other of said actuating means relative to said one actuating means and release said lock means; and valve means closing said port conducting means and shiftable along said body means to open position in response to fluid pressure in said body means.

5. In apparatus adapted to be set in a well bore: a body; normally retracted means disposed about said body and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging an upper portion of said normally retracted means and comprising an upper setting sleeve; lower actuating means engaging a lower portion of said normally retracted means and comprising a lower setting sleeve; a piston connected to said upper sleeve and slidably and sealingly engaging said body and lower sleeve; a piston connected to said lower sleeve and sealingly engaging said body; said pistons, lower sleeve and body providing an atmospheric chamber into which well bore fluid cannot enter initially; at least one of said pistons being responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and upper and lower actuating means to expand said normally retracted means; releasable lock means for preventing relative shifting between said body and upper actuating means and held in locked position preventing such shifting by said lower actuating means; releasable means interconnecting said body and lower actuating means; and means for shifting said lower actuating means from holding relation to said lock means to release said lock means.

6. In apparatus adapted to be set in a well bore: a body; normally retracted means disposed about said body and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging an upper portion of said normally retracted means and comprising an upper setting sleeve; lower actuating means engaging a lower portion of said normally retracted means and comprising a lower setting sleeve; a piston connected to said upper sleeve and slidably and sealingly engaging said body and lower sleeve; a piston connected to said lower sleeve and sealingly engaging said body; said pistons, lower sleeve and body providing an atmospheric chamber into which well bore fluid cannot enter initially; at least one of said pistons being responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and upper and lower actuating means to expand said normally retracted means; releasable lock means for preventing relative shifting between said body and upper actuating means and held in locked position preventing such shifting by said lower actuating means; means for conducting the pressure of fluid externally of said body to said lower actuating means to shift it relative to said upper actuating means and release said lock means; and means closing said conducting means and shiftable to open position in response to fluid pressure in said body.

7. In apparatus adapted to be set in a well bore: a body; normally retracted means disposed about said body and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging an upper portion of said normally retracted means and comprising an upper setting sleeve; lower actuating means engaging a lower portion of said normally retracted means and comprising a lower setting sleeve; a piston connected to said upper sleeve and slidably and sealingly engaging said body and lower sleeve; a piston connected to said lower sleeve and sealingly engaging said body; said pistons, lower sleeve and body providing an atmospheric chamber into which well bore fluid cannot enter initially; at least one of said pistons being responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and upper and lower actuating means to expand said normally retracted means; releasable lock means for preventing relative shifting between said body and upper actuating means and held in locked position preventing such shifting by said lower actuating means; means for conducting the pressure of fluid externally of said body means to said lower actuating means to shift it relative to said upper actuating means and release said lock means; and piston valve means closing said conducting means and shiftable downwardly of said body to open position in response to fluid pressure in said body.

8. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means for preventing relative shifting between said body means and one of said actuating means and held in locked position preventing such shifting by the other of said actuating means; port means for conducting the pressure of fluid externally of said body means to said other of said actuating means to shift said other of said actuating means relative to said one actuating means and release said lock means; and piston valve means closing said conducting means and shiftable downwardly of said body means to open position in response to fluid pressure in said body means.

9. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; lock means for preventing relative shifting between said body means and one of said actuating means and held in locked position preventing such shifting by the other of said actuating means; a cylinder connected to said body means; means releasably connecting said cylinder to said other of said actuating means; said cylinder having a passage therein extending from the well bore externally of the cylinder to said other of said actuating means; and means closing said passage and shiftable to open position in response to fluid pressure in said body means, whereby the hydrostatic head of fluid in the well bore can

shift said other of said actuating means to a position releasing said releasable means and said lock means.

10. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; lock means for preventing relative shifting between said body means and one of said actuating means and held in locked position preventing such shifting by the other of said actuating means; a cylinder surrounding said body means; frangible means connecting said cylinder to said body means; means releasably connecting said cylinder to said other of said actuating means; said cylinder having a passage therein extending from the well bore externally of the cylinder to said other of said actuating means; and means closing said passage and shiftable to open position in response to fluid pressure in said body means, whereby the hydrostatic head of fluid in the well bore can shift said other of said actuating means to a position releasing said releasable means and said lock means.

11. In apparatus adapted to be set in a well bore: a body; normally retracted means disposed about said body and adapted to be exapended outwardly into engagement with the wall of the well bore; upper actuating means engaging an upper portion of said normally retracted means and comprising an upper setting sleeve; lower actuating means engaging a lower portion of said normally retracted means and comprising a lower setting sleeve; a piston connected to said upper sleeve and slidably and sealingly engaging said body and lower sleeve; a piston connected to said lower sleeve and sealingly engaging said body; said pistons, lower sleeve and body providing an atmospheric chamber into which well bore fluid cannot enter initially; at least one of said pistons being responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and upper and lower actuating means to expand said normally retracted means; lock means for preventing relative shifting between said body and upper actuating means and held in locked position preventing such shifting by said lower actuating means; a cylinder connected to said body; means releasably connecting said cylinder to said lower actuating means; said cylinder having a passage therein extending from the well bore externally of the cylinder to said lower actuating means; and means closing said passage and shiftable to open position in response to fluid pressure in said body, whereby the hydrostatic head of fluid in the well bore can shift said lower actuating means to a position releasing said releasable means and said lock means.

12. In apparatus adapted to be set in a well bore: a body; normally retracted means disposed about said body and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging an upper portion of said normally retracted means and comprising an upper setting sleeve; lower actuating means engaging a lower portion of said normally retracted means and comprising a lower setting sleeve; a piston connected to said upper sleeve and slidably and sealingly engaging said body and lower sleeve; a piston connected to said lower sleeve and sealingly engaging said body; said pistons, lower sleeve and body providing an atmospheric chamber into which well bore fluid cannot enter initially; at least one of said pistons being responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and upper and lower actuating means to expand said normally retracted means; lock means for preventing relative shifting between said body and upper actuating means and held in locked position preventing such shifting by said lower actuating means; a cylinder surrounding said body; frangible means connecting said cylinder to said body; means releasably connecting said cylinder to said lower actuating means; said cylinder having a passage therein extending from the well bore externally of the cylinder to said lower actuating means; and means closing said passage and shiftable to open position in response to fluid pressure in said body, whereby the hydrostatic head of fluid in the well bore can shift said lower actuating means to a position releasing said releasable means and said lock means.

13. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means interconnecting said body means and one of said actuating means to prevent relative shifting between said upper and lower actuating means; means for releasing said lock means; pressure counteracting means providing a closed atmospheric chamber between said body means and said one of said actuating means, whereby the force of the hydrostatic head of fluid acting in one direction on said one actuating means is substantially counteracted by the hydrostatic head of fluid acting in the opposite direction on said counteracting means to substantially relieve said lock means of load.

14. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means interconnecting said body means and one of said actuating means to prevent relative shifting between said upper and lower actuating means; means for releasing said lock means; pressure counteracting means providing a closed atmospheric chamber between said body means and said one of said actuating means, whereby the force of the hydrostatic head of fluid acting in one direction on said one actuating means is substantially counteracted by the hydrostatic head of fluid acting in the opposite direction on said counteracting means to substantially relieve said lock means of load, said one actuating means being movable along said body means to open said atmospheric chamber to the pressure of the well bore fluid.

15. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means interconnecting said body means and said upper actuating means to prevent relative shifting be-

tween said upper and lower actuating means; means for releasing said lock means; pressure counteracting means providing a closed atmospheric chamber between said body means and said upper actuating means, whereby the force of the hydrostatic head of fluid acting downwardly on said upper actuating means is substantially counteracted by the hydrostatic head of fluid acting upwardly on said counteracting means to substantially relieve said lock means of load.

16. In apparatus adapted to be set in a well bore: body means; normally retracted means disposed about said body means and adapted to be expanded outwardly into engagement with the wall of the well bore; upper actuating means engaging said normally retracted means; lower actuating means engaging said normally retracted means; said upper and lower actuating means being movable toward each other to expand said normally retracted means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for relatively shifting said upper and lower actuating means toward each other; releasable lock means interconnecting said body means

and said upper actuating means to prevent relative shifting between said upper and lower actuating means; means for releasing said lock means; pressure counteracting means providing a closed atmospheric chamber between said body means and said upper actuating means, whereby the force of the hydrostatic head of fluid acting downwardly on said upper actuating means is substantially counteracted by the hydrostatic head of fluid acting upwardly on said counteracting means to substantially relieve said lock means of load; said upper actuating means being movable downwardly along said body means to open said atmospheric chamber to the pressure of the well bore fluid.

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