June 9, 1964 W. D. MYERS 3,136,364

HYDRAULICALLY SET WELL PACKER

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FIG. 1.

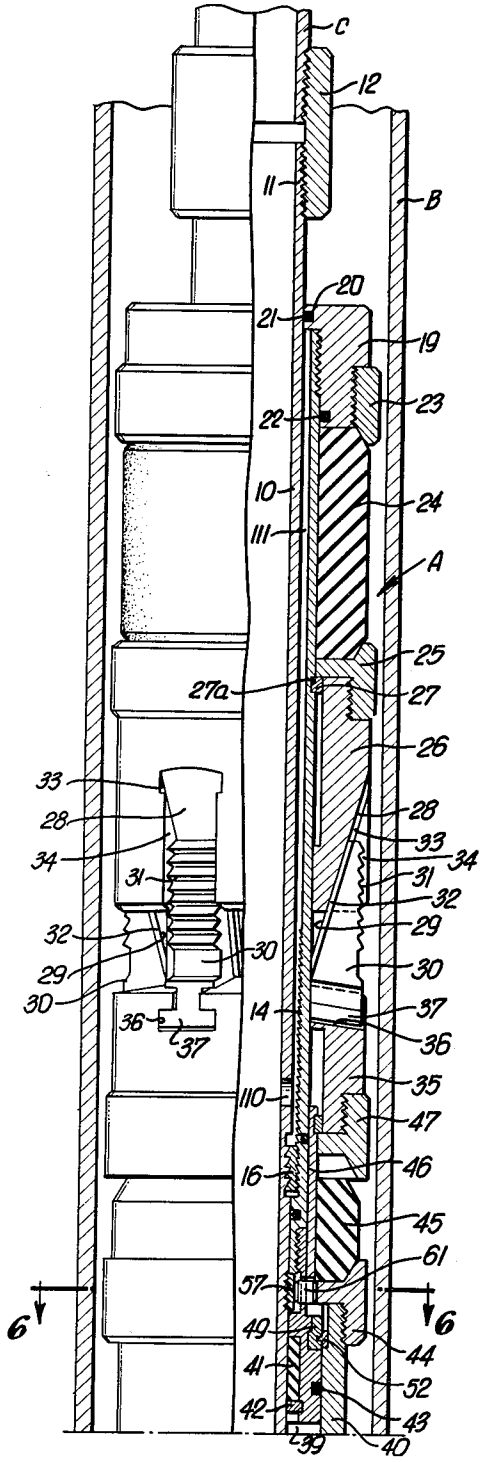

FIG. 1a.

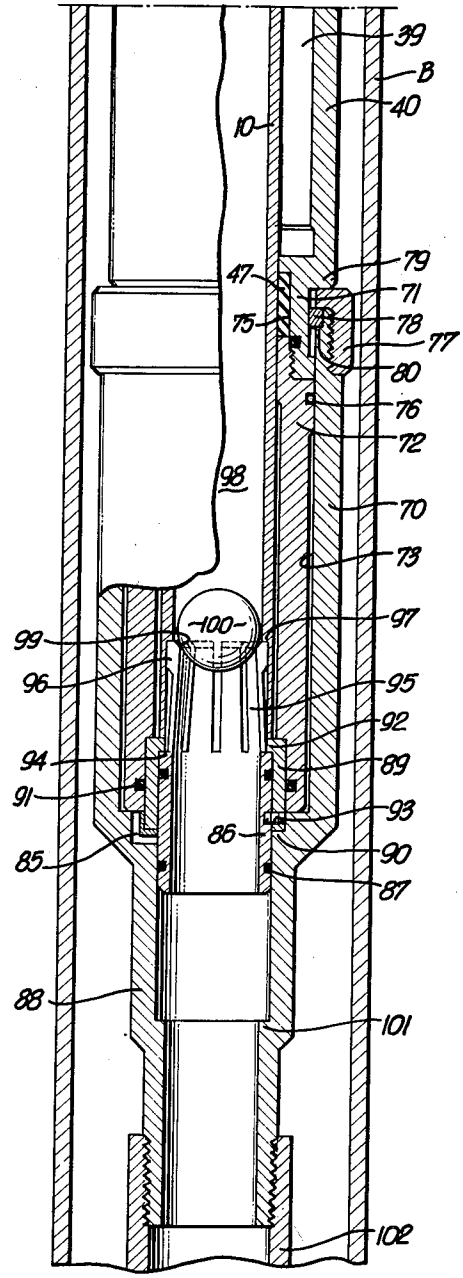

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FIG. 2.

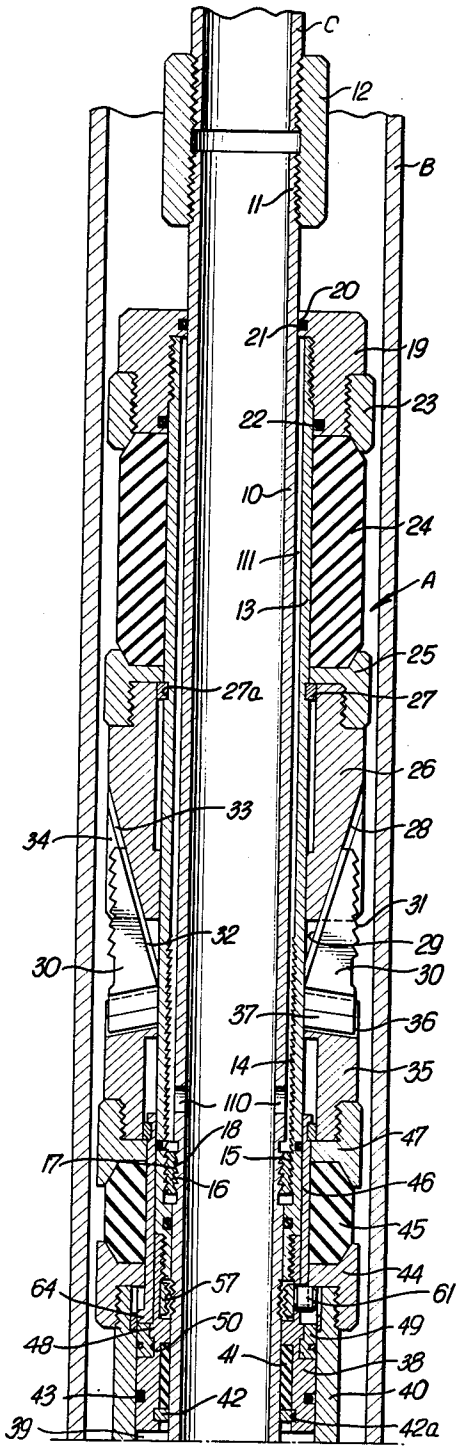

FIG. 2a

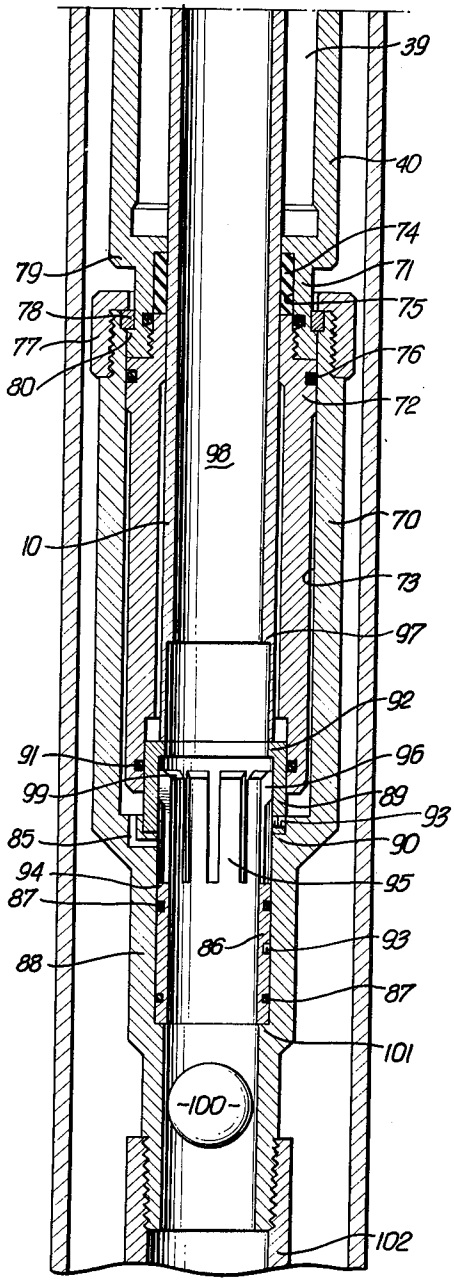

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FIG. 3.

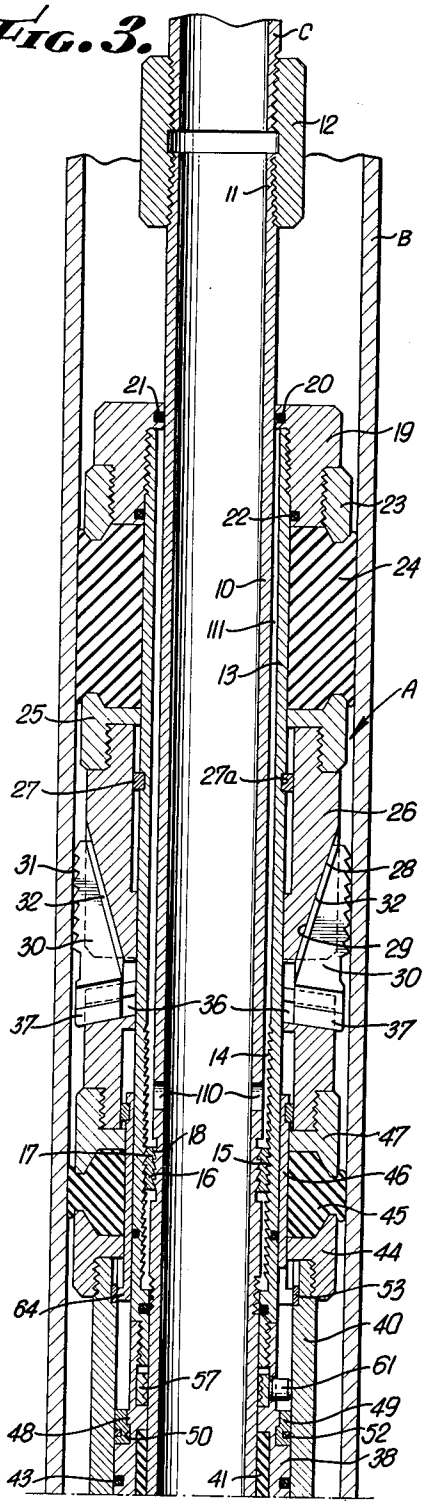

FIG. 3a

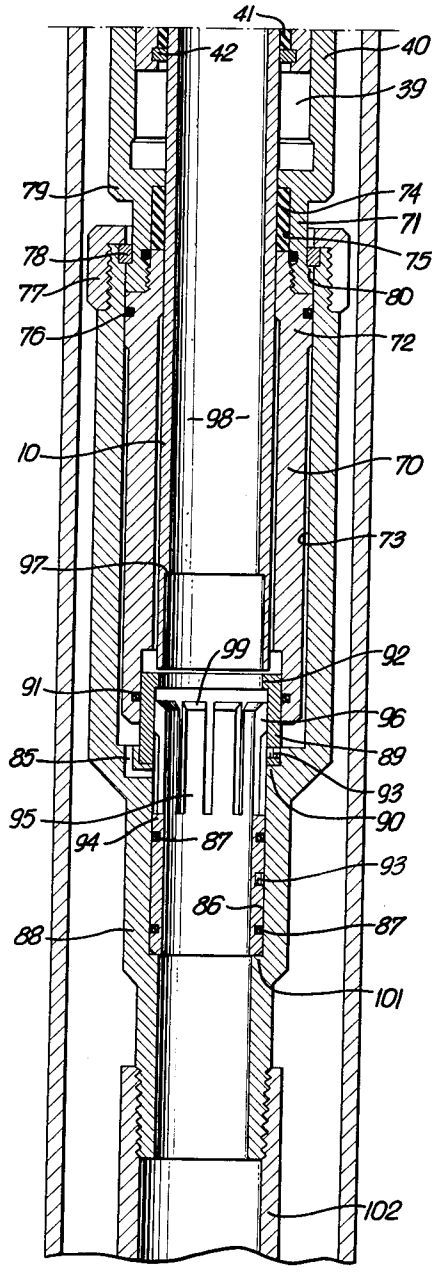

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FIG. 4.

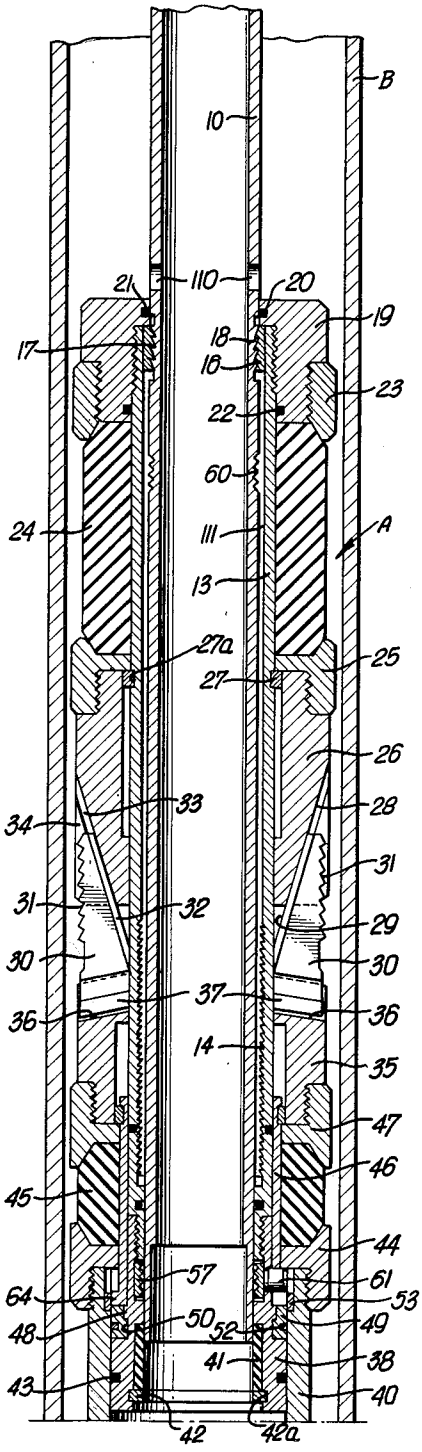

FIG. 4a.

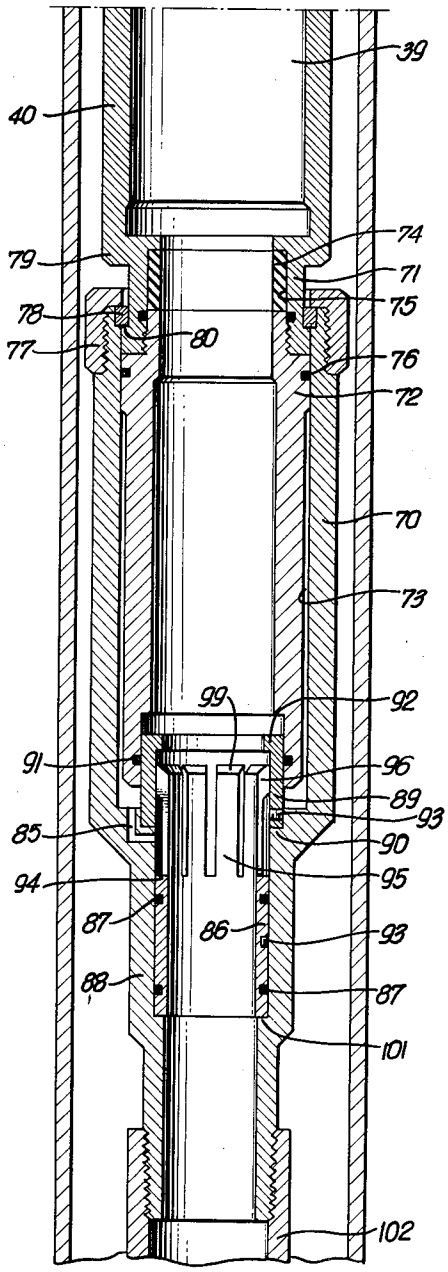

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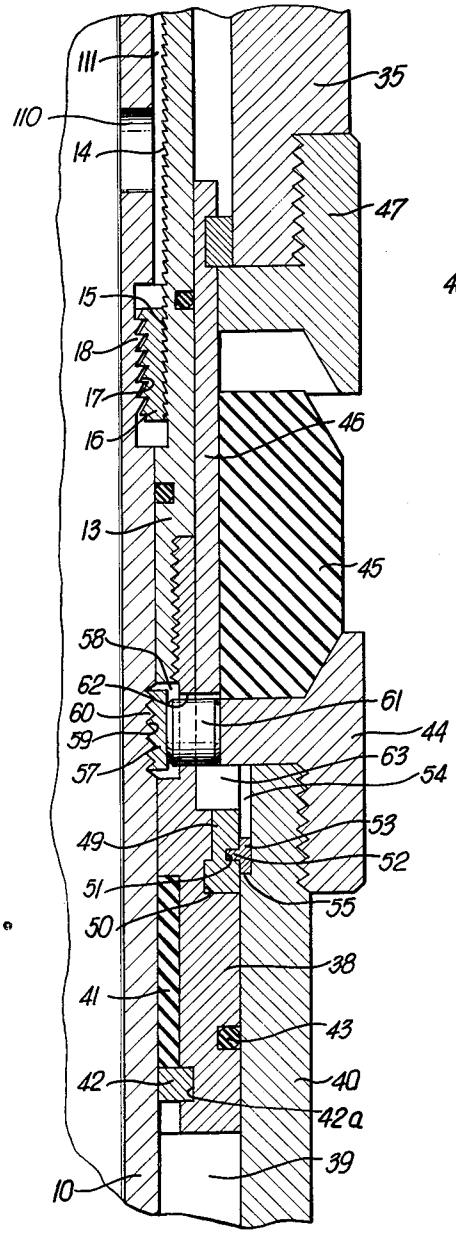
FIG. 5.



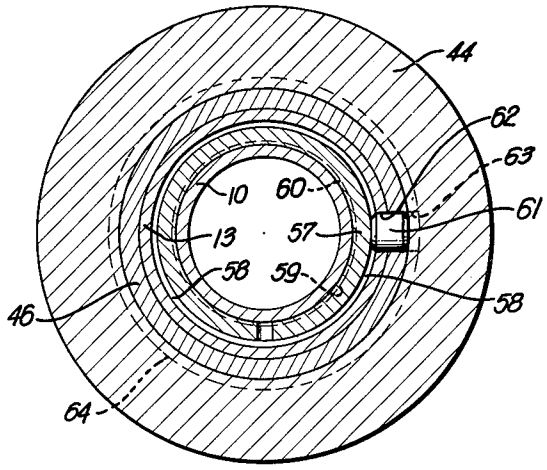


FIG. 6.

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United States Patent Office 3,136,364 Patented June 9, 1964

3,136,364
HYDRAULICALLY SET WELL PACKER

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Filed Mar. 30, 1961, Ser. No. 99,391
19 Claims. (Cl. 166—120)

The present invention relates to subsurface well bore equipment, and more particularly to well tools, such as well packers, adapted to be lowered and set in conduit strings, such as well casing, disposed in well bores.

An object of the invention is to provide a subsurface well tool adapted to be set hydraulically in a well bore, and in which the tool is retained in set position by constant hydraulic force despite relative movement of some of the tool parts after the tool has been set, which movement tends to diminish the hydraulic force, resulting in inadvertent release of the tool or its leakage.

Another object of the invention is to provide an improved subsurface well tool adapted to be set hydraulically in a well bore by a hydrostatic head of fluid therewithin, and without the need for imposing any pressure on the fluid in the well bore, or in a tubular string to which the tool is connected.

A further object of the invention is to provide a subsurface well tool adapted to be lowered in a well bore on a running-in string and set therewithin by a hydrostatic head of fluid in the well bore, release of the tool being accomplished readily by merely moving the running-in string to cause the hydrostatic head of fluid to equalize itself in the tool.

An additional object of the invention is to provide a subsurface well tool, such as a well packer, adapted to be lowered in a well bore on a tubular running-in string, setting of the tool in the well bore being accomplished by utilizing the hydrostatic head of fluid therewithin and without the necessity for moving the tubular string, thereby enabling all surface connections to be made at the top of the well bore before the tool is set, in order to insure that the well is maintained under control.

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 and 1*a* together constitute a combined side elevational view and longitudinal section through a well packer embodying the invention, with the parts in their initial retracted position for lowering the tool in a well casing, or similar conduit string, FIG. 1*a* constituting a lower continuation of FIG. 1;

FIGS. 2 and 2*a* are longitudinal sections corresponding to FIGS. 1 and 1*a* illustrating the well packer conditioned to be set hydrostatically in the well casing, FIG. 2*a* constituting a lower continuation of FIG. 2;

FIGS. 3 and 3*a* are longitudinal sections corresponding to FIGS. 2 and 2*a* illustrating the well packer anchored in packed-off condition in a well casing, FIG. 3*a* constituting a lower continuation of FIG. 3;

FIGS. 4 and 4*a* are views similar to FIGS. 2 and 2*a* illustrating the well packer after it has been released from set condition in the well casing, enabling the well packer to be removed from the well casing;

FIG. 5 is an enlarged fragmentary longitudinal section through a portion of the well packer, with its parts in the position they occupy in FIG. 1;

FIG. 6 is an enlarged cross section taken along the line 6—6 on FIG. 1.

The well tool A illustrated in the drawings is a packer adapted to be lowered in a well casing B on a tubular string C, such as a string of tubing or drill pipe, to a desired location therein at which the tool is to be anchored in packed-off condition against the wall of the well casing. The well tool may thereafter be released from the well casing and removed completely therefrom by elevating the tubular string.

As disclosed, the well packer includes a central tubular mandrel or body **10** having an upper threaded pin **11** threadedly secured to a coupling **12**, which is, in turn, threadedly attached to the tubular string C extending to the top of the well bore. Surrounding the tubular body **10** is an elongate upper setting sleeve **13** movable downwardly relative to the body, but which is prevented from moving upwardly relative thereto. Thus, the inner wall of the setting sleeve **13**, which is spaced to a small extent from the periphery of the tubular body **10**, has a plurality of upwardly facing ratchet teeth **14** extending around the entire circumference of the sleeve and engageable with companion downwardly facing ratchet teeth **15** on a split ratchet ring or sleeve **16** having internal cam teeth **17** adapted to coengage with companion cam teeth **18** on the periphery of the body **10**. The coengaging surfaces of the cam teeth **17**, **18** taper in a downward and inward direction, such that any tendency for the upper setting sleeve **13** to move upwardly along the body **10** moves the ratchet ring **16** upwardly with it, causing the coengaging cam teeth **17**, **18** to urge the ratchet ring outwardly and maintain its ratchet teeth **15** coengaged with the setting sleeve teeth **14**. There is sufficient clearance or play between the internal circular cam teeth **17** on the ratchet ring **16** and the external circular cam teeth **18** on the body **10** to permit lateral movement of the ring **16** and its ratchet teeth **15** into full engagement with the sleeve teeth **14**, or completely from engagement therewith. As an example, downward movement of the sleeve **13** relative to the body **10** is permitted, since the ratchet teeth **14**, **15** ride past one another, the ratchet ring **16** springing inwardly of the body to a sufficient extent to allow the ratchet teeth to disengage. However, upward movement of this sleeve **13** relative to the body **10**, or downward movement of the body relative to the sleeve, is prevented by the coengagement of the one-way ratchet teeth **14**, **15**.

The upper end of the upper setting sleeve **13** is threadedly secured to an upper abutment **19** having a flange **20** carrying a seal ring **21** slidably sealing against the periphery of the mandrel or body **10**. Leakage of fluid between the upper annular abutment **19** and the sleeve **13** is prevented by a suitable thread seal **22**. This upper abutment may have an abutment gauge ring **23** thereon, the external diameter of which can be selected to provide the proper clearance with the wall of the well casing B, allowing the tool to be used in casings of different internal diameters. The upper abutment **19** engages the upper end of a packing structure **24**, such as a pliant, elastic packing sleeve (of rubber or rubber-like material), which engages a lower annular abutment **25** threadedly secured to the upper end of a slip expander **26** slidably mounted on the sleeve **13**. Downward movement of the lower abutment **25** along the sleeve is limited by its engagement with a split limit or stop ring **27** mounted within a peripheral groove **27***a* in the sleeve. The expander has circumferentially spaced tapered surfaces **28** inclined in a downward and inward direction engageable with companion tapered surfaces **29** on the inner portions of a plurality of slips **30** movable longitudinally of the expander. These slips have external wickers or

teeth 31 adapted to embed themselves in the wall of the well casing B. They are positively movable laterally relative to the expander upon relative longitudinal movement between the expander and slips by inclined spline connections between the slips and expander, provided by oppositely directed side tongues 32 on each slip sliding in companion grooves 33 in the expander on opposite sides of slots 34 in the expander in which the slips are disposed. The lower ends of the slips 30 are coupled for movement longitudinally with one another by being connected to a slip ring 35 having generally T-shaped slots 36 therein receiving companion T-shaped heads 37 on the lower portions of the slips. Thus, the slips 30 move longitudinally jointly with the slip ring 35, although they are still permitted to move radially or laterally inwardly and outwardly of the slip ring, upon relative longitudinal movement between the slips 30 and expander 26.

The lower portion of the upper setting sleeve 13 is threadedly, or otherwise suitably attached, to an upper annular piston 38 mounted in a cylinder space 39 provided between the tubular mandrel or body 10 and a lower, outer setting sleeve 40 encompassing the piston 38 and extending downwardly therefrom. A suitable inner seal ring or packing 41 is held in the upper piston 38 by a split snap ring 42 received within a groove 42*a* in the piston, the packing slidably sealing against the periphery of the tubular body 10 to prevent leakage between the piston and body. Similarly, leakage of fluid between the periphery of the piston 38 and the inner wall of the lower setting sleeve 40 is prevented by a suitable seal ring 43 on the piston slidably and sealingly engaging the inner wall of the lower setting sleeve or cylinder 40.

The upper end of the lower setting sleeve 40 is threadedly secured to a lower annular abutment or holding member 44 engaging the lower end of an elastic, initially retracted anchor sleeve 45, made of rubber or similar pliant, elastic material, the upper end of this elastic sleeve being mounted upon a metallic sleeve 46 encompassing the upper setting sleeve 13 and disposed within an upper annular abutment 47 initially spaced above the elastic sleeve 45 and threadedly secured to the slip ring 35. The lower end of the metallic sleeve 46 rests upon a shoulder 48 on the upper piston 38 and also upon a two-piece coupling ring 49 having a portion fitting within a groove 50 in the piston, the two-piece coupling ring having a circumferential groove 51 receiving the inner relatively thin portion 52 of a shear ring 53 disposed within a counterbore 54 in the upper end of the lower setting sleeve or cylinder 40, and resting upon the lower shoulder 55 of the counterbore.

With the shear ring 53 intact, any upward force imposed on the lower setting sleeve 40 is transmitted through the shear ring and coupling ring 49 to the upper piston 38 and the upper setting sleeve 13. The upper setting sleeve cannot move upwardly of body 10 because of the clutching action of the ratchet ring 16.

Similarly, the body 10 cannot move downwardly relative to the upper setting sleeve 13 by virtue of the coupling engagement of the ratchet teeth 14, 15 on the upper setting sleeve and the ratchet ring 16. Initially, the body 10 is also prevented from moving upwardly relative to the sleeve 13, and the sleeve downwardly of the body, by virtue of a split lock ring 57 disposed in an internal groove 58 provided by and between the piston 38 and the lower end of the setting sleeve 13. This split lock ring has circular V-shaped internal teeth 59 engaging companion teeth 60 on the periphery of the body 10. The coengagement between the body teeth 60 and lock ring teeth 59 tends to cam the ring 57 outwardly, to free it from the body 10, but such camming action is initially prevented by the engagement of the lock ring 57 with a lock pin 61 mounted in a bore 62 of the piston 38 and initially abutting the inner periphery of the lower holding abutment 44. It is to be noted that this lock pin 61 extends into a slot 63 in the metallic sleeve 46 disposed within the elastic anchor sleeve 45, and that the lower abutment 44 rests initially upon an external flange 64 of this metallic sleeve so that elevation of the abutment 44 above the lock pin 61 allows the split ring 57 to expand into the groove 58, which expansion can occur inherently because of its spring-like characteristics. Prior to release of the lock pin 61, movement in both longitudinal directions between the body 10 of the tool and the sleeve 13 can be transmitted through the lock ring 57, preventing setting of the well packer in the casing.

The setting of the slips 30 and packing 24 is secured hydraulically, and actually by the hydrostatic head of fluid in the well bore or casing B. Part of the hydraulic or hydrostatic setting mechanism includes the lower setting sleeve 40, the lower portion 71 of which projects into the upper end of a cylinder 70, such portion being threadedly secured to the upper end of a lower annular piston 72 slidably mounted in the annular cylinder space 73 between the cylinder 70 and the periphery of the tubular mandrel or body 10. Leakage of fluid between the upper portion of the piston 72 and the tubular body 10 is prevented by a suitable seal ring 74 mounted in an internal circumferential groove 75 provided by the lower portion of the lower setting sleeve 40 and the upper end of the piston 72. Leakage of fluid between the upper portion of the periphery of the piston 72 and the cylinder wall is prevented by a suitable seal ring 76 on the piston slidably and sealingly engaging the wall of the cylinder.

Threadedly mounted on the upper end of the cylinder 70 is a clamp ring 77 holding a two-piece stop or limit ring 78 in the cylinder, which is disposed against a lower shoulder 79 of the lower setting sleeve 40 and above a stop flange 80 provided on the latter. The stop flange 80 is initially spaced a short distance below the stop ring 78, which distance is slightly greater than the distance that the lower abutment 44 must move upwardly of the holding pin 61 to free the latter and allow the split lock ring 57 to expand and remove its teeth 59 from engagement with the tubular mandrel or body 10 of the tool.

The upper piston 38 closes the annular cylinder space 39 between the lower setting sleeve 40 and the body 10 at one end thereof, and that the engagement of the seal ring 74 at the lower end of the setting sleeve 40 with the periphery of the body closes the cylinder space 39 at the lower portion of the setting sleeve. Accordingly, such cylinder space is initially confined and contains air at substantially atmospheric pressure. As the tool is lowered through the fluid in the well bore, the lower setting sleeve 40 and the upper piston 38 cannot move longitudinally relative to one another since such action is prevented by the shear ring 53. It is only after a sufficient force is imposed on the shear ring to disrupt it that setting of the tool can occur, such disrupting occurs by allowing fluid pressure to act on the lower piston 72, and the setting sleeve 40.

As shown, an inlet port 85 is provided in the cylinder 70 between its inner wall of the cylinder below the lower piston 72 and the annular cylinder space 73 containing this piston. This inlet port is closed initially by a valve sleeve 86 having side seal rings 87 in its periphery, the lower ring engaging the inner wall of the lower portion 88 of the cylinder below the port 85 and the upper side seal ring sealingly engaging a stop sleeve 89 bearing against the shoulder 90 in the lower cylinder. A seal ring 91 is mounted in the piston 72 to sealingly engage the periphery of the stop sleeve 89. The stop sleeve 89 also has an inwardly directed flange 92 engaged by the lower end of the tubular body or mandrel 10, so that downward forces imposed on the tubular body 10 are transmitted directly through the stop sleeve 89 to the cylinder 70 of the tool.

The valve sleeve 86 is held in closed position across the inlet port 85 by a shear screw 93 securing it to the stop sleeve 89, the valve sleeve having a shoulder 94 engaging the stop sleeve flange 92, thereby determining

the upper position of the valve sleeve relative to the port 85. This valve sleeve includes upwardly extending latch arms 95 integral therewith and terminating in latch fingers 96, the arms and fingers tending to spring outwardly. They are disposed initially in a position in which the fingers 96 engage a downwardly facing shoulder 97 of the body 10 and the inner wall of the body to provide a restriction in the passage 98 through the body and a valve seat 99 adapted to be engaged by a suitable valve element 100, such as a trip ball, adapted to be dropped into the tubular string and allowed to gravitate therethrough into engagement with the upper ends or seat 99 of the latch fingers.

After the ball 100 reaches the seat 99 provided by the fingers, sufficient pressure can be applied to the fluid in the tubular string C and the body 10 of the tool, which will act in a downward direction on the ball. When such pressure exceeds the shear strength of the screw 93, the sleeve and ball are shifted downwardly to a position limited by engagement of the lower end of the valve sleeve 86 with a stop shoulder 101 in the lower cylinder portion 88, at which time the spring fingers 96 are disposed below the stop sleeve flange 92, allowing the arms 95 and fingers 96 to expand outwardly to a position increasing the effective diameter of the seat 99 to a value less than that of the ball diameter, the ball 100 then dropping downwardly through the sleeve 86 and the cylinder 70, and through a tubular extension 102, that may be threadedly attached to the lower end of the cylinder 70, and into the well casing or well bore therebelow.

In the use of the apparatus described, the packing sleeve 24, slips 30, and anchor sleeve 45 are initially in their retracted positions, such as disclosed in FIGS. 1 and 1*a*, the shear ring 53 being intact, the shear screw 93 securing the valve sleeve 86 in closed position across the inlet port 85. At this time, the ball member 100 has not been dropped into the tubular string C. The holding pin 61 is retained against the lock ring 57 by the abutment 44, which prevents the upper piston 38 from moving downwardly in the lower setting sleeve or cylinder 40, the shear ring 53 preventing the cylinder 40 from moving upwardly of this piston. All of the parts are coupled together to prevent their relative movement at this time. The well packer A is lowered in the well casing B by means of the tubular string C to the desired setting point. When such point has been reached, the ball or corresponding valve element 100 is dropped into the tubular string C and will gravitate downwardly therethrough, until it comes into engagement with its companion seat 99 at the upper end of the valve sleeve fingers 96. Sufficient pressure is then imposed on the fluid in the tubular string C and the body 10 of the tool to shear the screw 93, shifting the sleeve valve 86 downwardly from its closed position across the inlet port 85, as limited by engagement of the sleeve with the lower stop shoulder 101. The hydrostatic head of fluid in the tubular string C can now enter the inlet port 85 and act in an upward direction on the lower piston 72, shearing the shear ring 53 and elevating the lower piston 72 in the lower cylinder 70 to the extent determined by engagement of the stop flange 80 on the lower setting sleeve 40 with the stop ring 78. Such elevating movement carries the lower setting sleeve 40 and the lower abutment 44 upwardly with it, shifting the lower abutment above and from the holding pin or abutment 61, the elastic anchor sleeve 45 moving upwardly until it engages the abutment 47 upwardly thereof. The lock ring 57 can then expand outwardly in the groove 58, shifting the pin 61 outwardly in the slot 63 in the sleeve 46, the lock ring 57 being freed from the body 10 of the tool, which also frees the piston 38 and upper setting sleeve 13 for downward movement along the body (see FIGS. 2 and 2*a*).

The lower piston 72 cannot move upwardly in the cylinder 70 to any further extent, the flange 80 engages the stop ring 78, nor can the lower cylinder 40 move upwardly of the body 10 to any further extent, inasmuch as the stop sleeve 89 is engaging the lower end of the body. However, the hydrostatic head of fluid in the well casing can act downwardly on the upper piston 38, the lower end of which is only confronted by air at substantially atmospheric pressure in the atmospheric chamber 39, forcing the lower piston downwardly along the body 10 and within the lower setting sleeve 40. This downward movement of the piston 38 under the action of hydrostatic pressure pulls the upper setting sleeve 13 downwardly with it, the upper setting sleeve ratcheting freely over the ratchet ring 16 and moving the upper abutment 19 secured to it, the packing sleeve 24, and the expander 26 downwardly with it, the slips 30 being prevented from moving downwardly by the fact that the slip ring 35 and abutment 47 are resting upon the elastic anchor sleeve 45, which, in turn, bears against the lower abutment 44 secured to the lower setting sleeve 40. The expander 26 moves longitudinally downwardly along the slips 30, shifting them outwardly and embedding their wickers or teeth 31 in the wall of the well casing B.

After the slips 30 are anchored against the wall of the well casing B, the expander 26 is prevented from moving downwardly to any further extent; whereupon the hydrostatic head of fluid continues to move the piston 38 and upper setting sleeve 13 downwardly, shifting the upper abutment 19 toward the lower abutment 25 and expander 26 to shorten the packing sleeve or structure 24 and expand the latter outwardly into sealing engagement with the wall of the well casing. The hydrostatic head of fluid is also acting in an upward direction over the annular area of the lower piston 72, urging the lower setting sleeve 40 (and body 10) upwardly, and moving the lower abutment 44 below the elastic anchor sleeve 45 toward the upper abutment 47, shortening the elastic sleeve 45 and expanding it outwardly into firm engagement with the wall of the well casing B. This elastic sleeve 45 is constantly tending to expand and will, therefore, tend to urge the slip ring 35 and the slips 30 upwardly along the expander 26, to insure the retention of the slip wickers 31 in gripping engagement with the wall of the well casing. Accordingly, if pressure from below the tool A tends to shift it upwardly, it acts on the anchor sleeve 45, the force being transmitted through the sleeve to the slips 30 and tending to wedge the latter upwardly along the expander 26 and more firmly into engagement with the wall of the well casing B. In the event that pressure above the well packer A acts in a downward direction on the upper packing sleeve 24, it forces the latter downwardly and the expander 26 more firmly in wedging engagement with the wall of the well casing, to prevent downward movement of the well packer in the well casing. The well packer is thus held in packed-off condition within the well casing, the parts then occupying the position illustrated in FIGS. 3 and 3*a*. At this time, it is to be noted that the body 10 of the tool is free to move upwardly, since the ratchet ring 16 will ratchet freely over the upwardly facing ratchet teeth 14 of the upper setting sleeve 13. However, the tubular body 10 and tool cannot be moved downwardly. It is also to be noted that during downward shifting of the upper setting sleeve 13 in setting the slips 30 and packing 24 against the well casing, any fluid between the upper setting sleeve and body of the tool can escape therefrom by passing into the body through the vent port or ports 110 provided in the body and establishing communication between the interior of the body 10 and the annular space 111 between the upper setting sleeve 13 and the body.

The well packer will remain anchored in packed-off condition in the well casing with the parts occupying the position disclosed in FIGS. 3 and 3*a*. The passage 98

through the well packer is clear and open, and if the well packer is used as a production packer, the well production from below the packer can pass upwardly through the lower tubular extension 102 and the lower portion 83 of the cylinder, flowing upwardly through the valve sleeve 86 and the tubular body 10 into the tubular string C thereabove, to be conducted to the top of the well bore. The hydrostatic head of fluid is constantly acting in a downward direction on the upper piston 38, and in an upward direction over the annular area of the lower piston 72 to hold the packer anchored in packed-off condition in the well casing. This condition will remain constant despite the fact that there may be some extrusion of rubber or rubber-like material of the packing 24 between the abutments 19, 25 and the surrounding wall of the well casing B. The well packer A remains anchored as the result of the column of liquid in the well casing B, and without the necessity for the presence of any fluid pressure in the tubular body 10 of the tool.

In the event the well packer is to be released, it is merely necessary to elevate the tubular string C, which will raise the body 10 upwardly along the lower piston 72, lower setting sleeve 40, upper piston 38, and upper setting sleeve 13, as permitted by the ratcheting of the ratchet ring 16 along the teeth 14 of the upper setting sleeve. The body 10 is elevated until its lower end 10*a* moves above the inner seal ring 74 of the lower piston 72, which then communicates the atmospheric chamber 39 with the hydrostatic head of fluid in the tubing string C, allowing the hydrostatic pressure therewithin to act on the lower side of the piston 38 in an upward direction, and also to act in a downward direction on the lower piston 72, thereby equalizing the hydrostatic forces acting in the opposite direction on the respective upper and lower pistons. As the result, there is no longer any hydrostatic pressure differentials present for holding the well packer parts expanded against the well casing. Accordingly, continued upward movement of the tubular body or mandrel 10 along the setting sleeve 13 will bring the ratchet ring 16 into engagement with the inwardly directed flange 20 at the upper end of the upper abutment 19, the upward movement of the body 10 then moving the upper abutment away from the lower abutment 25 and allowing the packing sleeve 24 to retract. As the upper abutment 19 moves upwardly, it carries the upper setting sleeve 13 with it, until its limit ring 26 engages the lower abutment 25, which will then elevate the expander 26 with respect to the slips 30, the inclined tongue and groove arrangement 32, 33 between the slips 30 and expander 26 causing the slips to move inwardly to fully retracted position.

Continued upward movement of the expander 26 carries the slips 30 and slip ring 35 upwardly with it, and will move the abutment 47 connected to the slip ring upwardly into engagement with a stop ring 120 on the metallic sleeve 46, the upper abutment 47 moving away from the lower abutment 44 and allowing the elastic anchor sleeve 45 to return inherently to its initial retracted position. The setting sleeve 13 moves the piston 38 upwardly, carrying the lock pin 61 upwardly until it moves back into the slot 63 and into engagement with the lower abutment 44, or until the piston 38 reengages the lower end of the metallic sleeve 46, which will then carry the lower setting sleeve 40 upwardly with it, and also the lower piston 72 upwardly with it. The flange 80 on the lower setting sleeve then engages the limit ring 78 on the lower cylinder 70, carrying the latter upwardly with it, as well as the tubular extension 102 extending therefrom, and the sleeve valve 86 and the stop sleeve 89 disposed therewithin. All of the parts are now in retracted position, and the entire well packer A can be elevated in the well casing B by means of the tubular string C and removed entirely therefrom at the top of the well bore, the parts occupying the relative positions illustrated in FIGS. 4 and 4*a*.

It is, accordingly, apparent that a well tool or well packer has been provided, in which the hydrostatic head of fluid shifts the slips and packing into anchoring engagement with the wall of the well casing, and retains them in such anchoring engagement, the well tool being able to withstand pressure differentials of a high order without being moved from its anchoring condition, regardless of the well pressures being imposed from below the tool or from above the tool. The well packer A can be run in the well casing B to the desired setting point and the tubing string C then secured to suitable connections at the top of the well bore, subsequent movement of the tubing being unnecessary in securing setting of the tool. All that is necessary is to drop the tripping ball 100 in the tubular string B and into engagement with its seat 99, whereupon presure is applied to the latter for the purpose of removing the sleeve valve 86 from its position closing the inlet port 85, whereupon the hydrostatic head of fluid releases the parts and sets them against the well casing. In the event that any rubber or rubber-like material tends to extrude, as between the abutments 19, 25, 44, 47 and the wall of the well casing, the hydrostatic head of fluid is still present to move the parts and hold them firmly anchored and sealed off against the well casing, preventing leakage. When the tool is to be released and retrieved, it is a simple matter to accomplish such action since the tubular string C and the tubular body 10 connected thereto need merely be elevated to automatically communicate the atmospheric chamber 39 with the hydrostatic head of fluid.

The inventor claims:

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 and adapted to act simultaneously on said upper and lower actuating means 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; and hydraulically operable means for releasing 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 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 adapted to act simultaneously on said upper and lower actuating means 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; and hydraulically operable means for releasing 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 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; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means; and means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable 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 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, said lock means being held in locked condition by said hydraulically operable means; means for preventing fluid pressure from actuating said hydraulically operable means; and means for shifting said preventing means to a position permitting fluid pressure to actuate said hydraulically operable means and shift said hydraulically operable means to a position releasing said lock means and expanding said normally retracted 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; hydraulically operable means on said sleeves and adapted to act simultaneously on said upper and lower actuating means for shifting said upper and lower actuating means relative to each other to expand said normally retracted means; releasable lock means interconnecting said body and one of said sleeves; and hydraulically operable means for releasing 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; hydraulically operable means on said sleeves responsive to the hydrostatic head of fluid in the well bore for shifting said upper and lower actuating means relative to each other to expand said normally retracted means; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means; and means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable means.

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; hydraulically operable means on said sleeves responsive to the hydrostatic head of fluid in the well bore for shifting said upper and lower actuating means relative to each other to expand said normally retracted means; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means; means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable means; and means operable by said body for equalizing the hydrostatic head of fluid acting on said hydraulically operable means to enable said normally retracted means to be retracted from its outwardly expanded position.

8. 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; means including said sleeves providing an atmospheric chamber into which well bore fluid cannot enter initially and further including hydraulically operable means on said sleeves closing said atmospheric chamber and responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and said upper and lower actuating means to expand said normally retracted means; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means; and means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable means.

9. 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; means including said sleeves providing an atmospheric chamber into which well bore fluid cannot enter intiially and further including hydraulically operable means on said sleeves closing said atmospheric chamber and responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and said upper and lower actuating means to expand said normally retracted means; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means, means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable means; and means for opening said atmospheric chamber to the hydrostatic head of fluid in the well bore to enable said normally retracted means to retract from its outwardly expanded position.

10. 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; means including said sleeves providing an atmospheric chamber into which well bore fluid cannot enter initially and further including hydraulically operable means on said sleeves closing said atmospheric chamber and responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and said upper and lower actuating means to expand said normally retracted means; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means; means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable means; and means operable by said body for opening said atmospheric chamber to the hydrostatic head of fluid in the well bore to enable said normally retracted means to retract from its outwardly expanded position.

11. 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; means including said sleeves providing an atmospheric chamber into which well bore fluid cannot enter initially and further including hydraulically operable means on said sleeves closing said atmospheric chamber and responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves and said upper and lower actuating means to expand said normally retracted means; means for preventing the hydrostatic head of fluid from actuating said hydraulically operable means; means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said hydraulically operable means; releasable lock means interconnecting said body and one of said sleeves; and means for releasing 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; means for preventing the hydrostatic head of fluid from actuating said one of said pistons; and means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said one of said pistons.

13. 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; means for preventing the hydrostatic head of fluid from actuating said one piston; means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said one piston; and means operable by said body for opening said atmospheric chamber to the hydrostatic head of fluid in the well bore to enable said normally retracted means to retract from its outwardly expanded position.

14. 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; means for preventing the hydrostatic head of fluid from actuating said one piston; means for shifting said preventing means to a position permitting the hydrostatic head of fluid to actuate said one piston; releasable lock means interconnecting said body and upper sleeve for preventing movement of said upper sleeve relative to said body; and means connected to said lower sleeve for preventing release of said lock means and movable with said lower sleeve to a position releasing said lock means.

15. In apparatus adapted to be set in a well bore: a body; an upper setting sleeve surrounding said body; an upper abutment on said upper sleeve; normally retracted packing means on said upper sleeve and engaging said upper abutment; expander means on said sleeve engaging said packing; slip means engaging said expander means and movable longitudinally therealong and outwardly into engagement with the wall of the well bore; means comprising a lower setting sleeve operatively connected to said slip means; means providing an atmospheric chamber into which well bore fluid cannot enter initially and including a piston secured to said upper sleeve and a piston secured to said lower sleeve and disposed below said other piston, said pistons being responsive to hydrostatic head of fluid in the well bore for relatively shifting said upper sleeve downwardly and said lower sleeve upwardly to expand said normally retracted packing means and slip means against the wall of the well bore; means for preventing the hydrostatic head of fluid from shifting said pistons toward each other; and means for releasing said preventing means to permit said hydrostatic head of fluid to shift said pistons toward each other.

16. In apparatus adapted to be set in a well bore: a body; an upper setting sleeve surrounding said body; an upper abutment on said upper sleeve; normally retracted packing means on said upper sleeve and engaging said upper abutment; expander means on said sleeve engaging said packing; slip means engaging said expander means and movable longitudinally therealong and outwardly into engagement with the wall of the well bore; means comprising a lower setting sleeve operatively connected to said slip means; means providing an atmospheric chamber into which well bore fluid cannot enter initially and including a piston secured to said upper sleeve and a piston secured to said lower sleeve and disposed below said other piston, said pistons being responsive to hydrostatic head of fluid in the well bore for relatively shifting said upper sleeve downwardly and said lower sleeve upwardly to expand said normally retracted packing means and slip means against the wall of the well bore; means for preventing the hydrostatic head of fluid from shifting said pistons toward each other; means for releasing said preventing means to permit said hydrostatic head of fluid to shift said pistons toward each other; and means operable by said body for opening said atmospheric chamber to the hydrostatic head of fluid in the well bore to enable said packing means and slip means to retract from their outwardly expanded positions.

17. In apparatus adapted to be set in a well bore: a body; an upper setting sleeve surrounding said body; an upper abutment on said upper sleeve; normally retracted packing means on said upper sleeve and engaging said upper abutment; expander means on said sleeve engaging said packing; slip means engaging said expander means and movable longitudinally therealong and outwardly into engagement with the wall of the well bore; means comprising a lower setting sleeve operatively connected to said slip means; means providing an atmospheric

chamber into which well bore fluid cannot enter initially and including a piston secured to said upper sleeve and a piston secured to said lower sleeve and disposed below said other piston, said pistons being responsive to hydrostatic head of fluid in the well bore for relatively shifting said upper sleeve downwardly and said lower sleeve upwardly to expand said normally retracted packing means and slip means against the wall of the well bore; releasable lock means preventing movement of said pistons toward each other under the action of the hydrostatic head of fluid in the well bore; and means connected to said lower sleeve for preventing release of said lock means and movable with said lower sleeve to a position releasing said lock means.

18. In apparatus adapted to be set in a well bore: a body; an upper setting sleeve surrounding said body; an upper abutment on said upper sleeve; normally retracted packing means on said upper sleeve and engaging said upper abutment; expander means on said sleeve engaging said packing; slip means engaging said expander means and movable longitudinally therealong and outwardly into engagement with the wall of the well bore; means comprising a lower setting sleeve operatively connected to said slip means; means providing an atmospheric chamber into which well bore fluid cannot enter initially and including a piston secured to said upper sleeve and a piston secured to said lower sleeve and disposed below said other piston, said pistons being responsive to hydrostatic head of fluid in the well bore for relatively shifting said upper sleeve downwardly and said lower sleeve upwardly to expand said normally retracted packing means and slip means against the wall of the well bore; releasable lock means preventing movement of said pistons toward each other under the action of the hydrostatic head of fluid in the well bore; means connected to said lower sleeve for preventing release of said lock means; and means responsive to the pressure of fluid in said body for moving said lower sleeve upwardly to a position releasing said lock means.

19. In apparatus adapted to be set in a well bore: a body; an upper setting sleeve surrounding said body; an upper abutment on said upper sleeve; normally retracted packing means on said upper sleeve and engaging said upper abutment; expander means on said sleeve engaging said packing; slip means engaging said expander means and movable longitudinally therealong and outwardly into engagement with the wall of the well bore; means comprising a lower setting sleeve operatively connected to said slip means; means providing an atmospheric chamber into which well bore fluid cannot enter initially and including 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; said pistons being responsive to the hydrostatic head of fluid in the well bore for relatively shifting said sleeves to expand said packing means and slips outwardly; releasable lock means interconnecting said body and upper sleeve preventing movement of said upper sleeve relative to said body; and means connected to said lower sleeve for preventing release of said lock means and movable with said lower sleeve to a position releasing said lock means.

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