March 8, 1966 K. LEUTWYLER 3,239,009

HYDRAULICALLY SET WELL TOOLS

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FIG. 1.

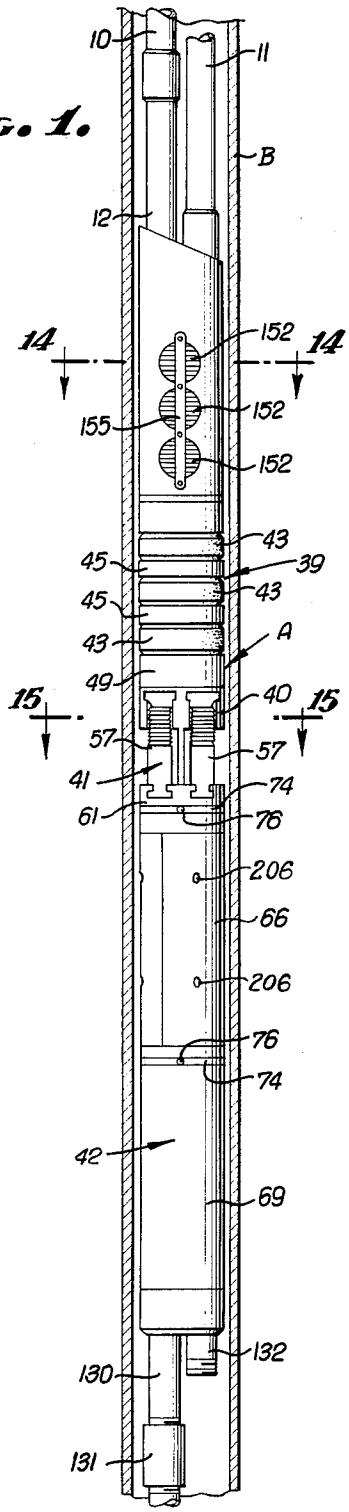


FIG. 14.

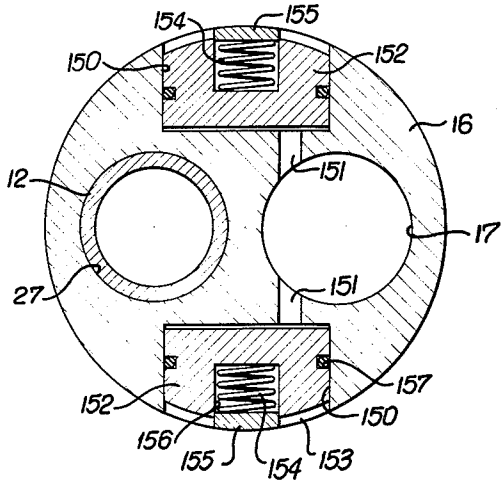
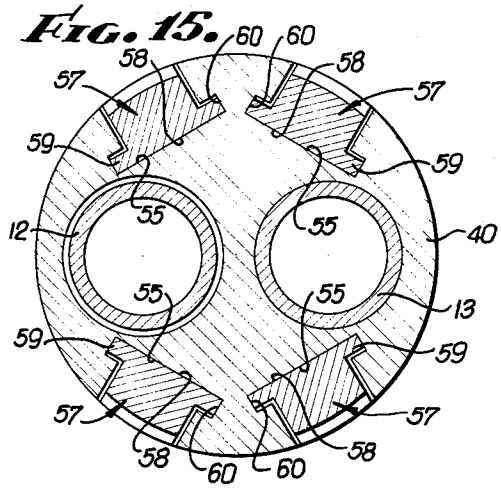


FIG. 15.



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FIG. 2a.

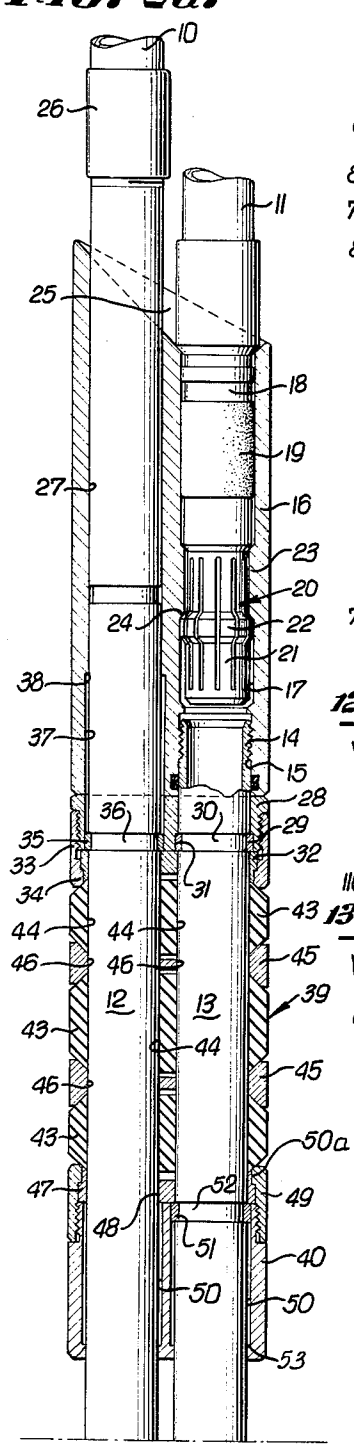


FIG. 2b.

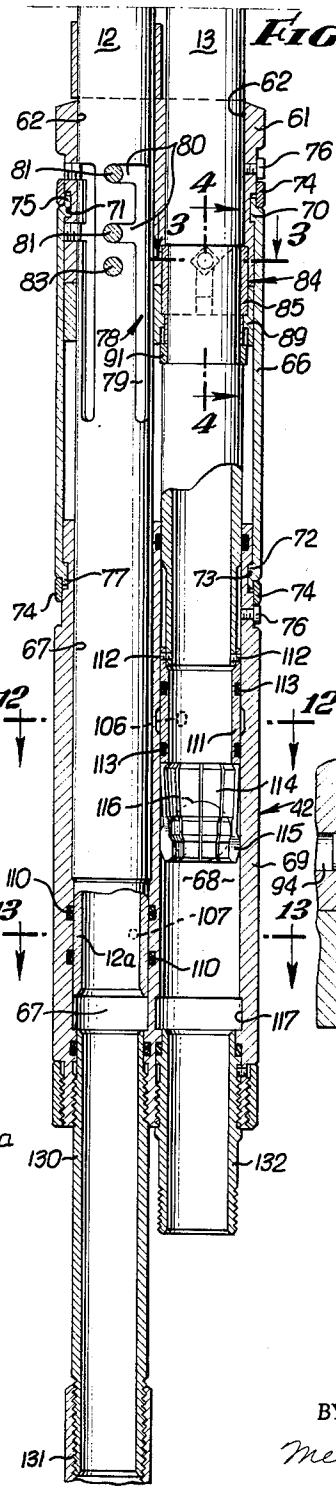


FIG. 3.

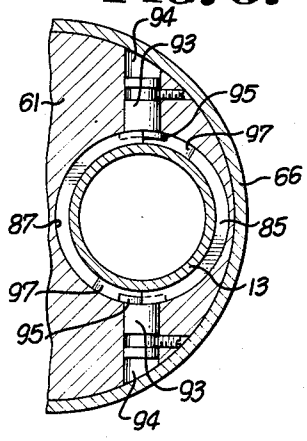
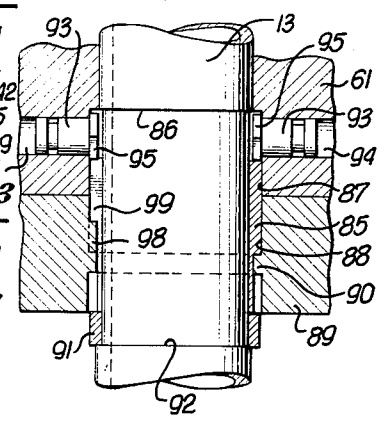


FIG. 4.



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FIG. 5a.

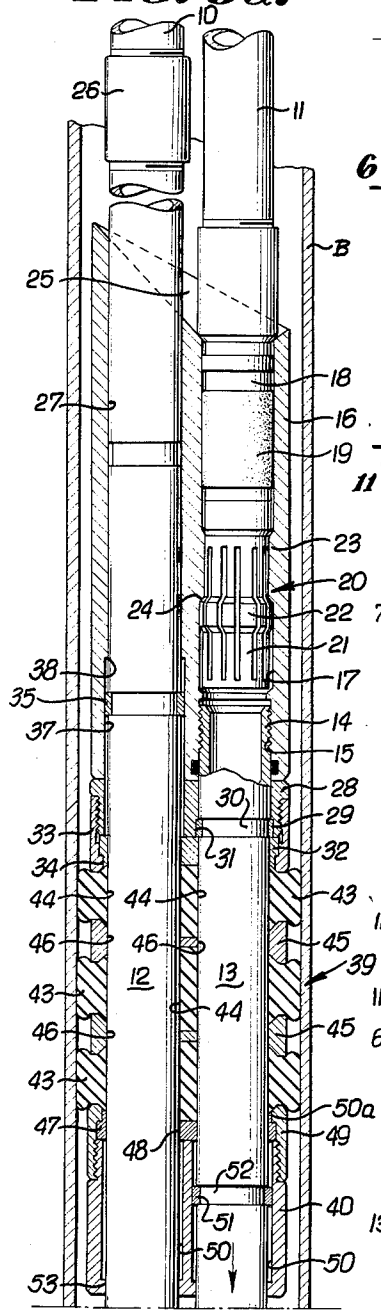


FIG. 5.

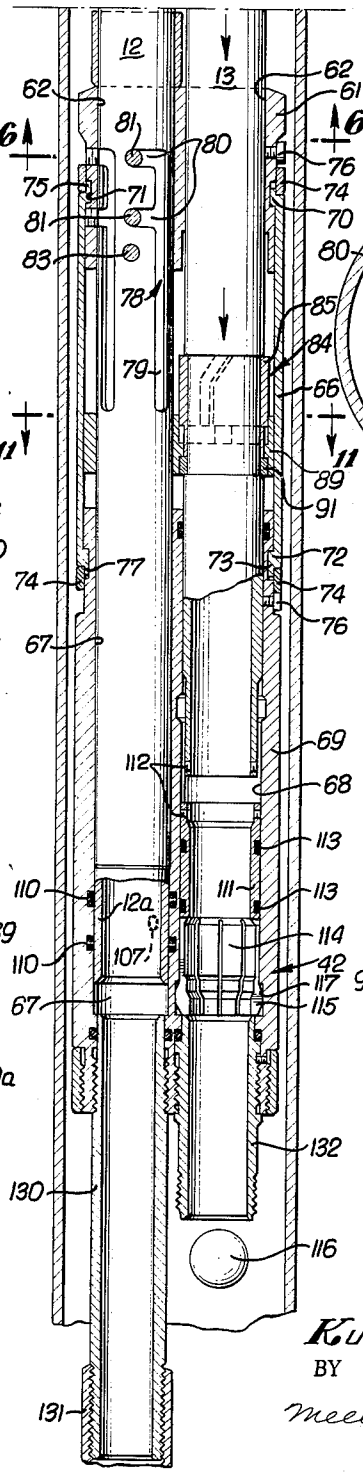


FIG. 6.

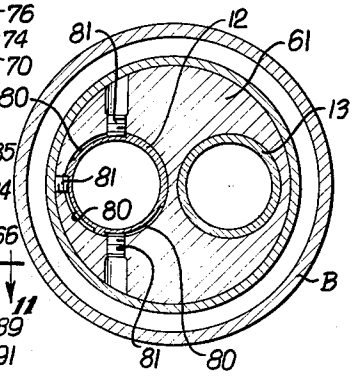
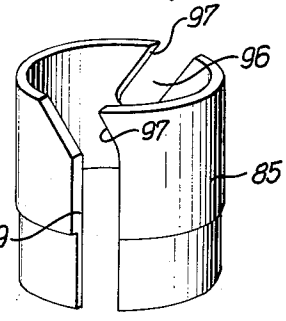


FIG. 7.



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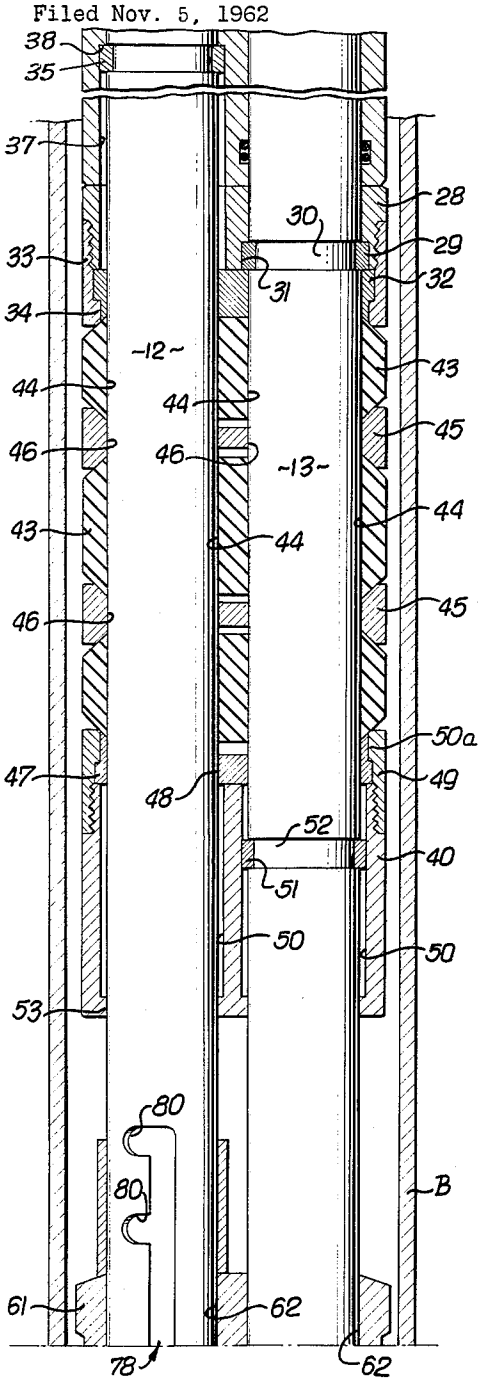
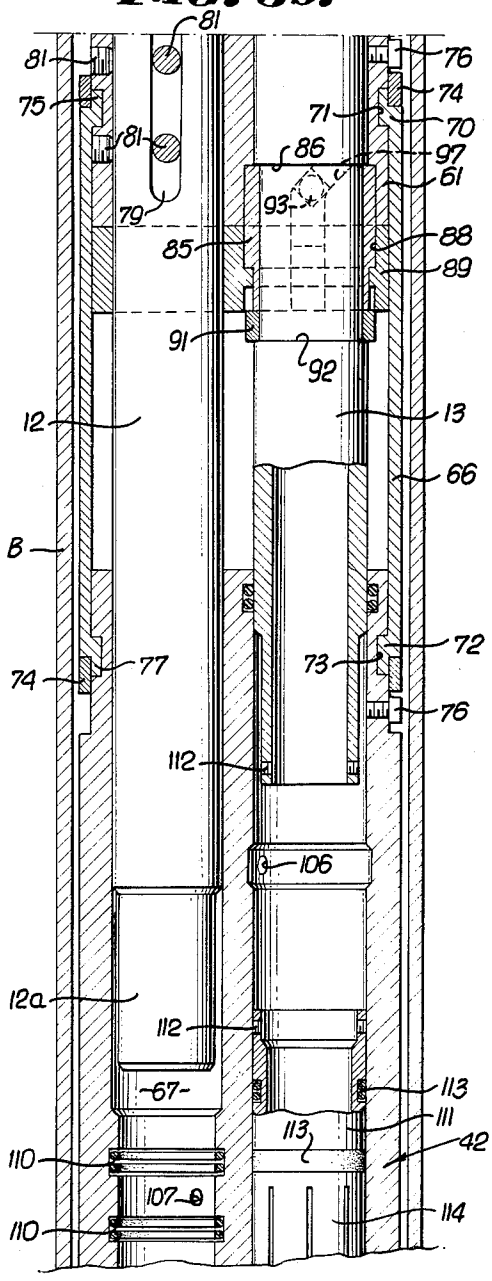


FIG. 8a.

FIG. 8b.



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FIG. 9.

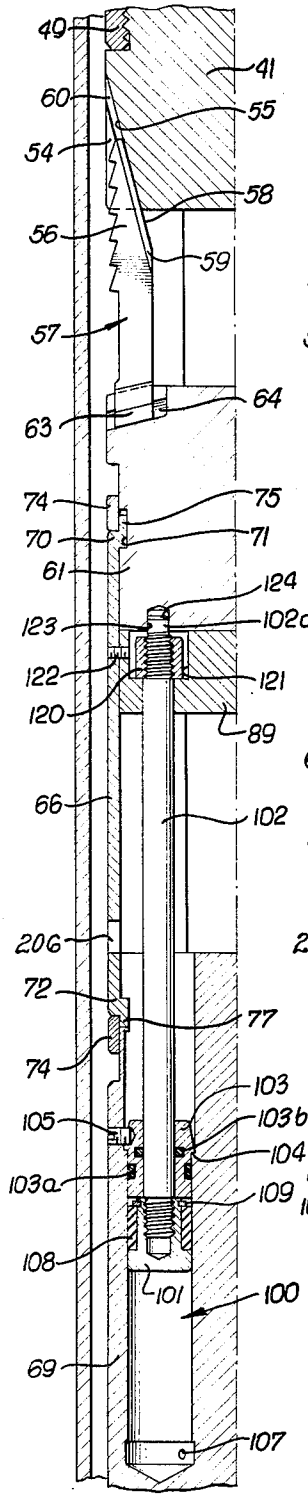


FIG. 10.

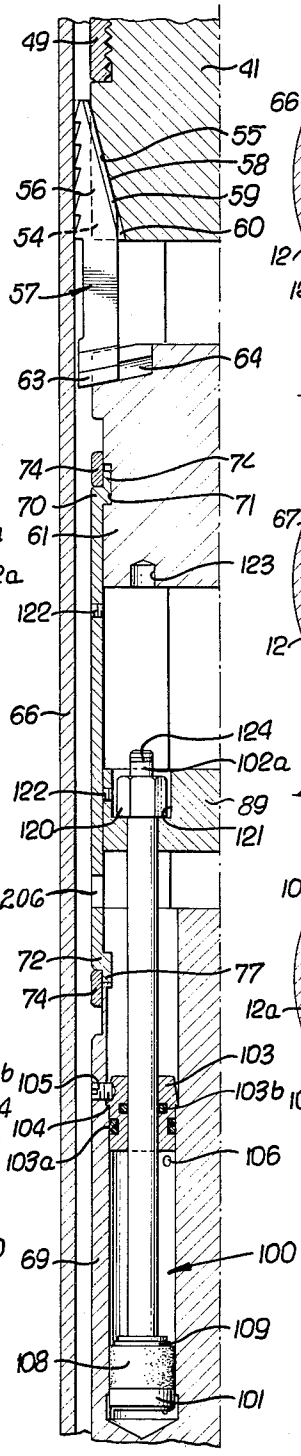


FIG. 11.

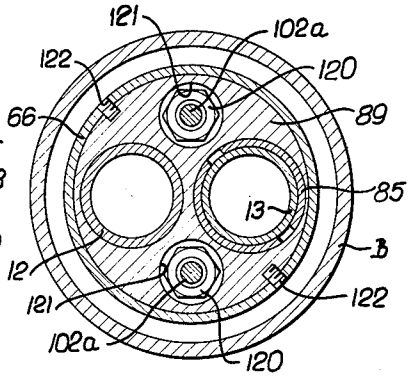


FIG. 12.

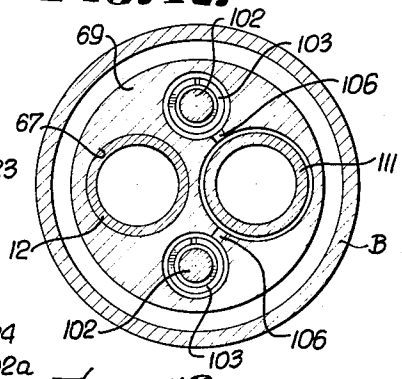
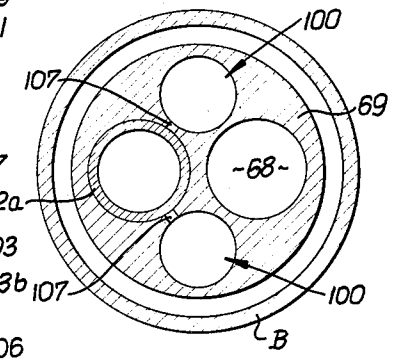


FIG. 13.



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3,239,009

HYDRAULICALLY SET WELL TOOLS

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Filed Nov. 5, 1962, Ser. No. 235,353
19 Claims. (Cl. 166—120)

The present invention relates to subsurface well tools, and more particularly to well packers, and similar well tools, adapted to be set in well bores.

An object of the present invention is to provide a well packer, or the like, adapted to be set hydraulically in a well bore without the necessity for moving the lower portion of the packer, thereby enabling the packer to be used in tandem with another packer in the well bore without disturbing the relationship between the packers.

Another object of the invention is to provide a well packer, or the like, having a plurality of separate parallel passages for association with parallel tubular strings extending to the top of the well bore, the packer being adapted to be placed in appropriate relation to another packer therebelow, and in which setting of the parallel passage packer in the well bore can be accomplished hydraulically without moving its lower portion and without disturbing its relation to the packer therebelow.

A further object of the invention is to provide a well packer, or the like, having a plurality of separate parallel passages for association with parallel tubular strings extending to the top of the well bore, the packer being adapted to be run in the well bore to its setting location on one of the tubular strings and then set in the well bore without the necessity for any longitudinal movement of such tubular string. The absence of longitudinal movement of the tubular string enables the packer to be appropriately related to a lower well packer, if one is present in the well bore, and also permits the surface connections with the tubular string at the top of the well bore to be completed before the parallel passage packer is set.

An additional object of the invention is to provide a well packer adapted to be set in a well bore by the hydrostatic head of fluid therein acting on a piston and piston rod device, in which such head of fluid is caused to act over the area of the piston rod, as well as on the piston, thereby increasing the effective setting force on the packer.

Another object of the invention is to provide a packer, or the like, adapted to be set hydraulically in the well bore, in which its premature or inadvertent setting is prevented by an improved lock device embodied in the packer.

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:

FIGURE 1 is a side elevational view of a well packer with its parts in position for running in a well casing on a tubular string;

FIGS. 2*a* and 2*b* constitute a longitudinal section through the well packer disclosed in FIG. 1, FIG. 2*b* being a lower continuation of FIG. 2*a*;

FIG. 3 is an enlarged cross-section taken along the line 3—3 on FIG. 2*b*;

FIG. 4 is an enlarged longitudinal section taken along the line 4—4 on FIG. 2*b*;

FIGS. 5*a* and 5*b* are views corresponding to FIGS. 2*a* and 2*b* disclosing the well packer set in the well casing, FIG. 5*b* constituting a lower continuation of FIG. 5*a*;

FIG. 6 is a cross-section taken along the line 6—6 on FIG. 5*b*;

FIG. 7 is an isometric projection of the lock sleeve forming a portion of the well packer apparatus;

FIGS. 8*a* and 8*b* are longitudinal sections through a portion of the apparatus, disclosing the parts in the position they occupy after retraction of the well packer from the well casing, FIG. 8*b* constituting a lower continuation of FIG. 8*a*;

FIG. 9 is an enlarged fragmentary longitudinal section through a cylinder and piston portion of the apparatus and associated slip and expander structure, with the piston in its initial upper position in the cylinder and the slips retracted;

FIG. 10 is a view similar to FIG. 9 with the piston device shifted and the slips expanded against the well casing;

FIG. 11 is an enlarged cross-section taken along the line 11—11 on FIG. 5*b*;

FIG. 12 is an enlarged cross-section taken along the line 12—12 on FIG. 2*b*;

FIG. 13 is an enlarged cross-section taken along the line 13—13 on FIG. 2*b*;

FIG. 14 is an enlarged cross-section taken along the line 14—14 on FIG. 1, and

FIG. 15 is an enlarged cross-section taken along the line 15—15 on FIG. 1.

The apparatus A exemplifying the invention in the drawings is a well packer adapted to be set in a well casing B disposed in a well bore for the purpose of conducting well production from a plurality of separate producing zones in the wall bore through separate paths and tubular strings **10**, **11** to the top of the hole. As shown in the drawings, the well packer A is of the retrievable type, and is adapted to be anchored in packed-off condition in a well casing against movement in a downward direction, and, if desired, also against movement in an upward direction.

The packer includes first and second parallel tubular body members **12**, **13**, the second body member **13** having an upper threaded pin **14** threaded in a lower bore **15** in a receptacle or parallel string head **16**. The passage through the second tubular string **11** communicates with a second passage **17** extending upwardly through the parallel string head **16**. The second tubular string **11** can be lowered from the top of the well bore into the casing for reception within the second passage **17**. As shown, the lower portion of the second tubular string includes a sub **18** having a suitable side seal **19** mounted thereon for sealing against the wall of the second passage. Depending from this sub is a latch device **20**, including a plurality of spring-like arms **21** having central cam projections or fingers **22** adapted to be received under a flange or shoulder **23** in the parallel string head below its sealing region of the second passage. These fingers **22** are engageable with the head shoulder **23** when the second tubular string is being inserted in the passage, such engagement springing the fingers **22** and arms **21** inward sufficiently so that the fingers ride past the shoulder to a position therebelow for the purpose of retaining the second tubular string **11** in the second passage **17** with its seal **19** engaging the wall of the latter. The exertion of a sufficient upward pull on the second tubular string **11** will cause the fingers **22** to engage the lower tapered surface **24** of the head shoulder **23**, which cams or forces the fingers **22** and the latch arms **21** inwardly until the fingers ride past the flange **23**, whereupon the second tubular string **11** can be withdrawn completely from the

second passage 17, and, if desired, removed entirely from the well casing B and the well bore.

In the use of the well packer apparatus A illustrated in the drawings, it may be lowered in the well casing on the first tubular string 10 to its setting location. Thereafter, the second tubular string 11 is lowered in the well casing and will engage an inclined head or guide surface 25 at the top of the receptacle or head 16, such surface causing the lower portion of the second tubular string to slide toward and into the second passage 17.

The first tubular string 10 is suitably connected, as by means of a coupling 26, to the first tubular body member 12 that extends downwardly through a first longitudinal passage 27 in the receptacle or head. The first tubular body member 12 is slidable in the first longitudinal passage 27 and extends downwardly therefrom to a substantial extent and almost throughout the longitudinal extent of the well packer, as described in detail hereinbelow.

The first and second tubular body members 12, 13 extend through an upper connector 28 engaging the lower end of the parallel string head or receptacle 16, this upper connector being secured to the second tubular body or mandrel 13 by a two-piece ring 29 engaged in a peripheral groove 30 in the second tubular body and received within a counterbore 31 in the upper connector, and also contacting an upper insert 32 through which the body members 12, 13 pass. The insert is clamped to the lower end of the upper connector 28, and also against the coupling ring 29 mounted on the second tubular body, by an upper gauge ring 33 threaded on the upper connector and having an inwardly directed flange 34 engaging the upper insert 32. The upper insert 32 also contacts a two-piece stop ring 35 mounted in a peripheral groove 36 in the first tubular body member, the ring 35 also being received within an enlarged diameter bore or counterbore 37 in the upper connector, which counterbore 37 continues upwardly into the receptacle 16 and terminates in a downwardly facing shoulder 38 therewithin. As explained hereinbelow, the first tubular body member 12 may be moved by the first tubular string 10 upwardly of the connector 28 and the receptacle 16, its stop ring 35 sliding in the counterbore 37 until it engages the downwardly facing receptacle shoulder 38.

The first and second tubular body members 12, 13 extend downwardly through an initially and normally retracted packing structure 39, an expander 40, a slip structure 41 for anchoring the well packer against longitudinal movement in the well casing B, and a hydraulic actuating mechanism 42. The packing structure 39 can assume any desired form. As disclosed, it includes a plurality of pliant, elastic packing elements 43, made of rubber or rubber-like material, having bores 44 therethrough to accommodate the first and second body members 12, 13, and also including intervening spacers 45 provided with bores 46 through which the body members 12, 13 extend. The upper packing element 43 is engageable by the upper gauge ring 33 and insert 32, its lower end engaging a spacer 45, which, in turn, engages an intermediate packing element 43 contacting a spacer 45 which engages a lower pliant, elastic packing element 43 that contacts a lower insert 47 having bores 48 receiving the body members 12, 13. The lower packing element 43 also contacts a lower gauge ring 49 threaded on the expander 40 and having an inwardly directed flange 50*a* clamping the lower insert 47 against the upper end of the expander 40. The expander is provided with a pair of bores or passages 50 through which the first and second body members 12, 13 extend. The expander 40, lower insert 47, and lower gauge ring 49 are movable as a unit relative to the first and second tubular body members 12, 13. Downward movement of these parts relative to the second tubular body member 13 is prevented by a two-piece stop ring 51 mounted in a peripheral groove 52 in the second body member and engaging the lower end of the lower insert 47. The bore through the expander 40 below the insert 47 is of an enlarged diameter along an extended length to permit relative downward movement of the second body member 13 to an extent limited by engagement of its stop ring 51 with the lower end 53 of the expander defining its enlarged diameter bore 50.

The lower expander 40 has a plurality of spaced slots 54, the bases 55 of which provide expander surfaces tapering in a downward and inward direction (see FIGS. 1, 9, 10 and 15). The upper portions 56 of slips 57 are disposed in these slots 54, the inner portion of the slips having tapered surfaces 58 companion to the expander surfaces 55 and movable longitudinally relative thereto, as well as laterally outwardly and inwardly into and from engagement with the wall of the surrounding well casing. Each slip has opposed side tongues 59 slidable in companion grooves 60 in the expander, so that the slips 57 are moved positively from an expanded to retracted position upon longitudinal separating movement between the expander 40 and slips 57. The lower ends of the slips are connected to a slip ring 61 having a pair of bores 62 through which the body members 12, 13 extend, there being a slidable connection between lower T-shaped heads 63 of the slips and companion T-shaped grooves 64 formed in the slip ring 61. Such T-shaped connection 63, 64 causes the slips 57 to move jointly longitudinaly with the slip ring 61, while permitting their movement radially of the slip ring toward the well casing B and from the well casing. To facilitate such radial movement, the T-shaped heads and the companion grooves in the slip ring are inclined to a small extent in an outward and downward direction, as disclosed most clearly in FIGS. 9 and 10.

The first and second tubular body members 12, 13 extend downwardly from the slip ring 61 through a thrust sleeve structure 66 and into the first and second parallel passages 67, 68 of a hydraulic housing 69 forming a portion of the hydraulic actuating mechanism 42. The thrust sleeve 66 interconnects the hydraulic housing 69 with the slip ring 61. As disclosed, the thrust sleeve 66 is formed in two halves and has an upper internal flange 70 received within a peripheral groove 71 in the slip ring 61. Similarly, the thrust sleeve has a lower internal flange 72 received within a peripheral groove 73 in the upper portion of the hydraulic housing 69. The upper flange 70 is prevented from being removed from the slip ring groove by a retainer ring 74 encompassing the slip ring 61 and an upwardly extending skirt 75 on the thrust sleeve, upward longitudinal movement of the retainer ring from the skirt being prevented by a screw 76 threaded into the slip ring. In a similar manner, the lower flange 72 is prevented from being removed from its groove 73 by a retainer ring 74 encompassing the hydraulic housing 69 and also a lower skirt 77 of the thrust sleeve, this retainer ring being prevented from sliding downwardly from the skirt by a stop screw 76 threaded into the hydraulic housing.

The first tubular body member 12 is releasably connected to the slip ring 61 by pin and slot connections. As shown, the exterior of the first body member 12 is provided with circumferentially spaced control slots or grooves 78, each slot including a longitudinal leg 79 and longitudinally spaced upper lock slot or groove portions 80 communicating with the longitudinal leg. Shearable lock pins or screws 81 are threadedly secured to the slip ring 61 and extend into the control slots 78. Initially, they extend into the horizontal or locking slot portions 80 to prevent relative longitudinal movement between the first body member 12 and the slip ring 61, as well as between the first body member 12 and the hydraulic housing 69. Upon turning the first body member 12 to the right, its longitudinal slots 79 are aligned with the shear pins or screws 81, which will then permit upward longitudinal movement of the first body member 12 within the

slip ring **61** and also within the first passage **67** in the hydraulic housing. However, inadvertent turning of the first body member **12** relative to the slip ring **61** and the hydraulic housing **69** is precluded initially by one or more shear screws **83** threaded in the slip ring **61** and also into the first tubular body member **12**.

Initially, longitudinal movement of the second body member **13** relative to the slip ring **61**, and also relative to the hydraulic housing **69**, is prevented by a releasable lock device **84**, which will prevent the receptacle or head **16** and other portions of the well packer above the packing structure **39** from moving downwardly toward the slip ring **61**, so as to effect outward expansion of the slips **57** and shortening and outward expansion of the packing structure **39** into engagement with the well casing. The lock structure (FIGS. 2*b*, 3, 4 and 7) includes a two-piece sleeve **85** disposed around the second body member **13** with its upper end engaging a downwardly facing shoulder **86** thereon. The sleeve **85** also extends into an enlarged diameter lower portion **87** of the slip ring **61** and is also disposed within a counterbore **88** of a connector plate **89** through which the body members **12, 13** extend and which forms part of the hydraulic actuating mechanism **42**. This plate **89** can move downwardly relative to the first body memer **12**, but it can only move downwardly to a limited extent along the second body member **13**, as determined by engagement of its inwardly directed flange **90** with a split coupling ring or C-ring **91** disposed around the second body member and resting upon a lower shoulder **92** thereon. Initially, the connector plate flange **90** is spaced above the coupling ring **91** of the second body member to allow the connector plate **89** to move downwardly to a limited extent along the second body member **13** for the purpose of releasing the lock device **84** and permitting the second body member **13** to move downwardly of the slip ring **61** and within the hydraulic housing **69**. At first, such downward movement cannot occur since a pair of opposed lock pins **93** are disposed swivelly in bores **94** in the slip ring **61** radial of the lock sleeve **85**, with the inner square head portions **95** of the pins received within inclined upper slot portions **96** of the sleeve. The sleeve **85** is initially prevented from turning within the slip ring **61**, so as to maintain the square pin heads **95** engaged with the upper inclined sides **97** of the slots **96**, by a key **98** fixed to the connector plate and extending into a vertical slot **99** in the sleeve **85**. So long as the key **98** is disposed in the slot **99**, the sleeve **85** cannot turn. Downward thrust of the second body member **13**, which will be transmitted through its upper shoulder **86** to the lock sleeve **85**, cannot effect a turning of the sleeve **85**, which is necessary for the sleeve to shift downwardly relative to the swivel pins **93** and be disconnected therefrom. It is the shifting of the connector plate **89** downwardly to the extent limited by engagement of its flange **90** with the coupling or C-ring **91** which will remove its key **98** from the sleeve slot **99**. The downward thrust of the plate **89** on the second body member **13**, imposed through the coupling ring **91**, can then cause the upper inclined sides **97** of the sleeve to engage the pins **93** and effect a partial rotation of the sleeve **85** and its downward shifting along the pins **93** until the sleeve is disposed below and completely disengaged from them. The second body member **13** can thereafter shift downwardly through the slip ring **61**.

Downward movement of the second body member **13** with respect to the slip ring **61** will result in outward expansion of the slips **57** and shortening and outward expansion of the packing structure **39** into engagement with the wall of the well casing B. Such downward movement and setting of normally retracted parts of the well packer is effected hydraulically, and more specifically by the hydrostatic head of fluid in the well bore or well casing. As disclosed perhaps most clearly in FIGS. 9 to 13, inclusive, the hydraulic housing **69** is provided with a plurality of longitudinal cylinders **100** closed at their lower ends, each cylinder containing a piston structure comprising a piston **101** suitably secured to a piston rod **102** extending upwardly through a cylinder head **103** secured to the housing by engaging an upwardly facing shoulder **104** of the housing surrounding the cylinder and by a set screw **105** threaded in the housing and into the cylinder head. Each cylinder has an inlet port **106** above its piston **101** and immediately below the cylinder head **103** communicating with the second passage **68** through the housing **69**, and each cylinder also has a pressure equalizing or vent port **107** communicating with the first passage **67** extending through the housing.

The piston **101** has a suitable seal ring structure **108** thereon slidably and sealingly engaging the wall of the cylinder **100** and held on the piston by a suitable retainer **109**. Initially, the cylinder space below the piston **101** contains air at atmospheric pressure, the lower portion **12***a* of the first body member **12** extending across the pressure equalizing or vent ports **107** to prevent any fluid pressure from entering such ports. Suitable side seal rings **110** are mounted in the housing on opposite sides of the vent ports **107**, which sealingly engage with the periphery of the first body member **12***a* to prevent passage of fluid into such ports and into the lower ends of the cylinders **100**. The head **103** also has suitable seal rings **103***a*, **103***b* engaging the cylinder wall and rod **102** to prevent leakage therealong.

Fluid under pressure is initially prevented from entering the inlet ports **106** opening into the cylinders **100** above the pistons **101** by a valve sleeve **111** in the second housing passage **68** which is secured initially to the lower end of the second body member **13** by shear screws **112**. The valve sleeve carries suitable spaced side seal rings **113** sealingly engaging with the wall of the second housing passage on opposite sides of the inlet ports **106**. The valve sleeve has spring-like legs **114** terminating in fingers **115** which project inwardly of the sleeve to an effective internal diameter less than the internal diameter through the second body member **13** and also through the upper imperforate portion of the valve sleeve **111**. When a suitable tripping ball valve element **116** is lowered or pumped through the second tubular string **11**, it will pass through the second body member **13** and come to rest upon the fingers **115**. Thereafter, fluid pressure can be built up of a sufficient value to overcome the shear strength of the screws **112**, shifting the valve sleeve **111** downwardly in the housing passage **68** to a position opening the inlet ports **106** and allowing the hydrostatic head of fluid in the second tubular string **11** and in the well casing B to enter the cylinders **100** above the pistons **101** and shift the latter in a downward direction. The valve sleeves **111** is moved downwardly hydraulically within the housing **69** to a position in which its fingers **115** expand outwardly into a housing recess **117** to increase the internal diameter of the fingers and allow the ball **116** to pass downwardly therethrough and out of the well packer into the well casing, thereby opening the second passage **68** through the well packer.

When the hydrostatic head of fluid in the well casing can act downwardly on the pistons **101**, they move downwardly and pull the rods **102** downwardly with them, there being thrust nuts **120** threaded on the piston rods and received within counterbores **121** in the connector plate, the downward movement of the rods carrying the connector plate **89** downwardly with them. Initially, however, the connector plate is held in its upward position by one or more shear screws **122** connecting it to the thrust sleeve **66**. With the parts in their initial position, the upper end **102***a* of each piston rod **102** is disposed in an atmospheric chamber **123** in the slip ring **61**, fluid being prevented from passing into this chamber by a suitable side seal ring **124** on the upper end of each rod engaging the cylindrical wall of the atmospheric chamber. In view of the sealing of the upper end **102***a* of each rod in its associated

atmospheric chamber **123**, the hydrostatic head of fluid cannot act initially on the upper end of each rod and tend to shift it downwardly. However, when the hydrostatic head of fluid acting on the pistons **101** exerts a sufficient force thereon and on the rods **102** to shear the screws **122** and move the rods **102** and connector plate **89** downwardly to a slight extent, the upper ends **102***a* of the rods are pulled out of the atmospheric chambers **123**, so that the hydrostatic head of fluid can also act in a downward direction over the entire cross-sectional area of the piston rods **102**. In effect, the hydrostatic head of fluid can then act in a downward direction over the entire cross-sectional area of each piston **101**, bringing to a maximum the total hydraulic force available for downward movement of the piston rods **102** and connector plate **89**. Fluid in the thrust sleeve **66** will not resist movement of the plate **89** therewithin since it can pass into and out of the sleeve **66** through the upper and lower bleeder holes **206**.

A connector sub **130** is threaded into the lower portion of the hydraulic housing in communication with the first passage **67** so that a suitable length of tubing **131** can be attached to this connector sub, which is adapted to be placed in sealing relation to a lower packer (not shown) anchored in packed-off condition in the well casing. Similarly, if desired, a connector sub **132** can also be threadedly attached to the lower end of the hydraulic housing **69** in communication with the second housing passage **68**. A desired length of tubing (not shown) can also be attached to this connector sub for association with a passage through a lower packer (not shown), if such association is necessary, in view of the particular combination of packers installed in the well casing.

The well packer A is run in the well casing on the first tubular string **10** with the packing structure **39** and the slips **57** in retracted position, the parts occupying the relative positions illustrated in FIGS. 1, 2*a*, 2*b* and 9. At this time, the lock sleeve structure **84** positively prevents relative movement of the receptacle **16** toward the slip ring **61**, and thereby prevents expansion of the slips and packing structure. The connector plate **89** is secured in its upper position by the shear screws **122**, the valve sleeve **111** closing the inlet ports **106** and the lower portion **12***a* of the first body member **12** closing the equalizer or vent ports **107**. The well packer is run to its setting location in the well casing. If a lower packer (not shown) is present in the well casing, the tubing associated with either of the passages **67**, **68** in the packer is placed in appropriate relation the passage through the lower packer. The second tubular string **11** is then lowered in the well casing B alongside the first tubular string to the well packer, it lower end engaging the inclined guide **25** of the receptacle **16** and being shifted into the second receptacle passage **17**, the latches **20** riding past the flange **23** and releasably securing the second tubular string to the receptacle with its seal **19** in engagement with the wall of the second passage **17** of the receptacle **16**.

If desired at this time, the surface connections (not shown) can be completed with the first and second tubular strings, and circulating fluid pumped down through the second tubular string **11**, this fluid discharging from the second passage **68** into the casing B, and flowing upwardly around the packer A and the tubular strings **10**, **11** back to the top of the well bore, removing the drilling mud, or other fluid, present in the casing string therefrom, and thereby conditioning the well. When the packer A is to be set, the trip ball **116** is lowered or pumped down through the second tubular string **11**, passing into the second body or mandrel **13** and coming to rest upon the inwardly projecting fingers **115** of the valve sleeve **111**. The pressure of the fluid in the second tubular string **11** and second tubular body **13** is then increased to an extent sufficient to overcome the shear strength of the screws **112**, whereupon the valve sleeve **111** is disconnected from the second body member **13** and shifted downwardly in the second passage **68** to open the inlet ports **106** to the cylinders **100**, the valve sleeve **111** shifting downwardly in the housing **69** until its fingers **115** spring into the enlarged recess **117**, allowing the ball **116** to be ejected downwardly from the well packer.

Since the cylinders below the pistons **101** contain air at substantially atmospheric pressure, the hydrostatic head of fluid in the well casing and in the second tubular string **11** provide a pressure differential and can pass through the inlet ports **106** into the cylinders **100** above the pistons **101**, shifting the latter and the piston rods **102** downwardly, the downward force being transferred through the connector plate **89** to the shear screws **122**, disrupting the latter and shifting the connector plate **89** downwardly along the first and second body members **12**, **13**. Downward shifting along the second tubular body member **13** can only occur until the flange **90** engages the coupling ring **91** therebelow. The distance of travel of the connector plate **89**, however, has been sufficient to remove the key **98** from the sleeve slot **99**, whereupon the downward force of the connector plate is transmitted through the coupling ring **91** to the second tubular member **13**, which will shift the sleeve **85** downwardly along the swivel lock pins **93**, the sleeve turning around the slip ring **61** and around the second body member **13** until its inclined slots **96** move down free of the swivel pins **93**.

The downward force of the hydrostatic head of fluid on the pistons **101** and rods **102** is now transmitted from them to the connector plate **89**, the upper ends **102***a* of the rods having shifted out of their atmospheric chambers **123**, this downward movement being transferred through the connector plate flange **90** and coupling ring **91** to the second tubular body member **13**, urging this body member downwardly and carrying the upper receptacle or head **16** downwardly with it. At this time, the slip ring **61** is connected to the first body member **12** through the shear screws **81**, **83** and cannot move downwardly. Accordingly, the downward movement of the upper receptacle or head **16** toward the slip ring **61** will first shift the packing structure **39** downwardly with it and move the expander **40** downwardly along the slips **57**, expanding the slips outwardly against the wall of the well casing B. Continued downward movement of the second body member **13** under the influence of the pistons **101**, piston rods **102** and connector plate **89** will then shift the receptacle **16**, its upper connector **28**, upper insert **32**, and upper gauge ring **33** downwardly toward the lower gauge ring **49**, lower insert **47**, and expander **40**, since the expander cannot move downwardly to any further extent, shortening the packing structure **39** and expanding its packing elements **43** outwardly into sealing engagement with the wall of the well casing, and also firmly against the outer surfaces of the tubular body members **12**, **13**. The hydrostatic head of fluid will act constantly upon the pistons **101**, firmly anchoring the slips **57** against downward movement in the well casing and holding the packing structure **39** sealed against the wall of the well casing. Such action will be maintained continuously since the pressure will be constantly acting on the pistons **101** so long as there is sufficient pressure in the cylinders **100**.

With the packer A anchored in packed-off condition in the well casing B, well production from a lower zone can then pass upwardly through a lower packer (not shown) and through the first tubular body member **12** and first tubular string **10** to the top of the well bore. Well production from an upper zone between the lower packer and the packer A illustrated in the drawings can pass upwardly through the second body member **13** and the second tubular string **11** to the top of the well bore.

If at some future time it is desired to release the packer and retrieve it from the well casing, the first tubular string **10** and body member **12** are turned to the right with a sufficient torque to shear the screws **83** preventing its rotation relative to the slip ring **61**. Upon shearing of such screws, the tubular body member **12** can turn to place the longitudinal legs **79** of its slots in alignment with the lock pins **81**, whereupon the first tubular string

10 is elevated, moving the first body member 12 upwardly within the hydraulic housing 69 and within the slip structure and packing structure, as well as within the upper receptacle or head 16, until the lower portion 12a of the first body member is moved above the seal rings 110 to open the pressure equalizing or vent ports 107 communicating with the atmospheric chambers in the cylinders 100 below the piston 101. The hydrostatic head of fluid can now enter the atmospheric chambers and equalize the hydraulic pressures on opposite sides of each of the pistons 101, thereby relieving the setting and anchoring force on the well packer parts.

Following equalizing of the pressure, the second tubular string 11, if desired, can be shifted upwardly of the receptacle 16 to retract its latches 20 and remove the string 11 from the receptacle, whereupon it can be removed completely from the well casing B. Thereafter, the first tubular string 10 and the first body member 12 are elevated until the connector ring 35 shifts upwardly in the enlarged bore 37 of the receptacle and engages the downwardly facing shoulder 38 thereof. Upward movement of the first tubular string 10 and body member 12 will then elevate the receptacle 16 and the second tubular body member 13 connected thereto with respect to the expander 40, allowing the packing structure 39 to retract from the well casing, whereupon the ring 51 secured to the second tubular body member 13 will engage the lower insert 47 and move the expander 40 upwardly with respect to the slips 57, the tongue and groove interconnections 59, 60 between the expander and slips effecting retraction of the latter. The entire well packer A can now be removed from the well casing B by elevating the tubular string 10.

In the event that turning of the first tubular string 10 and first body member 12, to effect release of the well packer, cannot take place, the taking of an upward pull on the first tubular string 10 and first body member 12 of a sufficiient extent will shear all of the screws 81, 83 and thereby release the first body member 12 from the slip ring 61, allowing its upward movement with respect to the latter and also within the first passage 67 through the hydraulic housing 69 for the purpose of opening the equalizer or vent ports 107. The well packer parts can then be shifted to a retracted position, allowing the well packer A to be removed from the well casing B in the manner described above.

From the foregoing description, it is evident that a well tool has been provided in which the lower portions of the tool do not move at all in connection with its setting in the well casing. The first tubular string 10, the first body member 12, the slip ring 61, thrust sleeve 66 and hydraulic housing 69 do not shift longitudinally. The slip ring 61 is held in a fixed position by the first body member 12, the second tubular body member 13 being shifted downwardly hydraulically in order to shift the receptacle 16 toward the slip ring 61 and thereby effect expansion of the slips 57 and of the packing structure 39 against the well casing. Because of this structural arrangement, the tubing 131 associated with the lower portion of the packer may be caused to rest or otherwise be related to a lower packer (not shown), and such tubing need not partake of any movement thereafter, until removal of the well packer may be desired. This enables an appropriate and definite relationship between the packer illustrated in the drawings and the lower packer to be maintained, free from interference by the act of setting the upper well packer in the well casing.

The packer structure described is anchored in packed-off condition in the well casing against downward movement therein. If desired, it can also be anchored against upward movement. The receptacle or head 16 is provided with generally radially disposed cylinders 150 (FIGS. 1, 14), the inner portions of which communicate with the second passage 17 of the head through intervening ports 151. Each cylinder contains a gripping member 152 having wickers or teeth 153 adapted to embed themselves in the wall of the well casing and resist upward movement. The gripping members are initially urged toward a retracted position completely within the cylinders 150 by helical compression springs 154 engaging retainers and spring seats 155 extending across vertical slots 156 in the gripping members and suitably secured to the receptacle or head 16, and also engaging the gripping members themselves, urging them inwardly of the cylinders. The fluid pressure in the second passage 17 will pass through the ports 151 into the inner portions of the cylinders, urging the gripping members or pistons 152 outwardly into firm gripping engagement with the wall of the well casing. Leakage of fluid around the gripping members is prevented by suitable side seal rings 157 on each of them, slidably and sealingly engaging the wall of the radial cylinders 150.

I claim:

1. In apparatus adapted to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom, the lower portion of said normally retracted means being secured to said body means and the upper portion of said normally retracted means being movable downwardly of said body means; hydraulically operable means responsive to the hydrostatic head of fluid in the well bore for shifting the upper portion of said normally retracted means downwardly of said body means, while said lower portion remains secured to said body means, to expand said normally retracted means outwardly; means operatively associated with said hydraulically operable means for preventing said hydrostatic head of fluid from actuating said hydraulically operable means; means for shifting said preventing means to a position permitting said hydrostatic head of fluid to actuate said hydraulically operable means; and means for substantially 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.

2. In apparatus adapted to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom; hydraulically operable means for expanding said normally retracted means outwardly and having an upper high pressure side and a lower low pressure side; means operatively associated with said hydraulically operable means for preventing the hydrostatic head of fluid in the well bore from acting on said high pressure and low pressure sides; means for shifting at least a portion of said preventing means to a position permitting action of said hydrostatic head of fluid on said high pressure side, but not on said low pressure side, to cause said hydraulically operable means to move downwardly and expand said normally retracted means; and means for shifting at least a portion of said preventing means to a position permitting action of said hydrostatic head of fluid on said low pressure side to substantially equalize the hydrostatic head acting on said high and low pressure sides and enable said normally retracted means to be retracted from its outwardly expanded position.

3. In apparatus to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom; a cylinder on said body means; piston means in said cylinder; means operatively connecting said piston means with said normally retracted means; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said normally retracted means outwardly; second passage means for conducting said hydrostatic head of fluid to said cylinder below said piston means to enable said normally retracted means to retract from its outwardly expanded

position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

4. In apparatus to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom; a cylinder on said body means; piston means in said cylinder; means operatively connecting said piston means with said normally retracted means; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said normally retracted means outwardly; second passage means for conducting said hydrostatic head of fluid to said cylinder below said piston means to enable said normally retracted means to retract from its outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means movable by manipulation of said body means for shifting said second closing means to open position.

5. In apparatus adapted to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom; hydraulically operable means for expanding said normally retracted means outwardly and having an upper high pressure side and a lower low pressure side; means for conducting fluid pressure to said high and low pressure sides of said hydraulically operable means; means operatively associated with said hydraulically operable means for preventing fluid pressure from passing through said conducting means and acting on said high pressure and low pressure sides; means for shifting at least a portion of said preventing means to a position permitting fluid pressure to pass through said conducting means and act on said high pressure side, but not on said low pressure side, to cause said hydraulically operable means to move downwardly and expand said normally retracted means; and means for shifting at least a portion of said preventing means to a position permitting fluid pressure to pass through said conducting means and act on said low pressure side and enable retraction of said normally retracted means from its outwardly expanded position.

6. In apparatus to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom; a cylinder on said body means; piston means in said cylinder; means operatively connecting said piston means with said normally retracted means; first passage means for conducting fluid under pressure to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said normally retracted means outwardly; second passage means for conducting fluid under pressure to said cylinder below said piston means to enable said normally retracted means to retract from its outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

7. In apparatus adapted to be set in a well bore: body means adapted to be connected to a tubular string extending to the top of the well bore; a normally retracted expandable and retractable packing on said body means; abutment means on said body means engageable with said packing at the upper end thereof; expander means on said body means engageable with said packing at the lower end thereof; retractable normally retracted slip means connected to said body means and engaging said expander means and expandible outwardly thereby; a cylinder on said body means; piston means in said cylinder; means operatively connecting said piston means with said abutment means; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing and slip means outwardly; second passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder below said piston means to enable said packing and slip means to retract from their outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

8. In apparatus adapted to be set in a well bore: body means adapted to be connected to a tubular string extending to the top of the well bore; a normally retracted expandable and retractable packing on said body means; abutment means on said body means engageable with the upper end of said packing; expander means on said body means engageable with the lower end of said packing; retractable normally retracted slip means connected to said body means and engaging said expander means and expandible outwardly thereby; a cylinder on said body means; piston means slidable in said cylinder; means operatively connecting said piston means with said abutment means; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing and slip means outwardly; second passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder below said piston means to enable said packing and slip means to retract from their outwardly expanded position; a sleeve initially closing said first passage means; manipulative means movable by said body means initially closing said second passage means; means for shifting said sleeve to a position opening said first passage means; said manipulative means being movable by said body means to a position opening said second passage means.

9. In apparatus adapted to be set in a well bore: body means adapted to be connected to a tubular string extending to the top of the well bore; a normally retracted expandable and retractable packing on said body means; abutment means on said body means engageable with said packing at the upper end thereof; expander means on said body means engageable with said packing at the lower end thereof; retractable normally retracted slip means connected to said body means and engaging said expander means and expandible outwardly thereby; a cylinder on said body means; piston means in said cylinder; means operatively connecting said piston means with said abutment means; first passage means for conducting fluid under pressure to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing and slip means outwardly; second passage means for conducting fluid under pressure to said cylinder below said piston means to enable said packing and slip means to retract from their outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

10. In apparatus adapted to be set in a well bore: body means adapted to be connected to a tubular string extending to the top of the well bore; a normally retracted expandable and retractable packing on said body means; abutment means on said body means engageable with said packing at the upper end thereof; expander means on said body means engageable with said packing at the lower end thereof; retractable nor-

mally retracted slip means connected to said body means and engaging said expander means and expandible outwardly thereby; a cylinder on said body means; piston means in said cylinder; means operatively connecting said piston means with said abutment means; first passage means for conducting fluid under pressure to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing and slip means outwardly; second passage means for conducting fluid under pressure to said cylinder below said piston means to enable said packing and slip means to retract from their outwardly expanded position; a sleeve initially closing said first passage means; manipulative means movable by said body means initially closing said second passage means; means for shifting said sleeve to a position opening said first passage means; said manipulative means being movable by said body means to a position opening said second passage means.

11. In apparatus adapted to be set in a well bore: first and second tubular body members disposed in side-by-side relation; abutment means connected to said second body member; normally retracted expandable and retractable packing means on said body members having an upper end portion engaging said abutment means; expander means on said body members engaging the lower end portion of said packing means; retractable and expandable slip means operatively connected to said first body member and engaging said expander means to be expanded outwardly thereby; a housing secured to said first body member and having a passage receiving said second body member; said housing having a cylinder therein; piston means in said cylinder operatively connected with said second body member; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said piston means downwardly in said cylinder and correspondingly more said second body member, abutment means and expander means toward said slip means to expand said packing means and slip means outwardly; second passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder below said piston means to enable said packing means and slip means to retract from their outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

12. In apparatus adapted to be set in a well bore: first and second tubular body members disposed in side-by-side relation; normally retracted expandable and retractable packing means on said body members; abutment means operatively connected to said second body member and engaging the upper end of said packing means; expander means on said body members engaging the lower end of said packing means; retractable and expandable slip means releasably connected to said first body member and engaging said expander means to be expanded outwardly thereby; a housing secured to said slip means and having first and second passages receiving said first and second body members, respectively; said housing having a cylinder therein; piston means in said cylinder operatively connected to said second body member; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing means and slip means outwardly; second passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder below said piston means to enable said packing means and slip means to retract from their outwardly expanded position; first means initially closing said first passage means; manipulative means movable by said first body member initially closing said second passage means; means for shifting said first closing means to open position; said first body member being releasable from said slip means and adapted to shift said manipulative means to a position opening said second passage means.

13. In apparatus adapted to be set in a well bore: first and second tubular body members disposed in side-by-side relation; abutment means connected to said second body member; normally retracted expandable and retractable packing means on said body members having an upper end portion engaging said abutment means; expander means on said body members engaging the lower end portion of said packing means; retractable and expandable slip means operatively connected to said first body member and engaging said expander means to be expanded outwardly thereby; a housing secured to said first body member and having a passage receiving said second body member; said housing having a cylinder therein; piston means in said cylinder operatively connected with said second body member; first passage means for conducting fluid under pressure to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing means and slip means outwardly; second passage means for conducting fluid under pressure to said cylinder below said piston means to enable said packing means and slip means to retract from their outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

14. In apparatus adapted to be set in a well bore: first and second tubular body members disposed in side-by-side relation; normally retracted expandable and retractable packing means on said body members; abutment means operatively connected to said second body member and engaging the upper end of said packing means; expander means on said body members engaging the lower end of said packing means; retractable and expandable slip means releasably connected to said first body member and engaging said expander means to be expanded outwardly thereby; a housing secured to said slip means and having first and second passages receiving said first and second body members, respectively; said housing having a cylinder therein; piston means in said cylinder operatively connected to said second body member; first passage means for conducting fluid under pressure to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing means and slip means outwardly; second passage means for conducting fluid under pressure to said cylinder below said piston means to enable said packing means and slip means to retract from their outwardly expanded positions; first means initially closing said first passage means; means movable by said first body member initially closing said second passage means; means for shifting said first closing means to open position; said first body member being releasable from said slip means for moving said movable means to a position opening said second passage means.

15. In apparatus adapted to be set in a well bore: first and second tubular body members disposed in side-by-side relation; normally retracted expandable and retractable packing means on said body members; abutment means connected to said second body member and engaging the upper end of said packing means; expander means on said body members engaging the lower end of said packing means; retractable and expandable slip means connected to said first body member and engaging said expander means to be expanded outwardly thereby; a housing connected to said slip means having first and second passages receiving said first and second body members, respectively; said housing having a cylinder therein; piston means in said cylinder operatively connected to said second body member; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston means to shift said

piston means downwardly in said cylinder and expand said packing means and slip means outwardly; releasable lock means operatively associated with said piston means and initially securing said second body member to said slip means, said lock means being released upon initial downward movement of said piston means in said cylinder; second passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder below said piston means to enable said packing means and slip means to retract from their outwardly expanded positions; first means initially closing said first passage means; and means controlled by said first body member for initially closing said second passage means; means for shifting said first closing means to open position; said first body member being releasable from said slip means and movable in said housing to shift said second closing means to open position.

16. In apparatus adapted to be set in a well bore: first and second tubular body members disposed in side-by-side relation; normally retracted expandable and retractable packing means on said body members; abutment means connected to said second body member and engaging the upper end of said packing means; expander means on said body members engaging the lower end of said packing means; retractable and expandable slip means connected to said first body member and engaging said expander means to be expanded outwardly thereby; a housing connected to said slip means having first and second passages receiving said first and second body members, respectively; said housing having a cylinder therein; piston means in said cylinder operatively connected to said second body member; first passage means for conducting fluid under pressure to said cylinder above said piston means to shift said piston means downwardly in said cylinder and expand said packing means and slip means outwardly; releasable lock means operatively associated with said piston means and initially securing said second body member to said slip means, said lock means being released upon initial downward movement of said piston means in said cylinder; second passage means for conducting fluid under pressure to said cylinder below said piston means to enable said packing means and slip means to retract from their outwardly expanded positions; first means initially closing said first passage means; and means controlled by said first body member for initially closing said second passage means; means for shifting said first closing means to open position; said first body member being releasable from said slip means and movable in said housing to shift said second closing means to open position.

17. In apparatus adapted to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore and to be retracted therefrom; a cylinder on said body means; a piston in said cylinder; a piston rod secured to said piston and extending from said cylinder; means operatively connecting said piston rod to said normally retracted means; means initially enclosing an end portion of said piston rod to prevent the hydrostatic head of fluid in the well bore from acting thereon; first passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder on one side of said piston to shift said piston in said cylinder to expand said normally retracted means outwardly, the shifting of said piston moving said end portion of said rod from said confining means to permit the hydrostatic head of fluid to act on said piston rod; second passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder on the other side of said piston to enable said normally retracted means to retract from its outwardly expanded position; first means initially closing said first passage means; second means initially closing said second passage means; means for shifting said first closing means to open position; and means for shifting said second closing means to open position.

18. In apparatus adapted to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore; a cylinder on said body means; a piston in said cylinder; a piston rod secured to said piston and extending from said cylinder; means operatively connecting said piston rod to said normally retracted means; means initially enclosing an end portion of said piston rod to prevent the hydrostatic head of fluid in the well bore from acting thereon; passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder on one side of said piston to shift said piston in said cylinder to expand said normally retracted means outwardly, shifting of said piston moving said end portion of said rod from said enclosing means to permit the hydrostatic head of fluid to act on said piston rod; means initially closing said passage means; and means for shifting said closing means to open position.

19. In apparatus adapted to be set in a well bore: body means; normally retracted means on said body means adapted to be expanded outwardly into engagement with the wall of the well bore; a cylinder on said body means; a piston in said cylinder; a piston rod secured to said piston and extending upwardly thereof from said cylinder; means confining the upper end of said piston rod to prevent the hydrostatic head of fluid in the well bore from acting thereon; means operatively connecting said piston rod to said normally retracted means to expand said normally reracted means outwardly; passage means for conducting the hydrostatic head of fluid in the well bore to said cylinder above said piston to shift said piston and rod downwardly of said cylinder to remove said piston rod from said confining means and to expand said normally retracted means outwardly; means initially closing said passage means; means for shifting said closing means to open position.

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