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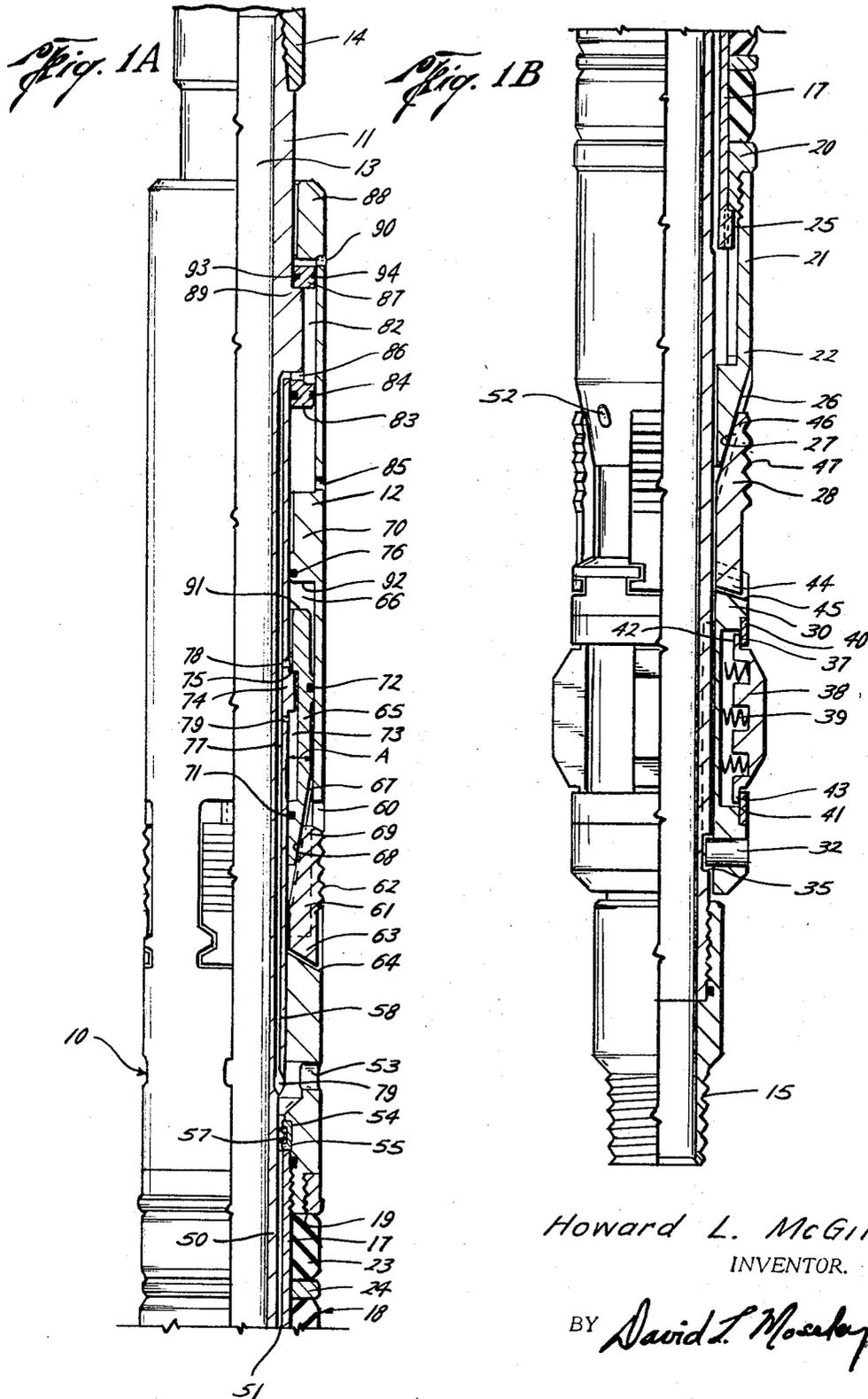
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RETRIEVABLE WELL PACKER

Filed Dec. 30, 1966

3 Sheets-Sheet 1



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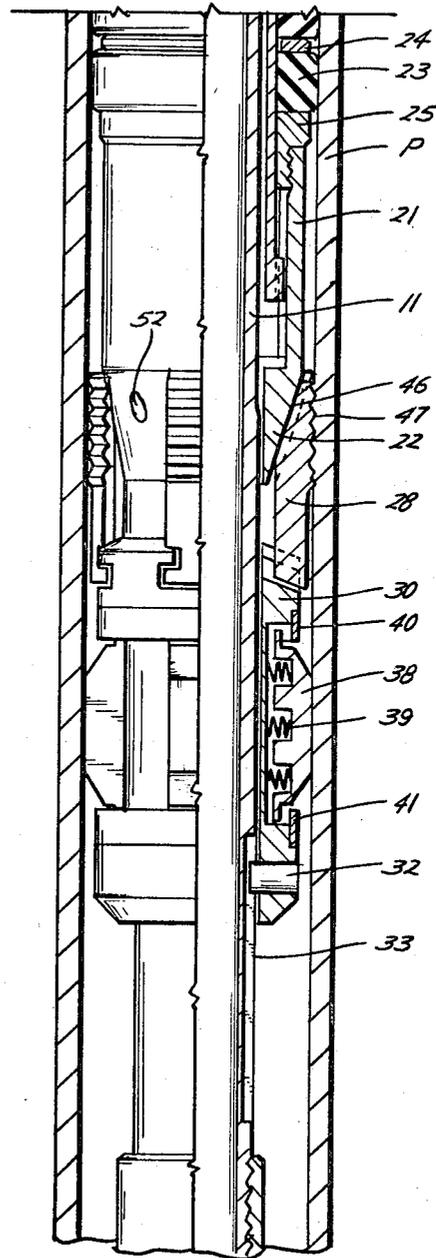
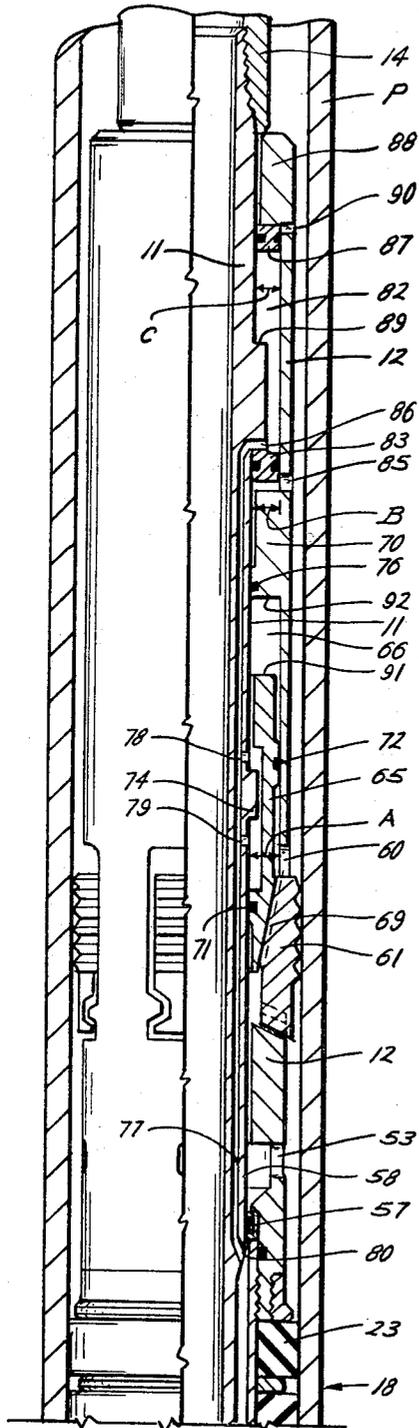
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Fig. 2A

Fig. 2B



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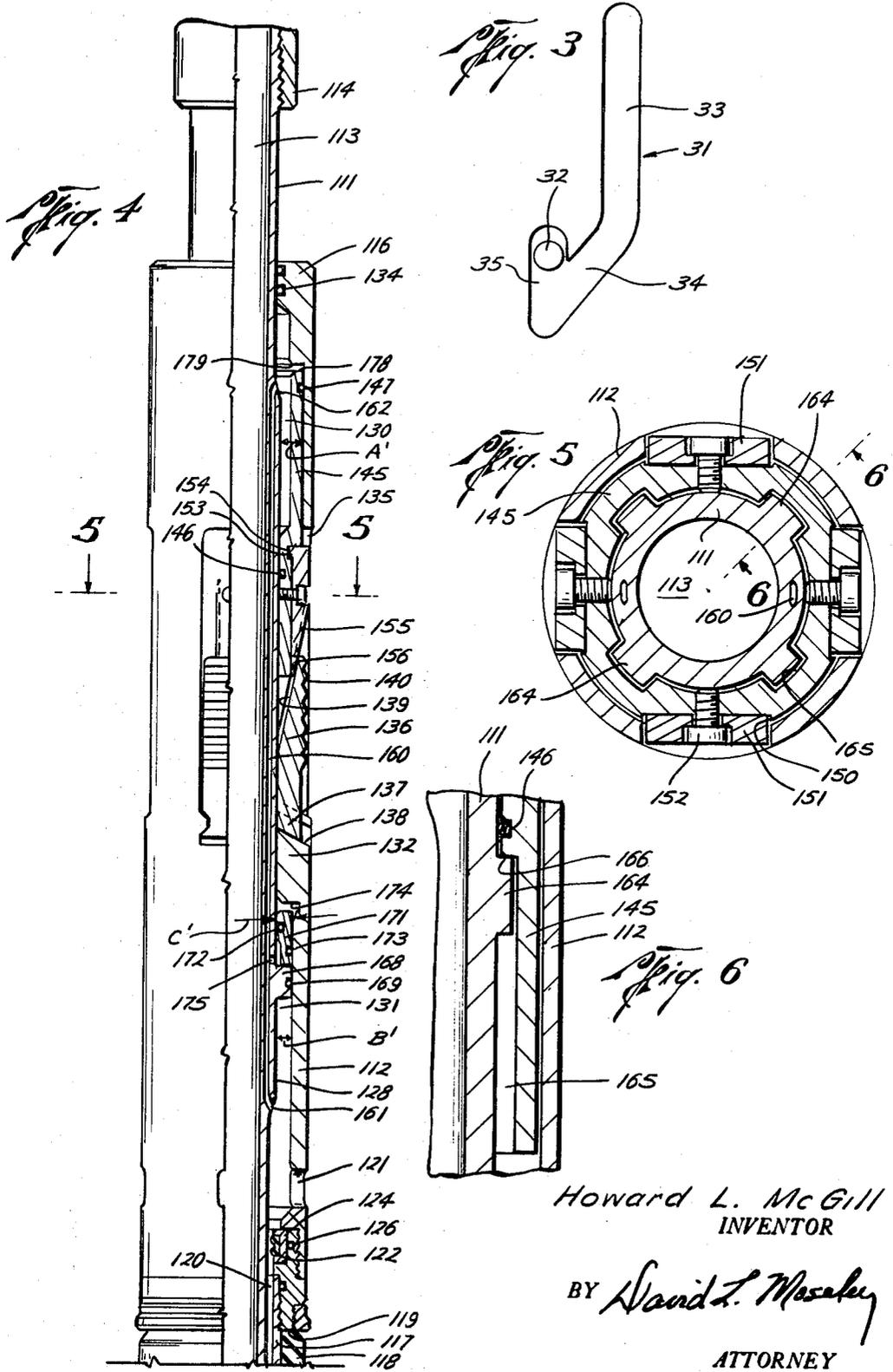
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RETRIEVABLE WELL PACKER

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3 Sheets-Sheet 3



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RETRIEVABLE WELL PACKER

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16 Claims. (Cl. 166—120)

ABSTRACT OF THE DISCLOSURE

A well packer apparatus wherein the expanding anchor comprises two distinct means, one being mechanically actuated and adapted to anchor the packer against movement in one direction and the other being hydraulically operated and adapted to anchor the packer against movement in the other direction. Structure is provided for positively preventing premature operation of either of the anchor means. Additionally, an integral bypass device is included for selective pressure equalization as well as a pressure balancing system.

This invention relates generally to subsurface well tools and more particularly to a new and improved retrievable well packer apparatus adapted to be positioned in a well conduit and anchored against longitudinal movement therein.

A typical retrievable well packer which can be used for performing pressure operations in a well generally includes normally retracted slips and packing which can be selectively expanded for respectively anchoring against downward movement in a well casing and packing off the annulus between the well casing and a tubing string on which the well packer is lowered into the well. A fluid bypass can be provided which is normally open to facilitate rapid movement of the packer through the well fluids during lowering and retrieving and which can be utilized to equalize fluid pressures on the packer after a pressure operation is completed. With the slips and packing expanded and the bypass closed, fluids can be displaced under pressure through the tubing string and well packer and into the well casing below the packer for performing various pressure operations common in the art, such as squeeze cementing, acidizing or hydraulic fracturing.

The pressures developed during such operations act as forces on the packer tending to shift it upwardly within the casing. Since upward movement can unset the packer, it is common practice to provide an auxiliary anchoring mechanism which functions to prevent upward movement. Typically, such auxiliary anchoring mechanisms include normally retracted gripping pistons or buttons which are actuated into gripping engagement with the well conduit in response to fluid pressures developed during the above-mentioned pressure operation.

During rapid descent into a well, fluid pressure surges can be created which cause premature operation of the gripping pistons. The gripping pistons are moved outwardly by the pressure surges and dragged along the well conduit wall until their gripping portions are dulled or otherwise damaged to an extent that they will not function properly when the packer is set.

An object of the present invention is to provide a new and improved well packer apparatus which can be set in a well conduit and anchored against movement in either longitudinal direction.

Another object of the present invention is to provide a new and improved well packer apparatus of the type described which is more positive in operation than has heretofore been known in the art in preventing premature actuation of hydraulically operated anchors.

Another object of the present invention is to provide

a new and improved well packer apparatus of the type described having auxiliary anchors for preventing upward movement under pressure, the anchors being structurally arranged in a manner to positively prevent their operation as the well packer is shifted in either longitudinal direction in a fluid filled well bore. Moreover, the well packer of the present invention can have an integral fluid bypass arrangement which will not be inadvertently opened during a pressure operation.

Yet another object of the present invention is to provide a new and improved well packer apparatus which is effective, simple and reliable in operation.

These and other objects are obtained in accordance with the present invention by providing an apparatus including an anchor body having expansible packing means mounted for sealing engagement with the well conduit and a mandrel movable in said anchor body. A first passageway between the mandrel and the anchor body is provided for bypassing well fluids through the packing means and a valve means is provided for selectively closing the first passageway, the valve means being actuated by movement of the mandrel. Normally retracted gripping members on the anchor body are shiftable outwardly of the anchor body into gripping engagement with the well conduit and a hydraulic member is movable in response to fluid pressure for shifting the gripping members outwardly. A second passageway in communication with the first passageway is provided to enable fluid pressure to act on the hydraulic member. Means on the mandrel is engageable with the hydraulic member to prevent movement of the hydraulic member, and thus actuation of said gripping member, when the bypass valve is in its open condition.

The present invention has other objects and advantages which will become more apparent in connection with the following detailed description. The novel features of the present invention being set forth with particularity in the appended claims, the operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments and taken in conjunction with the accompanying drawings, in which:

FIGURES 1A and 1B are longitudinal sectional views, with portions in side elevation, of one embodiment of a well packer apparatus in accordance with the present invention and with parts in retracted positions for longitudinal movement in a well bore, FIG. 1B forming a lower continuation of FIG. 1A;

FIGURES 2A and 2B are views similar to FIGURES 1A and 1B except with various parts in expanded positions and the well packer set in a well casing;

FIGURE 3 is a plan view of a J-slot which can be used in controlling relative movement of parts of the well packer;

FIGURE 4 is a longitudinal sectional view, with portions in side elevation, of another embodiment of an apparatus in accordance with the present invention;

FIGURE 5 is a cross section on line 5—5 of FIGURE 4 and;

FIGURE 6 is a fragmentary cross section on line 6—6 of FIGURE 5.

Referring initially to FIGURE 1, a well packer apparatus 10 which embodies the principles of the present invention is illustrated with parts thereof in "running-in" positions. The well packer 10 includes a tubular mandrel 11 which is telescopically disposed within an anchor body 12 for sliding movement therein between the extended and contracted positions. The mandrel 11 has a central bore 13 and extends throughout the full length of the tool. A threaded box portion 14 at the upper end of the mandrel 11 is adapted for connection with a tubing string

(not shown) and the lower end of the mandrel has a threaded pin portion 15 to which a section of pipe or another well tool can be connected. The mandrel bore 13 is arranged to continue the full bore size of the tubing string to which the mandrel is coupled.

The anchor body 12 has a reduced diameter compression sleeve 17 coupled to its lower end around which a pliant, elastomeric packing means 18 can be mounted. The upper end of the packing means 18 engages a downwardly facing annular shoulder or abutment 19 and the lower end engages the upper face of an annular abutment ring 20 which is slidable on the compression sleeve 17. The abutment ring 20 is connected to the upper end of a sleeve 21 which extends downwardly to an expander member 22. The packing means 18 can take any conventional form and is shown for purposes of illustration as comprising a plurality of elastomeric packing rings 23 separated by metallic gauge rings 24, the packing rings being adapted for lateral expansion upon compression thereof. The expander member 22 and sleeve 21 can be co-rotatively secured to the compression sleeve 17 by means of coengaging splines 25 or the like. The expander member 22 has downwardly and inwardly inclined outer surfaces 26 thereon which are engageable with mating inner surfaces 27 on a plurality of slip members 28 in a manner whereby downward movement of the expander member relative to the slip members will cause outward shifting of the slip members.

Movably mounted at the lower end portion of the mandrel 11 is a tubular cage member 30. A J-slot 31 typically can be formed in the outer periphery of the mandrel 11 for cooperation with a lug 32 extending inwardly from the cage member 30, the J-slot and lug functioning to control relative movement between the cage member and the mandrel. The J-slot 31, shown in developed view in FIGURE 3, can have a long vertical segment 33 and a relatively short vertical segment 35, the segments 33 and 35 being connected by a tapered segment 34. The lug 32 engages in the short segment 35 when the parts are in a "running-in" position as shown in FIGURES 1A and 1B so that the cage member 30 cannot move substantially relative to the mandrel 11 in either longitudinal direction.

The cage member 30 has a plurality of circumferentially spaced, radially directed recesses 37 in its outer periphery, each of the recesses receiving a typical drag block 38. The drag blocks are urged outwardly by springs 39 for frictional engagement with a well casing wall and function to retard movement of the cage member 20 within the well conduit in a conventional manner. Outward movement of the drag blocks 38 can be limited by annular bands 40 and 41 which are arranged to engage tangs 42 and 43, respectively on each drag block 38.

The slip elements 28 can be movably connected on the upper end of the cage member 30 by T shaped extensions 44 which slidably engage in complementary recesses 45 in the cage member 30. Moreover, a conventional "dovetail" flange and groove connection 46 between each slip element 28 and the expander member 22 may be provided so that relative movement between the slip elements and the expander member will effect lateral movement of the slip elements to and from a well casing wall. Wickers or teeth 47 on the peripheral surfaces of each slip element 28 are formed to face downwardly and are adapted to bite into and grip a well casing to anchor the well packer 10 against downward movement therein.

An intermediate portion 50 of the mandrel 11 is spaced laterally away from the inner surface of the compression sleeve 17 to provide an annular fluid bypass passageway 51. The passageway 51 extends from a plurality of side ports 52 in the expander member 22 to a plurality of bypass ports 53 which extend through the wall of the anchor body 12 above the packing means 18. An internal annular recess 54 in the anchor body 12 adjacent to the upper end of the bypass passageway 51 is arranged to

receive a seal ring 55. The seal ring 55, in turn, has an internal groove 56 in which a suitable bypass seal element 57 is located. For selectively closing the bypass passageway 51, the mandrel 11 has an enlarged diameter section 58 to provide a valve head which is normally located above the seal element 57 and above the bypass ports 53 when the mandrel is in its extended position as shown in FIGURE 1A. In this relative position of parts, the bypass passageway 51 is open for bypassing well fluids through the packing means 18 as the well tool is shifted longitudinally in a well conduit. When the mandrel 11 is moved to a lower or contracted position relative to the anchor body 12, the valve head 58 is moved adjacent to the bypass seal element 57 to block fluid flow through the bypass ports 53 and thus prevent any fluid movement through the bypass passageway 51. Although the seal element 57 has been shown positioned on the anchor body 12, it will be appreciated that the seal element 57 could be alternatively arranged around the valve head 58 and adapted to seal against an inner seal surface on the anchor body when the mandrel is moved downwardly.

The portion of the anchor body 12 above the bypass ports 53 is provided with a plurality of circumferentially spaced, generally rectangular shaped openings 60 each of which receives a holding slip 61. Each holding slip 61 has an inner inclined surface extending downward and inwardly toward the mandrel 11 and has upwardly facing wickers or teeth 62 on its outer surface. Each slip 61 can be slidably connected to the anchor body 12 by an extension 63 which is received within an inclined groove 64 so that the holding slips can be shifted laterally between inner or retracted positions as shown in FIGURE 1A and outer or anchoring positions where the teeth 62 can grip a well conduit wall to prevent upward movement therein.

A hydraulically operated slip expander member 65 is provided for shifting the holding slips 61 between their retracted and extended positions. The expander member 65 is generally tubular in form and is arranged for longitudinal movement within an internal annular recess or chamber 66 formed in the anchor body 12. The chamber 66 is closed off at its upper end by an inwardly extending flange 70 and a seal ring 76 sealingly engages the outer surface of the mandrel 11. The expander member 65 has outer inclined surfaces 67 at a lower portion extending downward and inwardly toward the mandrel 11. The inclined surfaces 67 are complementary in shape and engageable with inclined surfaces 68 on the holding slips 61 so that downward movement of the expander member 65 will effect outward extension of the slips. Each slip 61 can also have a conventional "dovetail" flange and groove connection 69 to the expander member 65 so that upward movement will effect retraction of the slips 61 away from a conduit wall.

The bore of the expander member 65 is sized for sliding reception on the mandrel 11 and a suitable seal element such as an O-ring 71 seals between the inner periphery of the expander member and the outer surface of the mandrel. Another seal element 72 seals between the outer periphery of the expander member 65 and the wall surface of the chamber 66. The cross-sectional area A between the two seal rings 71 and 72 defines a differential area piston on which fluid pressure can act. An internal, elongated annular recess 73 is formed intermediate the ends of the expander member 65 and a shoulder or flange 74 on the mandrel 11 extends outwardly into the recess 73. The mandrel shoulder 74 is arranged to engage a downwardly facing shoulder 75 on the expander member 65 when the mandrel is in its upper or extended position as shown in FIGURE 1A. In this manner, the engaged shoulders 74 and 75 can function positively to prevent any downward movement of the expander member 65 relative to the holding slips 61. Accordingly, the holding slips 61 are positively prevented from being shifted outwardly as long as the parts of the well packer

are in their relative positions for longitudinal movement in a well bore.

The expander member 65 is adapted to be hydraulically operated, when desired, to effect outward shifting of the holding slips 61 into anchoring engagement with a well casing. For hydraulic operation, a pressure communicating passageway 77 is formed in the mandrel 11 to extend from a location below the bypass valve head 58 to lateral ports 78 and 79 which communicate the passageway 77 with the expander member recess 73 and with the anchor body chamber 66 above the expander member 65. When the bypass valve head 58 is engaged with the bypass seal element 57 by movement of the mandrel 11 to its lower or contracted position relative to the anchor body 12, the lower end 80 of the pressure communicating passageway 77 is disposed in a position below the bypass seal element 57. Accordingly, the fluid pressure which exists in the bypass passageway 51 is communicated to the pressure communicating passageway 77 and into the body chamber 66 to act on the upper side of the expander member 65. The lower side of the expander member 65 is in communication with the well annulus above the packing element 18 via the anchor body recesses 60. Therefore, a pressure difference between fluids in the bypass passageway 51 and in the annulus above the packing element 18 can act on the differential area A as a force tending to move the hydraulic expander member 65 vertically relative to the holding slip 61.

An upper internal annular recess in the anchor body 12 forms a chamber 82 which receives a balance piston 83, the balance piston being integrally formed on the mandrel 11. A suitable seal element 84 is positioned to seal between the balance piston 83 and the wall of the chamber 82. Several side ports 85 in the anchor body 12 enable annulus pressures above the packing element 18 to act on the lower face of the balance piston 83. The pressure communicating passageway 77 is arranged to extend upwardly to a port means 86 above the piston 83 to enable fluid pressure in the bypass passageway 51 to act on the upper face of the balance piston 83. Additionally, an annular floating piston member 87 is received at the upper portion of the chamber 82 for sliding movement between an upper position where the floating piston engages the inwardly extending flange 88 at the upper end of the chamber 82, and a lower position where the balance piston abuts against a stop shoulder 89 formed on the mandrel 11. Inner and outer seal elements 93 and 94 prevent fluid leakage past the floating piston 87. Annulus pressures outside of the anchor body 12 can act through side ports 90 on the upper face of the floating piston 87 while fluid pressures in the bypass passageway 51, being reflected in the pressure communicating passageway 77, can act on the lower face of the floating piston member 87. Accordingly, any pressure differential which may be developed can act on the area B of the balance piston 83 and the area C of the floating piston 87 for purposes which will be subsequently described.

In operation, the parts of the well packer 10 are assembled as shown in FIGURES 1A and 1B and the mandrel 11 coupled to a tubing string for lowering into a well casing. During lowering, the cage member 30 is retained in its lower position on the mandrel 11 by engagement of the lug 32 within the short vertical segment 35 of the J-slot 31. The drag blocks 38 can slide along in frictional engagement with a well casing wall and the lower slips 28 are maintained in retracted positions because the cage member 30 cannot move relatively upwardly toward the expander member 22. The packing rings 23 are unexpanded and the valve head 58 on the mandrel 11 is positioned above the bypass seal element 57 so that well fluids can enter the bypass passageway 51 through the lower side ports 52 and exit through the upper bypass ports 53.

The hydraulic expander member 65 is held in its

upper or inactive position by the mandrel shoulder 74 and therefore cannot move downwardly in a manner to actuate the holding slips 61 outwardly. Accordingly, it will be appreciated that although the holding slips 61 can be eventually hydraulically operated, they are positively prevented from being prematurely operated by fluid pressure surges which can be developed within the well packer during rapid descent into a fluid filled well bore.

At setting depth, the well packer is halted and a small upward movement coupled with right hand rotation of the mandrel 11 will position the lug 32 for entry into the long vertical J-slot segment 33 to permit substantial downward movement of the mandrel 11 relative to the cage member 30 for setting the well packer. During downward movement of the mandrel 11, the slips 28 and the cage member 30 are held against downward movement by the drag blocks 38. Downward movement of the mandrel 11 will advance the expander member 22 downward relative to the slips 28 to shift them outwardly into gripping engagement with the well casing P as shown in FIGURE 2B. Further mandrel movement will move the valve head 58 adjacent to the bypass seal element 57 to close the bypass passageway to fluid flow and to engage the mandrel box portion 14 with the upper flange 88 on the anchor body 12.

Inasmuch as the abutment sleeve 21 is supported against further downward movement by the slips 28, the weight of the tubing string can be applied to the mandrel 11 and transmitted through the anchor body 12 to the upper end of the packing element 18. As weight is applied, the upper abutment 19 is advanced toward the lower abutment ring 20 to compress and expand the packing rings 23 outwardly into sealing engagement with the surrounding well casing wall. The weight of the tubing string can be maintained on the well packer to maintain its set condition. It will be noted that when the well packer is set and the bypass ports 53 closed off by the valve head 58, the lower 80 of the pressure communicating passageway 77 is disposed below the bypass seal element 57 so that whatever fluid pressures may exist within the mandrel bore 13 and in the annulus below the expanded packing element 18 are communicated through the bypass passageway 51, the pressure communicating passageway 77 and to the upper side of the hydraulic expander member 65 via the ports 78 and 79. Moreover, the pressure is also communicated to a location between the balance piston 83 and the floating piston 87 via the ports 86. As previously mentioned, whatever fluid pressures may exist in the well annulus above the expanded packing element 18 can act on the lower side of the hydraulic expander member 65 through the holding slip recesses 60, on the lower face of the balance piston 83 through the side ports 85, and on the upper face of the floating piston 87 via the upper side ports 90.

A pressure operation such as squeeze cementing, acidizing, or hydraulic fracturing can now be performed in an interval below the packer 10. If, as is usually the case, tubing pressure should exceed annulus pressure, the pressure difference will act as a force attempting to shift the well packer 10 upwardly within the casing P as well as attempting to move the mandrel 11 upwardly. However, the high tubing pressure is also acting on the upper side of the hydraulic expander member 65, while the lower annulus pressure is acting on the lower side of the hydraulic expander member. Accordingly, the pressure difference acts on the area A as a downward force which moves the hydraulic expander member 65 downwardly to shift the holding slips 61 into gripping engagement with the well casing, thereby preventing any upward movement of the well packer 10. Moreover, the higher tubing pressure is communicated into the balance chamber 82 to act downwardly on the upper face of the mandrel balance piston 83, while lower annulus pressures are acting on the lower face on the balance piston. Accord-

ly, the pressure difference can act across the area B as a downward force tending to counterbalance the upward force on the mandrel 11 due to high tubing pressure, thereby substantially minimizing the net upward force on the mandrel and preventing any upward shifting of the mandrel 11 during a pressure operation. The pressure differential is also acting upwardly on the area C of the floating piston 87 but the floating piston can merely shift upwardly into engagement with the anchor body flange 88. Since the anchor body 12 is anchored against upward movement by the holding slips 61, the upward force on the floating piston 87 is of no consequence.

Should annulus pressure exceed tubing pressure, for example, where fluid is lifted within the tubing by "swabbing" to test the success of an acidizing operation, the higher annulus pressure acts downwardly on the well packer 10 in a conventional manner to set the packing element 18 and the lower slips 28 even more tightly within the well casing P. However, the higher annulus pressure will tend to lift the hydraulic expander member 65 upwardly within the anchor body 12 since the lower tubing pressure is acting on the upper side of the hydraulic expander member 65. Under this influence, the hydraulic expander member 65 can move upwardly until its upper end surface 91 engages a downwardly facing shoulder 92 on the anchor body 12. This movement will retract the holding slips 61 and can occur without the hydraulic member 65 engaging the mandrel stop shoulder 74. Since the lower tubing pressure is now acting on the upper face of the balance piston 83 and the higher annulus pressure is acting on the lower face thereof, there is an upward force on the area B on the balance piston 83. However, the pressure difference is now acting downwardly on the floating piston 87 which can move downwardly to engage the stop shoulder 89 on the mandrel 11. The effective pressure areas B and C of the balance piston and floating piston respectively can be made substantially the same so that force on the mandrel 11 due to pressure acting on the pistons is counterbalanced. Accordingly, the mandrel 11 will not be moved upwardly to inadvertently open the bypass ports 53.

To release the well packer 10 for retrieval to the surface it is only necessary to remove the tubing weight from the mandrel 11 and lift the mandrel upwardly. If the holding slips 61 are not already retracted by higher annulus pressure as previously described, upward movement of the mandrel 11 will engage the mandrel shoulder 74 with the hydraulic expander member 65 and thus shift it upwardly to retract the holding slips 61. Also, upward movement of the mandrel 11 will position the valve head 58 above the bypass seal element 57 to open the bypass ports 53 and permit equalization of any existing pressure differentials across parts of this packer. As compressive force is removed from the packing rings 23, they will inherently retract and eventually the lower expander member 65 will be moved upwardly relative to the lower slip elements 28 to cause their release and retraction. When sufficient upward mandrel movement has occurred, the cage member 30 will occupy its initial lower position relative to the mandrel 11 and the lug 32 will again engage in the slot segment 35 to "re-jay" and lock the packer parts in retracted positions for longitudinal movement in the casing P.

An alternative embodiment of an apparatus which embodies the principles of the present invention is shown in FIGURE 4. Only the upper portion of the apparatus is shown for convenience of illustration and it will be appreciated that the lower portion can embody structural elements similar to those shown in FIGURE 1B or their equivalents. A mandrel 111 is telescopically disposed for movement in anchor body 112 between an extended position, as shown, and a contracted position where a box portion 114 on the mandrel 111 engages an inwardly extending flange 116 on the anchor body. The mandrel 111

has a central bore 113 extending throughout its length which can continue the full bore of a tubing string (not shown) to which the box portion 114 can be connected.

The anchor body 112 has a reduced diameter compression sleeve 117 threadedly coupled to its lower end; the compression sleeve having an elastomeric packing element 118 mounted around its periphery with its upper end engaging a downwardly facing shoulder or abutment 119 on the anchor body 112. The inner periphery of the compression sleeve 117 is laterally spaced from the outer periphery of the mandrel 111 to provide an annular bypass passageway 120 which extends upwardly to several side ports 121 in communication with the well annulus above the packing element 118. A bypass seal element 122 is disposed adjacent the upper end portion of the bypass passageway 120 and can be positioned within an internal annular groove formed in a seal ring 124 which is, in turn, located with an internal annular recess in the anchor body 112. A suitable seal element 126 can be positioned adjacent to the seal ring 124 to prevent any fluid leakage past the seal ring.

An annular valve head 128 is formed on the mandrel 111 by an enlarged diameter portion thereof. The valve head 128 is normally positioned above the bypass seal element 122 when the mandrel 111 is in its extended position so that fluids can flow freely through the bypass passageway 120 and the side ports 121. When the mandrel 111 is moved downwardly relative to the anchor body 112, the outer peripheral surface of the valve head 128 can sealingly engage the bypass seal element 122 to block fluid flow from the bypass passageway 120 to the well annulus via the side ports 121.

The anchor body 112 has upper and lower annular chambers 130 and 131, respectively, formed therein and separated by an annular, inwardly extending flange 132. The upper annular flange 116 extends inwardly to close the upper end of the upper chamber 130 and a seal element 134 sealingly engages the outer surface of the mandrel 111. The upper chamber 130 is opened to the exterior of the anchor body 112 by a plurality of circumferentially spaced, generally rectangular shaped openings 135 and each of the openings receive a holding member in the form of a slip element 136. The slip elements 136 are each movable within a respective opening between a retracted position, as shown, and an extended position. Each slip element 136 can be slidably connected to the anchor body 112 by a T shaped extension 137 at its lower end which engages in a mating inclined groove 138 in the inwardly extending flange 132. Moreover, each slip element 136 has inner inclined surfaces 139 which extend downwardly and inwardly toward the mandrel 111 and has upwardly facing wickers or teeth 140 on its outer periphery which are adapted, when the slip element is extended, to grip a well casing wall.

For actuating the holding slips 136 between retracted and extended positions, a hydraulic member 145 is provided which is arranged for reciprocating movement within the upper chamber 130. The hydraulic member 130 is generally tubular in form and has a bore there-through which is sized for sliding reception on the mandrel 111. An inner seal element 146 seals between the inner surface of the hydraulic member and the outer surface of the mandrel 111 while an outer seal element 147 seals between the outer periphery of the hydraulic member and the wall surface of the chamber 130. The cross-sectional area A' between the two seal elements 146 and 147 defines a differential area piston on which fluid pressure can act.

The lower end portion of the hydraulic member 145 can have a plurality of longitudinally extending pockets 150, each of which receives a wedge-shaped expander insert 151. The expander inserts 151 can be rigidly but removably connected to the hydraulic member 145 by suitable fasteners such as threaded studs 152. Each insert can have an inwardly extending lip 153 which engages

in a recess 154 to further secure the inserts for longitudinal movement with the hydraulic member 145. The outer surface 155 of each expander insert 151 is formed to incline downwardly and inwardly toward the mandrel 111 and is complementary in shape to the inner inclined surfaces 139 on the holding slips 136. Each slip 136 is arranged to engage a respective insert 151 in a manner whereby downward movement of the hydraulic member 145 will effect outward movement of the slips. Each holding slip 136 can further be slidably connected to a respective expander insert 151 by a conventional "dovetail" flange and groove arrangement 156 so that upward movement of the hydraulic member 145 will effect inward retraction of the slips.

To enable fluid pressure to act on the hydraulic member 145, a pressure communicating passageway 160 can be formed to extend along the mandrel 111 from an opening 161 below the valve head 128 to an opening 162 which is in communication with the upper chamber 130 above the hydraulic member 145. Thus it will be appreciated that whatever fluid pressures exist in the bypass passageway 120 are reflected in the upper chamber 130 to act on the upper side of the hydraulic member 145 whether the valve head 128 is in its open or closed position. Also, whatever fluid pressure may exist in the well annulus above the packing element 118 is communicated through the anchor body openings 135 to act on the lower side of the hydraulic member 145. Accordingly, whenever the fluid pressure in the bypass passageway 120 exceeds the annulus pressure, the pressure difference acts on the area A' as a force in a downward direction tending to move the hydraulic member 145 downwardly and to expand the holding slips 136.

In order to prevent premature expansion of the holding slips 136 when the mandrel 111 is in its extended position for lowering or retrieving in a well bore, the mandrel is provided with several outwardly extending lugs or shoulders 164 as shown in FIGURES 5 and 6 which can be circumferentially offset relative to the slips 136. The shoulders 164 are slidably received in grooves 165 which extend longitudinally in the hydraulic member 145, the upper end of each groove 165 defining a downwardly facing shoulder 166 against which the upper face of a respective mandrel lug 164 can engage when the mandrel 111 is in its extended position. Accordingly, the hydraulic member 145 is positively retained in an upper or inactive position and cannot move downwardly to shift the holding slips 136 outwardly. It will be appreciated that this structural arrangement prevents any possibility of premature actuation of holding slips 136 when the parts of the well packer are in relative positions for longitudinal movement in a well. However, when the well packer is set and the mandrel 111 is in its contracted position within the anchor body 112, the mandrel lugs 164 are moved downwardly away from the groove shoulders 166 a sufficient distance to permit free longitudinal movement of the hydraulic member 145 as it functions to actuate the holding slips 136.

The pressure differential necessary to operate the hydraulic member 145 and thus the holding slips 136 is derived from the high tubing pressures normally developed during a pressure operation. The high tubing pressure is communicated from below the well packer upwardly through the closed bypass passageway 120, through the pressure communicating passageway 160, the passageway opening 162 and into the upper chamber 130 to act on the upper side of the hydraulic member 145. As the tubing pressure exceeds the annulus pressure which is acting on the lower side of the hydraulic member 145, downward force is developed to reciprocate the hydraulic member 145 downwardly and thereby shift the holding slips 136 outwardly to anchor the well packer 110 against upward movement in response to high pressure from below.

The higher fluid pressure within the mandrel 111 also acts on the mandrel in an upward direction and tends to

lift or pump the valve head 128 upwardly to an open position. This occurrence is undesirable because it would serve to equalize pressures on the well packer prematurely. Accordingly, a balancing system is included in accordance with the present invention and comprises a piston 168 which can be integrally formed on the mandrel 111 and arranged for reciprocating motion within the lower chamber 131. A seal element 169 in a suitable groove around the outer periphery of the piston 168 engages the wall surface of the chamber 131 to prevent fluid leakage past the piston. An annular floating piston member 171 is also positioned within the chamber 131 above the balance piston 168 and inner and outer seals 172 and 173 prevent fluid leakage past the floating piston. It will be appreciated that the floating piston 171 is free to move longitudinally within the chamber 131 between limits defined by the lower face 174 of the flange 132 and the upper face of the balance piston 168. The chamber space located between the balance piston 168 and the floating piston 171 is placed in communication with the pressure communicating passageway 160 by a lateral port means 176.

The balancing system operates in the following manner. When there exists high tubing pressure, the pressure is communicated through the bypass passageway 120, past the valve head 128 via the pressure communicating passageway 160 and into the chamber space between the two piston members 168 and 171. The pressures in the annulus above the packer are communicated to the upper face of the floating piston 171 through the anchor body openings 135, and to the lower face of the balance piston 168 through the bypass ports 121. The pressure difference will act on the balance piston area B' as a downward force on the mandrel 111 tending to counterbalance the upward force on the mandrel due to high pressure from below. Accordingly, the bypass valve head 128 will not be lifted to an open position by the high tubing pressure. Under these conditions, the floating piston member 171 can merely move upwardly until it engages the anchor body flange 132. Forces on the floating piston 171 cannot cause upward movement of the anchor body 112 because it is anchored against upward movement by holding slips 136.

Moreover, should annulus pressure exceed tubing pressure, the pressure difference will act upwardly on the hydraulic member 145 to shift it upwardly until its upper end surface 178 engages the lower surface 179 of the upper anchor body flange 116. This movement will retract the holding slips 136 and can occur without transmitting any force directly to the mandrel 111. Since the upper end of the anchor body 112 is engaging the box portion 114 on the mandrel 111, the anchor body 112 cannot move upwardly relative to the mandrel 111 responsive to high annulus pressures. Also, the directions are reversed in which pressure forces are acting on the balance piston 168 and the floating piston 171. That is to say, should annulus pressure exceed tubing pressure, the pressure difference acts on the area B' as an upward force, and on the area C' as a downward force. Under these influences, the floating piston 171 can move downwardly to engage the balance piston 168 and the areas B' and C' can be made the same so that the net force is zero due to pressures acting on the floating and balance pistons.

The various parts of the apparatus shown in FIGURE 4 can be operated to retracted positions for retrieval from the well by upward movement of the mandrel 111 in the same manner as described relative to the apparatus shown in FIGURES 1A and 1B. Upward movement of the mandrel 111 will open the bypass passageway 120 to equalize pressures and permit retraction of the packing element 118 as well as engaging the mandrel lugs 164 with the hydraulic member shoulders 166 to retain the hydraulic member 145 in its upper or inactive

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position. The well packer 110 can then be retrieved from the well bore or moved to another setting position.

A new and improved well packer has been disclosed which can be anchored in a well conduit against movement in either longitudinal direction. The well packer has an integral bypass and pressure equalizing means as well as a pressure balancing system. The well packer is structurally arranged to prevent premature operation during lowering or retrieving.

Since certain changes or modifications may be made in the disclosed embodiments of the present invention without departing from the inventive concepts involved, it is intended that the appended claims cover all such changes or modifications falling within the true spirit and scope of this invention.

I claim:

1. A well packer for use in a well bore comprising: a body member; a mandrel movable in said body member and adapted for connection to a running-in string, said mandrel having a bore; packing means on said body member adapted for sealing off said body member in a well bore; slip means movable between retracted and expanded positions for anchoring said body member in a well conduit against substantial movement in either direction, at least one of said slip means disposed on said body member on one side of said packing means; hydraulic means for actuating said one slip means; passage means extending from said hydraulic means to the other side of said packing means along said body member said mandrel and externally of said bore to enable fluid pressure on said other side to act on said hydraulic means; and means on said mandrel engageable with said hydraulic means for releasably holding said slip means in a retracted position.

2. The well packer of claim 1 further including chamber means between said mandrel and said body member; balancing means on said mandrel and movable in said chamber means; and means to enable said fluid pressure to act on said balancing means.

3. A well tool comprising: an anchor body having expansible packing means mounted thereon for sealing engagement with a well conduit; a mandrel movable in said anchor body; a first passageway between said mandrel and anchor body for bypassing well fluids through said packing means; passageway closing means actuated by movement of said mandrel for selectively closing said first passageway; a second passageway in communication with said first passageway; normally retracted gripping members on said anchor body shiftable outwardly of said anchor body for gripping a well conduit; hydraulic means movable in response to pressure in said first and second passageways for shifting said gripping members outwardly; and means on said mandrel engageable with said hydraulic means for normally preventing movement of said hydraulic means to actuate said gripping members when said passageway closing means is open.

4. The well packer of claim 3 including piston means on said mandrel subject to fluid pressure to said first and second passageways when said passageway closing means is closed for exerting a force on said mandrel in a direction to maintain said first passageway closing means closed.

5. A well tool comprising: an anchor body; a mandrel telescopically arranged in said anchor body; expansible packing means on said anchor body adapted for lateral expansion to pack off a well conduit; a bypass passageway between said packing means and said mandrel and extending along said mandrel between locations above and below said packing means; valve means actuated by telescoping movement of said mandrel and arranged to close said bypass passageway adjacent an end portion thereof; holding means on said anchor body shiftable outwardly thereof for gripping a well conduit to prevent movement in one longitudinal direction; hydraulic means movable between said mandrel and said anchor body for shifting

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said holding means outwardly; pressure communicating means for enabling fluid pressure in said bypass passageway to act on said hydraulic means; and means on said mandrel engageable with said hydraulic means for selectively preventing operation of said hydraulic means, thereby selectively preventing operation of said holding means.

6. The well tool of claim 5 further including cylinder means in said anchor body; balance means on said mandrel and sealingly engaging said cylinder means; and means to enable fluid pressure in said bypass passageway to act on said balance means.

7. The well tool of claim 5 wherein said hydraulic means has inclined surfaces slidably engageable with inclined surfaces on said holding means for shifting said holding means outwardly.

8. The well tool of claim 7 further including coengageable means on said inclined surfaces for shifting said holding means inwardly to retracted positions.

9. The well tool of claim 5 further including first cylinder means in said anchor body, and wherein said hydraulic means includes seal means slidably and sealingly engaging said first cylinder means.

10. The well tool of claim 9 further including second cylinder means in said anchor body; balancing means on said mandrel and sealingly engaging said second cylinder means; and means to enable fluid pressure in said bypass passageway to act on said balance means.

11. A well packer comprising: body means having expansible packing means mounted thereon for sealing engagement with a well conduit; a mandrel adapted for connection to a pipe string and movable in said anchor body between first and second positions; a bypass passageway between said mandrel and body means and extending along said mandrel between locations above and below said packing means; bypass passageway closing means actuated by movement of said mandrel for closing said bypass passageway in one of said positions, said bypass passageway being open in the other of said positions; another passageway in communication with said bypass passageway when said mandrel is in at least one of said positions; normally retracted gripping members on said body means and shiftable outwardly thereof for gripping a well conduit; hydraulic means actuated in response to pressure in said other passageway for shifting said gripping members outwardly; and means including a shoulder on said mandrel engageable with said hydraulic means for holding said hydraulic means against movement when said bypass passageway is open to positively prevent outward shifting of said gripping members.

12. A well packer apparatus comprising: a body; a mandrel telescopically disposed in said body for movement between extended and contracted positions; normally retracted slips and packing means for respectively anchoring in a well conduit and packing off well conduit, said slip means being arranged to prevent movement of said apparatus in one longitudinal direction; a bypass passageway between said packing means and said mandrel; valve means operable when said mandrel is in said contracted position for closing said bypass passageway; normally retracted gripping members on said body for anchoring said apparatus against movement in the opposite direction; hydraulic means for actuating said gripping members into anchoring engagement with a well conduit; means for enabling fluid pressure in said bypass passageway, when closed, to act on said hydraulic means; and means on said mandrel engageable with said hydraulic means when said mandrel is in its extended position for preventing operation of said hydraulic means.

13. A well packer comprising: an anchor body; a sleeve coupled to the lower end portion of said anchor body; elastomeric packing means mounted around said sleeve and adapted for expansion to pack off a well bore; a mandrel adapted for connection to a tubing string and extending concentrically through said anchor body

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and sleeve, said mandrel being arranged for telescoping movement therein between extended and contracted relative positions; a bypass passageway between said sleeve and said mandrel and extending between locations above and below said packing means; bypass closing means operated by movement of said mandrel to said contracted position for selectively closing said bypass passageway; slip members on said anchor body and shiftable outwardly thereof for anchoring against movement in a well casing; hydraulic means for shifting said slip member outwardly, said hydraulic means being movable along said mandrel and said anchor body; means to enable fluid pressure to act on said hydraulic means including a pressure communicating passageway extending between locations below said bypass closing means and above said hydraulic means; and means engageable with said hydraulic member when said mandrel is in said extended position for preventing movement of said hydraulic means, thereby to prevent outward shifting of said slip members.

14. The well packer of claim 13 further including chamber means between said anchor body and said mandrel; a balance piston coupled to said mandrel and movable in said chamber means; and means to enable fluid pressure in said pressure communicating passageway to act on said balance piston for exerting a balancing force on said mandrel when said hydraulic member is actuating said slip members.

15. The well packer of claim 14 further including a floating piston member movable in said chamber means relative to both said mandrel and said anchor body; and means to enable fluid pressure to act on said floating piston member for balancing force on said balance piston when said hydraulic member is not actuating said slip members.

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16. A well packer comprising: an anchor body; a mandrel movable in said anchor body between extended and contracted positions; expansible packing means mounted on said anchor body and arranged to pack off a well bore; means operable when said mandrel is in said contracted position for expanding said packing means; holding means on said anchor body and shiftable between extended and retracted positions for anchoring against movement in one longitudinal direction; hydraulic means between said anchor body and mandrel and movable relative to both said anchor body and said mandrel for shifting said holding means between extended and retracted positions; means for enabling fluid pressure to act on said hydraulic means including a normally open bypass passageway between said mandrel and said anchor body and extending between locations above and below said packing means; valve means operable when said mandrel is in said contracted position for closing off said bypass passageway, said enabling means being in communication with said bypass passageway when closed; and means engageable with said hydraulic means when said mandrel is extended for holding said hydraulic means in an inactive position so that said hydraulic means cannot function to shift said holding means.

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