July 29, 1969 J. E. STACHOWIAK 3,457,994

WELL PACKER VALVE STRUCTURE

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Fig. 1B

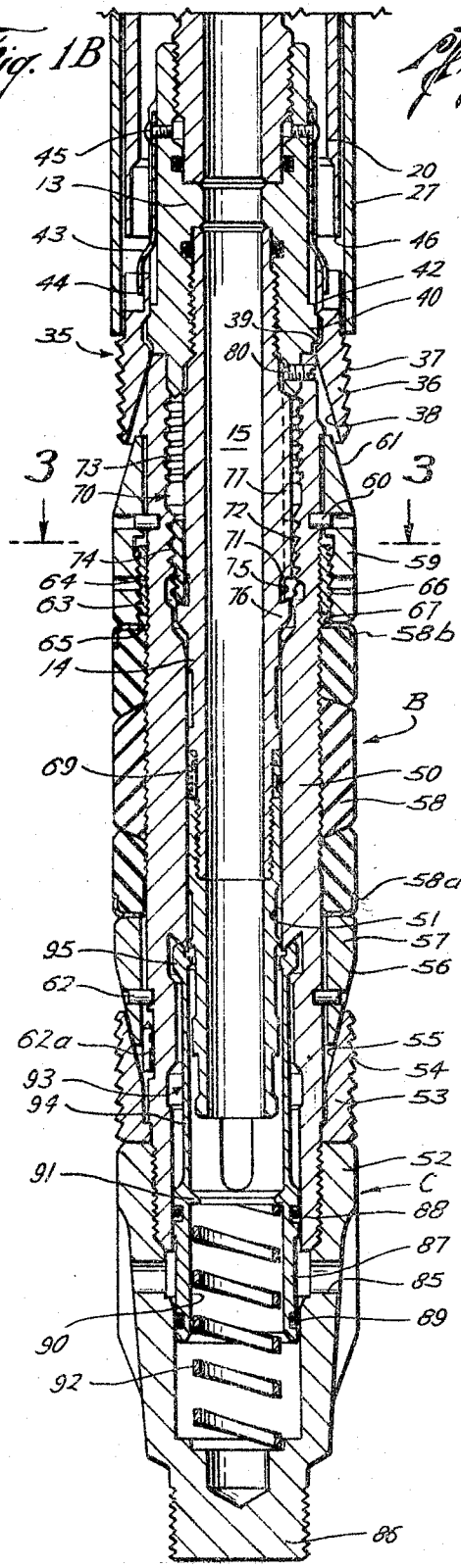
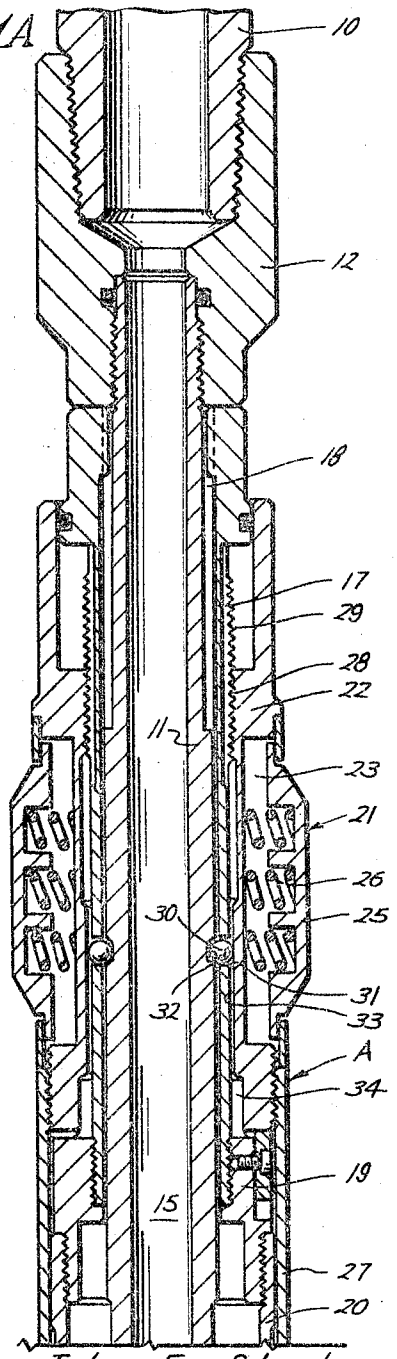


Fig. 1A



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WELL PACKER VALVE STRUCTURE

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Fig. 2B

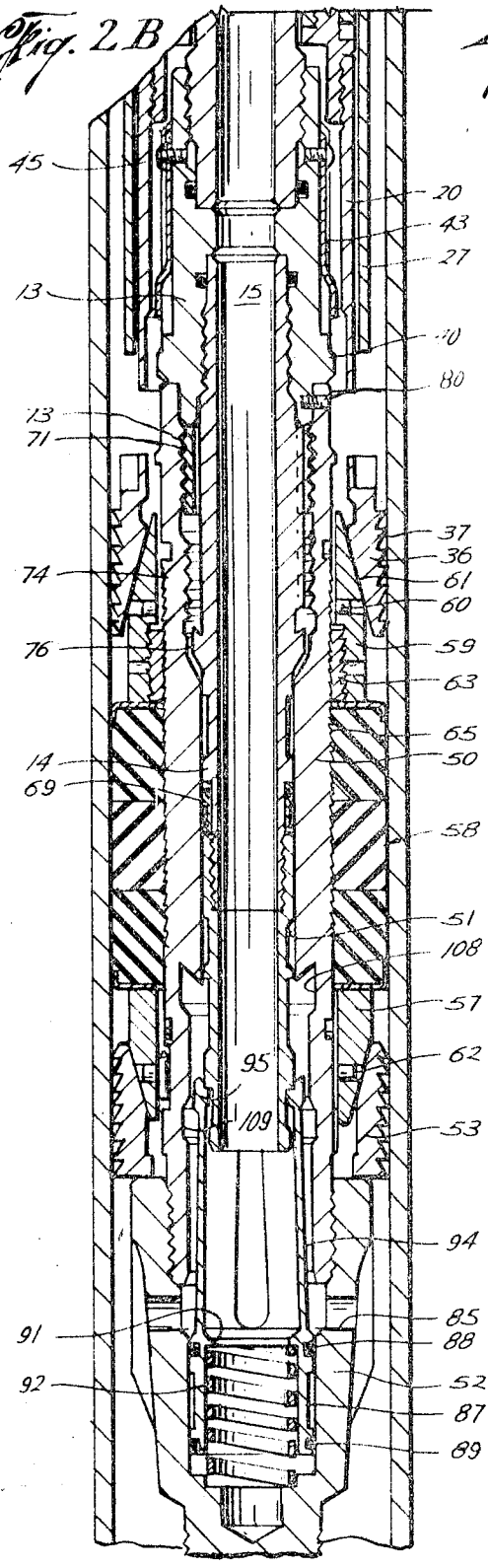
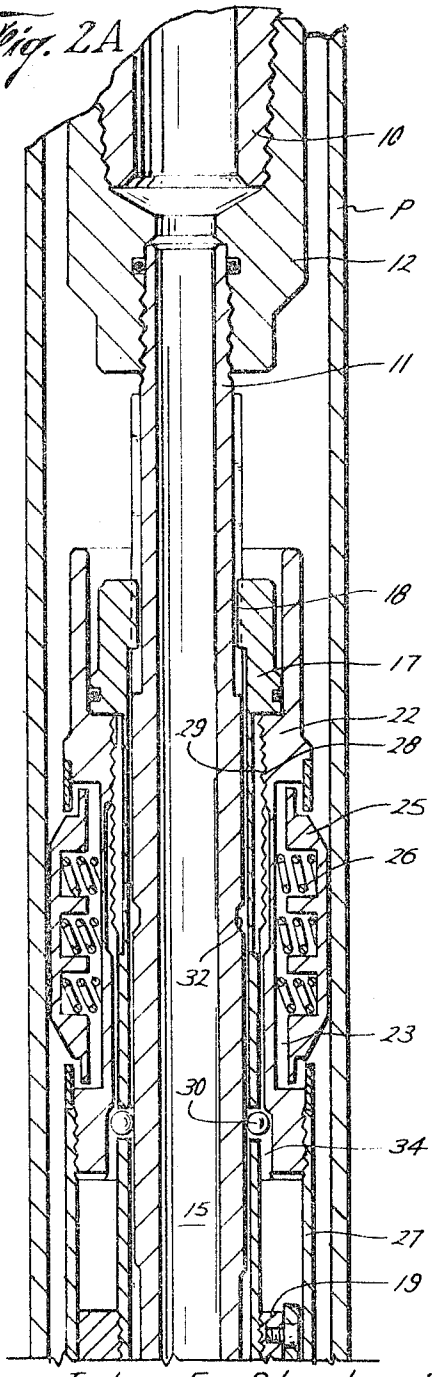


Fig. 2A



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WELL PACKER VALVE STRUCTURE

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Fig. 4

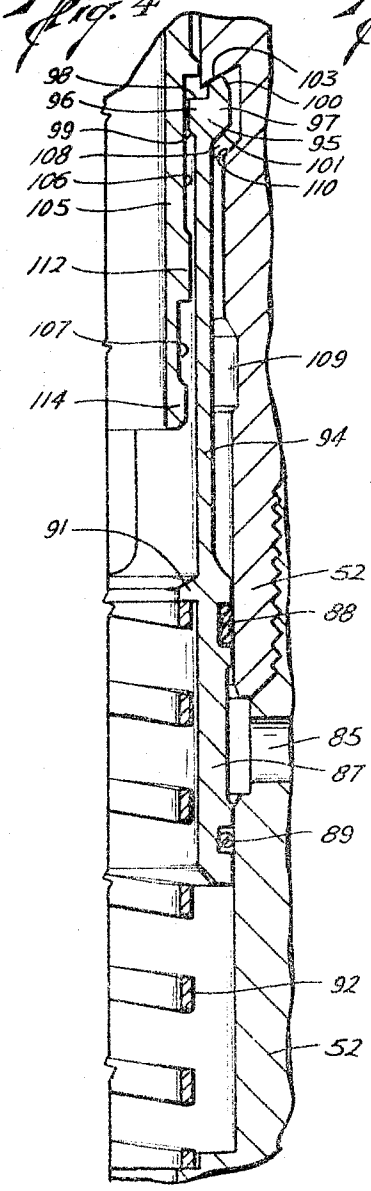


Fig. 5

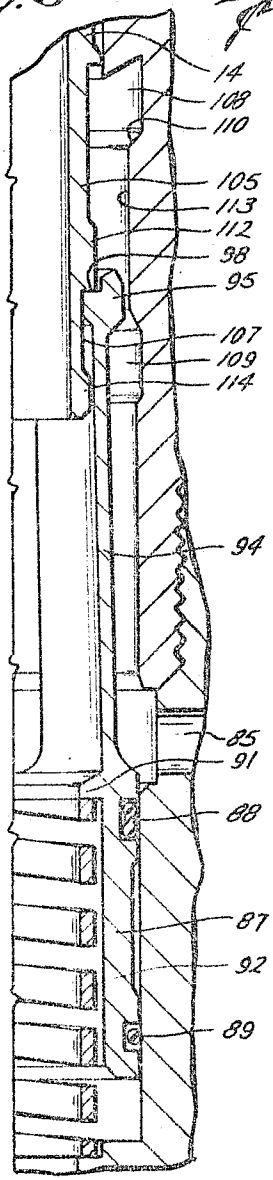


Fig. 6

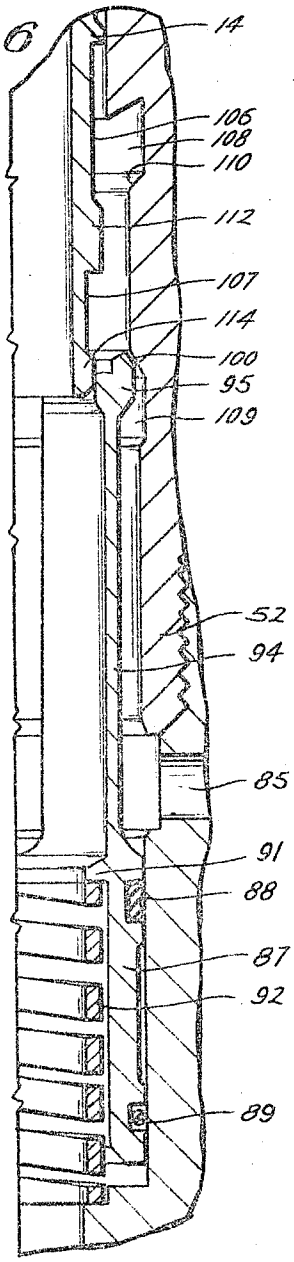
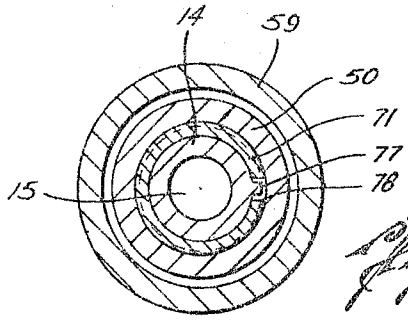


Fig. 3



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United States Patent Office

3,457,994

Patented July 29, 1969

3,457,994

WELL PACKER VALVE STRUCTURE

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Filed May 18, 1967, Ser. No. 639,441
Int. Cl. E21b 33/12, 23/00
U.S. Cl. 166—125 14 Claims

ABSTRACT OF THE DISCLOSURE

A well packer apparatus for use in performing pressure operations in a well includes a body having a fluid passage. A pressure balanced valve element is movable upwardly and downwardly in the body for opening and closing the passage. The valve element is releasably coupled to an actuator by a latch device which permits initial positioning of the valve element in open or closed position, and which positively couples the valve element to the actuator during movement of the valve element by the actuator between open and closed positions. Moreover, the valve element and actuator can be recoupled to one another after release of the latch device regardless of the position of the valve element with respect to the flow passage.

The present invention relates generally to well packers. More specifically, the present invention relates to a well packer apparatus adapted to be lowered into a well on a running-in string and set in packed-off condition, such apparatus having a flow passage and a valve structure for controlling fluid flow through the passage.

An object of the present invention is to provide a new and improved well packer apparatus having a flow passage and a valve for controlling fluid flow through the passage, the valve being arranged for opening and closing by longitudinal motion of an actuator and to be initially either opened or closed during lowering as desired.

Another object of the present invention is to provide a new and improved well packer apparatus of the type described having a pressure balanced valve structure which can be shifted between open and closed condition by upward and downward motion imparted to the running-in string at the top of the well bore, the actuator for the valve structure being releasably coupled thereto by a latch device which can couple the valve and actuator to one another in various initial conditions of the valve structure with respect to the flow passage.

Yet another object of the present invention is to provide a new and improved well packer apparatus of the type described and wherein the valve is more positive in operation and free of malfunction than has heretofore been known in the art.

These and other objects are attained in accordance with the concepts of the present invention by providing a well packer having a valve body with a fluid passage therethrough. A valve element is movable upwardly and downwardly in the valve body between positions opening and closing the fluid passage. The valve element can be releasably coupled by a latch device to an actuator which can be moved upwardly and downwardly in the valve body for imparting motion to the valve element.

The latch device is cooperable with the actuator and valve body for initially positioning the valve element in either its open or closed condition as desired; in either condition, the latch device is locked with respect to the actuator so that the valve element cannot inadvertently move to the other condition. Regardless of the initial condition of the valve element, reciprocating motion of the

actuator will cause positive movement of the valve element between its open and closed conditions as desired.

The latch device is also structurally arranged together with the valve body and actuator so that the valve element can be coupled for positive movement with the actuator even though the valve element does not initially occupy either its open or closed position. The structural arrangement includes a groove in the valve body into which the latch means can move to permit proper positioning of the actuator and valve element, and a biasing means to force the valve element toward the actuator and the latch means into coupled relationship therewith.

This invention has other objects and advantages which will become more apparent in connection with the following detailed description. A preferred embodiment of the present invention is shown in the accompanying drawings in which:

FIGURES 1A and 1B are longitudinal sectional views, with portions in side elevtaion, of the present invention with parts in retracted positions for lowering into a well, FIGURE 1B forming a lower continuation of FIGURE 1A;

FIGURES 2A and 2B are views similar to FIGURE 1 except with the invention illustrated in packed-off condition in a well conduit;

FIGURE 3 is a cross section on line 3—3 in FIGURE 1B; and

FIGURES 4–6 are enlarged, fragmentary sectional views illustrating in detail the structure and operating modes of the valve structure in accordance with the present invention.

Referring to FIGURES 1A and 1B, the apparatus of the present invention broadly includes a setting tool assembly A, a packer assembly B and a valve assembly C. The entire apparatus is arranged to be lowered into a well bore on a running-in string **10** of tubing or drill pipe. When set in the well bore, the packer assembly B packs off the annulus between the well casing and the running-in string **10**. The running-in string **10** provides a conductor through which fluid under pressure can be supplied to the well bore below the packer assembly B, as well as an operating member which can be manipulated at the earth's surface for setting the packer assembly B and for opening and closing the valve assembly C.

The setting tool assembly A includes a central mandrel **11** which is coupled at its upper end by a collar **12** to the running-in string **10**, and coupled at its lower end by a mounting sub **13** to an elongated mandrel extension or "stinger" **14**. The mandrel **11** and extension **14** have a fluid passage **15** therethrough in communication with the bore of the running-in string **10**. A control sleeve **17** is co-rotatively secured to the mandrel **11** by splines **18** or the like, the control sleeve being threadedly coupled by a sub **19** to a downwardly depending setting sleeve **20**. A friction drag mechanism **21** is mounted on the control sleeve **17** and includes a tubular cage **22** having a plurality of circumferentially spaced, radially directed recesses **23**, each of which receives a typical drag block **25** which is urged outwardly by coil springs **26**. The drag blocks **25** are arranged to frictionally engage the inner surface of a well casing to resist both longitudinal and turning motion of the cage **22** within the well casing in a conventional manner.

The cage **22** is connected at its lower end to a retainer sleeve **27** which initially extends downwardly below the lower end of the setting sleeve **20** for purposes which will be hereinafter described. Moreover, the cage **22** is coupled to the control sleeve **17** by internal right-hand threads **28** which engage companion external threads **29** on the control sleeve. It will be appreciated that the cage **22** is vertically fixed in a lower position relative to the control sleeve during lowering into a well bore. At setting depth,

right-hand rotation of the mandrel **11** and control sleeve **17** will cause upward feeding of the cage **22** and retainer sleeve **27** along the control sleeve due to the interengagement of the threads **28** and **29**, the cage **22** being held against rotation by frictional engagement of the drag blocks **25** with the well casing.

The control sleeve **17** will rotate with the mandrel **11** due to the interengagement of the splines **18**. The control sleeve **17** is initially locked against longitudinal movement relative to the mandrel **11** by a suitable latch device which can include a ball **30** which is engaged in an aperture **31** in the control sleeve and in a mandrel detent **32**, the ball being held inwardly in engaged condition by an inner surface **33** on the cage **22**. However, upward feeding of the cage **22** along the control sleeve **17**, as previously described, will eventually position an internal cage recess **34** opposite the ball **30** and permit the ball to shift outwardly and disengage from the mandrel detent **32** to free the mandrel **11** for upward movement relative to the control sleeve **17** and the cage **22**.

The mounting sub **13** located between the mandrel **11** and the mandrel extension **14** is arranged to carry the upper slips **35** for the packer assembly B. The upper slips can be formed in segments **36** with each segment having external wickers or teeth **37** which face upwardly and are adapted to grip a well conduit wall and prevent upward movement. Each segment **36** further has an inner surface **38** which inclines downwardly and outwardly, and has an internal annular recess **39** which receives an external flange **40** on the mounting sub **13**. Each segment **36** also has an upwardly extending section **42** over which the lower end portion of the retainer sleeve **27** extends to hold the segments in engagement with the sub flange **40**, thereby preventing any vertical motion of the slip segments relative to the mounting sub **13** as long as the retainer sleeve **27** encompasses the upper sections **42** of the segments as shown in FIGURE 1B. Each slip segment **36** is further retained on the mounting sub **13** by a leaf spring **43** having its free end engaging in an external notch **44** formed in each segment, the other end of each leaf spring being connected to the mounting sub by a screw **45** or other suitable fastening device. It will be appreciated that the engagement of the retainer sleeve **27** over the upper sections **42** of the slip segments **36** provides a strong and rigid coupling to prevent any longitudinal motion which might result in prematurely setting the slips. Even when the retainer sleeve **27** is removed by upward feeding of the cage **22**, as previously described, the slip segments are still retained on the mounting sub **13** by the inward bias of the leaf springs **43**. However, upward feeding of the retainer sleeve **27** clears the lower end surface **46** of the setting sleeve **20** for engagement with the upper end surfaces of the slip segments **36** so that the setting sleeve can exert a holding force on the segments. Accordingly, when the mandrel **11** is freed from the control sleeve **17** by rotation, as previously described, the mandrel can then be elevated by upward movement of the running-in string **10** to engage the slips with the setting sleeve **20**. Inasmuch as the control sleeve **17** is still coupled to the drag cage **22** by the threads **28** and **29**, the drag cage **22**, control sleeve **17** and setting sleeve **20** will transmit the holding force of the drag blocks **25** to the slip segments **36** to hold the segments against upward movement as the mandrel **11** is moved upwardly for shifting the slips outward into gripping engagement with the well casing.

As shown in FIGURE 1B, the packer assembly B includes a body **50** having a central bore **51** which is sized to receive the mandrel extension **14**, the lower end of the body being constituted as a valve housing by a guide and valve body **52** threadedly coupled at its lower end. Mounted at the lower portion of the packer body **50** are slips **53** of any typical construction having wickers or teeth **54** facing in a downward direction and capable of anchoring, when expanded, against downward movement in the well casing. The slips **53** rest on the guide **52** and have inner surfaces **55** inclined downward and inwardly and arranged to engage companion external surfaces **56** on a lower expander **57** mounted on the body **50**. The expander **57** can be releasably secured to the body **50** by one or more shear pins **62** and can also be co-rotatively coupled to the body **50** by a lock pin **62***a*.

The upper end of the lower expander **57** engages the lower portion of a packing structure **58**, such as a plurality of elastomeric rings, surrounding the body, the upper end of which engages an upper expander **59** initially releasably secured to the body **50** by one or more shear pins **60**. The ends of the packing structure **58** can be confined by typical anti-extrusion rings **58***a* and **58***b*. The upper expander **59** has an outer surface **61** which inclines upwardly and inwardly and which is companion to the inner inclined surfaces **38** on the upper slips **36**.

For the purpose of locking the compression force in the packing structure **53** during setting as well as locking the slips **35** and **53** in set condition, a split lock ring **63** is provided which has internal ratchet teeth **64** facing in an upward direction and arranged to mesh with like downwardly facing ratchet teeth **65** on the outer periphery of the body **50**. The lock ring **63** also has external tapered cam teeth **66** arranged to engage companion cam surfaces **67** in the expander **59**, the cam surfaces tending to urge the ratchet teeth **64** and **65** into mesh with one another. However, upward movement of the body **50** relative to the lock ring **63** can expand the lock ring outwardly, due to the lateral play between the cam surfaces **66** and **67** when the lock ring is moved upwardly relative to the expander **59**. The lock ring **63** functions as a one-way clutch to permit upward movement of the body **50** relative to the expander **59** but prevent converse relative movement in a conventional manner.

The mandrel extension **14** is arranged to reciprocate upwardly and downwardly within the body bore **51** in response to manipulation of the running-in string **10** to operate the valve assembly C. An external seal device **69**, of any suitable construction, is provided to seal between the mandrel extension **14** and the body **50** so that fluid under pressure can be displaced through the valve assembly C without leakage back into the well annulus above the packing assembly B. The mandrel extension **14** is coupled to the upper end of the body **50** by a sliding ratchet arrangement **70** which permits rigid connection between the running-in string **10** and the body **50** during setting, partial release to enable positive valve assembly operation, selective disengagement by upward strain on the running-in string **10** to permit circulation of well fluids if desired, and selective engagement by downward motion of the running-in string for further operations.

As shown in FIGURES 1B and 3, this ratchet arrangement **70** includes a split ratchet nut **71** having external, upwardly facing ratchet teeth **72** formed on a left-hand helix. Due to the fact that the nut **71** is split, it is capable of assuming an unstressed expanded size where the teeth **72** are engageable with upper, larger diameter threads **73** on the body **50**, and a contracted size where the teeth are engageable with lower, smaller diameter companion threads **74** on the body. The body threads **73** and **74** are formed on the same lead so that the ratchet nut **71** can readily mesh with both threads. The ratchet nut **71** is seated in an annular recess **75** in the upper portion of the mandrel extension **14**, the recess being terminated at its upper end by the lower face of the mounting sub **13** and at its lower end by an annular flange **76**. A longitudinal spline or key **77** extends radially outwardly in the recess **75** to engage in the slot or cut **78** formed in the split ratchet nut **71** so that the nut is corotatively secured to the mandrel extension **14**.

In the running-in position of parts shown in FIGURES 1A and 1B, the ratchet nut **71** occupies a lower position within the recess **75** and is contracted and threaded into the lower body threads **74**. Inadvertent unthreading of the ratchet nut is precluded by a shear screw **80** engaging in

the body **50** and in the mounting sub **13**. Since the mounting sub **13** engages the upper end of the mandrel **50** and the extension flange **76** engages the lower surface of the ratchet nut **71**, the extension **14** and body **50** are rigidly coupled to one another. After setting, right-hand rotation of the mandrel extension **14** relative to the body **50** will shear the screw **80** and cause the ratchet nut **71** to feed upwardly and out of engagement with the lower body threads **74**. When the nut clears the lower threads **74**, it will expand into mesh with the upper threads **73** and continued rotation of the nut can eventually cause it to unthread out of the upper threads also. It will be noted that both the upper and lower faces of the ratchet nut threads **72** are inclined to some extent. This construction permits the threads **72** to be ratcheted through the upper body threads **74** in either longitudinal direction without rotation. That is to say, the nut can repeatedly expand and contract and ratchet through the upper body threads **74**, there being sufficient lateral play between the inside surface of the nut and the bottom of the recess **75** when the nut **71** is adjacent to the upper body threads to permit this to occur. Due to the inclination of the upper faces of the teeth **72**, the nut **71** can be released from the upper body threads **74** in response to a predetermined upward strain on the mandrel extension. In like manner, the ratchet nut **71** can be reengaged with the upper body threads **74** by lowering the mandrel extension until the nut ratchets back into engagement with the body threads. This arrangement permits a positive yet releasable coupling between the mandrel extension **14** and the body **50** which is highly advantageous in that, initially, a rigid connection between the extension and body is effected for transmitting high setting loads to expand the packing structure **58** and to firmly set the slips **35** and **53**. Then, with the ratchet nut **71** engaging the upper body threads **73**, a coupling is effected which permits a limited amount of reciprocating motion between the extension and the body for operating the valve assembly C without disconnecting the extension from the body. When desired, a predetermined upward strain on the running-in string **10** will completely release same from the body **50** without rotation should a quick disconnection be advisable, and the extension **14** can later be merely lowered into the body bore **51** to reengage the ratchet nut **71** within the upper body threads **73** for further operations.

Fluid flow through the body bore **51** is controlled by the valve assembly C which includes the valve housing **52** as previously described. The valve housing **52** has side ports **85** through the wall thereof, and the lower portion **86** of the valve housing is closed. A valve sleeve **87** is positioned within the bore of the valve housing **52** and arranged for upward and downward motion therein between an upper position shown in FIGURE 1B where upper and lower seal rings **88** and **89** seal above and below the side ports **85** to block fluid flow therethrough, and a lower position shown in FIGURE 2B where the side ports **85** are open for fluid flow. The valve sleeve bore **90** provides a fluid communication path through the valve sleeve **87** so that fluid pressure will act on the sleeve in equal but opposite directions and will not tend to move the valve sleeve. An annular flange **91** is provided in the bore of the valve sleeve **87**, and a coil spring **92** of any suitable construction presses upwardly against the flange **91** tending to move the valve sleeve upwardly.

The upper portion of the valve sleeve **87** is constituted as a latch device **93** comprising a plurality of circumferentially spaced, upwardly extending latch fingers **94** having enlarged head portions **95** at their upper ends. The latch fingers **94** are spring-like or resilient and inherently tend to resile outwardly to the extent shown in detail in FIGURE 4. Each head portion **95** has an inner projection **96** and an outer projection **97**, each inner projection having an upwardly facing shoulder **98** and a lower upwardly and inwardly inclined surface **99**, each outer projection **97** having upper and lower oppositely inclined surfaces **100** and **101**. Moreover, the outer portion of each head is formed to extend upwardly beyond the shoulder **98** to provide a tang having an inner surface **103** which inclines downwardly and inwardly.

The lower end portion **105** of the mandrel extension **14** is formed for coupling with the latch device **93** and has spaced annular recesses **106** and **107** thereon in which the inner projections **96** of the finger heads **95** can engage. The lower recess **107** is formed to extend to a greater depth in the coupling portion **105** than is the upper recess **106**. The valve body **52** is provided with spaced annular grooves **108** and **109** in which the outer projections **97** on the finger heads **95** can extend, the upper groove **108** extending more deeply into the valve body than the lower groove **109** and having a lower downwardly and inwardly inclined cam surface **110**.

Assuming that it is desirable to lower the tool into the well with the valve sleeve **87** in its upper closed position, the valve assembly parts are positioned as shown in FIGURE 4 with the finger heads **95** opposite the upper groove **108** and with the outer projections **97** extending into the upper groove and with the inner projections **96** engaging within the upper extension recess **106**. The upper extension recess **106** is not sufficiently deep to allow the finger heads **95** to disengage from the upper body groove **108** and the valve sleeve **87** is locked in closed condition and cannot be moved downwardly. However, after the packing assembly B is set and the ratchet nut **71** disengaged by mandrel rotation as previously described, the mandrel extension **14** can be elevated until the lower recess **107** is either somewhere above, or opposite to, the finger heads **95**. The extension flange **112** can readily force or cam the heads **95** outwardly and pass upwardly past the heads. Then, lowering the extension **14** will engage the extension flange **112** with the head shoulders **98** and, due to the interengagement of the inclined surfaces **101** and **110**, cam the heads **95** inwardly. The lower extension recess **107** is sufficiently deep to allow the heads **95** to shift inwardly and disengage from the groove **108**. Accordingly, the valve sleeve **87** can be pushed downwardly to open position as shown in FIGURE 5 by downward movement of the extension **14**. Also the valve sleeve **87** can be moved upwardly to closed position by merely elevating the extension **14** because the heads **95** are held inwardly in locked position within the lower recess **107** by the inner surface **113** of the valve body. When the heads **95** move upwardly and opposite the upper groove **108**, they will resile outwardly into the groove and the end flange **114** on the extension **14** can bypass the heads to free the coupling portion **105** from the latch device **93**.

Assuming that it is desired to run the tool into the well with the valve sleeve **87** in open position, the parts are assembled as shown in FIGURE 5 with the valve sleeve in the lower position and with the head portions **95** locked in engagement within the lower extension recess **107**. To move the valve sleeve **87** to closed position, the extension **14** is elevated and the latch fingers **94** will pull the valve sleeve upwardly. When the upper groove **108** is reached, the head portions **95** will resile into the groove **108** to release the valve sleeve from the extension as previously described.

An important feature of the present invention resides in a structural arrangement to permit positive recoupling of the mandrel extension **14** and valve sleeve **87** even though the valve sleeve may be intermediate its open and closed positions. Should this occur, the head portions **95** will be located at some point below the upper groove **108**. As the mandrel extension **14** moves downwardly, the end flange **114** will engage and push the head portions **95** downwardly until they are opposite the lower body groove **109**, as shown in FIGURE 6, at which point they will resile outwardly and into the lower groove, thereby permitting the flange **114** to bypass the head portions. Then, the valve spring **92**, being compressed

by downward movement of the valve sleeve **87**, will function to force the valve sleeve **87** and fingers **94** upwardly, camming the head portions **95** inwardly into locked engagement within the lower extension recess **107**. This coaction positively couples the valve sleeve **87** to the extension **14** for further and repeated movements between open and closed positions.

Operation

In operation, the various parts of the present invention can be assembled as shown in FIGURE 1 with the mandrel **11** connected to the lower end of the running-in string **10**, and then lowered into a well bore to a desired setting point. The slips **35** and **53** and the packing structure **58** are retracted, the upper slips **35** being encompassed by the retainer sleeve **27**. The drag blocks **25** can slide along in frictional engagement with the well casing P and the cage **22** and the control sleeve **17** cannot move upwardly on the mandrel **11** due to the engagement of the threads **28** and **29** and the locking condition of the latch ball **30**. The ratchet nut **71** is in full mesh with the lower body threads **74** and engages the extension stop flange **76**. The lower surface of the mounting sub **13** abuts against the upper end of the mandrel **50** so that the mandrel **11** and the mandrel extension **14** are, in net effect, integrally connected to the packer body **50**.

The valve sleeve **87** can initially occupy its upper port closing position by positioning the finger heads **95** within the upper body groove **108**. This can be conveniently accomplished during assembly by exerting an upward force on the lower end of the valve sleeve **87** so that the engagement of the upper head surfaces **103** with the inclined top surface of the upper groove **108** will cause the heads **95** to extend to their fullest extent into the upper groove. Thus extended, the extension flange **112** can readily bypass downwardly beyond the heads to position upper extension recess **106** opposite the heads. On the other hand, the valve sleeve **87** can initially occupy its lower open position by making up the valve assembly C such that the finger heads **95** are engaged in the lower extension recess **107**.

At setting depth, the running-in string **10** is rotated a sufficient number of turns to the right to feed the cage **22** and the retainer sleeve **27** upwardly as previously described. Upward movement of the retainer sleeve **27** disengages the sleeve from the upper sections **42** of the slip segments **36** so that the segments can be shifted outwardly. At this point, the segments **36** are still retained on the mounting sub **13** by the leaf springs **43**. Upward movement of the cage **22** positions the cage recess **34** opposite the ball **30** so that the ball can move out of the mandrel detent **32** to release the mandrel **11** for upward movement relative to the control sleeve **17** and the cage **22**.

The mandrel **11** is then elevated by upward strain on the running-in string **10** to set the packer assembly B. The engagement of the drag blocks **25** against the well casing P produces a holding force which is transmitted through the threads **28** and **29** to the control sleeve **17**, thereby resisting upward movement of the setting sleeve **20**. Accordingly, as the mandrel **11** is elevated, the upper end surfaces of the slip segments **36** are brought into engagement with the lower end surface of the setting sleeve **20** and continued upward movement of the mandrel **11** causes the setting sleeve **20** to push the slip segments **36** out of retained relationship with the leaf springs **43** and out of engagement with the mounting sub flange **40**. The setting sleeve **20** then functions to hold the segments against upward movement as the upper expander **59** is moved underneath the segments **36** to expand them outwardly as shown in FIGURE 2B. As the expander **59** moves upwardly, its outer inclined surfaces **61** wedge the slip segments **36** outwardly until the teeth **37** grip the well casing wall. Now, the upper expander **59** cannot move any further upwardly relative to the well casing and continued upward movement of the mandrel **11** and packer body **50**, after shearing the pins **60** and **62**, serves to expand the lower slips **53** over the lower expander **57** and to compress and expand the packing structure **58**. When a predetermined upward strain has been taken on the running-in string **10**, both the upper and lower slips **35** and **53** are shifted outwardly to grip the well casing P and prevent movement in either longitudinal direction, and the packing structure **58** is expanded to pack off the annulus between the well casing and the body **50**. During upward movement of the body **50** relative to the upper expander **59**, the lock ring **63** will ratchet over the external body teeth **65** and trap the mandrel in the highest relative position to which it is moved, thereby trapping the compression load in the packing structure **58** and locking the slips **35** and **53** in set condition.

If it is desired to test the running-in string **10** for leakage, this can be accomplished. Should the valve sleeve **87** be initially positioned in closed condition as shown in FIGURE 4 and as previously described, the running-in string **10** will already be closed off at its lower end and can be pressure tested for leakage by applying pump pressure to the inside of the string at the earth's surface. Should the valve sleeve **87** be initially positioned in open condition, the valve sleeve can be moved to closed position as will be subsequently described and the running-in string **10** leak tested in the same manner.

At any rate, the packer assembly B is now set and a pressure operation, such as squeeze cementing or hydraulic fracturing can be undertaken. To operate the valve assembly C, a relatively small upward strain, say 1000 pounds above the "free" point, is taken in the running-in string **10** and the string is torqued to the right. Since the packer body **50** is now fixed in the well bore due to the set condition of the packer assembly B, rotation of the mandrel extension **14** will shear the screw **80** and feed the ratchet nut **71** upwardly and out of the lower body threads **74**. When the nut **71** clears the lower threads **74**, it will expand into mesh with the upper ratchet threads **73** and continued rotation to the right will feed the nut upwardly through the upper threads also. When the "free" point is indicated at the surface, the nut **71** is completely disengaged and the extension **14** is uncoupled from the packer body **50**. Then the running-in string **10** can be lowered without rotation to ratchet the nut **71** back into the upper body threads **73** as shown in FIGURE 2B. With this relative position of parts, it will be appreciated that the mandrel extension **14** can be reciprocated upwardly relative to the packer body **50** until the stop flange **76** bumps against the ratchet nut **71**, and downwardly until the mounting sub **13** bumps against the upper end of the mandrel **50**. The relative travel permitted is sufficient to operate the valve assembly C while providing positive surface indications of the position of the valve sleeve **87** relative to the side ports **85** in the valve body **52**.

When the mandrel extension **14** is moved upwardly during complete release of the ratchet nut **71** from the body threads **73** and **74** as previously described, the lower portion **105** of the extension is positioned at some point above the finger heads **95** which are located within the upper body groove **108**. Accordingly, downward movement of the mandrel extension **14** will cause the extension flange **112** to engage the head shoulders **98** and push the valve sleeve **87** downwardly against the bias of the valve spring **92**. As the heads **95** move downwardly, they are cammed inwardly out of the upper body groove **108** and into locked relationship within the lower extension recess **107** and held locked therein by the inner surface **113** on the valve body **52** as shown in FIGURE 5. Accordingly, the valve sleeve **87** is positively coupled to the mandrel extension **14** and downward movement of the mandrel extension will shift the valve sleeve to open position and

upward movement will move the sleeve to closed position. During upward movement, when the heads **95** move opposite the upper body groove **108**, they will resile into the groove and permit the end flange **114** on the extension **14** to bypass the inner projections **96** to release the extension **14** from the valve sleeve **87** and permit removal of the extension from the packer body **50**. It will be appreciated that whenever the mandrel extension **14** is thus removed, the valve sleeve **87** should always be in its upper closed position shown in FIGURE 4 with the seal elements **88** and **89** spanning the side ports **85** to block fluid flow. Inasmuch as the valve seals **88** and **89** are arranged to encompass substantially the same areas, fluid pressure either within the valve body **52** or externally thereof will act in equal and opposite directions and will not tend to shift the valve sleeve **87**.

However, should it be desired to further operate the valve sleeve **87** and if, for some reason, the head portions **95** are located at some point below the upper body groove **108** (e.g., the valve sleeve is either already in open position, or in a position intermediate its open and closed positions) the extension **14** can be again lowered into the body bore **51**. When the extension end flange **114** reaches the head portions **95**, the flange will push the head portions and thus the valve sleeve **87** downwardly against the bias of the valve spring **92**. When the head portions **95** are moved opposite the lower body groove **109**, the head portions will reside into the lower groove and permit the end flange **114** to bypass the inner projections **96** as shown in FIGURE 6. When this occurs, the valve spring **92** will force the valve sleeve **87** upwardly, camming the head portions **95** inwardly, until the head portions are again locked within the extension recess **107** as shown in FIGURE 5. Accordingly, the parts are in relative positions for further and repeated operation.

As was previously noted, a predetermined upward strain on the running-in string **10** without rotation will cause the ratchet nut **71** to release from the upper body threads **73** by repeated contraction or ratcheting action. Therefore, it will be appreciated that the mandrel extension **14** can be quickly removed from the packer body **50** by an upward pull on the running-in string **10** should circulation or reverse circulation above the packer assembly B be desirable. An unlimited number of connections and disconnections of the mandrel extension **14** and packer body **50** can be effected by simply moving the running-in string **10** up and down to engage and disengage the ratchet nut **71** with the upper body threads **73**.

A new and improved well packer apparatus has been disclosed which can be lowered on a running-in string and set in a well bore. The well packer has a flow passage and a pressure balanced valve for opening and closing the passage as desired. The valve element can be operated by an actuator in response to up and down motion of the running-in string and can be releasably coupled to the actuator to occupy either its open or closed position during lowering to setting depth. Moreover, the actuator can be uncoupled from the valve element and then positively recoupled thereto regardless of the position of the valve element within the valve body at the time of recoupling.

Since certain changes or modifications may be made in the invention without departing from the inventive concepts involved, it is the aim of the appended claims to cover all such changes or modifications which fall within the true spirit and scope of the present invention.

I claim:

1. A well packer apparatus adapted to be lowered and set in a packed-off condition in a well bore, comprising: a body having a flow passage; a valve element movable upwardly and downwardly in said flow passage and relative to said body between positions opening and closing said passage; actuating means adapted for connection to a running-in string extending to the top of a well bore and movable upwardly and downwardly by the running-in string for moving said valve element relative to said body; and latch means including latch elements on said valve element for initially selectively coupling said valve element to said actuator in spaced longitudinal positions relative to said body and said actuator, said positions corresponding to one of said open and said closed positions, said latch means and valve element being thereafter responsive to reciprocating motion of said actuator for moving said valve element between positions opening and closing said passage.

2. The apparatus of claim **1** further including means engaging said latch elements for locking said latch means in coupled relationship with said actuator during longitudinal movement of said valve element by said actuating means.

3. The apparatus of claim **1** further including port means in said valve element for communicating fluid pressure to locations above and below said valve element whereby said fluid pressure will act with equal force in opposite directions on said valve means.

4. Apparatus for use in a well tool in a well bore comprising: an outer member having a passageway through which fluid can flow; valve means in said outer member movable longitudinally for opening and closing said fluid passageway; an inner member telescopically movable in said outer member for imparting like motion to said valve means; upper and lower annular recesses in one member; upper and lower grooves in the other member; a locking surface between said grooves; and latch means on said valve means cooperable with said recesses, grooves, and locking surface for coupling said valve means to said actuator to transmit longitudinal motion, and for permitting selective relative positioning of said valve means and said actuator, and for permitting selective connecting and disconnecting of said actuator and valve member.

5. The apparatus of claim **4** wherein said passageway includes side ports in said outer member, said valve means being constituted by a sleeve having seal elements thereon for sealing off said side ports.

6. The apparatus of claim **5** further including shoulder means on said sleeve; and means engaging said shoulder means for biasing said sleeve toward said inner member.

7. Apparatus for use in a well tool in a well bore comprising: a body member having a fluid passageway; a valve member in said body movable upwardly and downwardly therein for respectively closing and opening said passageway; an actuator in said body for moving said valve member; latch means on said valve member cooperable with said actuator for transmitting movement of said actuator to said valve member, said actuator having an end surface and a coupling portion engagable with said latch means for shifting said valve member downwardly to open position; a first groove in said body member into which said latch means can move to permit said end surface to disengage from said latch means; biasing means for shifting said valve member upwardly to a position where said latch means can engage said coupling portion; and a second groove in said body member located above said first groove, and into which said latch means can move for disengaging said latch means and coupling portion.

8. The apparatus of claim **7** further including means between said grooves engageable with said latch means for locking said latch means to said coupling portion.

9. Apparatus for use in a well tool in a well bore comprising: a valve body having a flow passage; a valve sleeve movable upwardly and downwardly in said valve body for controlling fluid flow in said passage; an actuator extending into said valve body and movable upwardly and downwardly therein for moving said valve sleeve, said actuator having a coupling portion; latch means for coupling said valve sleeve to said coupling portion to transmit upward and downward motion of said actuator to said valve sleeve; means including a groove in said body to uncouple said latch means and coupling portion

during upward movement of said actuator to permit removal of said actuator from said valve body; and means including another groove in said body to permit coupling of said latch means and coupling portion during downward movement of said actuator.

10. Apparatus for use in a well tool in a well bore comprising: a valve body having a flow passage; a valve element movable upwardly and downwardly in said valve body for controlling fluid flow in said passage; actuating means for moving said valve element upwardly and downwardly, said actuating means having a flow passage in communication with said body flow passage; and latch means for coupling said actuating means and valve element during downward movement of said actuating means and for disconnecting said actuating means and valve element during upward movement of said actuating means, said latch means including longitudinally spaced grooves in said valve body, a recess in said actuating means, and latch fingers on said valve element cooperable with one of said grooves for disconnecting said valve element and actuating means and cooperable with said other groove to permit coupling of said valve element and actuating means and cooperable with said recess for coupling said actuating means and valve element.

11. The apparatus of claim **10** further including means between said grooves engageable with said latch fingers for locking said latch fingers in coupled relationship in said recess during upward movement of said actuating means and said valve element.

12. A well packer apparatus adapted to be lowered and set in packed-off condition in a well bore, comprising: a body having a flow passage; packing means and anchor means on said body for respectively packing off a well bore and anchoring against movement in the well bore; a valve element in said passage movable upwardly and downwardly in said body between positions opening and closing said passage; actuating means adapted for connection to a running-in string extending to the top of the well bore and movable upwardly and downwardly by the running-in string for moving said valve element; and means for selectively releasably coupling said valve element to said actuator in spaced longitudinal positions relative to said actuator and in an upper or lower position relative to said body to correspondingly dispose said valve element in passage closing or opening position during lowering.

13. In a well bore for use in a well bore, the combination comprising: a body having a flow passage; a valve element in said body movable upwardly and downwardly between positions opening and closing said passage; an actuator in said body movable upwardly and downwardly for moving said valve element, said actuator having a coupling portion; latch means for coupling said valve element to said coupling portion during upward and downward movement of said valve element; and means for releasing said latch means from said coupling portion including a groove in said body into which said latch means can move to a normal extent to disengage said latch means from said coupling portion during upward movement of said actuator, said groove having a downwardly and inwardly inclined upper surface engageable with said latch means to permit said latch means to be forced thereinto to a greater extent to permit said coupling portion to bypass said latch means during downward movement of said actuator.

14. The apparatus of claim **13** further including means engageable with said latch means to lock said latch means within said groove when said coupling portion has bypassed said latch means.

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U.S. Cl. X.R.

166—128, 226