Dec. 27, 1966 E. A. KELLEY 3,294,171

HYDRAULIC OPERATED WELL TOOLS

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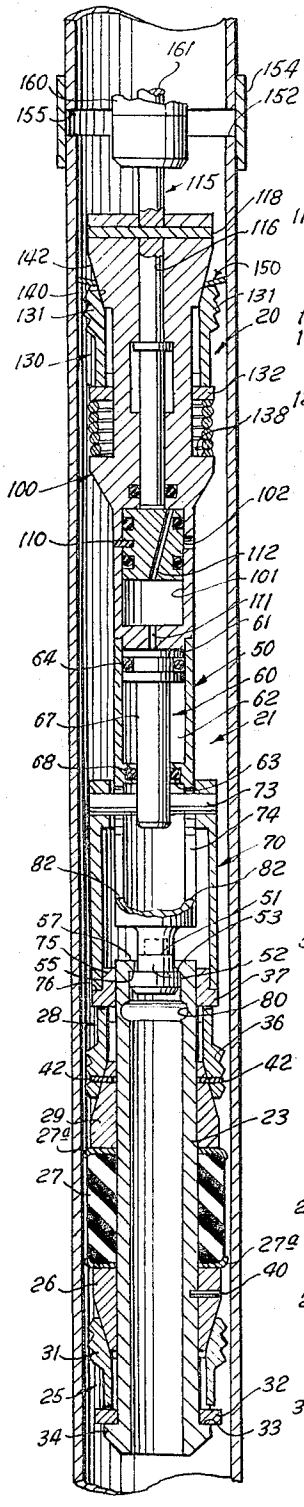


Fig. 1

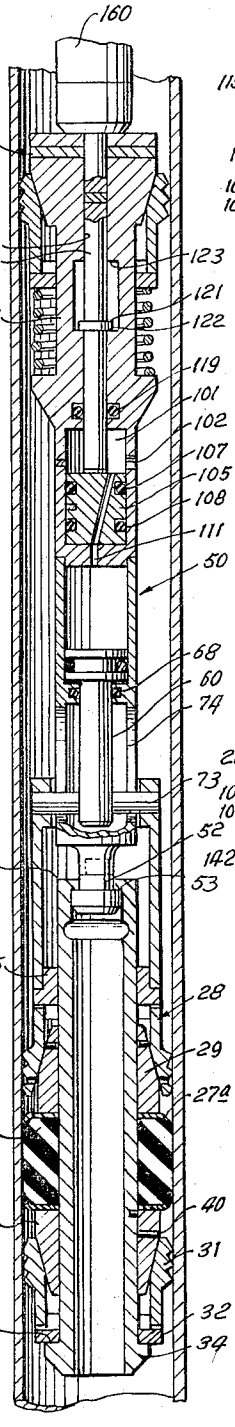


Fig. 2

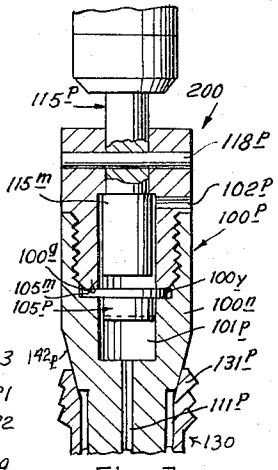


Fig. 3

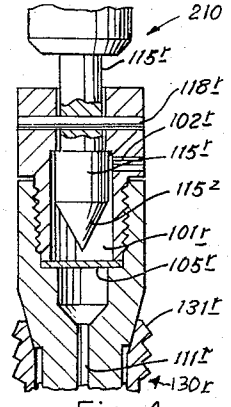


Fig. 4

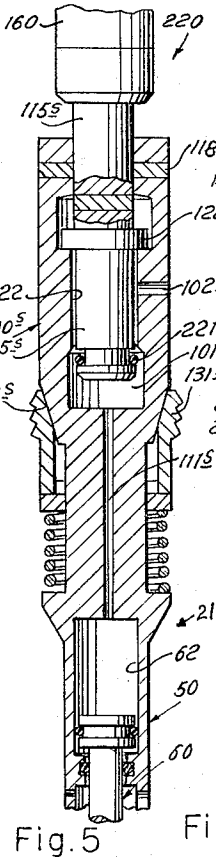


Fig. 5

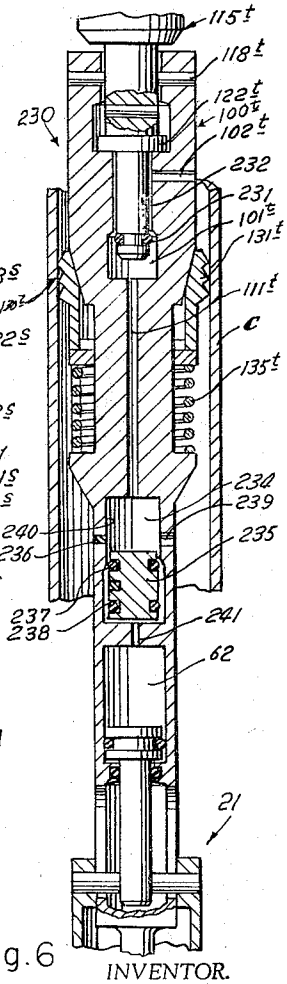


Fig. 6

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HYDRAULIC OPERATED WELL TOOLS

Filed Feb. 10, 1964 2 Sheets-Sheet 2

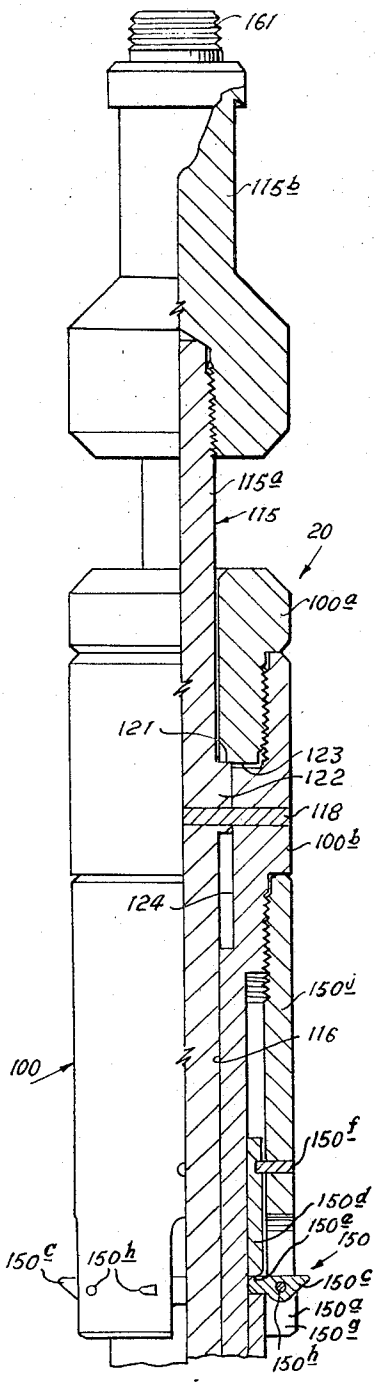


Fig. 7

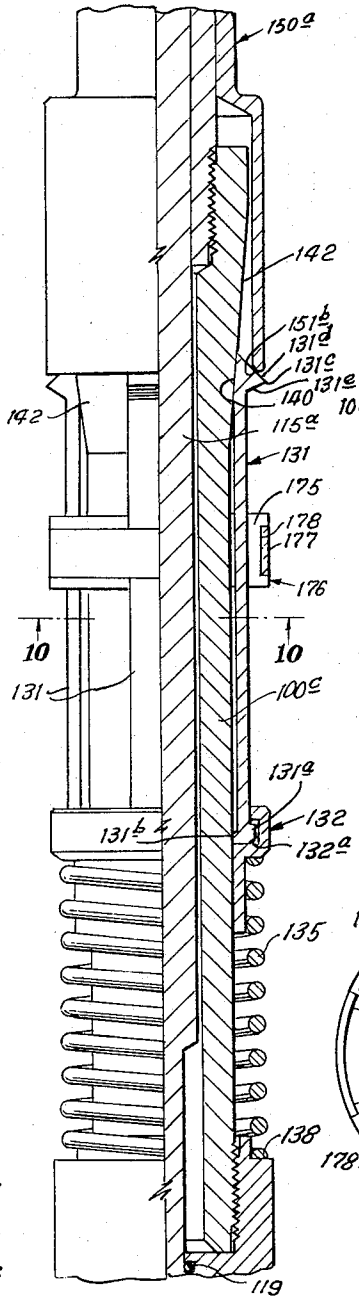


Fig. 8

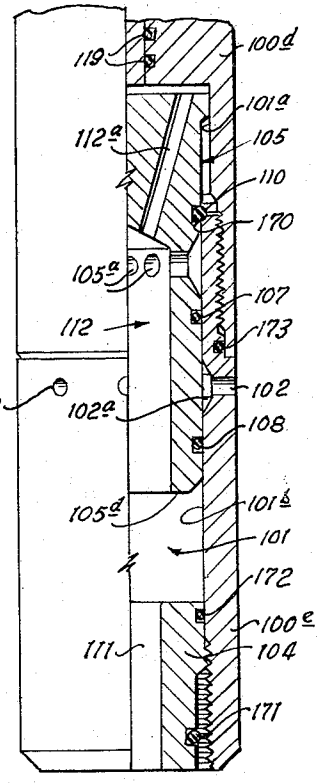


Fig. 9

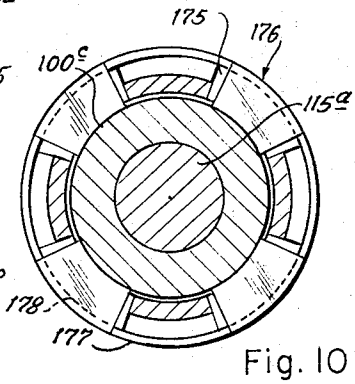


Fig. 10

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HYDRAULIC OPERATED WELL TOOLS

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Filed Feb. 10, 1964, Ser. No. 343,738
10 Claims. (Cl. 166—120)

This invention relates to well tools and more particularly to an actuator tool for initiating the operation of a fluid pressure operated well tool.

An object of this invention is to provide a new and improved actuator well tool for initiating the operation of another well tool whose operation is effected by the fluid pressure in a well.

Still another object is to provide an actuator tool for actuating another well tool, such as a packer or a bridge plug, whose operation is effected by the hydrostatic pressure in a well.

Still another object is to provide a well tool for actuating another well tool which is lowerable into the well with such other well tool by means of a flexible line and which has means operable when the well tools are positioned in a predetermined location in the well for transmitting the fluid pressure in the well to the operator mechanism of the other well tool.

A further object is to provide a new and improved actuator tool for transmitting fluid pressure to a fluid pressure operated well tool connected thereto which is operable upon predetermined longitudinal movement thereof in the well, the actuator tool having a valve which is moved to open position to transmit the fluid pressure to the operator mechanism of the pressure operated well tool connected thereto.

A still further object is to provide a well tool including a tubular mandrel having a valve closing a flow passage of the mandrel, anchoring means mounted on the mandrel for movement to its expanded position upon upward movement of the actuator tool in a well for anchoring the mandrel against downward movement in the well, and a support member connected to a mandrel for a limited longitudinal movement thereto for opening the valve upon downward movement of the support member relative to the mandrel.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of a device constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

FIGURE 1 is a schematic vertical view of the actuator well tool and a fluid pressure actuated bridge plug connected thereto showing the actuator well tool and the bridge plug in the positions assumed thereby during the lowering of the well tools through a well flow conductor;

FIGURE 2 is a view similar to FIGURE 1 showing the bridge plug in its anchored and sealing position in the flow conductor;

FIGURE 3 is a fragmentary partly sectional schematic view of a modified form of the actuator tool;

FIGURE 4 is a fragmentary partly sectional schematic view showing another modified form of the actuator tool;

FIGURE 5 is a fragmentary partly sectional schematic view of another modified form of the actuator tool;

FIGURE 6 is a fragmentary partly sectional schematic view of another modified form of the actuator well tool;

FIGURE 7 is a vertical partly sectional view of the upper portion of an actuator well tool shown schematically in FIGURES 1 and 2;

FIGURE 8 is a view similar to FIGURE 7, being a continuation thereof, and showing an intermediate portion of the actuator tool;

FIGURE 9 is a view similar to FIGURE 8, being a

continuation thereof, showing the lower portion of the actuator tool; and

FIGURE 10 is a sectional view taken on line 10—10 of FIGURE 8.

Referring now particularly to FIGURES 1 and 2 of the drawing, the actuator well tool 20 is shown connected to a fluid pressure actuated bridge plug 21 having a tubular mandrel 23 on which is mounted a lower anchor assembly 25 and its expander 26, a tubular resilient seal element 27, and an upper anchoring assembly 28 and its expander 29, the seal element 27 being disposed between the two expanders. The lower anchor assembly 25 includes a plurality of outwardly expansible slips 31 and an annular slip carrier 32 to which they are movably secured. Downward movement of the slip carrier on the mandrel is limited by its engagement with the upwardly facing annular shoulder 33 provided by the external annual end flange 34 of the mandrel.

The upper anchor assembly 28 similarly includes a plurality of outwardly expansible slips 36 supported by an annular slip carrier 37. Deformable back-up rings 27*a* may be positioned between the expanders and the adjacent ends of the seal element to bridge the gaps between the expanders and the internal surfaces of the well flow conductor C when the seal element is compressed and in expanded sealing engagement with the flow conductor to prevent its extrusion between the expanders and the flow conductor.

The expander 26 is releasably held in its upper position illustrated in FIGURE 1 by any suitable means such as a shear screw or shear pin 40. The upper slips 36 may be releasably secured against downward movement relative to their expander 29 by shear pins or screws 42.

The bridge plug 21 includes a piston cylinder 50 having a dependent extension 51 disposed into the upper end of the plug mandrel 23. The dependent extension has a bottom section 52 provided with an external end flange 52 whose top annular surface 53 engages the downwardly facing annular shoulder 55 provided by the top internal annular flange 57 of the plug mandrel.

A piston 60 has an annular flange 61 disposed in the longitudinal piston chamber 62 of the piston cylinder above the internal annular flange 63 thereof. An O-ring 64 which seals between the piston and the internal surfaces of the piston sleeve, is disposed in a suitable external annular recess of the piston flange. The dependent stem or rod 67 of the piston extends downwardly through the internal flange 63 which has an internal annular recess in which is disposed an O-ring 68 which seals between the flange and piston rod.

An operator sleeve 70 is connected to the piston by means of a pin 73 which extends through suitable aligned apertures in the upper end of the operator sleeve and in the lower end the piston rod and also through the diametrically opposed longitudinal slots 74 of the cylinder 50 below its internal flange 63. The lower end of the operator sleeve telescopes over the upper end portion 75 of reduced diameter of the upper slip carrier and its annular downwardly facing bottom end shoulder engages the upwardly facing annular shoulder 76 of the upper slip carrier.

It will be apparent to those skilled in the art, that the bridge plug 21 is of a well known structure and that the upper and lower slip assemblies and the seal element are moved to their expanded anchoring and sealing positions upon downward movement of the operator sleeve relative to the mandrel from the position of FIGURE 1 to that of FIGURE 2. Such downward movement of the operator sleeve first causes the shear pin 40 securing the lower expander 26 to the plug mandrel to fail, whereupon the lower expander 26, the seal element 27, the upper expander 29, and the upper anchor assembly 28

move downwardly on the mandrel until the lower expander moves the lower slips outwardly into anchoring engagement with the flow conductor C. Once the downward movement of the lower expander is thus stopped, further downward movement of the operator sleeve causes the seal element to be expanded into its expanded sealing position whereupon the shear pins **42** securing the upper slips to the upper expander **29** shear and the upper slip assembly **28** moves downwardly relative to the upper expander until the slips **36** are moved into anchoring engagement with the internal surfaces of the flow conductor. The engagement of the downwardly facing teeth of the lower slips with the flow conductor now holds the lower expander, the seal element and the upper expander against downward movement on the plug mandrel and in the flow conductor and the engagement of the upwardly facing teeth of the upper slips with the flow conductor now hold the upper expander, the seal element and the lower expander against upward movement on the plug mandrel and in the flow conductor. Once the bridge plug has been thus set in anchored and sealing engagement in the flow conductor, an upward pull thereafter exerted on the piston cylinder which first causes the plug mandrel to shear at its line of mechanical weakness provided by the internal annular groove **80** thereof since the plug mandrel is now held against upwafd movement. Continued upward movement of the piston cylinder now causes the piston flange **61** to engage the piston cylinder flange **63** and the piston is then moved upwardly with the piston cylinder. When the pin **73** engages the upwardly facing surfaces **82** defining the lower ends of the longitudinal slots **74** of the operator sleeve, the operator sleeve is moved upwardly with the piston and cylinder sleeve thus leaving the lower portion of the plug mandrel, the upper anchor assembly, the upper expander, the seal element, the lower anchor assembly and the lower expander in the positions illustrated in FIGURE 2.

The actuator tool **20** for transmitting pressure from the well casing to the upper end of the piston chamber **62** of the piston cylinder includes the tubular mandrel or body **100** threaded in the upper end of the piston cylinder. The body **100** has a longitudinal chamber **101** and a lateral port **102** opening to the chamber from the exterior of the body at a point intermediate the ends of its chamber. The lateral port **102** is closed by a valve **105** having longitudinally spaced O-rings **107** and **108** which seal with the internal surfaces of the body above and below the lateral port **102** to prevent communication of pressure from the exterior of the actuator tool body to the chamber **101** when the valve is held in the upper position illustrated in FIGURE 1 by the shear screw **110**. The body also has a port **111** which communicates the lower end of the chamber **101** with the upper end of the piston chamber **62**. The valve **105** is provided with a longitudinal passage **112** so the upper end of the chamber above the valve **105** is in communication with the bottom port **111**. The upper end of the valve passage **112** is spaced from the lower end of the piston while its lower end is aligned with the bottom port **111** so that when the valve is in its lower open position, FIGURE 2, the pressure from the exterior of the body **100** is communicated to the upper end of the piston chamber.

A support rod or member **115** extends through a longitudinal bore **116** of the body which opens into the upper end of the valve chamber **101** and is releasably held in its upper position, FIGURE 1, by a shear pin **118** which extends through suitable aligned transverse apertures in the actuator tool body and the support rod. An O-ring **119** disposed in a suitable internal annular recess of the body seals between the support rod and the body. Upward movement of the support rod relative to the body is limited by the engagement of the top surface **121** of its external annular flange **122** with the downwardly facing internal annular shoulder **123** of the body defining the upper end of the internal annular recess **124** of the body.

An anchoring assembly **130** disposed on the body includes a plurality of slips **131** whose lower ends extend upwardly from an annular slip carrier **132**. The slip carrier is biased upwardly by a spring **135** whose lower end bears against the annular upwardly facing shoulder **138** of the body and whose upper end engages the lower end of the slip carrier. The slips have upwardly and outwardly extending cam surfaces **140** which engage an outwardly and upwardly extending expander surface **142** of the body so that upward movement of the slips relative to the expander causes outward movement of the slips. The slips and the slip carrier are releasably held against movement from their lower positions on the body, illustrated in FIGURE 1, by any suitable detent means **150** which pivot inwardly during downwardly movement of the actuator tool past upwardly facing internal obstructions of the flow conductor, such as the upper end shoulders **152** of the sections of the flow conductor at the connections of adjacent sections by the usual coupling collars **154**, but which engage downwardly facing internal obstructions, such as the lower end shoulder **155** of a flow conductor section at a coupling recess, and release the slips and slip carrier for upward movement on the body upon upward movement of the body in the flow conductor.

In use, a fluid pressure operated well tool, such as the bridge plug **21**, is secured to the body of the actuator tool with its piston **60** in its upper position and with the piston chamber **62** below the piston flange **61** filled with a compressible gas, such as air, at a relative low pressure, such as atmospheric pressure. The upper end of the support rod **115** of the actuator tool is secured by a connector sub **160**, threaded on the support rods threaded top end pin **161**, of the usual set of flexible or wire line tools so that the assembly of the actuator tool and the bridge plug is lowerable by the line in the flow conductor C. The actuator tool and the bridge plug are lowered by the flexible line until the bridge plug is located at a desired position in the flow conductor. An upward movement then imparted to the assembly, by means of the wire line, then causes the detent means **150** to engage a downwardly facing obstruction, such as the lower end **155** of a flow conductor section, and as the upward movement of the body **100** is continued, the detent means are actuated and release the slips and the slip carrier **132** for upward movement relative to the body. The spring **135** moves the slip carrier and the slips upwardly, and, as the slips move upwardly on the body, they are moved outwardly into engagement with the internal surfaces of the flow conductor due to the camming engagement of their surfaces **140** with the expander surface **144** of the body. The downwardly facing teeth or serrations of the slips now engage the internal surfaces of the flow conductor and prevent downward movement of the slips, and therefore of the body **100**. A downward force or jar then imparted to the support rod by means of the usual set of flexible or wire line tools, then causes the shear pin **118** to shear and free the support rod for downward movement in the body passage **116** to the position illustrated in FIGURE 2. Downward movement of the rod in the body causes its lower end surface to engage the top surface of the valve **105** and the downward force thus applied to the valve causes its shear pin to fail and the valve is moved downwardly in the body to the position illustrated in FIGURE 2.

The upper end of the longitudinal passage **112** of the valve then opens to the exterior of the body through the valve chamber **101** and the body port **102** above the valve and its lower end communicates with the upper end of the longitudinal port **111** of the valve body so that the pressure from within the flow conductor, which is considerably higher than the pressure of the compressible gas in the piston chamber below the piston flange, is now communicated to the upper end of the piston chamber and

moves the piston **60** of the bridge plug downwardly. Such downward movement of the piston moves the anchor assemblies and the seal element of the bridge plug to their expanded positions illustrated in FIGURE 2.

When the bridge plug is thus set by the fluid pressure within the flow conductor, an upward pull is again imparted to the support rod by means of the flexible line and the operator rod moves upwardly relative to the body until its flange **122** engages the downwardly facing shoulder **123** of the body. Continued upward movement of the support rod then causes upward movement of the body **100** relative to the slips and slip carrier. The downwardly facing or biting teeth of the slips are thus freed for movement inwardly during upward movement of the body against the resistance of the spring **135**. Upward movement of the body **100** also causes upward movement of the piston cylinder of the piston when the surfaces or shoulders **82** of the cylinder engage the pin **73**. The upward force then imparted to the upper end of the plug mandrel as the body **100** continues to move upward causes its weakened section to fail and permit upward movement and removal of the operator sleeve **70**, the piston cylinder and the piston of the bridge plug with the actuator tool, leaving the upper anchor assembly, the upper expander, the seal element, the lower anchor assembly and the lower expander in the well flow conductor.

It will now be seen that the new and improved actuator tool **20** actuates a fluid pressure operated well tool, such as the bridge plug **21** which has an operator means such as a piston **60** mounted in a chamber thereof which, when exposed to the fluid pressure in the flow conductor, causes the well tool to be operated.

It will further be seen that the actuator tool includes a body connectable to the well tool **21** provided with a passage for transmitting fluid pressure from the exterior of the actuator tool body to the piston chamber, and a valve for closing the passage.

It will further be seen that the actuator tool is lowerable into and removable from a flow conductor by means of a flexible line and the usual set of flexible line tools and that the operation of the actuator tool is easily accomplished by predetermined longitudinal movement in a flow conductor imparted to the actuator tool through the flow conductor.

Referring now particularly to FIGURES 7 through 10 which show the actual structure of the actuator tool **20** illustrated schematically in FIGURES 1 and 2, the tubular body or mandrel of the actuator tool **20** includes a tubular top section **100***a*, a connector section **100***b*, an expander section **100***c*, a spring retainer section **100***d*, a bottom section **100***e* and a port section **100***f*. The top section **100***a* has a reduced lower end portion threaded into the upper end portion of the connector section **100***b* and provides the downwardly facing annular shoulder **123** which is engageable by the top annular shoulder or surface **121** of the external annular flange **122** of the support rod **150**.

The connector section **100***b* has its lower end portion threaded into the upper end of the expander section **100***c* whose upper end portion is enlarged to provide the upwardly and outwardly extending expander or cam surface **142**. The lower end portion of the expander section **100***c* is threaded in the upper end portion of the spring retainer section **100***d*. The bore of the spring retainer section **100***d* is enlarged as at **101***a* to provide the upper end portion of the valve chamber **101**, the lower portion of the chamber **101** being defined by the bore **101***b* of the bottom section **100***e* of slightly smaller internal diameter which provides an annular shoulder **170** engageable by a detent means **110**, such as a resilient ring disposed in an external annular recess of the valve **105**, to hold the valve **105** in the upper position illustrated in FIGURE 9. The port section **100***f* is threaded in the lower end portion of the bottom section and provides the longitudinal port **111**.

The valve **105** has a plurality of ports **105***a* which are aligned with the inernal annular recess **102***a* of the body, into which open the lateral ports **102** of the bottom body section **102***e*, when the valve is in its lowermost position in the chamber **101** with its bottom shoulder **105***d* engaging the upper annular end shoulder of the orifice or port section **100***f* of the body. The lateral ports **105***a*, when the valve is in its lowermost position, communicate with the longitudinal passage or bore **112** of the valve to permit fluid flow from the exterior of the body into the chamber **101**, and the valve passage **112** to the orifice or longitudinal port **111** and thence into the piston chamber of a well tool, such as the bridge plug **21**, which is threaded into the bottom section **100***e* of the body. The port section **100***f* telescopes into the upper end of such piston chamber and has an external annular recess in which is disposed an O-ring **171** to provide a fluid type connection. The passage **112** of the valve also has an upwardly extending section **112***a* which communicates with the upper end of the valve chamber **101** above the valve. An O-ring **172** seals between the port and bottom sections of the body **100** and an O-ring **173** seals between the bottom and spring retainer sections of the body.

The operator rod **115** has a rod section **115***a* and a top connector section **115***b*. The rod section extends through the longitudinal bore **116** of the body and its annular external flange **122** is positioned in the internal annular body recess **124**. The support rod is releasably secured to the body in the upper position illustrated in FIGURES 7, 8 and 9 by the shear pin **118** which extends through suitable aligned apertures in the rod section **115***a* and the connector section **100***b* of the body. The spring retainer section **100***d* has suitable internal annular apertures in which suitable sealing means, such as O-rings **119**, are disposed and seal between the support rod and the body above the chamber **101** thereof.

The slips **131** of the anchor assembly **130** have lower end portions provided with external bosses **131***a* which are received in the internal annular recess **132***a* of the annular slip carrier **132** and with internal bosses **131** which engage the outer surface of the expander section **100***c* of the body so that the slips are free to pivot outwardly above their lower ends and are held against longitudinal movement relative to the slip carrier. The slips extend through the radial circumferentially spaced slots **175** of an annular flange **176** of the expander body shown. Outward movement of the slips is limited by the retainer ring **177** which is positioned in the external circumferential slot **178** of the flange **176**. Each of the slips is provided with an outwardly extending tooth **131***c* defined by the downwardly and outwardly convergent upper and lower shoulders or surfaces **131***d* and **131***e*.

The detent means **150** for releasably holding the slips **131** in their lower retracted positions on the body **100** against the resistance of the spring **135** includes a slip sleeve **150***a* having an enlarged lower portion which telescopes over the upper end of the expander section **100***c* and whose lower annular curved end surface **150***b* engages the upper shoulders **131***d* of the collet fingers to hold the slips in their lower positions and at the same time its engagement with the slip shoulders **131***d* cams the upper ends of the slips inwardly. The slip sleeve thus holds the slips in their inner retracted positions due to the camming engagement of its shoulder **150***b* with the upper upwardly and inwardly extending shoulders **131***d* of the slips. The slip sleeve is held in its lower position on the body by means of the pivot pawls **150***c* and the lock sleeve **150***d* disposed about the connector section **100***b* whose bottom annular end shoulder **150***e* engages the upper surfaces of the inner end portions of the pivot pawls **150**. The lock sleeve is held in the lower position illustrated in FIGURE 7 by a shear pin **150***f* which extends through a lateral bore on top of the pawl sleeve **150***f* into a suitable external bore of the lock sleeve. The pawl sleeve is threaded on the body connector section **100***b* and its lower portion is spaced therefrom to provide an annular space in which the lock sleeve is posi-

tioned. The pawls are disposed in circumferentially spaced downwardly opening slots **150***g* of the pawl sleeve and are pivotally secured to the pawl sleeve by the pins **150***h* which extend through the slots **150***g*. The pawls are resiliently biased to their outer positions illustrated in FIGURE 7 by the spring **135** and pivot upwardly upon engaging upwardly facing obstructions such as the annular end surfaces or shoulders **152** of flow conductor sections during downward movement of the actuator tool through the flow conductor, slip sleeve, the slips and the slip carrier moving downwardly against the resistance of the spring **135** to permit such pivotal movement of the pawls. Upon upward movement of the actuator tool through the well flow conductor, the outer ends of the pawls engage the first downwardly facing obstruction which they encounter, such as the downwardly facing end shoulder or surface **155** of a flow conductor section, and further upward continued movement of the well tool then causes the outer ends of the pawls to pivot downwardly and to exert an upward force on the lock sleeve **150** which shears the shear pin **150***f*. The force of the spring **135** is then effective to move the slip sleeve, the slips and the slip carrier upward on the body. As the internal surfaces **140** of the slips move upwardly on the expander surface **142** of the expander section **100**, the upper ends of the slips are moved outwardly the camming action between the top surfaces **131***d* of the slips and the bottom annular shoulder surface **150***b* of the slip sleeve **150***a* moving the slip sleeve upwardly relative to the slips to permit such outward movement of the upper ends of the slips. The teeth of the slips then engage the internal surfaces of the flow conductor in which the well tool is disposed and thereafter limit downward movement of the body in such flow conductor.

In use, the actuator tool is connected by means of the threaded pin **161** of its top connector section **115***b* to a flexible line by the usual set of wire line tools while the support rod **115** is held in the upper position relative to the body **100** of the tool by the shear pin **118** and its valve **105** is held in its upper position illustrated in FIGURE 9 by the detent means or ring **170** which engages the shoulder **170** of the body to hold the valve in its upper position against accidental downward movement therein. A fluid pressure operated well tool, such as the bridge plug **21**, is connected to the lower end of the body **100** in the manner described with the O-ring **172** sealing therebetween so that the chamber **101** of the actuator which communicates with the upper end of the piston chamber of such well tool through the port **111** is sealed and filled with a compressible gas, such as air, at relatively low pressure, such as atmospheric pressure. As the assembly of the two well tools is lowered into the flow conductor, the outer ends of the pawls **150***c* engage the internal surfaces of the flow conductor and their outer ends pivot upwardly to permit downward movement of the actuator tool therethrough. When it is desired to set or operate the fluid pressure operated tool, the assembly of the two tools is lifted upwardly until the pawls **150***c* engage a downwardly facing obstruction of a flow conductor whereupon the shear pin **150***f* is sheared, the lock sleeve is freed for upward movement and the force of the spring **135** moves the slip carrier, the slips and the slip sleeve upwardly on the body **100** causing the upper ends of the slips to move outwardly as they move over the expander surface **142** of the body and their teeth **131***c* engage the internal surfaces of the well flow conductor and then prevent downward movement of the body **100** in the flow conductor since any downward movement of the body tends to move the slips further outwardly due to the engagement of its expander surface **142** therewith. Downward movement then imparted to the support rod **115** causes the shear pin **118** to shear since the body will now be held against downward movement by the slips and as the support rod moves downwardly in the body, the lower end of the support rod engages the upper end of the valve **105** and moves it downwardly, the detent means **110** being resiliently deformed inwardly to permit such downward movement of the valve until the valve is in its lowermost position with its ports **105***a* in alignment and communication with the ports **102** of the actuator body whereupon the fluid pressure from the exterior of the well tool is communicated through the ports **112** and **111** to the well tool whose operation is thus initiated by the actuation of the actuator tool.

The actuator tool may then be removed together with the upper portions of the well tool connected to the body **100** in the manner previously described, leaving the fluid pressure operated well tool in set or operative position in the flow conductor.

Referring now particularly to FIGURE 3 of the drawing, the well tool **200** is similar to the actuator tool **20** and accordingly corresponding elements thereof have been provided with the same reference numerals as the well tool **20** to which the subscript *p* has been added. The body **100***p* of the actuator tool **200** includes an upper section **100***m* and a lower section **100***n*. The reduced lower end portion of the upper body section is threaded into the upper end of the lower body section and the valve or closure **105***p* which is in the form of a frangible disk has an external annular flange which extends outwardly between and in sealing engagement with the lower annular end shoulder **100***g* of the upper body section and the upwardly facing annular shoulder **100***y* of the lower body section.

The support rod **115***p* has an enlarged lower end portion **115***m* which extends into the passage or valve chamber **101***p* for engaging and breaking the disk **105***p* when the support rod **115***p* moves downwardly relative to the body **100***p* after the shear pin **118***p* is sheared.

It will be apparent that the actuator tool will permit communication of fluid pressure from the exterior thereof to a fluid pressure operated tool, such as the bridge plug **21**, upon downward movement of the support rod **115***p* relative to its body **100***p* after the body has been anchored against downward movement by the slips **131***p* of an anchoring assembly **130***p* which is identical in structure and function to the anchoring assembly **130** of the actuator tool **20**.

Referring now to FIGURE 4 of the drawing, the well tool **210** is also similar to the well tools **20** and **200**, and, accordingly its elements have been provided with the same reference numerals, to which the subscript *r* has been added, as the corresponding elements of the well tools **20** and **200**. The frangible disc or valve **105***r* closing the passage **101***r* of the body **100***r* of the well tool **210** is pierced or fragmented by the pointed end **115***z* of the support rod **115***r*, when the shear pin **118***r* is sheared as the support rod **115***r* moves downwardly relative to the body, to permit fluid to flow through the port **102***r*, the passage or valve chamber **101***r* and the longitudinal port **111***r* to the fluid pressure operated well tool.

Referring now particularly to FIGURE 5, the well tool **220** there illustrated is similar to the well tool **20** and, accordingly, the elements of the well tool **220** have been provided with the same reference numerals, to which the subscript *s* has been added, as the corresponding elements of the well tool **20**. The valve chamber or passage **101***s* of the actuator tool **220** between the ports **102***s* and **111***s* is closed by the valve or closure portion **105***s* of the support rod **115***s* having an O-ring **221** disposed in a suitable external annular recess thereof which sealingly engages the surface **222** of the body below the port **102***s* when the support rod **115***s* is held in its upper position by the shear pin **118***s*. The external flange **122***s* of the support rod limits longitudinal movement of the support rod **115***s* relative to the body so that when the support rod has been moved to its lowermost position, wherein the O-ring **221** is moved out of sealing engagement with the internal surface **212** of the body, FIGURE 5, fluid from

the exterior of the body may flow into the upper end of the piston chamber **62** of the fluid pressure operated well tool **21** through the valve chamber or passage **101***s* and the longitudinal passage **111***s* to move the piston **60** to its lower position.

Referring now particularly to FIGURE 6, the well tool **230** is also similar to the actuator well tool **20** and, accordingly, its elements have been provided with the same reference numerals, to which the subscript *t* has been added, as the corresponding elements of the well tool **20**. The support rod **115***t* of the well tool **230** extends into the valve chamber or passage **101***t* of the body **100***t* and has an O-ring **231** which sealingly engages the internal surface **232** of the body, when the support rod **115***t* is held in its upper position relative to the body by the shear pin **118***t*, to prevent fluid flow through the valve chamber **101***t* to the longitudinal port **111***t* of the body. The body **100***t* also has a second passage or chamber **234** in which is disposed a valve or closure **235** which initially is held in an upper position in the chamber **234** by a shear pin **236** wherein its longitudinally spaced O-rings **237** and **238** are disposed above and below the lateral ports **239** of the body and sealingly engage the internal surface **240** of the body to prevent communication of pressure from the exterior of the body through the port **239** and the chamber **234** to the longitudinal port **241** which opens into the upper end of the piston chamber **62** of the fluid pressure operated tool **21**.

In use, the well tool **230** may be lowered into a well flow conductor and then moved upwardly to release its slips **131***t* of its anchoring assembly **130***t* with engagement with the internal surfaces of the flow conductor C and thereafter prevents downward movement of the body **100***t* in the flow conductor. A downward force then imparted to the support rod **115***t* causes the shear pin **118***t* to shear and subsequent downward movement of the support rod **115***t* then moves its O-ring **231** out of sealing engagement with the surface **232** and permits the fluid pressure from the flow conductor to be communicated to the upper end of the second chamber **234** thereof.

The fluid pressure operated tool will not open if the fluid pressure in the flow conductor is below a certain value predetermined by the shear strength of the shear pin **236**. The pressure in the flow conductor may then be increased to the such predetermined value, as by pumping fluid thereinto at the surface, and such increased fluid pressure will then cause the shear pin **236** to shear and the valve to move downwardly to its open position. The pressure from the flow conductor is thus communicated to the upper end of the piston chamber **62** of the fluid pressure operated well tool **21** through the port **239**, the chamber **234** and the port **241**. It will be apparent that the actuator tool **230** may be employed in installations where it is desirable to control the operation of the actuator tool not only by the downward movement of the support rod **115***t* after the anchoring assembly **130***t* has been set but also by a subsequent increase in the fluid pressure in the flow conductor.

It will now be apparent that each of the illustrated and described actuator tools includes a body which is connectable to a fluid pressure operated tool and is provided with a flow passage which communicates with the fluid pressure operated tool and with the exterior of the body, a valve or closure means which initially closes the passage and prevents communication of fluid pressure from the exterior of the actuator tool to the operator means such as a piston, of the fluid pressure operated tool, a support rod which is initially releasably held in an upper position relative to the body and which is movable downwardly, after an anchoring assembly carried by the body has been set to limit downward movement of the actuator tool in a flow conductor, to engage the valve or closure means to open the flow passage for the flow of fluid therethrough to the fluid pressure operated well tool.

It will further be seen that in the well tools illustrated in FIGURES 3 and 4 of the drawings, the valve or closure member closing the flow passage of the actuator tube is a frangible disk which is fragmented or pierced upon a very short downward movement or stroke of the support rod relative to the body and that the operation of the well tool **230** is responsive not only to the downward movement of its suport rod relative to its body but also to the fluid pressure in the flow conductor.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed and desired to be secured by Letters Patent is:

1. An actuator tool for a fluid pressure operated tool, said actuator tool including: a body connectable to a fluid pressure operated tool and having a flow passage therethrough, said flow passage communicating with the exterior of the body and with a fluid pressure operated tool when the fluid operated tool is connected thereto; closure means closing said flow passage; anchor means on said body operable upon upward movement of said body in a flow conductor and engageable with the flow conductor to prevent subsequent downward movement of the body in the flow conductor; a support rod by means of which said actuator tool may be moved in a flow conductor releasably secured to said body, said support rod being movable downwardly relative to said body and said closure means, when downward movement of the said body in a flow conductor is arrested by said anchoring means, to cause said closure means to open said flow passage whereby fluid from the exterior of the body is communicated through said flow passage to a fluid pressure operated tool connected to said body.

2. An actuator tool for a fluid pressure operated tool, said actuator tool including: a body connectable to a fluid pressure operated tool and having a flow passage therethrough, said flow passage communicating with the exterior of the body and with a fluid pressure operated tool when the fluid operated tool is connected thereto; closure means closing said flow passage; anchor means on said body operable upon upward movement of said body in a flow conductor and engageable with the flow conductor to prevent subsequent downward movement of the body in the flow conductor; a support rod by means of which said actuator tool may be moved in a flow conductor releasably secured to said body, said support rod being movable downwardly relative to said body and said closure means when downward movement of the said body in a flow conductor is arrested by said anchoring means, to cause said closure means to open said flow passage whereby fluid from the exterior of the body is communicated through said flow passage to a fluid pressure operated tool connected to said body, said closure means comprising a frangible disk, said support rod extending into said flow passage and engageable with said frangible disk to rupture said disk upon downward movement of said support rod relative to said body.

3. An actuator tool for a fluid pressure operated tool, said actuator tool including: a body connectable to a fluid pressure operated tool and having a flow passage therethrough, said flow passage communicating with the exterior of the body and with a fluid pressure operated tool when the fluid operated tool is connected thereto; closure means closing said flow passage; anchor means on said body operable upon upward movement of said body in a flow conductor and engageable with the flow conductor to prevent subsequent downward movement of the body in the flow conductor; a support rod by means of which said actuator tool may be moved in a flow conductor releasably secured to said body, said support rod being movable downwardly relative to said body and said closure means when downward movement of

the said body in a flow conductor is arrested by said anchoring means, to cause said closure means to open said flow passage whereby fluid from the exterior of the body is communicated through said flow passage to a fluid pressure operated tool connected to said body, said closure means comprising a valve member releasably secured in an upper position in said flow passage closing said flow passage and movable downwardly to a lower open position to open said flow passage by said support rod when said support rod is moved downwardly relative to said body.

4. An actuator tool for a fluid pressure operated tool, said actuator tool including: a body connectable to a fluid pressure operated tool; anchor means on said body; means biasing said anchoring means toward expanded anchoring position; detent means for holding said anchoring means in retracted and inoperative position, said detent means being engageable with a downwardly facing obstruction of a well flow conductor upon upward movement of the body in a well flow conductor for releasing said anchoring means for movement to expanded anchoring position in engagement with a well flow conductor wherein the anchoring means prevents downward movement of the body in the well flow conductor; a support rod releasably secured to said body by means of which said body is movable through a well flow conductor, said body having a flow passage communicating with the exterior and the fluid pressure operated tool connected thereto; closure means closing said flow passage, said support rod being engageable with said closure member upon downward movement of said support rod relative to said body for opening said flow passage whereby fluid from the exterior of the body is communicated through said flow passage to the fluid pressure operated tool upon downward movement of said support rod relative to said body.

5. A tool assembly movable through a well flow conductor; said tool assembly including: a well tool having a body provided with a piston chamber; a piston movably disposed in said chamber and operator means carried by said body and operable by said piston, said piston being movable from an initial inoperative position to an operative position in said chamber by fluid pressure; and an actuator tool having a body connected to the upper end of said well tool body, said actuator tool body having a flow passage opening into said piston chamber and a lateral port communicating said passage with the exterior of said actuator tool body, closure means in said passage closing said passage and preventing fluid flow from the exterior of said actuator tool body to said chamber through said passage, a support rod releasably secured to said well tool body in an upper position and movable downwardly relative to said well tool body, said support rod opening said closure means when moved longitudinally downwardly relative to said well tool body, and anchor means on said well tool body movable to expanded position to anchor said body against downward movement in a flow conductor.

6. A tool assembly movable through a well flow conductor, said tool assembly including; a well tool having a body provided with a piston chamber, a piston movably disposed in said chamber and operator means carried by said body and operable by said piston, said piston being movable from an initial inoperative position to an operative position in said chamber by fluid pressure; and an actuator tool having a body connected to the upper end of said well tool body, said actuator tool body having a flow passage opening into said piston chamber and a lateral port communicating said passage with the exterior of said actuator tool body, closure means in said passage initially closing said passage and preventing fluid flow from the exterior of said actuator tool body to said chamber through said passage and slidable longitudinally in said passage to open said lateral port, a support rod releasably secured to said well tool body in an upper position and movable downwardly relative to said well tool body, said support rod moving said closure means longitudinally of said passage to a position opening said closure means when moved longitudinally downwardly relative to said well tool body, and anchor means on said well tool body movable to expanded position to anchor said body against downward movement in a flow conductor.

7. An actuator tool for a fluid pressure operated tool, said actuator tool including; a body connected to a fluid pressure operated tool and having a flow passage therethrough, said flow passage communicating with the exterior of the body and with the fluid pressure operated tool when the fluid pressure operated tool is connected to said body; anchor means on said body operable upon upward movement of said body in a flow conductor for movement to expanded position wherein said anchor means engage a flow conductor to prevent subsequent downward movement of the body in the flow conductor; a support rod by means of which said actuator tool may be moved in a flow conductor releasably secured in an upper position relative to said body, said support rod extending into said passage and having seal means engageable with said body preventing fluid flow through said flow passage when said support rod is in said upper position, said support rod being movable downwardly relative to said body when downward movement of said body in a flow conductor is arrested by said anchor means to move said seal means out of sealing engagement with said body to open said flow passage whereby fluid pressure from the exterior of the body is communicated through said passage to a fluid pressure operated tool connected to said body.

8. An actuator tool including: a tubular body having a longitudinal bore; a support rod extending into said bore by means of which the body may be supported during movement through a flow conductor; means releasably securing said support rod in an upper position relative to said body; an anchor assembly on said body including means biasing said anchor assembly toward expanded position wherein said anchor assembly engages internal surfaces of the flow conductor to prevent downward movement of the body in the flow conductor; detent means releasably holding said anchoring assembly against movement toward expanded position, said detent means being engageable with internal downwardly facing obstructions of a well flow conductor for causing said detent means to release said anchor assembly for movement toward its expanded position upon upward movement of the body in a well flow conductor, said body having a lateral port communicating with said longitudinal bore; and closure means in said bore preventing fluid flow therethrough, said closure means being engageable by said support rod and openable thereby when said support rod is moved downwardly in said body to permit fluid flow from the exterior of said body into said bore, the lower end of said body having means for securing said body to a fluid pressure operated tool whereby fluid pressure from the exterior of the body is communicated through said bore to said fluid pressure operated tool when said closure means is open.

9. An actuator tool including: a body having a longitudinal bore; a support rod extending into said bore by means of which the body may be supported; means releasably securing said support rod in an upper position relative to said body; an anchor assembly on said body including a plurality of slips, means biasing said slips upwardly, said slips and said body having coengageable means for moving said slips outwardly toward expanded position upon upward movement of said slips relative to said body; detent means releasably holding said slips against upward movement on said body, said detent means including means engageable with internal downwardly facing obstructions of a well flow conductor for causing said detent means to release said slips for upward movement on said body upon upward move-

ment of said body in a flow conductor, said body having a lateral port communicating with said longitudinal bore; and closure means in said bore preventing fluid flow therethrough, said closure means being movable by said support rod and openable when said support rod is moved downwardly in said body to permit fluid flow from the exterior of the body through said bore, the lower end of said body having means for securing said body to a fluid pressure operated tool whereby fluid pressure from the exterior of the body is communicable through said bore to said fluid pressure operated tool when said closure means is open.

10. An actuator tool including: a body having a longitudinal bore; a support rod extending into said bore by means of which the body may be supported; means releasably securing said support rod in an upper position relative to said body; an anchor assembly on said body including a plurality of slips, means biasing said slips upwardly, said slips and said body having coengageable means for moving said slip outwardly toward expanded position upon upward movement of said slips relative to said body; detent means including a slip sleeve engageable with said slips for holding said slips against upward movement, pawl means pivotally secured to said body and extending outwardly of said body for engaging

downwardly facing obstructions, a lock sleeve releasably secured to said body holding said pawl means against pivotal movement on said body, said pawl means having inner end portions disposed between said lock sleeve and said slip sleeve, the engagement of said inner end portions of said pawl means with said lock sleeve preventing upward movement of said slip sleeve, said pawl means being pivotally movable to release said lock sleeve from securement to said body to permit movement of said slip sleeve relative to said body.

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