Sept. 8, 1964 G. A. THOMAS 3,147,809

APPARATUS FOR ACTUATING SLEEVE VALVES AND THE LIKE IN WELLS

Filed Sept. 17, 1962 2 Sheets-Sheet 1

FIG.1

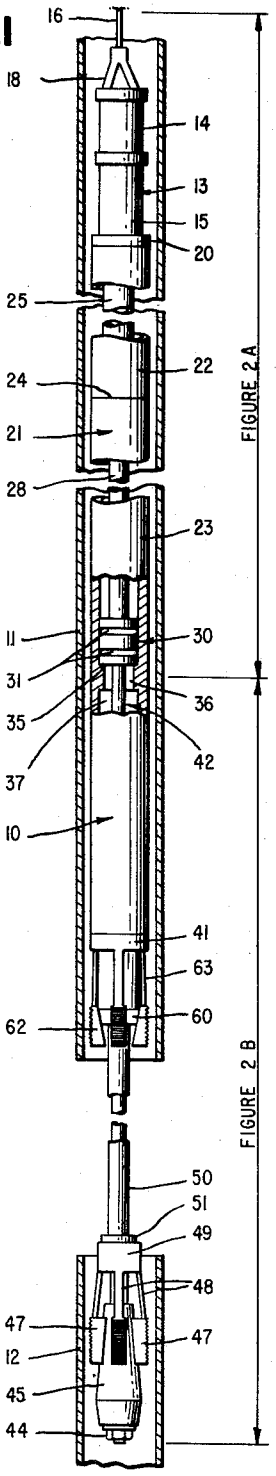


FIG.2A

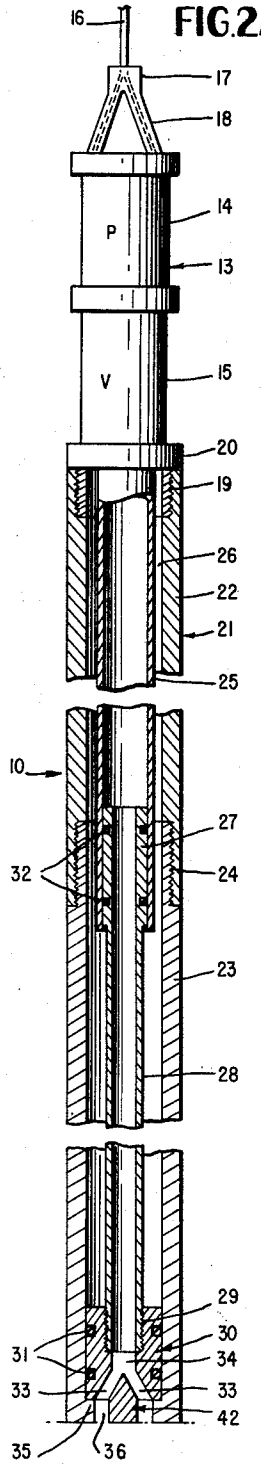
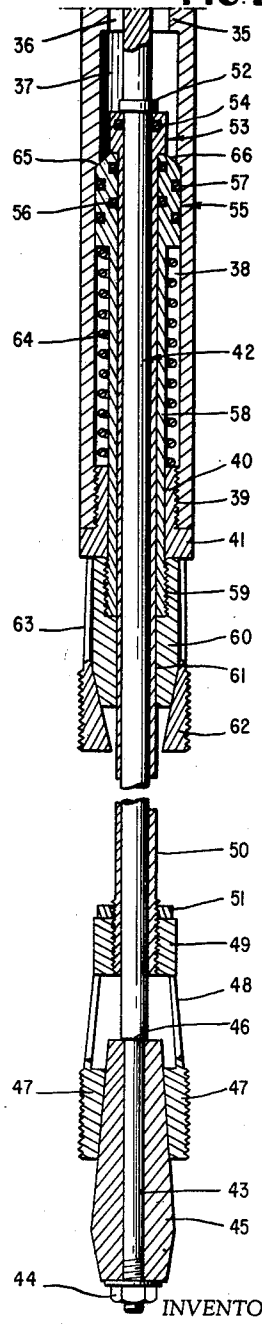


FIG.2B



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FIG. 3

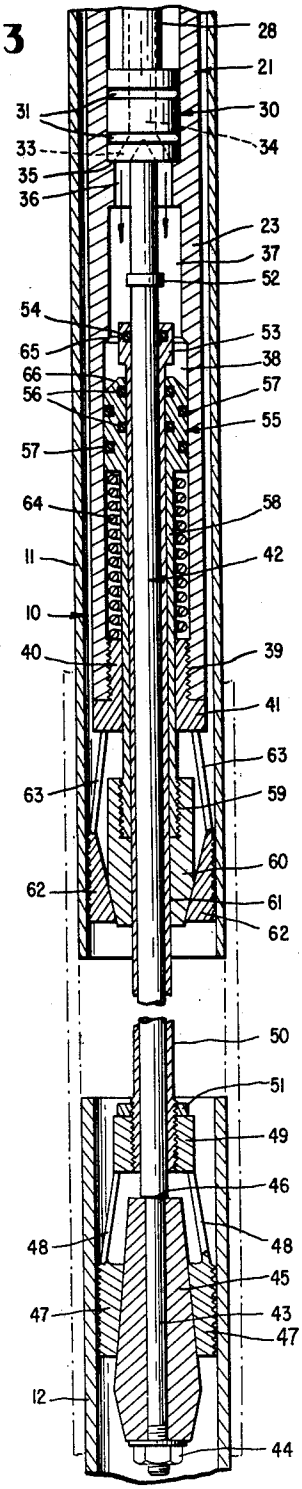


FIG. 4A

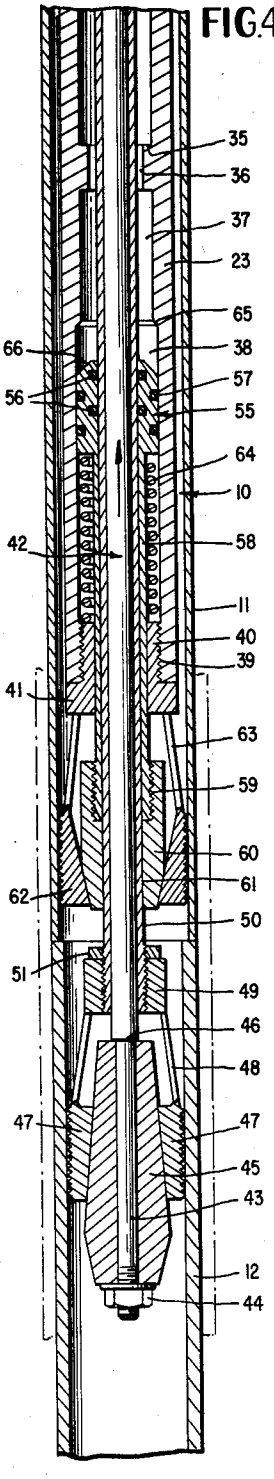
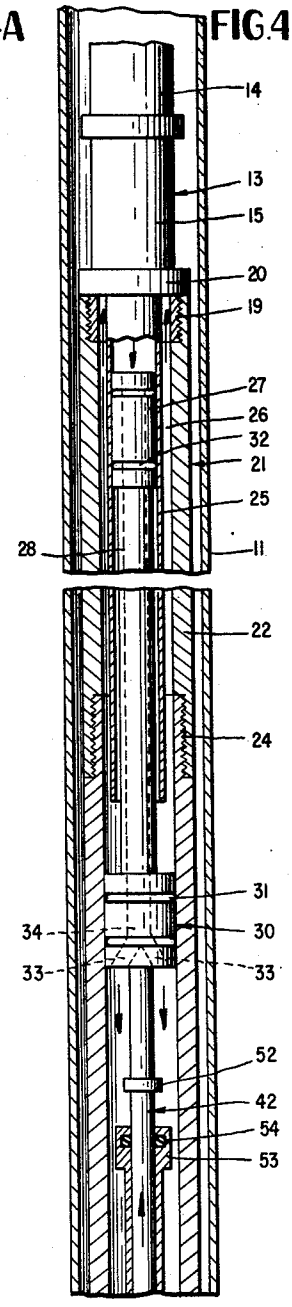


FIG. 4B



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3,147,809

APPARATUS FOR ACTUATING SLEEVE VALVES AND THE LIKE IN WELLS

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5 Claims. (Cl. 166—98)

This invention relates to an actuating apparatus or tool utilized to move a sleeve valve, section of tubing, or the like, far down in a well or in any other remote and inaccessible location.

More particularly, the invention herein is designed to operate the sleeve valve elements disclosed in my prior copending applications Serial Number 172,019, filed February 8, 1962, for Method of and Apparatus for Completing Oil Wells and the Like, and Serial Number 193,107, filed May 8, 1962, for Method of and Apparatus for Completing Wells.

An object of the invention is to provide an actuator tool of the mentioned character which is reliable and efficient in operation, simplified and economical in construction, and substantially foolproof when properly used.

Another object is to provide an apparatus of the above-mentioned character which is fluid pressure operated by a readily available self-contained pump and control valve unit, of a type known in the art, and which may be operated and controlled from ground level without difficulty.

Another object of the invention is to provide an apparatus of the mentioned character having a closed fluid pressure circulating and control system which is quick and positive in operation and requiring little or no maintenance.

Still another object is to provide an apparatus of the mentioned type which is highly compact in construction, enabling it to be used inside of relatively small well tubing and the like.

Other objects and advantages of the invention will become apparent to those skilled in the art during the course of the following detailed description.

In the accompanying drawings forming a part of this application and in which like numerals are employed to designate like parts throughout the same,

FIGURE 1 is a fragmentary side elevational view, partly broken away and partly in section, of a complete apparatus embodying the invention and showing the same during use in relation to a section of well tubing and a sleeve valve element to be moved axially relative to said tubing,

FIGURE 2*a* is a central vertical fragmentary longitudinal section on an enlarged scale, partly broken away, showing an upper portion of the apparatus according to the invention,

FIGURE 2*b* is a similar sectional view of the apparatus and forming a continuation of FIGURE 2*a*,

FIGURE 3 is a central vertical longitudinal section through the lower portion of the apparatus showing one step in the operation of the same for gripping the tubing and sleeve valve or the like prior to moving the latter,

FIGURE 4*a* is a similar view of the apparatus showing another step in the operation thereof for shifting the sleeve valve in one direction toward the tubing, and

FIGURE 4*b* is a similar view of the upper portion of the apparatus positioned in accordance with FIGURE 4*a* and forming a continuation of that figure.

In the drawings, wherein for the purpose of illustration is shown a preferred embodiment of the invention, attention is directed first to FIGURES 1 through 2*b*,

wherein the invention apparatus is designated in its entirety by the numeral **10**, such apparatus being shown inside of a section of well tubing **11**, far down in an oil well or the like. Also shown in FIGURE 1 is an axially movable sleeve valve element **12**, receiving the lower portion of the apparatus **10** and adapted to be shifted by the apparatus axially toward the tubing section **11** in a manner to be described in detail. The sleeve valve element **12** may be the sleeve valve element in either of my prior copending applications Serial Numbers 172,019 and 193,107 mentioned above.

The apparatus **10** proper, as best shown in FIGURES 2*a* and 2*b*, comprises a conventional pump and control valve unit **13** having a preferably electrically driven pump **14** and a flow reversing and control valve **15**, all integrated in the unit **13** as shown. The unit **13** is suspended at any desired location in the well by a combined suspension and power cable **16**, having its lower end secured in a fluid tight manner at **17** to the top of a suspension yoke **18**, rigid with the top of the unit **13** and having passages therein through which the wires of the cable **16** extend for electrical connection with the terminals of the self-contained motor, not shown, of the pump **14**. All of this construction is well-known and conventional and need not therefore be further described herein.

The lower end of the unit **13** has a screw-threaded coupling part **19** rigid therewith and extending below a bottom abutment flange **20**, also rigid with the unit **13**. A tubular barrel or casing **21**, adapted to be formed in sections **22** and **23** with a screw-threaded joint **24**, has its upper end internally screw-threaded and detachably rigidly secured to the tubular screw-threaded coupling element **19** of the pump and control valve unit **13**. The latter has a tubular guide and pressure fluid conducting pipe **25** extending from its lower end and secured thereto in any suitable manner in direct communication with one discharge port of the reversible valve **15**, and the pipe **25** is of smaller diameter than the casing **21** and is arranged concentrically therein in spaced relation to the bore of the casing **21**. This construction forms an annular passage **26** surrounding the pipe **25** and between the latter and the bore of barrel or casing **21**. The top of the annular passage **26** communicates with a second discharge opening of the reversible valve **15**, so that the latter may introduce fluid under pressure selectively into the pipe **25** or into the annular passage **26**, as will be fully described.

The lower open end of pipe **25** terminates within the sectional casing **21** well below the pump and valve unit **13**, FIGURE 2*a*, and slidably mounted within the bore of the pipe **25** is the tubular plunger head **27** of a tubular connecting rod **28**, having its lower end connected by screw-threads **29** with a main relatively large piston **30**, as shown. The piston **30** is therefore rigid with the reciprocatory tubular rod **28** and movable therewith relative to the pipe **25** and surrounding casing or barrel **21**. The piston **30** is slidable within the bore of casing **21** and is preferably sealed therewith by O-ring seals **31** or the like. Similar seals **32** are preferably provided on the plunger head **27** to seal the latter with the bore of the pipe **25**, FIGURE 2*a*.

The piston **30** has downwardly opening divergent branch ports **33**, communicating at their tops with a common central passage **34** of the piston, in turn communicating directly with the bore of the tubular connecting rod **28**. The lower end of piston **30**, FIGURES 2*a* and 3, is adapted to engage an internal annular collar or shoulder **35** formed integral with the casing **21** and projecting into the bore of the same. The fixed collar **35** has a bore or port **36** therethrough, adapted to register

with the branch ports 33 when the piston 30 is seated against the top of collar 35.

Below the collar or shoulder 35, FIGURE 3, the bore 37 of casing 21 continues and communicates with the port 36. Near and above the lower end of casing 21, the bore thereof is somewhat enlarged at 38 for a purpose to be described. The lower end of casing 21 is internally screw-threaded at 39, for the reception of a tubular screw-threaded plug or fitting 40, having an enlarged head 41 which abuts the lower open end of casing 21 in assembly, FIGURE 3.

A long relatively slender centrally disposed solid rod 42 has its top end formed integrally with the piston 30, between the divergent ports 33. The rod 42 is therefore rigid with the piston 30 and moves with the latter relative to casing 21 and associated elements. The solid rod 42 extends to the extreme bottom of the apparatus 10, as shown in the drawings, and is provided near its lower end with a relatively short reduced integral extension 43, upon which is rigidly mounted by separable screw-threaded means 44 a reversely conically tapering wedge or expander element or head 45. The top of head 45 abuts an annular shoulder 46 on the solid rod 42, formed by the reduced rod extension 43.

Surrounding the tapered expanding head 45 for coaction therewith is an annular spaced group of tapered expanding jaws or slips 47, having teeth to engage the bore of sleeve valve element 12 when expanded. The jaws 47 are bodily carried by a corresponding number of spring arms 48, suitably secured thereto, and secured at their upper ends to a nut element 49 having screw-threaded engagement with the screw-threaded lower end of a long tube 50 which receives the solid rod 42 telescopically and slidably therethrough, FIGURES 2*b* and 3. A lock nut 51 is preferably provided above the nut element 49 so that the latter may be securely locked in the selected adjusted position upon the lower end of tube 50. The solid rod 42 is provided near and below its upper end with an integral enlargement or collar 52, serving as a stop in a manner to be described.

The top end of long tube 50 carries a relatively small diameter piston head 53 integral therewith, and having its bore sealed to the rod 42 by an O-ring seal 54 or the like. The piston head 53 is materially smaller in diameter than the main piston 30. A third larger diameter piston head 55 surrounds the tube 50 and slidably engages the latter and also slidably engages the enlarged bore portion 38 of casing 21. O-ring seals 56 and 57 are provided on the piston head 55 to seal the latter respectively against the tube 50 and bore 38. The piston head 55 is secured integrally to a depending relatively short tube extension 58, also within the bore portion 38 and surrounding the long tube 50 telescopically and slidably.

The lower end of tube extension 58 projects below the lower end of casing 21 and head 41 and is screw-threaded at 59 and carries a conically tapered expander head or wedge 60 having screw-threaded engagement therewith. The expander head 60 is tapered oppositely to the head 45 for reasons which will soon become apparent. The bore of the tubular head 60 receives the long tube 50 therethrough as indicated at 61.

An additional spaced annular group of gripping jaws 62 or slips surrounds the expander head 60 in coacting relation therewith, and the jaws 62 have external teeth as shown adapted to grip the bore of tubing section 11, or the like, when expanded. The expandable jaws 62 are bodily carried by spring arms 63, secured at their upper ends to the flange or head 41.

A relatively strong compressible coil spring 64 surrounds the long tube 50 within the bore portion 38 and has its top end bearing upon the underside of piston head 55 and its lower end bearing upon the top of tubular fitting 40. This spring therefore constantly urges the piston head 55 upwardly within the bore portion 38, toward a beveled stop shoulder 65 therein which is adapted, FIGURE 2*b*, to engage a similarly tapered face 66 of piston head 55. As shown in FIGURE 2*b*, the smaller piston head 53 is also adapted to engage the top of piston head 55, and the piston head 53 is also engageable with the stop collar 52 of solid rod 42.

Operation

The actuating apparatus or tool for use in wells and above-described has a simple essentially three-stage cycle of operation.

The entire apparatus 10 is lowered into and through the well tubing 11 by means of the cable 16, until the upper set of jaws 62 are positioned near the bottom of the tubing section 11 and the lower set of jaws 47 are positioned within the sleeve valve 12 or like element which it is desired to draw upwardly toward tubing section 11. At this time, both sets of jaws 47 and 62 are collapsed so that their teeth are spaced from the bores of the well tubing and sleeve valve element, and the component parts of the apparatus 10 are arranged as illustrated in FIGURES 1–2*b* inclusive. That is to say, the plunger head 27 is disposed near the bottom end of pipe 25. The piston 30 is resting upon the fixed collar 35. The spring 64 is urging the piston head 55 upwardly against the smaller piston head 53, and the latter is engaging the stop collar 52 of solid rod 42.

With the parts and apparatus thus positioned, the electric motor of pump 14 is started from above ground and current to the motor is supplied through the combined suspension and power cable 16. The pump 14 is operated to build up pressure in the closed fluid pressure system of the apparatus, and the control valve 15 of unit 13 acts automatically to supply fluid under pressure downwardly through the bore of pipe 25, and through the bore of tubular connecting rod 28, and through the ports 33, 36 and into the casing bore 37, FIGURE 3, where such fluid pressure acts upon the tops of both piston heads 53 and 55, to urge the latter downwardly in unison against the force of spring 64.

As pressure continues to be applied through the apparatus in the described manner by the unit 13, and as the piston heads 53 and 55 move downwardly within the bore portion 38 of the suspended casing 21, the tube extension 58 attached to piston head 55 will cause the expander head 60 to move downwardly relative to the jaws 62, expanding the latter into gripping engagement with the bore of well tubing 11. Substantially simultaneously, downward movement of the piston head 53 and the long tube 50 attached to it will shift the jaws 47 downwardly over the expanding head 45, which expanding head is relatively stationary at this time. This, therefore, effects the expansion of the jaws or slips 47 into gripping engagement with the bore of sleeve valve element 12. At this time, the various parts are arranged as shown in FIGURE 3. The tubing 11 and sleeve valve element 12 are both gripped by the respective jaws 62 and 47, but the sleeve valve 12 has not yet been drawn upwardly toward the tubing 11. The piston 30 is still seated upon the collar 35, but the piston head 53 has moved down away from the stop collar 52 and the larger piston head 55 has separated from the piston head 53, FIGURE 3.

As fluid under pressure continues to be delivered by the pump valve unit 13, in the manner described, and since the jaws 62 and 47 can expand no further and the piston heads 53 and 55 can move down no further within the casing 21, the further build-up of fluid pressure in the system will now begin to act upon the bottom of piston 30 and cause the same to be elevated within the bore of casing 21 along with the tubular connecting rod 28 and the long solid rod 42 and associated elements. As the rod 42 moves upwardly, FIGURES 4*a* and 4*b*, relative to the piston heads 53 and 55, the jaws 47 and head 45 are likewise elevated and the sleeve valve ele-

ment 12 is drawn upwardly and into abutting engagement with the lower end of tubing 11 in the desired manner to effect the opening or closing of the sleeve valve. At this time, the plunger head 27 correspondingly moves upwardly within the bore of pipe 25 as indicated in FIGURE 4*b*. When the sleeve valve 12 reaches the top of its travel, the upward movement of the piston 30 and associated elements will be positively arrested.

In order to release the sleeve valve 12 after it is elevated, FIGURE 4*a*, the control valve 15 automatically is operated in a manner well known in the art to relieve fluid pressure in the bore of pipe 25 and in the bore of tubular connecting rod 28 and in the ports 33 and 36 and bore 37 above the piston heads 53 and 55. Simultaneously, pressure is built up by the unit 13 in the annular chamber 26 and therefore on the top of piston 30 immediately forcing the latter downwardly toward engagement with the collar or shoulder 35. When this occurs, the solid rod 42 shifts downwardly and moves the expander head 45 downwardly relative to the jaws 47, consequently releasing the same from gripping engagement with the sleeve valve element 12. Substantially simultaneously, since pressure is relieved above the piston heads 53 and 55, the spring 64 elevates these piston heads back into engagement with the stop collar 52 on rod 42, and this action elevates the expander head 60 and releases the jaws 62 from gripping engagement with the well tubing section 11. The apparatus is now returned to its original condition illustrated in FIGURES 1–2*b*, and the entire apparatus may be lifted from the well tubing by means of the suspension cable 16.

Quite obviously, when it is desired to move the sleeve valve element 12 downwardly from its position shown in FIGURE 4*a*, the identical mode of operation described above is repeated with the apparatus 10 located in a different manner relative to the sleeve valve element and well tubing. That is to say, in order to move the sleeve valve downwardly, the apparatus 10 is positioned initially so that the upper set of jaws 62 engage within the bore of the sleeve valve element 12 while the lower jaws 47 engage within the bore of the next lowermost section of well tubing not shown in the drawings. When the apparatus 10 is thus positioned, the same cycle of operation above-described will first cause the sets of jaws 62 and 47 to grip the bores of the sleeve valve 12 and the section of tubing immediately below it, and the subsequent movement of the two sets of jaws toward each other relatively by the apparatus will cause the sleeve valve to be lowered because the well tubing below the sleeve valve is immovable and cannot move upwardly. It should now be apparent that by proper positioning of the apparatus in the well, sleeve valves or like elements can be shifted selectively in either direction axially and released automatically after proper positioning. The apparatus and fluid pressure control system is simplified, highly compact and trouble-free in operation. The tool or apparatus enables the manipulation of elements with accuracy far down in a well bore, remote from ground level.

As is well known to those skilled in the art, a conventional electronic collar locater may be utilized in conjunction with radioactive pellets and the like to locate the tool relative to the work deep down in the well. These conventional instrumentalities form no direct part of the invention and are not shown and need not be described in detail herein.

While the tool has been described primarily in connection with the movement of a sleeve valve of the type shown in my mentioned prior copending applications, still it should be understood that the tool or apparatus is capable of other like uses in wells or in inaccessible locations below ground, where direct operation on parts to be moved is impossible.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred example of the same, and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of the invention or scope of the subjoined claims.

Having thus described my invention, I claim:

1. An actuating apparatus for sub-surface instrumentalities in a well or the like adapted to be operated by a fluid pressure pump and control valve unit having a suspension and power cable secured thereto, said apparatus comprising a tubular casing secured dependingly to said unit, said casing having an internal shoulder intermediate its ends, said shoulder having fluid passage means therethrough, a piston within said casing above said shoulder and having fluid passage means communicable with the passage means of said shoulder and with an inner fluid outlet of said unit and adapted to be seated upon said shoulder, a rod dependingly secured to said piston and extending below the lower end of said casing, a first expander head on said rod near the lower end thereof, a first piston head slidably surrounding said rod within said casing below said shoulder, said rod having a stop shoulder thereon below said shoulder and above said first piston head, a tube dependingly secured to the first piston head and slidably surrounding said rod and extending below the lower end of said casing, a first expanding jaw assembly secured to said tube near the lower end thereof and having spaced jaws adjacent to said first expander head and expanded thereby during relative movement between said jaws and head, a second piston head within said casing below the first piston head and slidably surrounding said tube and including a depending tubular extension slidably surrounding said tube and extending below the lower end of said casing, a second expander head on said tubular extension near the lower end thereof and slidably surrounding said tube, another expanding jaw assembly on the lower end of said casing having spaced jaws adjacent to said second expander head and expanded thereby during relative movement between the last-named jaws and head, a spring within said casing below said second piston head and bearing upwardly thereon for urging the second piston head toward the first piston head and said rod stop shoulder, said casing having a fluid passage above said piston separated from said fluid passage means of the piston and communicating with an outer fluid outlet of said unit, whereby fluid pressure may be applied to the top of said piston.

2. The invention as defined by claim 1, and wherein said piston fluid passage means includes a tubular connecting rod secured to said piston and extending above the top thereof within said casing, and a pipe telescopically receiving said connecting rod and communicating directly with the first-named fluid outlet of said pump and control valve unit, said unit operable to selectively pressurize said piston fluid passage means or said fluid passage above said piston separated from said piston fluid passage means.

3. An actuating tool for use in deep wells comprising a tubular casing adapted to be lowered through and positioned within well tubing, an electrically operated pump and control valve unit secured to the top of said casing and carrying the casing, a power and suspension cable connected with and carrying said unit and extending to ground level, a pipe connected with one outlet of the pump valve unit and extending below such unit and into the bore of the casing and terminating within such bore, a tubular connecting rod having telescopic sliding engagement within said pipe and extending therebelow within the bore of the casing, a piston secured to said tubular connecting rod and having a passage communicating therewith and branch passages leading therefrom and opening through the bottom of the piston, said piston slidable within the bore of said casing, said casing having an internal shoulder upon which the bottom of said piston is adapted to be seated, said shoulder having a

through port adapted to register with the branch ports of the piston when the latter is seated upon said shoulder, an elongated rod secured to the bottom of said piston and depending therefrom through the bore of the casing and extending substantially below the lower end of the casing, a reversely tapered expander head secured to the lower end of said rod, a set of expandable gripping jaws surrounding said head and slidably engaging the same and adapted to expand when moved longitudinally of the head in one direction, said jaws and head positionable within a sleeve valve element adapted to be drawn upwardly toward abutting engagement with said well tubing, a tube connected with said jaws and slidably receiving said rod therethrough above said jaws, a first piston head on the upper end of said tube within the bore of the casing, a second piston head within the bore of the casing receiving said tube telescopically, a depending tubular extension carried by the second piston head and slidably surrounding said tube and extending below the lower end of the casing, a second expander head secured to the lower end of said tube extension, a second set of expandable gripping jaws surrounding the second head and disposed within the bore of the well tubing and adapted to expand into gripping engagement with such bore during movement of the second jaws longitudinally in one direction relative to said second head, means interconnecting the second jaws with the bottom of said casing, a spring within the bore of said casing having one end bearing upon the lower end of the second piston head and constantly urging the latter upwardly, and a stop element on said rod above said first and second piston heads and engageable with the first piston head to stop the same during upward movement of the first and second piston heads in response to the force of said spring.

4. An actuating apparatus for use in wells comprising an elongated tubular casing having an internal shoulder intermediate its ends, said shoulder having a through opening, a piston movably mounted within said casing above said shoulder and adapted to be seated thereon and having a through port communicating with said through opening, telescopic conduit means above said piston and within said casing connected with the piston and communicating with the through port of the piston, control valve means connected with the upper end of the casing for selectively delivering fluid under pressure to the conduit means or to the bore of the casing outwardly of the conduit means, the conduit means being spaced from the bore of the casing, fluid pressure in the bore of the casing outwardly of the conduit reacting upon said piston to urge the same downwardly toward engagement with said shoulder, an elongated rod dependingly secured to said piston and extending below the lower end of said casing, a first expansible gripping means connected with said rod below the lower end of said casing and shiftable upwardly bodily with said rod when sufficient fluid pressure builds up below said piston to elevate the same, a second expansible gripping means secured to the lower end of the casing above the first gripping means, telescopically interfitting piston head means within said casing and above the first and second expansible gripping means and connected with the latter and operable under influence of fluid pressure within said casing through and below said piston to expand said first and second gripping means, a spring within said casing opposing downward movement of said piston head means and automatically elevating the latter when fluid pressure is relieved thereabove within said casing, the fluid pressure within said casing above said piston head means increasing sufficiently subsequent to expansion of the first and second gripping means to cause said piston and rod to move upwardly thereby shifting the first expansible gripping means upwardly toward the second gripping means while both said gripping means remain expanded, subsequent relief of fluid pressure within said casing through and below said piston and a corresponding increase in fluid pressure within said casing and above said piston and outwardly of said conduit means allowing said spring to elevate said piston head means for causing retraction of the second gripping means and said piston then returning downwardly for seating against said shoulder to lower said rod and causing retraction of said first expansible gripping means.

5. The invention as defined by claim 4, and wherein said first and second expansible gripping means each comprises a central tapering expander head and a plurality of coacting tapered gripping jaws surrounding and engaging said tapered head and expanded by relative axial movements between the jaws and head, the expander head of said second gripping means secured to said piston head means, the expander head of said first gripping means secured to said rod and the jaws of said first gripping head secured to said piston head means.

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