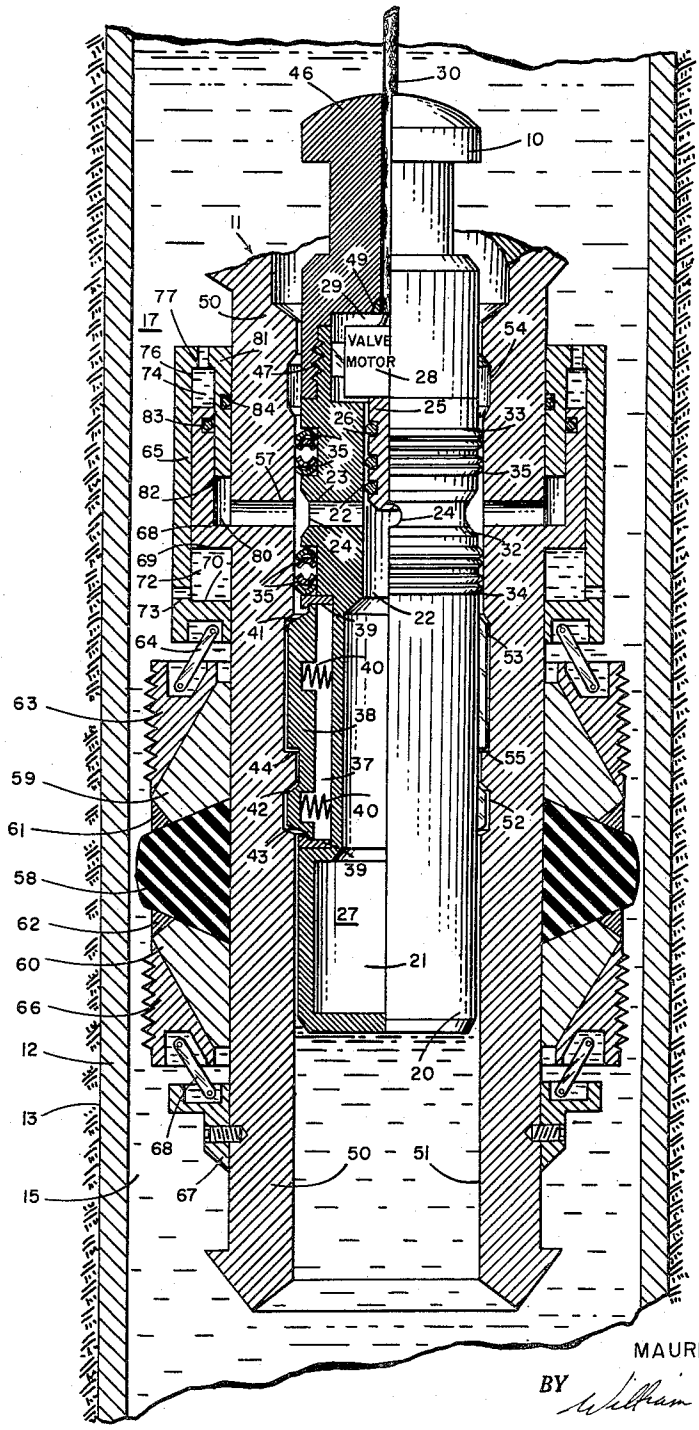
July 8, 1958 M. P. LEBOURG 2,842,212

WELL PRODUCTION EQUIPMENT

Filed May 31, 1955



INVENTOR.

MAURICE P. LEBOURG.

BY William R. Sherman

HIS ATTORNEY.

United States Patent Office 2,842,212 Patented July 8, 1958

2,842,212

WELL PRODUCTION EQUIPMENT

Maurice P. Lebourg, Houston, Tex., assignor, by mesne assignments, to Schlumberger Well Surveying Corporation, Houston, Tex., a corporation of Texas

Application May 31, 1955, Serial No. 512,108

1 Claim. (Cl. 166—125)

This invention relates to well production equipment and, more particularly, to subsurface well apparatus such as bridge plugs, packers and the like and tools for actuating the same.

In drilling and completing a well, various types of subsurface apparatus must be actuated as required. A convenient actuation of such subsurface apparatus has been afforded in the past by wire line or cable operations. To develop the necessary actuating forces, cables have been used to support actuating tools which may be electrically and, in some instances, chemically energized. For example, packer setting tools have been arranged for electrical initiation of a chemical reaction which provides combustion products for exerting a considerable pressure. In this manner, sustained forces of considerable magnitude may be developed for actuation of subsurface apparatus.

To obtain the advantages of sustained high actuating forces through combustion products requires, however, that the setting tool be provided with carefully prepared combustible mixtures and igniters and that a number of such tools be available for attachment to the wire line corresponding to the number of successive actuations which may be required in a given operation. Frequently, the force developed by the combustion reaction must act in opposition to the high pressures which are encountered at great depths, whereby the net force available is minimized.

It is an object of the present invention, accordingly, to provide an operating tool for the actuation of subsurface apparatus which overcomes the disadvantages of the above-described setting tools.

Another object of this invention is to provide a new and improved tool for actuating subsurface well apparatus effectively in the presence of high well fluid pressures.

Another object of the invention is to provide a new and improved operating tool for applying sustained high actuating forces to subsurface well apparatus relying solely upon the pressure of weighting liquid in the well.

A further object of the invention is to provide an operating tool which may be quickly and conveniently recharged at the surface while attached to a wire line or a cable so as to be capable of developing a high differential pressure for the actuation of subsurface well apparatus.

Still another object of the present invention is to provide an effective arrangement for setting packers, bridge plugs or like subsurface apparatus without imposing stress upon the production tubing.

These and other objects are attained, in accordance with the present invention, by incorporating a pressure resistant reservoir in an operating tool for communication with a pressure responsive element in subsurface well apparatus. Communication is effected when a valved passage in the tool leading from the reservoir has its outlet brought into coupled relationship with the element. The tool carries a seal about the outlet for

engaging the subsurface apparatus to couple the outlet with the element. This seal also prevents the high pressure of surrounding well liquids from acting upon the element. With a low pressure fluid such as atmospheric air in the reservoir, a change in the pressure acting upon the element is accomplished by lowering the tool on a cable into coupled relationship with the subsurface apparatus and opening the valved passage from the reservoir. In one application of the operating tool, the pressure responsive element is a part of a subsurface packer, bridge plug or like apparatus. Setting of such apparatus is achieved by relieving only one face of the pressure responsive element from a high liquid pressure to create a pressure differential across the element.

Other objects and advantages will be discerned, and the invention more perfectly understood, from the following detailed description taken in conjunction with the drawing in which:

The only figure is an elevational view partially in section of an operating tool constructed in accordance with the invention and disposed in subsurface well apparatus.

In the drawing is shown an operating tool 10 seated in subsurface well apparatus 11 suspended in a casing 12 which lines a borehole 13. Within the casing 12 is a column of weighting liquid 15 such as a drilling mud, salt water or the like. At the depth of annulus 17 between the well apparatus 11 and the casing 12, such weighting liquid 15 will have a very considerable hydrostatic pressure. In one application of the operating tool 10, the well apparatus 11 is a bridge plug or production packer, as illustrated.

To supply a pressure different from this hydrostatic pressure, the operating tool 10 comprises a cylindrical pressure-resistant housing 20 defining a hollow fluid reservoir 21 which is in communication through a longitudinal valve passage 22 with radial passages 23 terminating in side ports 24. Slidably fitted in the valve passage 22 is a cylindrical piston-like valve 25 having seal rings 26 spaced along its length. The valve 25 is shown in its open position which places the radial passages 23 in free communication with a low pressure fluid 27, such as atmospheric air, within the reservoir 21. This open position is secured by energization of a valve motor 28 disposed in a chamber 29 of the housing 20. Thus, the valve 25 is opened when an energizing signal is applied in any suitable manner to a mono-conductor supporting cable 30 electrically connected with the motor 28. In the closed position of the valve 25 obtained when the valve motor 28 is not energized, the valve 25 extends across the radial passages 23 to seal them off from the valve passage 22.

So that the reservoir 21 may communicate with packer 11, the radial passages 23 open at the side ports 24 upon an annular recess 32 in the housing 20 spaced intermediate two annular grooves 33, 34 in which seal rings 35 are received. These seal rings 35 project somewhat outwardly beyond the profile of the housing 20 for a sealed coupling with the packer 11.

To position the operating tool 10 relative to the packer 11, the housing 20 has longitudinally extending pockets 37 in which selective locking keys 38 are retained by flanged elements 39. Springs 40 acting in compression between the pockets 37 and the inner face of the keys 38 resiliently urge the latter outwardly of the pockets 37 beyond the profile of the housing 20. Each of the keys 38 has sloped upwardly facing surfaces 41, 42 and a sloped downwardly facing surface 43 which are adapted to cam the keys 38 into retracted position. However, each key 38 is also provided with a radially extending downwardly directed surface 44 which serves as a stop.

For raising and lowering the operating tool 10, the

cable 30 may be connected with a winch (not shown) at the earth's surface. A secure mechanical coupling between the cable 30 and the housing 20 is provided by leading the cable 30 through a fishing head 46 coupled to the housing 20 by a threaded connection 47, the cable 30 being secured in the fishing head 46 by a wedge-like element 49.

While a specific form of subsurface well apparatus is illustrated, namely the packer of Fig. 1, it will be understood that this packer is merely exemplary of subsurface apparatus which may be actuated by the operating tool 10. Usually, such apparatus is made up in a drill string or production tubing (not shown) for suspension in the casing 12. Thus, the packer 11 may be made up, for example, at the lower end of a tubing string to seal off the annulus 17 between such end and the surrounding casing. As the valve 25 of the operating tool is shown in its opened position, the packer 11 is correspondingly shown in an intermediate stage of actuation.

The packer 11 comprises a tubular mandrel 50 defining a cylindrical bore 51 from which spaced annular locking recesses 52, 53 and 54 are relieved. These locking recesses may conveniently have a configuration and spacing similar to that of the landing nipple described in Miller Patent No. 2,673,614, issued March 30, 1954, so that other tools (not shown) as well as the operating tool 10 may be landed within the bore 51. Thus, the recesses 52, 53 are shaped to receive the keys 38 by a complementary configuration, with radial shoulder 55 of the recess 53 engageable with the stop shoulder 44 of the keys to arrest downward movement of the tool 10. In the arrested position of the tool 10, its annulus 32 with which the radial passages 23 communicate is in registry with radial passages 57 formed in the mandrel 50. As the bore 51 is sized to receive the tool cartridge 20 in a sliding fit, the seal rings 35 engage the bore to seal the communication between the side ports 24 and the radial passages 57 from the surrounding hydrostatic pressure.

Slidably mounted concentric with the mandrel 50 are a packing element 58 composed, for example, of Buna-N synthetic rubber, an upper cone 59, and a lower cone 60. Intermediate the upper cone 59 and the packing element 58 is an upper retaining ring 61, while a corresponding lower retaining ring 62 is disposed between packing element 58 and the lower cone 60. Secured to the conical periphery of the upper cone 59 for sliding thereover are upper slips 63 connected by links 64 to an actuating or setting sleeve 65. Similarly, lower slips 66 are slidably secured to the conical periphery of the lower cone 60 and placed in articulated connection with a guide ring 67 by means of links 68*a*.

The sleeve 65 cooperates with a bell-shaped piston 68 extending outwardly and upwardly from the mandrel 50 to provide for hydraulic pressure setting of the slips 63, 66. Thus, between the lower face 69 of the piston 68 and the confronting face 70 of the sleeve 65 is a lower chamber 72 communicating through a port 73 in the sleeve with the annulus 17. An upper chamber 74 is provided between the upper end of the piston 68 and a re-entrant portion 76 of the sleeve 65. This upper chamber 74 is in communication with the annulus 17 through a port 77 in the re-entrant portion 76. A third chamber 80 is included between the piston 68 and the outer surface of the mandrel 50. A down-turned portion 81 of the sleeve 65 extending from the re-entrant portion 76 is received in this chamber 80 to define a movable upper wall 82 therefor. Since a reduction in pressure in the chamber 80 may be effected by the operating tool 10 relative to the pressure existing in the annulus 17, seal rings 83, 84 carried by the piston and sleeve, respectively, are positioned to effect a seal both between the piston 68 and sleeve 65 and also between the sleeve 65 and the mandrel 50. To obtain normally balanced forces on sleeve 65, the downwardly facing surfaces at 76 and 82 together equal the area of upwardly facing surface 70. A compression spring (not shown) may be disposed in the chamber 74, if desired, to overcome the force of gravity and maintain the setting sleeve 65 in its upper position in the absence of an hydrostatic unbalance.

Assuming that the packer is originally in a released condition, the setting tool 10 in an exemplary operation is lowered by means of the cable 30 until the keys 38 engage in and abut with the locking recesses 52, 53 formed in the bore 51 of the packer 11. At this instant, the reservoir 21 contains air at atmospheric pressure obtained at the surface of the earth by opening and then closing the valve 25. Thus, when the tool 10 is positioned in the packer 11 with its side ports 24 registering with the packer passages 57, the closed valve 25 will inhibit the force available by the pressure differential until actuation of the valve motor 28.

Upon actuation of the valve motor 28, the pressure in the chamber 80 is dropped by placing it in communication through passages 57, 23 and 22 with the low pressure reservoir 21. That is, the high hydrostatic pressure present in the chamber 80 prior to seating the tool 10 in the bore 51 is dropped substantially to atmospheric pressure. The pressure exerted upwardly upon the down-turned portion 81 of the sleeve 65 is thus diminished. While the upwardly directed pressure acting upon the re-entrant portion 76 of the sleeve remains at the value of the hydrostatic pressure, the similar high pressure acting in the chamber 72 downwardly against the surface 70 of the sleeve results in a net downward force on the settling sleeve 65. So long as the operating tool 10 remains positioned in the bore 51 with the seal rings 35 excluding hydrostatic pressure from the chamber 80, a net downward force will be maintained on the setting sleeve 65 tending to set the slips 63, 66.

This force thus produces a downward movement of the sleeve 65 which is transmitted through links 64 to move the slips 63 downwardly and outwardly relative to the upper cone 59. As the slips 63 approach engagement with the casing 12, the packing element 58 is compressed between the cones 59, 60 to extend outwardly into sealing engagement with the casing. At the same time, the packing element 58 transmits a force between cone 59 and cone 60 tending to move lower slips 66 outwardly also into engagement with the casing. Ultimately, both the upper and lower slips 63, 66 will securely engage the casing to retain the packing element 58 in tightly sealed relation with the casing. When a time has elapsed sufficient for the setting of the slips, the valve motor 28 may be de-energized to close valve 25. Thereupon, the tool 10 is withdrawn by pulling on the cable 30 to cam the keys 38 inwardly into a disengaged position relative to the locking recesses 52, 53. If other subsurface apparatus is to be actuated by the operating tool 10, the valve motor 28 may be energized when the tool is again at the surface to restore the reservoir 21 to atmospheric pressure and to permit drainage of any well liquid 15 which may have entered in the preceding operation. The valve 25 is then closed to place the tool in readiness for another operation.

Because only the lateral surface of the valve 25 is exposed to the hydrostatic pressure of well fluids while the tool is being lowered with the valve 25 closed, the valve motor 28 is not required to overcome a pressure differential in opening the valve. When the valve is opened with the tool seated in the bore 51, the annular recess 32 will ensure communication of the passages 57 with the reservoir 21 regardless of the angular orientation of the tool.

The operating tool 10 not only has utility in the setting of packers or bridge plugs but may serve to actuate any subsurface well apparatus having an element responsive to a pressure differential. Various modifications in the operating tool 10 may, of course, be made for adaptation to these various applications and for convenience of design. For example, a valve with a rotary, rather than a linear movement might be employed to control communi-

cation between the pressure resistant reservoir and a suitably positioned port. Rather than filling the reservoir with air at atmospheric pressure, a high pressure gas may instead be employed, as for the purpose of releasing the packer. To avoid the necessity of even a single conductor in the cable **30**, the valve motor **28** may have associated with it in the tool **10** a battery or other power supply together with a time delay switch (not shown). The switch may then be readied for operation after an interval allowing seating of the tool in the bore of selected subsurface well apparatus.

Other modifications in form and detail may be made within the true scope of the invention. The invention, therefore, is not to be limited to the illustrative embodiment but is defined in the appended claim.

I claim:

In well production equipment, a packer including a tubular mandrel having a bore provided with a locking recess, a packing element carried by said mandrel, means including slips slidably mounted on said mandrel for expanding said packing element, a passage extending from said bore, a setting sleeve slidably mounted on said mandrel for moving said expanding means including said slips therealong, said sleeve providing one wall of a sealed chamber in communication with said passage and having an opposite wall exposed for subjection to well fluid pressure, a setting tool sized to fit in said bore, a low pressure reservoir in said setting tool, a passage in said setting tool terminating in a side port, locking means carried by said setting tool for engagement in said locking recess for registering said setting tool passage with said packer passage, means carried by said setting tool for sealing with said bore above and below said passages, and electrically operated valve means movably mounted in said setting tool passage for selectively opening the same to place said reservoir in communication with said chamber through said passages.

References Cited in the file of this patent

UNITED STATES PATENTS

2,307,171	Tutton	Jan. 5, 1943
2,637,400	Brown	May 5, 1953
2,673,614	Miller	Mar. 30, 1954