June 2, 1953 R. O. CHILDERS 2,640,543

HYDRAULICALLY OPERABLE VALVE CONTROLLED WELL TOOLS

Filed Aug. 18, 1947

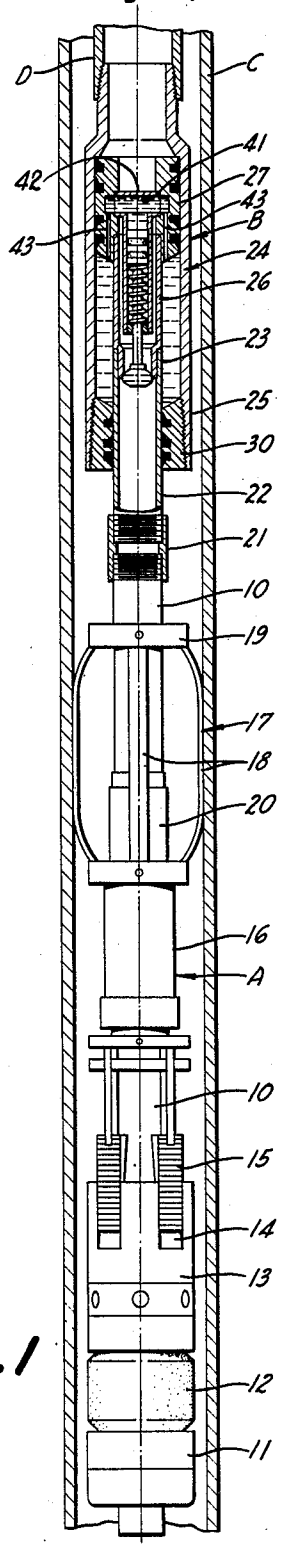


FIG. 1

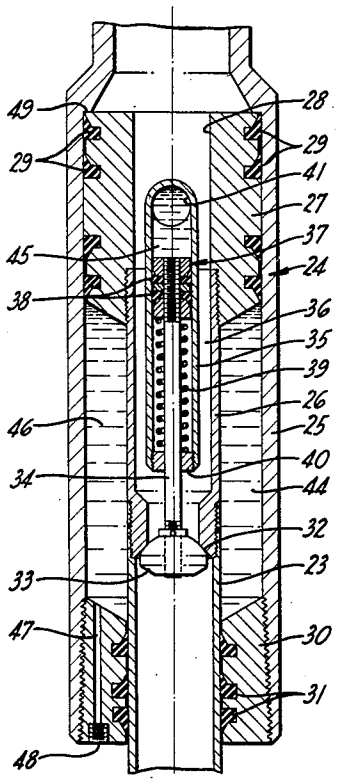


FIG. 2

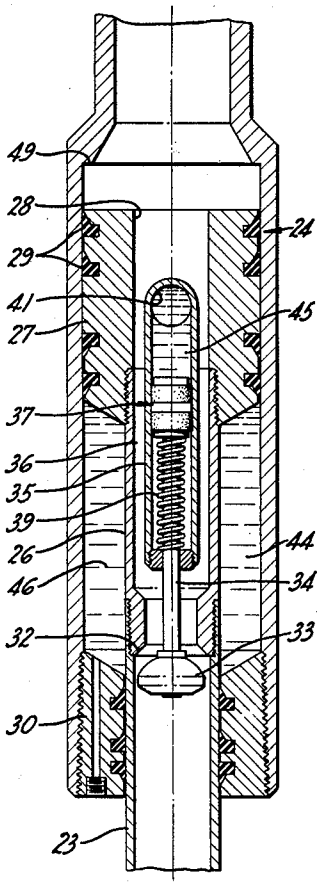


FIG. 3

INVENTOR
ROSCOE O. CHILDERS
BY
Mellin & Hanscom
ATTORNEYS

Patented June 2, 1953

2,640,543

UNITED STATES PATENT OFFICE

2,640,543

HYDRAULICALLY OPERABLE VALVE CONTROLLED WELL TOOL

Roscoe O. Childers, Norman, Okla., assignor to Baker Oil Tools, Inc., Vernon, Calif., a corporation of California

Application August 18, 1947, Serial No. 769,273

16 Claims. (Cl. 166—4)

1

The present invention relates to well tools, and more particularly to sub-surface well tools employable in the testing, cementing, acidizing, washing, etc., of well bores.

It is an object of the invention to provide a tool capable of use for making water shut-off tests, production tests, and the like, as well as squeeze cementing, plastic plugging, acidizing, and similar operations following or prior to such tests, without withdrawing the tool from the well bore.

Another object of the invention is to provide a well apparatus adapted to perform both production testing and squeeze cementing operations without danger of the apparatus being forced up the well bore during the squeeze cementing operation.

Still another object of the invention is to provide a well tool embodying a valve operable hydraulically by manipulation of the running-in string attached to the well tool.

This invention has other objects which will become apparent from a consideration of the apparatus shown in the drawings accompanying and forming part of the present specification. This apparatus will be described in detail to illustrate the general principles of the invention, but it is to be understood that such detailed description is not to be taken in a limited sense, since the scope of the invention is best defined by the claims appended hereto.

Referring to the drawings:

Fig. 1 is a longitudinal sectional and elevation view of a well casing and a well tool operable therewithin.

Fig. 2 is a longitudinal section, on an enlarged scale, of the valve mechanism,

Fig. 3 is a longitudinal section, on an enlarged scale, of the valve mechanism disclosed in Fig. 1, with the valve in open position.

As disclosed in the drawings, the apparatus includes a lower well packer A and an upper valve mechanism B adapted to be run in a well casing C on a tubular string D to a desired setting or operating point. The well packer is particularly designed for anchoring in packed-off condition against longitudinal movement within the casing in an upward direction. For this purpose, the mandrel or body 10 of the packer, which is of the retrievable type, has a lower abutment 11 secured thereto and a sleeve type of packing 12, of rubber or corresponding material, disposed above the abutment and around the body. The upper end of the packing engages the lower end of a slip expander 13 having upwardly and inwardly tapering expander surfaces 14 engageable

2

with companion surfaces on slips 15 which are suitably coupled to a sleeve 16 forming part of a drag device 17. The drag device consists of a plurality of drag springs 18 frictionally engaging the wall of the well casing C, with their lower ends connected to the upper end of the sleeve 16 and their upper ends to a collar 19 slidably mounted upon the mandrel 10 of the tool.

The well packer A shown is of the retrievable type, specifically illustrated and described in the patent of Reuben C. Baker, No. 2,368,400, patented January 30, 1945, to which reference may be had for further particulars. For purposes of understanding the present invention, it is sufficient to state that the retrievable packer is run in the well casing with its slips 15 and packing 12 in retracted positions, and that whenever the packer is to be set, an upward pull is taken on its mandrel 10 to move the slips 15 radially outward in firm anchoring engagement with the casing C, and to expand the packing 12 into leakproof engagement with the wall of the casing. Conversely, lowering of the tubular mandrel 10 effects retraction of the slips and packing, whereupon these elements can be locked in such retracted positions by a suitable lock device 20 (details not shown) to enable the packer to be moved upwardly and retrieved from the well casing. One form of lock is disclosed in the patent referred to above.

The valve mechanism B is connected to the upper end of the tubular packer mandrel or body 10 through the agency of a suitable coupling or collar 21 threaded thereon. The other end of the coupling 21 is threaded on the lower portion 22 of a tubular valve body 23, telescopically arranged within a cylinder 24 threaded to the lower end of the tubular string D running to the top of the well bore, by means of which the entire apparatus is moved longitudinally within the well casing. The tubular body 23 is disclosed as being made in two sections, including the lower section 22 threaded into the coupling collar, and also threadedly attached to an upper body section 26, which, in turn, is threaded into a piston 27 having a central passage 28 therethrough. This piston carries suitable side seals 29 on its periphery for slidable sealing engagement with the wall of the cylinder 24 to prevent leakage of fluids therebetween in both longitudinal directions. The cylinder 24 is also provided with a lower cylinder head 30 threaded into its skirt 25, and having inner side seals 31 slidably engaging the exterior of the body 23 to prevent leakage therebetween in both longitudinal directions.

The lower end of the upper body member 26 is

formed as a valve seat 32 adapted to be engaged by a valve head 33 secured on a valve stem or piston rod 34 extending upwardly within the upper body member 26 into an inner cylinder 35 disposed in the latter. This cylinder is of substantially smaller diameter than the inside diameter of the upper body section 26 to provide a substantial annular space 36 therebetween through which fluids may flow. This annular space is communicable with the central passage 28 in the upper piston 27.

The upper end of the valve stem or piston rod 34 is secured to a piston 37 having suitable packings or piston rings 38 engageable with the wall of the inner cylinder 35, to prevent fluid leakage therebetween in both longitudinal directions. The piston 37 and the valve head 33 connected thereto are urged in an upward direction, to tend to maintain the latter in engagement with the seat 32, by a compressed helical spring 39, whose lower end engages a retainer 40 threaded into the lower end of the cylinder 35 and through which the rod 34 extends, and whose upper end engages the piston 37.

The piston 37 is moved downwardly to effect corresponding downward movement of the valve head 33 from its seat 32 by hydraulically operable means. The upper end of the cylinder 35 is communicable with lateral passage 41 formed in a generally T-shaped member 42 suitably secured to the piston 27 and extending across its central passage 28. The outer ends of the lateral branches 41 of the T-shaped member are communicable with longitudinal passages 43 extending downwardly through the piston 27 and communicating with the annular cylinder space 44 between the cylinder 24 and valve body 23. It is to be noted that there is no fluid communication between the central piston passage 28, or the annular valve passage 36, and the inner cylinder space 45 above the piston 37, the T-shaped member lateral fluid passages 41, and the annular chamber 44 between the outer cylinder and tool body. In fact, these last-mentioned elements are enclosed in order to confine a liquid 46, such as light oil, therein, for a purpose to be later described. Such oil may be introduced into the chamber through a filler hole 47 extending longitudinally through the lower cylinder head 30 and closed by a suitable plug 48 threaded into the lower end of the latter.

When it is desired to effect opening of the valve by moving the valve head 33 downwardly from its cooperable seat 32, the tubular string D is moved upwardly to move the outer cylinder 24, including its attached cylinder head 30, upwardly with respect to the valve body 23 and upper piston 27. Such motion imposes a pressure upon the oil 46 in the chamber 44, fluid passages 43, T-connection 42 and inner cylinder space 45, exerting a downward force on the piston 37 and its attached valve stem 34 which, when sufficient, overcomes the force of the spring 39 and moves the valve head 33 downwardly from its seat 32, which then enables fluid to pass in both longitudinal directions between the tubular string D and the lower section 22 of the valve body, such fluid flowing through the valve seat 32, annular space 36 and central piston passage 28. Of course, as the cylinder head 30 is moved upwardly toward the piston 27, the light oil 46 or other fluid pressure transmitting medium is moved into the upper inner cylinder space 45 and forces the piston 37 downwardly in the manner described.

Conversely, when the valve is to be closed, the tubular string D and attached outer cylinder 24 are moved downwardly relative to the piston 27 and valve body 23, which enables the spring 39 to move the inner piston 37 upwardly and force the oil 46 back into the chamber 44, also reengaging the valve head 33 with its seat 32 to prevent upward movement of fluid through the valve seat 32, annular passage 36 and central piston passage 28.

In effect, the outer cylinder 24, body 23 and large piston 27 constitute a fluid pump, and the inner cylinder 35 and piston 37 a fluid motor communicable with the pump through the T-member 42 and longitudinal passages 43.

The valve mechanism B and packer A attached thereto have a variety of uses, including performance of a water shut-off or production test followed by a squeeze cementing operation, without moving the equipment within the well casing C. If it is desired to determine the efficacy of a cement job disposed behind the casing, the apparatus is lowered to a location immediately above the point at which the cementitious material had been ejected from the well casing, as immediately above a shoe or collar (not shown). The tubular string D is dry, since the valve 33 engages its seat 32 during the running-in operation and prevents any fluid in the well casing from flowing upwardly through the valve mechanism. No pressure is imposed on the oil 46 in the chamber 44 during the running-in operation, since the direction of the longitudinal force on the cylinder 24 is downward, which will not result in the transmission of any effort to the inner piston 37 through the intervening hydraulic medium 46. In lowering the tool through the well casing, the downward telescoping of the cylinder 24 and its head 30 over the piston body 23 is limited by engagement of the upper end of the piston 27 with a shoulder 49 at the upper end of the cylinder 24.

When it is desired to determine the effectiveness of the cementing operation, an upward strain is taken on the tubular string D, which first causes the tapered expander 13 to anchor the slips 15 firmly against the casing C, and then causes the packing 12 to be compressed between the lower abutment 11 and expander 13 and expanded into firm sealing engagement with the well casing, thereby preventing the hydrostatic head of fluid in the annulus above the packing 12, and between the casing C and tubing string D, from being subjected upon the formation. A continuation of the upward pull or strain on the tubular string D engages the packing 12 and slips 15 more firmly with the casing, and also causes a displacement of the oil 46 in the chamber 44, passages 43 and T member 42 into the inner cylinder 35, the pressure incident to such displacement forcing the piston 37 downwardly and moving the valve head 33 downwardly from its seat 32, thus effecting communication between the formation and the interior of the tubing string D, which, as indicated above, is initially devoid of fluid and is, accordingly, at atmospheric pressure.

If the cement job disposed behind the casing is defective, water or gas, as the case may be, passes upwardly through the unobstructed tubular body or mandrel 10 of the well packer A, through the lower valve body section 22, and through the open valve 32, 33 into the annular passage 36 around the inner cylinder 26, moving upwardly through the central piston passage 28

into the tubular string D. After opening of the valve has been permitted to continue for any desired time, the tubing string may be lowered, which enables the spring **39** to shift the piston **37** upwardly and engage the valve head **33** with its seat **32**, thus preventing any further upward flow of fluid through the apparatus. The spring **39** is preferably made relatively strong so as to prevent any fluid that may be contained within the tubular string D from imposing sufficient downward force on the valve head **33** to effect its opening as the tool is withdrawn from the well casing. Accordingly, the valve remains closed and the fluid sample within the tubular string is withdrawn to the top of the well bore, if the apparatus is then removed from the well casing C.

In the event the cement deposited behind the casing has not effected a proper water or gas shut-off, the tool may be allowed to remain in the same location. If the downward movement of the tubular string D to reclose the valve has effected retraction of the slips **15** and packing **12**, they may again be expanded against the casing C by the taking of an upward pull on the tubular string, which may or may not be sufficient to create sufficient pressure in the chamber **44** to displace the oil **46** downwardly in the cylinder **35** to move the valve member **33** to open position. During subsequent pumping of cement slurry through the tubing string D to recement the casing, fluid pressure need not necessarily be produced, since the valve head **33** can be forced from its seat **32** against the action of the spring **39** by the pressure imposed on the cement slurry and displacement fluid within the tubular string. This charge of slurry is pumped down the tubular string flowing downwardly through the tool and discharging from the lower end of the packer body **10**, thence passing outwardly of the casing C to fill the voids or channels that might have existed in the previous hardened cement deposited behind the well casing. After the desired squeeze pressure has been built up and sufficient additional cement has been placed behind the casing C, the bleeding off of the pressure in the tubular string D allows the valve head **33** to reengage its seat **32** and prevent return flow of the cement slurry into the casing. The tubular string D may then be lowered to effect retraction of the slips **15** and packing **12** from the well casing, such elements being locked in their retracted positions, and the entire apparatus withdrawn from the well bore.

It is, accordingly, apparent that an apparatus has been provided which is capable of resisting pressures, including comparatively high pressures, acting upwardly on the well packer A and tending to pump it up the hole, and which also has a valve mechanism B which can be controlled through movement of the tubular string D in the same direction as is required for anchoring the packer in packed-off condition against the well casing C. The apparatus lends itself to both formation testing and squeeze cementing without the necessity for running a separate tool in the well bore for each operation at separate times, thus effecting substantial economies in both testing and squeeze cementing the formation.

The valve mechanism B itself is operable through the simple expedient of moving the tubular string D, and may be used with other devices than the well packer A disclosed and may be used alone, if desired. It is to be noted that, in a more limited sense, it effects opening of a valve in one direction upon movement of its control and operating devices in the opposite direction.

While I have shown the preferred form of my invention, it is to be understood that various changes may be made in its construction by those skilled in the art without departing from the spirit of the invention as defined in the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. Well apparatus, including inner and outer members telescopically arranged with respect to each other and defining an annular fluid pressure chamber therebetween, means providing a passage non-communicating with said chamber, said passage being communicable with a region externally of the apparatus, a fluid medium in said chamber, a valve device in said inner member controlling fluid flow through said passage, and means in said inner member communicable with said chamber and engaging said valve device for operating said valve device in response to pressure imposed on said fluid medium upon telescopic movement between said members.

2. Well apparatus, including a body having a fluid passage, an outer cylinder around said body and spaced therefrom to form an annular fluid pressure chamber therewith, a valve seat on said body surrounding said passage, an inner cylinder within said body, a valve head engageable with said seat to close said passage, means engaging said head and including a piston in said inner cylinder, and means providing a fluid passage communicating with said chamber and inner cylinder.

3. Well apparatus, including a tubular body, an outer cylinder around said body and spaced therefrom to form an annular fluid pressure chamber therewith, an inner cylinder within said body and spaced therefrom to form an annular passage, a valve seat on said body surrounding said passage, a valve head engageable with said seat to close said passage, means engaging said head and including a piston in said inner cylinder, spring means for urging said head in one direction into engagement with said seat, a fluid medium in said chamber, and means providing a fluid passage communicating with said chamber and inner cylinder to enable relative movement between said body and outer cylinder to generate pressure in said fluid medium and impose such fluid pressure medium on said piston to urge said head from engagement with said seat.

4. Well apparatus, including first and second members movable with respect to each other and cooperatively providing an expansible fluid pressure chamber, means providing a passage non-communicating with said chamber, said passage being communicable with a region externally of the apparatus, said passage having a valve seat therein, a valve head engageable with said seat, a cylinder communicating with said chamber, means engaging said head and including a piston slidable in said cylinder, and a fluid medium in and between said chamber and cylinder, said medium having pressure imposed upon it in response to relative movement between said members to cause said fluid pressure medium to pass into said cylinder to shift said piston and head relative to said valve seat.

5. Well apparatus adapted to be lowered in a well bore on a running-in string, including a

passage having a valve seat, a valve head engageable with said seat, fluid pressure operable means engageable with said head for moving said head with respect to said seat, and means attachable to said running-in string and operable by said running-in string when said running-in string is moved for generating fluid pressure that is non-communicating with said passage and for imposing such fluid pressure upon said fluid pressure operable means.

6. Well apparatus adapted to be lowered in a well bore on a running-in string, including a well tool having normally retracted means movable laterally outwardly in response to movement of said running-in string in one longitudinal direction, said well tool having a passage for the flow of fluid through the tool from the exterior thereof, a valve for controlling fluid flow through said passage and movable to open position in a longitudinal direction which is opposite to the longitudinal direction in which the running-in string is moved when said normally retracted means is moved outwardly, and means operable by movement of said running-in string in said one longitudinal direction for moving said valve in said opposite longitudinal direction to open position.

7. Well apparatus adapted to be lowered in a well bore on a running-in string, including a well tool having normally retracted means movable laterally outward in response to upward movement of said running-in string, said well tool having a passage for the flow of fluid through the tool from the exterior thereof, a downwardly opening valve for controlling fluid flow through said tool passage, and means connectible to the running-in string and operable by the running-in string when the running-in string is moved upwardly relative to the well tool to move said valve downwardly to open position.

8. Well apparatus adapted to be lowered in a well bore on a running-in string, including a well tool having normally retracted means movable laterally outward in response to upward movement of the running-in string, said well tool having a passage for the flow of fluid through the tool from the exterior thereof, a valve device for controlling fluid flow through the tool from the exterior thereof, a valve device for controlling fluid flow through said tool passage, a pump device connected to the well tool and connectible to the running-in string and operable by the running-in string when the running-in string is moved upwardly relative to the well tool to generate pressure in fluid in said pump device, and means for conducting said fluid under pressure to said valve device to operate the same.

9. Well apparatus adapted to be lowered in a well bore on a running-in string, including a well tool having normally retracted means movable laterally outward in response to movement of the running-in string, said well tool having a passage for the flow of fluid through the tool from the exterior thereof, a valve device for controlling fluid flow through said passage and into the running-in string, a pump device connected to the well tool and connectible to the running-in string and operable by the running-in string when the running-in string is moved relative to the well tool to generate pressure in fluid in said pump device, and means for conducting said fluid under pressure to said valve device to operate the same.

10. Well apparatus adapted to be lowered in a well conduit on a running-in string, including a packer adapted to be anchored to the conduit in response to longitudinal movement of the running-in string, said packer having a passage for the flow of fluid through the packer from the exterior thereof, a normally closed valve device for controlling flow of fluid through said packer passage and into the running-in string, a pump device connected to the packer and connectible to the running-in string and operable by the running-in string when the running-in string is moved longitudinally relative to the packer to subject fluid in said pump device to pressure, and means for conducting said fluid under pressure to said valve device to open the same.

11. Well apparatus adapted to be lowered in a well conduit on a running-in string, including a packer adapted to be anchored to the conduit against upward movement in response to upward movement of the running-in string, said packer having a passage for the flow of fluid through the packer from the exterior thereof, a normally closed valve device for controlling flow of fluid through said packer passage and into the running-in string, a pump device connected to the packer and connectible to the running-in string and operable by the running-in string when the running-in string is moved upwardly relative to the packer to subject fluid in said pump device to pressure, and means for conducting said pump fluid under pressure to said valve device to shift the same downwardly to open position.

12. Well apparatus, including a tubular body, an outer cylinder around said body in slidable sealing engagement therewith to form an annular fluid pressure chamber, an inner cylinder within said body and spaced therefrom to form an annular passage non-communicating with said chamber, a valve seat on said body surrounding said passage, a valve head engageable with said seat to close said passage, means engaging said head and including a piston in said inner cylinder, and means providing a fluid passage communicating with said chamber and inner cylinder to enable fluid under pressure to act upon said piston to urge said valve head in one direction with respect to said seat.

13. Well apparatus, including inner and outer members movable with respect to each other and cooperatively defining a fluid pressure chamber therebetween, one of said members having a passage therethrough non-communicating with said chamber but communicable with a region externally of said one member, a valve for closing said passage, a fluid medium in said chamber pressurized upon relative movement between said members tending to reduce the volume of said chamber, and fluid operable means engageable with said valve and communicable with said chamber, in order that said fluid operable means is subject to the pressure of said fluid medium to operate said valve.

14. Well apparatus, including inner and outer members telescopically arranged with respect to each other and cooperatively defining a fluid pressure chamber therebetween, said inner member having a passage therethrough non-communicating with said chamber but communicable with a region externally of said inner member, a valve for closing said passage, a fluid medium in said chamber pressurized upon relative longitudinal movement between said members tending to reduce the volume of said chamber, and

fluid operable means engageable with said valve and communicable with said chamber, in order that said fluid operable means is subject to the pressure of said fluid medium to operate said valve.

15. Well apparatus, including a tubular body having a piston, an outer cylinder slidable along said piston and having a head slidable along said body, said body and cylinder forming an annular chamber therebetween, an inner cylinder within said body and spaced therefrom to form an annular passage non-communicating with said chamber, a valve seat on said body surrounding said passage, a valve head engageable with said seat to close said passage, means engaging said valve head and including a piston in said inner cylinder, and means providing a fluid passage communicating with said chamber and inner cylinder to enable fluid under pressure to act upon said piston to urge said valve head in one direction with respect to said seat.

16. A well tool adapted to be lowered in a well bore on a running-in string, including relatively movable parts cooperable with each other to perform a function in said well bore, a fluid motor engageable with one of said parts to move the same, and a fluid pump communicable with said motor and operable by manipulation of said running-in string.

ROSCOE O. CHILDERS.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,915,716	Bradshaw	June 27, 1933
2,033,563	Wells	Mar. 10, 1936
2,077,760	Knoerr	Apr. 20, 1937
2,121,002	Baker	June 21, 1938
2,196,664	Kofahl	Apr. 9, 1940
2,229,635	Boynton	Jan. 28, 1941
2,246,348	Coffey	June 17, 1941
2,307,983	Barnes	Jan. 12, 1943
2,323,321	Futral	July 6, 1943
2,368,400	Baker	Jan. 30, 1945
2,447,827	Turechek	Aug. 24, 1948
2,458,631	Parks	Jan. 11, 1949