

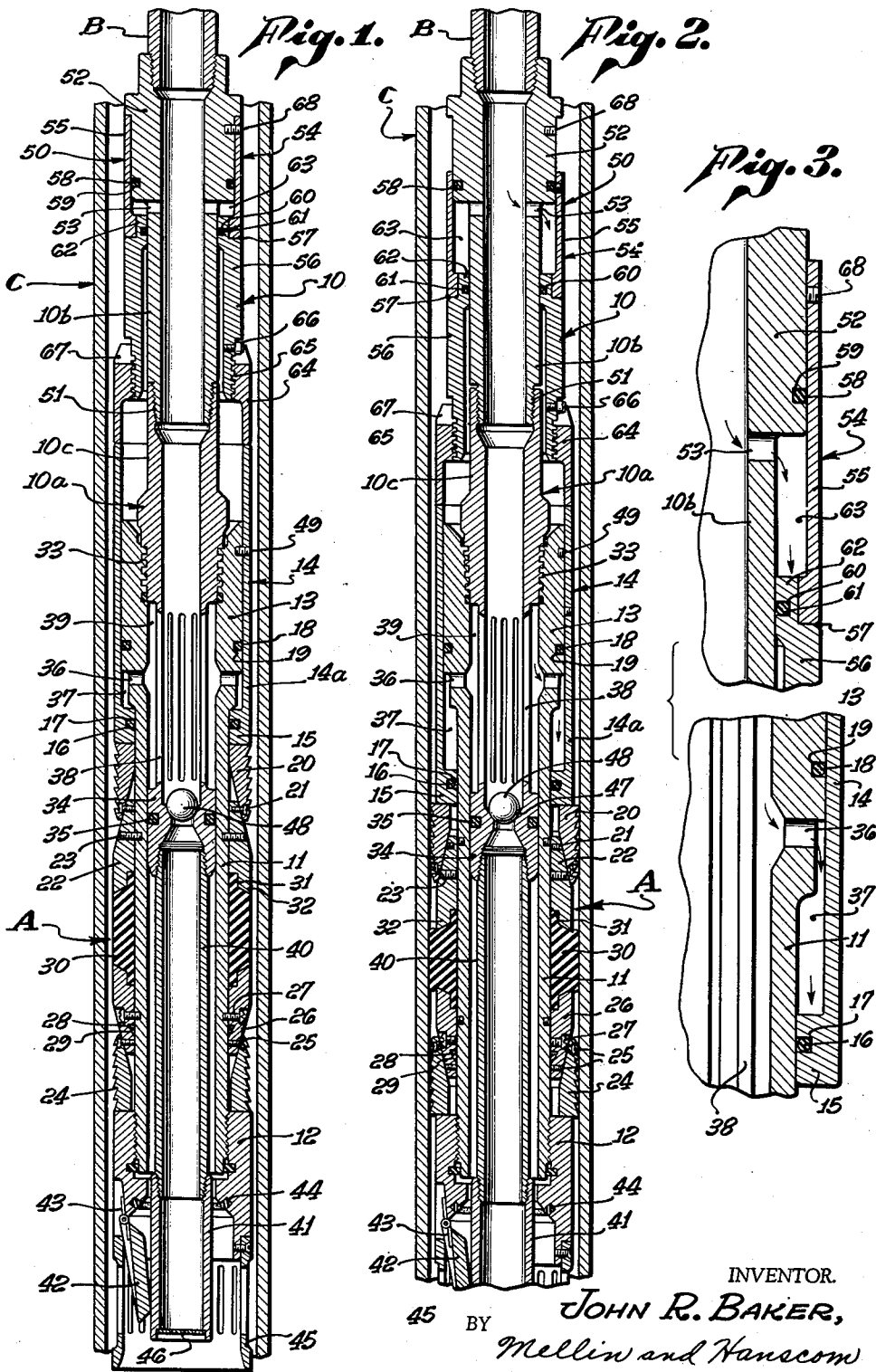
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HYDRAULICALLY OPERATED WELL PACKER

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HYDRAULICALLY OPERATED WELL PACKER

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The present invention relates to well packers adapted to be anchored in packed-off condition in casings, liners and similar conduits positioned in well bores.

Certain types of well packers employ slips and packing elements that are held normally in retracted position and are then expanded outwardly into engagement with the wall of a well casing. Such outward expansion may be accomplished through the use of hydraulically operated instrumentalities, and also by longitudinally moving the tubing string to which the packer may be attached and on which it is run to the desired location in the well casing. The slips may be anchored in retracted position by one or more shear screws, designed to rupture at a predetermined pressure imposed on the hydraulically operated instrumentalities. To insure against premature and undesired disruption of the screws, they should be made of ample strength. However, any increase in diameter of the screws, or the use of screw materials having higher shear strengths, necessitates the imposition of a greater unit fluid pressure on the hydraulically operated instrumentalities. Such unit pressures may be inordinately high.

It is sometimes not desired to set a well packer in the casing by a combination of applying hydraulic pressure to the setting instrumentalities and by moving the tubular string, to which the packer is attached, longitudinally in the well casing. At times, a comparatively large strain on the tubing string is required to set the packer fully against the casing, which strain should be avoided.

Accordingly, it is an object of the present invention to make it possible to employ shear screws and the like of higher shear value for holding the well packer slips in retracted position, and yet disrupt these shear screws hydraulically with a lower unit hydraulic pressure of the fluid in the tubing string than has heretofore been necessary.

Another object of the invention is to provide a hydraulically operated well packer arrangement, in which the running-in string, or tubing string, to which the well packer is attached need not be subjected to a strain in effecting complete anchoring of the packer in packed-off condition within the well casing.

A further object of the invention is to provide a well packer apparatus which is set in packed-off condition against both upward and downward movement in the well casing by hydraulic means alone, and without the necessity

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for manipulating the tubing string to which the well packer is attached. Despite the full hydraulic setting of the well packer, inordinately high unit fluid pressures are avoided.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a longitudinal section through a well packer apparatus disposed within a well casing, with the parts of the apparatus occupying their relative initial positions for movement through the well casing;

Fig. 2 is a view similar to Fig. 1, disclosing the well packer apparatus fully anchored against the well casing;

Fig. 3 is an enlarged fragmentary longitudinal section through the hydraulic portions of the well packer apparatus.

As disclosed in the drawings, a well packer A is detachably secured to a setting tool 10, forming the lower end of a tubular string B running to the top of the well bore, and by means of which the packer is lowered to the desired setting or anchoring point within a well conduit or casing C.

The packer A includes a tubular body 11 having an abutment 12 threaded on its lower end, and an enlarged head 13 at its upper end, around which the skirt 14 of a cylinder 14a is mounted. A cylinder head 15 extends inwardly from the lower end of the skirt and carries one or more suitable side seal rings 16 in one or more ring grooves 17, which slidably engage the external cylindrical surface of the body 11. One or more suitable side seal rings 18 are also disposed in one or more body head grooves 19 for slidable engagement with the interior of the skirt 14.

A set of upper segmented slips 20 are disposed around the body immediately below the cylinder head 15. These slips are held initially in retracted position by shear screws 21, attaching them to an upper conical expander 22 initially secured to the body 11 by one or more shear screws 23. The converging surfaces of the upper set of slips 20 and upper expander 22 are so

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disposed with respect to one another as to secure the packer against movement in an upward direction within the casing C, following outward expansion of the slips 20 into engagement with the casing.

A set of lower segmental slips 24 is provided adjacent the abutment 12, and these slips are also secured by shear screws 25 to a lower tapered expander 26 attached initially to the body 11 by one or more shear screws 27. The direction of taper on the exterior of the lower expander 26 and the taper on the cooperable surfaces of the lower slips 24 are such as to hold the well packer against movement in a downward direction, following expansion of the slips 24 outwardly to casing engaging position.

A suitable lock is provided between the body 11 and lower expander 26 to permit upward movement of the body within this expander, but to preclude its downward movement. Such lock may be of any suitable form. It is illustrated as including a split tapered wedge ring 28 received within the tapered groove 29 in the lower expander 26.

A suitable packing, such as a packing sleeve 30, of rubber or similar pliant material, is disposed around the body between the upper and lower expanders 21, 26. The ends of the packing sleeve 30 are received within annular pockets 31 formed between the expander skirts 32 and the exterior of the body 11.

The setting tool 10 includes a tubular member 10a, which is threaded, as by a left-hand thread 33, into the head 13 of the packer body. This setting tool member 10a has a lower head 34 carrying a suitable side seal 35 for sealing engagement with the inner wall of the body. The head 34 is disposed below body ports 36 positioned between the body and cylinder head seals 18, 16 to establish communication between the interior of the body 11 and the elongated annular clearance space 37 between the body head 13 and cylinder head 15. Elongated ports 38 in the form of slots extend through the tubular member 10a between its threaded portion 33 and head 34, establishing communication between the interior of the setting tool member 10a and elongated annular space 39 between the exterior of the member 10a and the interior of the body 11.

The tubular member 10a has a depending tubular section 40 secured to the lower head 34 and terminating in a lower portion 41 projecting from the body 11 and abutment 12, for the purpose of holding a back pressure valve in open position. This valve includes a valve head 42 pivoted on the abutment 12 and urged upwardly by a spring 43 into engagement with a valve seat 44 in the abutment. The lower tubing portion 41 can engage the valve head 42 and hold it in open position, as shown in Figs. 1 and 2.

A slotted junk pusher and feeler 45 may be secured to the lower end of the lower abutment 12, to insure against premature setting of the well packer during its descent in the well casing C. A screen 46 may also be provided across the mouth of the tubing section 41 to prevent undesired substances from entering the setting tool.

The setting tool member is provided with a valve seat 47 in the lower head 34, on which a valve ball element 48 is adapted to come to rest, upon being dropped through the tubular string B, in order to prevent downward passage of fluid through the tubular string B and setting tool 10 below the setting tool head 34, and allow fluid pressure to be built up in the setting tool, the elongated ports 38, and the body ports 36, for the

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purpose of urging the cylinder 14a downwardly against the upper slips 20. The cylinder 14a is retained initially in an upward position by one or more shear screws 49 securing its skirt 14 to the body head 13.

The setting tool 10 also includes an upper hydraulic booster portion 50. An upper tubular member portion 10b is connected to the lower portion 10c of the tubular member, as by means of the interconnecting threads 51. The inner tubular member 10b has an enlarged upper head 52, there being ports 53 disposed through the member 10b immediately below the head. A cylinder 54 is disposed around the tubular member 10b. As disclosed in the drawings, it is formed of two parts 55, 56 secured together, as by the use of welding material 57. The upper part 55 comprises a sleeve slidable along the upper head 52, leakage therebetween being prevented by one or more suitable side seals 58 disposed in one or more grooves 59 in the head and slidable along the inner surface of the sleeve. The lower skirt portion 56 of the cylinder 54 is provided with one or more internal grooves 60 receiving one or more side seal rings 61 slidable along the exterior of the tubular member below the ports 53.

The sleeve and skirt 55, 56 together provide an annular cylinder head 62 adapted to be acted upon by fluid under pressure in the tubular string B and setting tool, acting through the ports 53 and passing into the annular cylinder space 63 between the sleeve 55 and member 10b. Leakage of this fluid from the cylinder space along the body in an upward and downward direction is prevented by the side seals 58, 61.

A setting ring 64 is adjustably secured, as by a threaded connection 65, to the lower end of the cylinder skirt 56 and bears against the upper end of the lower skirt 14 of the lower cylinder 14a. The setting ring is adjusted on the skirt 56 until it engages the skirt 14. It is then retained in this position by a lock screw 66 passing through one of the slots 67 on the setting ring 64 and threaded into the skirt 56.

As above stated, one or more shear screws 49 hold the lower cylinder 14a initially in an upward position. Similarly, one or more other shear screws 68 secure the upper cylinder skirt 55 to the head 52, and thereby hold the upper cylinder 54 and setting ring 64 in an initially upward position, with the setting ring contiguous the upper end of the lower cylinder skirt 14.

The setting tool 10 and well packer A are assembled in the manner disclosed in Fig. 1, with the slips 20, 24 and packing element 30 in retracted position, and with the packer cylinder 14a and booster cylinder 54 in an upward position. The tool is attached to a string of tubing or drill pipe B and is lowered into the well casing C to the desired setting point therein. During this lowering operation, the lower tubing portion 41 of the setting tool retains the back pressure valve head 42 in open position, allowing fluid to enter the tubular setting tool 10 and the tubing string B.

When the setting point in the well casing has been reached, the ball valve element 48 is dropped into the tubing string B from the top of the well bore and is allowed to gravitate through the tubing string and the setting tool into engagement with the valve seat 47 in the lower head 34, thereby closing the central passage through the setting tool tubular member 10a. Fluid pressure is then built up in the tubing string and setting tool, this fluid under pressure passing outwardly through the lower setting tool ports

38 and body ports 36 into the annular cylinder or clearance space 37 in the well packer.

The fluid under pressure also passes outwardly through the booster ports 53 into the cylinder space 63 between the booster cylinder 54 and tubular member portion 10b. This fluid under pressure acts simultaneously in a downward direction upon the upper cylinder head 62 in the booster portion of the setting tool and upon the lower cylinder head 15 of the packer. When the pressure has increased to a sufficient value to shear the screws 68, 49 holding the cylinders in their upward position, they move downwardly jointly to shear the upper slip screws 21 and shift the slips 20 downwardly along the upper expander 22 and outwardly into firm anchoring engagement with the wall of the casing C.

As the pressure of the fluid in the tubing string B, setting tool 10, and annular cylinder spaces 63, 37 is increased to a further degree, the setting tool 10 and packer body 11 are elevated by the fluid pressure acting upwardly upon the heads 52, 13, inasmuch as the wedging of the upper slips 20 against the casing precludes further downward movement of the tandem arranged cylinders 54, 14a. Such upward movement of the packer body 11 first shears the screws 23 holding the upper expander to the body; the body 11, lower abutment 12, lower expander 26, and lower slips 24 moving upwardly towards the upper expander 22, and compressing the packing sleeve 30 between the expanders, in order to expand it outwardly into firm sealing engagement with the wall of the well casing.

A further increase in the fluid pressure within the setting tool causes the pressure to act upon the heads 52, 13 in an upward direction with a greater force, which results in shearing of the lower expander screws 27 and lower slip screws 25, enabling the body 11 to move upwardly to a further extent and causing the lower abutment 12 to shift the lower slips 24 upwardly along the lower expander 26 and radially outwardly into anchoring engagement with the wall of the well casing C.

In the manner described above, the well packer A is anchored in packed-off condition within the well casing C. The upper slips 20 preclude upward movement of the packer, whereas the lower slips 24 preclude downward movement of the packer. Any tendency for the packer body to move downwardly is resisted by the wedging of the tapered ring 28 within the tapered groove 29 in the lower expander 26. Such downward force is transmitted through the lock device 28, 29 to the expander 26, and from this expander to the lower slips 24, which are embedded in the well casing.

Following complete setting of the well packer, the tubing string B and the setting tool 10 are rotated to the right, which unscrews the setting tool, at the left-hand threaded connection 33, from the packer body 11, and allows the setting tool 10 to be withdrawn from the well casing. As the setting tool is moved upwardly within the packer body, its lower portion 41 is removed from engagement with the flapper valve head 42, allowing its spring 43 to close it against the valve seat 44. This precludes upward passage of fluids through the packed-off well packer A.

If desired, following the outward expansion of the upper slips 20 against the well casing, an upward strain can be taken on the tubing string B, to effect sealing of the packing sleeve 30 against the casing and setting of the lower slips

24. However, it may not be necessary to impose such a setting strain on the tubing string B, since the arrangement of hydraulic devices in the packer and booster provides ample area over which fluid under pressure can act, to effect full setting of the well packer. It is apparent that the fluid is acting simultaneously over the area of the upper and lower cylinder heads 62, 15, and also over the area of the annular body and setting tool heads 13, 52 that are opposed to these cylinder heads, allowing a substantially great total force to be imposed on the well packer, of sufficient extent to anchor the well packer firmly and in leak-proof engagement against the well casing. Accordingly, the well packer may be set properly by the use of hydraulic force alone, or, as indicated, it may be set by a combination of tripping the upper slips 20 and moving them outwardly against the casing, and by then taking an upward strain on the tubing string B.

The relatively large fluid pressure actuatable areas provided in the packer cylinder 14a and the booster cylinder 54 enable the shear screws 21 holding the upper slips 20 to the expander 22 to be disrupted with a lower unit pressure in the tubing string B, setting tool 10 and well packer A, than has heretofore been necessary. The tandem arrangement of the hydraulic cylinders 54, 14a permits this to occur. Despite the use of lower pressures, the shear screws 21 may be made of a greater shear value to preclude inadvertent tripping of the upper slips 20. Despite such increased shear values of the screws, they can still be disrupted at relatively low pressures. As an example, the pressures may be of the order of 300 to 600 p. s. i.

It is to be noted that following complete setting of the well packer A, the setting tool 10, including its upper booster portion 50, is removed from the well bore, enabling the entire tool to be used over again in connection with the setting of other well packers.

The inventor claims:

1. In well apparatus: a body; normally retracted means on said body; a first hydraulically operable means on said body engageable with said normally retracted means for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a second hydraulically operable means engageable with said first hydraulically operable means to supplement the force of said first hydraulically operable means; and a common conductive means for feeding fluid under pressure simultaneously to both said first and second hydraulically operable means to actuate said first and second hydraulically operable means in a direction to shift said normally retracted means outwardly against the well conduit on said normally retracted means.

2. In well apparatus: a body having a first port; normally retracted means on said body; a first hydraulically operable means on said body responsive to the pressure of fluid passing through said first port for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said setting tool comprising a tubular member communicable with said first port and having a second port, and a second hydraulically operable means on said tubular member engageable with said first hydraulically operable means and responsive to the pressure of fluid passing through said second port to provide a force supplementing the force of said first hy-

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draulically operable means on said normally retracted means.

3. In well apparatus: a body having a first port; normally retracted means on said body; a first hydraulically operable means on said body responsive to the pressure of fluid passing through said first port for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said setting tool comprising a tubular member communicable with said first port and having a second port, and a second hydraulically operable means on said tubular member engageable with said first hydraulically operable means and responsive to the pressure of fluid passing through said second port to provide a force supplementing the force of said first hydraulically operable means on said normally retracted means; and means for restricting fluid flow through said body to enable the pressure of fluid to be built up in said tubular member, body and said first and second ports for action upon said first and second hydraulically operable means.

4. In well apparatus: a body having a first port; normally retracted means on said body; a first hydraulically operable means on said body responsive to the pressure of fluid passing through said first port for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said setting tool comprising a tubular member communicable with said first port and having a second port, and a second hydraulically operable means on said tubular member responsive to the pressure of fluid passing through said second port to provide a force supplementing the force of said first hydraulically operable means on said normally retracted means.

5. In well apparatus: a tubular body having a first port; normally retracted means on said body; a first sleeve slidable along said body and disposed over said first port, said first sleeve being shiftable by the pressure of fluid passing through said first port to shift said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said setting tool having a tubular member extending into said body to a location below the said first port, said tubular member having a second port communicable with said first port and also having a third port, a second sleeve slidable along said tubular member and engageable with said first sleeve, said second sleeve being disposed over said third port and being shiftable by the pressure of fluid passing through said third port to provide a force supplementing the force of said first sleeve on said normally retracted means; and means for closing the central passage through said tubular member below said second port.

6. In well apparatus: a tubular body having a cylindrical portion, an enlarged head above said portion and a first port through said portion below said head; normally retracted means on said body below said first port; a cylinder slidable along said head and the cylindrical portion of said body below said port and engageable with said normally retracted means for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said tool having a tubular member extending into said body to a location below said first port which has a second port communicable with said first port,

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said tubular member having a second cylindrical portion and also having a second enlarged head above said second portion and a third port through said second portion below said second head, a second cylinder slidable along said second head and the second cylindrical portion of said tubular member below said third port and engageable with said first cylinder; and means for closing the central passage through said tubular member below said second port.

7. In well apparatus: a tubular body having a cylindrical portion, an enlarged head above said portion and a first port through said portion below said head; normally retracted means on said body below said first port; a cylinder slidable along said head and the cylindrical portion of said body below said port and engageable with said normally retracted means for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said tool having a tubular member extending into said body to a location below said first port which has a second port communicable with said first port, said tubular member having a second cylindrical portion and also having a second enlarged head above said second portion and a third port through said second portion below said second head, a second cylinder slidable along said second head and the second cylindrical portion of said tubular member below said third port and engageable with said first cylinder; means for closing the central passage through said tubular member below said second port; and frangible means initially securing one of said cylinders in an upper position.

8. In well apparatus: a tubular body having a cylindrical portion, an enlarged head above said portion and a first port through said portion below said head; normally retracted means on said body below said first port; a cylinder slidable along said head and the cylindrical portion of said body below said port and engageable with said normally retracted means for shifting said normally retracted means outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said tool having a tubular member extending into said body to a location below said first port which has a second port communicable with said first port, said tubular member having a second cylindrical portion, and also having a second enlarged head above said second portion and a third port through said second portion below said second head, a second cylinder slidable along said second head and the second cylindrical portion of said tubular member below said third port, an annular member adjustably mounted on said second cylinder and engageable with said first cylinder; and means for closing the central passage through said tubular member below said second port.

9. In well apparatus: a body; an expander on said body; slips cooperable with said expander; a first hydraulically operable means on said body for relatively moving said expander and slips, in order to shift said slips outwardly against a well conduit positioned in a well bore; a second hydraulically operable means engageable with said first hydraulically operable means to supplement the force of said first hydraulically operable means in shifting said slips against the well conduit; and a common conductive means for feeding fluid under pressure simultaneously to both said first and second hydraulically operable

means to actuate said first and second hydraulically operable means in a direction to shift said slip outwardly against the well conduit.

10. In well apparatus: a body having a first port; an expander on said body; slips cooperable with said expander; a first hydraulically operable means on said body responsive to the pressure of fluid passing through said first port for relatively shifting said slips and expander, in order to shift said slips outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said setting tool comprising a tubular member communicable with said first port and having a second port, and a second hydraulically operable means on said tubular member engageable with said first hydraulically operable means and responsive to the pressure of fluid passing through said second port to provide a force supplementing the force of said first hydraulically operable means in shifting said slips against the well conduit.

11. In well apparatus: a tubular body having a first port; an expander on said body; slips cooperable with said expander; a first sleeve slidable along said body and disposed over said first port, said first sleeve being responsive to the pressure of fluid in said port to shift said slips and expander relatively to each other, in order to shift said slips against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said setting tool having a tubular member extending into said body to a location below said first port, said tubular member having a second port communicable with said first port and also having a third port, a second sleeve slidable along said tubular member and engageable with said first sleeve, said second sleeve being disposed over said third port and being responsive to the pressure of fluid in said third port to provide a force supplementing the force of said first sleeve in shifting said slips against the well conduit; and means for closing the central passage through said tubular member below said second port.

12. In well apparatus: a tubular body having a cylindrical portion, an enlarged head above said portion and a first port through said portion below said head; an expander on said body; slips slidable along said expander; a cylinder slidable along said head and the cylindrical portion of said body below said port and engageable with said slips for shifting said slips along said ex-

pander and outwardly against a well conduit positioned in a well bore; a setting tool detachably secured to said body, said tool having a tubular member extending into said body to a location below said first port which has a second port cooperable with said first port, said tubular member having a second cylindrical portion and also having a second enlarged head above said second portion and a third port through said second portion below said second head, a second cylinder slidable along said second head and the second cylindrical portion of said tubular member below said third port and engageable with said first cylinder; and means for closing the central passage through said tubular member below said second port.

13. In well packer apparatus: a tubular body having a cylindrical portion, an enlarged head above said portion and a first port through said portion below said head; upper and lower expanders on said cylindrical portion of said body; upper and lower slips slidable along said upper and lower expanders, respectively; packing means on said body between said expanders; a cylinder slidable along said head and the cylindrical portion of said body below said port and engageable with said upper slips; a setting tool having a tubular member detachably secured to said body and extending into said body to a location below said first port, said tubular member having a second port communicable with said first port and also having a second cylindrical portion, as well as a second enlarged head above said second portion and a third port through said second portion below said second head, a second cylinder slidable along said head and the second cylindrical portion of said tubular member below said third port and engageable with said first cylinder; and means for closing the central passage through said second passage below said second port.

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