June 28, 1955 T. M. RAGAN 2,711,795

HYDRAULICALLY OPERATED WELL TOOLS

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Fig. 1.

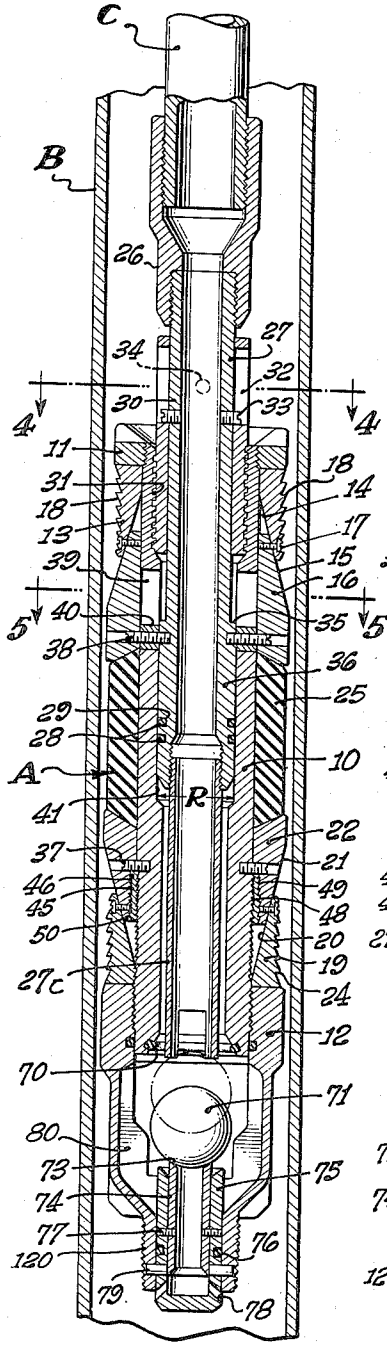


Fig. 2.

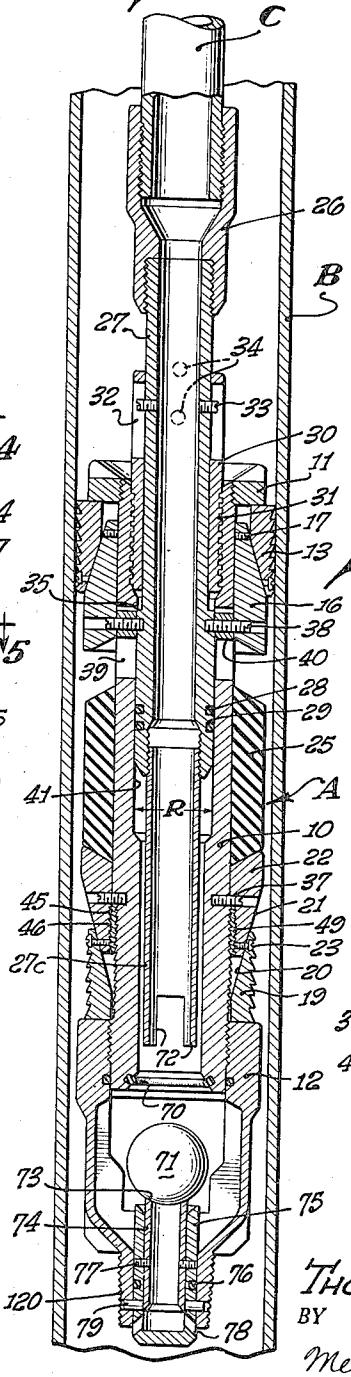


Fig. 3.

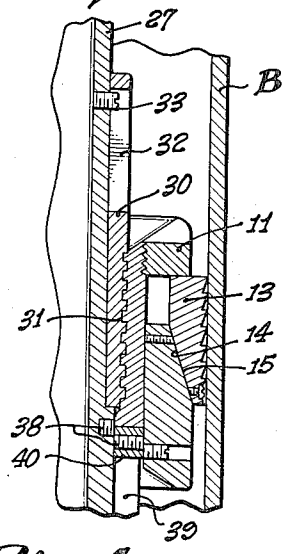


Fig. 4.

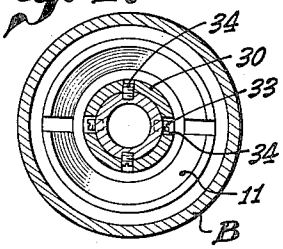
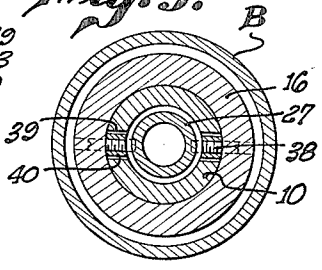


Fig. 5.



INVENTOR.
THOMAS M. RAGAN,
BY
Mellin and Hanscom
ATTORNEYS.

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Fig. 6.

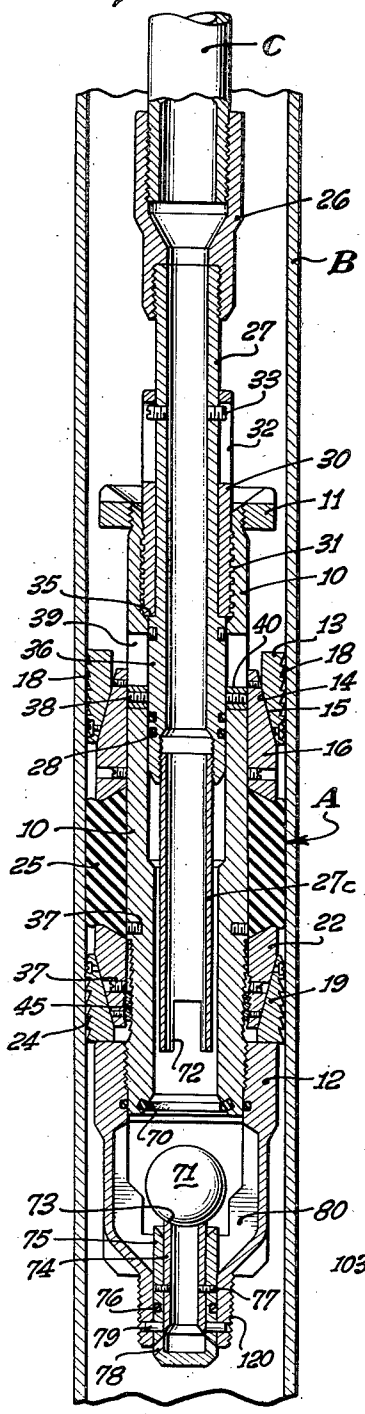


Fig. 7.

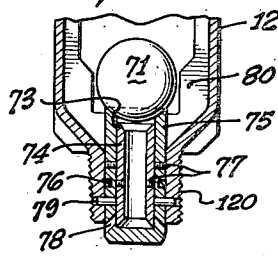


Fig. 8.

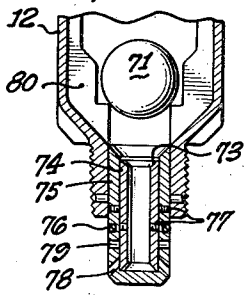


Fig. 10.

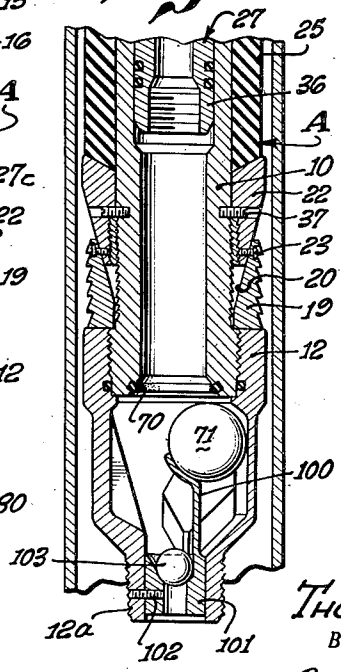
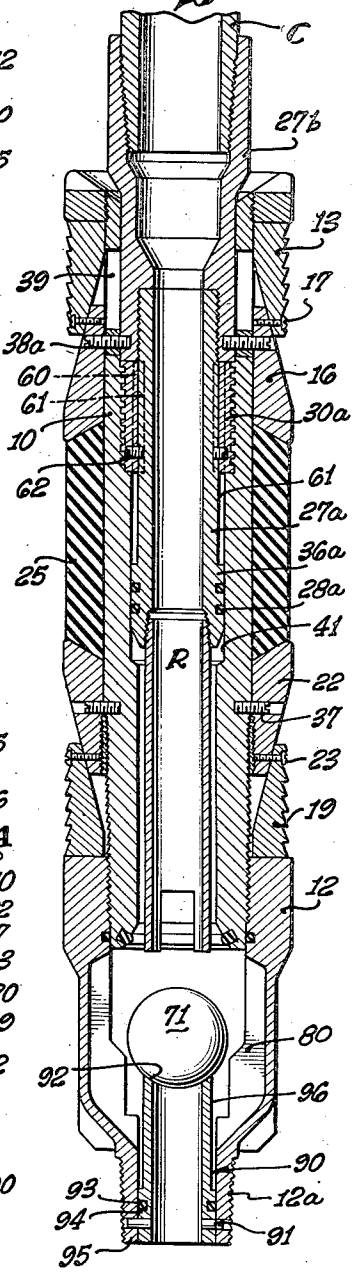


Fig. 9.



INVENTOR.
THOMAS M. RAGAN,
BY
Mellin and Hanscom
ATTORNEYS.

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HYDRAULICALLY OPERATED WELL TOOLS

Thomas M. Ragan, Downey, Calif., assignor to Baker Oil Tools, Inc., Vernon, Calif., a corporation of California

Application October 18, 1949, Serial No. 122,082

18 Claims. (Cl. 166—120)

The present invention relates to well packers and like tools adapted to be anchored in well bores, and more particularly to such tools that are set in the well bores by hydraulic or fluid action.

A well packer of the type illustrated in United States Patent No. 2,204,648 is set in a well casing as a result of hydraulically inflating its rubber or rubber-like packing element. Such packing element is inflated and elongated to a substantial extent to release a set of segmental slips, and move them outwardly into engagement with the casing.

In certain well bores, well packers are subjected to high temperatures and pressures, and also to the deleterious action of hydrocarbons on the packing elements. As an example, the temperature may be of the order of 400 degrees Fahrenheit and the packer may also be subjected to 8000 p. s. i. pressure. Packing elements that will stretch sufficiently to release and expand the segmental slips flow away when subjected to such high pressures and temperatures. In addition, they are attacked by the oil and other hydrocarbons in the well bore. On the other hand, oil resistant packing elements that can withstand the high pressures and temperatures have insufficient elongation to release the segmental slips from retracted position and urge them outwardly against the casing.

Accordingly, an object of the present invention is to provide a well packer capable of being set as a result of hydraulic action, and which embodies a packing element capable of withstanding high temperatures and pressures.

Another object of the invention is to set a well packer hydraulically without the necessity for elongating or inflating its packing element.

Still another object of the invention is to provide an improved manner of hydraulically setting a well packer, or anchoring device, in a well casing.

A further object of the invention is to utilize the hydraulic movement of the body portion of a well packer, or anchoring device, in effecting setting of the well packer, or device, against a well casing or similar conduit.

Yet a further object of the invention is to incorporate hydraulically actuatable elements in a well packer, or like device, for the purpose of setting the device in the well bore, which enables the device to be made of comparatively short length and of simple and economical construction.

Another object of the invention is to facilitate disconnection of a running-in string from a well packer or similar subsurface well tool.

This invention possesses many other advantages and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, 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 disposed in a well casing, with the packer parts in retracted position;

Fig. 2 is a view similar to Fig. 1, disclosing the packer partially set in the well casing;

Fig. 3 is a fragmentary longitudinal section, on an enlarged scale, of an upper portion of the packer;

Figs. 4 and 5 are cross-sections taken along the lines 4—4 and 5—5, respectively, on Fig. 1;

Fig. 6 is a view similar to Fig. 1, disclosing the well packer fully anchored in the well cashing;

Fig. 7 is a longitudinal section through the valve portion of the packer, with the parts in another operative position;

Fig. 8 is a view similar to Fig. 7, disclosing the valve parts in still another operative position;

Fig. 9 is a longitudinal section through a modified form of well packer, with the parts in retracted position;

Fig. 10 is a partial longitudinal section through still another form of the invention.

As disclosed in the drawings, it is desired to set a well packer A, or like tool, in a well casing B. The packer may be lowered to the desired setting point in the casing by the aid of a tubular string C, of drill pipe or tubing, and by actuating certain parts of the device hydraulically.

The well packer includes a main body comprising a tubular portion **10**, an upper annular abutment **11** threadedly secured at the upper end of the latter, and a lower guide and abutment **12** threadedly secured on its lower end. This lower guide and abutment may also constitute a valve housing for enclosing certain valve elements, to be described hereinafter.

A plurality of upper segmental slips **13** are disposed around the body adjacent its upper abutment **11**. These slips have inner tapered surfaces **14** inclined in a downward and outward direction, being slidable along a companion tapered surface **15** on an upper frusto-conical expander **16** disposed around the body **10**. A plurality of shear screws **17**, or similar frangible devices, initially secure the upper slips **13** to the upper expander **16**, holding the slips in retracted position against the body **10**. The upper slips have upwardly facing wickers or teeth **18** on their external portions for engagement with the inner wall of the well casing B, to prevent upward movement of the packer therewithin.

In a similar manner, a plurality of lower segmental slips **19** are disposed around the lower portion of the body adjacent the lower body guide and abutment **12**. These lower slips have inner tapered surfaces **20** that are inclined in a downward and inward direction for cooperation with companion tapered surfaces **21** on a lower frusto-conical expander **22** mounted on the body of the tool. The lower slips are held in retracted position against the body by a plurality of shear screws **23**, or other frangible devices, which initially secure them to the lower expander **22**. The lower slips have downwardly facing wickers or teeth **24** for engagement with the wall of the casing B, for preventing downward movement of the well packer therewithin.

An annular seal is to be provided between the packer body **10** and the wall of the well casing. This seal may be furnished by a packing sleeve **25**, which may be of synthetic rubber, mounted on the body between the upper and lower expanders **16, 22**. Initially, the packing sleeve **25** is in retracted position and has a substantial clearance with the well casing, the ends of the sleeve abutting or being adjacent the upper and lower expanders **16, 22**. The sleeve **25** is urged outwardly against the casing by moving the upper and lower expanders toward each other, for the purpose of foreshortening the sleeve and

compressing it firmly between the body 10 and casing B, in a manner described hereinafter.

The well packer A is lowered in the well casing B by the aid of the tubular string C. The lower end of this tubular string is threadedly secured to a tubular adapter 26 that is threaded onto the upper end of a tubular mandrel 27 extending into the packer body 10. Leakage between the body and mandrel may be prevented by providing one or more seal rings 28, such as rubber O rings, in peripheral grooves 29 in the mandrel engaging the body wall.

The tubular mandrel extends through a coupling sleeve 30 having left-hand threads 31 on its periphery engaging companion threads on the upper end of the packer body 10. The coupling sleeve extends outwardly from the upper end of the body and may have a pair of elongate longitudinal slots 32 slidably receiving pins 33 secured to the upper portion of the mandrel 27. Initially, the mandrel is maintained in a lower position with respect to the coupling sleeve 30, with its pins 33 in the lower portions of the longitudinal slots 32, by one or more shear screws 34 threaded into the upper portion of the coupling sleeve and mandrel, as shown in Fig. 1. When the parts are in this position, a shoulder 35 at the upper end of the lower head portion 36 of the mandrel 27 is disposed a substantial distance below the lower end of the coupling sleeve 30. As described hereinafter, this lower shoulder may be moved relatively upwardly into engagement with the lower end of the coupling sleeve to effect anchoring of the well packer in packed-off condition within the well casing. The pin and slot connection 33, 32 enables the tubular string C and mandrel 27 to be rotated, for the purpose of unthreading the coupling sleeve 30 from the packer body 10, which allows the entire tubular mandrel to be withdrawn from the latter.

Originally, the upper and lower expanders 16, 22 are spaced apart a sufficient distance to allow the packing sleeve 25 to occupy its retracted position. The lower expander 22 is held in its original position by one or more shear screws 37 threaded through the expander and into the packer body 10. The upper expander 16 is held in its original position by a plurality of shear screws 38, of relatively long extent, threaded into the expander 16 and projecting through elongate body slots 39, for threaded reception in the tubular mandrel 27 below its shoulder 35. These screws 38 may extend through short guide blocks 40 slidable in the body slots. The guide blocks 40 have the purpose of insuring proper shearing of the elongate screws 38, as explained hereinafter.

The well packer A is run in the well bore on the lower end of the tubular string C and with its parts occupying the retracted positions disclosed in Fig. 1. In anchoring the tool in packed-off condition in the well casing, it is desired first to expand the upper slips 13 against the casing B, and then to move the packer body 10 upwardly, for the purpose of foreshortening the packing element 25 and compressing it between the body 10 and casing B, and also to shift the lower slips 19 outwardly against the well casing. This sequence of events is obtained by properly proportioning the relative strengths of the various sets of shear screws in the tool. Thus, the screws 17 holding the upper slips 13 to the upper expander 16 have a lesser combined shear value than the elongate screws 38 initially securing the upper expander 16 to the tubular mandrel 27. These latter screws, in turn, have a lesser combined shear strength than the shear strength of the screws 37, 23 holding the lower expander 22 to the packer body 10 and the lower slips 19 to the lower expander.

When the location in the well casing has been reached at which the well packer is to be set, the passage through the lower guide and abutment portion 12 of the body is closed, in any suitable manner, so as to enable the pressure of the fluid in the tubular string C, tubular mandrel 27, and lower portion of the packer body 10 to be increased. This fluid under pressure acts across the area of the body below the mandrel head 36 in several directions. The resultant area over which the fluid under pressure acts on the body is the cross-sectional area R across the body bore 41. The fluid acts on this resultant area R in a downward direction. With the valve housing 12 closed against downward flow of fluid, the building up of pressure in the body of the packer urges the body 10 downwardly along the tubular mandrel 27, which is attached to the tubular string, C. All parts of the well packer are urged downwardly with the exception of the upper expander 16, since the latter is secured to the mandrel 27 by the elongate shear screws 38. This downward force imposed on the packer body 10 is exerted in a downward direction upon the upper slips 13 through the agency of the upper abutment 11. When the pressure increases sufficiently, the screws 34 and upper shear screws 17 are disrupted and the packer body 10 moves downwardly to slide the upper slips 13 in a downward direction along the stationary upper expander 16. In view of the inclined surfaces 14, 16 on the slips and upper expander, the slips 13 are urged outwardly against the casing, as disclosed in Fig. 2.

Such downward movement of the body 10 relative to the upper expander 16 is permitted, since the elongate shear screws 38 extend through the slots 39 in the packer body 10. In addition, the coupling sleeve 30, threadedly secured to the body 10, can also move downwardly without restraint, in view of the fact that the elongate slots 32 in the sleeve are of sufficient length to avoid interference with the coupling pins 33 extending outwardly from the tubular mandrel 27.

When the upper slips 13 have been engaged with the casing B, there is still a substantial distance or space between the mandrel shoulder 35 and the lower end of the coupling sleeve 30. An upward strain can then be taken on the tubular string C and mandrel 27 of sufficient extent to shear the elongate screws 38, freeing the mandrel from the upper expander 16. The mandrel 27 can then move upwardly until its shoulder 35 engages the lower end of the coupling sleeve 30. Such engagement precludes further relative upward movement of the mandrel 27 within the packer body 10 and the coupling sleeve 30. A continuation of the upward strain and movement then moves the packer body 10, and all of the packer parts below the upper expander 16, in an upward direction until the upper end of the packer sleeve 25 engages the upper expander 16. Since the latter is prevented from moving upwardly by virtue of its wedging engagement within the slips 13, continued upward movement of the mandrel 27 and packer body 10 will move the lower expander 22 toward the upper expander 16, foreshortening the packing sleeve and compressing it between the expanders, which is associated with outward expansion of the packing against the wall of the well casing B, and its provision of a firm seal between the periphery of the body 10 and the casing.

As the upward strain on the mandrel 27 and packer body 10 is increased, the compressed packing 25 restrains upward movement of the lower expander 22 with the body. Accordingly, the imposition of sufficient upward force on the body shears the screws 37 holding the lower expander 22 to the body 10, and also the screws 23 holding the lower slips 19 to the lower expander. The body then moves upwardly within the lower expander 22, with its lower abutment 12 sliding the lower slips 19 upwardly along the lower expander and radially outwardly into anchoring engagement with the wall of the well casing B.

A sufficient upward strain is taken on the tubular string C, mandrel 27, coupling sleeve 30 and body 10, to insure that the slips 13, 19 are firmly embedded in the casing B, with the packing 25 providing an annular leakproof seal between the body 10 and the casing B (Fig. 6).

Upward movement of the well packer A within the casing is prevented by the embedding of the upper slips

13 in the casing wall. Downward movement of the packer body is prevented by the wickers 24 on the lower slips 19 embedding themselves in the casing wall. The downward force on the packer body 10 is transmitted to the lower slips 19 through a suitable lock device. As disclosed in the drawings, this lock device may take the form of a split, contractile sleeve 45 disposed within a recess 46 in the lower expander 22, and having inner upwardly facing teeth 47 cooperable with companion downwardly facing ratchet teeth 48 on the exterior of the packer body 10. The outer portion of the ring 45 is provided with a plurality of downward and inwardly inclined cam faces 49 engageable with companion cam faces 50 in the lower expander 22. Any downward force imposed on the body 10 is transmitted through the teeth 48, 47 to the ring 45, the tapered surfaces 49, 50 on the ring and expander urging the ring more firmly against the body 10, and also transmitting the downward force to the lower expander 22, from where the force passes through the lower slips 19 to the well casing B. The ratchet teeth 48, however, do not interfere with upward movement of the body 10 within the lower expander 22, inasmuch as the split ring 45 is caused to expand automatically, avoiding interference with such upward movement.

After the well packer A has been firmly anchored in the well casing and a particular function or operation performed, the tubing string C, mandrel 27, and coupling sleeve 30 may be removed by rotating the tubing string to the right, which, through the agency of the pin and slot connection 33, 32, between the tubing mandrel 27 and coupling sleeve 30 unthreads the latter from the packer body 10, and allows the mandrel 27 and coupling sleeve 30 to be elevated to the top of the well bore.

A modified form of well tool is illustrated in Fig. 9. This packer, however, operates in essentially the same manner as the other well packer. The main differences reside in the location of the threaded coupling sleeve 30*a*, and of the manner of rotatably connecting this coupling sleeve to the tubular mandrel 27*a*.

As shown in Fig. 9, the lower end of the tubing string C is connected to an upper mandrel portion 27*b*, which is threaded onto an intermediate mandrel portion 27*a* having a lower head 36*a* carrying the side seals 28*a* engageable with the interior of the body passage 41. The coupling sleeve 30*a* has a plurality of keys 60 slidable in elongate keyways 61 on the intermediate mandrel portion 27*a*, the intermediate mandrel portion initially occupying a lower position with respect to the coupling sleeve 30*a*, with its head 36*a* disposed a substantial distance below the lower end of the coupling sleeve. The mandrel 27*a*, 27*b* is originally retained in this position with respect to the sleeve 30*a* by one or more shear screws 62 threaded through the sleeve 30*a* and into the mandrel 27*a*.

The elongate shear screws 38*a* extend through longitudinal slots 39 in the packer body 10 above the coupling sleeve 30*a*, the screws 38 originally occupying a lower position along the body slots.

The tool disclosed in Fig. 9 is set in the same manner as in the other form of the invention. When fluid cannot flow outwardly through the valve housing 12, a pressure is built up in the interior of the body 10 below the seal rings 28*a*, this pressure acting downwardly on the body over the area R, overcoming the shear value of the screws 62 connecting the coupling sleeve 30*a* to the mandrel 27*a*. When this occurs, and when the shear value of the screws 17 holding the upper slips 13 to the upper expander 16 is also exceeded, the body 10 is moved downwardly to slide the upper slips 13 over the upper expander 16 and radially outwardly into engagement with the well casing B. The coupling sleeve 30*a* is moved downwardly with the body 10 along the relatively stationary tubular mandrel 27*a*. Thereafter, an upward strain and movement is taken on the tubing string C and mandrel 27*b*, 27*a* to shear the elongate screws 38 and to shift the body 10 upwardly for the purpose of expanding the packing element 25 against the well casing B, and also the lower slips 19 against the well casing B.

It is apparent from the foregoing disclosure that the well packer A is set in the well casing B as a result of hydraulic actuation of certain well parts, such as the packer body 10. It is unnecessary to subject the packing element 25 to any elongation or inflation, as in the packer in the patent above referred to. The packing element is merely subjected to a compressive load, and, as such, may be made of synthetic rubber substitutes that are oil resistant, as well as being able to withstand the combination of high pressures and temperatures of the order of 8000 p. s. i. and 400 degrees Fahrenheit. One such rubber is Buna-N rubber. The hydraulic actuation of the tool occurs without the use of any setting devices connected to the tool itself, which not only make the well packers more expensive, but add considerably to its length.

In addition to the foregoing desirable features of the present packer, it has the further desirable feature that the area over which the hydraulic pressure is acting is fixed and known, which insures that the shear screws 17 and 34 or 62 will be disrupted when the device is subjected to a predetermined hydraulic pressure.

The pin slot connection 33, 32 between the tubular mandrel 27 and the sleeve 30 facilitates unscrewing of the coupling sleeve from the packer body 10. The slidable splined connection afforded by the pin 33 and the slot 32 relieves the coupling sleeve 30 of the weight of the tubular string C. If this weight were imposed on the coupling sleeve, binding of the left-hand threaded connection 31 might occur, tending to resist unthreading of the sleeve 30 from the body 10.

As indicated above, any suitable arrangement can be used for closing the well packer body 10 against downward flow of fluid; so as to enable pressure to be built up therein. As disclosed in Figs. 1 to 8, inclusive, a valve arrangement is employed which is capable of preventing return flow of fluids through the well packer after it has been set in the well casing, and which also precludes downward flow of fluid through the well packer until after the latter has been hydraulically actuated. The valve arrangement also enables fluid to flow upwardly through the well packer when it is being run down through the well casing, in order to allow the tubing string C to fill automatically with the well fluid.

The valve device includes the lower guide and abutment which forms a valve housing 12. The lower end of the body 10 may have a flexible valve seat 70 engageable by a back pressure and trip ball 71 disposed in the valve housing 12. The ball may move upwardly into engagement with the seat, to prevent upward or reverse flow of fluid through the packer body 10. However, originally, the ball 71 is prevented from engaging its seat 70 by a depending extension 27*c* of the tubular mandrel 27 threaded into the mandrel head 36. When the mandrel 27 is connected to the coupling sleeve 30 and body 10 through the agency of its shear pin 34, a plurality of fingers 72 on the extension 27*c* project through the valve seat 70 and will engage the ball 71, to forestall its upward engagement with the valve seat (see dotted line position in Fig. 1).

The back pressure and trip ball 71 is adapted to engage the upper end or seat 73 of an inner valve sleeve 74 which is slidable within an outer valve sleeve 75, the latter making a close sliding fit with the lower portion 12*a* of the valve housing 12. Leakage around the outer valve 75 is prevented by a side seal 76. The inner sleeve valve 74 initially occupies an upper position relative to the outer sleeve valve 75, being held in this relationship by one or more shear screws or pins 77 connecting the sleeve valves together. When the pins 77 are intact, the lower end of the inner sleeve valve 74 is disposed above a plurality of side ports 78 extending through the wall of the outer sleeve valve 75 below the lower end of

the valve housing 120. Originally, the outer sleeve valve 75 is connected to the valve housing by one or more shear pins or screws 79.

While the tool is being lowered through the well casing, fluid can enter the tool through the lower ports 78, flowing upwardly through the sleeves 75, 74, unseating the ball 71 from the inner sleeve 71 and flowing up through the tubular mandrel 27 and into the tubular string C. When the well packer is to be anchored in the well casing, the pumps at the top of the well bore are started, urging the fluid in the tubing strings C, tubular mandrel 27 and packer body 10 downwardly. This seats the back pressure and trip ball 71 against the upper end 73 of the inner sleeve valve 74, closing the passage through the latter and allowing the pressure to be built up within the tool for the purpose of tripping the upper set of slips 13, in the manner described above. Such tripping action occurs as a result of downward movement of the packer body 10 along the tubular mandrel 27. During this downward movement, the valve seat 70 moves downwardly below the tubular mandrel extension 27*c*, and, therefore, removes the fingers 72 on the extension from interference with the ability of the back pressure ball 71 to move upwardly into engagement with the valve seat 70 (see Fig. 2).

After the upper slips 13 have been set, the sleeve valves 74, 75 are ejected hydraulically from the valve housing 12; so as not to interfere with the downward pumping of cement slurry, or other fluids, through the well packer. Such ejection can take place immediately after the tripping of the upper slips 13, or after the full setting of the packer in the well casing, as desired. An increase in the pressure of the fluid in the tubular mandrel 27 and valve housing 12 exerts a downward force on the trip ball 71, which is engaging the inner sleeve valve 74, this downward force being transmitted through the inner sleeve valve to the shear pins 77. These shear pins have a greater shear value than the upper slip shear screws 17, but a lesser shear value than the lower pins 79 holding the outer sleeve valve 75 to the housing 12.

When sufficient hydraulic force has been exerted to overcome the shear strength of the pins 77, they are disrupted and the inner sleeve valve 74 moved downwardly within the outer sleeve valve to a position closing the ports 78 through the latter (Fig. 7). The trip ball 71 may now engage the upper end of the outer sleeve valve 75 and pressure imposed thereon, which pressure is transmitted through the outer sleeve valve to the other shear pins 79. Eventually, these shear pins 79 are disrupted when the fluid pressure exceeds a predetermined value, and the sleeve valves 74, 75 are moved downwardly out of the valve housing 12. Before this occurs, however, the trip ball 71 engages inwardly directed ribs 80 in the valve housing 12, and is precluded from moving downwardly to a further extent. However, since the inner sleeve valve 74 has closed the ports 78 through the outer sleeve valve, the two valves together constitute a piston that is acted upon by the fluid under pressure within the valve housing, such fluid forcing the piston in a downward direction completely out of the valve housing, in the manner illustrated in Fig. 8.

After the sleeves 74, 75 have been ejected from the valve housing 12, fluids can be pumped freely through the tubular string and into the valve housing, passing around the ball 71, and between the circumferentially spaced, inwardly directed ribs 80, and out through the lower end of the housing and guide 12. In the event that fluids tend to flow in a reverse direction, they carry the ball 71 upwardly into engagement with the valve seat 70, precluding such reverse flow. To insure upward seating of the ball 71 against the seat 70, the ball preferably has a specific gravity which is less than that of the cement slurry, so as to be buoyant in the latter.

The valve arrangement disclosed in Fig. 9 employs a single sleeve 90 secured to the valve housing 12 by one

or more shear pins 91. The trip ball 71 will engage the upper seat 92 on the sleeve to prevent downward passage of fluid through the well packer, and allows the fluid pressure to be increased for the purpose of setting the packer against the wall of the well casing. Thereafter, the imposition of sufficient pressure will shear the pins 91 and force the sleeve 90 downwardly out of the housing 12. To guard against leakage of fluid around the valve housing, a side seal 93 may be provided in a groove 94 at the lower portion 95 of the sleeve in sealing engagement with the cylindrical wall of the lower housing portion 12*a*. When the shear pins 91 are disrupted, the sleeve valve element 90 is moved downwardly until the ball 71 engages the ribs 80. When this occurs, the lower portion 95 of the sleeve has been forced out of the housing and its upper reduced diameter portion 96, which does not slidably seal with the housing, will then allow the sleeve 90 to drop or gravitate completely out of the housing.

As was pointed out above, any suitable means can be used for closing the passage through the packer body 10 to enable fluid pressure to be built up therein to shift the body downwardly along the tubular mandrel 27. As disclosed in Fig. 10, the tubular mandrel may terminate with the lower head 36. The valve housing has a back pressure ball 71 adapted to engage the body seat 70 and prevent return flow of fluid upwardly through the body. When running the tool in the well bore, this ball is held in ineffective position against the side of the valve housing by an arm 10 extending upwardly from a sleeve-like seat 101 secured to the lower portion 12*a* of the valve housing by one or more shear screws 102.

During running of the tool in the well bore, fluid can pass upwardly through the trip seat 101 into the body 10, tubular mandrel 27 and tubing string C. When the location in the well bore has been reached at which the packer A is to be anchored in the well casing, a tripping ball 103 may be pumped or allowed to gravitate down through the tubular string C, falling through the tubular mandrel 27 and body 10 into engagement with the seat 101. Such engagement closes the passage through the body 10, and allows pressure to be built up of sufficient extent to shift the body 10 downwardly along the tubular mandrel 27, and move the upper slips 13 along the upper expander 16 and into engagement with the well casing B. To accomplish this purpose, the shear screws 102 holding the trip seat 101 to the valve housing 12 have a much greater shear strength than the screws 17 holding the upper slips 13 to the upper expander 16.

Thereafter, the pressure may be increased to overcome the shear strength of the trip seat screws 102, forcing the seat 101 and trip ball 103 out through the lower end of the valve housing. This action also removes the arm 100 from the housing, and releases the back pressure ball 71 for upward movement into engagement with its cooperable seat 70.

An upward movement of the tubular string C, mandrel 27, and body 10 can then expand the packing sleeve 25 and lower slips 19 against the casing B, in the same manner as described in connection with the other forms of well packers.

The inventor claims:

1. In a well tool: a body; expander means on said body; initially retracted slip means shiftable by said expander means outwardly into engagement with a well casing; releasable means initially holding said slip means in retracted position relative to said expander means; a member within said body, said body being shiftable longitudinally with respect to said member; devices connecting one of said means to said member; abutment means on said body engageable with the other of said means; and fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body longitudinally along said member to release and expand said slip means against the well casing.

2. In a well tool: a body having a laterally extending abutment; an expander slidable on said body; initially retracted slips engageable by said abutment and shiftable by said expander outwardly into engagement with the well casing; releasable means initially holding said slips in retracted position relative to said expander; a member within said body, said body being shiftable longitudinally with respect to said member; devices connecting said member to said expander; and fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body and its abutment longitudinally along said member to release and expand said slips against the well casing.

3. In a well tool: a body having a laterally extending abutment; an expander below said abutment and slidable on said body; initially retracted slips below and engageable by said abutment and shiftable by said expander outwardly into engagement with the well casing; releasable means initially holding said slips in retracted position relative to said expander; a member within said body, said body being shiftable downwardly with respect to said member; devices connecting said member to said expander; and fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body and its abutment downwardly along said member to release and expand said slips against the well casing.

4. In a well tool: a body having a laterally extending abutment; an expander slidable on said body; initially retracted slips engageable by said abutment and shiftable by said expander outwardly into engagement with the well casing; releasable means initially holding said slips in retracted position relative to said expander; a member within said body, said body being shiftable longitudinally with respect to said member; devices connecting said member to said expander; and means for shifting said body and its abutment longitudinally along said member to release and expand said slips against the well casing.

5. In a well tool: a body having a laterally extending abutment, said body having one or more longitudinal slots therein; an expander slidable on said body; initially retracted slips engageable by said abutment and shiftable by said expander outwardly into engagement with the well casing; releasable means initially holding said slips in retracted position relative to said expander; a member within said body, said body being shiftable longitudinally with respect to said member; devices extending through said one or more slots and connecting said member to said expander; and fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body and its abutment longitudinally along said member to release and expand said slips against the well casing.

6. In a well tool: a body having a laterally extending abutment, said body having one or more longitudinal slots therein; an expander slidable on said body; initially retracted slips engageable by said abutment and shiftable by said expander outwardly into engagement with the well casing; releasable means initially holding said slips in retracted position relative to said expander; a member within said body, said body being shiftable longitudinally with respect to said member; frangible means extending through said one or more slots and connecting said member to said expander; and fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body and its abutment longitudinally along said member to release and expand said slips against the well casing.

7. In a well tool: a body having a laterally extending abutment, said body having one or more longitudinal slots therein; an expander slidable on said body; initially retracted slips engageable by said abutment and shiftable by said expander outwardly into engagement with the well casing; releasable means initially holding said slips in retracted position relative to said expander; a member within said body, said body being shiftable longitudinally with respect to said member; devices extending through said one or more slots and connecting said member to said expander; fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body and its abutment longitudinally along said member to release and expand said slips against the well casing; a sleeve coupled to said body; and means providing a slidable splined connection between said member and sleeve.

8. In a well apparatus: a tubular body adapted to be lowered in a well casing; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body engageable by said first member; first means on said body adapted to engage said initially retracted means; a second member telescopically mounted within said body; means connecting said first member to said second member to prevent relative movement therebetween; means to provide fluid under pressure in said body; and second means on said body cooperating with said pressure providing means to build up pressure in said body to shift said body longitudinally with respect to said first and second members, whereby said first means on said body engages said initially retracted means and moves toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

9. In a well tool: a body having laterally extending upper and lower abutments, said body having one or more longitudinal slots therein; a tubular member slidable relatively within said body; an upper expander slidable on said body; first frangible means extending through said one or more slots and connecting said expander to said member; upper slips slidable along said expander outwardly into engagement with a well casing and engageable with said upper abutment; second frangible means securing said slips initially in retracted position; a lower expander slidable on said body; lower slips slidable along said lower expander and engageable with said lower abutment; third frangible means securing said lower slips initially in retracted position; fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body downwardly along said tubular member to release and expand said upper slips against the well casing; said first frangible means having a higher shear value than said second frangible means and a lower shear value than said third frangible means.

10. In a well tool: a body having laterally extending upper and lower abutments, said body having one or more longitudinal slots therein; a tubular member slidable relatively within said body; an upper expander slidable on said body; first frangible means extending through said one or more slots and connecting said expander to said member; upper slips slidable along said expander outwardly into engagement with a well casing and engageable with said upper abutment; second frangible means securing said slips initially in retracted position; a lower expander slidable on said body; lower slips slidable along said lower expander and engageable with said lower abutment; third frangible means securing said lower slips initially in retracted position; fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body downwardly along said tubular member to release and expand said upper slips against the well casing; a sleeve

coupled to said body; and means providing a slidable splined connection between said sleeve and tubular member.

11. In a well tool: a body having laterally extending upper and lower abutments, said body having one or more longitudinal slots therein; a tubular member slidable relatively within said body; an upper expander slidable on said body; first frangible means extending through said one or more slots and connecting said expander to said member; upper slips slidable along said expander outwardly into engagement with a well casing and engageable with said upper abutment; second frangible means securing said slips initially in retracted position; a lower expander slidable on said body; lower slips slidable along said lower expander and engageable with said lower abutment; third frangible means securing said lower slips initially in retracted position; fluid pressure actuated means on said body and member for enabling fluid pressure to be built up in said body, whereby said fluid pressure shifts said body downwardly along said tubular member to release and expand said upper slips against the well casing; and a packing sleeve around said body between said upper and lower expanders.

12. In a well tool: a body having laterally extending upper and lower abutments, said lower abutment having a fluid passage, said body having one or more longitudinal slots therein; a tubular member slidable relatively within said body; an upper expander slidable on said body; first frangible means extending through said one or more slots and connecting said expander to said member; upper slips slidable along said expander outwardly into engagement with a well casing and engageable with said upper abutment; second frangible means securing said slips initially in retracted position; a lower expander slidable on said body; lower slips slidable along said lower expander and engageable with said lower abutment; third frangible means securing said lower slips initially in retracted position; and fluid pressure actuated means on said body and member for closing the passage through said lower abutment to enable fluid pressure to be built up in said body, whereby said fluid pressure shifts said body downwardly along said tubular member to release and expand said upper slips against the well casing.

13. In a well apparatus: a tubular body adapted to be lowered in a well casing; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body engageable by said first member; first means on said body adapted to engage said initially retracted means; a second member telescopically mounted within said body; means connecting said first member to said second member to prevent relative movement therebetween; means for closing said tubular body against downward flow of fluid therethrough to cause fluid pressure to be built up in said body; and second means on said body subject to the pressure built up in said body to shift said body longitudinally with respect to said first and second members, whereby said first means on said body engages said initially retracted means and moves toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

14. In a well apparatus: a tubular body adapted to be lowered in a well casing; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body above and engageable by said first member; first means on said body above and adapted to engage said initially retracted means; a second member telescopically mounted within said body; means connecting said first member to said second member to prevent relative movement therebetween; means to provide fluid under pressure in said body; and second means on said body cooperating with said pressure providing means to build up pressure in said body to shift said body downwardly with respect to said first and second members, whereby said first means on said body engages said initially retracted means and moves downwardly toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

15. In a well apparatus: a tubular body adapted to be lowered in a well casing and having a laterally extending abutment; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body engageable by said first member and abutment; a second member telescopically mounted within said body; means connecting said first member to said second member to prevent relative movement therebetween; means to provide fluid under pressure in said body; and means on said body cooperating with said pressure providing means to build up pressure in said body to shift said body longitudinally with respect to said first and second members, whereby said abutment engages said initially retracted means and moves toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

16. In a well apparatus: a tubular body adapted to be lowered in a well casing; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body engageable by said first member; first means on said body adapted to engage said initially retracted means; a second member connectible to a running-in string and telescopically mounted within said body; means connecting said first member to said second member to prevent relative movement therebetween; a coupling member releasably secured to said body; means providing a slidable splined connection between said coupling member and second member; means below said second member to cause fluid pressure to be built up in said body; and second means on said body subject to the pressure built up in said body to shift said body and coupling member longitudinally with respect to said first and second members, whereby said first means on said body engages said initially retracted means and moves toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

17. In a well apparatus: a tubular body adapted to be lowered in a well casing; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body engageable by said first member; first means on said body adapted to engage said initially retracted means; a second member connectible to a running-in string and telescopically mounted within said body; frangible means connecting said first member to said second member to prevent relative movement therebetween; a coupling member releasably secured to said body; means providing a slidable splined connection between said coupling member and second member; means below said second member to cause fluid pressure to be built up in said body; and second means on said body subject to the pressure built up in said body to shift said body and coupling member longitudinally with respect to said first and second members, whereby said first means on said body engages said initially retracted means and moves toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

18. In a wall apparatus: a tubular body adapted to be lowered in a well casing; a first member mounted on the exterior of said body so as to be movable longitudinally along the exterior of said body; initially retracted means on said body engageable by said first member; first means on said body adapted to engage said initially retracted means; a second member connectible to a running-in string and telescopically mounted within said body; means connecting said first member to said second member to prevent relative movement therebetween; a coupling member; means providing a left-hand threaded connection between said coupling member and body; means providing a slidably splined connection between said coupling member and second member; means below said second member to cause fluid pressure to be built up in said body; and second means on said body subject to the pressure built up in said

body to shift said body and coupling member longitudinally with respect to said first and second members, whereby said first means on said body engages said initially retracted means and moves toward said first member to engage the latter with said initially retracted means and expand said initially retracted means laterally into engagement with the well casing.

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