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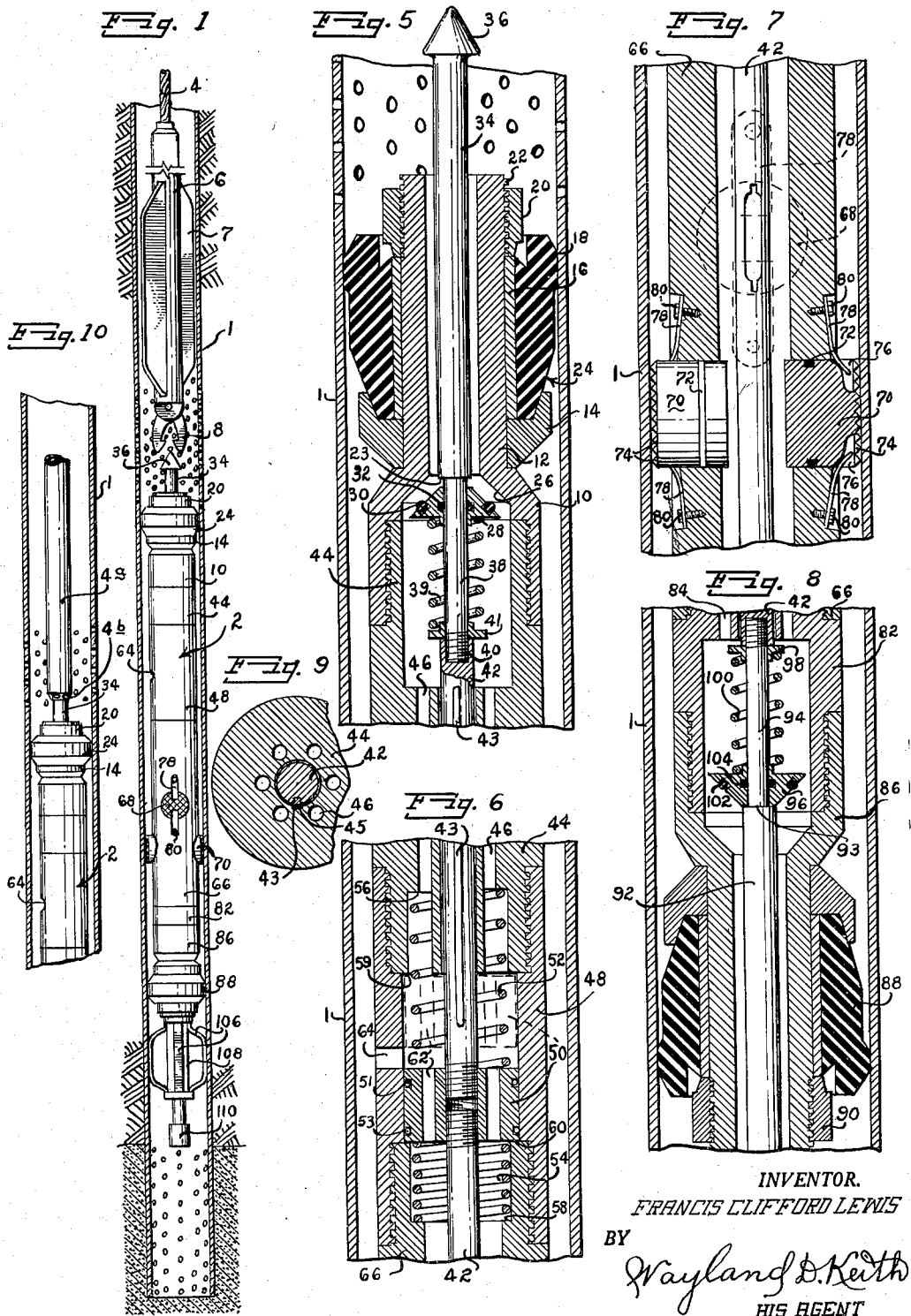
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BRIDGE PLUGS AND PACKERS FOR OIL WELLS

Filed July 30, 1957

2 Sheets-Sheet 1



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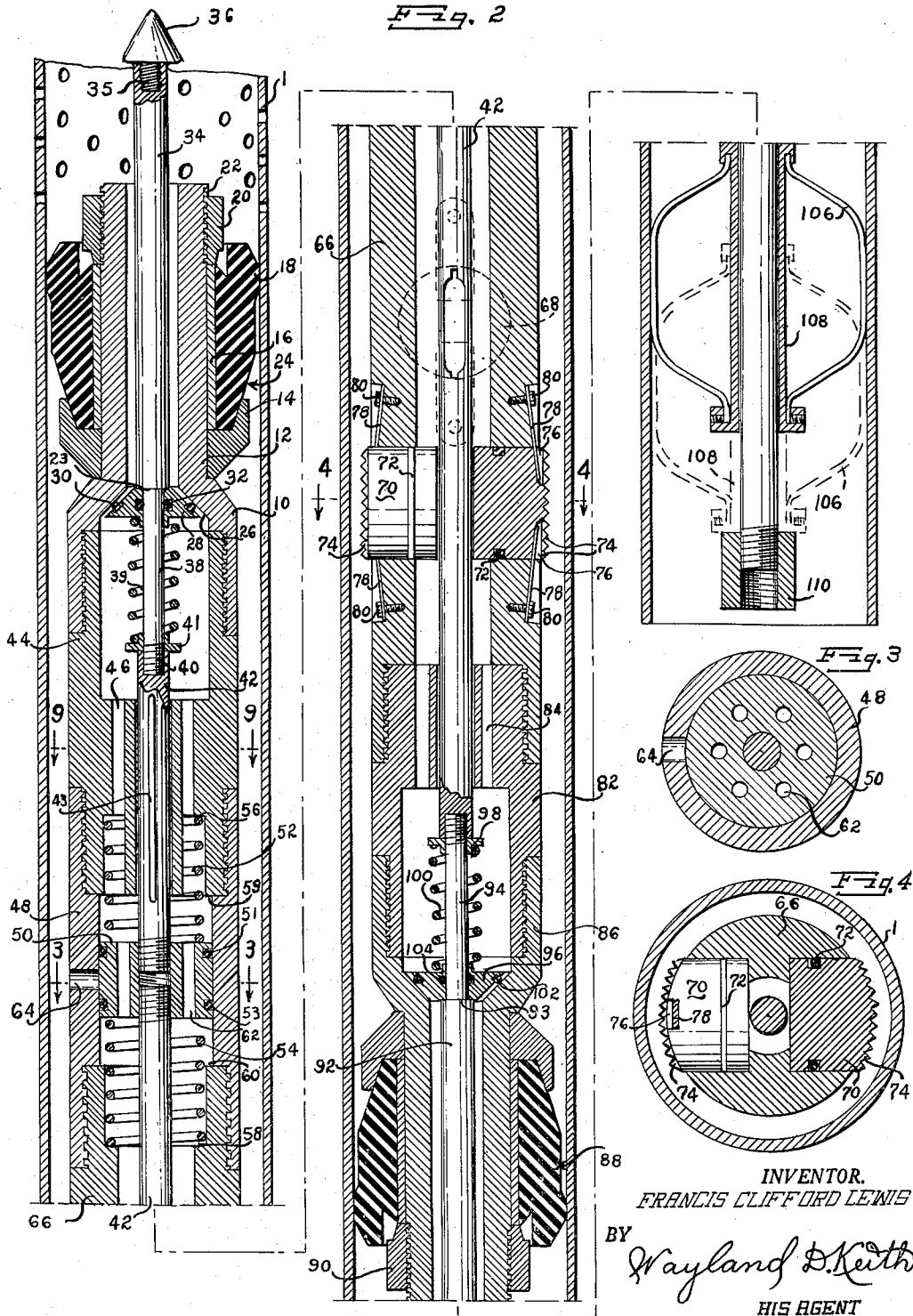
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2,990,883 BRIDGE PLUGS AND PACKERS FOR OIL WELLS

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This invention relates to improvements in bridge plugs and packers for use in oil wells and the like, and more particularly to a bridge plug and packer which may be set at any desired level within the well, which will resist movement by fluid pressure in either direction, and which will grip the casing tighter, in event additional pressure is exerted to move the plug and packer in either direction.

The present bridge plug and packer is of the retrievable type, which may be readily set in or removed from a well by the use of wire line, and which may be used for testing purposes, and also for squeeze cementing, sand-fracing, acidizing, and other types of work to be done within the bore hole of a well where pressure is used and must be retained.

The present plug and packer may be run within the well casing on a wire line, tubing, or rods to the location desired within the well casing, then, by manipulation of the wire line, and the release tool, the packer may be released at the desired level within the well, for the desired operation to be performed, then the packer may be recovered by the use of the wire line, tubing or rods, or by a special type of pick-up slips, which will enable the packer to be removed from the casing of the well under most conditions, without the necessity of running pipe, having special fishing tools thereon, into the well.

Various packers have been proposed heretofore, which where held in place within the well casing by various types of slips, including pressure actuated slips, which engage the inner wall of the casing, upon pressure being directed into the inner portion of the body to urge the slips outward into gripping engagement with the inner diameter of the well casing.

The present bridge plug and packer arrangement has a valve system provided therein, whereby pressure, which is directed into the inner body of the bridge plug will be so entrapped as to maintain the slips in contact relation with the inner diameter of the well casing and which maintains the plug against longitudinal movement therein; however, the valves further provide for the entrance of pressure fluid from either direction into the inner bore of the packer body, which pressure automatically puts additional thrust on the slips so as to grip the inner diameter of the pipe to prevent longitudinal movement of the packer.

An object of this invention is to provide a bridge plug and well packer for a well casing which may be readily set within the well casing at the desired level and released, which will enable the removal of the bridge plug and packer by means of a wire line, under most conditions.

Another object of the invention is to provide a bridge plug and well packer for a well casing, which has a multiplicity of friction springs thereon to maintain the bridge plug and packer in a temporary position until pressure may be applied to set the packer in a fixed position within the well.

Still another object of the invention is to provide a valve arrangement within the body of the bridge plug and packer, whereby, as additional pressure is applied, the casing engaging slips on the packer will be engaged more tightly therewith.

Still another object of the invention is to provide a bridge plug and well packer wherein pressure within the inner chamber of the bridge plug may be readily relieved

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by the manipulation of the mandrel on which the valves are mounted, by means of a wire line, tubing, rods, or the like.

With these objects in mind, and others which will become manifest as the description proceeds, reference is to be had to the accompanying drawings in which like reference characters designate like parts in the several views thereof, in which:

FIG. 1 is a longitudinal sectional view through a portion of a well having a casing therein, showing a bridge plug and well packer, in elevation, installed therein, and showing the slips and packer elements in engaged position;

FIG. 2 is a longitudinal sectional view through the bridge plug and packer within the well casing, with parts shown in elevation and with parts broken away and shortened to show the details of construction;

FIG. 3 is a cross sectional view taken on the line 3—3 of FIG. 2, looking in the direction indicated by the arrows;

FIG. 4 is a sectional view taken on the line 4—4 of FIG. 2, looking in the direction indicated by the arrows, with parts being shown in elevation to bring out the details of construction;

FIG. 5 is a fragmentary vertical, sectional view through the upper portion of the bridge plug and packer, and showing the upper pressure valve as it is maintained in open position by fluid pressure;

FIG. 6 is a longitudinal sectional view through the center portion of the packer element, and showing the pressure relief valve in full outline in position to open equalization ports upon movement of the mandrel in one direction, and showing the pressure relief valve in dashed outline in the opposite position, upon movement of the mandrel in the opposite direction;

FIG. 7 is a fragmentary vertical, sectional view through the portion of the body which mounts the slips in sliding relation for engagement with the inner diameter of the casing;

FIG. 8 is a fragmentary vertical, sectional view through the lower portion of the bridge plug and packer, and showing the pressure maintaining valve as it is maintained in open position by the mandrel which passes there-through;

FIG. 9 is a fragmentary sectional view taken on the line 9—9 of FIG. 2, looking in the direction indicated by the arrows; and

FIG. 10 is a fragmentary view showing the upper portion of the packer element within the well casing, and showing a tubing connected to the upper end of the mandrel.

With more detailed reference to the drawing, the numeral 1 designates generally a well casing. The bridge plug and packer, designated generally by the numeral 2, is lowered to the desired level in the well casing by means of a wire line 4, which usually has a sinker bar 6 thereon to provide additional weight so as to position the packer downward in the well casing 1. The lower end of the sinker bar 6 usually has a special tool thereon, as indicated at 8, which, when going into the "hole," will allow the sinker bar and wire line to be released from the upper end of the packer tool by special manipulation of the wire line, however, when desired to remove the packer 2 from the well casing 1, another tool is substituted for tool 8, which tool will grip the upper end of the mandrel of the bridge plug and packer to enable the movement of the mandrel, and the subsequent removal of the bridge plug.

The bridge plug and packer 2 is composed of several tubular elements screw threaded together to form a longitudinal sectional, tubular body. The upper portion of the body is designated at 10, which portion 10 has a

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reduced upper end member 12 to receive a packer assembly, which packer assembly comprises a metal back-up cup 14, a tubular sleeve 16, a packer rubber 18, and a retaining nut 20, which nut is screw threaded onto threads 22 of the reduced end 12, so as to maintain the packer, designated generally by the numeral 24, in fixed relation on the end of body 10. A valve seat 26 is formed within body 10 to complementarily receive valve 28. The valve 28 preferably has O-ring sealing elements 30 in the face thereof to seat against valve seat 26. Furthermore, the pressure retaining valve 28 has an axial bore therein, in which is formed an annular groove, which groove has an O-ring seal 32 fitted therein and surrounding the axial bore. A mandrel 34, which is shouldered at 23, has an enlarged head 36 screw threaded thereon as indicated at 35, which head is engageable with a "setting" tool or a retrieving tool.

The lower end of the mandrel 34, as indicated at 38, is reduced and passes through the axial bore of valve 28, and is in sliding, fluid tight relation therewith. A spring 39 is telescoped over the reduced portion 38 and has one end seating on valve 28 and the other end seating on an abutment washer 41, which abuts with mandrel 42, so as to normally hold the valve 28 on seat 26. The lower end of the mandrel 34 is threaded as indicated at 40, to threadably engage the upper end of mandrel 42, as will best be seen in FIG. 2. The upper portion 10, of the body, threadably engages the end of a second tubular body portion 44, which second body portion has an axial opening therethrough for the passage of mandrel 42 therethrough in sliding relation. A plurality of circumferentially spaced, parallel openings 46 formed in the body 44 connect with the bore within the body 44 so as to pass fluid therethrough.

A third tubular body portion 48 is screw threaded onto the lower end of second body portion 44, which third body portion forms a sleeve for a valve member 50, which valve member 50 is slidably mounted therein.

The mandrel 42 has a key 43 fitted therein, which key is longitudinally movable therewith. The key 43 slides within a keyway 45 within tubular section 44. This arrangement maintains the tubular portion 44 and the mandrel 42 against relative turning movement, which enables the turning of the entire tool 2 within the well, which makes possible the orientation thereof. Other type tools, such as anchor tools or the like, using J-slots, may be connected to the lower end of nut 110 at the lower end of mandrel 92 so that additional anchor means may be used with the tool, as desired, thereby, when running the tool into the well on a string of pipe or rods, as indicated at 4a, the entire tool 2 may be turned in the prescribed manner so as to lock or unlock the J-slot anchor tool therebelow, in a manner well understood in the art. When the tool 2 is used in connection with anchor tools having J-slots therein, the head 36, which is threadably attached to mandrel 34 by a threaded pin 35, is removed and a string of pipe 4a, rods or the like is screw threaded thereinto, for running the tool into the well in a manner well understood in the art of setting packers, fishing tools, and the like. The pipe 4a may have holes 4b therein (FIG. 10) for discharge of fluid therefrom.

Springs 52 and 54 are telescoped over mandrels 42 and are positioned on each side of slide valve member 50. The spring 52 abuts with the shoulder portion 56 of the second body portion 44. The spring 54 has one end thereof abutting with slide valve member 50 and the other end thereof is seated on shoulder 58 within the fourth body portion 66, which body portion 66 is screw threaded onto the lower end of the third body portion 48. The second body portion 44 has a counterbore in the lower end thereof to receive and center spring 52. The counterbore is smaller in diameter than the bore of the body portion 48, so as to form a shoulder 59 for abutment of the slide valve 50 thereagainst, when the slide valve is in one position. The body portion 66 is

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counterbored at its upper end to receive spring 54 therein. The counterbore is smaller than the bore within the body portion 48 so as to form a shoulder 60 against which slide valve 50 abuts when it is in the lower-most position. The counterbores within the respective body portions 44 and 66 are of such length as to completely receive the respective springs 52 and 54 in compressed condition, without putting undue strain on the respective springs, as indicated in FIG. 6.

The sliding valve 50 has O-rings 51 and 53 fitted within grooves formed therein, so as to form a fluid tight seal with the inner bore of the third body portion 48. The sliding valve 50 has longitudinally aligned passages 62 therethrough, as will best be seen in FIGS. 2 and 3. When the sliding valve 50 is in position as shown in FIG. 2, the lateral port 64, in body 48, is closed, with O-rings 51 and 53 positioned on either side thereof, which O-rings form a seal between the bore of body 48 and the annular space between casing 1 and the outer portion of body 48.

The body 66 has two pairs of transversely bored, cylindrical holes formed therein which form cylinders to receive pistons 68 and 70, with the pistons 70 being mounted at right angles to pistons 68. It is preferable to have at least one O-ring sealing element 72 to encircle each of the pistons to form a gasket between the piston and the respective transverse bores. The outer end of each piston has teeth 74 thereon, which teeth are in the form of a pyramid; however, each of the pistons has a pair of grooves 76 formed therein to receive return springs 78, which are secured to the body 66 by bolts 80. The respective springs 78 will return the respective pistons to their inner-most position, as shown in FIGS. 2 and 4, when no pressure is exerted within the body of the bridge plug and packer.

The lower end of the body portion 66 is screw threaded to threadably receive the upper end of a fifth tubular body portion 82, which body portion 82 has circumferentially spaced, longitudinally aligned holes 84 formed therethrough. The tubular body portion 82 is screw threaded at the lower end thereof to threadably receive the upper end of the lower-most body portion 86, which body portion 86 is substantially identical with the upper body portion 10, but which is inversely arranged.

The lower body portion 82 has a packer designated generally at 88 thereon, which is maintained in place by a nut 90 which is screw threaded onto the lower end of the body portion 86 in the same manner as nut 20 is screw threaded onto the body portion 10. The mandrel 92 has a reduced end portion 94 which is screw threaded into the lower end of mandrel 42, as will best be seen in FIGS. 2 and 8. A pressure retaining valve 96 is slidably mounted on reduced end portion 94 of mandrel 92, which reduced end portion has an abutment washer 98 mounted thereon which abuts with the lower face of mandrel 42. A spring 100 is telescoped over the reduced end portion 94 of mandrel 92, and which spring has one end abutting with abutment washer 98, and the other end thereof abutting with the upper face of pressure retaining valve 96.

The pressure retaining valve 96 is substantially identical with pressure retaining valve 28, which valve 96 has an O-ring seal within the face thereof so as to form a sealing gasket, when the valve is in closed position. The valve 96 is axially bored so as to slide on reduced end portion 94 of mandrel 92, so that O-ring 104 fitted within an annular groove within the bore of valve 96, will form a sealing ring between the valve and the reduced end portion 94. The mandrel 92 has a shoulder 93 thereon which shoulder abuts with the lower face of valve 96, so upon upward movement of mandrel 92, the valve 96 will be lifted from its seat by the shoulder 93 thereon, or, if pressure passes upward therethrough, the annulus formed between the inner bore of the lower body portion 96 and the outer diameter of mandrel 92, the pressure will cause the valve 96 to lift against tension of spring 100, so the

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fluid pressure will flow upward thereby. The mandrel 92 extends downward and has a drag spring element, designated generally at 106, which is mounted on a tubular element 108, which tubular element abuts with the lower face of tubular element 86 so as to temporarily support the bridge plug and packer within the well casing 1, before the application of pressure to the packer to cause the pistons 68 and 70, having toothed slip elements 74 thereon, to move outward into engagement with the inside of the casing 1. A nut or abutment 110 is provided on the lower end of mandrel 92, so when the tool is removed from the casing the lower end of tubular element 108 will seat on the upper face of nut 110, so as to lift the drag spring element 106. It is preferable to have the nut 110 screw threaded to the lower end of mandrel 92 so that the drag spring 106 may be readily removed and replaced.

Operation

The packers may be run into a well on a wire line, as indicated at 4, FIG. 1, or on a string of rods or pipe, as indicated at 4a, to which the packer tool is screw threaded, as shown in FIG. 10.

Normally, it is more expedient to run a packer into a well on a wire line 4, however, special or unusual circumstances, at times make it expedient for the packer to be run into the well on rods or pipe, as indicated at 4a, to which the mandrel 34 is screw threaded.

By using a wire line, as indicated at 4, FIG. 1, and with a setting tool attached to the lower end of a sinker bar 6, the packer tool is lowered into the well to the desired depth, as the weight of the sinker bar 6 overcomes the friction of drag springs 106, so the packer, designated generally at 2, may be positioned at the desired level within the well, whereupon, by special movements of the wire line 4, the setting tool 8 releases from the conical head 36, to leave the packer element at the desired position in the well. With the packer rubber 18 positioned to spread outward in sealing relation with casing 1, upon pressure being introduced from above, and with the packer element 88 positioned to spread outward into sealing relation with the casing 1, upon pressure being introduced from below the packer, and with the tool 2 positioned within the casing 1, as explained above, it is hydraulically anchored so as to form a bridge plug. With the plug thus positioned, and sealed within the casing, it will prevent blowouts from below, or will prevent fluid, such as cement, acid or the like, from passing to the bottom of the well, when such material is introduced into the well above the packer.

In event a well starts to flow or to gas heavily, the pressure will pass upward through tubular member 86 to lift valve 96 from its seat by compressing spring 100, whereupon, the bores of tubular members 82, 66, 48 and 44 are filled with fluid under pressure, which pressure closes valve 28. As the pressure increases, pistons 68 and 70, which have toothed slip members 74 on the respective outer ends thereof, move outward into gripping relation with casing 1, and as the pressure on the pistons increases, the slips 74 will grip the interior of the casing 1 more tightly, as the pressure within the tool is greater than the pressure exterior thereof, because of the sealing action of rubber sealing elements 18 and 88.

As the pressure is reduced, the valve 96 will close, and since the pressure was against valve 28, the valve 28 would not open, therefore, the pressure becomes trapped in the hollow space within the body of the tool, and since neither valve will yield until the mandrel, comprising sections 34, 42, and 92 is moved, the plug is anchored in position. When the plug is so anchored, such servicing as acidizing, cementing or the like, can be performed, or a certain stratum within the well can be tested for productivity. Upon the completion of such testing or servicing as needs to be performed, the plug may be raised or lowered within the well, either by moving the plug up-

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ward and resetting it, or by removing the plug from the well entirely, by means of a special wire line tool, similar to that shown in FIG. 1, and using the resetting tool to again lower the plug to the desired depth, whereupon, by manipulation of the line, the setting tool is disconnected from the packer unit, in the same manner as set out above.

It is preferable to use a sinker bar which has three or more centering fins 7 thereon, which fins radiate from the sinker bar 6, so as to center the tool during the setting or removal thereof, but which will permit free passage of fluid past the sinker bar.

When it is desired to release the pressure from within the tool 2, the mandrel 34 may be moved downward until shoulder 23 engages the upper face of valve 28, as shown in FIG. 5, which will release the pressure from within the tool. This will permit pistons 68 and 70 to move inward under the tension of springs 78, which causes the teeth 74 to disengage from the inner bore of the casing 1. Simultaneously with the movement of the mandrel 34 downward, the slide valve 50 will move from the position shown in FIG. 2 to the position shown in full outline in FIG. 6, whereby pressure will be equalized on the inside of the tool with that in the annular space between the tool and the casing 1, whereupon, the packer elements 18 and 88 will release from the sealing engagement with the wall of the casing 1, which will enable the tool 2 to be moved downward.

By engaging the mandrel 34 with a removing tool, the mandrel 34 together with the interconnecting mandrels 42 and 92 may be moved upward, then shoulder 93 will engage the lower face of valve 96 which will lift the valve from its seat, and as the mandrel moves upward, the slide valve 50 will be moved to uncover port 64, so as to equalize the pressure on both sides of the packers 18 and 88, which will permit the tool to be moved upward within the well.

As the tool is moved, either up or down, a free flow of fluid is permitted to pass therethrough. As the tool moves upward, fluid passes downward within the upper tubular member 12, and the pressure thereof will cause valve 28 to open, to allow the fluid to flow downward through tubular member 44, passage 46, third tubular member 48 through passage 62 in slide valve 50, through tubular member 66, and thence downward through passage 84 in tubular member 82, and since the shoulder 93 on mandrel 92 has moved the valve 96 upward, the fluid passes down through tubular member 86, so the movement of the tool through the fluid will not be impeded.

In lowering the tool into the well, the reverse process occurs, that is, the fluid passes upward through the tool in a reverse manner to that described above, with the valves 96 and 28 being shifted in reverse relation, thereby permitting the tool to be lowered in the well.

It is to be pointed out that, once the packer element is lowered to the desired level in the well, either by a wire line as indicated at 4, or by a pipe or rods as indicated at 4a, the differential of pressure from either direction will cause either valve 96 or valve 28 to open to allow fluid to flow into the inner portion of the hollow body of the packer element 2, whereupon the slip elements 68 and 70 will be forced outward into frictional engagement with well casing 1. Considering that the pressure has been in an upward direction, valve 96 will cause spring 100 to yield to perform this setting action, however, if cementing, acidizing or other type work is to be performed which requires pressure to be introduced into the well from the upper end thereof, when the pressure is applied from the upper end and if the pressure so applied is greater than the pressure from below, the differential of the pressures will cause valve 28 to open and valve 96 to seat, whereupon the increase in pressure within the tubular body of the packer 2 will cause the pistons 68 and 70 to move out-

ward to cause the teeth 74 thereon to engage more tightly with the wall of the casing 1, thereby preventing slippage of the packer element in either direction. Upon application of pressure in either direction, the packer elements 18 and 88, due to the conical construction thereof, will press outward into sealing engagement with the casing 1, thereby preventing leakage into the annulus between tubular element of the packer 2 and the casing 1, therefore the pressure within this annulus will not be as great as the pressure within the inner portion of the tubular body of the packer 2, therefore, the pistons will readily move outward under pressure introduced to the inside thereof.

While the invention has been described and illustrated in some detail as to one embodiment thereof, it is to be understood that changes may be made in the minor details of construction and adaptations made to different installations, without departing from the spirit of the invention or the scope of the appended claims.

Having thus clearly shown and described the invention, what is claimed as new, and desired to secure by Letters Patent is:

1. In a retrievable packer for forming a fluid tight seal within a well casing, a tubular body, elastomer packer elements mounted on said tubular body, one near each end thereof, a mandrel mounted longitudinally within said tubular body for sliding movement relative thereto, which mandrel has shoulder means formed thereon near each end thereof, said tubular body having valve seats formed therein in opposed relation, valves fitted on said mandrel in slidable, opposed relation, resilient means normally maintaining said valves in seated relation on said respective valve seats to form a normally closed chamber and to normally hold said valves adjacent said respective shoulder means, said tubular body having at least two cylindrical holes formed transversely therein intermediate said valves, a piston slidably fitted within each of said holes, said pistons being movable in said holes by hydraulic pressure, each of said pistons having a toothed outer end, a head on an end of said mandrel by which said packer may be raised and lowered within said casing, the shouldered means of which mandrel selectively engage the respective valves upon longitudinal movement of said mandrel to open said normally closed chamber.

2. A retrievable well packer as defined in claim 1; wherein said shoulder means are spaced longitudinally outward from the respective resiliently pressed valves, each of said shoulder means being engageable with one or the other of said valves upon longitudinal movement of said mandrel, so when said mandrel is moved in one direction one of said resiliently pressed valves will be opened inwardly and upon movement of said mandrel in the other direction, the other of said resiliently pressed valves will be opened inwardly.

3. A retrievable well packer as defined in claim 1; wherein a piston type slide valve is movable with said mandrel, said tubular body having at least one further transverse hole in the wall thereof, and wherein

resilient means urges said piston type slide valve to normally close said further transverse hole.

4. The device as defined in claim 3; wherein said piston type slide valve is longitudinally movable in either direction, and wherein said tubular body has an abutment formed therein at each end of the stroke of said piston type slide valve so as to maintain said piston type slide valve in a gauged position with respect to said further transverse hole in said tubular body.

5. A retrievable well packer for forming a fluid tight seal within a well casing as defined in claim 1; wherein hydraulic pressure is provided in said well casing, which hydraulic pressure will open one of said resiliently pressed valves inwardly, said pistons being movable outwardly in said transverse holes by said hydraulic pressure so said toothed outer ends of said pistons will engage the inner wall of said well casing, one of said inwardly opening, resiliently pressed valves being positioned near each end of said tubular body so when pressure is applied to either end of said packer one of said resiliently pressed valves will be opened and the other of said resiliently pressed valves will be maintained in seated position and will maintain the ends of said piston elements in frictional engagement with the inner wall of said casing.

6. A retrievable tool adapted to be run into a well or removed therefrom on a wire line, which tool forms a fluid tight seal with the well casing; which tool comprises, a tubular body, elastomer packer elements mounted on said tubular body, one near each end thereof, a mandrel mounted within said tubular body for slidable movement relative thereto, said tubular body having valve seats formed therein in opposed relation, valves fitted on said mandrel to complementally seat on said respective valve seats, resilient means normally maintaining said valves in seated relation on said respective valve seats to form a normally closed chamber, said tubular body having at least two cylindrical holes formed transversely therein intermediate said valves and being in communication with the hollow portion of said tubular body, a piston slidably mounted in each of said cylindrical holes, each of said pistons having a toothed outer end, a head on the outer end of said mandrel for attachment of a cable tool thereto for raising or lowering said tool in said casing, a slide valve mounted within said body, said tubular body having a lateral port formed therein, said slide valve being mounted on said mandrel and being movable therewith and positioned within said body so as to normally close said port, said slide valve being movable in either direction to open said port upon movement of said mandrel in either direction.

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