

July 17, 1962

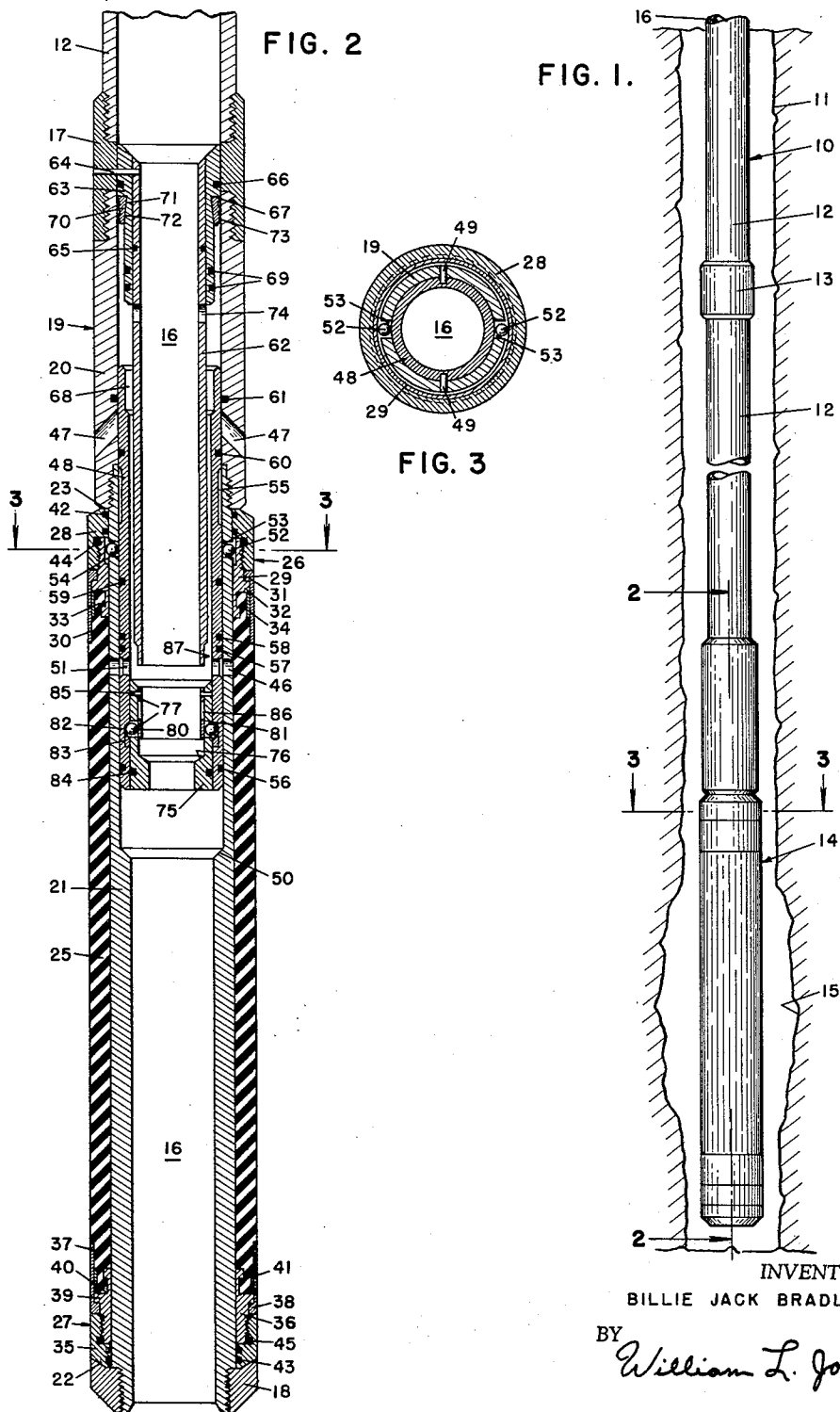
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3,044,553

WELL PACKER

Filed May 5, 1958

3 Sheets-Sheet 1



July 17, 1962

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3 Sheets-Sheet 2

FIG. 4.

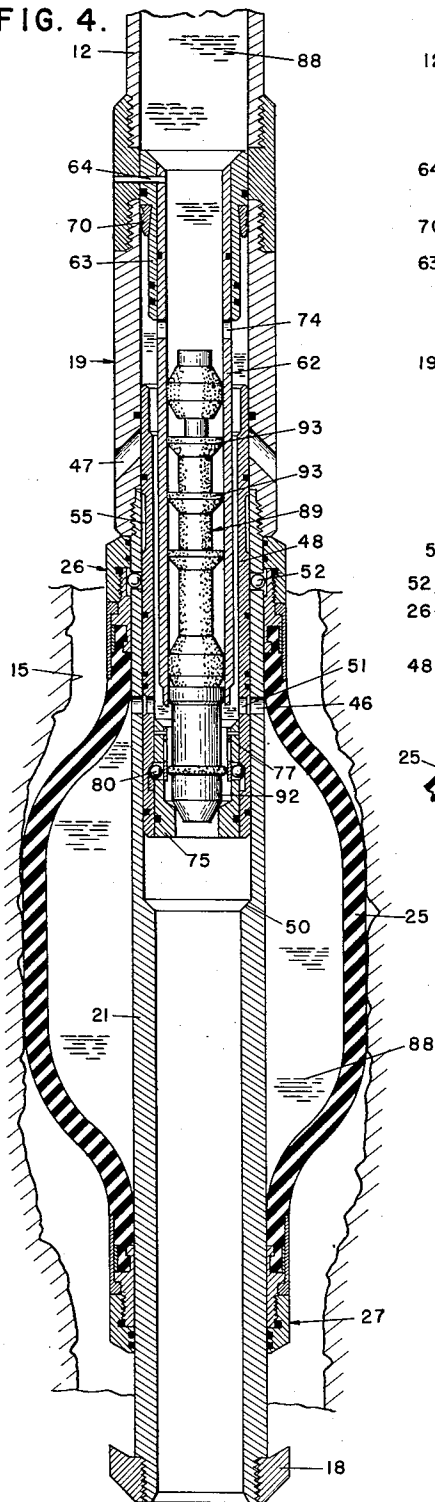


FIG. 5.

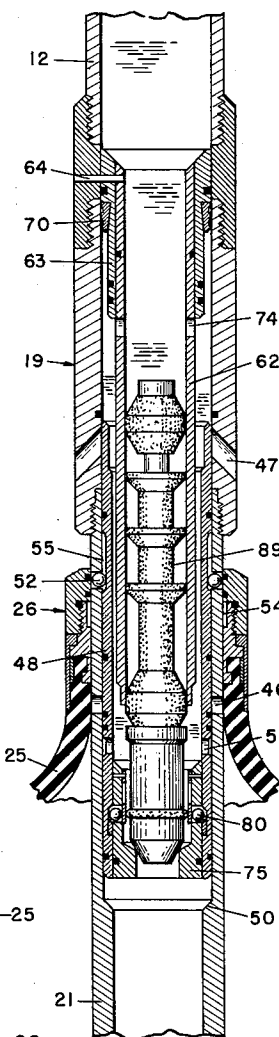
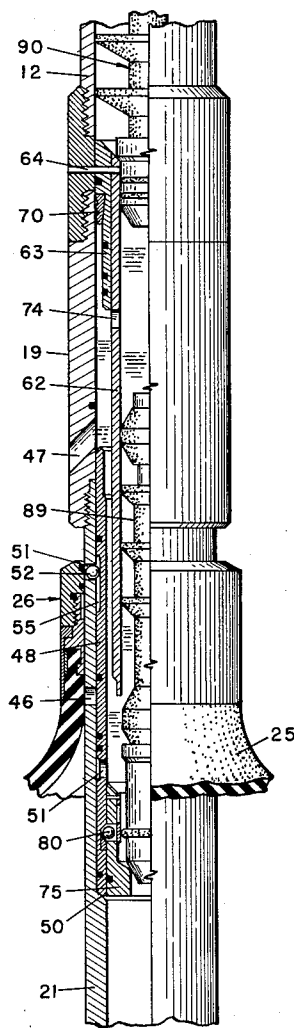


FIG. 6.



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3 Sheets-Sheet 3

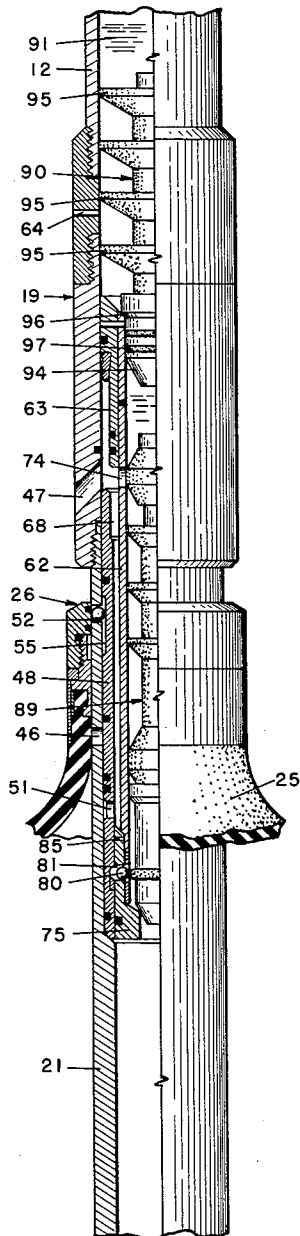


FIG. 7.

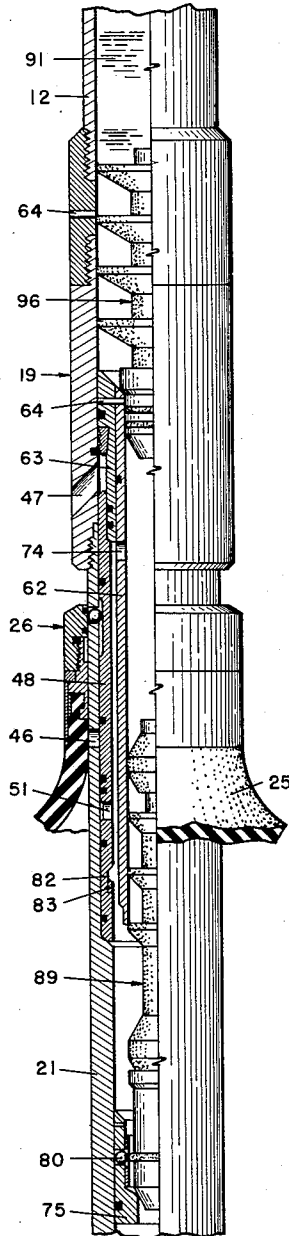


FIG. 8.

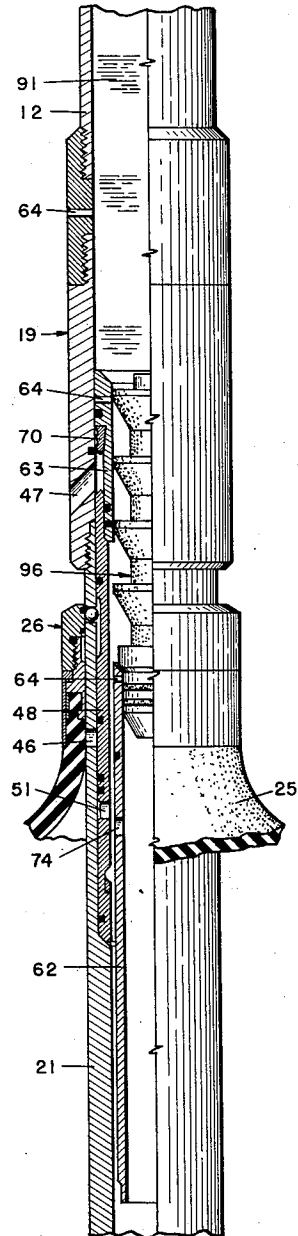


FIG. 9.

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1

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WELL PACKER

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7 Claims. (Cl. 166-187)

This invention relates to packers for use in oil and gas wells or the like. More particularly, the invention relates to a well packer which in unexpanded condition may be lowered into a well on a pipe or other conduit and then may be set or expanded to seal-off or bridge the annular space between the pipe or conduit and a surrounding wall surface in the well.

It is believed that the invention will be most widely applied in connection with the sealing-off or bridging of relatively large spaces in wells, such as where the surrounding wall surface is disposed a relatively great distance from the sealing surface on the packer when unexpanded. Also, particular advantages may be obtained where the packer is set or expanded against a discontinuous or irregular wall surface, such as in an uncased or open section of a bore hole, where difficulties have heretofore commonly been encountered using prior art arrangements. Further, the invention permits the provision of a packer which may be successfully used to effect a reliable seal under any of a variety of conditions, such as in well casings or bore holes of any of a variety of sizes or wherein any of a variety of temperature or pressure conditions are likely to prevail. As will appear more fully hereinafter, a packer in accordance with the invention is substantially more resistant to or less likely to be adversely affected by certain changing pressure conditions which have heretofore commonly interfered with the operation of prior art devices, such as by resulting in the application of forces tending to unseat or displace the packer from its desired sealing position in the well.

One object of the invention is to provide an improved well packer especially suited for use in an uncased or open section of a bore hole or where otherwise a reliable seal is to be effected with a surrounding wall surface which is relatively distant and/or irregular.

A further object of the invention is to provide an improved assembly for use in wells, the assembly including a hydraulically operable well packer and including provision permitting fluid, such as a cementitious or other treating or servicing fluid used to set or expand the packer, to be supplied to a space outside the assembly after the packer has been set or expanded in the well.

In one aspect thereof, the invention involves the concept of a well packer including an elongated packing element or sleeve encircling a tubular body or mandrel with respect to which one of the opposite end portions of the sleeve is initially movable and the other is initially fixed, such as by releasable latching means. Passage and valve means are provided for permitting the packer to be set or expanded by supplying preferably cementitious fluid to inflate the sleeve. During the inflation or expansion thereof, the sleeve in effect becomes foreshortened due to movement of its movable end portion along the mandrel as its intermediate portion moves radially outward. The packer also includes pressure-responsive means for closing a valve to confine fluid within the sleeve after inflation or expansion thereof and releasing a latch to permit the initially fixed end portion of the sleeve to move along the mandrel.

In a related aspect thereof, the invention involves the concept of an assembly including a well packer, as aforesaid, with an additional valve which is opened by the aforesaid pressure-responsive means to permit fluid, such as an additional or excess quantity of a cementitious or

2

other treating or servicing fluid used to inflate or expand the sleeve, to be supplied to a desired location, such as to the annular space extending upwardly around the pipe or conduit on which the assembly is lowered into the well. The assembly preferably also includes pressure-responsive means for subsequently closing the additional valve and for releasing a latch to permit the assembly to be readily cleared of obstructions, thus providing a preferably full-opening passageway through the assembly for use during subsequent operations performed in the well.

Novel features in the construction and arrangement of these and other parts of the well packer, together with the foregoing and additional objects and advantages of the invention, will become more apparent from the following description when read in connection with the accompanying drawing in which similar reference characters designate similar parts and wherein:

FIGURE 1 is a side elevational view of a portion of a string of well equipment positioned in an uncased or open bore hole, the string including a packer assembly in accordance with the invention, with the packer being shown in an unexpanded condition, such as during and immediately after the lowering thereof to a desired location in the well;

FIGURE 2 is a longitudinal cross-sectional view of the packer assembly of FIGURE 1, taken along the line 2-2 thereof;

FIGURE 3 is a transverse cross-sectional view of the packer assembly of FIGURE 1, taken along the line 3-3 thereof;

FIGURE 4 is a view similar to that of FIGURE 2, but showing the position of the assembly and its parts after the packing sleeve has been substantially fully inflated or expanded;

FIGURES 5 to 9 inclusive, are each fragmentary views similar to that of FIGURE 4, but showing the position of certain parts of the assembly at selected later stages in the operation thereof.

Referring first to the arrangement of FIGURE 1 of the drawing, an equipment string 10 is there shown positioned in a bore hole 11 after having been lowered to a desired depth therein. The string 10 includes a hollow drill pipe 12 which extends upwardly to the surface of the ground (not shown). A releasable connection or safety joint 13, which may be of conventional design, is shown connected between two adjacent sections of the drill pipe 12 a suitable distance above the lower end of the string 10.

The present invention is concerned with a well packer assembly 14 which is included as part of the string 10 and is shown positioned in the well at a desired location opposite a discontinuous or irregular wall surface 15 defining an enlarged, uncased section of the bore hole 11.

An interior passageway 16 extends lengthwise through the entire equipment string 10. One purpose of the passageway 16 is to provide means whereby certain substances and objects, as will appear more fully hereinafter, may be introduced into the well at the surface and then pumped or moved downwardly into the packer assembly 14.

It is understood that the packer assembly 14 is shown in the drawing and is hereinafter described, by way of example, with particular reference to its use where a cementitious fluid is among the substances introduced into the passageway 16, as aforesaid. However, as will appear more fully hereinafter, certain illustrated parts of the packer assembly 14 would not be needed, and may be omitted, where a cementitious fluid is not used or where otherwise the advantages arising from the inclusion of these parts are not to be obtained.

Referring now to FIGURES 1 and 2 together, the

packer assembly 14 is shown as including, at the upper end thereof, coupling means in the form of a hollow adapter 17 for threadedly or otherwise making connection with the adjacent or lower section of the drill pipe 12. At the lower end thereof, the assembly 14 is shown as including a hollow guide member or nut 18 which, if desired, may be replaced by suitable coupling means for making connection with apparatus included therebelow in the string 10.

Intermediate the adapter 17 and nut 18, the assembly 14 includes an elongated hollow, tubular body or mandrel 19 which may be made of several parts threadedly or otherwise connected together. As shown, the mandrel 19 includes an upper portion 20 which is screwed at its upper end into the adapter 17 and at its lower end onto a somewhat longer lower portion 21 of the mandrel 19.

It will be noted that the nut 18 is shown screwed onto the lower end of the mandrel 19 and provides thereon a lower fixed, upwardly facing abutment 22. An upper fixed, downwardly facing abutment 23 is shown provided on the mandrel 19 by the lower end surface of its upper portion 20.

The lower portion 21 of the mandrel 19 is encircled by an elongated packing element or sleeve 25 having each of its opposite end portions securely fastened to one of two shoes 26 and 27 which are mounted on the mandrel 19 between the aforesaid abutments 22 and 23. The shoes 26 and 27 encircle the mandrel 19 and are disposed in close but slidable relation thereto.

As illustrated, the top shoe 26 includes an upper portion 28 screwed onto the upper end of an inner portion 29 which is encircled by a downwardly extending skirt portion 30 having at its upper end an inwardly extending flange 31 shown fitted between the lower end of the upper portion 28 and an annular ridge 32 provided on the inner portion 29. Below the ridge 32 thereon, the inner portion 29 is provided with an annular recess 33 into which the upper end portion of the packing sleeve 25 is tightly compressed, such as by means of a clamping wire or band 34.

In a like but inverted arrangement, the bottom shoe 27 is shown as including a lower portion 35 screwed onto the lower end of an inner portion 36 which is encircled by an upwardly extending skirt portion 37 having at its lower end an inwardly extending flange 38 shown fitted between the upper end of the lower portion 35 and an annular ridge 39 provided on the inner portion 36. Above the ridge 39 thereon, the inner portion 36 is provided with an annular recess 40 into which the lower end portion of the packing sleeve 25 is tightly compressed, such as by means of a clamping wire or band 41.

Fluid sealing means is preferably provided between the mandrel 19 and each of the shoes 26 and 27, such as by means of O-type sealing rings 42 shown carried on the inner surface of the upper portion 28 of the top shoe 26 and by similar rings 43 shown similarly carried on the lower portion 35 of the bottom shoe 27. Also, sealing means is preferably provided between the screwed together parts of each of the shoes 26 and 27, such as by means of O-type sealing ring 44 shown disposed between the portions 28 and 29 of the top shoe 26 and by similar ring 45 shown disposed between the portions 35 and 36 of the bottom shoe 27.

The packing sleeve 25 is preferably made of a relatively thin, resilient and expansible material, such as rubber or the like, suitably reinforced particularly along the upper and lower portions thereof. For example, a multiplicity of longitudinally extending cords (not shown) made of nylon or other relatively strong material may be embedded in the sleeve 25. These cords may be arranged in several layers, with one or more layers extending substantially the length of the sleeve 25 and with the other layers being staggered so as to provide progressively greater reinforcement at successive locations approaching the ends of the sleeve 25.

The packing sleeve 25 is adapted to be hydraulically inflated or expanded by supplying fluid under pressure from the aforesaid passageway 16 into the interior space provided between the sleeve 25 and mandrel 19. To this end, initially open valve means including a lateral port 46 in the mandrel 19 is shown providing fluid communication between the passageway 16 and the upper interior portion of the packing sleeve 25.

During the inflation or expansion of the packing sleeve 25, the top shoe 26 is supported by releasable latching means in an initial upward position on the mandrel 19, as will appear more fully hereinafter. However, the bottom shoe 27 is freely slidable along the mandrel 19 and thus moves upwardly toward the initially fixed top shoe 26 as the intermediate portion of the packing sleeve 25 moves radially outward into engagement with the surrounding wall surface 15 (see FIGURE 4).

An important feature of the invention resides in the construction and arrangement whereby, after the packing sleeve 25 has been inflated or expanded, as aforesaid, the aforesaid initially open valve means is then closed to confine or entrap fluid so as to hold the sleeve 25 in set or expanded condition and, at approximately the same time, the aforesaid releasable latching means is operated to release the top shoe 26 for movement along the mandrel 19.

An additional important feature resides in the construction and arrangement whereby, at approximately the same time that the aforesaid initially open valve means closes and the aforesaid releasable latching means is operated, an initially closed, additional valve means including one or more lateral openings 47 in the upper portion 20 of the mandrel 19 is opened to provide fluid communication between the passageway 16 and the annular space located outside the packer assembly 14 above the packing sleeve 25. It is believed that this additional feature will provide particular advantages where the fluid in the passageway 16 is a cementitious or treating fluid which is to be utilized by conducting it into contact with the wall of the bore hole 11 extending upwardly from the set or expanded packing sleeve 25.

To these ends, a main control member 48 in the form of an elongated hollow, inner sleeve is shown closely but slidably fitted within the hollow mandrel 19. The main control member 48 is initially supported in an upward position within the mandrel 19 by yieldable means, such as by frangible pins 49 (see FIGURE 3) shown extending through the wall of the mandrel 19 and into the wall of the member 48. A fixed, upwardly facing abutment 50 is provided on the inner surface of the mandrel 19 for engaging the lower end of the main control member 48 to limit its relative downward movement therein.

It will be noted in FIGURE 2 that when the main control member 48 is in its initial or upward position, its lower end is disposed a suitable distance above the abutment 50 and its upper end is disposed above the lateral openings 47 in the mandrel 19. Also, it will be noted that, intermediate the ends thereof, the main control member 48 has lateral ports 51 which are initially in registry with the companion lateral ports 46 in the mandrel 19.

As shown best in FIGURES 2 and 3 together, the releasable latching means between the mandrel 19 and the top shoe 26 includes one or more latching balls 52 each of which is initially positioned partly within an aperture 53 provided in the wall of the mandrel 19 and partly within an inner annular recess 54 provided on the inner portion 29 of the top shoe 26.

It will be noted that the diameter of each of the balls 52 is somewhat greater than the depth of the aperture 53 in which it is positioned and that relative inward movement of the balls 52 along the apertures 53 is limited by the inwardly adjacent portion of the main control member 48. When in its initial or upward position (see FIGURE 2), the main control member 48 substantially prevents relative inward movement of the balls 52 along the apertures 53, with the result that the balls 52 then

5

always protrude sufficiently into the recess 54 to engage the top shoe 26 and limit or prevent relative movement thereof along the mandrel 19.

In order that the top shoe 26 may be released for relative sliding movement along the mandrel 19 after the packing sleeve 25 has been inflated or expanded, the main control member 48 is shown provided with an outer annular recess 55 which is alignable with but is initially disposed a suitable distance above the apertures 53 in the mandrel 19.

The arrangement is such that upon the main control member 48 being moved to its downward position, as will appear more fully hereinafter, its lateral ports 51 first move out of registry with the companion ports 46, then its annular recess 55 moves into continuing alignment with the apertures 53, and then its upper end moves below the lateral openings 47. The main control member 48 is held in its upper position by means of the frangible pins 49, and in this position the ports 46 and 51 are in registry while the openings 47 are closed, and the latching balls 52 are maintained in latching position to prevent longitudinal movement of the shoe 26. In its lower position, the main control member 48 rests on the upwardly facing shoulder 50 and in this second position the ports 46 and 51 are out of registry while the openings 47 are open, and the latching balls 52 are free to move into the annular recess 55 and thereby permit longitudinal movement of the shoe 26 on the mandrel 19.

Fluid sealing means are preferably provided between the mandrel 19 and the main control member 48 at locations such that seals are effected both above and below the ports 46 and 51 when aligned and also both above and below the port 46 in the mandrel 19 after the port 51 has moved downwardly out of alignment therewith. To these ends, O-type sealing rings 56, 57, 58 and 59 are shown carried by the control member 48 and suitably arranged thereon so that, when the ports 46 and 51 are aligned (see FIGURE 2), the ring 56 is therebelow and each of the rings 57, 58 and 59 is thereabove; however, when the control member 48 has been moved to its downward position wherein the ports 46 and 51 are not aligned (see FIGURE 6), the ring 59 is above them both, the rings 57 and 58 are between the two, and the ring 56 is below them both. Fluid sealing means is also preferably provided between the control member 48 and the mandrel 19 at locations such that seals are initially effected both above and below the lateral openings 47, such as by O-type sealing rings 60 and 61 shown carried by the member 48 and the mandrel 19, respectively.

The packer assembly 14 as described up to this point could be operated if a suitable seating surface were provided near the lower end of the main control member 48 for receiving a sealing ball or plug member or the like. Thus, the sealing member could be introduced into the passageway 16 ahead of a fluid which could be pumped downwardly therein and thence through the ports 46 and 51 to inflate or expand the packing sleeve 25. Thereafter sufficient fluid pressure could be built up in the passageway 16 above the sealing member to overcome the frangible pins 49 and move the main control member 48 to its downward position, whereupon additional fluid could be conducted into the bore hole 11 through the openings 47. If the fluid were cementitious, a drilling operation or the like would be necessary in order to subsequently clear the passageway 16 of obstructions.

However, the arrangement illustrated is particularly suited for use where it is desirable for the passageway 16 to be substantially cleared of obstructions without the necessity of performing an expensive or complicated operation. To this end, certain additional parts are preferably included in the packer assembly 14.

Among these additional parts, the assembly 14 is shown as including an elongated container or tubular

6

liner 62 which is initially disposed within the hollow mandrel 19 and as also including a collar member 63 which encircles the upper end portion of the container 62 and initially supports it in an upward position within the mandrel 19. The arrangement is such that the collar member 63 is yieldably mounted within the upper portion 20 of the mandrel 19 while the container 62 is yieldably mounted within and extends downwardly a suitable distance below the collar member 63. Yieldable connections between these parts are shown provided by a frangible pin 64 which extends through the walls of each of the mandrel 19, the collar member 63 and the elongated container 62.

Sealing means is preferably provided between the container 62 and the surrounding collar member 63, such as by O-type sealing ring 65. Also, sealing means is preferably provided between the collar member 63 and the surrounding part of the mandrel 19, such as by O-type sealing ring 66 shown carried by the member 63.

As illustrated, the collar member 63 is provided with a downwardly facing abutment 67 disposed below the sealing ring 66 mounted thereon. The portion of the collar member 63 below the abutment 67 is of reduced outside diameter and is adapted to be received, as will appear more fully hereinafter, within a counterbored or enlarged upper end portion 68 of the main control member 48. Means is preferably provided for then effecting a seal between the collar member 63 and the upper end portion 68 of the control member 48, such as by O-type sealing rings 69 shown carried by the collar member 63 on the reduced lower portion thereof.

Below the abutment 67 thereon, the collar member 63 is shown encircled by a slip member 70 having an inner tapered surface 71 which extends upwardly and inwardly thereof and is disposed adjacent a companion outer tapered surface 72 provided on the collar member 63. The slip member 70 is shown provided with external upwardly facing teeth 73 which are adapted to bitingly engage the mandrel 19 in such manner as to prevent relative upward but permit relative downward movement of the collar member 63 therein. It will be noted that the slip member 70 is in effect supported by the tapered surface 72 on the collar member 63 against relative downward movement thereon and is supported by the abutment 67 on such member 63 against relative upward movement thereon.

The elongated container 62 is shown extending downwardly into the main control member 48, the walls of the container 62 and member 48 being disposed in generally parallel spaced relation to each other. A suitable distance below the upper end thereof, the container 62 is provided with one or more lateral openings 74 providing fluid communication between the passageway 16 and the space between the container 62 and main control member 48.

A plug support or stop member 75 in the form of a hollow inner sleeve is shown closely but slidably fitted within the main control member 48 below the lateral ports 51 therein. The stop member 75 is suitably counterbored or enlarged from its upper end to provide an upwardly facing inner annular surface 76. Above the surface 76 is shown a latch control member 77 in the form of a hollow inner sleeve which is closely but slidably fitted within the enlarged or upstanding portion of the stop member 75.

Releasable latching means is provided between the main control member 48 and the stop member 75. This latching means includes one or more latching balls 80 each of which is initially positioned partly within an aperture 81 provided in the wall of the stop member 75 and partly within an inner annular recess 82 provided on the main control member 48.

As illustrated, the annular recess 82 extends downwardly along the inner surface of the main control member 48 a suitable distance below the portions of the balls

80 projecting thereinto. A ring 83 made of hard metal, such as steel or the like, is positioned within the lower portion of the recess 82 so as to provide a resistant surface below the projecting portions of the balls 80, for a purpose which will appear more fully hereinafter. Fluid sealing means is preferably provided between the main control member 48 and the stop member 75, such as by O-type sealing ring 84 shown carried by the member 75.

The latch control member 77 is initially supported in an upward position within the stop member 75 by yieldable means, such as by one or more frangible pins 85 shown extending through the walls of the members 75 and 77 near the upper ends thereof. When in such position, the latch control member 77 has its lower end disposed a suitable distance above the surface 76 but below the apertures 81 in which the balls 80 are mounted.

It will be noted that the diameter of each of the balls 80 is somewhat greater than the depth of the aperture 81 in which it is positioned, with the result that the inwardly adjacent latch control member 77 when in its initial or upward position prevents substantial relative inward movement of the balls 80 along the apertures 81. As a result, the balls 80 then always protrude sufficiently into the recess 82 to be engageable with the hard ring 83 therebelow and thereby limit or prevent at least relative downward movement of the stop member 75 within the main control member 48.

In order that the latching balls 80 may be released to permit the stop member 75 to be removed from the main control member 48, the latch control member 77 is shown provided with lateral openings 86 which are initially disposed a suitable distance above the apertures 81 containing the balls 80 but are adapted to move into registry with such apertures 81 upon the latch control member 77 being moved to its downward position within the stop member 75 (see FIGURE 7).

It will be noted in FIGURE 2 that the latch control member 77 is initially disposed a suitable distance directly below the container 62 mounted, as aforesaid, in the upper portion of the mandrel 19. Also, it will be noted that the container 62 has its lower end portion 87 of suitably reduced outside diameter to be received within the upstanding portion of the stop member 75. Thus, upon the container 62 being moved downwardly within the mandrel 19 and within the main control member 48, as will appear more fully hereinafter, its reduced lower end portion 87 engages the latch control member 77 and applies downward force thereto tending to overcome the frangible pins 85 initially interconnecting the members 75 and 77.

As shown best in FIGURES 4 to 9, inclusive, the operation of the complete packer assembly 14 involves introducing a quantity of fluid 88, which may be cementitious, into the passageway 16 between separating or sealing members, such as behind a bottom plug 89 and ahead of a top plug 90. These are followed by any suitable displacing liquid 91 (see FIGURE 7), such as water or oil, which upon being pumped into the upper end of the passageway 16 moves the plugs 89 and 90 and the interposed fluid 88 downwardly therein.

As illustrated, the bottom plug 89 includes a lower nose portion 92 made of metal or the like and an elongated upper portion carrying a series of annular sealing elements and wipers 93 made of rubber or the like.

Continued pumping of the displacing liquid 91 causes the bottom plug 89 to reach and move downwardly within the hollow container 62 and thence within the hollow stop member 75 therebelow until the nose portion 92 of the plug 89 engages and becomes seated on the inner annular surface 76, as shown in FIGURE 4. When thus seated, the bottom plug 89 effects a fluid-tight seal closing-off the passageway 16 at a location therein below the initially aligned ports 46 and 51.

The nose portion 92 of the plug 89 is preferably of suitable size and shape so that, when seated on the surface 76, as aforesaid, it extends upwardly therefrom into the

hollow container 62, as shown. It will be noted that the sealing elements and wipers 93 on the plug 89 are shown effecting seals at locations within the container 62 below the lateral openings 74 therein.

The arrangement is such that, after the bottom plug 89 has become seated, as aforesaid, the cementitious fluid 88 thereabove is permitted to pass through the lateral openings 74 into the space between the container 62 and main control member 48 and thence is caused to pass through the aligned ports 46 and 51 into the space between the mandrel 19 and packing sleeve 25. This results in the sleeve 25 being inflated or expanded due to entry of the cementitious fluid 88 thereinto as the pumping of the displacing liquid 91 continues.

As hereinbefore described, the bottom shoe 27 is freely slidable along the mandrel 19 while the releasable latching means between the mandrel 19 and top shoe 26 initially retains or supports the top shoe 26 in a fixed position thereon. As a result, the inflation or expansion of the packing sleeve 25 is accompanied by a foreshortening thereof occurring only at its lower end as its intermediate portion moves radially outward into engagement with the surrounding wall surface 15 (see FIGURE 4).

The inflation or expansion of the packing sleeve 25 continues, as aforesaid, until sufficient fluid pressure builds up above the seal effected within the stop member 75 by the bottom plug 89 to overcome the frangible pins 49 (see FIGURE 3) and move the main control member 48 downwardly within the mandrel 19. The pins 49 are preferably selected so as to be overcome after the packing sleeve 25 has been inflated or expanded into tight engagement with the surrounding wall surface 15.

It will be noted in FIGURE 5 that upon the main control member 48 moving downwardly sufficiently to move the ports 51 therein out of alignment with the ports 46 in the mandrel 19, further entry of cementitious fluid 88 into the packing sleeve 25 is prevented and the fluid 88 already therein is confined or entrapped to hold the sleeve 25 in an inflated or expanded position. At about the same time, the recess 55 on the main control member 48 moves into continuing alignment with the apertures 53, whereupon the latching balls 52 are permitted to move radially inward along the apertures 53 a sufficient distance so that they no longer protrude into the recess 54 provided on the top shoe 26. This results in unlocking the releasable latching means between the mandrel 19 and top shoe 26, whereupon the shoe 26 is then freely slidable along the mandrel 19.

The unlocking or releasing of the top shoe 26, as aforesaid, permits the packing sleeve 25 after being inflated or expanded to adjust itself and assume a more efficient disposition within the well. For example, if the fluid pressure in the annulus above the sleeve 25 is greater than that in the bore hole 11 below the sleeve 25, the top shoe 26 upon being unlocked or released will move downwardly somewhat along the mandrel 19, as shown in FIGURE 5, permitting the upper end portion of the sleeve 25 to move relatively toward the lower end portion thereof. This may actually result in moving the intermediate portion of the sleeve 25 into even tighter engagement with the surrounding wall surface 15. In any event, the greater pressure above the sleeve 25 is relieved somewhat and the likelihood of this pressure acting to move the intermediate portion of the sleeve 25 out of engagement with the wall surface 15 is reduced.

It will be noted that, in the arrangement shown, the abutment 23 provided on the mandrel 19 above the top shoe 26 limits its relative upward movement. If desired, the abutment 23 may be omitted or may be disposed a suitable distance above the initial fixed position of the shoe 26 to provide any desired upper limit to movement thereof along the mandrel 19.

As shown in FIGURE 6, the downward movement of the main control member 48, and also of the stop member 75 and bottom plug 89 supported therein, continues until the lower end of such member 48 engages the abutment

50 provided in the mandrel 19. At this time the upper end of the main control member 48 is disposed in the mandrel 19 below the lateral openings 47 which are thus open to permit the excess or additional cementitious fluid 88 in the passageway 16 to pass out of the packer assembly 14 into the annular space above the inflated or expanded packing sleeve 25.

The amount of excess or additional fluid 88 thus introduced into the space outside the assembly 14 will, of course, depend upon the requirements of the particular well operation involved. For example, where the main purpose of the excess or additional fluid 88 is to provide a cement plug supporting and providing an additional seal adjacent the packing sleeve 25, it may be necessary or desirable to include only enough excess or additional fluid 88 to allow filling of the annular space for a distance of only several feet above the sleeve 25. On the other hand, where a string of pipe or casing extending upwardly from the assembly 14 is to be cemented in place, it may be necessary or desirable to include many times as much excess or additional fluid 88. Also, the type of the cementitious fluid 88 may be varied in accordance with the needs of the particular operation. For example, a gypsum type cement with closely controllable, relatively rapid setting time may be used in one instance while ordinary Portland cement may be used in another instance. After substantially all of the excess or additional fluid 88 has passed through the lateral openings 47, as aforesaid, the top plug 90 will then have moved downwardly along the passageway 16 sufficiently to be received within the upper portion of the assembly 14, as shown in FIGURE 6.

As shown best in FIGURE 7, the top plug 90 includes a nose portion 94 made of metal or the like and an elongated upper portion carrying a series of sealing wipers 95 made of rubber or the like. On the nose portion 94 is a downwardly facing annular surface 96 which engages and becomes seated on the upper end surface of the container 62. Below the surface 96, the plug 90 carries O-type sealing rings 97 which engage and effect seals within the container 62 upon the nose portion 94 being received therein.

Continued pumping of the displacing liquid 91 after the top plug 90 has first become seated, as in FIGURE 6, causes fluid pressure to build up thereabove within the passageway 16. Upon this pressure becoming sufficient to overcome the portion of the frangible pin 64 initially interconnecting the collar member 63 and surrounding mandrel 19, such member 63 and the container 62 and top plug 90 supported therein move downwardly together, as shown in FIGURE 7. This results in the reduced lower end portion 87 of the container 62 being received within the upstanding portion of the stop member 75 where it engages and applies downward force against the latch control member 77, thereby overcoming the frangible pin 85 and moving such member 77 to its downward position within the stop member 75.

When in this position, the latch control member 77 has its lateral openings 86 aligned with the apertures 81 in the member 75, thereby permitting the latching balls 80 to move radially inward along the apertures 81 until they no longer protrude into the recess 82 provided on the main control member 48. This has the effect of unlocking the releasable latching means between the main control member 48 and stop member 75. Thereafter the stop member 75 and parts supported thereby are free to drop or be moved downwardly (see FIGURE 8) and thence out of the assembly 14. However, it is understood that the tightness of the seals still effected, such as by the wiper and sealing elements 93 of the bottom plug 89 in engagement with the container 62, may desirably be made sufficient to retain some or all of the thus released parts within the control member 48 until additional downward force is applied.

It will be noted in FIGURE 8 that the container 62

and surrounding collar member 63 continue to move downwardly together until the lower reduced end portion of such member 63 is received and comes to rest within the counterbored upper portion 68 of the main control member 48. When thus seated, the collar member 63 is disposed in the mandrel 19 inwardly of the lateral openings 47 and is effecting seals with the mandrel 19 and main control member 48 at locations such that the fluid 88 outside the assembly 14 is not permitted to reenter the passageway 16 through such openings 47.

For certain applications, it may be necessary or desirable to continue to provide a seal closing-off the portion of the passageway 16 within the packer assembly 14 for a period of time after the lateral openings 47 in the mandrel 19 have been closed-off by the collar member 63, as aforesaid. This may be done by interrupting the pumping of the displacing liquid 91 immediately after the collar member 63 has become seated within the main control member 48, whereupon the top plug 90 continues to provide a seal within the assembly 14, as shown in FIGURE 8.

However, it is anticipated that in many instances it will be desirable to clear the passageway 16 of obstructions as soon as possible after the lateral openings 47 in the mandrel 19 have been closed-off, particularly where the cementitious fluid 88 is of the quick-setting or gypsum type and the portion thereof passing through the openings 47 is primarily to effect a seal or provide a supporting cement plug above the inflated or expanded packing sleeve 25.

In any event, continued pumping of the displacing liquid 91 occurring after the collar member 63 has become seated within the main control member 48, as aforesaid, results in the building up of fluid pressure above the top plug 90 tending to overcome the portion of the frangible pin 64 interconnecting the container 62 and collar member 63. Upon this portion of the pin 64 being sheared, the container 62 and plug 90 are permitted to move downwardly (see FIGURE 9) and thence out of the assembly 14. Thereafter the passageway 16 has a substantially full-opening throughout its length, permitting subsequent operations to be conducted in the well without the necessity of first performing a drilling or other expensive and time-consuming operation to remove obstructions from the packer assembly 14.

While the invention has been described herein with particular reference to an illustrative embodiment thereof, various modifications and changes may be made without departing from the scope of the appended claims, which best define the invention.

What is claimed is:

1. A well packer comprising a tubular body, an elongated packing sleeve encircling said body, two shoes each disposed in close but slidable relation to said body and each secured to one of the opposite end portions of said sleeve, means including a lateral port in said body for supplying fluid under pressure to the space between said body and sleeve to inflate said sleeve, releasable latch means on the body preventing movement of one of said shoes along said body toward the other shoe, and a control member mounted within the body for movement between a first position permitting flow of fluid through said lateral port to a second position shutting off such flow, said control member having means operable in said first position to maintain said latch means against release and operable in said second position to release said latch means.

2. A well packer comprising a tubular body, having an axial fluid passageway and a lateral port therein, an elongated packing sleeve encircling said body, two shoes each disposed in close but slidable relation to said body and each secured to one of the opposite end portions of said sleeve, valve means communicating with said passageway for supplying fluid under pressure through the lateral port to the space between said body and sleeve to inflate

said sleeve, releasable latch means on the body holding one of said shoes against relative sliding movement along said body toward the other shoe, said valve means including a movable common control member mounted within said passageway for movement between a first position permitting flow of fluid through said lateral port to a second position shutting off such flow, said control member having means operable in said first position to maintain said latching means against release and operable in said second position to release said latching means.

3. For use with a pipe string in a well and a plug adapted to be pumped down the interior of the pipe string, a well packer assembly comprising in combination: a tubular mandrel adapted to be connected to the lower end of the pipe string, a flexible annular packer encircling a portion of the mandrel, the mandrel having lateral ports through the wall thereof communicating with the interior of the packer, a shoe fixed to the upper end of the packer and slidably mounted on the mandrel, latch means on the mandrel preventing relative downward movement of said shoe, a control sleeve slidably mounted within the interior of the mandrel and movable longitudinally from a first position to a second position, the control sleeve having lateral ports in the wall thereof aligned with said mandrel ports when the control sleeve is in said first position so that fluid under pressure from the pipe string may pass through the interior of the control sleeve and into the interior of the packer to expand the latter into contact with the wall of the well, frangible means holding said control sleeve in said first position with respect to said mandrel, means mounted on said control sleeve and provided with a seat for engagement by a plug pumped downward through the pipe string, fluid pressure above the plug when seated serving to break said frangible means to permit downward movement of the control sleeve within said mandrel to said second position thereby moving said ports out of registry, means whereby downward movement of said control sleeve acts to release said latch means, and ports in the wall of the mandrel above said latch means, the latter said ports being closed by the control sleeve in said first position and opened when said control sleeve is in said second position to permit fluid flow from the interior of the pipe string into the well above said packer.

4. For use with a pipe string in a well and a plug adapted to be pumped down the interior of the pipe string, a well packer assembly comprising in combination: a tubular mandrel adapted to be connected to the lower end of the pipe string, a flexible annular packer encircling a portion of the mandrel, the mandrel having lateral ports through the wall thereof communicating with the interior of the packer, an upper shoe fixed to the upper end of the packer, a lower shoe fixed to the lower end of the packer, said shoes each being slidably mounted on the mandrel, latch means on the mandrel preventing relative downward movement of said upper shoe, a control sleeve slidably mounted within the interior of the mandrel and movable longitudinally from a first position to a second position, the control sleeve having lateral ports in the wall thereof aligned with said mandrel ports when the control sleeve is in said first position so that fluid under pressure from the pipe string may pass through the interior of the control sleeve and into the interior of the packer to expand the latter into contact with the wall of the well, holding means holding said control sleeve in said first position with respect to said mandrel, means on said control sleeve provided with a seat for engagement by a plug pumped downward through the pipe string and into the interior of the mandrel, fluid pressure above the plug when seated serving to overcome said holding means and move the control sleeve to said second position thereby moving said ports out of registry, means whereby downward movement of said control sleeve acts to release said latch means, ports in the wall of the mandrel

above said latch means, said ports being closed by the control sleeve in said first position and open when said control sleeve is in said second position to permit fluid flow from the interior of the pipe string into the well above said packer.

5. For use with a pipe string in a well and a plug adapted to be pumped down the interior of the pipe string, a well packer assembly comprising in combination: a tubular mandrel adapted to be connected to the lower end of the pipe string, a flexible annular packer encircling a portion of the mandrel, the mandrel having lateral ports through the wall thereof communicating with the interior of the packer, a control sleeve slidably mounted within the interior of the mandrel and movable longitudinally from a first position to a second position, the control sleeve having lateral ports in the wall thereof aligned with said mandrel ports when the control sleeve is in said first position so that fluid under pressure from the pipe string may pass through the interior of the control sleeve and into the interior of the packer to expand the latter into contact with the wall of the well, means holding said control sleeve in said first position with respect to said mandrel, means mounted on said control sleeve and provided with a seat for engagement by a plug pumped downward through the pipe string, fluid pressure above the plug when seated serving to overcome said holding means to permit downward movement of the control sleeve within said mandrel to said second position thereby moving said ports out of registry, and ports in the wall of the mandrel above said packer, the latter said ports being closed by the control sleeve in said first position and opened when said control sleeve is in said second position to permit fluid flow from the interior of the pipe string into the well above said packer.

6. For use with a pipe string in a well and a plug adapted to be pumped down the interior of the pipe string, a well packer assembly comprising in combination: a tubular mandrel adapted to be connected to the lower end of the pipe string and provided with an internal upward facing shoulder, a flexible annular packer encircling a portion of the mandrel, the mandrel having lateral ports through the wall thereof communicating with the interior of the packer, a control sleeve slidably mounted within the interior of the mandrel and movable longitudinally from a first position to a second position, the control sleeve having lateral ports in the wall thereof aligned with said mandrel ports when the control sleeve is in said first position so that fluid under pressure from the pipe string may pass through the interior of the control sleeve and into the interior of the packer to expand the latter into contact with the wall of the well, frangible means holding said control sleeve in said first position with respect to said mandrel, the control sleeve engaging said mandrel shoulder in said second position, a seat member mounted on said control sleeve and provided with a seat for engagement by a plug pumped downward through the pipe string and into the interior of the mandrel and control sleeve, fluid pressure above the plug when seated serving to break said frangible means and move the control sleeve to said second position thereby moving said ports out of registry, and ports in the wall of the mandrel above said packer, the latter said ports being closed by the control sleeve in said first position and open when said control sleeve is in said second position to permit fluid flow from the interior of the pipe string into the well above said packer.

7. For use with a pipe string in a well and a pair of plugs adapted to be pumped down the interior of the pipe string, a well packer assembly comprising in combination: a tubular mandrel adapted to be connected to the lower end of the pipe string and provided with an internal upward facing shoulder, a flexible annular packer encircling a portion of the mandrel, the mandrel having lateral ports through the wall thereof communicating with the interior of the packer, a control sleeve slidably

13

mounted within the interior of the mandrel and movable longitudinally from a first position to a second position, the control sleeve having lateral ports in the wall thereof aligned with said mandrel ports when the control sleeve is in said first position so that fluid under pressure from the pipe string may pass through the interior of the control sleeve and into the interior of the packer to expand the latter into contact with the wall of the well, first frangible means holding said control sleeve in said first position with respect to said mandrel, the control sleeve engaging said mandrel shoulder in said second position, a tubular liner positioned within the mandrel and extending into the control sleeve, second frangible means connecting the liner to the mandrel, a seat member mounted on said control sleeve and provided with a seat for engagement by a first plug pumped downward through the pipe string and into the interior of the tubular liner, fluid pressure above said plug when seated serving to break the first said frangible means and move the control sleeve to said second position thereby moving said

14

ports out of registry, ports in the wall of the mandrel above said latch means, said ports being closed by the control sleeve in said first position and opened when said control sleeve is in said second position to permit fluid flow from the interior of the pipe string into the well above said packer, the tubular liner having a shoulder adapted to be engaged by a second plug pumped downward through the pipe string to break said second frangible means and move said tubular liner longitudinally, and interengaging means on the seat member and control sleeve actuated by engagement by the tubular liner therewith for releasing the seat member from the control sleeve.

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