

July 26, 1960

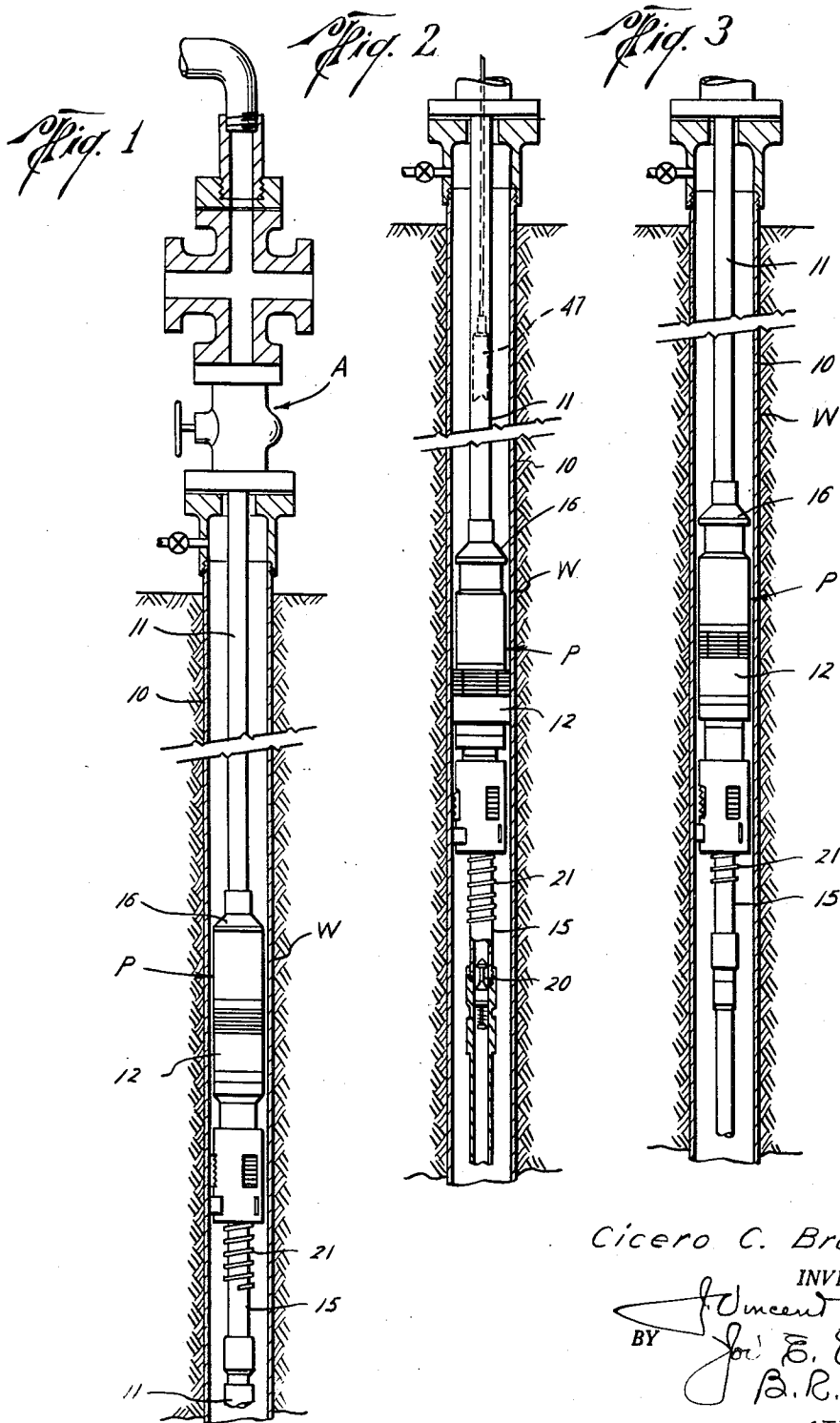
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WELL COMPLETION AND WELL PACKER APPARATUS AND METHOD

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4 Sheets-Sheet 1



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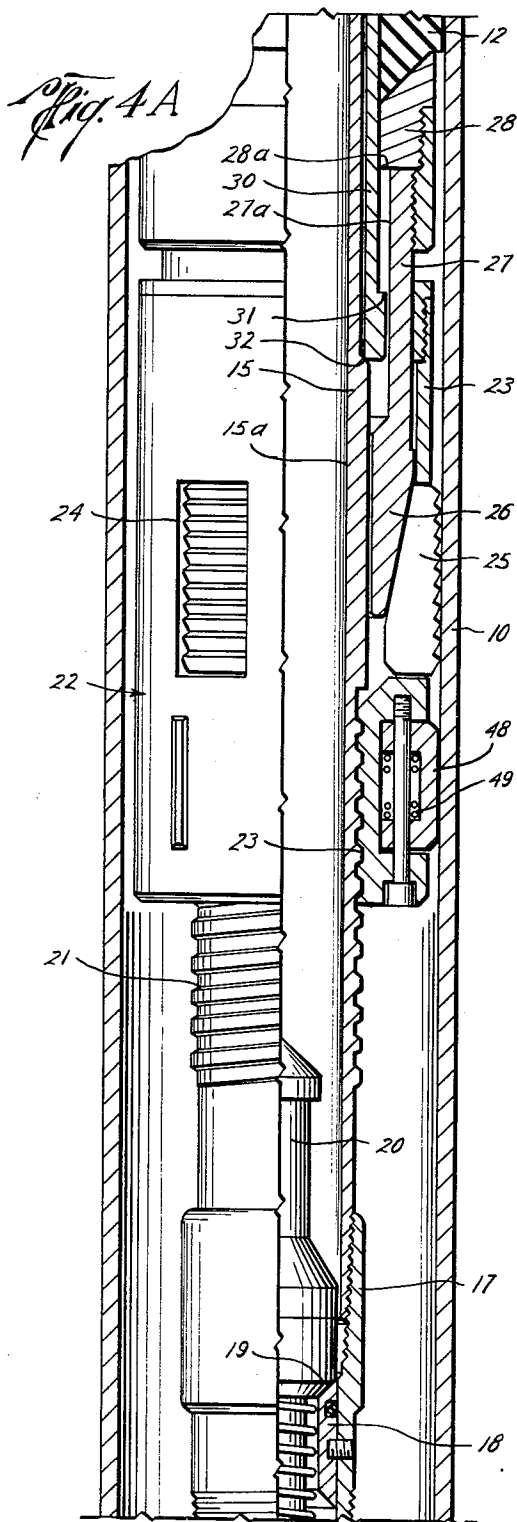
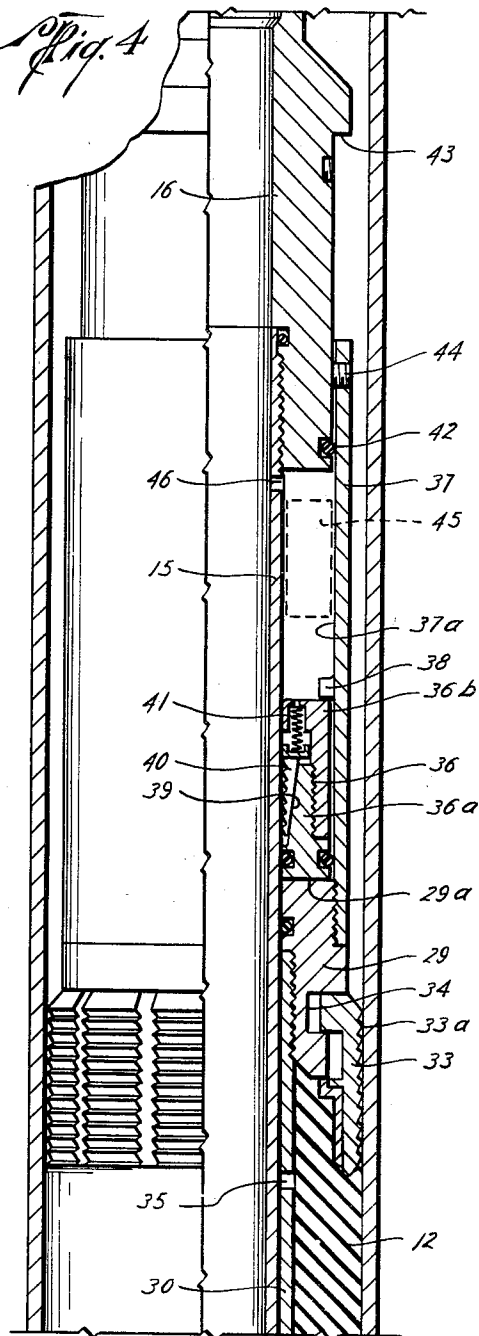
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WELL COMPLETION AND WELL PACKER APPARATUS AND METHOD

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4 Sheets-Sheet 2



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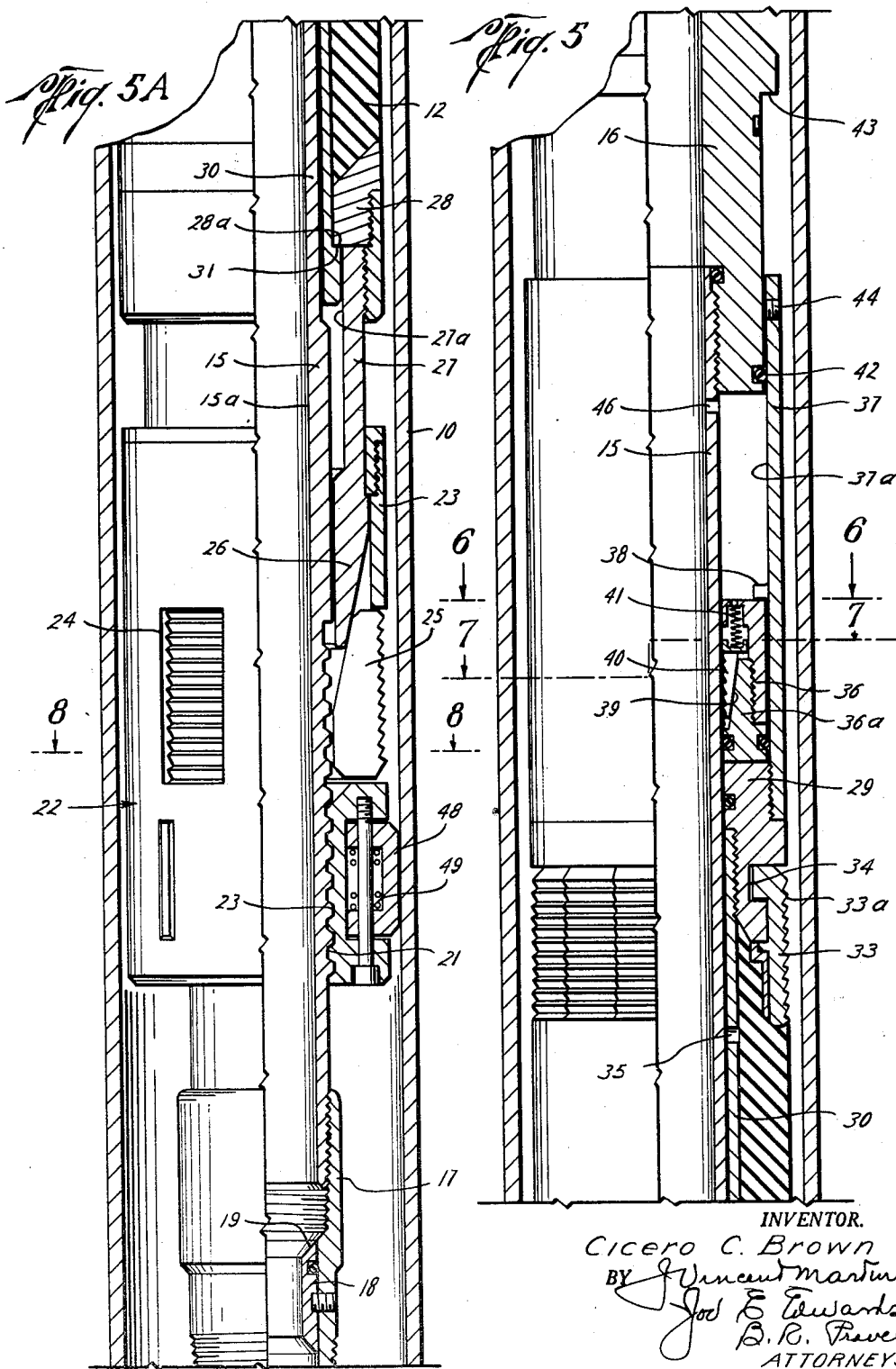
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WELL COMPLETION AND WELL PACKER APPARATUS AND METHOD

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4 Sheets-Sheet 3



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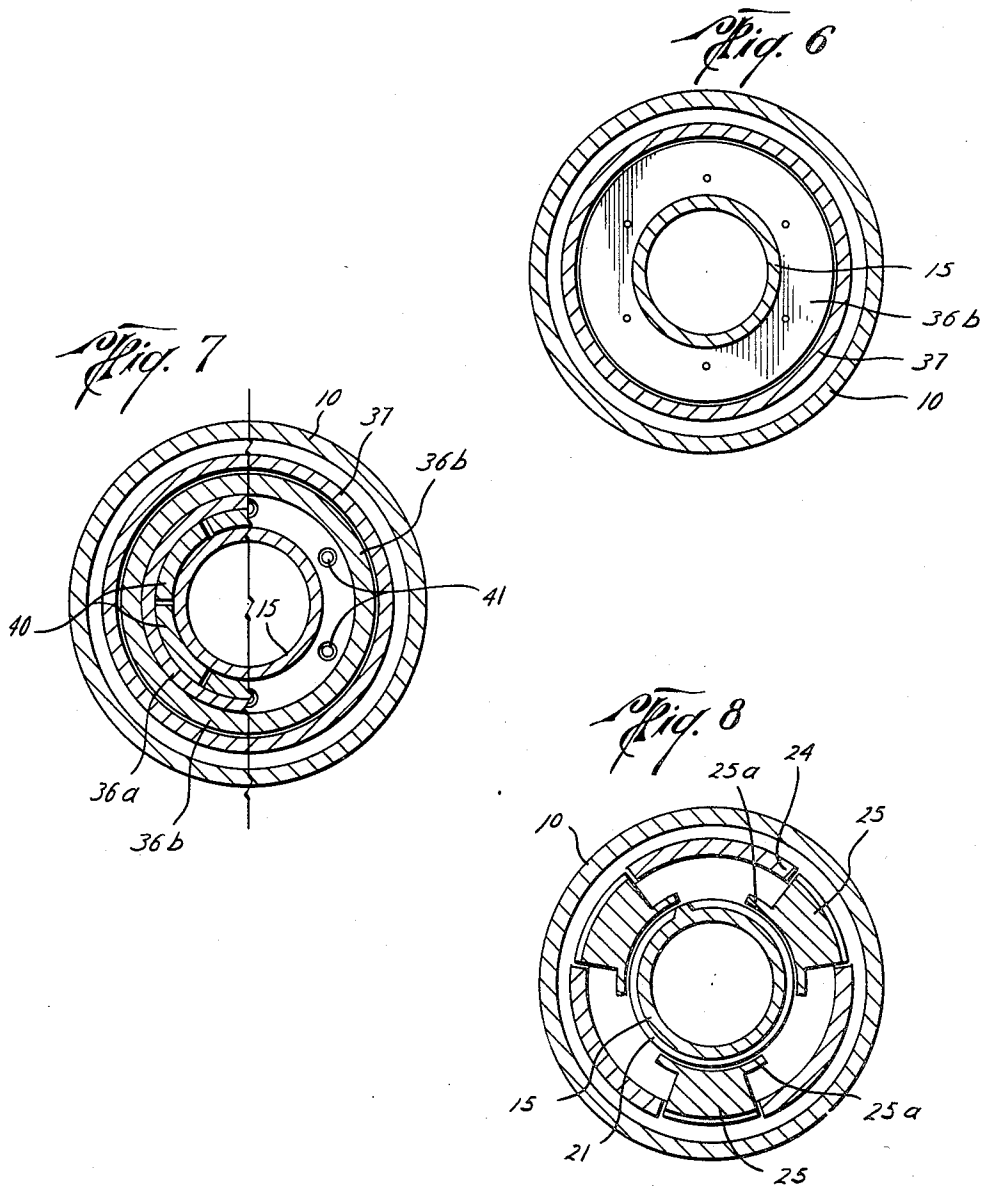
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WELL COMPLETION AND WELL PACKER APPARATUS AND METHOD

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4 Sheets-Sheet 4



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2,946,384

WELL COMPLETION AND WELL PACKER APPARATUS AND METHOD

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11 Claims. (Cl. 166—46)

This invention relates to new and useful improvements in well completion apparatus and relates particularly to improvements in well packer assemblies.

One object of the invention is to provide an improved well completion apparatus including a well packer assembly which packer assembly is adapted to be lowered into a well bore on the usual tubing or pipe string and thereafter set within the well bore without any longitudinal, rotative or other movement of the tubing, whereby the tubing may be properly positioned and supported in its final position in the well head assembly prior to setting of the packer.

An important object is to provide an improved well packer assembly or apparatus wherein the tubing or pipe on which the packer apparatus is lowered may be attached to or suspended from the well head before the packer is set so that circulation of fluid for any desired purpose downwardly through and around the unset packer may be accomplished after the tubing or pipe has been mounted in final position with respect to the well head assembly; said packer apparatus being so constructed that it may be set at any desired time by the application of fluid pressure and without disturbing the tubing or the well head assembly from which said tubing is suspended.

Another object is to provide a well packer apparatus which is moved to its set or packing position by the application of hydraulic fluid pressure and which is released from such set position by a manipulation of the pipe string on which it is mounted.

A further object is to provide a well packer, of the character described, having a normally open passage there-through which passage is selectively closed when it is desired to set the packer, whereby hydraulic pressure fluid conducted to the passage will be directed to the operating parts of said packer to effect the setting thereof; said passage being adapted to be closed by a removable plug or valve element which may be dropped or pumped downwardly through the pipe on which said apparatus is mounted.

A further object is to provide a well packer which is movable to a set position by hydraulic fluid pressure and which includes means for locking said packer in its set position; release of the locking means and unsetting of the packer being accomplished by a rotation of the tubing or pipe string on which the packer is disposed.

The construction designed to carry out the invention will be hereinafter described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown and wherein:

Figure 1 is a longitudinal sectional view of a well bore showing a well packer apparatus, constructed in accordance with the invention, mounted on a tubing string which is suspended in its final position from a well head assembly, the packer apparatus being in an inset position;

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Figure 2 is a similar view illustrating the packer apparatus in its set position;

Figure 3 is a similar view showing the packer apparatus released by manipulation of the tubing string;

Figures 4 and 4A are enlarged longitudinal, sectional views of the well packer apparatus illustrating the various parts thereof in their respective positions when the packer is set;

Figures 5 and 5A are views similar to Figures 4 and 4A, showing the various parts of the apparatus in the positions which such parts assume when the packer is released;

Figure 6 is a horizontal, cross-sectional view, taken on the line 6—6 of Figure 5;

Figure 7 is a horizontal, cross-sectional view, taken on the line 7—7 of Figure 5 and

Figure 8 is a horizontal, cross-sectional view, taken on the line 8—8 of Figure 5A.

In the drawings (Figures 1 to 3) the numeral 10 designates the usual well casing which extends downwardly through a well bore W. A well tubing 11 extends downwardly through the well casing in the usual manner and is suitably supported in a well head assembly which is generally indicated by the letter A. The well head assembly may be the usual Christmas tree or other control manifold and the well tubing 11 may be mounted thereon or therein in any suitable manner well known in the art. The improved well packer apparatus which constitutes the present invention is generally indicated by the letter P and is connected in the well tubing string 11.

In Figure 1 the well packer apparatus is shown in position within the well casing 10, with the tubing 11 in its final suspended position in the well head assembly A. The well packer apparatus P has an annular elastic packing element 12, which is shown in Figure 1 as being in an unset position, that is, the packing element is not in sealing engagement with the wall of the well casing 10. With the packer in this unset position but with the well tubing 11 in its finally suspended position, it is possible to circulate fluids downwardly through the well tubing, through the well packer apparatus P, and such fluids may then return upwardly through the annulus between the casing and the tubing. Any suitable operation which would require the circulation of fluid may be performed.

As will be explained, the packing element 12 of the well packer apparatus P, may be moved to a sealing or set position, as illustrated in Figure 2, without imparting any movement to the well tubing 11. When actuated and moved to a set position, it is evident that the packing element 12 will seal off the annular space between the well tubing and the well casing. Since no movement, either longitudinal, rotative or other movement of the tubing 11 is necessary in order to effect the setting of the packing element 12 of the well packer apparatus P, it is evident that the well tubing may be mounted in its final suspended position with respect to the well head assembly A prior to the time that the packer is set. Thus, the well tubing is finally positioned, after which any desired fluid circulation may be carried out through the well and then subsequently a setting of the packer P may be effected.

When it is desired to remove the packer, which would be at a time when the tubing string 11 is to be pulled from the well, the packing element 12 may be retracted and the packer apparatus P released by a rotation of the tubing string 11. This release, as well as the setting of the packer, will be hereinafter described in detail. Figure 3 illustrates the apparatus P in an unset position to which it has been removed by a rotation of the tubing string 11.

Figures 4, 4A, 5 and 5A illustrate the details of the

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well packer apparatus P, with Figures 4 and 4A showing the packet in its set position, and Figures 5 and 5A illustrating said packer with its parts in the position they assume after the packer has been released by a rotation of the tubing string or other conductor on which the packer is mounted. Referring to Figures 4 and 4A, the apparatus comprises a central support or mandrel 15 which has an axial bore 15a extending entirely therethrough. The upper end of the mandrel is connected to the lower end of a coupling 16 which has its upper end attached to the tubing string 11; the lower end of the mandrel (Figure 4A) is threaded to a coupling 17 which has its lower end attached to the tubing string. It is thus evident that the main support or mandrel of the well packer apparatus A is directly connected in the tubing string and has its bore 15a communicating with the bore of said string. The coupling 17 at the lower end of the mandrel has an annular seat 18 mounted within its bore and the upper beveled surface 19 forms a seating surface for a plug or valve member 20 which, as will be explained, is adapted to be dropped or lowered into position to the well tubing when it is desired to set the packer.

Above the coupling 17 the mandrel 15 is formed with a series of relatively coarse threads 21, which are preferably left-hand threads, and a tubular slip carrier support means 22 surrounds the mandrel and has the lower portion of its bore formed with threads 23 which interengage with the threads 21 whereby the slip carrier is attached to and supported by the mandrel. The slip carrier construction is clearly shown in Figure 4A and includes an outer housing 24 having elongate slots or openings 24a extending through its wall. Gripping slips 25 are mounted to move radially within the openings 24a and radial outward movement of each slip member is limited by flanges 25a formed on each slip member. The slips are adapted to be expanded by an expander or cone 26, which is movable downwardly between the slip members. The slip expander or cone 26 is formed at the lower end of a tubular body 27, which body extends upwardly above the slip carrier housing 24 and is attached to the lower end of the base rings 28 of the packing element 12. It is thus evident that the packing element 12 will be supported by the body 27 and expander cone 26 when said cone is, in turn, supported upon the gripping slips 25 which are adapted to move outwardly into pipe gripping engagement with the well casing 10.

The upper end of the annular elastic packing element 12 is confined by an upper coupling member or collar 29 and the upper portion 29a of the bore of this collar is slidable upon the upper surface of the mandrel 15. An inner sleeve 30 also surrounds the mandrel 15 and has its upper end secured to the collar 29; this inner sleeve extends downwardly through the bore of the elastic packing element 12 and has its lower end projecting into the bore 27a of the body 27 which carries the expander cone 26. As is clearly shown in Figure 4A, the lower end of the inner sleeve 30 has an enlargement thereon which forms an upper shoulder 31 and this shoulder is adapted under certain conditions to engage the underside 28a of the base ring of the packing element; the lower end of the enlargement is engageable with an external shoulder 32 which is formed on the mandrel 15. Sliding movement of the sleeve 30 with respect to the packing element and mandrel is therefore limited by the distance between the shoulder 32 on the mandrel and the underside 28a of the base ring 28. If desired, the upper portion of the packing element 12 may be formed with external gripping elements 33 which have their lower portions embedded in the elastic material of the packing element 12. The gripping elements 33 may undergo limited radial movement which is effected by the inter-engagement of the upper portion of each element with an annular groove 34 formed in the external surface of the coupling 29. The gripping elements are formed with teeth 33a on their outer surfaces and said teeth are engageable with the wall

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of the casing when the packing element 12 is distorted into sealing position; when in gripping engagement with the well casing the gripping elements prevent an upward movement of the elastic packing element 12 after said element has been moved to a set position. However, as pointed out, the gripping elements 33 are not essential and may be omitted.

When the gripping slips 25 of the slip assembly are engaged with the wall of the well casing, the expander or cone 26 is supported by the slips and through the body portion 27, said expander supports the lower end of the packer element 12. With the lower end of the element 12 supported, the application of a downward force to the upper surface 29a of the coupling 29 will cause a downward movement of the coupling and a downward sliding movement of the inner sleeve 30; such movement of the coupling member 29 will apply a downwardly directed endwise force to the packing element 12 and will distort or expand the same into sealing engagement with the inner wall of the well casing 10. For the purpose of equalizing pressures exteriorly of and interiorly of the packing element 12, when said packing element is in its unset position, the inner sleeve 30 is formed with an equalizing port 35 which extends through its wall and which establishes communication between the bore of the packing element 12 and the area exteriorly of said element.

For applying a downward force to the coupling 29 on the upper end of the packing element 12 which downward force will be initially transmitted to the slip expander to move the expander downwardly relative to the gripping slips 25 and thereby effect a radially outward movement of said slips, an annular piston 36 (Figure 4) surrounds the mandrel 15 above said coupling. The piston is disposed within the bore 37a of an outer sleeve or cylinder 37 which has its lower end secured to the coupling 29 and which has its upper end slidably surrounding the exterior surface of the coupling 16 which connects the mandrel 15 to the tubing. A suitable sealing ring 42 seals off between the bore of the outer sleeve and the exterior of the coupling. The piston 36 is restricted against upward movement within the bore 37a of the outer sleeve 37 by an inwardly projecting flange 38 which engages the upper end of said piston while the lower end of the piston is in engagement with the upper surface 29a of the coupling 29. When the piston is urged downwardly by a pressure from above, a downward force is applied to the coupling 29 and such force is transmitted directly to the upper end of the packing element 12.

The annular piston 36 is constructed of a lower section 36a and an upper section 36b (Figure 4) and said lower section is provided with an inclined expander surface 39. Gripping slips 40 are carried by the upper section of the piston and said slips are adapted to be engaged with the outer surface of the mandrel 15; the teeth of the slips are disposed in a direction to lock the piston against upward movement relative to the mandrel. Coil springs 41 constantly urge the slips downwardly with respect to the expanding surface 39. When in engaged position, the slips 40 function to prevent a reverse or upward movement of the piston 36 relative to the mandrel and therefore after the piston has been moved downwardly along the mandrel, in order to apply a force to the packing element, the gripping slips 40 will prevent the piston from moving upwardly on the mandrel and will thereby lock the packing element in its expanded or sealing position.

When the apparatus is in an unset position, the upper end of the outer sleeve cylinder 37 is abutting an external shoulder 43 formed on said coupling, and if desired, a suitable shear pin 44 may releasably connect the outer sleeve 37 to the coupling 16 to maintain the outer sleeve in its raised position with respect to said coupling and also with respect to the mandrel. Obviously, since the piston 36 is confined within the outer sleeve 37, said piston will

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be in the position indicated in the dotted lines 45 (Figure 4) when the outer sleeve is raised with respect to the coupling and mandrel. With the piston in such position the coupling 29 at the upper end of the packing element is adjacent the lower end of said piston 36 and the packing element is in a normal undistorted position in non-sealing engagement with the wall of the well casing. Also at this time, the gripping slips 25 are in retracted position and are held so by the engagement of the enlargement at the lower end of the inner sleeve 30 with the underside 28a of the base ring 28 of the packing element.

For applying a pressure to the upper surface of the piston 36, in order to move said piston downwardly and thereby apply an endwise pressure to the packing element 12, the mandrel is formed with a pressure inlet port 46, which communicates with the area within the bore 37a of the outer sleeve 37 just below the lower end of the coupling 16. When the plug 20 is dropped or lowered through the mandrel and is engaged with the seat 19 at the lower end thereof, pressure which is applied through the tubing string 11 will act through the port 46 and against the upper end of the piston 36 to apply a downward force to the piston. The mandrel is of course stationary because it is secured to the tubing string and since the slip carrier 22 is mounted on the mandrel through the threads 23, the slips 25 are also stationary. Thus, when the piston 36 moves downwardly from the dotted line position 45, shown in Figure 4, to the full line position, the upper coupling of the packing element 12 is moved downwardly and also the outer sleeve 37, as well as the inner sleeve 30, are moved downwardly. Downward movement of the inner sleeve moves the shoulder 31 away from the base ring 28 of the packing element 12 and therefore the force which is applied to the upper end of the packing element 12 is transmitted downwardly through the packing element to the slip expanding cone. As the cone 26 moves downwardly with respect to the slips 25, said slips are expanded radially outwardly into gripping position with the well casing 10 and thereafter continued application of fluid pressure to the piston 36 will result in the packing element 12 being expanded into its sealing position as shown in Figures 4 and 4A.

As the piston 36 is moved downwardly along the mandrel 15, any tendency of the piston to be moved upwardly with respect to the mandrel is resisted by the gripping slips 40 and thus after the packing element has been set in its sealing position, the hydraulic fluid pressure acting against the piston 36 may be removed and the packing element will remain in its set position. If the gripping members 33 are employed at the upper end of the packing element, these gripping members will assist in preventing the packing element from returning to its normal non-sealing position. However, it is noted that the gripping slips 40 which are carried by the piston 36 perform the primary function of preventing the packing element from returning to a non-sealing position when fluid pressure is removed from the upper end of the piston.

In the operation of the apparatus, said apparatus is connected in the well tubing string with the outer sleeve 37 in its raised position with respect to the mandrel 15 and with the piston 36 in the position shown in dotted lines 45 in Figure 4. In such position there is no endwise force on the packing element 12 and the same is in its normal or retracted position. The inner sleeve 30, which is attached to the upper coupling 29 of the packing element, is supporting the body 27 of the slip expander 26 and said slip expander is in a raised position with respect to the gripping slips 25 of the slip carrier 22.

After the tubing is lowered to its final position in the well bore it is landed or supported in any desired manner in a suitable well head assembly A. Such assembly is the final control assembly which will control the production from the well after the same is "brought in." At this time the plug 20 is not within the bore of the mandrel 15, so that the tubing string is completely open; therefore,

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after the tubing is finally positioned in the control equipment, the packer is still not set so that any operation which involves the circulation of fluid downwardly through the tubing and upwardly through the annulus may be carried out. Of course, it is obvious that circulation could be in a reverse direction and so long as the packing element 12 is in non-sealing engagement any type of fluid circulation may be carried out.

When it is desired to set the packer, it is only necessary to lower the plug 20 into position, and this may be done by either dropping or pumping said plug or lowering the plug on a suitable line downwardly through the tubing and mandrel until it engages the seat 19; whereby the bore of the mandrel is closed at its lower end.

With the plug 20 in position closing the lower end of the bore of the mandrel 15, a hydraulic fluid pressure may be applied through the tubing string and such pressure will act through the port 46 to apply a downward force to the piston 36. As explained, the piston 36 is initially in the position shown in dotted lines 45, with the outer sleeve or cylinder 37 being raised with respect to the mandrel and coupling 16, and the inner sleeve 30 being raised relative to the packing element. If the shear pin 44 has been employed, the application of fluid pressure to the piston will first shear this pin and then cause a downward movement of the piston together with the outer sleeve or cylinder and the inner sleeve 30 relative to the mandrel. The mandrel 15, being attached to the well tubing, is stationary at this time and since the slip carrier 22 which supports the slips is secured to the mandrel through the threads 21 and 23, the slips 25 are held stationary. The downward movement of the inner sleeve 30, together with the application of an endwise force to the upper end of the packing element 12 will force the slip expander 26 downwardly between the slips 25, which will thereby be moved outwardly into pipe-gripping engagement with the well casing 10. Thereafter continued application of fluid pressure will expand or distort the packing element 12 into its sealing position. As has been explained, any upward movement of the piston 36 along the outer surface of the mandrel is prevented by the gripping slips 40, which are carried by the piston and said piston 36 is locked against return to its original position with respect to the mandrel. The slips 40 mounted on the piston thus prevent the packing element 12 from returning to a normal, non-sealing position, even though the application of fluid pressure is discontinued. After the fluid pressure has been relieved following setting of the packer, the plug or closure 20 may then be removed by any suitable wire line retrieving tool, such as is indicated in dotted lines 47 in Figure 2, and upon removal of this plug or closure the tubing bore is again open for free flow therethrough. The packer will of course remain set so long as production through the tubing is maintained.

When it is desired to remove the packer, which would be at a time when the well tubing 11 is to be withdrawn from the casing, it is only necessary to impart a rotation, preferably in a right-hand direction, to the tubing string. The slip carrier 22, which has the gripping slips 25 secured thereto, is held stationary because of the engagement of the slips with the wall of the casing, and a rotation of the tubing imparts a rotation to the mandrel 15 thereby causing the mandrel to travel upwardly with respect to the slip carrier 22. If desired, a suitable friction shoe 48 may be mounted in the lower portion of the slip carrier to assist in preventing rotation of said carrier; the friction shoe to be provided with a sharp, longitudinal edge which is urged into engagement with the wall of the casing by a suitable spring 49. As the tubing rotation is continued, the mandrel travels upwardly with respect to the slip carrier and results in an upward movement of the piston 36, which is attached to the mandrel through the gripping slips 40. This upward movement of the mandrel and piston 36 will result

in first relieving the applied force which is acting upon the packing element and to thereafter withdraw the expander cone from the slips 25. Of course, the outer sleeve or cylinder 37 and inner sleeve 30, being connected with piston 36, also move upwardly with respect to the packing element 12 and the slip expander cone 26, and when the upward movement of the mandrel, piston and inner sleeve is sufficient to engage the shoulder 31 at the lower end of the inner sleeve 30 with the base ring 28 of the packing element, all endwise force which was previously applied to the packing element has been removed. Thereafter the inner sleeve 30 through its shoulder 31 engaging the base ring 28 will function to apply a lifting force to the body 27 of the slip expander, and the slip expander will thus be withdrawn from between the slips 25 whereby said slips may move radially inwardly and out of engagement with the wall of the well casing. It is evident that subsequent lifting of the tubing will remove the device from the well casing.

Although the gripping slips 25 have been found satisfactory, it is pointed out that such slips could be eliminated. In such event, the inner sleeve 30 would also be omitted, and the base ring 28 would be directly supported upon the body 24 of the slip carrier.

From the foregoing it will be seen that a simple and efficient well packer apparatus is provided. The device is set hydraulically at any predetermined time, it being only necessary to lower the plug or closure 20; obviously a ball valve or similar closure could be substituted for the plug. The apparatus makes it possible to lower the well tubing string into the well to its final position and to mount the well head assembly A prior to the time that the well packer is set. Since the packer apparatus is moved to a set position by hydraulic pressure, there is no necessity for imparting any movement, longitudinal, rotative or otherwise, in order to effect a setting of the packer. By suspending the tubing in its final position in the well head assembly prior to setting of the packer, it is possible to carry out any operations which require a free circulation of fluid through and around the packer after the well head assembly is in position. Whenever desired, the plug or closure 20 may be dropped and the packer may be set. At any time that the tubing must be removed, the packer may be released by a manipulation of the well tubing. It is thus apparent that the packer may function as a circulating packer and may then be employed as a final production packer, since it may be released at any desired time.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof, and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim is:

1. A well packer apparatus including a mandrel, a slip carrier mounted on said mandrel by a threaded connection and having gripping slips movably supported in the carrier, a slip expander surrounding the mandrel and telescopically connected with the slip carrier whereby the expander is movable relative to the slips of the carrier to effect an expansion thereof into gripping position, an annular, elastic packing element supported upon the expander and surrounding the mandrel, an annular force-applying member surrounding the mandrel and slidable thereon and engageable with the upper end of the packing element, there being a cylinder surrounding said force-applying member, and means for conducting fluid pressure to the cylinder to move the force-applying member downwardly to apply a downward force to the packing element and expander to set the slips and expand the packing element into sealing position, and means for locking the force-applying member against upward movement on the mandrel after it has been moved downwardly with respect thereto by the applica-

tion of fluid pressure, whereby the packing element is locked against release from a sealing position.

2. A well packer apparatus as set forth in claim 1, wherein the threaded connection between mandrel and the slip carrier permits rotation of the mandrel with respect to the slip carrier when the slip carrier is held stationary by its slips engaging the wall of the bore, such rotation of the mandrel actuating said threaded connection to thereby cause an upward movement of the mandrel and the force-applying member which is locked thereto, whereby the endwise force on said packing element is relieved to release the packer.

3. A well packer apparatus including a mandrel, a slip carrier mounted on said mandrel by a threaded connection and having gripping slips movably supported in the carrier, a slip expander surrounding the mandrel and telescopically connected with the slip carrier whereby the expander is movable relative to the slips of the carrier to effect an expansion thereof into gripping position, an annular, elastic packing element supported upon the expander and surrounding the mandrel, an annular force-applying member surrounding the mandrel and slidable thereon and engageable with the upper end of the packing element, there being a cylinder surrounding said force-applying member, and means for conducting fluid pressure to the cylinder to move the force-applying member downwardly to apply a downward force to the packing element and expander to set the slips and expand the packing element into sealing position.

4. A well packer apparatus including a mandrel, a slip carrier mounted on said mandrel by a threaded connection and having gripping slips movably supported in the carrier, a slip expander surrounding the mandrel and telescopically connected with the slip carrier whereby the expander is movable relative to the slips of the carrier to effect an expansion thereof into gripping position, an annular, elastic packing element supported upon the expander and surrounding the mandrel, an annular force-applying member surrounding the mandrel and slidable thereon and engageable with the upper end of the packing element, there being a cylinder surrounding said force-applying member, and means for conducting fluid pressure to the cylinder to move the force-applying member downwardly to apply a downward force to the packing element and expander to set the slips and expand the packing element into sealing position, and locking means carried by the force-applying member and engageable with the mandrel to lock the force-applying member against upward movement relative to the mandrel after the packing element and slips have been moved to set position by the fluid pressure, rotation of the mandrel with respect to the slip carrier after the packing element and slips are set causing the threaded connection to move the mandrel, and the locking means and force-applying member upwardly relative to the slip carrier and packing element to release the force acting on the packing element and thereby move said packing element and slips to an unset position.

5. A well packer apparatus including, a mandrel connected in a well tubing string and lowerable therewith into a well casing, an annular support on the mandrel, connecting means between the mandrel and support for initially maintaining the support in one predetermined position on the mandrel, an annular elastic packing element surrounding the mandrel and maintained against longitudinal displacement in one direction thereon by said support, a movable piston adjacent that end of the packing element remote from the support and slidable on the mandrel and adapted to apply an endwise force to said element when said piston is moved on the mandrel in a direction toward the support to set said packing element, and means for applying pressure fluid to the piston to apply a force to the packing element to distort the latter into set position, means for locking the packing element in set position, said tubing string being

rotatable relative to the annular support when the packing element is in set position to actuate the connecting means between the mandrel and support and thereby move the support longitudinally relative to the mandrel in a direction away from the packing element to unset the packer.

6. In well production apparatus as set forth in claim 5, wherein said connecting means between the mandrel and support comprises threads which are operable by a rotation of the tubing string with respect to the annular support.

7. A well packer apparatus including, a mandrel connected in a well tubing string and lowerable therewith into a well casing, an annular support on the mandrel, connecting means between the mandrel and support for maintaining the support in predetermined positions on the mandrel, an annular elastic packing element surrounding the mandrel and maintained against downward displacement thereon by said support, a movable piston above the packing element slidable on the mandrel and adapted to apply an endwise force to said element when said piston is moved downwardly relative to the element, and means for applying pressure fluid to the piston to apply a force to the packing element to distort the latter into set position, said connecting means between the mandrel and support being operable by manipulation of the tubing string to move the support relative to the mandrel and to the packing element after said packing element has been set, whereby the force acting on said packing element may be released to unset the packer, said connecting means between the mandrel and support comprising threads which are operable by a rotation of the tubing string with respect to the annular support.

8. A well packer apparatus including, a mandrel, a support means mounted on said mandrel by a threaded connection, anchoring means including pipe gripping members on the mandrel and supported on said support means, an annular elastic packing element surrounding the mandrel and supported upon the anchoring means, hydraulically-actuated means on the mandrel associated with the upper end of the packing element for applying a downward force to said element and to the anchoring means to set said packing element and to engage the gripping members of said anchoring means with the well bore, locking means on one element of the hydraulically-actuated means engageable with the mandrel for locking the packing element in set position, pressure fluid being conducted from the mandrel to the hydraulically-actuated means to operate the same, rotation of the mandrel relative to the support means after the packing element and anchoring means are set causing the threaded connection to effect a longitudinal movement of the mandrel and said one element of the hydraulically-actuated means relative to the support means and also relative to the packing element and anchoring means to release the setting force acting thereon and thereby unset the packer.

9. A well packer apparatus including, a mandrel, a packing element carried by the mandrel, a first abutment confining the packing element against longitudinal move-

ment in one direction relative to said mandrel, a cylinder surrounding the mandrel, an annular piston within the cylinder and acting against that end of the packing element remote from the confining abutment for applying an endwise force to the packing element to set the same, said piston forming a second abutment confining the packing element, means conducting pressure fluid from the mandrel into the cylinder and against the piston to actuate the same and set the packing element, locking means carried by the piston engageable with the mandrel for locking said piston to the mandrel after said piston has set the packing element, means including a threaded connection between the mandrel and one of the abutments whereby rotation of the mandrel relative to the abutment after the packing element has been set causes a longitudinal movement of the mandrel relative to the abutment and packing element to release the setting force acting thereon and thereby unset the packer.

10. The method of completing a well having a production zone and containing a weighted fluid which consists in, positioning a tubing string having an unset well packer thereon within the well to locate the well packer above the producing zone, thereafter installing well head control equipment at the surface of the well, supporting the tubing string from the well head control equipment, then circulating the weighted fluid out of the well, then setting the well packer while the tubing string remains stationary and the well head control equipment remains in place, and thereafter producing well fluids from the producing zone through said tubing string.

11. The method of completing a well having a well fluid producing formation traversed by the well bore and having a weighted fluid therein which maintains the well under control, said method consisting in, lowering a well tubing string having a well packer in unset position thereon into the well bore to locate the packer in a predetermined position relative to the producing formation, thereafter installing well head control equipment on the well, suspending the tubing string from said well head control equipment, then pumping a sufficient quantity of the weighted fluid out of the well to initiate flow of well fluids from the producing formation while the packer is in unset position, thereafter setting the packer while the tubing remains stationary and the well head control equipment remains in place, and then producing well fluids from the producing zone through said tubing string.

References Cited in the file of this patent

UNITED STATES PATENTS

2,164,195	Waltermire	June 27, 1939
2,277,380	Yancey	Mar. 24, 1942
2,378,469	Denton	June 19, 1945
2,624,412	Ragan	Jan. 6, 1953
2,630,865	Baker	Mar. 10, 1953
2,704,579	Brown	Mar. 22, 1955
2,764,243	Page	Sept. 25, 1956