

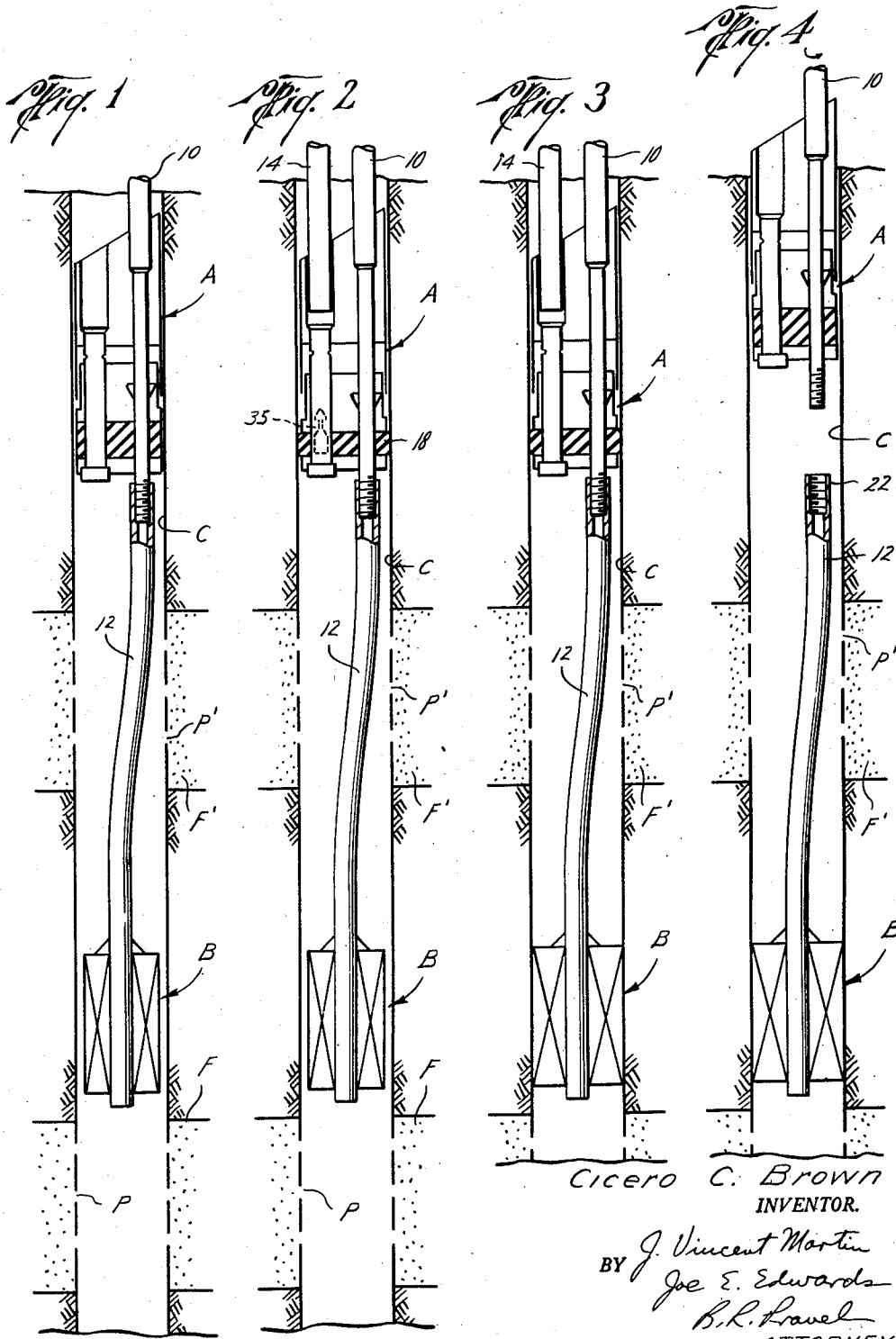
Sept. 8, 1959

C. C. BROWN
WELL COMPLETION AND WELL PACKER APPARATUS
AND METHODS OF SELECTIVELY MANIPULATING
A PLURALITY OF WELL PACKERS

2,903,066

Filed Aug. 1, 1955

7 Sheets-Sheet 1



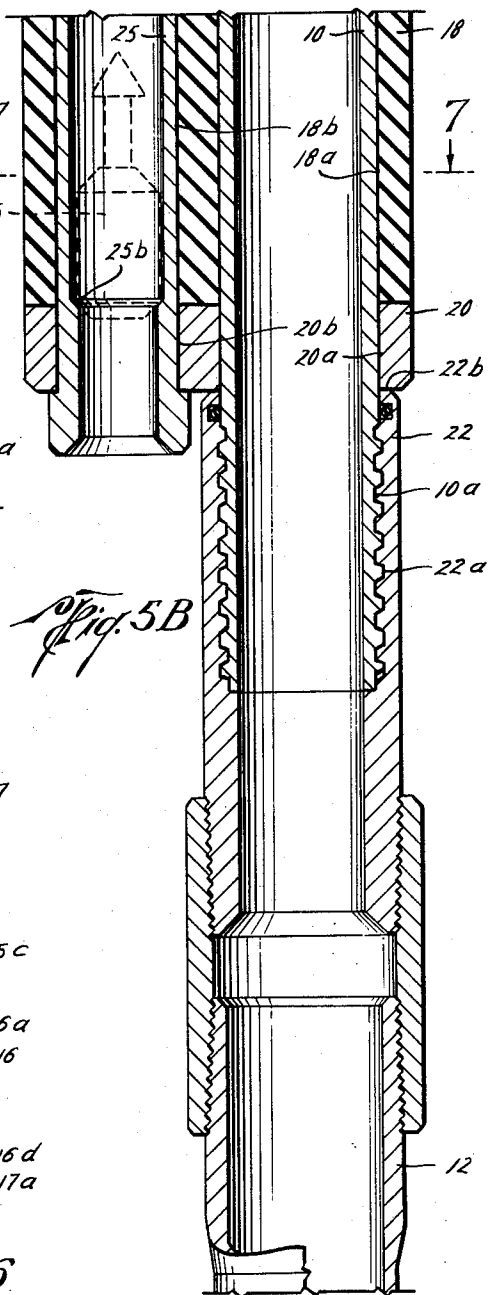
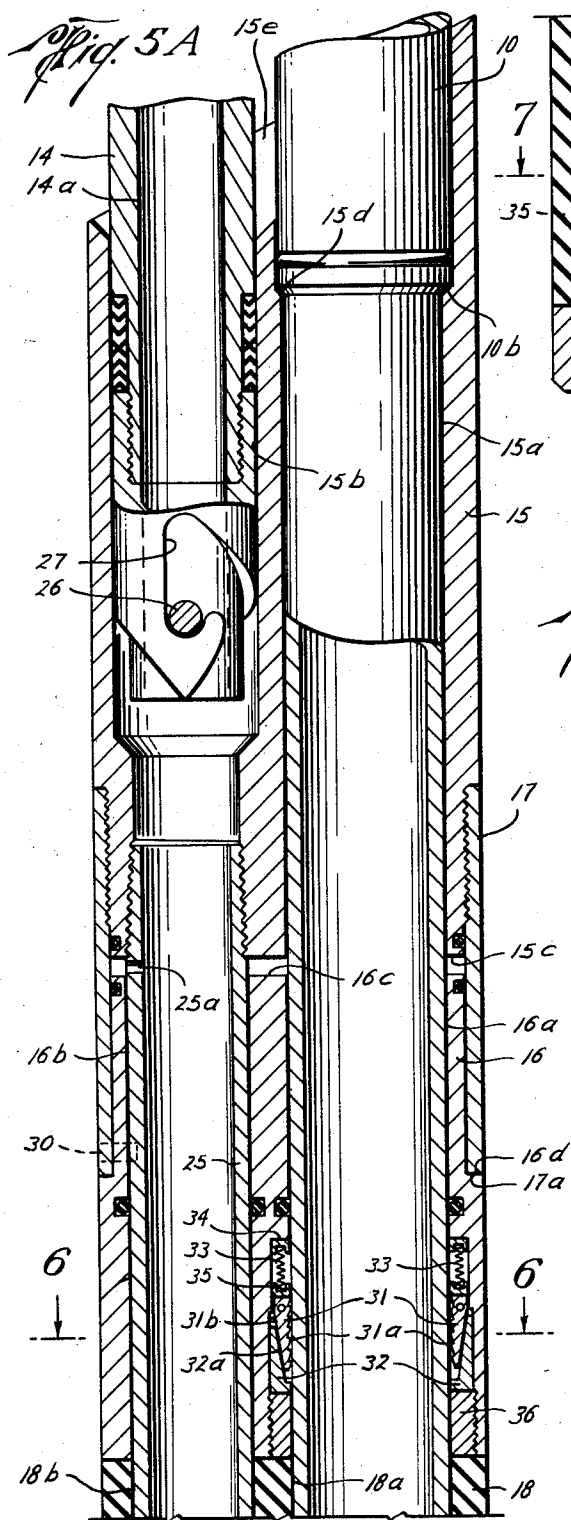
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7 Sheets-Sheet 2



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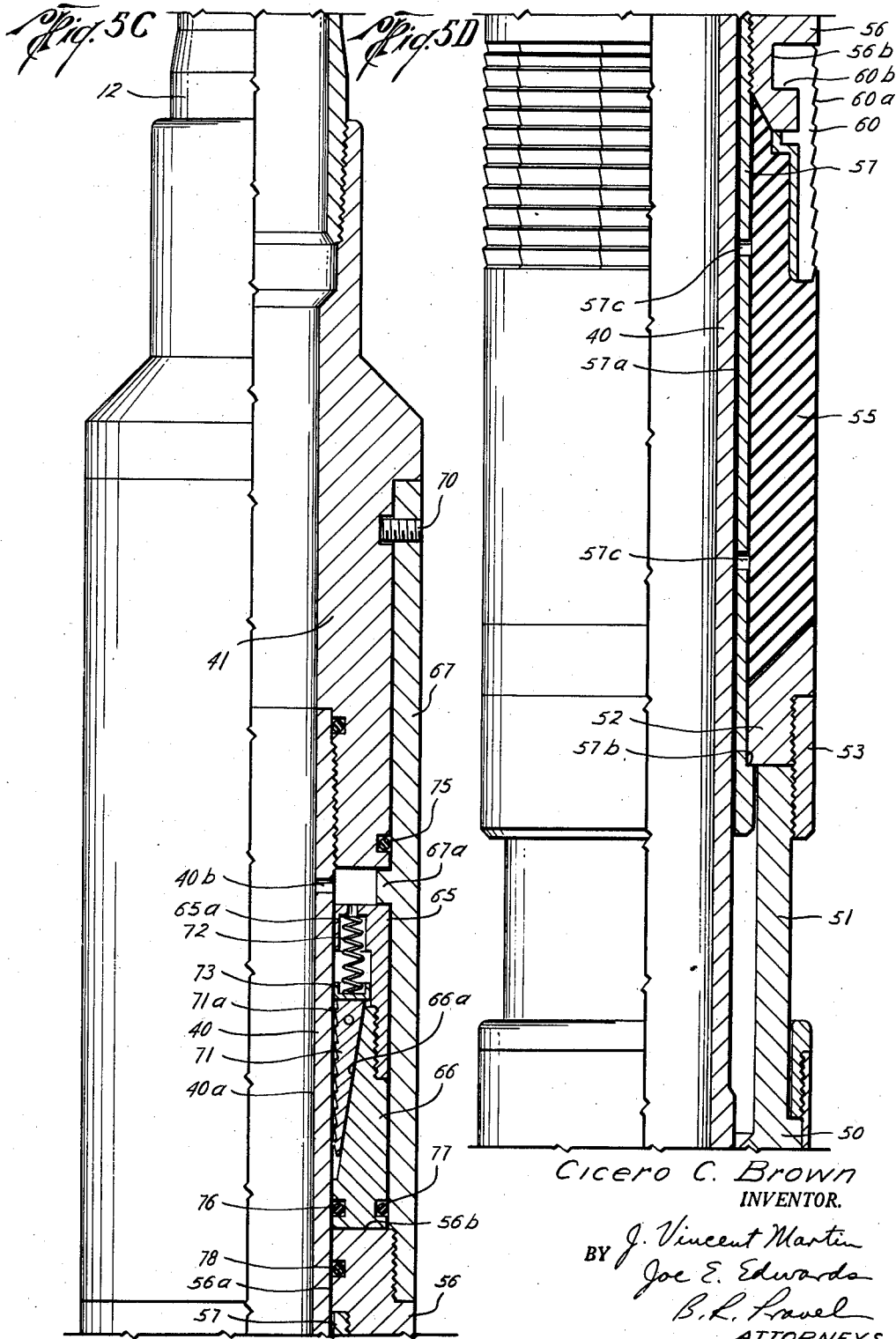
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7 Sheets-Sheet 3



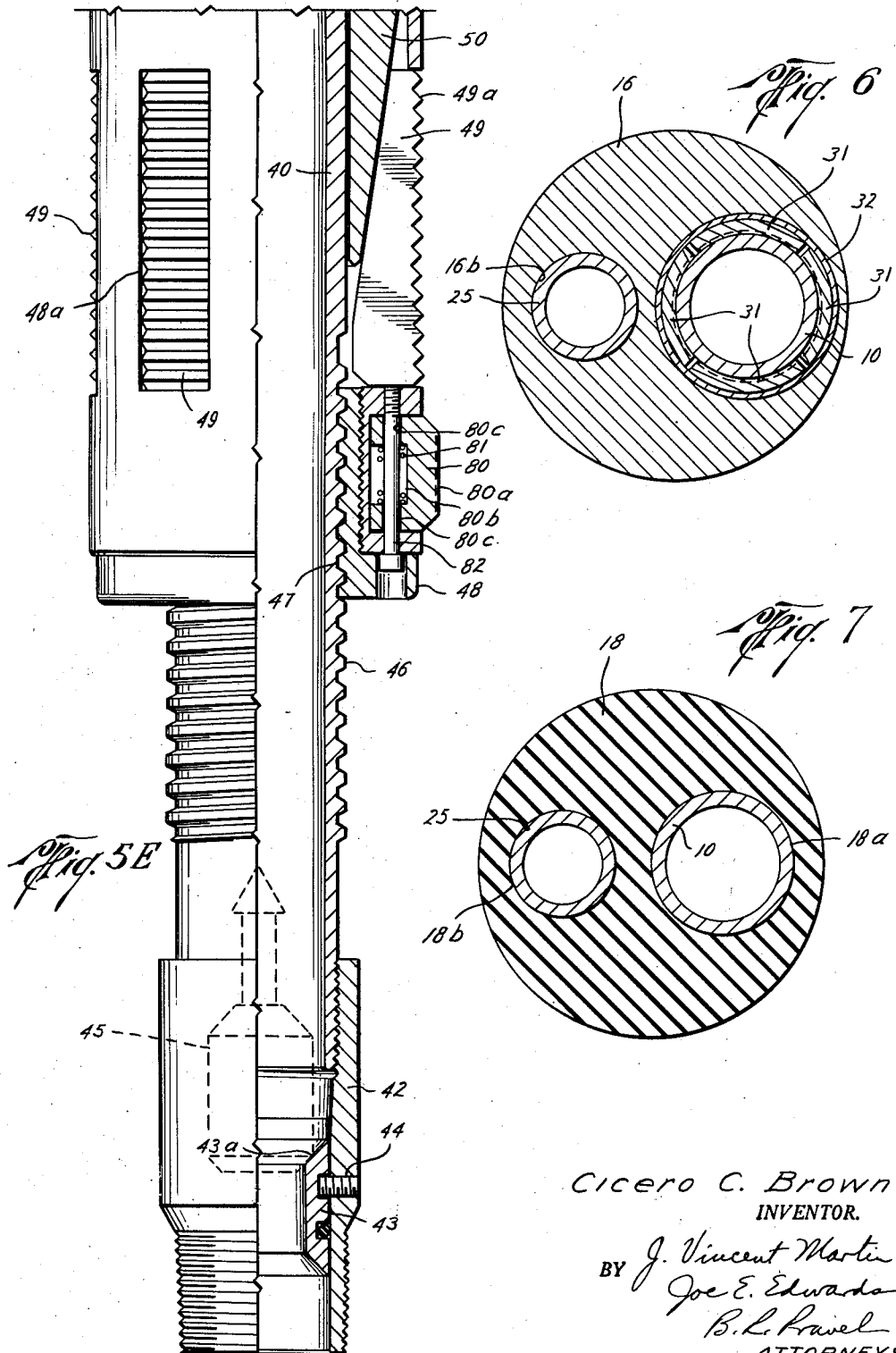
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7 Sheets-Sheet 4



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7 Sheets-Sheet 5

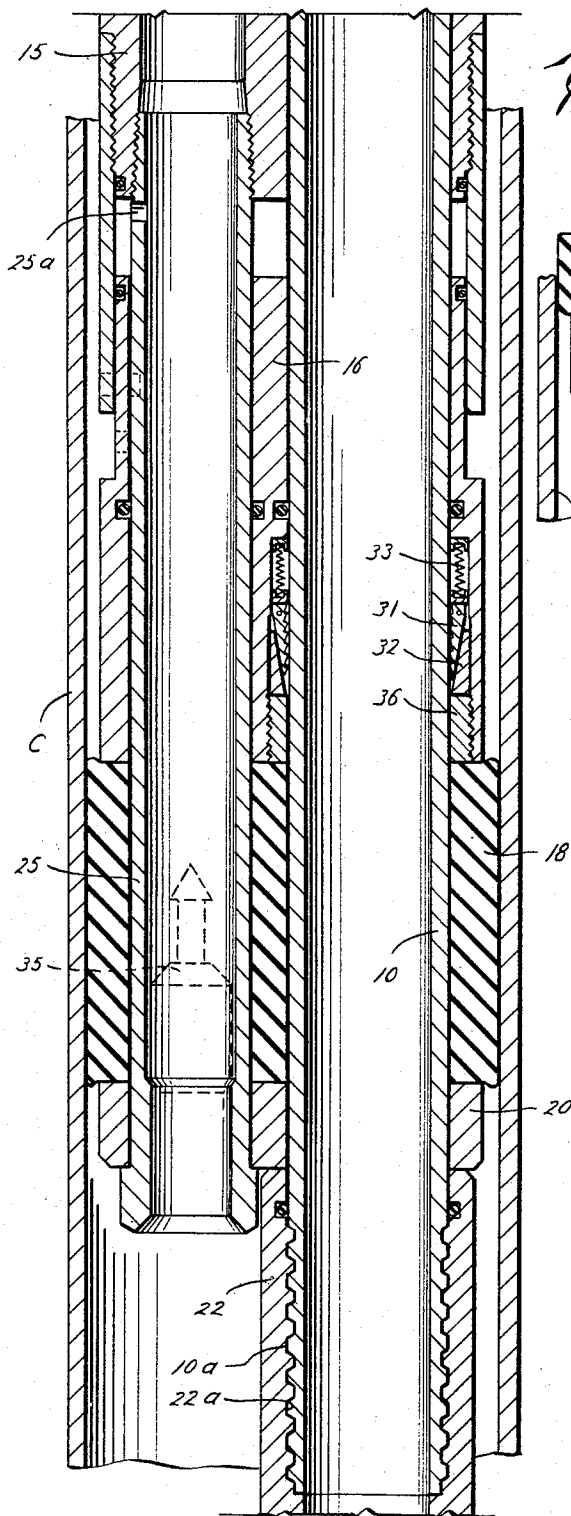


Fig. 8

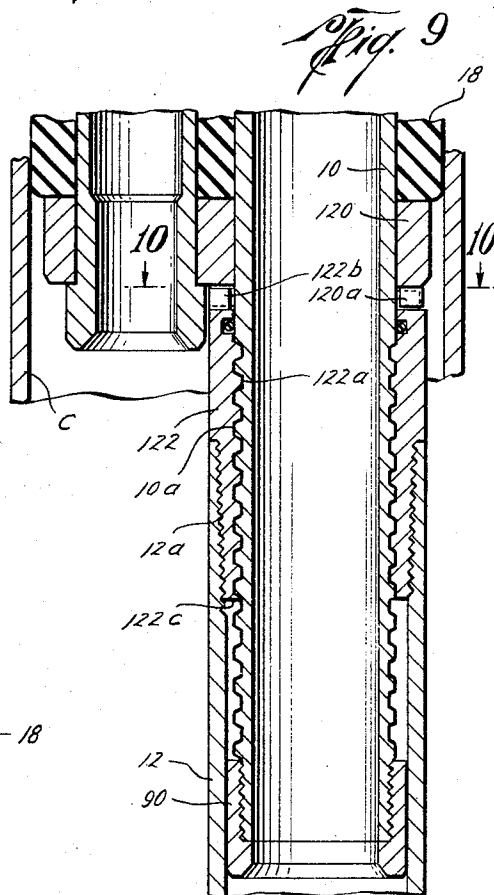


Fig. 9

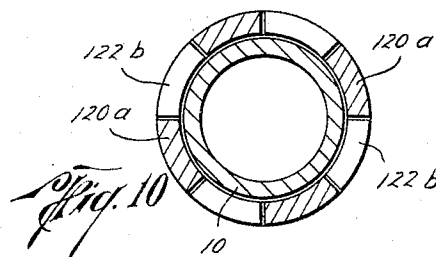


Fig. 10

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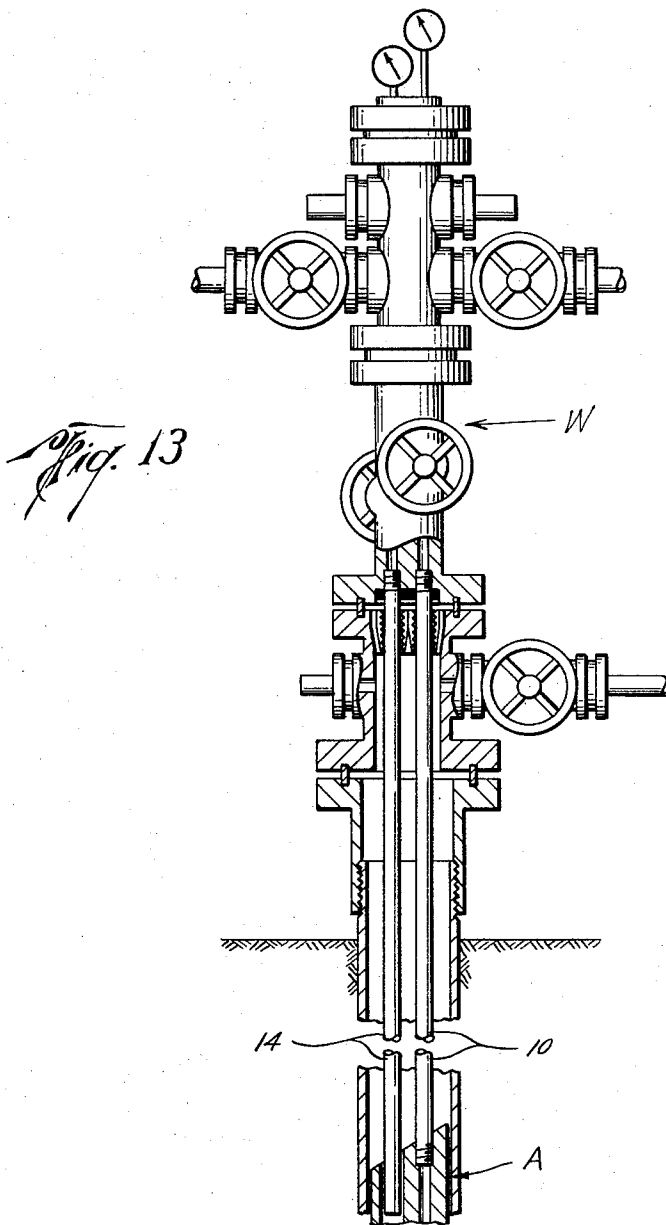
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7 Sheets-Sheet 7



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2,903,066

WELL COMPLETION AND WELL PACKER APPARATUS AND METHODS OF SELECTIVELY MANIPULATING A PLURALITY OF WELL PACKERS

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Application August 1, 1955, Serial No. 525,585

19 Claims. (Cl. 166—46)

This invention relates to new and useful improvements in well completion and well packer apparatus and methods of selectively manipulating a plurality of well packers.

One object of this invention is to provide a new and improved well packer apparatus having a plurality of well packers for production from a plurality of well formations and a new and improved method of selectively manipulating said apparatus, wherein the apparatus is adapted to be positioned in a well bore with the well head equipment in place prior to the setting of the well packers of the apparatus, whereby circulation around the packers can be accomplished for acidizing, washing and the like, and wherein the packers can be thereafter set in the well bore without disturbing the well head equipment so that thereafter production from the well formation can be obtained.

An important object of this invention is to provide a new and improved well packer apparatus having a plurality of well packers for production from a plurality of well formations and a new and improved method of selectively manipulating said apparatus, wherein said apparatus is supported or suspended within a well bore on a well tubing or pipe which is attached to a well head assembly, and wherein said apparatus is supported or suspended in a well bore on a well tubing or pipe which is attached to a well head assembly, and wherein said apparatus is so constructed that the well packers can be selectively set in the well bore for conducting various types of well operations without moving said well tubing or pipe.

Another object of this invention is to provide a well packer apparatus having a plurality of well packers supported by a well pipe, wherein at least one of said packers is adapted to be set by the application of hydraulic fluid pressure and which is released from a set position by a manipulation of the pipe on which the packer is mounted.

A further object of this invention is to provide a well packer apparatus having a plurality of well packers adapted to be lowered to a predetermined depth in a well bore on a single pipe string, and wherein the upper of said packers is adapted to receive a second pipe string after the apparatus has been lowered to said predetermined depth, said packers being set without requiring the manipulation of the pipe strings.

Another object of this invention is to provide a new and improved method of running a plurality of well packers into a well bore, wherein the packers are initially lowered into the well bore to a predetermined depth on a single tubing string, and thereafter a second tubing string is connected to the upper of the packers, and said packers being selectively set in the well bore for conducting various well operations therein.

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

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to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a view, partly in elevation and partly in section, illustrating diagrammatically the apparatus of this invention as it is lowered into a well bore or casing.

Figure 2 is a view similar to Figure 1, illustrating the apparatus with the second tubing string positioned therewith.

Figure 3 is a view similar to Figure 1, but showing the lower well packer of the apparatus in a set position.

Figure 4 is a view similar to Figure 3, but showing the upper well packer disconnected from the lower well packer for the removal of the upper well packer from the well bore or casing.

Figures 5A-5E, inclusive, are views, partly in elevation and partly in section, which illustrate in detail one form of the apparatus shown diagrammatically in Figures 1-4, with Figure 5A showing the upper portion of the apparatus, Figures 5B, 5C and 5D showing the intermediate portions of the apparatus and Figure 5E showing the lower portion thereof.

Figure 6 is a horizontal sectional view taken on line 6-6 of Figure 5A.

Figure 7 is a horizontal sectional view taken on line 7-7 of Figure 5B.

Figure 8 is a view, partly in elevation and partly in section, illustrating a portion of the upper packer of the apparatus shown in Figures 5A-5E, wherein the portion is illustrated in the set position.

Figure 9 is a sectional view illustrating a modification of the releasing mechanism associated with the upper packer of the apparatus for releasing the upper and the lower packers.

Figure 10 is a horizontal sectional view taken on line 10-10 of Figure 9.

Figure 11 is a view, partly in elevation and partly in section, illustrating a portion of a modified form of the upper packer construction, wherein the valve means for use during the setting of the upper packer is shown in an open position.

Figure 12 is a view similar to Figure 11, but illustrating the valve means of the upper packer in a closed position.

Figure 13 is a view partly in section and partly in elevation and illustrating a well head assembly which supports the tubing strings from the surface of the well.

In the drawings, the letters A designates generally the upper well packer of the well packer apparatus of this invention and the letter B designates generally the lower well packer of the apparatus of this invention, which are adapted to be lowered into a well bore or casing C for positioning relative to a lower well formation F and an upper well formation F'. The packers A and B of the packer apparatus of this invention are preferably lowered on a single tubing or pipe string 10 which is connected to the upper packer A, and, as will be explained, has connection with a lower tubing section 12 which extends downwardly and connects with the lower well packer B. With the lower packer B positioned between the formations F and F' and with the upper packer A positioned above the upper well formation F', a second tubing string 14 is lowered into the well bore or casing C and connection is established with the lower end of such second tubing string 14 and the upper well packer A, as will be explained. With the apparatus in such position, the well head assembly at the surface of the well generally indicated at W in Figure 13 is connected in the usual fashion and thereafter, the packers A and B can be selectively set in the well bore or casing C without disturbing the well head assembly. Also, as will be explained, prior to the setting of either of the packers A

or B, circulation can be maintained around such packers for thereby conducting various well operations such as washing for the removal of mud and the like. When the packers are set, production from the formations F and F' is obtained through the usual perforations P and P', respectively.

Considering the invention more in detail, the details of the upper well packer A are shown in Figures 5A and 5B. such packer A includes an upper tubular body 15 which has longitudinal passages or bores 15a and 15b extending therethrough. A tubular piston 16 is positioned below the body 15 and is likewise formed with longitudinal passages or bores 16a and 16b which are in axial alignment with the bores 15a and 15b, respectively. The piston 16 is adapted to move downwardly with respect to the body 15 from the position shown in Figure 5A upon the application of a fluid pressure to the upper end 16c of the piston 16. Accordingly, the upper end 16c of the piston 16 is maintained a predetermined distance below the lower end 15c of the body 15, such distance being maintained by a sleeve or cylinder 17 which is threaded or otherwise connected to the lower end of the body 15 and which surrounds the upper portion of the piston 16. The piston 16 is provided with a reduced external diameter at its upper portion so as to form an annular shoulder 16d which is contacted by the lower end or lateral surface 17a of the sleeve 17 so as to limit the upward movement of the piston 16 with respect to the body 15 so as to always maintain the space between the surfaces 15c and 16c. The piston 16c is supported on an expansible packing element 18 which is formed of rubber or other similar elastic material and which is generally cylindrical with longitudinal passages 18a and 18b being provided therethrough in alignment with the passages 16a and 16b, respectively. The lower end of the expansible packing element 18 rests upon a support ring 20 which is formed of metal or other similar material and which is provided with longitudinal passages 20a and 20b which are in axial alignment with the longitudinal passages 18a and 18b, respectively.

The first tubing string 10 extends through the passages 15a, 16a, 18a and 20a and is coupled at its lower end with a release collar 22 by means of interengaging left-hand threads 10a and 22a which are relatively coarse to permit easy disconnection thereof. Since the usual tool joints are formed with right-hand threads, the disconnection of the left-hand threads 10a and 22a does not tend to release the usual tool joint connections upon a rotation of the tubing string 10 to the right; however, it will be understood that the threads 10a and 22a could be right-hand threads, if so desired.

It will be observed that the upper end 22b of the release coupling 22 has the support ring 20 resting thereon. Since the support ring 20 has the packing element 18, piston 16 and body 15 resting thereon, it is believed evident that all of such structure is resting upon the release collar 22 when the well packer A of Figures 5A and 5B is in the position for running the packer into the well bore or casing C. It will also be noted that the tubing string 10 is limited in its downward movement relative to the body 15 by the contact of an annular shoulder 10b with a similar inwardly extending annular shoulder 15d on the body 15. When the release coupling 22 is held against movement downwardly, by reason of a support from above with the tubing string 10 or by reason of a support from below, the packing element 18 can be expanded by the application of fluid pressure to the upper end of the piston 16. For directing hydraulic pressure or other fluid pressure to the upper end 16c of the piston 16, an inner tube 25 is connected to the lower end of the body 15 so as to establish fluid communication with the passage 15b, such tube 25 having one or more ports 25a which establish fluid communication from the bore of the tube 25 to the area above the piston 16 within the sleeve or cylinder 17. The second tubing string 14 is,

of course, adapted to be connected into the bore 15b by means of any suitable type of connection. As shown in the drawings, the string 14 is connected in the bore 15b by means of a pin 26 which extends inwardly from the body 15 into a J-slot 27 at the lower end of the tubing string 14. Such construction is of the type described in detail in my U.S. patent application, Serial No. 514,047, filed June 8, 1955, but it will be appreciated that other types of connections for the tubing string 14 can be employed. In any event, with the tubing string 14 connected in position in the bore 15b, fluid under pressure can be supplied downwardly through the bore 14a of the tubing string 14 to the tube 25 for passage through one or more of the ports 25a and into the annular area above the piston 16. During the running in of the well packer A, the piston 16 is prevented from moving downwardly by means of a suitable shear pin 30 which extends through the outer sleeve 17, the piston 16 and the tube 25, as shown in dotted lines in Figure 5A. Also, under ordinary circumstances the fluid is not confined within the tube 25 but is permitted to flow therethrough, but when it is desired to close off the fluid flow through the tube 25 in order to build up hydraulic or fluid pressure above the piston 16, a plug 35 (shown in dotted lines in Figure 5B) may be lowered through the pipe 14 and seated at the annular shoulder 25b of the tube 25.

For preventing the normal return of the packing expander 18 to its normal unset position (Figures 5A and 5B) after the packing element 18 has been set (Figure 8), a plurality of slips or slip segments 31, each having upwardly directed gripping teeth 31a formed thereon, or provided for movement with the piston 16. The slips 31 rest upon an annular expander or wedge 32 which has a downwardly and inwardly inclined inner surface 32a which is in engagement with a similarly inclined surface 31b on each of the slips 31. One or more coil springs 33 are confined between retaining rings 34 and 35 so that the springs 33 act to urge the slips 31 downwardly into constant engagement with the expander 32. The expander 32 is maintained in a fixed position relative to the piston 16 by means of a lock ring 36 which is threaded or otherwise secured to the piston 16 below the expander 32. Since the teeth 31a are directed upwardly, a downward movement of the piston 16 relative to the tubing string 10 is not prevented by the slips 31 since the teeth 31 simply slide along the outer surface of the tubing string 10 during such downward relative movement of the piston 16. However, upon an upward movement of the packing element 18, the expander 32 wedges behind the slips 31 to urge the teeth 31a of the slips 31 into gripping engagement with the external surface of the tubing string 10 to prevent any upward relative movement of the piston 16 relative to the tubing string 10. Thus, in order to release the packing element 18 from its set position (Figure 8), it is necessary to move the tubing string 10 upwardly relative to the packing element 18 so as to move the slips 31 therewith. Such is accomplished when the tubing string 10 is rotated so as to release the threads 10a from the threads 22a, whereupon the inherent resiliency of the packing element 18 returns the packing element 18 to its normal non-sealing or unset position (Figures 5A and 5B).

Although the packer B may be of various constructions, it is preferably a packer which is of the type set by hydraulic or fluid pressure so as to avoid the necessity of manipulating the lower tubing section 12 connected therewith, but which is releasable by a rotation of such tubing section 12 supporting the packer B. The packer B as shown in Figures 5C, 5D and 5E is the preferred type of packer for use as the lower packer of the apparatus of this invention and is of the type shown in my copending U. S. patent application, No. 523,544, filed July 21, 1955. As shown herein in Figures 5C, 5D and 5E, the lower packer B comprises a central support or mandrel 40 which has an axial bore 40a extending entirely there-

through. The upper end of the mandrel 40 is connected to the lower end of an annular coupling 41 which has its upper end attached to the lower tubing section 12. The lower end of the mandrel 40 has a coupling 42 threaded or otherwise secured thereto for connecting with a lower portion of the tubing or a tail pipe (not shown) which may be used if desired. Thus, the mandrel 40 of the well packer B is directly connected in the tubing string and has its bore 40a communicating with the bore of the tubing string. A sleeve 43 is mounted in the lower coupling 42 with one or more set screws 44 so as to provide an annular seat 43a for a conventional plug or valve member 45 (shown in dotted lines) which, as will be explained, is adapted to be dropped or lowered into position in the well tubing when it is desired to set the lower packer B.

Above the coupling 42, the mandrel 40 is provided with a series of relatively coarse threads 46, which are preferably left-hand threads, for threaded engagement with similar threads 47 on the inner surface of a tubular slip carrier 48 which surrounds the mandrel 40. The slip carrier 48 is tubular in construction and is provided with slots or windows 48a through which slips 49 extend. Such slips 49 are provided with gripping teeth 49a which are adapted to grip the interior of the casing C when the slip expander or cone 50 moves downwardly relative to the slips 49. Thus, upon a downward movement of the expander or cone 50, the slips 49 move radially through the slots or windows 48a of the slip carrier 48 to move the slips 49 into gripping engagement with the inside of the casing C.

The slip expander or cone 50 is formed at the lower end of a tubular body 51 which extends upwardly above the slip carrier 48 and is attached to the lower end of a base ring 52 by a connecting sleeve 53.

A resilient annular packing element 55 formed of rubber or other similar plastic material is disposed above the base ring 52 so that the packing element 55 is supported on the ring 52 and thus on the expander 50, whereby downward movement of the packing element 55 is transmitted directly to the expander 50, as will be explained more in detail hereinafter.

The upper end of the annular elastic packing element 55 is confined by an upper collar 56 which has its upper portion of its bore 56a in contact with the external surface of the mandrel 40 for relative longitudinal movement with respect to such mandrel 40. An inner sleeve 57 is threaded or otherwise secured to the collar 56 so as to have its bore 57a in axial alignment with the bore 56a at the upper portion of the collar 56. Such inner sleeve 57 also surrounds the mandrel 40 and extends downwardly inside of the packing element 55 to a point below the base ring 52, with such inner sleeve 57 being formed with a radial outwardly extending annular shoulder 57b which is in contact with the lower surface of the base ring 52 (Figure 5D) when the packer B is lowered into the well bore or casing C. However, it is to be noted that there is no connection between the sleeve 57 and the base ring 52 so that the sleeve 57 is adapted to move downwardly relative to the packing element 55 and the base ring 52 for the setting of the packing element 55, as will be more evident hereinafter.

If desired, the packing element 55 may be formed with auxiliary gripping elements 60 which are provided with gripping teeth 60a on their external surfaces and which are embedded in the elastic material of the packing element 55 for limited radial movement during the expansion and retraction of the packing element 55. Thus, when the packing element 55 is expanded outwardly into contact with the casing C, the auxiliary gripping elements 60 are also in contact with the casing C. It will be noted that each of the auxiliary gripping elements 60 has an inwardly extending flange portion 60b which extends into an annular groove 56b of the collar 56 so that the gripping elements 60 are prevented from shifting upwardly relative to the collar 56 while they move radially relative

thereto. Such gripping elements 60 can, of course, be omitted if desired.

The packing element 55 is expanded by the application of a fluid pressure through the openings 40b which transmit a force to the upper end 56b of the collar 56, as will be explained, so as to move the upper end of the packing element 55 downwardly. The initial downward movement of the packing element 55 is transmitted through the tubular body 51 to the expander 50 for initially setting the slips 49 and for thereafter applying an endwise compressive force to the packing element 55 for expanding same radially outwardly into sealing engagement with the casing C. For equalizing the fluid pressure on the inside and outside of the packing element 55 during the lowering of the packer B into the well casing C, equalizing ports 57c are provided in the inner sleeve 57. The fluid pressure which is supplied from the surface of the well through the tubing string to the interior of the mandrel 40 and thence through the port or ports 40b to effect the foregoing expansion of the packing element 55 is actually directed to a piston 65 which is annular in construction and surrounds the mandrel 40 below the port or ports 40b. Such piston 65 is connected with an annular expander 66 having an expanding surface 66a and which rests upon the annular lateral upper end 56b of the coupling 56. The coupling 56 is threaded or otherwise connected to a longitudinally extending sleeve 67 which surrounds the expander sleeve 66 and the piston 65 and extends upwardly and around the body 41. A radially inwardly extending flange 67a is provided on the sleeve 67 for limiting the upward movement of the piston 65 so as to confine same between such flange 67a and the lateral surface 56b of the coupling 56. The sleeve 67 is urged to its upper position (Figure 5C) by the inherent resiliency of the packing element 55, and during the initial running in of the packer B, the sleeve 67 is connected to the body 41 by a shear pin or screw 70.

A plurality of slip segments or gripping slips 71 having upwardly extending gripping teeth 71a formed on the inner surfaces thereof are positioned within the bore of the expander sleeve 66 so as to coact with the inclined expander surface 66a thereof. One or more coil springs 72 are disposed in a recess 65a of the piston 65 and an annular retaining ring 73 which rests upon the slips 71 so as to constantly urge the slips 71 downwardly relative to the expander sleeve 66. It will be evident that the expander sleeve 66 in effect forms a continuation of the piston 65 and may be considered as an integral part thereof. In fact, except for assembly purposes, the piston 65, expander sleeve 66 and the collar 56 could be formed integral with each other. The upwardly extending teeth 71a on the slips 71 prevent an upward movement of the piston 65 relative to the mandrel 40 because the expander surface 66a wedges the teeth 71a into gripping engagement with the external surface of the mandrel 40 upon a relative upward movement of the piston 65 with respect to the mandrel 40, but upon a downward movement of the piston 65 by reason of the application of an hydraulic fluid pressure thereto, the teeth 71a simply slide along the external surface of the mandrel 40 and do not prevent such downward movement.

It will be noted that suitable seal rings are provided above and below the fluid inlet ports 40b in the mandrel 40 so as to confine the fluid pressure action to the piston 65. Thus, an annular seal ring 75 is disposed on the body 41 in sealing contact with the inner surface of the sleeve 67. Similarly, seal rings 76, 77 and 78 are provided.

As will be explained, during the release of the packing element 55 from a set or expanded sealing position, the mandrel 40 is rotated to the right to move same upwardly relative to the slips 49 and the slip carrier 48. Ordinarily, the slips 49 are sufficient to prevent any movement of the carrier 48 during the rotation of the mandrel 40 for the release of the packing element 55. However, if desired, a suitable friction shoe 80 (Figure 5E) may be mounted in the lower portion of the slip

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carrier 48 to assist in preventing rotation of said slip carrier 48. The shoe 30 has a sharp longitudinal edge 80a which is urged into engagement with the wall of the casing C by a suitable spring 81 which is positioned within a recess 80b of the friction shoe 30. A bolt or screw 82 extends through suitable openings 80c of the shoe 80 to support the shoe 80 in the slip carrier 48.

In the operation or use of the apparatus of Figures 5A-7, and in carrying out the method of this invention when using such apparatus, the packers A and B are initially lowered into the well casing or bore C on the first tubing string 10, with the lower well packer B being suspended from the upper well packer A by means of the lower tubing section 12 (Figure 1). The packers A and B are lowered until the packer B is disposed between the well formations F and F', at which time the packer A is positioned above the upper well formation F'. If the packer B is of the type illustrated in Figures 5C, 5D and 5E, it can then be set in the manner to be hereinafter explained, but ordinarily, prior to the setting of either of the packers A or B, the second tubing string 14 is also lowered into the well bore or casing C and is guided into the longitudinal passage or bore 15B of the body 15 on the upper packer A by means of the inclined cup-shaped end 15e of the body 15 which automatically forces the lower end of the tubing string 14 into the passage 15b. The tubing string 14 is then automatically connected to the J-pin or pins 26 which slide within the J-slots 27 at the lower end of the tubing string 14 to prevent inadvertent release of the string 14 from the body 15 during use. With the tubing string 10 and 14 both connected to the upper well packer A, the conventional well head assembly for the dual strings is connected at the surface of the well (not shown) because with the apparatus of this invention, and in carrying out the method thereof, it is unnecessary to thereafter disturb the well head assembly during the setting of the packers of the apparatus of this invention. The packers A and B are then in a position for conducting various well operations such as the circulation of fluid for the removal of mud from the well formations and such operations are carried out with the well head assembly in place so that the danger of a blowout and loss of control at the well head is eliminated with this apparatus.

The packers A and B may be selectively set, that is, either packer may be set first. As shown in the drawings, Figure 2, the packer A is initially set by lowering through the second tubing string 14 a plug 35 (shown in dotted lines) which closes off the lower end of the tube 25 and thereafter prevents fluid flow from the tubing 14 from passing below the packer A. Fluid under pressure is therefore directed through the tubing string 14 from the surface of the well so as to expand the packing element 18. Such expansion occurs by reason of the fluid pressure entering the area above the piston 16 through the port or ports 25a in the sleeve 25. The shear pin 30 is initially severed so that the piston 16 thereafter moves downwardly relative to the tube 25 and the outer sleeve 17 which is connected to the body 15. Since the support ring 20 is held against downward movement by the support of the tubing string 10 at the well head, the downward movement of the piston 16 is also relative to the tubing string 10 and the support ring 20 so that the lower end of the packing element 18 is held against downward movement while the upper end thereof is forced downwardly by the downward movement of the piston 16. Such compression of the packing element 18 effects a radial or lateral movement thereof into sealing contact with the well casing or bore C (Figure 2). When the packing element 18 has thus been expanded, it is prevented from returning to its unexpanded or non-sealing position by reason of the wedging action on the slips 31. Thus, there is an inherent resiliency in the packing element 18 which tends to return it to its normal non-sealing condition and such

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resiliency tends to force the piston 16 upwardly after the fluid pressure acting on the piston 16 is discontinued or stopped. Such upward force from the resilient packing element 18 forces the expander or wedge member 32 into wedging contact with the slips 31 so as to cause the teeth 31a of the slips 31 to grip the external surface of the tubing string 10.

With the upper packer A thus set in sealing contact with the well casing C, the lower packer B is then set (Figure 3) by dropping or lowering a conventional plug 45 (Figure 5E) downwardly through the tubing string 10 and the lower tubing section 12 to its seat 43a at the lower end of the mandrel 40. Such plug 45 prevents fluid flow through the open lower end of the mandrel 40 and, therefore, fluid pressure supplied through the tubing string 10 from the surface of the well is directed to the upper end of the piston 65 through the ports 40b in the sleeve 40 (Figure 5C). Such fluid pressure initially causes the piston 65 and all of the parts therebelow, including the ring 66, coupling 56, packing element 55, base ring 52 and expander 50, downwardly relative to the mandrel 40. Such downward movement of the expander 50 urges the slips 49 outwardly into gripping engagement with the casing C. When the slips 49 have thus been set, continued application of hydraulic or fluid pressure to the upper end of the piston 65 forces the upper end of the packing element downwardly relative to its lower end which causes the packing element 55 to be expanded radially or laterally outwardly into sealing engagement with the casing C.

When the fluid pressure is relieved at the upper end of the piston 65, the packing element 55 and the slips 49 are prevented from retracting due to the setting of the slips 71 in gripping engagement with the external surface of the mandrel 40. Such action occurs because the inherent resiliency of the packing element 55 tends to move the expander sleeve 66 upwardly relative to the slips 71 which action wedges the slips 71 into gripping engagement with the external surface of the mandrel 40. Thus, the lower packer B is set in substantially the same manner as the upper packer A, since both are set by the application of fluid or hydraulic pressure, and without requiring any manipulation of the tubing string supporting same. It should be noted that the shear pin 70 is severed as the piston 65 moves downwardly so that the guide sleeve 67 also moves downwardly relative to the body 41 during the setting of the packing element 55 and the slips 49.

For releasing the well packer apparatus of this invention from its set position in the well bore or casing C after the well formations F and F' have been produced, or for any other reason it is desired to remove such apparatus from the casing C, the packer A is initially separated from the packer B (Figure 4). Such separation is effected by first removing the second tubing string 14 separately and independently from the well casing C without disturbing the packer A. Such tubing string 14 can, of course, be readily removed by a rotation thereof to the right so as to cause the J-slot or slots 27 to move to the right relative to the J-pin or pins 26. With the tubing string 14 thus removed, the tubing string 10 is rotated to the right, assuming the threads 10a and 22a are left-hand threads. Since the packer B is still set in gripping engagement with the well casing C, the coupling 22 is held against turning during the rotation of the tubing string 10 so that there is a relative rotation between the threads 10a and 22a to cause the tubing string 10 to move upwardly relative to the coupling 22. As the tubing string 10 thus moves upwardly, it carries therewith the slips 31. The upward movement of the slips 31, of course, permits the inherent resiliency of the packing element 18 to move its upper end upwardly following the movement of the tubing string 10 until the packing element 18 is completely retracted to its non-sealing position. Continued rotation of the tubing string 10 com-

pletely releases the threads 10a from the threads 22a whereupon the entire packer A is removable from the casing C (Figure 4), leaving the packer B with the lower tubing section 12 extending upwardly therefrom in the well casing C.

The packer B can then be removed by lowering a conventional fishing tool into the well casing C to grip the upper end of the coupling 22 or the pipe 12 for thereafter imparting a rotation to the pipe or tubing 12.

The rotation of the tubing string 12 to the right, assuming the threads 46 and 47 are left-hand threads, effects a rotation of the threads 46 relative to the threads 47, because the threads 47 are on the slip carrier 48 which is held against rotation by the slips 49 and, in the usual case, also by the friction shoe 80. As the tubing string 12 is thus rotated for imparting the rotation to the threads 46 on the mandrel 40, the slips 71 are carried upwardly with the mandrel 40 so as to permit the resilient packing element 55 to return to its normal non-sealing condition by reason of the inherent resiliency of the material of such packing element 55. Continued rotation of the tubing string 12 and mandrel 40 causes continued upward movement of the mandrel 40 relative to the packing element 55 and, ultimately, the lower outwardly extending annular shoulder 57b engages the lower edge of the base ring 52 so as to impart a lifting force to the expander 50 for thereby releasing the expander 50 from its wedging action on the slips 49, whereby they can be readily disengaged from the casing C. Thereafter, the entire packer B is removed from the well casing C with the fishing tool connected at its upper end.

In some instances, it is desirable to eliminate the use of the fishing tool referred to above in connection with Figures 5A-8, and in such case the releasable connection between the tubing string 10 and the lower tubing section 12 is modified as shown in Figure 9. Except for such modification, as will be explained, the packer A and also the packer B are identical with that disclosed above in connection with Figures 5A-8. Thus, in Figure 9 the first tubing string 10 is shown as including a plurality of threads 10a which ordinarily are of greater length than the threads 10a shown in Figures 5B and 8. Such threads 10a are in threaded engagement with threads 122a on a modified coupling 122 which is similar in construction to the coupling 22 of Figure 5B and 8. The threads 10a and 122a are preferably left-hand threads so as to be releasable upon a rotation of the tubing string 10 to the right. At the lower end of the tubing string 10 below the coarse threads 10a, a nut 90 is threaded or otherwise suitably connected thereto for longitudinal movement with the tubing string 10 upon the rotation of the tubing string 10 relative to the coupling 122. The nut 90 is thus slidable or longitudinally movable relative to and within the bore of the lower tubing section 12 which is depending from the coupling 122 by the threaded connection at 12a, or any other suitable connection.

In order to prevent the possibility of the coupling 122 rotating with the tubing string 10 during the release procedure, which action might result in a disconnection of the coupling 122 from the tubing section 12 at the threads 12a, the upper end of the coupling 122 is formed with a plurality of circumferentially spaced longitudinally extending lugs or keys 122b which interengage with corresponding circumferentially spaced longitudinally extending lugs or keys 120a on the base or support ring 120, which otherwise is identical with the support ring 20 shown in Figures 5B and 8.

In the operation or use of the modified release mechanism shown in Figure 9, the packer apparatus is, of course, handled in exactly the same manner as described above in connection with Figures 5A-8 for the setting of the packers A and B, but when it is desired to release the packers from their set position in the well casing, and after the second tubing string 14 has preferably been removed from the casing C, then the rotation of the tub-

ing string 10 is commenced for causing a rotation thereof relative to the coupling 122. Assuming the threads 10a and 122a are left-hand threads, such rotation is to the right and the interengagement of the lugs 120a and 122b assure that the threads 122a and 10a are moved relative to each other instead of breaking out at the threaded joint 12a between the coupling 122 and the lower pipe section 12. During such rotation of the tubing string 10, the packer B is, of course, still set and prevents the rotation of the tubing section 12. Likewise, the packing element 18 is still set in engagement with the casing C and therefore the support ring 120 is prevented from rotating, so that the release of the threads 10a in an upward direction with respect to the threads 122a is assured.

As the tubing string 10 is thus rotated and is moved upwardly relative to the coupling 122, the packing element 18 is released in the same manner as previously described in connection with the first form of the invention shown in Figures 5A-8. Thus, the upper packer A is initially released and upon continued rotation of the tubing string 10, the nut 90 eventually contacts the lower surface or annular edge 122c of the coupling 122 so that thereafter the tubing string 10 cannot move upwardly with respect to the coupling 122. Instead, continued rotation of the tubing string 10 imparts a similar right-hand rotation to the tubing section 12 and to the coupling 122. There is no danger of breaking out the threads at the threaded connection 12a since such connection is made up in the usual manner with right-hand threads which, of course, would tend to tighten as the tubing string 10 is rotated to the right. The same would be true of any other threaded joints in the tubing section 12.

It will be also evident that the packer A will not prevent the rotation of the tubing string 12 because it has been released at that time. The rotation of the tubing string 12 effects the same coaction between the threads 46 and 47 (Figure 5E), as explained previously, so that the lower packer B is released in the same manner as previously explained. Thereafter, the packers A and B are removed from the casing C together on the tubing string 10, so that no fishing tools are necessary for removing the lower packer B as in the first form of this invention.

In Figures 11 and 12, a modified portion of the packer A (shown in Figures 5A and 5B) is illustrated, wherein all of the parts of the packer A shown in such figures are identical with those shown in Figures 11 and 12 except that a valve mechanism which is adapted to close the inlet ports to the area above the piston 16 is provided in the form of Figures 11 and 12 so as to close the inlet ports when such ports are not being used for injecting or admitting fluid to the area above the piston 16. With the construction of Figures 11 and 12, to be described, the collection of undesirable sediment and foreign matter in the area above the piston 16 and in the fluid inlet ports thereto is avoided so as to prevent the interference by such sediment and foreign matter with the operation of the piston 16.

Thus, in Figures 11 and 12, the body 15 has the same sleeve 17 connected thereto and the same expansible packing element 18, as well as the slips 31, wedge members 32 and springs 33. The other parts of the packer A which correspond with the parts of the packer A shown in Figures 5A and 5B bear like numerals to those in such figures. The modified valve construction of Figures 11 and 12 includes a longitudinally slidable sleeve 91 which has an outwardly extending annular radial shoulder 91a formed at its upper end for confining a spring 92 therebelow. Such spring rests upon an annular shoulder 15f formed in the bore 15b of the body 15 so that the spring 92 normally urges the slidable sleeve 91 to a raised position (Figure 12) to move the

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port or ports 91b which extend through the wall thereof to a position above a seal ring 93 (Figure 12).

In Figures 11 and 12, it will be observed that the tube 125 corresponds with the tube 25 of Figures 5A and 5B, except that it does not extend upwardly above the upper end 16c of the piston 16 and does not have any fluid ports therein as in the form of the invention shown in Figures 5A and 5B. Instead, the only ports provided for the admission of fluid to the upper end of the piston 16 is the port 91b, or ports 91b, which are in the longitudinally slidable sleeve 91.

At the lower end of the valve sleeve 91, an inwardly extending annular shoulder 91c is formed for receiving a plug X (Figure 11). The plug X shown in Figure 11 is merely an illustration of one type of plug which may be used in operating the form of the invention shown in Figures 11 and 12. Such plug X has a longitudinal body 95 which is threaded or otherwise connected to a fishing neck or head 96 at the upper end thereof. A sealing sleeve 97 with a resilient elastic sealing member 98 is positioned around the fishing head 96 and the body 95 and is constantly urged to an upper position (Figure 11) by a coil spring 99. When the plug X is seated on the annular shoulder 91c of the valve sleeve 91, fluid flow through the lower open end of the valve sleeve 91 is prevented and as will be explained, such closing of the sleeve 91 results in the application of a fluid pressure to the upper end of the sleeve 91 for moving same downwardly to position the port or ports 91b adjacent the area above the upper end 16c of the piston 16 for actuating such piston downwardly.

The operation or use of the form of the invention shown in Figures 11 and 12 is the same as explained above in connection with the operation of the packer A, except for the operation of the valve mechanism above described. Thus, when it is desired to set the packer A, having the modification of Figures 11 and 12 therewith, the plug X, or its equivalent, is dropped or lowered in the tubing string 14 and it seats itself on the annular shoulder or seat 91c of the valve sleeve 91. Fluid under pressure is then supplied through the tubing string 14 to cause the sleeve 91 to move downwardly in opposition to the spring 92. Such downward movement of the sleeve 91 necessarily results because the lower end of the sleeve 91 is closed by the plug X and all of the fluid force is applied to the upper end of the sleeve 91. Such downward movement of the sleeve 91 continues until the port or ports 91b are adjacent the upper end 16c of the piston 16, at which time the fluid pressure is directed to such upper end 16c of the piston 16 to move same downwardly for setting the packing element 18, as described above in connection with Figures 5A and 5B. When the packer A has thus been set, the spring 92 returns the sleeve 91 to its raised or upper position (Figure 12) so as to move the port or ports 91b upwardly above the lower end 15c of the body 15, and preferably above the annular elastic seal ring 93 so as to thereafter prevent any fluid flow through the port or ports 91b and so as to close the area above the piston 16 to prevent the accumulation of sediment or foreign matter in such space during the use of the packer A in carrying out the various well operations for which the apparatus is suited. The plug X can, of course, be removed in the usual manner by a fishing tool adapted to grapple or connect with the fishing neck or head 96, as is well understood.

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 is claimed is:

1. A well packer apparatus for dual production, including a tubular body having first and second longitudinal passages therethrough, a first tubing string extend-

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ing through said first longitudinal passage and a second tubing string adapted to be connected in the second longitudinal passage, an annular elastic packing element surrounding said first tubing string below said body, means on said first tubing string for supporting the lower end of said packing element, a cylinder connected to the first tubing string, a movable piston member within the cylinder and slidably mounted on the first tubing string and adapted to apply an endwise force to the upper end of the packing element to distort same into sealing position, and means for conducting a pressure fluid into the cylinder from one of said tubing strings to apply a force to the piston and packing element for effecting an expansion of the packing element into sealing position.

2. A well packer device including, a tubular mandrel, an annular packing element surrounding the mandrel, an enlargement having threaded engagement with the mandrel and having the lower end of the packing element supported thereon, a cylinder surrounding the mandrel, an annular piston slidable within the cylinder and upon the mandrel and having its lower end engaging the upper end of the packing element, whereby downward movement of the piston applies an endwise force to the element to deform said element radially outwardly into sealing position, means for conducting a hydraulic pressure into the cylinder above the piston to move the same downwardly, and locking means between the piston and the outer surface of the mandrel for locking the piston against upward movement with respect to the mandrel, whereby deformation of the packing element may be maintained even though the hydraulic pressure acting against the piston is relieved.

3. A well packer device as set forth in claim 2, wherein a rotation of the mandrel after the packing element has moved to sealing position will through the action of the threaded engagement between the mandrel and the enlargement effect upward movement of the mandrel relative to the enlargement and to the packing element, whereby the locking means and piston are moved upwardly relative to the packing element to permit return of the element to a normal undeformed position.

4. The method of positioning a plurality of well packers and tubing strings in a well bore, comprising the steps of, lowering a well packer assembly having the plurality of well packers thereon into the well bore on a first well tubing string to separate production zones, establishing communication between said first tubing string and one of the production zones, thereafter lowering a second well tubing string in the bore and landing said second well tubing string in the upper of said well packers to establish communication through said upper packer with the production zone between the packers, positioning a well head assembly in final position at the upper end of the well bore for controlling fluid flow through the tubing strings and the well bore, supporting said tubing strings from said well head assembly, and thereafter selectively setting said well packers without movement of either of the tubing strings extending from the well head assembly.

5. The method of positioning a plurality of well packers and tubing strings in a well bore, comprising the steps of, lowering said well packers into the well bore on a first tubing string to separate production zones, establishing communication between said first tubing string and one of the production zones, then lowering a second tubing string into the well bore and landing the same in the upper one of the packers to establish communication through said upper packer with the production zone between the packers, thereafter mounting the well head assembly in final position at the surface of the well for controlling the fluid flow to the tubing strings and the well bore, supporting said tubing strings from said well head assembly, circulating fluid around the well packers with the well head assembly in place, and thereafter setting

the packers in the well bore without disturbing the well head assembly.

6. The method of positioning a plurality of well packers and tubing strings in a well bore, comprising the steps of, lowering said well packers into the well bore on a first tubing string to separate production zones, establishing communication between said first tubing string and one of the production zones, then lowering a second tubing string into the well bore and landing the same in the upper one of the packers to establish communication through said upper packer with the production zone between the packers, thereafter mounting the well head assembly in final position at the surface of the well for controlling the fluid flow to the tubing strings and the well bore, supporting both tubing strings from the well head assembly, circulating fluid around the well packers with the well head assembly in place, and then applying a fluid pressure through the tubing strings to said packers to set the same in sealing engagement with the wall of the well bore.

7. A well apparatus lowered into a well bore comprising, a lower well packer having a passage therethrough and positioned within the well bore above a lower well formation, an upper well packer having a pair of passages therethrough and positioned within the well bore above an upper well formation, a first tubing string connected to said upper packer and extending to the surface and communicating with one of the passages in the said upper packer, a second tubing string separate from and independent of said first tubing string and having means for attaching it to said upper packer, said second string communicating with the second of said passages in the upper packer, a lower tubing section connecting said upper packer and said lower packer together and communicating the passage in the lower packer with one of the passages in the upper packer to establish communication between the area below the lower packer and one of said tubing strings, the other passage in said upper packer communicating the other tubing string with the area between the packers, and pressure-actuated means in each packer and operable by fluid pressure conducted downwardly through an associated one of the tubing strings for selectively setting said packers in said well bore while said tubing strings remain stationary during such setting.

8. The structure set forth in claim 7, including means forming part of the upper packer and maintaining said upper packer in set position and operable by rotation of one of said tubing strings for unsetting said upper packer from its sealing engagement with the well bore and for releasing said upper packer from said lower packer to permit the removal of said upper packer separately from the well bore.

9. The structure set forth in claim 7, including means forming part of each packer and maintaining each packer in set position and operable by rotation of one of said tubing strings for unsetting both of said packers to permit their removal from the well bore together.

10. The structure set forth in claim 7, including longitudinally slidable valve means disposed in said upper well packer and controlling fluid pressure flow between one of the tubing strings and the pressure-actuated means in said upper packer, said valve means being normally biased to close and openable by the application of fluid pressure thereto from said communicating tubing string.

11. A well completion apparatus including, a well casing within the well bore, a first well tubing string within the well casing, a pair of well packers mounted on said well tubing string, the upper packer having a passageway extending therethrough, a separate and independent second well tubing string and having means for connecting it with the passageway in the upper packer, a well head assembly mounted at the upper end of the well casing for controlling fluid flow through the tubing strings and through the casing, support means in the

well head assembly for suspending the well tubing strings longitudinally within the well casing, the lower packer having a passage through, means communicating the passage in the lower packer with one of the tubing strings to establish communication between the area below the lower packer and said first string, means communicating the other tubing string with the area between the packers, and pressure-actuated means in each packer operable while the well head assembly is in position controlling fluid flow through the strings and casing and while the well tubing strings remain stationary within the well bore for selectively setting said packers in sealing engagement with the well casing.

12. A well completion apparatus as set forth in claim 11, wherein one of said packers has an annular elastic packing element which is adapted to be expanded into sealing engagement with the well casing, and also wherein the pressure-actuated means in said packer co-acts with said annular packing element to move the same into sealing position, said pressure-actuated means being operable by fluid pressure conducted thereto through one of the tubing strings while the well head assembly is in position on the casing for applying an endwise force to the packing element to expand same into said sealing engagement, and port means for directing fluid pressure from the tubing string to the pressure-actuated means to effect such expansion of the packing element.

13. The structure set forth in claim 12, together with additional means in said last-named packer operable for locking the packing element in its sealing position when fluid pressure thereto is relieved.

14. The structure set forth in claim 13, together with packer releasing means engaging one end of the annular elastic packing element to maintain it in set position and having a connection with that tubing string upon which the packer element is mounted, said means being operable by a rotation of the tubing to permit retracting movement of the packing element to return it to its normal non-sealing position.

15. The method of completing a multiple production zone well containing drilling fluid which consists in, first lowering a plurality of unset packers and a plurality of tubing strings into the well to locate the packers in a position to separate different production zones and to communicate each of the tubing strings with a different production zone, suspending the tubing strings from their upper portions from a well head, installing well head control equipment on the well head to seal off the well, thereafter pumping the drilling fluid out of the well, then setting said packers to separate the different production zones while the well head control equipment is in its position sealing off the well, and then producing separately from each zone through one of the tubing strings.

16. In well completion apparatus for use in a well bore traversing a plurality of producing zones, the combination of control head equipment, a plurality of unset packers, and a plurality of tubing strings, said packers being in spaced relationship on said tubing strings and being located within the well in a position to separate different production zones, each tubing string having its lower portion in communication with a different formation, said control head equipment being mounted on the well head to seal off the well, means suspending the tubing strings from the well head, the unset packers permitting fluid circulation in said well bore while said tubing strings and control head equipment are in position, in the well and on the well head respectively, and means in each packer operable to set said packer while the suspending connection between said tubing strings and said control head equipment is maintained, whereby said packers separate the different production zones and direct fluid from each of said zones to one of said tubing strings.

17. In the combination set forth in claim 16, wherein each of said setting means is adapted to selectively set its associated packer.

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18. In the combination set forth in claim 16, wherein the said packers are hydraulically actuated and also wherein port means is provided between the tubing strings and said setting means in each packer whereby fluid under pressure from said tubing strings may be directed to each setting means to selectively set said packers.

19. In the combination set forth in claim 16, wherein said packers and tubing strings have unobstructed openings entirely therethrough.

References Cited in the file of this patent

UNITED STATES PATENTS

46,124 Lyon Jan. 31, 1865

381,013
597,316
2,164,195
2,177,601
2,189,701
2,189,703
2,231,282
2,335,355
2,605,637
2,624,412
2,672,934

5

10

16

Hoadley Apr. 10, 1888
Durbrow Jan. 11, 1898
Waltermire June 27, 1939
Smith Oct. 24, 1939
Burt Feb. 6, 1940
Burt Feb. 6, 1940
Norris Feb. 11, 1941
Penick et al. Nov. 30, 1943
Rhoades Aug. 5, 1952
Ragan Jan. 6, 1953
Miner Mar. 23, 1954