

Feb. 23, 1965

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3,170,518

WELL METHOD AND APPARATUS WHICH IS PARTICULARLY ADAPTED
FOR USE IN MULTIPLE ZONE WELLS

Filed May 23, 1960

2 Sheets-Sheet 1

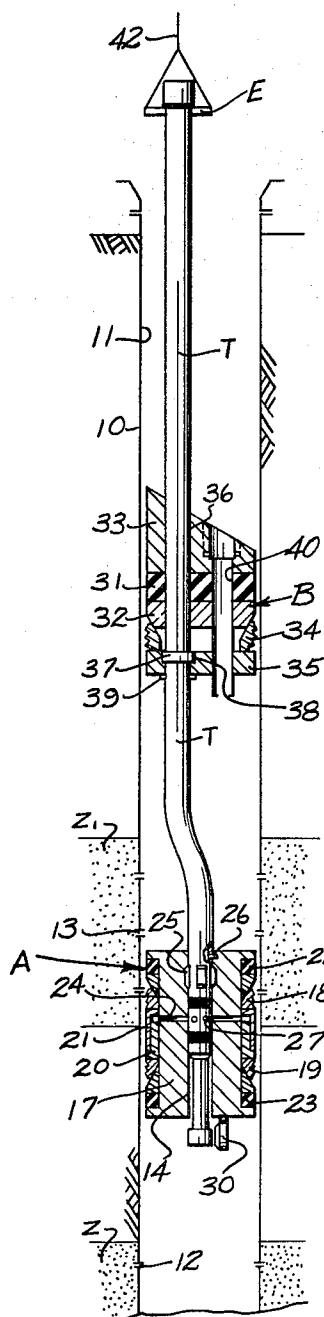


Fig. 1

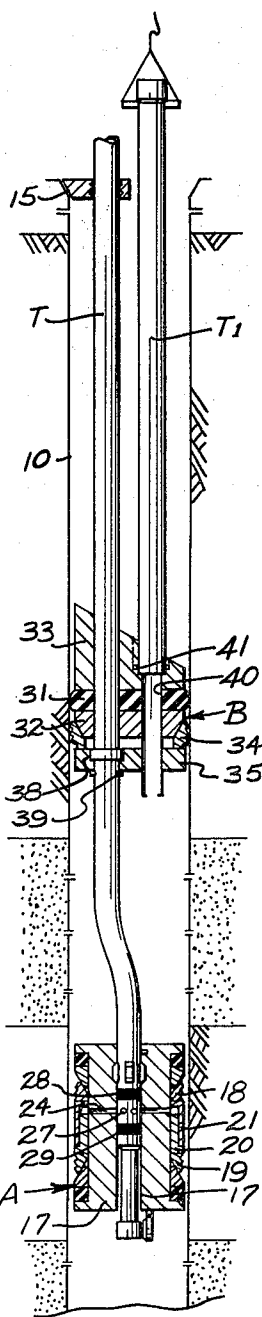


Fig. 2

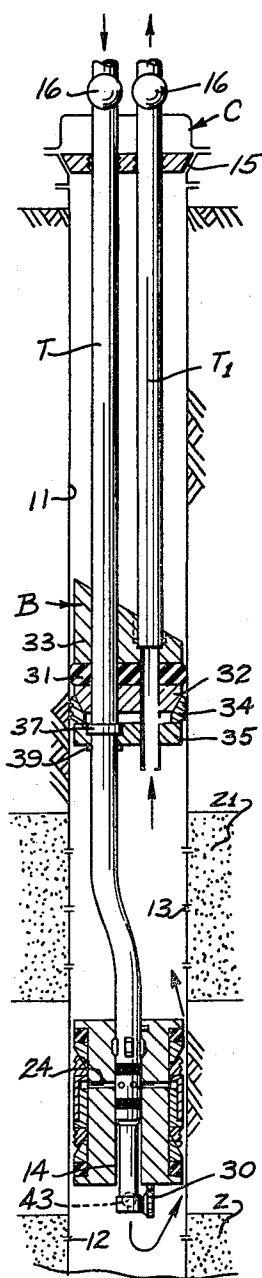


Fig. 3 CICERO C. BROWN
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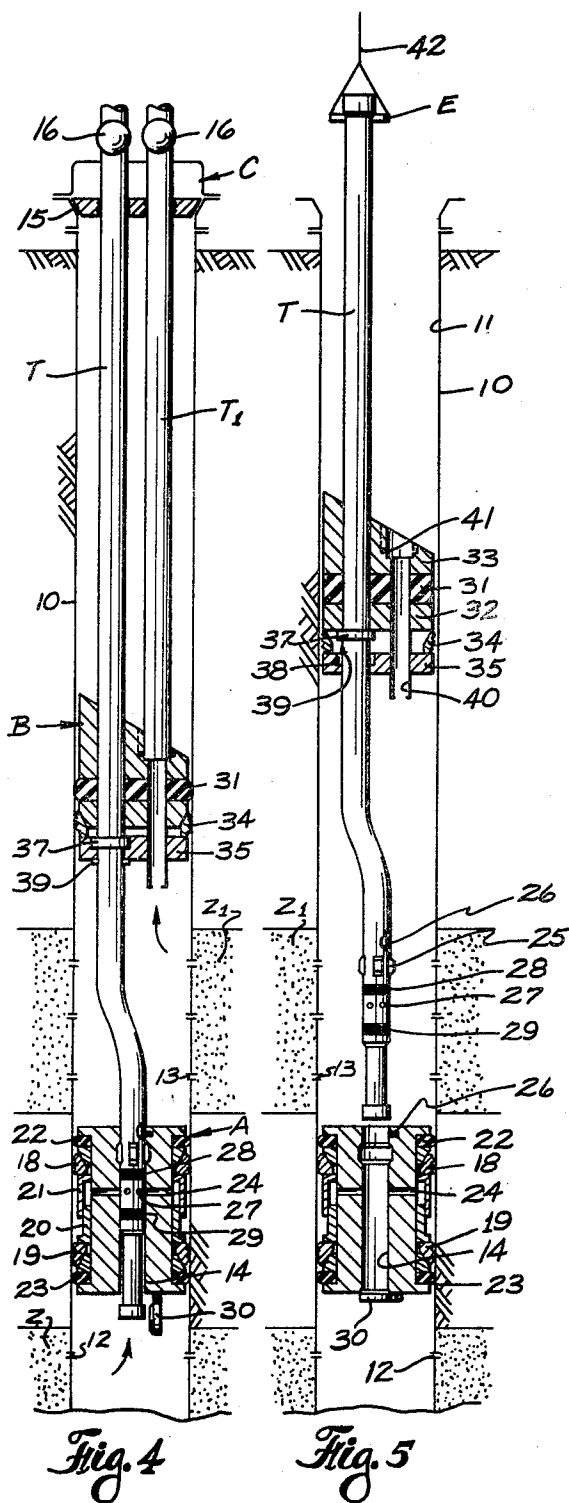
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1

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WELL METHOD AND APPARATUS WHICH IS PARTICULARLY ADAPTED FOR USE IN MULTIPLE ZONE WELLS

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Filed May 23, 1960, Ser. No. 31,189
6 Claims. (Cl. 166-48)

This invention relates to new and useful improvements in well apparatus which is particularly adapted for use in multiple zone wells and to methods of positioning said apparatus.

The simultaneous but independent production of well fluids through separate tubing strings from a plurality of producing zones traversed by a single bore has come into general use, and usually the producing zones are separated by suitable well packers. A separate tubing string is provided for each producing zone, and the apparatus is ordinarily arranged so that each tubing string may be handled independently of the other. Since the packers and strings are positioned just prior to "bringing the well in," it is desirable that the control head equipment be properly positioned at the surface before the well is unloaded, that is, before the effect of the weighted mud or fluid, which is maintaining the well under control, is removed from the producing zones or formation.

In my prior patent, No. 2,903,066, issued September 8, 1959, an improved method and apparatus is illustrated in which a pair of hydraulically actuated well packers are adapted to be positioned by a first tubing string, after which the second tubing string may be lowered; thereafter, and prior to the setting of both packers, the control head equipment may be mounted so that full control of the well is maintained during the removal of the weighted fluid from the bore. After the unloading of said weighted fluid, both packers may be set by the application of hydraulic pressure.

In certain instances it may be desirable to employ a well packer which is set by the weight imposed thereon by one of the tubing strings, as opposed to being set by hydraulic pressure; however, if two weight-set packers are employed, the setting thereof must occur at the time the tubing strings are landed, which means that circulation around the packers would not be possible after the control equipment is in place. This is a disadvantage because circulation and removal of the weighted mud would necessarily have to be carried out before the tubings are finally landed and prior to placement of said control equipment, with the result that unloading of the well would occur without proper and full control of the well.

It is, therefore, one object of this invention to provide an improved well apparatus for use in multiple zone production wells wherein a well packer adapted to be set by tubing weight is combined with a hydraulically actuated packer in such manner that the weight-set packer may be initially set by the tubing string weight, and thereafter both tubing strings may be landed and the control equipment placed prior to setting of the other packer. The arrangement makes it possible to circulate the weighted fluid upwardly to unload the well adjacent the producing zones or formations while maintaining proper control of the well.

An important object is to provide a well apparatus including a pair of tubing strings and a pair of spaced well packers, the upper one of which is arranged to be moved into set position by the weight of one of said strings, and the other of which is adapted to be moved into set position without requiring any motion of either

2

string, said packers being mounted on one string and lowerable into the bore by means of said string with the upper packer being movable into set position by the imposition of the weight of said second string thereon.

5 Still another object is to provide an apparatus, of the character described, which has all of the advantages of my prior Patent No. 2,903,066, insofar as properly maintaining control of the well during final completion thereof is concerned, but which permits the use of one well packer 10 which is set by the imposition of weight of the tubing string. The use of such weight-set packer has economic advantages in that it is of cheaper construction than an hydraulically actuated packer and also has the additional feature of providing for very accurate control of 15 setting weight applied to the packer which can be accomplished where tubing weight is the setting force.

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

20 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:

25 FIGURE 1 is a schematic view, illustrating the lower and upper well packers being lowered into the well bore on the first tubing string;

FIGURE 2 is a similar view with the first tubing string landed in final position and showing the second tubing 30 string imposing a weight on the upper packer to set the same;

FIGURE 3 is a similar view, showing the strings finally landed, the control equipment in place and circulation being carried out around the lower packer;

35 FIGURE 4 illustrates both packers in set position with well fluid flowing from the producing zones through the respective tubing strings; and

FIGURE 5 is a view, illustrating removal of the apparatus from the well bore.

40 In the drawings, the numeral 10 designates a well bore which traverses a lower producing zone or formation Z and an upper producing zone Z1. The usual well casing 11 is positioned within the well bore and is provided with perforations 12 opposite the zone Z and similar 45 perforations 13 opposite the upper zone Z1. The well fluids from the formations Z and Z1 may flow through the perforations and into the interior of the well casing.

For the purposes of separating or sealing off the producing zones Z and Z1 from each other so that each zone may be produced through its independent tubing string, a lower well packer A is adapted to be positioned between the formations Z and Z1 in the manner shown in FIGURE 4. An upper well packer generally indicated at B is arranged to be disposed above the upper 50 producing zone Z1 and a first tubing string T, which extends downwardly from the surface of the well, passes through the upper packer B and extends through the bore 14 of the lower packer A; the lower end of the tubing string T has communication with the zone or formation Z whereby the well fluids from this producing zone may be conducted to the surface through the first tubing string. A second tubing string T1 is adapted to extend downwardly in parallel relationship to the tubing T and has its lower end in engagement with the upper packer B. The lower end of the tubing string 60 T1 is in communication with the area between packers A and B, whereby production from the upper zone Z1 may be conducted to the surface through the second tubing string T1.

70 When the well packers and tubing strings are in final position as illustrated in FIGURE 4, the tubing strings

3

have been finally landed in a tubing head 15 at the upper end of the well casing. Suitable control equipment which is generally indicated by the letter C is mounted at the well head and maintains control of the well in the usual manner. Each tubing string T and T1 is provided with a suitable control valve 16.

The lower well packer A may be of any suitable construction and is a hydraulically actuated packer of the permanent type. A packer such as is illustrated in my co-pending application, Serial Number 812,263, filed May 11, 1959, now Patent No. 3,062,291, has been found satisfactory although other permanent type packers which are generally available on the open market may be employed. The packer A has been shown schematically and includes a body portion 17 having upper gripping slips 18 and lower gripping slips 19 each of which coact with expanding cones. The slips 19 abut a piston member 20 which is movable within a cylinder 21 having connection with the upper slips 18. An upper packer element 22 is disposed above the upper slips 18 while a similar lower packing element 23 is disposed below the lower slips 19. Fluid pressure conducting passages 24 extend from the bore 14 of the packer to the cylinder 21 and when pressure fluid is applied to the piston 20 and its cylinder 21, the slips 18 and 19 are moved along their respective expanding cones into gripping position with the wall of the well casing 11. After the slips are once set, they will remain in set position and the packer A is permanently mounted within the well casing. As is well known, the setting of the slips to firmly anchor the packer in place will also result in expanding the packing elements 22 and 23 whereby a permanent seal is effected.

The lower end of the first tubing string T is releasably connected by a releasable latch connection 25 within the bore of the lower packer A; a latch connection such as that disclosed and illustrated in my copending application, Serial No. 756,552, filed August 22, 1958, is satisfactory although any suitable latch connection available on the open market may be used, as the details of such latch connection form no part of the present invention. Additionally, the tubing T may be releasably connected by a shear pin 26. The extreme lower end of the tubing string T which extends through the bore 14 of the packer A is provided with radial ports 27 on each side of which is provided sealing rings 28 and 29. When the tubing string is connected to the packer A, the ports 27 establish communication between the bore of tubing string T and the passages 24 whereby when the lower end of the tubing is closed, pressure from the tubing string T may be applied through the passages to the piston 20 and cylinder 21 of packer A. As is usual with the permanent type packer, said packer is formed with a pivoted flap valve 30 at its lower end so that when the tubing string T is disconnected from packer A and removed, the valve 30 will swing upwardly to close the bore 14 of the packer.

The upper packer B is of the type which is commonly referred to as a weight-set packer. This packer includes an elastic packing element 31 which rests upon an expanding cone 32 and has its upper end confined by a head element 33. Gripping slips 34 are adapted to co-act with the inclined surface of the expander 32 and have their lower portions pivotally attached to a base plate 35 which is normally spaced from the expander 32 as shown in FIGURE 1. The usual dovetail connection between the gripping slips 34 and the expander cone 32 prevents complete separation of the gripping slips and expander cone while providing for limited longitudinal or vertical movement therebetween. A vertical passage 36 is formed through the packer B and extends completely therethrough whereby the tubing string T may extend completely through the packer B.

The tubing string T is connected to the base plate 35 of packer B by means of an annular enlargement or collar 37 which normally engages a recess 38 in the upper

4

surface of the plate 35; a shear pin 39 extends into a recess in the exterior of the tubing T and its projecting end engages the under side of the base plate to complete the connection between tubing T and packer B. With this arrangement, the tubing T may be employed to lower the upper packer B downwardly within the well as the tubing string T is run. With the lower portion of tubing string T releasably connected with the lower packer A, it will be evident that the first tubing string T may be utilized to lower both packers within the well casing, such packers being in spaced relationship in accordance with the spacing between the producing zones Z and Z1.

The second tubing string T1 is arranged to be lowered independently of the first string and as shown in FIGURE 2 is positioned within the well bore after the first string and the packers A and B have been positioned. The lower end of the string T1 is adapted to be engaged with the head element 33 of the upper packer B, such lower end engaging within a passage 40 which extends through the upper packer. It is preferable that the lower end of tubing T1 be engaged and connected with the head element 33 by means of a J-slot and pin connection generally indicated at 41. As will be explained, the weight of tubing string T1 may be applied to the upper packer B to effect a setting of the elastic sealing element 31 of said packer. The lower packer, as has been previously noted, will be set by the application of hydraulic fluid pressure through the first tubing string T.

After both strings are in place within the tubing head 15, the control equipment C is positioned. The preferred manner of operating the well apparatus is illustrated in the drawings FIGURE 1 through FIGURE 5. The drawings are schematic and illustrate the sequence of steps which are carried out in finally positioning both packers and tubing strings and in moving the packing elements thereof into their set or sealing position.

Referring to FIGURE 1, the packers A and B are connected with the first tubing string T which is run into the well by means of the usual elevators E and lowering line 42. Packers A and B are, of course, properly spaced in accordance with the spacing of the producing zones Z and Z1 and both packers are in an unset position as they are lowered into the well. Upon the packers reaching proper position to effect a subsequent separation of the producing zones Z and Z1, as shown in FIGURE 2, the first tubing string T is landed in its final position in the tubing head 15. Thereafter the second tubing string T1 is lowered into the well casing until its lower end makes connection through the J-slot 41 with the head element 33 of the upper packer. Lowering of the second tubing string is accomplished with the usual lowering equipment on the derrick floor and the second tubing string is handled separately and independently of the first string.

After the second tubing string T1 engages and is connected with the upper packer B, the weight of the tubing string is applied to the upper end of the packer B. The base plate 35 and slips 34 of the upper packer are supported by the first tubing string T by reason of the connection between said first tubing string and the base plate. Therefore, the application of weight by means of the second tubing string will result in a downward force upon the upper end of the packing element 31, which force is transmitted downwardly to the expander cone 32; this results in moving the gripping slips 34 outwardly to anchor the lower portion of the packer B to the wall of the well casing. The continued application of force by additional weight of tubing string T1 results in deforming the sealing element 31 of the upper packer into a set or sealing position in the manner shown in FIGURE 2. At this time the lower packer A is still in an unset position so that circulation around this packer is possible.

Following setting of the upper packer B by the applied weight of the second tubing string T1, said second string is landed in the tubing head 15 in the manner shown in

5

FIGURE 3. Thereafter the control head equipment C is mounted in place and the well is now under control. With the assembly as shown in FIGURE 3, the upper packer B is set but the lower packer A is still in an unset position. It is therefore possible to circulate fluid downwardly through tubing T outwardly from its lower end and such circulation will pass upwardly and around the unset lower packer A, returning to the surface through the second tubing string T1. Of course, if desired, the circulation could be downwardly through the second tubing string T1, around lower packer A and back up to the first tubing string T. In either event, the weighted fluid such as mud which is present in the well bore adjacent the producing zones Z and Z1, is circulated outwardly from the well and is brought to the surface. This results in relieving the producing zones from the effect of the weighted fluid.

After the desired circulation has been carried out, a closure which is indicated in the form of a ball 43 is dropped downwardly through the tubing string T and engages a seat (not shown) at the lower end of the tubing to close the bore thereof. Thereafter a fluid pressure is introduced into the tubing string T and this pressure is directed through the radial ports 27 and then through the lateral passages 24 to enter the space between the piston 20 and the cylinder 21 of the lower packer A. The application of pressure to the piston and cylinder results in moving the gripping slips 18 and 19 of packer A into anchoring position and at the same time accomplishes a deformation of the packing elements 22 and 23 to move the lower well packer A to its set position.

The set position of both packers A and B is illustrated in FIGURE 4 and at this time the packers function to seal off and separate the two well producing zones Z and Z1. Production of well fluids from the lower zone Z can then occur upwardly through the first tubing string T, the upward flow resulting in bringing the closure 43 to the surface. Well fluids from the upper producing zone Z1 may flow upwardly through the second tubing string T1.

If for any reason it becomes necessary to pull the tubing strings T and T1 and to remove the upper packer B from the well, this is accomplished by first disconnecting the pin and J-slot connection 41 between the second tubing string T1 and the upper well packer, after which the second tubing string T1 may be removed from the well. Its removal may be handled independently and separately of string T which would, of course, remain in position at this time. When the weight of the second tubing string T1 is removed from the upper packer B, the force maintaining this packer in its set position is removed and there is a tendency for the elastic packing element 31 thereof to return to its initial position.

Upon an upward movement of the first tubing string T, the shear pin 26 between the lower packer A and the tubing string T is sheared after which the releasable connection 25 permits removal of the tubing T from the lower packer A in the manner shown in FIGURE 5. However, prior to the removal of the tubing T from connection with packer A, the shear pin 39 connecting the tubing T to the under side of the base plate 35 of upper packer B is sheared and this allows the enlargement or collar 37 of tubing T to engage beneath the expander plate 32 of said upper packer. Further upward movement of tubing T results in the parts assuming the position in FIGURE 5 in which position the upper packer B is fully released and may thereafter be removed along with the tubing T. As has been noted, the usual dovetail connection between the slips 34 and the expander cone 32 may be utilized to prevent the slips and base plate 35 from sliding down the tubing T when the various parts are in the FIGURE 5 position. The lower well packer A, being of a permanent type, remains in the well bore and its flap valve 30 merely closes to close the bore 14 of said lower packer, whereby the packer becomes a

6

plug in the well to shut off the flow from the lower producing zone Z.

The tubing T and upper packer B may be brought to the surface and may thereafter be returned to the well bore in the manner hereinbefore described. After the first tubing string and upper packer have been repositioned with the lower end of the tubing string T again extending through the bore 14 of the lower packer A, the second string may be again run, the tubing strings landed and the control equipment positioned so that well production from the two zones through the independent strings may be again carried out.

It is noted that with the present well apparatus the upper well packer is a weight-set packer which is under the control of the application of weight by the second tubing string. The lower well packer is hydraulically-set which means that it can be moved into a set position without any motion of either of the tubing strings. It is, therefore, possible to set the upper packer (FIGURE 3), finally land both tubing strings, place the control head equipment C in position and then circulate around the lower unset packer. This circulation can be carried out while the well is under control of the equipment C and thus there is no danger of blowout during the unloading of the producing formations. After circulation has been accomplished, the lower packer A can be moved into its set or sealing position without having to impart any motion to either of the strings T and T1 and without disturbing the control head equipment. This makes it possible to unload both producing formations and bring in the well so that the well fluids from each zone are brought to the surface while maintaining the well under full and complete control.

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 apparatus for producing well fluids from upper and lower fluid producing zones traversed by a well bore, including,
 - a lower well packer located between the producing zones,
 - an upper well packer located above the upper producing zone,
 - a first tubing string connected with and supporting both well packers and having its lower end communicating with the lower zone below the lower packer,
 - said lower well packer including hydraulically-actuated means for moving said packer into set position and means communicating the hydraulically-actuated means with the bore of said first tubing string whereby pressure may be applied to said hydraulically-actuated means through said tubing to set said lower packer without manipulation of the tubing,
 - a second tubing string lowerable independently of the first string and well packers,
 - said upper well packer having means actuated by the imposition of weight for moving the packer into set position, said second tubing string being engageable with said upper packer to impose its weight thereon to set the same into sealing position with the wall of the well bore,
 - said second string having its lower end communicating with the upper producing zone between the packers,
 - and means for directing fluid pressure through said first tubing string to the hydraulically-actuated means of the lower packer subsequent to the setting of the upper packer to move said lower packer into set position within the well bore.
2. A well apparatus as set forth in claim 1, wherein

the second tubing string is disengageable from said upper packer to permit said second tubing string to be removed from the bore independently of the first string,

and means connecting the upper well packer to the first tubing string whereby said upper packer is removed with the first string when said first string is removed from the well.

3. A well apparatus for producing well fluids from upper and lower fluid producing zones traversed by a well bore, including,

a lower well packer located between the producing zones,

an upper well packer located above the upper producing zone,

a first tubing string connected with and supporting both well packers and having its lower end communicating with the lower zone below the lower packer,

said lower well packer including hydraulically-actuated means for moving said packer into set position and means communicating the hydraulically-actuated means with the bore of said first tubing string whereby pressure may be applied to said hydraulically-actuated means through said tubing to set said lower packer without manipulation of the tubing,

a second tubing string lowerable independently of the first string and well packers,

said upper well packer having means actuated by the imposition of weight for moving the packer into set position, said second tubing string being engageable with said upper packer to impose its weight thereon to set the same into sealing position with the wall of the well bore,

said second string having its lower end communicating with the upper producing zone between the packers, means at the surface of the well bore for landing both tubing strings in final position after the upper packer has been set, but before setting of the lower packer, control head equipment at the upper end of the well bore for closing in said well, whereby circulation through the tubing strings and around the unset lower packer may be carried out after the upper packer has been set and the tubings landed,

and means for directing pressure through said first tubing to the hydraulically-actuated means of the lower packer subsequent to the setting of the upper

packer to move said lower packer into set position within the well bore.

4. A well apparatus as set forth in claim 3 wherein the second tubing string is disengageable from the upper packer and is removable from the bore independently of the first tubing string,

and means detachably mounting the lower well packer on the first tubing string whereby said first tubing string and upper well packer may be removed separately from the lower well packer.

5. The method of positioning and setting a lower hydraulically-actuated well packer and an upper weight-set well packer and a pair of tubing strings within a well bore including,

lowering both packers in unset condition on a first tubing string into the well bore,

landing said first string in final position within the bore to locate said packers in final position,

thereafter lowering a second tubing string into the bore and connecting it with the upper packer,

imposing the weight of the second string on said upper packer to set the same by the imposition of weight, landing second tubing string in final position,

mounting control head equipment on the upper end of the well to control the same,

circulating fluid through the tubing strings and around the unset lower packer,

and finally setting the hydraulically-actuated lower packer while the tubing strings and control head equipment remain in place.

6. The method as set forth in claim 5, wherein setting of the lower packer is accomplished by applying hydraulic pressure to said lower packer through the first tubing string.

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