Feb. 21, 1961 C. C. BROWN 2,972,379

PRESSURE OPERATED DUAL COMPLETION APPARATUS AND METHOD OF POSITIONING SAME IN A WELL BORE

Filed May 6, 1955 2 Sheets-Sheet 1

Fig. 2

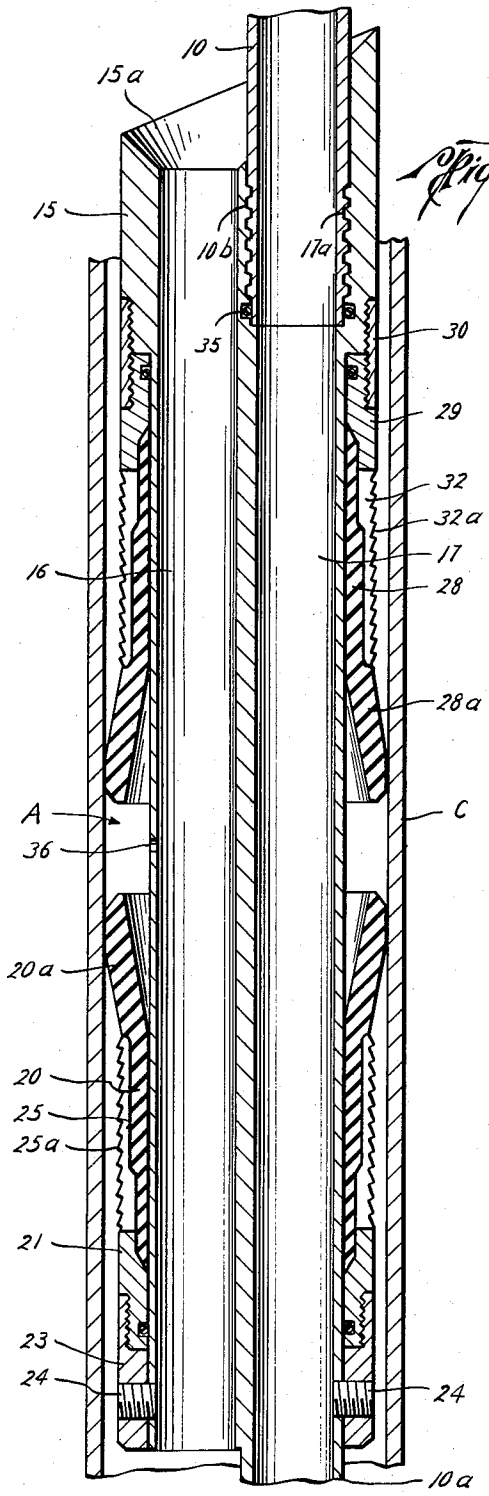
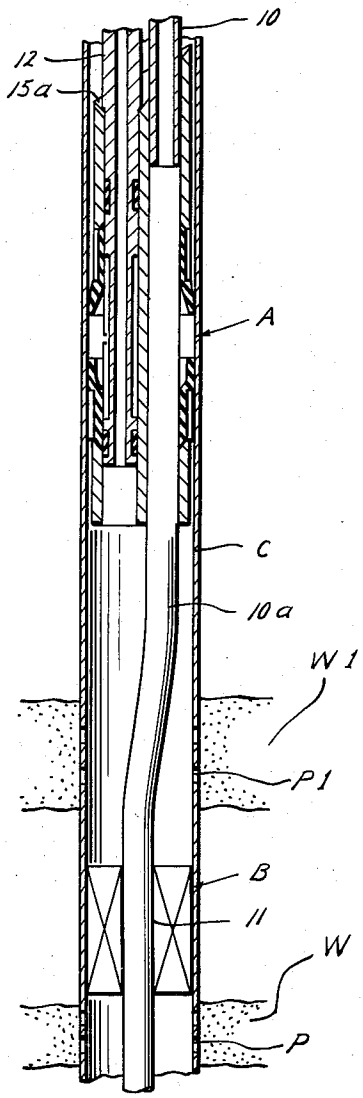


Fig. 1



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Fig. 3

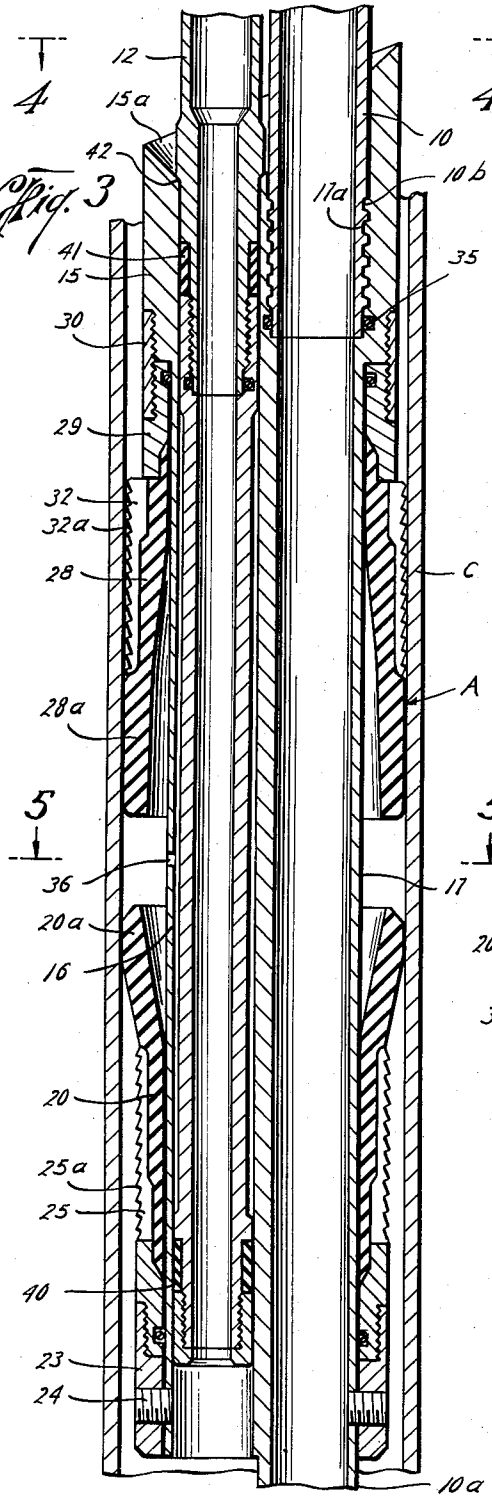


Fig. 4

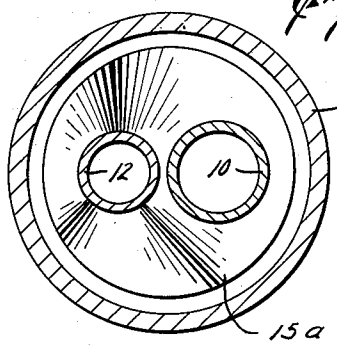
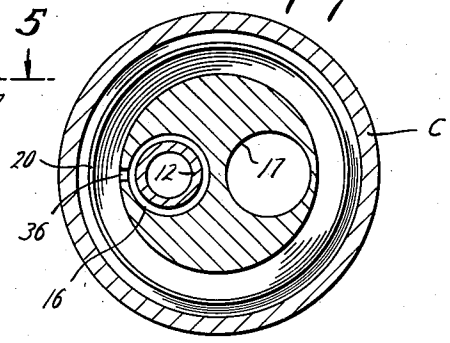


Fig. 5



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PRESSURE OPERATED DUAL COMPLETION APPARATUS AND METHOD OF POSITIONING SAME IN A WELL BORE

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15 Claims. (Cl. 166—46)

This invention relates to new and useful improvements in well apparatus and methods of running same in a well bore.

The invention relates especially to improved dual completion apparatus including, an upper well packer assembly which is positionable in the well bore by a differential in fluid pressure on either side of the packer; and to the method of positioning the apparatus in a well bore.

An object of this invention is to provide a means for equalizing fluid pressure between the packing cups of such well packer prior to the insertion of a detachable tubing string, whereby the lowering and raising of the upper well packer in the bore or casing is facilitated.

Another object of the invention is to provide a packer including, means permitting a detachable tubing string to be held in position with the packer by simply imposing a portion of the weight of the detachable tubing string on the packer.

Another object of the invention is to provide an improved method of positioning an upper well packer for a dual completion operation including, the step of equalizing fluid pressure between the packing cups of the well packer prior to the connection of the detachable tubing string to the upper well packer, so that the lowering and raising of the upper packer is facilitated.

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 view, partly in elevation and partly in section, which illustrates the apparatus of this invention diagrammatically for carrying out the method of this invention.

Figure 2 is a view, in section, illustrating the upper packer assembly in the position it assumes during the raising or lowering thereof in the well bore or casing.

Figure 3 is a view, in section, similar to Figure 2 but illustrating the upper packer assembly in its set position in the well bore or casing and with the second tubing string connected therewith.

Figure 4 is a horizontal sectional view taken on line 4—4 of Figure 3 and illustrates in particular the guide surface at the upper end of the upper packer assembly.

Figure 5 is a horizontal sectional view taken on line 5—5 of Figure 3.

In the drawings, the letter A designates generally the improved packer or packer assembly of this invention which is adapted to be lowered into a well pipe or casing C and set in a position above a second or lower well packer B (Figure 1). The well packer A has one tubing string 10 which extends to the surface of the well and which is normally used for the lowering and raising of the upper packer or packer assembly A in the well bore or casing C. A lower tubing section 10*a* extends downwardly from the upper packer A and through the bore 11 of the lower packer B when the upper packer A is in its set position in the bore or casing C. Such well packer B may be of any conventional construction such as a packer of the type which is lowered into the well casing and set therein on a wire line so as to leave the open bore 11 therethrough for receiving the lower tubing section 10*a*, an example of which is disclosed in my U.S. Patent No. 2,739,651. As will be explained more fully hereinafter, the packer A is so constructed that the pressure fluid is equalized above and below and between the packing elements thereof during the lowering of the packer A into its predetermined position with the lower tubing section 10*a* extending through the packer B. However, after the packer A has been so positioned, the second tubing string 12 is lowered into the well bore or casing C and is positioned with the packer A so as to close off the equalizing pressure fluid and thereafter the differential in the well fluid pressure effects a setting of the packer A in gripping and sealing engagement with the interior of the casing C.

The packer B is set between well formations W and W–1 while the packer A is set above the well formation W–1. The well casing C is, of course, perforated in the usual manner so that the perforations P establish communication between the lower formation W and the interior of the casing below the packer B while the perforations P–1 establish communication between the upper formation W–1 and the area interiorly of the casing between the packers A and B. With such arrangement, fluid flow from the lower formation A may occur through the tubing string 10 and at the same time flow from the upper well formation W–1 may be conducted through the tubing string 12.

In Figures 2–5, the details of the upper packer or packer assembly A are illustrated. The packer or packer assembly A has a tubular body 15 which is formed with longitudinal passages or bores 16 and 17 which are preferably parallel to each other and extend from the upper end of the body 15 to the lower end thereof. The lower tubing section 10*a* forms a continuation of the longitudinal passage 17, as illustrated in Figures 2 and 3, but it will be appreciated that such tubing extension 10*a* can be disposed below the longitudinal passage 16, if so desired, but ordinarily the construction will be as illustrated in the drawings.

A lower packing or sealing cup or element 20 which is formed of rubber or other resilient material surrounds the lower portion of the body 15 of the packer assembly A and is provided with an upwardly and outwardly extending lip or flared portion 20*a* which is adapted to be urged outwardly into sealing engagement with the interior of the casing C by a fluid pressure acting from above the sealing cup 20 and within the sealing cup lip portion 20*a* with a force greater than the fluid pressure below such sealing cup or element 20. The sealing cup or element 20 is connected to the body 15 by a retaining ring 21 which is molded or otherwise secured to the cup or element 20 and which is in turn threaded or otherwise suitably connected to another ring 23 which has screws 24 or similar means extending through the ring 23 and into the wall of the body 15. Thus, the packing element or cup 20 is prevented from moving longitudinally relative to the body 15, but it is adapted to be moved outwardly by a pressure differential which is greater above the packing cup than therebelow. Also, the cup 20 is adapted to be moved inwardly when the pressure fluid below the cup 20 is greater than thereabove so that the fluid can pass upwardly around the cup or element 20 when such condition exists. A plurality of arcuate slip segments 25 having gripping teeth 25*a*, which preferably extend downwardly, are molded or otherwise secured to the external

surface of the sealing cup 20 below the flared or lip portion 20*a* of the cup or element 20. When the flared portion 20*a* is expanded outwardly into sealing contact with the casing C, the slip segments 25 are also moved outwardly and into engagement with the interior of the casing C for gripping engagement therewith so as to prevent downward movement of the body 15 by reason of the fluid force expanding the sealing element or cup 20 outwardly into its sealing engagement.

Near the upper portion of the body 15, an upper sealing element or cup 28 is mounted around the external surface of such body 15 with the flared portion 28*a* which extends downwardly and outwardly facing the upwardly and outwardly extending flared portion 20*a* of the sealing element 20, whereby the sealing elements are mounted in opposed relationship. The upper end of the sealing element 28 is molded or otherwise secured to a retaining ring 29 which is held on the body 15 by means of a collar 30 which is threaded, or otherwise secured, to both the ring 29 and the body 15. Thus, the sealing element 28 is prevented from moving longitudinally with respect to the body 15, but upon the application of a predetermined fluid differential which acts upon the flared portion 28*a*, the cup 28 is expanded or distorted into sealing engagement with the interior of the casing C. The sealing cup 28 also has molded or otherwise secured thereto a plurality of gripping or slip segments 32 which have upwardly extending gripping teeth 32*a* formed thereon so that as the sealing cup or element 28 is expanded or moved outwardly into sealing engagement with the casing C, the gripping members or slips 32 are moved into gripping engagement with the interior of the casing C also, whereby the body 15 is prevented from moving upwardly when the fluid pressure acting upwardly on the cup 28 is in excess of the pressure acting downwardly thereon.

During the lowering or running in of the apparatus A into the well bore or casing C for positioning the lower tubing extension 10*a* within the bore 11 of the lower packer B, the tubing string 10 is connected to the packer A for such lowering operation. The particular connection of the tubing string 10 to the body 15 can be any number of known types of connections, but as illustrated in the drawings, such connection is effected by relatively coarse external threads 10*b* which are formed on the lower end of the tubing string 10 and which are in threaded engagement with relatively coarse internal threads 17*a* which are disposed near the upper end of the longitudinal passage 17. Preferably such threads 10*b* and 17*a* are of the acme type and are left-hand threads so that the tubing string 10 is released from the packer assembly A upon a rotation of the tubing string 10 to the right. It will be noted that an O-ring 35 which is formed of rubber or other resilient material is mounted below the internal threads 17*a* in the bore or passage 17 so as to engage the external surface of the tubing string 10 below the threads 10*b* to provide for sealing engagement therewith to prevent the flow of fluid around the outside of the tubing string 10 from the passage 17, whereby all of the fluid from the passage 17 is directed upwardly into the interior of the tubing string 10.

During the running in or lowering of the packer or packer assembly A into the well bore or casing C on the tubing string 10, the second tubing string 12 is ordinarily not in position with respect to the packer or packer assembly A, but instead the passage 16 is open so that fluid can pass upwardly or downwardly therethrough. In this connection, an equalizing port or ports 36 are provided through the wall of the body 15 to establish communication from the passage 16 to the area between the sealing elements or cups 20 and 28. Such communication thus permits fluid from the bore 16 to pass into the area between the sealing elements or cups 20 and 28 so as to equalize the pressure between the cups as well as above and below such cups, whereby the sealing cups 20 and 28 are not urged outwardly by the fluid pressure, but simply assume their normal undistorted position as the packer or packer assembly A is lowered into, or removed from, the well bore or casing C (Figure 2).

When the packer assembly A has reached the predetermined position in the well bore or casing C at which it is desired to set same and at which the lower tubing section 10*a* extends through the bore 11 of the packer B, then the tubing string 12 is lowered into the well bore or casing C. The upper end of the body 15 is inclined at 15*a* downwardly and inwardly towards the upper end of the passage 16 so that as the lower end of the tubing string 12 contacts the upper inclined surface 15*a*, it is automatically guided into the passage 16. The upper end 15*a* is thus actually concave or dished, and preferably at an angle of about 45° downwardly and inwardly toward the upper end of the passage 16.

The lower end of the tubing string 12 is provided with longitudinally spaced annular seals 40 and 41 which are formed of rubber or other resilent material and which are adapted to engage in sealing contact with the internal surface of the passage 16. When the tubing string 12 is in position with the packer or packer assembly A, the seal 41 is above the equalizing port 36 and the seal 40 is below the equalizing port 36 so that the fluid cannot pass from the passage 16 to the port 36 when the tubing string 12 is in position. In such case, if the pressure below the packer or packer assembly A is greater than the pressure thereabove, the fluid under pressure will pass upwardly around the external surface of the sealing element or cup 20 and into the area between the cups 20 and 28 and will urge the upper sealing element or cup 28 outwardly into sealing contact with the casing C and likewise will carry outwardly the gripping slips or members 32 into gripping engagement with such casing C. Thus, the upper packer A is set by the differential in the fluid pressure above and below such packer when the tubing string 12 is in its connected or seated position. The tubing string 12 is not ordinarily latched or threaded into its connected position, but instead it is maintained in such position by merely imposing the weight, or a portion thereof, of the tubing string 12 on the packer A so as to hold the annular shoulder 42 formed on the tubing string 12 in seated contact with the upper end 15*a* of the body 15. The annular shoulder 42 is, of course, positioned above the seal 41 and is positioned a sufficient distance above the lower seal 40 so that when the shoulder 42 is seated in contact with the inclined surface 15*a*, the seals 40 and 41 span the equalizing ports 36 to seal off such port against fluid flow therethrough. It will be evident, therefore, that the tubing string 12 is positioned with the well packer or packer assembly A by simply lowering same downwardly in the casing or bore C and is similarly removable from the packer or packer assembly A by simply lifting upwardly on the tubing string 12.

The operation of the apparatus of this invention, and the use of such apparatus in carrying out the method of this invention, involves initially the setting of the lower packer B in the manner such as is disclosed in my U.S. Patent No. 2,739,651. The packer B is thus set between the well formations W and W–1 with the bore or central passage 11 thereof open. Thereafter, the upper packer or packer assembly A is lowered into the well bore or casing C on the tubing string 10 to initially position the lower tubing section 10*a* in the bore 11 of the packer B so as to establish fluid communication between the well formation W and the interior of the tubing string 10. The packer A is lowered until it is positioned above the upper well formation W–1. Then, the tubing string 12 is lowered into the well bore or casing C, and as the lower end of the tubing string 12 contacts the upper end 15*a* of the packer A, it is guided into the passage 16 so as to close off the port 36 with the seals 40 and 41 (Figures 1 and 3). Thereafter, a differential in well-fluid pressure above and below the packer A acts to urge either

the upper cup **28** or the lower cup **20** outwardly into sealing engagement with the casing C. Thus, if the pressure above the packer A is greater than the pressure therebelow, the lower packing cup **20** will be urged outwardly into sealing contact with the casing C, but if the pressure therebelow is greater than the pressure above the packer A, then the upper cup **28** is urged outwardly into sealing engagement with the casing C (Figure 3). Sufficient weight is imposed on the tubing string **12** to maintain it in its seated position with the annular shoulder **42** resting upon the upper surface **15***a* of the body **15**. When it is desired to remove the apparatus of this invention from the well bore casing C, the tubing string **12** is ordinarily disconnected first so as to equalize the fluid pressure above and below the packer or packer assembly A and to therefore cause the cups **20** and **28** to return to a normal retracted position (Figure 2), whereupon the packer A and lower tubing extension **10***a* connected therewith are removed upwardly in the well bore casing. Thereafter, the lower wire line packer B is also removed, if desired.

It should be noted that the tubing string **10**, upon which the packer A is suspended during the lowering thereof into the well casing C, can be disconnected and removed from the packer A after the tubing string **12** is positioned in the packer A since the fluid pressure differential in the well acts to maintain same in a set position. Also, such tubing string **10** can be reconnected if it is disconnected while the packer A is in the set position in the casing C, by simply lowering the tubing string **10** and the upper surface **15***a* will guide the lower end of the tubing string **10** into the upper portion of the passage **17** and thereafter upon a rotation of the tubing string **10** to the left, the threads **10***b* and **17***a* will be reconnected.

Although the invention has been illustrated with only one embodiment thereof wherein the packing elements of the upper packer are disposed in a direction facing each other, it will be evident that the invention includes other types of fluid-set well packers.

The foregoing disclosure and description of the invention is illustrative and explanatory thereof and various changes in the size, shape and material, 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 apparatus adapted to be lowered into a well bore including, a lower well packer within the well bore above a lower well formation, an upper packer assembly within the well bore above an upper well formation, said assembly including a body having two longitudinal passages therethrough, sealing means carried by said body for sealing with the wall of the well bore, said sealing means being movable into sealing engagement with the wall of the well bore responsive to a differential in pressure across the sealing means, a first tubing string connected to said body for lowering said upper packer assembly into the well bore, said first tubing string communicating with one of the passages in the body, an equalizing port extending through the wall of the body and having its inner end in communication with the other of said passages within the body, whereby said port and passage allows an equalization of pressures on opposite sides of the sealing means during lowering of the upper packer into the well bore, a second tubing string adapted to be lowered into the well bore after the first string and upper packer have been positioned in the well bore above said upper formation, said second tubing string being movable into that passage having the equalizing port therein and closing off said port when in position in said passage, whereby a fluid pressure differential may be built up across the sealing means to move said sealing means into sealing engagement with the wall of the well bore, means for establishing communication between one of the well formations and the first tubing string, and additional means establishing communication between the other well formation and the second tubing string.

2. A well apparatus as set forth in claim 1, together with gripping means carried by said body and operable by a fluid pressure differential thereacross to effect a gripping engagement with the wall of the well bore.

3. A well apparatus adapted to be lowered into a well bore comprising, a lower well packer within the well bore above a lower well formation, an upper well packer assembly including, a body having two longitudinal passages therethrough, a flexible packing cup carried by said body adapted to be moved into sealing engagement with the wall of the well bore responsive to a differential in fluid pressure across the packing means, a first tubing string connected to said body in communication with one of said passages in said body for lowering said packing assembly into the well bore to a position above an upper well formation, an equalizing port in said body providing for fluid communication between the other of said passages and across the packing means, a second tubing string adapted to be lowered into the well bore after said packer assembly is positioned in the well bore above the upper well formation to position the lower portion of said second tubing string in the other of said passages to thereby close said equalizing port and to communicate through said other of said passages with the upper well formation, whereby said packing cup will be moved into sealing engagement with the bore, and means providing fluid communication between said first tubing string and the area below the lower well packer.

4. The structure set forth in claim 3, including means for disengaging said second tubing string from said body upon an upward nonrotative movement thereof relative to said body.

5. The structure set forth in claim 3, including a guide means on the upper end of said body for guiding said second tubing string into said other of said passages after said upper packer assembly has been positioned in the well bore above the upper well formation.

6. A well apparatus adapted to be lowered into a well bore comprising, a well packer assembly adapted to be positioned above a well formation including, a body having at least one longitudinal passage therethrough communicating with the well formation, an annular packing means on said bodq adapted to be moved into sealing engagement with the wall of the well bore, said packing means including a plurality of longitudinally spaced flexible packing cups mounted on said body facing in opposite directions, the peripheral portion of each of said packing cups being movable one at a time into sealing engagement with the wall of the well bore by a fluid-pressure differential across the packing means, means connected to said body for lowering said packer assembly into the well bore, said body having an equalizing port establishing communication between said passage and the area between the packing elements to equalize the fluid pressure above and below each of the packing elements, and a tubing string adapted to be lowered into the well bore after said packer assembly is positioned in the well bore above an upper well formation, said tubing string closing said equalizing port when the lower portion of said second tubing string is positioned in said passage to thereby permit a fluid-pressure differential across the packer assembly to move one of the packing cups outwardly into sealing engagement with the wall of the well bore.

7. The structure set forth in claim 6, including gripping slips associated with each packing element and adapted to be moved into gripping engagement with the wall of the well bore when the packing element therewith is moved into sealing engagement with the wall of the well bore.

8. The structure set forth in claim 6, including gripping slips associated with each packing element and

adapted to be moved into gripping engagement with the wall of the well bore when the packing element therewith is moved into sealing engagement with the wall of the well bore, and means for detaching said means connected to said body from the body when one of said upper elements and the gripping slips therewith are in engagement with the wall of the well bore.

9. A well apparatus adapted to be lowered into a well bore comprising, a lower well packer within the well bore above a lower well formation, an upper well packer assembly including, a body having two longitudinal passages therethrough, a flexible packing cup carried by said body adapted to be moved into sealing engagement with the wall of the well bore responsive to a differential in fluid pressure across the packing means, a first tubing string connected to said body in communication with one of said passages in said body for lowering said packing assembly into the well bore to a position above an upper well formation, an equalizing port in said body providing for fluid communication between the other of said passages and across the packing means, a second tubing string adapted to be lowered into the well bore after said packer assembly is positioned in the well bore above the upper well formation to position the lower portion of said second tubing string in the other of said passages to thereby close said equalizing port, means providing fluid communication between said first tubing string and one of said well formations, and additional means providing fluid communication between the second tubing string and the other well formation.

10. A well apparatus adapted to be lowered into a well bore including, a lower well packer within the well bore above a lower well formation, an upper packer assembly within the well bore above an upper well formation, said assembly including a body having two longitudinal passages therethrough, sealing means carried by said body for sealing with the wall of the well bore, said sealing means being movable into sealing engagement with the wall of the well bore responsive to a differential in pressure across the sealing means, a first tubing string connected to said body for lowering said upper packer assembly into the well bore, said first tubing string communicating with one of the passages in the body, means carried by the packer assembly having a portion thereof communicating with the bore of the other of said passages for allowing an equalization of pressures across the sealing means, a second tubing string adapted to be lowered into the well bore after the first string and upper packer have been positioned in the well bore above said upper formation, said second tubing string being movable into the passage having said equalizing means in communication therewith and closing off said equalizing means, whereby a fluid pressure differential may be built up across the sealing means to move the latter into sealing engagement with the wall of the well bore, means establishing communication between one of the well formations and the first tubing string, and additional means establishing communication between the other well formation and the second tubing string.

11. The method of lowering a plurality of tubing strings into a well bore comprising, the steps of, setting a first well packer within the well bore, lowering a fluid-set second well packer into the well bore on a first string of tubing to position said second packer in spaced relationship above the first well packer, establishing communication between the area between the packing elements of the second well packer and the area above and below said second well packer to prevent setting thereof during said lowering step, thereafter lowering a second tubing string in the well bore and mounting same within the second packer to close the communication between the area between the packing elements on the one hand and the area above and below said elements on the other hand to permit a differential in the well fluid pressure to urge one of the packing elements into sealing engagement with the wall of the well bore, establishing communication between the area below the first packer and one of the tubing strings, and establishing communication between the other tubing string and the area between the packers.

12. The method as set forth in claim 11, together with the additional step of, imposing a portion of the weight of the second tubing string on the second well packer to maintain said second tubing string mounted with said second packer in the well bore.

13. The method as set forth in claim 11, including the additional step of, raising said second tubing string upwardly without rotation to release same from its mounted position with the second well packer.

14. The method set forth in claim 11, together with the additional step of, releasing the first tubing string from the second well packer after the second packer is set in the well bore to permit removal thereof independently of the first tubing string and the second packer.

15. The method of lowering a plurality of tubing strings into a well bore comprising, the steps of, setting a first well packer within the well bore above a lower well formation, lowering a fluid-set second well packer having two longitudinal passages therethrough into the well bore on a first string of tubing to position said second packer in spaced relationship above the first packer and above an upper well formation, establishing communication from one of said passages in the second packer to said first string of tubing, establishing communication from the bore of the other of the passages to the area between the packing elements of the second packer, thereafter lowering a second tubing string into the well bore and mounting same with the second packer to close off the communication from the bore of said other passage to the area between the packing elements of the second packer to thereby permit a fluid-pressure differential in the well bore to urge one of the packing elements of the upper packer into sealing engagement with the wall of the well bore, establishing communication between the area below the first packer and one of the tubing strings, and establishing communication between the other tubing string and the area between the packers.

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