

June 20, 1961

C. C. BROWN
DUAL COMPLETION APPARATUS AND METHOD OF
POSITIONING SAME IN A WELL BORE

2,989,121

Filed April 29, 1955

4 Sheets-Sheet 1

Fig. 1

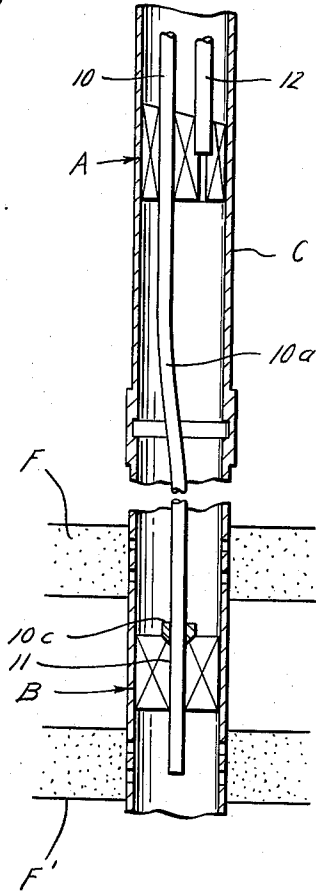


Fig. 3

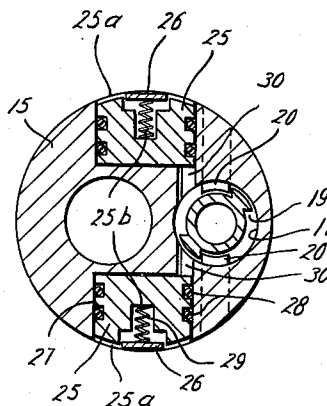
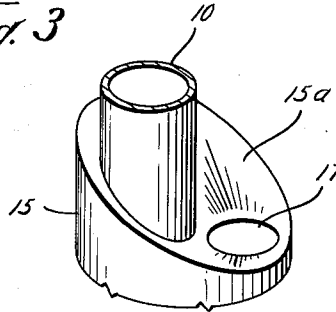


Fig. 4

Fig. 5

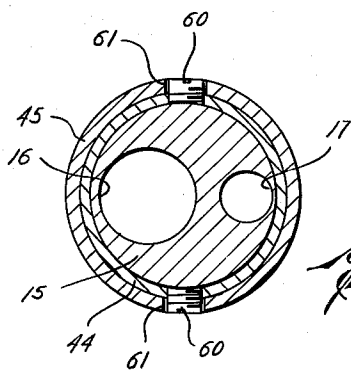
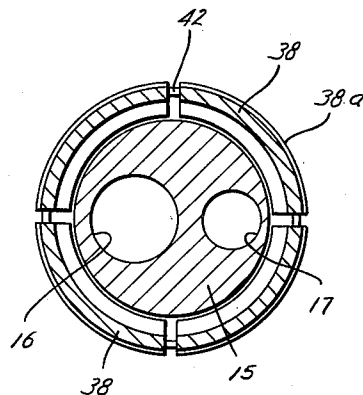


Fig. 6

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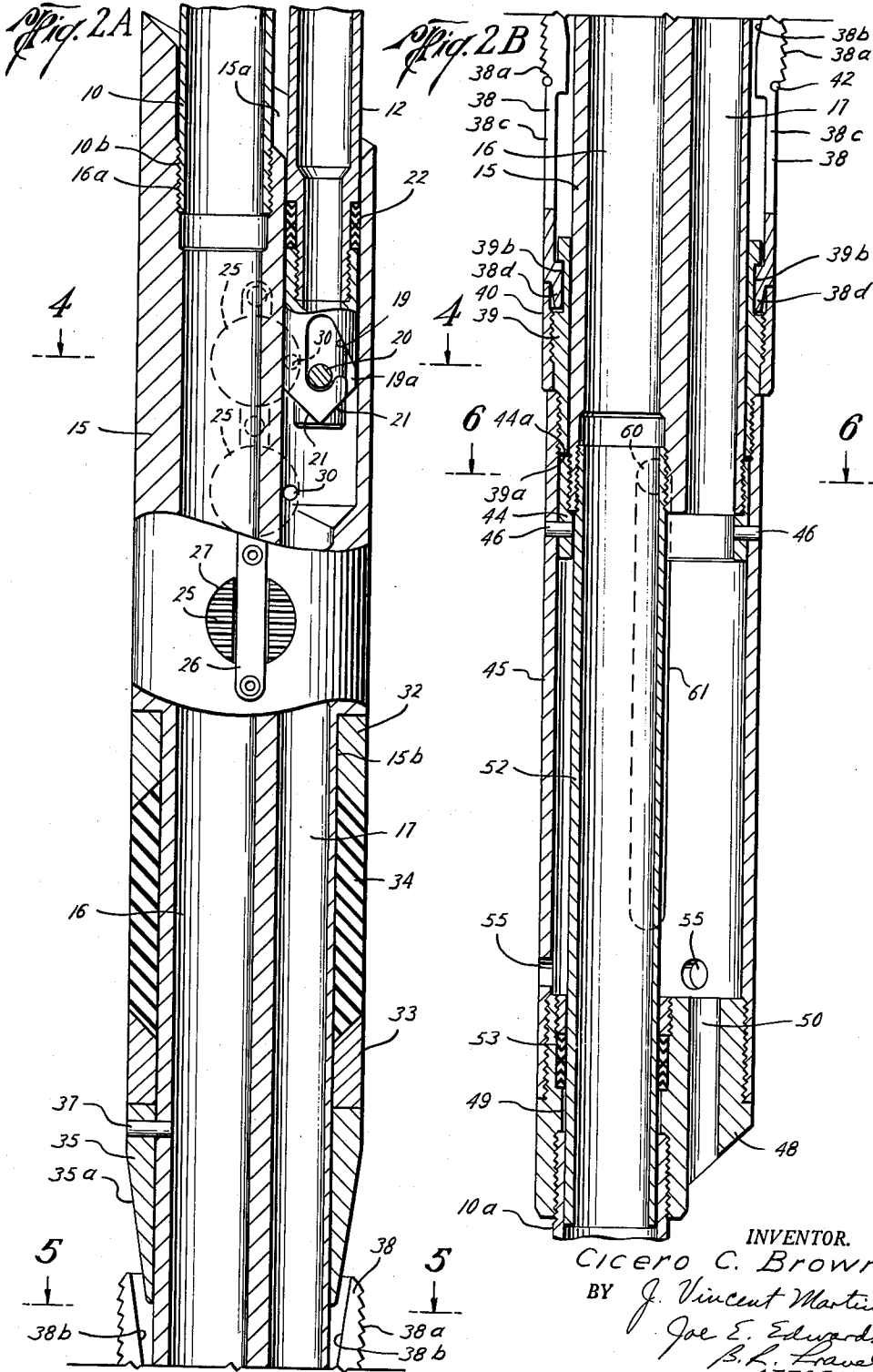
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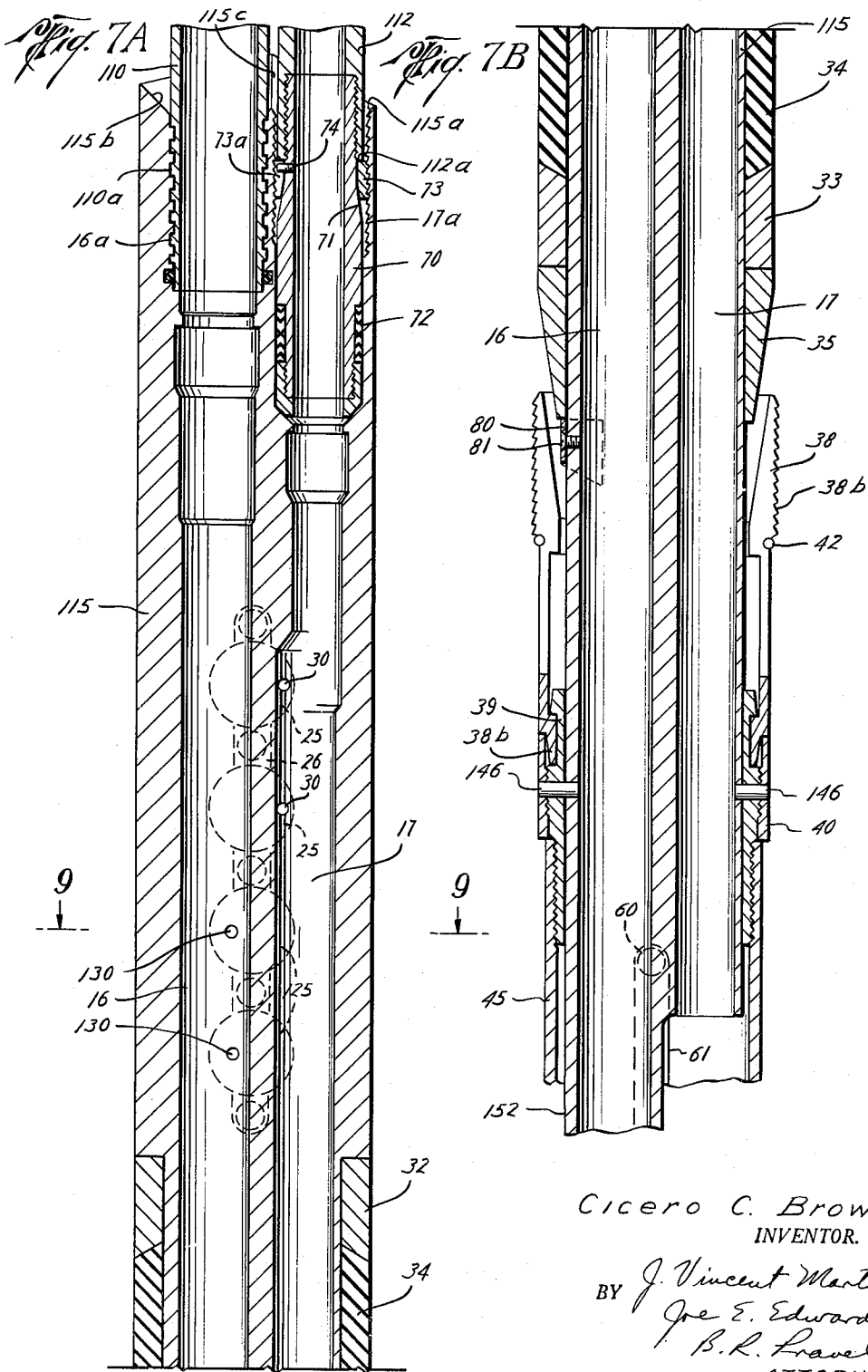
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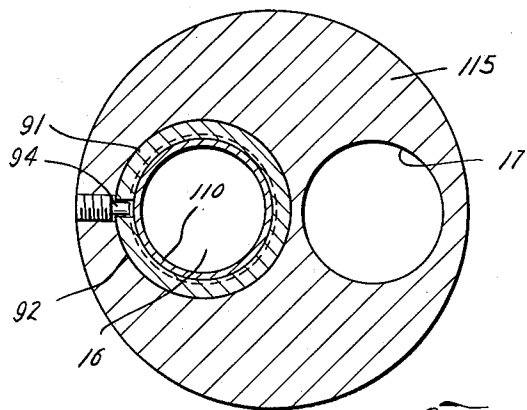
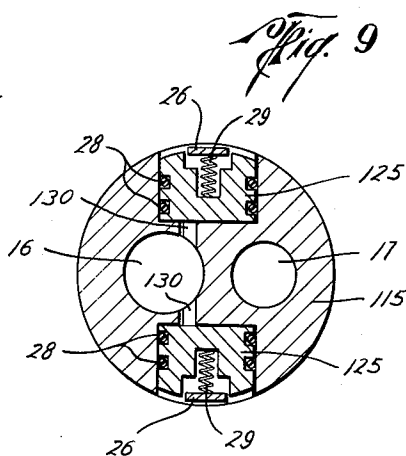
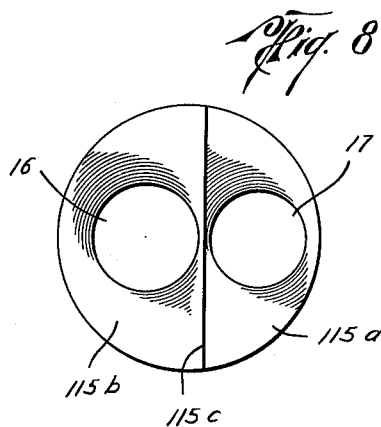
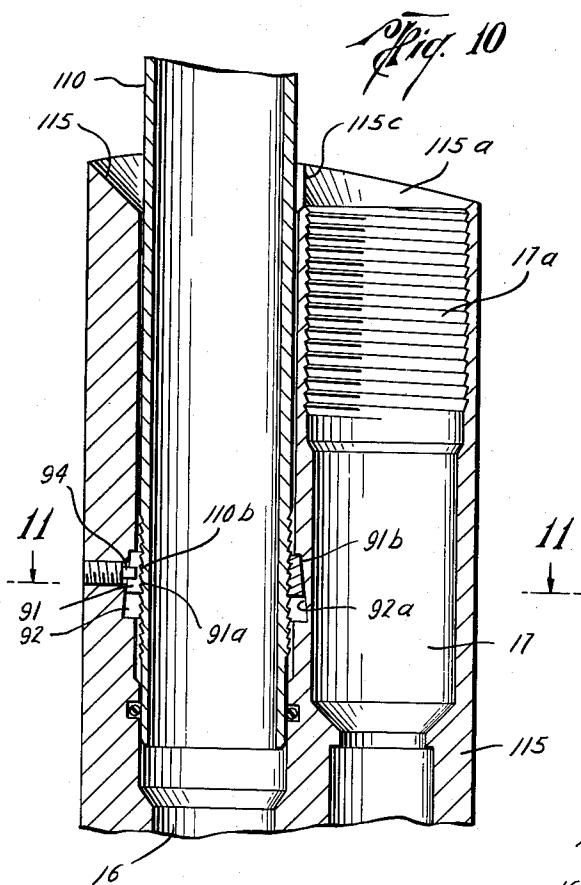
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DUAL COMPLETION APPARATUS AND METHOD OF POSITIONING SAME IN A WELL BORE

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18 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 especially relates to dual completion well apparatus and to methods of positioning same in a well bore including, a packer capable of being set in a well bore assembly by imposing the weight of one of the tubing strings thereon.

An object of this invention is to provide dual completion well apparatus and method of positioning same in a well bore including, a packer capable of being set in a well bore in which frangible means is provided to be broken by the imposition of the weight of one of the tubing strings thereon to set the packer in the bore.

Another object of this invention is to provide a new and improved well packer which is adapted to be positioned in a well pipe, said packer being so constructed that both of the tubing strings connected thereto can be removed from the packer after the packer is set in the well pipe.

Another object of this invention is to provide a new and improved well apparatus which includes a lower well packer which has been set in the well bore or casing and an upper well packer which is subsequently positioned in such bore or casing, and wherein the upper well packer includes auxiliary gripping members which are actuated by either the fluid pressure from below the lower well packer or the fluid pressure from the area between the lower well packer and the upper well packer.

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 diagrammatic view, partly in elevation and partly in section, illustrating the well apparatus of this invention disposed in a well bore or casing.

FIGURES 2A and 2B are views, partly in elevation and partly in section, which together illustrate the details of the upper well packer or packer assembly of this invention, with FIGURE 2A illustrating the upper portion thereof and FIGURE 2B illustrating the lower portion thereof.

FIGURE 3 is an isometric view of the upper end of the apparatus illustrated in FIGURE 2A, with one of the tubing strings detached.

FIGURE 4 is a horizontal sectional view taken on line 4-4 of FIGURE 2A.

FIGURE 5 is a horizontal sectional view taken on line 5-5 of FIGURE 2A.

FIGURE 6 is a horizontal sectional view taken on line 6-6 of FIGURE 2B.

FIGURES 7A and 7B are views, partly in section and partly in elevation, illustrating a modified form of the upper packer or packer assembly of this invention, with FIGURE 7A illustrating the upper portion thereof and FIGURE 7B illustrating the lower portion thereof.

FIGURE 8 is a plan view of the upper end of the apparatus illustrated in FIGURE 7A, with the tubing strings removed therefrom.

FIGURE 9 is a horizontal sectional view taken on the line 9-9 of FIGURE 7A.

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FIGURE 10 is a sectional view which illustrates a modified form of the upper end of the apparatus illustrated in FIGURE 7A.

FIGURE 11 is a horizontal sectional view taken on line 11-11 of FIGURE 10.

In the drawings, the letter A designates generally the dual string well packer of the apparatus of this invention which is adapted to be positioned in a well bore or casing C above a second well packer B. The well packer A has one tubing string 10 which extends to the surface of the well and has a lower portion 10a thereof which extends downwardly and through the bore 11 of the packer B. The packer A is normally lowered on the tubing string 10 after the packer B has been set in the well 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 C and set therein on a wire line so as to leave the open bore 11 therethrough for receiving the lower tubing section 10a of the tubing string 10. The section 10a has a shoulder or stop 10c, or any other suitable means for limiting the downward movement of the section 10a and the packer A relative to the packer B. The packer B is set in engagement with the well bore or casing C by a manipulation of the tubing string 10, as will be explained. After the packer A has been set, then the second tubing string 12 is lowered into position in the well casing C and is connected to the dual string packer A by a suitable removable connection, as will be explained more in detail. With the packers A and B thus set, well operations can be conducted with respect to the upper formation F and the lower formation F', with the upper formation F being in fluid communication with the tubing string 12 and the lower formation F' being in fluid communication with the other tubing string 10.

One form of the dual string packer A is illustrated in detail in FIGURES 2A and 2B. In that form of the invention, the packer A has a tubular body 15 which has bores or longitudinal passages 16 and 17 extending from the upper end of the body 15 to the lower end thereof. The tubing string 10 is connected in said bore or passage 16 and the tubing string 12 is connected in said bore or passage 17. The lower end of the tubing string 10 has external threads 10b thereon which are in threaded engagement with threads 16a within the upper end of the passage 16. The threads 10b and 16a are normally connected during the lowering of the upper well packer A into the well bore so that such packer is handled or manipulated by the tubing string 10.

Normally, during the running-in or lowering of the packer A into the well bore so as to position the lower portion or section 10a thereof within the lower packer B, the tubing string 12 is not in position within the upper end of the bore or passage 17. Instead, the upper well packer A is normally positioned in the bore or casing C by a manipulation of the tubing string 10 and thereafter the tubing string 12 is lowered in the well bore or casing C for positioning in the passage 17. The upper surface 15a is inclined and is also concave or dished (FIGURES 2A and 3) so as to guide the lower end of the tubing string 12 into the upper end of the passage 17. The lower end of the tubing string 12 is formed with one or more slots which have an open vertical section 19a through which a pin or pins 20 are adapted to pass for positioning same within the slot 19. Such pin or pins 20 are disposed within the passage 17 near the upper end thereof and extend inwardly so as to be contacted by the lower inclined surfaces 21 on the lower end of the tubing string 12 as the string 12 is lowered into the bore 17. Thus, the lower end of the tubing string 12 is turned so as to cause same to position the vertical opening 19a immediately above the pin 20 with which it is to be

connected so that upon continued lowering of the string 12, the lower end of the string 12 is moved downwardly relative to the pins 20 and upon a slight rotation of the string 12 to the left (as viewed from the top of FIGURE 2A) the pins 20 are positioned within the slot 19 in the hook portion thereof (FIGURE 2A). It will be understood, of course, that the rotation to the left may not be necessary in some instances because a slight twist will be placed in the tubing string 12 as the pins 20 slide along the surfaces 21 if such action does occur during the connecting operation. In any event, the pins 20 are located within the slots 19 so as to releasably connect the lower end of the tubing string 12 to the body 15. It will be noted that an annular packing or seal 22 is provided around the external surface of the tubing string 12 for contact with the wall of the bore or passage 17 for preventing fluid flow around the exterior of the lower end of the tubing string 12 so that fluid is directed from the bore 17 upwardly into the interior of the tubing string 12. The disconnection of the tubing string 12 can, of course, be readily effected by a slight rotation thereof to the right or clockwise (as viewed from the top of FIGURE 2A) and then a movement upwardly so as to move the tubing string 12 upwardly relative to the pins 20 as such pins 20 pass through the longitudinal openings 19a of the slots 19.

The body 15 has a plurality of hold-down members 25 (FIGURES 2A and 4) mounted thereon for actuation into gripping engagement with the well casing C by fluid pressure from the area below the packer A and if desired, specifically by the fluid pressures from the area between the packers A and B. As illustrated, the hold-down members 25 are arranged in a series of three on each side of the body 15 and such members 25 on each side are held against displacement outwardly by a strap 26 which is bolted or otherwise secured to the body 15. Each of the hold-down members 25 is in effect a piston which has gripping teeth 25a on the outer surface thereof for gripping contact with the interior of the well casing C. Each such member 25 is slidable within a cylindrical recess 27 provided in the side of the body 15 and annular seal rings 28 are provided on each member 25 for sealing contact with the surface of its recess 27. Normally, the members 25 are each held in a retracted position with their teeth 25a out of contact with the casing C by means of a spring 29 which is disposed in a socket 25b and in contact with the interior of the strap 26 along the outside of the body 15.

However, each of the cylindrical recesses 27 is in fluid communication with the bore or passage 17 by means of laterally extending ports 30 (FIGURE 4) which establish such fluid communication. Thus, when the fluid pressure within the bore 17 is in excess of the fluid pressure externally of the gripping members 25 and the spring pressure 29, such pressure fluid from the bore 17 urges the gripping members 25 outwardly into gripping engagement with the well casing or pipe C. As will be more evident hereinafter, such gripping members 25 are in the retracted position during the lowering of the upper well packer or packer assembly A into the well bore or casing C, due to the fact that the tubing string 12 is not in position and therefore the fluid pressure internally and externally of the gripping members 25 is equalized. However, after the packing or sealing element 34 has been compressed and set in sealing contact with the inside of the casing or pipe C and the tubing string 12 has been positioned in the bore 17 with the seal 22 in position, then the pressure fluid in the bore 17 from the formation F is sufficient to urge the gripping members 25 outwardly since it is considerably in excess of the pressure above the packer A under normal conditions.

The annular sealing or packing element 34 which is formed of rubber or other resilient material is positioned surrounding the body 15 and is longitudinally slidable relative thereto so that it is adapted to be compressed for

lateral or radial expansion into sealing contact with the inside of the casing C. The packing or sealing element 34 is confined between retaining rings 32 and 33 which are normally formed of metal or other similar rigid material. Such rings 32 and 33 are slidable relative to the body 15 which they surround, but as explained below, such rings 32 and 33 are maintained at the upper and the lower ends of the packing element 34, respectively, as the packer A is lowered into the well bore or casing C. The rings 32 and 33 are preferably held in their normal position by the upper end of the slip expander 35 which is secured to the body 15 by one or more shear pins 37 (FIGURE 2A). The expander 35 is also annular in construction and is longitudinally movable relative to the body 15 after the shear pin 37 has been severed or sheared as will be explained.

The external surface of the slip expander 35 is tapered or inclined downwardly and inwardly as indicated at 35a so that such expander 35 is adapted to enter into the bore or inner surface of the slips 38 disposed therebelow for effecting a setting or lateral movement of same into gripping engagement with the casing C.

The slips 38 are formed from a plurality of arcuate segments, each of which is separate from the other and has gripping teeth 38a thereon for engagement with the casing and also has downwardly and inwardly inclined inner surface 38b which is adapted to be engaged by the inclined surface 35a of the slip expander 35 during the expansion of the slips 38. Each of the slip segments is supported on a flexible arm 38c which carries the slip segment 38 and the material of such arm 38c may be of a resilient material. The lower end of the arm 38c has an inwardly extending lug 38d which is retained in a recess 39b of a support collar 39 by means of a lock ring 40 which is threaded onto the ring 39. Although the inherent resiliency of the arms 38c may be relied upon for urging the slip segments 38 inwardly to a retracted position for the lowering operation, a resilient spring 42 which is annular in construction and which surrounds the segments 38 may be used if desired so as to be certain that the slips 38 are in a retracted position during the lowering operation.

During the running-in of the apparatus A, the support ring 39 and therefore the slips 38 are prevented from downward movement relative to the body 15 because the lower lateral annular shoulder 39a of the support ring 39 rests upon the upper annular lateral surface 44a of the collar 44 which is threaded or otherwise connected to the lower end of the body 15 (FIGURE 2B). Similarly, the support ring 39 and therefore the slips 38 are prevented from moving upwardly relative to the body 15 during the lowering operation by reason of the engagement of one or more shear pins 46 with a lower housing 45 which is substantially cylindrical and which is threaded or otherwise connected to the lower end of the support ring 39. Thus, the shear pins 46 extend from the collar 44 through the housing 45 and such shear pins 46 are severed or sheared when the body 15 and collar 44 are moved downwardly relative to the housing 45 during the setting operation, as will be explained.

The lower end of the housing 45 has a plug 48 threaded or otherwise connected thereto and such plug 48 is provided with longitudinal passages or openings 49 and 50. The tubing string extension or section 10a is connected to the plug 48 at the lower end of the passage 49 so as to be in fluid communication from the area below the plug 48 and the area interiorly of the housing 45. The pipe 52 is thus movable downwardly with the body 15 and collar 44 relative to the slips 38 and the housing 45. The lower end of the pipe 52 extends through an annular packing or seal 53 in the opening 49 and fits within the bore of the lower tubing section 10a so that the pipe 52 is adapted to slide within and longitudinally relative to the tubing section 10a. Fluid communication is established therefore from the tubing section 10a through the pipe 52

to the interior of the passage 16. In the form of the invention illustrated, the tubing string 10a is in position in the bore 11 (FIGURE 1) of the packer B with the stop 10c resting on the upper end of the packer B so that the tubing string 10a, housing 45 and the slips 38 are prevented from moving downwardly once the stop 10c has contacted the upper portion of the packer B. However, the pipe 52 and the body 15 are not prevented from moving downwardly thereafter because the pins 46 can be sheared and then the pipe 52 is adapted to telescope or slide within the pipe section 10a during the setting of the slips 38, as will be more evident hereinafter. The interior of the housing 45 is in fluid communication with the area between the packers A and B by reason of the passage 50 and also by reason of the ports 55 so that such fluid is adapted to pass into the bore 17. It will be noted that during the lowering of the pipe 52 relative to the housing 45, the body 15 and therefore the pipe 52 are maintained in vertical alignment with the housing 45 so as to prevent any twisting or bending force being applied to the pipe 52 as it passes through the bore 49. Such vertical alignment is attained by means of a guide pin 60 which is on the external surface of the collar 44 and projects outwardly therefrom into a slot 61 in the housing 45. Thus, as the body 15 and the pipe 52 are lowered relative to the housing 45, the pin 60 moves downwardly in the slot 61 to prevent relative rotation between the parts.

In the operation or use of the apparatus illustrated in FIGURES 1-6 and in carrying out the method of this invention such apparatus is lowered into the well bore or casing C after the packer B has been set in position. As previously explained, the packer B is preferably a wire-line packer which has been previously lowered and set in position in the well casing C on a wire line, such as disclosed in my co-pending U.S. Patent No. 2,739,651. The dual string packer A of FIGURES 2A and 2B is lowered so as to position the lower tubing section 10a through the bore 11 of the packer B.

Such lowering of the packer A is preferably accomplished with the tubing string 10 supporting the packer A during the lowering and without the tubing string 12 connected thereto. When the packer A has reached the desired position in the well casing for setting same, the stop 10c has been seated on the packer B. Thereafter, a continued lowering of the apparatus A causes the tubing weight of the tubing string 10 to be imparted to the body 15 for applying a shearing force to the shear pins 46. Upon the shearing of the pins 46, the body 15 moves downwardly with the pipe 52 relative to the slips 38 and the housing 45. Such downward movement of the body 15 effects a downward movement of the slip expander 35 into the interior of the slips 38 to wedge or urge such slips 38 outwardly into gripping engagement with the well casing C. Once the slips 38 are thus set in gripping engagement with the casing C, the expander 35 can no longer move downwardly with the body 15 so that a continued application of weight or downward force to the body 15 effects a shearing of the pin or pins 37 so as to apply a downward compressive force to the resilient packing element 34 to expand the same into sealing contact with the casing C. The packing element 34 thus seals off fluid flow around the upper packer A. The fluid pressure from the well area between the packers A and B is exerted through the bore 17 on the hold-down members 25 to urge same into gripping engagement with the well casing. Such hold-down members 25 thus act to prevent the inadvertent release of the packing element 34. For releasing the hold-down members 25 from their gripping engagement with the well casing, the area in the casing above the packer A can be placed under a fluid pressure greater than the pressure therebelow so that the pressure on the outside of the hold-down members 25 is in excess of the pressure interiorly thereof, or is at least sufficient to permit the springs 29 to act to urge the members 25 inwardly to their retracted position (FIGURE 4). Nor-

mally, during the lowering of the well packer or packer assembly A into the well bore or casing C, the well fluid pressure interiorly and exteriorly of the hold-down members 25 is equalized due to the fact that the interior and exterior of the hold-down members 25 are in fluid communication with the same fluid, but after the seal 22 is effected with the bore 17, then, if the pressure in the bore 17 is in excess of the pressure above the packer A, the hold-down members 25 are actuated outwardly into the gripping contact with the well casing, provided that the pressure is sufficient to overcome the springs 29. Ordinarily, therefore, the hold-down members 25 are not set until the tubing string 12 has been landed in position with the seal 22 in contact with the bore 17. Also, ordinarily the hold-down members 25 are released by first removing the tubing string 12 from the packer A so as to effect an equalization of pressure interiorly and exteriorly of the hold-down members 25.

After the packers A and B have been set in the well bore or casing C, it will be evident that the usual well operations can be performed, as desired, including the producing of oil or other fluid from the formation F' through the lower tubing section 10a and the tubing string 10 to the surface of the well and the simultaneous production of oil or other fluid from the formation F through the tubing string 12 to the surface of the well.

When it is desired to remove the well apparatus of this invention from the well bore or casing C, the tubing string 12 is preferably first detached to equalize the fluid pressure above and below said packer A to permit the springs 29 to urge the hold-down members to a retracted position. Thereafter, the tubing string 10 is raised to release the packing element 34 and slips 38 from engagement with the well bore or casing C, whereupon continued raising of the string 10 effects a lifting of the packer A and a lifting of the lower tubing section 10a from the bore 11 of the lower packer B so as to effect their removal from the well bore or casing C. Then, if desired, the well packer B is removed from the well casing C by known retrieving equipment such as disclosed in my Patent No. 2,739,651.

It will be appreciated from the foregoing description that the method of this invention includes the method disclosed in my copending patent application, Serial No. 504,512, filed April 28, 1955 and in addition, the method of this invention includes the setting of the upper packer A by imposing the weight of the tubing string or strings thereon.

In FIGURES 7A and 7B, a modified form of the packer A illustrated in FIGURES 2A and 2B is shown, with like parts being identified by the same numerals. The body 115 in FIGURES 7A and 7B corresponds with the body 15 in FIGURES 2A and 2B but it has several differences. The upper end of the body 115 has guide surfaces 115a and 115b (FIGURE 8) which converge along a line 115c. The surface 115a is concave or dished so that when the tubing 110 is disposed in the bore 16 of the body 115, the other tubing string 112 is guided into the bore or passage 17. In other words, from the line 115c the surface 115a slopes downwardly and inwardly around the upper end of the bore 17 toward such bore 17. The surface 115b is likewise concave or dished so as to have a sloping surface from the line 115c downwardly and inwardly toward the upper end of the bore or passage 16 so that when the tubing string 112 is in position in the bore 17, the tubing string 110 is guided into the opening 16. Actually, whether the string 112 is in position or not, the surface 115b will guide the lower end of the tubing string 110 into the opening 16, but if the string 112 is not in position, the string 110 is apt to be guided into the opening 17 rather than the opening 16. The same is true with respect to the guiding of the tubing string 112 into the opening or bore 17. In other words, if the tubing string 110 is not in position in the bore 16, the tubing string 112 would nevertheless be guided into the upper end of

the bore 17 once the lower end thereof contacted the surface 115a, but the lower end 112 might contact the surface 115b unless the string 110 were in position to prevent such guiding motion of the string 112 along the surface 115b. In the packer or apparatus of FIGURES 7A and 7B, the tubing string 110 is used for lowering the apparatus into the well casing C, but such tubing string 110 is provided with relatively coarse threads 110a which are in engagement with corresponding relatively coarse threads 16a so that after the packer or apparatus A has been set in the well casing such tubing string 110 can be removed from the packer or apparatus if desired. Such removal would, of course, be accomplished by a rotation of the tubing string 110 and the slips 38 would prevent the rotation of the body 115 during such rotation.

The lower end of the tubing string 112 is provided with an automatic bottom type of connector and includes an adapter 70 which has a tapered or inclined outer portion 71 and which has therebelow a seal ring 72 which is adapted to seal with the interior of the bore or passage 17. An annular nut 73 surrounds the adapter 70 which is formed as a split ring which is of a metal or other material which enables such ring to be laterally expanded. A retaining pin 74 extends into the longitudinal split or slot 73a to prevent relative rotation of the nut 73 on the adapter 70 while still permitting relative longitudinal movement therebetween. The nut 73 is adapted to be expanded outwardly when the inclined surface 71 is moved upwardly into engagement with the inner surface of the nut 73. Thus, during the lowering of the tubing string 112 into the bore 17 of the body 115, the nut 73 rides on the adapter 70 above the inclined portion 71 and is thus in a retracted position to facilitate the downward sliding of the nut 73 along the internal threads 17a of the bore 17. A straight nonrotative upward pull on the tubing string 112 does not effect a release of the adapter 70 and tubing string 112 from the body 115 because the inclined or expander surface 71 urges the nut 73 outwardly so as to prevent any sliding upward movement of the external teeth on the nut 73 relative to the teeth 17a. Thus when it is desired to release the tubing string 112 from its connected position in the bore 17 of the body 115, the tubing string must be rotated in a right-hand direction if the internal threads 17a and the external threads on the nut 73 are left-hand threads. The nut 73 is rotated with the tubing string 112 by reason of the engagement of the pin 74 with the walls of the split or slot 73a in the nut 73. Therefore, a rotation to the right of the tubing string 112 imparts a right-hand rotation to the nut 73 to cause same to travel upwardly with respect to the threads 17a and to ultimately cause the nut 73 to move out of the bore 17 for effecting the release of the tubing string 112 from the body 115.

The hold-down members 25 of FIGURES 7A and 7B are identical with those illustrated in FIGURES 2A and 2B, but additionally the hold-down members 125 are provided for actuation by fluid pressure from the bore or passage 16. In other words, the hold-down members 25 are actuated by the fluid pressure through the ports 30 from the bore 17 whereas the hold-down members 125 are actuated by fluid pressure from the bore 16 which passes through similar ports 130. Otherwise, the hold-down members 125 are identical with the hold-down members 25.

The slip expander 35 of the packer illustrated in FIGURES 7A and 7B is held in a raised position with respect to the slips 38 by means of a block 80 which is secured to the body 115 by a screw 81 or other similar means and is positioned immediately below the slip expander 35 so that the expander 35 rests thereon. However, there is no connection between the block 80 and the slip expander 35 so that when the expander 35 has been stopped in its downward movement by reason of its wedged position with the slips 38, the block 80 can

continue to move downwardly with the body 115 relative to the slip expander 35. Shear pins 146 are used for the same purpose as shear pins 46 in FIGURES 2A and 2B, and are positioned upwardly from that shown in FIGURES 2A and 2B, but they are sheared in the same manner as described in connection with the shear pins 46. The pipe 152 is formed integral with the body 115 rather than as a separate pipe 52 as in the form of the invention of FIGURES 2A and 2B and telescopes the extension 10a (not shown in FIG. 7B).

From the foregoing, it will be evident that the modified packer construction of FIGURES 7A and 7B incorporates many individual modifications with respect to the packer of FIGURES 2A and 2B which could be incorporated separately or together in the packer of FIGURES 2A and 2B, if desired.

The operation or use of the packer of FIGURES 7A and 7B is substantially identical with that of FIGURES 2A and 2B, and the procedure for using same and for carrying out the method of this invention are substantially the same. Thus, the packer of FIGURES 7A and 7B is lowered into the well bore or casing C in the manner explained above so that the lower tubular extension 10a thereof extends through the previously-set packer B (FIGURE 1). Thereafter, the continued lowering of the tubing 110 with the packer A effects a shearing of the pins 146 and a setting of the slips 38. After the slips 38 have been set in gripping contact with the casing C, the lowering of the tubing 110 is continued and such lowering effects a continued lowering of the body 115 along with the wedge or block 80 which thus moves outwardly from the lower end of the slip expander 35. The continued lowering of the body 115 eventually effects a compression and outward radial expansion of the packing element 34 into sealing contact with the casing C. Thereafter, the tubing string 112 is ordinarily lowered so as to connect same into the upper end of the bore 17. The surface 115a will, of course, guide the lower end of the tubing string 112 into its proper position and no rotation is required for connecting the nut segments 73 to the internal threads 17a in the bore 17. After the connection of the tubing string 112 is effected, the equalization of the fluid pressure internally and externally of the hold-down members 25 and 125 is changed so that a sufficient pressure is obtained within the bores or passages 16 and 17 to effect an outward movement of the hold-down members 25 and 125 into gripping engagement with the casing. Since the hold-down members 25 are in communication with the bore 17, the pressure interiorly and exteriorly of the members 25 is always equalized so long as the tubing string 112 is not in position with the seal ring 72 in contact with the bore 17 of the body 115. Of course, the pressure from the bore 16 is not necessarily equalized with the pressure exteriorly thereof because of the tubing string 110 being in position in the upper end of the bore 16. Therefore, the hold-down members 125 might prematurely set unless the pressure from above the packer B is greater than or at least equal to the pressure from below the packer B. Therefore, during the setting of the packer A, it may be necessary to maintain sufficient pressure in the casing C by means of mud or other drilling fluid to prevent the premature setting of the hold-down members 125.

If it is desired to release the tubing string 110 from the body 115 after the tubing string 112 has been connected thereto, this can be accomplished if desired by a rotation of the tubing string 110. Preferably, the threads 110a and 16a are left-hand threads so that a rotation to the right effects such release. The tubing string 110 can, of course, be guided back into its position for reconnection into the bore 16 by means of the guide surface 115b.

When it is desired to remove the upper packer A from the well casing C, the tubing string 112 is ordinarily disconnected first by rotating same to the right to cause the

nut segments 73 to rotate relative to the threads 17a whereby the nut segments 73 and the adapter 70 at the lower end of the tubing string 112 are rotated upwardly and out of the bore 17. Such removal immediately equalizes the fluid pressure interiorly and exteriorly of the hold-down members 25. If the pressure in the well above the packer B is greater than the pressure therebelow, then the pressure on the members 125 will also be equalized and the members 125 will thus be released by reason of the spring force acting thereon in the same manner as the springs 29 act on the members 25, as previously explained. However, in the event that the pressure in the casing above the packer B is not sufficiently great to effect the release of the hold-down members 125, the well can be pressurized sufficiently to obtain such release and thereafter the tubing string 110 is raised to release the sealing element 34 and the slips 38 from their engagement with the casing C whereupon the entire apparatus can be removed from the well bore.

It is pointed out with reference to the form shown in FIGURES 7A and 7B that the body 115 is connected with the lower housing 45 by means of the aligning pin 60 and slot 61. As explained with respect to the first form, the pin 60 serves primarily as an aligning pin to non-rotatively connect the parts. However, in the form of FIGURES 7A, 7B which omits the collar 44 and its co-action with the support ring 39 as shown in the forms FIGURES 2A, 2B, the pin 60 may function as a releasable connection between body 115 and housing 45. Thus, if the slips 38 become stuck and the expander 35 cannot be pulled upwardly from between the slips by an upward pull on the pipe 110, the pin 81 holding the expander-supporting block 80 may first be sheared and then by sufficient upward strain on pipe 110 and body 115 will shear the pin 60. When this occurs, the pipe 110 and body 115 may be removed leaving only the housing 45 and slip assembly in the bore and said housing and slip assembly may be subsequently removed by well known fishing operations.

In FIGURE 10, the upper portion of the body 115 of FIGURE 7A is illustrated, with certain parts thereof modified. The tubing string 112 is not illustrated, but the threads 17a and the bore or passage 17 through the body 115 are illustrated in the same manner as in FIGURE 7A and therefore the same type of connector means at the lower end of the tubing string 112 would be utilized in the form of the invention shown in FIGURE 10 as illustrated in FIGURE 7A.

However, the means for connecting the tubing string 110 to the body 115 in the bore 16 is modified as compared to the illustration in FIGURE 7A. Thus, the lower end of the tubing string 110 is provided with threads 110b which are adapted to engage in threaded connection with the internal threads 91a of the nut 91. The nut 91 is in the form of a split ring having a longitudinal split or slot 91a. The nut 91 is adapted to slide longitudinally in the recess 92 in the bore of the upper portion of the passage 16 and a pin 94 extends from the body 115 into the split or slot 91a so as to permit longitudinal movement of the nut 91 relative to the body 115 but to prevent relative rotational movement therebetween. Such recess 92 is annular in construction and has an inclined wall 92a which is engageable by a similarly inclined rear surface 91b of the nut 91. By reason of the split ring construction of the nut 91, the nut 91 is normally at a minimum internal diameter, but is adapted to be expanded radially outwardly as the threads 110b slide downwardly along the threads 91a. Rotational movement of the tubing string 110 is not required because the nut 91 is urged to its lowermost position and is expanded outwardly to provide the enlarged internal diameter of sufficient size to let the threads 110b pass downwardly relative to the nut 91. When the threads 110b have thus engaged the threads 91a, a straight nonrotative upward movement of the tubing string 110 will not disconnect the tubing string

110 from the body 115. However, a rotation of the tubing string 110 to the right, assuming the threads 110b and 91a are left-hand threads, will effect a movement of the pipe 110 upwardly leaving the nut 91 in the recess 92 and effecting the disconnection of the string 110 from the body 115. Thus, the nut 91 in effect forms an automatic-bottom type of construction similar to the nut 73 previously described in connection with FIGURES 7A and 7B. It is thus believed evident that various types of connectors can be utilized for connecting the tubing strings 110 and 112 to the upper end of the body 115.

It should be pointed out that the lower tubing section 10a which extends through the lower packer B can be connected to the packer A for establishing fluid communication from the area below the packer B to either one of the tubing strings 10 or 12 (FIGURES 2A and 2B) or 110 or 112 (FIGURES 7A and 7B) and therefore, the lower tubing section 10a is not necessarily in fluid communication with the particular tubing string on which the packer A is lowered.

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 apparatus adapted to be positioned in a well pipe including, a body having a pair of longitudinal passages extending therethrough, a tubular housing telescoping said body and slidable relative thereto, co-acting means on the body and housing limiting the relative movement of said housing and body, a slip assembly comprising gripping slips and a slip expander with said gripping slips and said expander being mounted one upon the body and the other upon the housing whereby relative axial movement of the body and housing moves said expander relative to the slips to actuate the same into gripping position, disconnectible means on said body and housing holding the same in a position maintaining the expander out of slip-actuating position while the apparatus is being lowered in the well pipe, a first tubing string connected to said body in fluid communication with one of said passages for lowering the apparatus into the well pipe, a second tubing string detachably connected to said body and in fluid communication with the other longitudinal passage, and means for supporting the housing against downward movement within the well pipe whereby the application of a downward force to the body will disconnect said disconnectible means and move said body relative to the housing and thereby move the expander and slips with respect to each other to actuate said slips.

2. A well apparatus as set forth in claim 1, together with an annular packing element carried by the body above the expander, an annular abutment on the expander engaging the lower end of the packing element, said body having an annular abutment engaging the upper end of the expander whereby after the slips have been actuated and said slips and expander are held against further downward movement, a further downward movement of the body relative to the housing distorts the packing element into sealing position.

3. A well apparatus as set forth in claim 1, together with a hold-down member mounted on said body for lateral movement relative thereto, said hold-down member being movable by the pressure differential acting thereacross, and means for applying pressure fluid from one of the longitudinal passages to the inner end of the hold-down member to move the same radially outwardly into gripping engagement with the well pipe.

4. A well apparatus as set forth in claim 1, together with at least two hold-down members mounted on said body for lateral movement, the body having a radial opening for receiving each hold-down member and in

which the hold-down member is slidable, means for establishing communication between the inner end of one of the radial openings and one of the longitudinal passages in the body whereby pressure fluid from said passage may act against the hold-down member therein to move the same outwardly into gripping engagement with the well pipe, and additional means establishing communication between the inner end of the other radial opening and the second longitudinal passage whereby pressure fluid from said second passage may act against the hold-down member in said other opening to move the same outwardly into gripping engagement with the well pipe.

5. A well apparatus as set forth in claim 1, wherein the connection between the first tubing string and the body is also a detachable connection.

6. A well apparatus as set forth in claim 1, wherein the connection between the first tubing string and the body is also a detachable connection, and guide means on the upper end of said body for guiding either tubing string which may have been detached and removed back into its respective longitudinal passage upon subsequent return of said string into the well.

7. A well apparatus adapted to be lowered into a well bore including, an elongate body having a pair of longitudinal passages extending therethrough, the upper end of each passage communicating with the area above the body and the lower end of each passage communicating with the area below said body, the body having an annular packing element thereon, anchoring means carried by the body below the packing element for supporting the body and packing element within a well bore, said body having a radially disposed opening in its wall, a hold-down element slidable within the opening, and means providing communication between one of the passages in the body and said radially disposed opening whereby pressure from within said passage may be directed against the inner end of the hold-down element to move the same radially outwardly into gripping engagement with the wall of the well bore.

8. A well apparatus as set forth in claim 7, together with a first tubing string connectible with one of the longitudinal passages and a second tubing string connectible with the other of said passages.

9. A well apparatus as set forth in claim 7, together with retaining means secured to the exterior of the body and spanning the radially disposed opening for preventing complete outward displacement of the hold-down member from its opening.

10. A well apparatus adapted to be lowered into a well bore including, an elongate body having a pair of longitudinal passages extending therethrough, the upper end of each passage communicating with the area above the body and the lower end of each passage communicating with the area below said body, the body having an annular packing element thereon, anchoring means carried by the body below the packing element for supporting the body and packing element within a well bore, said body having a plurality of radially disposed openings in its wall above the packing element, a hold-down element slidable in each opening and having its inner portion sealing with the wall of the opening and having its outer end formed with a gripping surface, and means providing communication between at least one of the passages and the inner ends of the radial openings whereby pressure from said passage may be directed against the inner surfaces of the hold-down elements to move the same radially outwardly into gripping engagement with the well pipe.

11. A well apparatus adapted to be lowered into a well bore including, an elongate body having a pair of longitudinal passages extending therethrough, the upper end of each passage communicating with the area above the body and the lower end of each passage communicating with the area below said body, the body having an annular

packing element thereon, anchoring means carried by the body below the packing element for supporting the body and packing element within a well bore, said body having a plurality of radially disposed openings in its wall above the packing element, a hold-down element slidable in each opening and having its inner portion sealing with the wall of the opening and having its outer end formed with a gripping surface, means providing communication between one of the longitudinal passages and inner ends of certain of said radial openings whereby pressure from said longitudinal passage may be directed against the inner end of the hold-down elements in said openings to move the same radially outwardly, and additional means providing communication between the other longitudinal passage and the inner ends of the remaining radial openings so that the hold-down elements in said other openings are moved radially outwardly by pressure from said other longitudinal passage.

12. A well packer including, a body adapted to be connected with a lowering pipe and lowered into a well bore, a packing element on said body, a slip expander mounted on the body below the packing element and slidable thereon, a tubular housing surrounding the lower portion of said body and mounted for limited slidable movement thereon, gripping slips carried by the housing and adapted to co-act with the slip expander whereby the slips are moved into set position when the body and expander are moved in an axial direction with respect to the housing and slips, and connecting means on said body and said housing non-rotatively connecting said body and housing while permitting limited relative axial movement thereof, said connecting means being releasable upon the application of a predetermined upward pull on the body, whereby in the event said gripping slips become stuck in the well bore the body and its associate parts may be separated from the housing and slips and independently removed from the well.

13. In a well packer having an elongated body, a housing carried by and slidably surrounding the lower portion of the elongated body, a plurality of pipe-gripping slips carried by said housing, a slip expander slidably surrounding and carried by said elongated body above said slips, and an annular deformable packing element surrounding the elongated body and having its upper end confined by an abutment on the elongated body and having its lower end engaging said slip expander, the improvement including, frangible means connecting the elongated body to said housing and maintaining the slips in such position relative to the expander that the slips are in nongripping position, disconnectible means normally supporting said slip expander on said elongated body out of engagement with said slips against downward movement with respect to said elongated body connecting the elongated body to the slip expander and of greater strength than said frangible means, whereby when downward movement of the housing is arrested, the imposition of weight on the elongated body fractures the frangible means to first set the slips and thereafter disconnects the disconnectible means to move the elongated body relative to the slip expander and to the packing element to deform the latter into sealing position.

14. A well apparatus adapted to be lowered into a well bore including, a lower packer adapted to be set in sealing position within the well bore and having an opening extending longitudinally therethrough, an upper packer assembly consisting of an elongate body having two longitudinal passageways therethrough; a housing slidably surrounding the lower portion of the elongate body; a plurality of pipe-gripping slips carried by said housing; a slip expander surrounding said elongate body above said slips; and an annular deformable packing element carried by said elongate body having its lower end supported on said slip expander and having its upper end confined by an abutment on the elongate body, a first tubing string connected to said elongate body in com-

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munication with one of the longitudinal passageways for lowering said upper packer assembly into the well bore, a second tubing string having means at its lower end for attaching the same to said elongate body in communication with the other of said longitudinal passageways and positioned adjacent to said first tubing string, a lower tubing section extending downwardly from said first tubing string from one of the longitudinal passageways in the body of the upper packer assembly through the lower packer and adapted for communication with the area below the lower packer, means on said tubing section engageable with the lower packer for arresting the housing against further downward movement when the lower tubing section is in position establishing communication with the area below the lower packer, frangible means normally fixing said housing with respect to said body with the slips in retracted position, and disconnectible means normally supporting said slip expender on said body out of engagement with said slips against downward movement with respect to said body and of greater strength than the frangible means, whereby after the frangible means has been fractured to set the slips an additional downward force disconnects the disconnectible means to set the upper packer.

15. The structure set forth in claim 14, including a hold-down member mounted on said body for lateral movement relative thereto, and communicating means between said hold-down member and one of said longitudinal passages for applying pressure fluid from one of said longitudinal passages to said member to urge said member outwardly into gripping engagement with the well pipe to assist in holding said body in a predetermined position in the well pipe.

16. The structure set forth in claim 14, including at least two hold-down members mounted on said body for lateral movement relative thereto, communicating means between one of the hold-down members and one of said longitudinal passages for applying a pressure fluid from one of said longitudinal passages to one of said members to urge same outwardly into gripping engagement with the well pipe, and additional communicating means between the other hold-down member and the other longitudinal passage for applying a pressure fluid from the other of said passages to the other of said members to urge the same outwardly into gripping engagement with the pipe.

17. The method of positioning a pair of well packers

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and a pair of tubing strings within a well bore including, setting a lower packer having a passage therethrough within a well bore, thereafter simultaneously lowering a first tubing string and an upper well packer which is mounted thereon intermediate its length into the bore to position said tubing and said upper packer within the bore with the upper packer spaced above the lower packer and the lower end of said first tubing string seated in the lower packer supporting the upper packer upon the lower packer, thereby establishing communication between the first tubing string and the passage in the lower packer after the upper packer and first tubing string reach their final positions within the bore, then lowering a second tubing string within the well bore and connecting its lower portion to the upper packer, imposing the weight of one of the tubing strings upon the upper packer to set said upper packer, thereby establishing communication between said second tubing string and the area between the upper and lower packers subsequent to the positioning of the second tubing string.

18. The method as set forth in claim 17, together with the additional steps of disconnecting the second tubing string from the upper packer and removing it from the well bore, thereafter removing the first tubing string and upper packer from the well bore, and finally removing the lower packer from said well bore.

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