

Dec. 27, 1960

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2,966,216

SUBSURFACE WELL BORE ANCHOR

Filed May 12, 1958

2 Sheets-Sheet 1

FIG. 1.

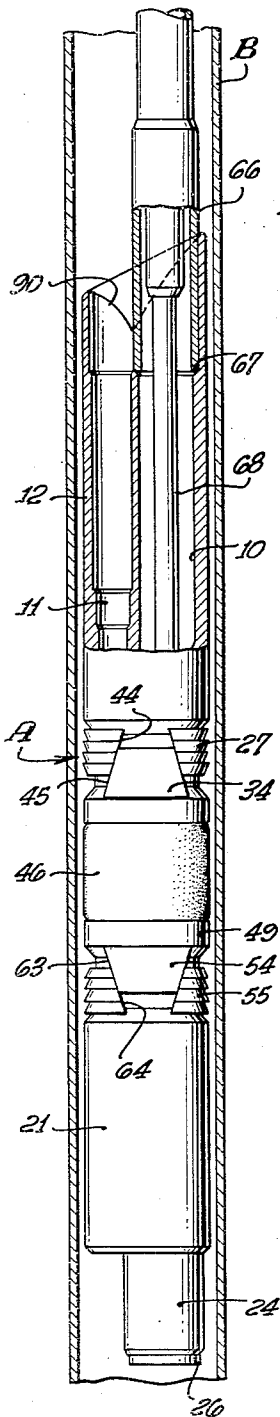


FIG. 2.

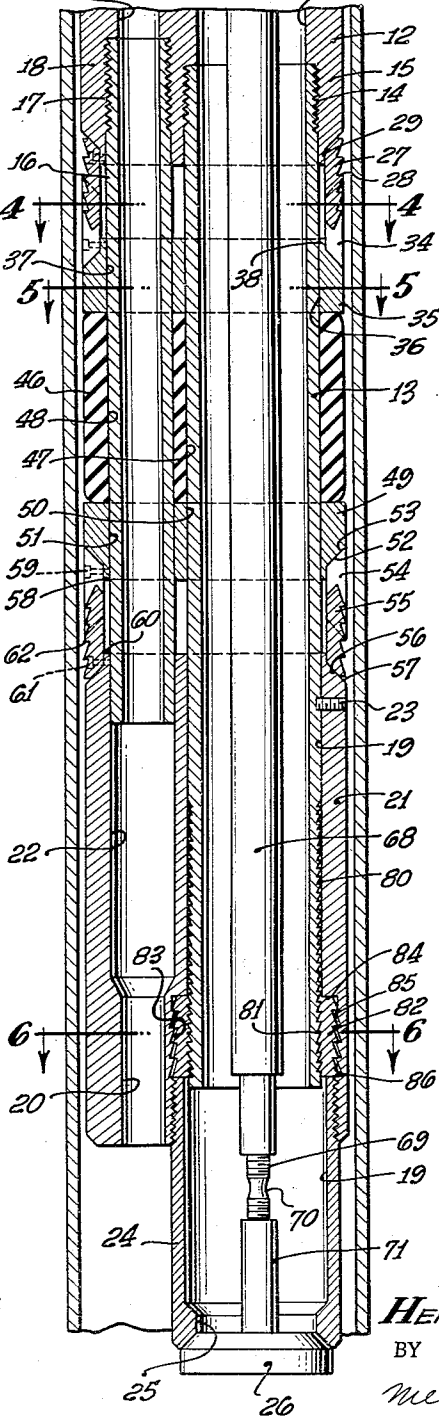


FIG. 4.

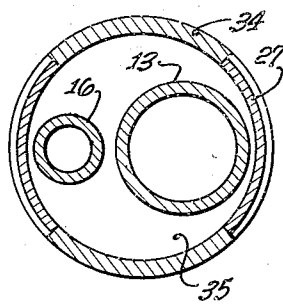


FIG. 5.

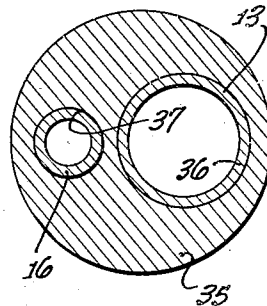
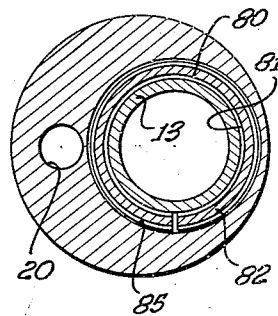


FIG. 6.



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FIG. 3.

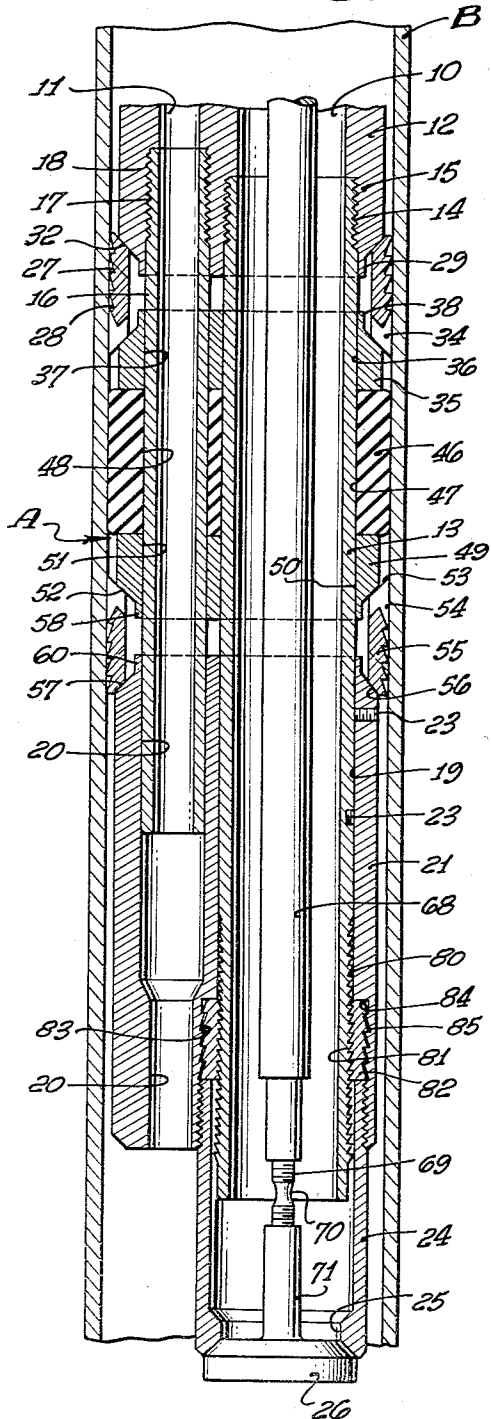


FIG. 7.

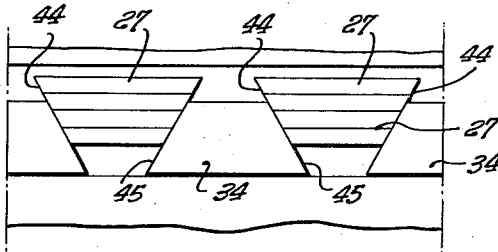
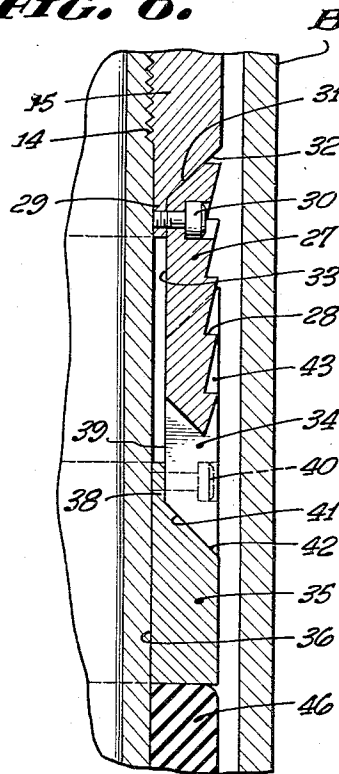


FIG. 8.



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SUBSURFACE WELL BORE ANCHOR

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Filed May 12, 1958, Ser. No. 734,633

4 Claims. (Cl. 166—134)

The present invention relates to subsurface well bore equipment, and more particularly to apparatus for anchoring well tools in well casings, or similar conduit strings, disposed in well bores.

Certain well tools are anchored to well casing disposed in a well bore by shifting normally retracted slips outwardly against the wall of the casing under the influence of a tapered or frusto-conical expander movable longitudinally behind the slips. In effect, the expander acts as a wedge holding the slips outwardly in anchoring engagement with the casing. Where the outward wedging force is great, there is a correspondingly large inward force on expander and on the tool body or other member on which the expander is mounted. At times, the wedging force is sufficient to permanently distort or crush the expander or body, or cause other failure of the parts.

It is, accordingly, an object of the invention to provide a well tool adapted to be anchored to a well casing, and the like, by slips, in which the reactive radial or inward load of the slips is reduced considerably with respect to their holding force against the casing.

Another object of the invention is to provide a subsurface well tool adapted to be secured to a well casing by slips, in which the slips can be anchored to the well casing to withstand relatively large loads and yet do not impose any substantial inward collapsing forces on the well tool.

A further object of the invention is to provide a subsurface well tool adapted to be anchored to a well casing by a slip structure capable of withstanding a high holding force, in which the radial dimensions of the structure can be made relatively small or "thin" to enable a larger size main body portion of the tool to be used.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figure 1 is a combined side elevational view and longitudinal section through an apparatus embodying the invention disposed in a well casing;

Fig. 2 is an enlarged longitudinal section through the well tool, with certain of its parts in their initial or retracted position;

Fig. 3 is a view similar to Fig. 2 disclosing the parts expanded against the well casing;

Fig. 4 is a cross-section taken along the line 4—4 on Fig. 2;

Fig. 5 is a cross-section taken along the line 5—5 on Fig. 2;

Fig. 6 is a cross-section taken along the line 6—6 on Fig. 2;

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Fig. 7 is a diagrammatic plan view of the slip and expander structure;

Fig. 8 is an enlarged longitudinal section through the slip structure portion of the apparatus.

The well tool A specifically illustrated in the drawings to exemplify the invention is a well packer adapted to be anchored in packed-off condition in the well casing B against movement in both longitudinal directions. The well packer has a plurality of passages 10, 11 therethrough and can be set in the well casing by a mechanism associated with the well packer and passing through one of such passages.

The well packer includes an upper body member 12 having the pair of longitudinal parallel passages 10, 11 extending therethrough. One of such passages 10 extends through a depending tubular member 13, which actually constitutes part of the upper body member 12, having an upper threaded pin 14 threadedly secured within a companion bore or box 15 provided in the latter. The upper body member also includes a second tubular part 16 depending from its main portion and having a threaded pin 17 threadedly received within a box 18 in the latter. This second tubular member 16 also has a passage therethrough forming a portion of the second passage 11 through the upper body member 12.

The depending first and second tubular portions 13, 16 of the upper body member 12 are slidable within passages 19, 20 extending through a lower body member 21. Thus, the second tubular member 16 is piloted within a counterbore 22 of the second longitudinal passage 20 extending through the lower body member 21 and opening through its lower end. The first tubular member 13 is telescoped within the first passage 19 in the lower body member, the first tubular member being initially secured to the lower body member 21 by a frangible device 23 in the form of one of more shear screws. A tubular extension 24 is threadedly secured within the lower portion of the lower body member 21, forming a continuation of its first passage 19. The lower portion of the extension 24 has an inwardly directed flange 25 adapted to coact with a lower disc portion 26 of a mechanism for setting the well packer in the well casing, as described hereinbelow.

The well packer A is adapted to be anchored to the well casing B against upward movement therewithin by a plurality of circumferentially spaced upper slip segments 27 having upwardly facing external wickers or teeth 28 adapted to engage the wall of the well casing. These segments initially engage a depending circumferential leg portion 29 of the upper body member 12, to which the slip segments are initially secured in retracted position by shear screws 30. The upper inner ends 31 of the slip segments are tapered in a downward and inward direction, being adapted to engage a companion tapered surface 32 on the lower portion of the upper body member 12. It is to be noted, however, that the inner surfaces 33 of the slip segments 27 conform generally to a portion or surface of a cylinder, and that the radial dimension of each slip segment between its inner surface 33 and the outermost portions of its teeth 28 is relatively small.

Disposed between the slip segments 27 and in engagement therewith are circumferentially spaced wedge segments 34 which extend below the slip segments 27 and engage an upper abutment or ring 35, the ring having bores 36, 37 through which the first and second tubes 13, 16 extend. The upper portion 38 of the abutment is cylindrical, the periphery of such portion being initially engaged by the inner surface 39 of the wedge segments 34, the wedge segments being initially secured to the upper abutment by shear screws 40 so as to hold such segments initially in retracted position. The lower ends 41 of the wedge segments are tapered in an upward and inward direction, engaging a companion external

tapered surface 42 on the upper abutment 35. Here again, the inner surface 39 of each wedge segment is cylindrical, or conforms to a cylindrical surface, with its outer surface 43 also being of generally cylindrical shape, the radial thickness of each wedge conforming generally to the radial thickness of each slip segment 27. When the wedge segments 34 are in retracted position, their outermost surfaces 43 extend radially outward to substantially the same extent as the wickers or teeth 28 on the slip segments 27.

It will be noted that the sides 44 of each upper slip segment 27 taper downwardly toward each other and that such sides engage correspondingly tapered sides 45 on the intervening wedge segments 34, which, of course, taper or converge in an upward direction. In view of such arrangement, when the slips 27 and wedges 34 are moved longitudinally toward each other, the coengaging tapered sides 44, 45 will cause the slip segments and the wedge segments to expand outwardly into engagement with the wall of the well casing B. Such expansion must occur since the movement of the slip and wedge segments 27, 34 toward each other will require a corresponding increase in the combined circumference of the slip and wedge segments and an attendant increase in their effective diameter. The sides 45 of the wedge segments 34, in effect, constitute expander surfaces engaging companion expander surfaces 44 on the sides of the slip segments 27, to result in outward expansion of the slip segments and embedding of their wickers 28 firmly into anchoring engagement with the wall of the well casing.

The upper abutment 35 engages the upper end of a packing member 46 of cylindrical shape, which has parallel bores 47, 48 therethrough to snugly receive the first and second tubular members 13, 16. The lower end of the packing member engages a lower abutment 49 having a pair of bores 50, 51 therethrough through which the first and second tubes 13, 16 are slidably mounted. This lower abutment 49 has an expander surface 52 tapering in a downward and inward direction and engaging companion inner surfaces 53 on the upper ends of circumferentially spaced lower wedge segments 54 disposed between circumferentially spaced lower slip segments 55, the lower ends 56 of which are tapered in an upward and inward direction and engage a companion tapered surface 57 at the upper end of the lower body member 21. The structural coaction between the lower abutment 49, lower wedge segments 54, lower slip segments 55, and the upper end 57 of the lower body member 21 is essentially the same as the upper body member 12, upper slip segments 27, upper wedge segments 34, and upper abutment 35, except that the parts are in inverted relation to the upper set.

Thus, the lower wedge segments 54 initially bear upon a depending cylindrical portion 58 of the lower abutment 49, being secured thereto by shear screws 59. The lower slip segments 55 initially bear against the upwardly extending cylindrical portion 60 of the lower body member 21, to which portion the lower slip segments are initially secured, as by shear screws 61, in order to hold the slip segments 55 in their normal retracted positions. These slip segments 55 have external downwardly facing wickers or teeth 62 adapted to be anchored in the wall of the well casing B. The radial thickness of the lower wedge segments 54 and lower slip segments 55 is substantially the same as the corresponding upper parts. The sides 63 of each wedge segment 54 taper or converge in a downward direction, engaging companion sides 64 on the slip segments 55 which taper or converge in an upward direction. Thus, movement of the lower wedge segments 54 and lower slip segments 55 toward each other will result in an outward expansion of both sets of segments against the wall of the well casing, with the wickers 62 of the slip segments being embedded or anchored in the wall of the well casing

B to prevent downward movement of the well packer therewithin.

The expansion of the upper and lower segments 27, 34, 54, 55 against the well casing is effected by shifting the upper body member 12, and the first and second tube portions 13, 16 thereof, downwardly with respect to the lower body member 21. For that matter, the lower body member 21 may be shifted upwardly with respect to the upper body member 12 and its depending first and second tubes 13, 16. Such relative movement can occur through use of any suitable device. As illustrated, a sleeve 66 extends downwardly within the first passage 10 of the upper body member and engages a shoulder 67 therein. A tension mandrel 68 extends downwardly through this sleeve 66 and through the first passage 10 and first tubular member 13, the lower portion of this tension mandrel being suitably secured to a release stud 69 having a small diameter or weakened portion 70 at which the stud can pull apart when subjected to a predetermined tensile force. This release stud 69 is attached to a lower rod 71 that has the disc 26 secured thereto which engages the inwardly directed flange 25. A downward force is imposed on the sleeve 66 and an upward pull taken on the tension mandrel 68, release stud 69, rod 71 and disc 26, to urge the upper body member 12 and the first and second tubes 13, 16 downwardly and the lower body member 21 upwardly. The apparatus may be lowered in the well bore on wire line equipment of the type disclosed in Patent No. 2,687,775, in which the power or piston portion (not shown) of the apparatus is connected to the sleeve 66, and the cylinder portion (not shown) of the apparatus is connected to the tension mandrel 68.

The force created in the setting equipment will urge the sleeve 66 downwardly and exert an upward pull on the tension mandrel 68. Such downward force is thus imposed on the upper body member 12 and the upward force is imposed through the tension mandrel 68, release stud 69, rod 71 and disc 26 to the lower body member 21. When the force imposed exceeds the strength of the shear screws 23, 30, 40, 59, 61, the latter are disrupted and the upper body member 12 and lower body member 21 are shifted toward each other, the lower body member, in effect, sliding relatively upwardly along the first and second tubes 13, 16. Such movement of the parts will result in the upper abutment 35 moving toward the upper body member 12, moving the upper wedge segments 34 upwardly within the upper slip segments 27 and effecting an outward expansion of the upper slips and wedge segments against the wall of the well casing B with the wickers 28 digging into the wall of the well casing. Similarly, such movement will effect a shifting of the lower abutment 49 toward the upper abutment 35, foreshortening the packing member 46 and resulting in its outward expansion into sealing engagement with the wall of the well casing B, as well as against the peripheries of the first and second tubular portions 13, 16 of the upper body member 12. The upward shifting of the lower body member 21 toward the upper body member 12 will also cause it to shift upwardly toward the lower abutment 49, the lower wedge segments 54 moving downwardly relative to the lower slip segments 55. In view of the coengaging tapered side surfaces 63, 64 on these wedge and slip segments, they are all expanded outwardly until the external wickers 62 on the slip segments 55 are embedded in the wall of the well casing.

The downward force imposed on the upper body member 12 and the upward force imposed on the lower body member 21 will continue, to insure a firmer wedging action between and against the upper slip segments 27 and a firmer embedding of the upper slip wickers 28 into the well casing. The packing member 46 will be foreshortened and expanded outwardly against the wall of the well casing still more firmly, and the lower wedge

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segments 54 will be wedged between the lower slip segments 55 more firmly, to insure the embedding and holding of the lower slip wickers 62 into the wall of the well casing. The setting force imposed upon the parts will continue until the upward pull on the tension mandrel 68 exceeds the strength of the release stud 69 at its weakened or reduced diameter portion 70, this stud then pulling apart and permitting the setting apparatus, including the sleeve 66 and mandrel 68, to be withdrawn upwardly through the well casing to the top of the hole, as set forth in the aforementioned Patent No. 2,687,775. The disc 26 and rod 71 can drop downwardly from the packer, so as to leave an unimpeded first passage 10 through the packer.

Assurance is had that the removal of the downward force on the upper body member 12 and the upward force on the lower body member 21 will not allow the parts to return to their initial retracted positions, by providing a one-way ratchet or lock device, which acts between the lower body member 21 and the first tube 13 of the upper body member or structure 12. As disclosed, the first tube has circumferential ratchet teeth 80 thereon facing in an upward direction, which are adapted to engage companion downwardly facing ratchet teeth 81 on a ratchet ring or sleeve 82 disposed in a groove 83 defined between the upper end of the lower body extension 24 and a downwardly facing shoulder 84 on the body member 21. The outer surfaces 85 of the split ratchet ring or sleeve 82 are formed as tapered cam teeth or faces engaging companion internal cam teeth or faces 86 in the lower body member 21. It is evident that the first tubular member 13 can move downwardly relative to the lower body member 21, but any tendency for the first tubular member to move back upwardly will cause the ratchet teeth 80, 81 to engage and the cam surfaces 85, 86 to urge the ratchet ring 82 inwardly to hold the ratchet teeth engaged. Upward movement of the lower body 21 along the first tubular member 13 is permitted, since the inner teeth 81 on the ratchet ring will merely ratchet or slide over the external ratchet teeth 80 on the inner tubular member 13. However, any tendency for the lower body member 21 to move downwardly will be prevented by the coengagement between the ratchet teeth 80, 81 and the camming action of the cam teeth or faces 85, 86 tending to urge and hold the ratchet teeth inwardly to maintain them in engagement with one another.

After the well packer has been set in the well casing, a tubing string (not shown) of the proper diameter can be lowered in the casing. The diameter of this tubing string is greater than the diameter through the second passage 11 of the upper body member or head 12, so that such member will feed into the upper portion of the first passage 10 in the head. Accordingly, fluid flowing upwardly through the first passage 10 in the apparatus will continue passing upwardly through such tubing string (not shown) to the top of the hole. A second tubing string (not shown) having a smaller diameter than the first tubing string (not shown) can then be lowered through the well casing B and will be guided by the upper tapered guide surface 90 on the upper body member or head 12 into the second passage 11. Accordingly, fluid moving upwardly through the second passage of the apparatus will continue to flow through the second tubing string (not shown) to the top of the hole.

By virtue of the slip and wedge arrangement disclosed, the wedging force between the slips and the wedge segments is primarily in a circumferential direction, in view of the coengagement between the tapered side surfaces of these parts. There is very little inward radial collapsing force imposed on the parts. There is even very little force imposed between the end tapered surfaces 31, 41 on the slip segments 27 and wedge segments 34 and the companion tapered surfaces 32, 42 on the upper body member 12 and upper abutment 35, for example. For that matter, tapering of such surfaces need not be pro-

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vided, since they could be normal to the axis of the apparatus. However, it is preferred that the tapered surfaces be used to insure that the slip segments and wedge segments will move outwardly. However, the angle of taper to the axis of the apparatus is rather large, so that any inward component of force is relatively small. Essentially, the wedge force holding the slips embedded in the wall of the well casing is carried circumferentially around the slip and wedge structures, passing from one slip segment to an adjacent wedge segment and thence to the next slip segment and so on completely around the apparatus. Moreover, since the radial thickness of the slip and wedge segments is rather small, the dimensions of parts of the apparatus within the slip and wedge segments can be much greater than heretofore provided, where conventional tapered expanders were disposed behind companion tapered slips. In fact, the slip and wedge segments are relatively thin, but despite such thinness, have a great holding force against the well casing and a relatively large load transmitting force circumferentially around the slip and expander segments.

The inventor claims:

1. In a well tool adapted to be anchored in a well conduit disposed in a well bore: a supporting structure; upper and lower abutments on said structure; split slip means on said structure between said abutments engaging one of said abutments, said slip means having tapered side faces on opposite sides of its split; wedge means between said side faces engaging said other abutment and having expander side faces engaging said slip side faces and tapered in a direction opposite thereto; and means for moving said abutments relatively toward each other to force said wedge means toward said slip means and expand said slip means and wedge means outwardly into engagement with the well conduit; said abutments having tapered surfaces behind and engaging companion tapered surfaces on said slip means and wedge means to urge said slip means and wedge means laterally outwardly upon relative movement of said abutment toward each other.

2. In a well tool adapted to be anchored in a well conduit disposed in a well bore: a supporting structure; upper and lower abutments on said structure; circumferentially spaced slips between said abutments engaging one of said abutments, the side faces of each slip being tapered in one direction; circumferentially spaced segmental wedges disposed arcuately between said slips and engaging said other abutment, each of said wedges having side faces engaging said slip faces and tapered in the opposite direction thereto; and means for moving said abutments relatively toward each other to force said wedges toward and between said slips to expand said slips and wedges outwardly into engagement with the well conduit; said abutments having tapered surfaces behind and engaging companion tapered surfaces on said slips and wedges to urge said slips and wedges laterally outwardly upon relative movement of said abutments toward each other.

3. In a well tool adapted to be anchored in a well conduit disposed in a well bore: a supporting structure; upper and lower abutments on said structure; split slip means on said structure between said abutments engaging one of said abutments, said slip means having tapered side faces on opposite sides of its split; wedge means between said side faces engaging said other abutment and having expander side faces engaging said slip side faces and tapered in a direction opposite thereto; and means for moving said abutments relatively toward each other to force said wedge means toward said slip means and expand said slip means and wedge means outwardly into engagement with the well conduit; said abutments having tapered surfaces behind and engaging companion tapered surfaces on said slip means and wedge means to urge said slip means and wedge means laterally outwardly upon relative movement of said abutments toward each other; said slip means and wedge means hav-

ing inner surfaces substantially parallel to the axis of said supporting structure.

4. In a well tool adapted to be anchored in a well conduit disposed in a well bore: a supporting structure; upper and lower abutments on said structure; circumferentially spaced slips between said abutments engaging one of said abutments, the side faces of each slip being tapered in one direction; circumferentially spaced segmental wedges disposed arcuately between said slips and engaging said other abutment, each of said wedges having side faces engaging said slip faces and tapered in the opposite direction thereto; and means for moving said abutments relatively toward each other to force said wedges toward and between said slips to expand said slips and wedges outwardly into engagement with the well con-

duit; said abutments having tapered surfaces behind and engaging companion tapered surfaces on said slips and wedges to urge said slips and wedges laterally outwardly upon relative movement of said abutments toward each other; each of said slips and wedges having inner surfaces substantially parallel to the axis of said supporting structure.

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