May 29, 1962 E. H. CLARK, JR 3,036,640

AUTOMATICALLY ADJUSTABLE TUBING ANCHOR

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FIG. 1.

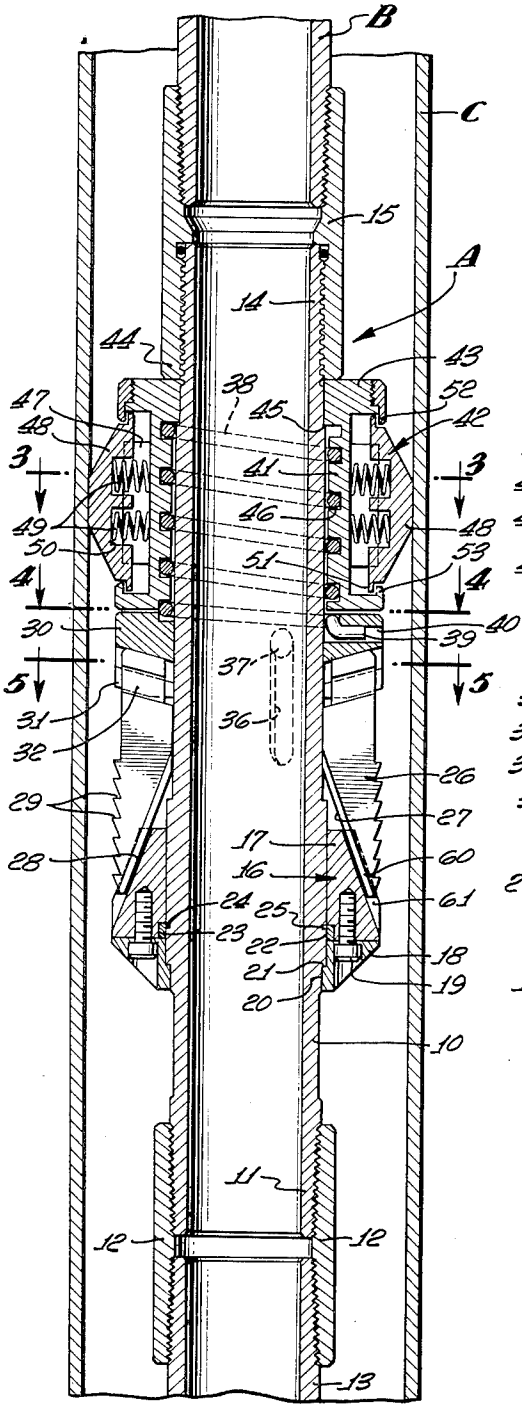
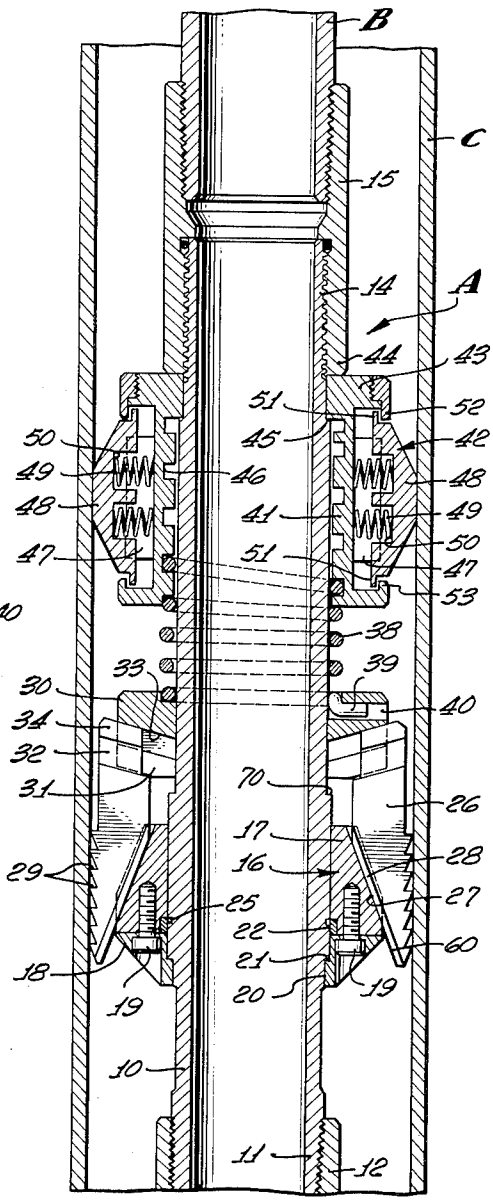


FIG. 2.



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FIG. 3.

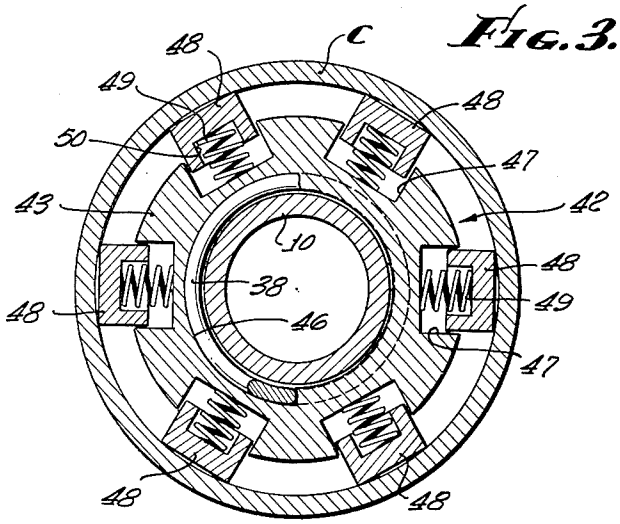


FIG. 4.

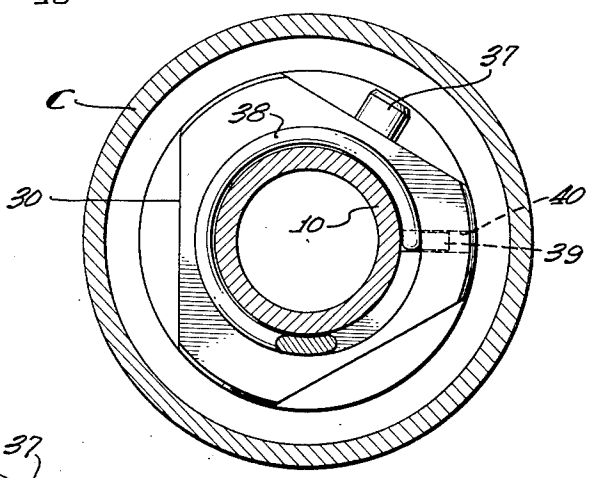
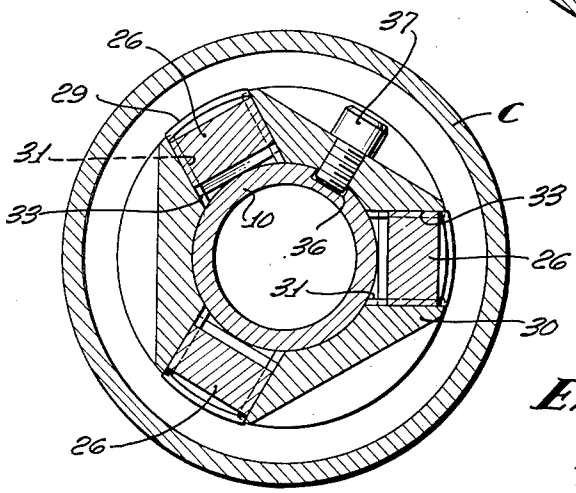


FIG. 5.



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3,036,640 AUTOMATICALLY ADJUSTABLE TUBING ANCHOR

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12 Claims. (Cl. 166—216)

The present invention relates to subsurface well bore equipment, and more particularly to anchors for securing tubular strings, such as strings of production tubing, in well casings, or similar conduits, disposed in well bores.

An object of the invention is to provide an anchor for securing a string of production tubing in well casing disposed in a well bore, which is relatively simple, economical to manufacture, and compact.

Another object of the invention is to provide an improved anchor for securing a string of production tubing in well casing, the anchor automatically shifting to a new anchoring location in the well casing as the string of tubing elongates as a result of its increase in temperature, reciprocation of a deep well pump in the tubing string, increase in the hydrostatic head differential within the tubing string, etc.

A further object of the invention is to provide an anchor particularly useful in securing a string of production tubing in a well casing, having slips which are held initially in a retracted position and which are expanded into engagement with the well casing and retracted therefrom by a yieldable or spring-like device that tends to shift the slips downwardly and maintains them against the casing as the tubing string elongates.

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 longitudinal section through an apparatus disposed in a well casing, with the slips in retracted position;

FIG. 2 is a view similar to FIG. 1, with the slips expanded into anchoring engagement with the well casing;

FIG. 3 is an enlarged cross-section taken along the line 3—3 on FIG. 1;

FIG. 4 is an enlarged cross-section taken along the line 4—4 on FIG. 1;

FIG. 5 is an enlarged cross-section taken along the line 5—5 on FIG. 1.

In the embodiment of the invention illustrated in the drawings, an anchor A is disposed in and actually forms part of a string of production tubing B extending to the top of the well bore. The anchor is particularly adapted to prevent upward movement of the string of production tubing in a well casing C, and will automatically adjust itself so as to move to a lower position in the well casing in the event the production tubing B elongates for any reason. As an example, assuming a deep well pump to be disposed in a production tubing reciprocated by a string of sucker rods extending through the tubing, such reciprocation tends to cause the tubular string to "breathe", alternately tending to contract and elongate. Again, elongation may result from the rise of the fluid in the production tubing after pumping of the well has started, accompanied by a fall in the hydrostatic head of fluid

in the tubing-casing annulus. Such differential in hydrostatic heads would cause the liquid to tend to stretch the tubing downwardly. The present apparatus shifts downwardly as the tubing string B elongates to prevent its subsequent contraction.

The anchor A includes a tubular body or mandrel 10 which preferably has the same inside diameter as the inside diameter of the tubing string B itself. The lower end of this mandrel is constituted as a threaded pin 11 for threadedly receiving a coupling 12 which is, in turn, threadedly secured to a lower section 13 of the tubing string B. The body or mandrel 10 has an upper body portion 14 threadedly attached thereto which has a threaded box 15 at its upper end for threadedly securing the apparatus to a tubing section B thereabove, which extends to the top of the well casing.

Releasably secured to the body or mandrel 10 of the tool is an expander 16, including an upper portion 17 and a lower portion 18 which are secured together by a plurality of longitudinally extending screws 19. The lower portion has an internal flange 20 engaging a downwardly facing shoulder 21 on the body, which thereby prevents relative upward movement of the expander 16 along the body 10. Both upward and downward movements of the expander 16 along the body are initially prevented by a frangible device, such as a split shear ring 22, the outer portion of which is disposed in an internal groove 23 defined between the upper and lower expander portions 17, 18, the inner portion 24 of the shear ring being much thinner than the outer portion and received within a peripheral groove 25 in the body of the tool.

Surrounding the tool mandrel 10 and the expander 16 are a plurality of circumferentially spaced slips 26 which have inner surfaces 27 tapering in an upward and inward direction for coaction with companion tapered or expander surfaces 28 on the expander 16. These slips have external wickers or teeth 29 facing in an upward direction, and are movable downwardly along the body and the expander to cause outward expansion of the slips until their wickers or teeth 29 engage the well casing. It is evident that relative upward movement of the expander 16 within the slips 26 will force the wickers 29 of the latter into the wall of the well casing, thereby anchoring the tubing B to the well casing C against upward movement therewithin.

The slips 26 are movable longitudinally together, but can partake of lateral or radial movement with respect to the body of the tool and the well casing. Thus, a slip ring 30 is slidably mounted on the body 10 of the tool, this slip ring having circumferentially spaced generally radial grooves 31 receiving the upper portions or heads 32 of the slips. The upper side walls of the slots are provided with grooves 33 adapted to receive companion tongues 34 on the upper parts of the head. The tongues 34 and grooves 33 are inclined to a slight extent in an upward and outward direction so as to facilitate embedding of the wickers 29 in the wall of the well casing and also the removal or retraction of the slips 26 with respect to the casing.

Although the slips 26 and slip ring 30 are movable longitudinally of the body 10 of the tool and the expander 16, they are rotatable therewith by virtue of providing a slidable spline connection between the slip ring 30 and the body of the tool. Thus, the body of the tool has a longitudinal groove or keyway 36 in its exterior adapted to receive a key 37 in the form of a screw threaded through the ring 30. When the slips 26 are in their fully retracted position, the key 37 is located at the upper end of the groove 36. Downward movement of the slips 26 along the body will shift the key 37 downwardly in the slot 36, thereby allowing the slips 26 to move rela-

tively downward of the body 10 and the expander 16, and effecting their outward expansion into anchoring engagement with the wall of the well casing.

Surrounding the mandrel 10 is a helical spring 38, the lower end 39 of which is secured to the slip ring 30 as by having this lower end extend laterally outwardly and be disposed within a hole 40 in the slip ring. This spring 38 is disposed within the drag body 41 of a drag device 42 relatively rotatable with respect to the mandrel 10, but preferably prevented from moving longitudinally with respect thereto by virtue of the fact that the upper end 43 of the drag body engages the lower end or shoulder 44 of the upper body member 14, the drag body also engaging an upwardly facing shoulder 45 on the mandrel 10. The helical spring 38 is disposed within a helical internal groove 46, such as a helical thread, in the inner surface of the drag body 41, the helical spring preferably being wound left hand and the corresponding internal threaded groove 46 in the drag body also being wound left hand. Rotation of the helical spring 38 to the left will effect a relative downward feeding of the spring along the drag body 41; whereas its rotation to the right will effect a relative upward feeding of the spring with respect to the drag body.

The drag device 42 includes the drag body 41 which has circumferentially spaced longitudinally extending slots 47 receiving radially movable drag blocks 48 adapted to frictionally engage the wall of the well casing C. The necessary friction force is provided by helical compression springs 49 disposed in each slot or groove 47 and engaging the base of the slot or groove, their outer ends being received within drag block sockets 50 and engaging the bases of the sockets. The drag blocks 48 can move inwardly against the force of the helical compression springs 50, their outward movement under the influence of the springs being limited by engagement of the termini 51 of the drag blocks with an upper stop ring 52 threadedly secured to the upper portion of the drag body 41 and with a lower stop rim 53 projecting upwardly from the lower portion of the drag body.

When the spring 38 is fully threaded within the drag body 41, the slip ring 30 and slips 26 occupy an upper position with respect to the tubular mandrel 10 and the expander 16, the slips being disposed in their retracted position, such as disclosed in FIG. 1. Assurance is had that the slips 26 will move to the retracted position when elevated relative to the expander 16 by providing side tongues 60 on each slip sitting within side grooves 61 in the expander, the tongues 60 and grooves 61 being inclined to the same extent as the expander surfaces 27, 28. Thus, elevation of the slips 26 relative to the expander 16 will result in the retraction or inward movement of the slips. Lowering of the slips with respect to the expander will result in their outward expansion into engagement with the wall of the well casing.

The apparatus A is run in the well casing with the parts occupying the position illustrated in FIG. 1, the slips 26 being fully retracted. During the downward movement of the apparatus in the well casing, the expander 16 is prevented from moving upwardly within the slips by the connection of the expander to the body through the shear ring 22 and also by the engagement between the expander flange 20 and the downwardly facing mandrel shoulder 23, which relieves the shear ring of any forces tending to relatively shift the expander upwardly along the body 10. The drag device 42 is secured to the body 10 against longitudinal movement, and since the spring 38 is threaded fully upwardly within the drag body 41 and is attached to the slip ring 30, the slips 26 are prevented from moving downwardly along the body 10. They are, therefore, positively retained in their retracted positions, their inadvertent expansion being precluded.

When the location in the well casing C is reached at which the anchor A is to be set, the tubular string B and the mandrel 10 are rotated to the left, or in a counterclockwise direction. Such rotary motion will be transmitted through the keyway 36 and key 37 to the slip ring 30 and from the latter to the slips 26 and expander 16, as well as to the spring 38. The frictional engagement of the drag blocks 48 against the wall of the casing will resist or prevent rotation of the drag body 41. Accordingly, the rotation of the spring 38 to the left will cause it to feed downwardly in the drag body 41, the spring pushing the slip ring 30 and the slips 26 downwardly along the body 10 and the expander 16 to expand the slips outwardly against the well casing to the positions illustrated in FIG. 2. After the slips 26 have engaged the well casing, they may slide around the casing to some extent. However, they are incapable of further downward movement along the body 10 of the tool. Accordingly, a continuation of the rotation will cause the upper turns of the spring 38 to continue to feed downwardly within the helical left hand threaded groove 46 of the drag body 41, which will effect a shifting of the upper portion of the spring toward the slip ring 30 and effect a compression of the spring. The spring may actually be compressed to some extent when fully disposed within the drag body, the continued downward feeding of the upper portion of the spring within the drag body 41 producing its further compression. Thus, the spring 38 will exert a force tending to shift the slip ring 30 and the slips 26 downwardly relative to the body 10 of the tool and the expander 16.

An upward strain can now be taken on the tubular string B, which will be transmitted through the body 10 and the shear ring 22 to the expander 16, tending to wedge the expander further behind the slips 26 and resulting in their outward shifting to a small extent to embed their wickers 29 in the wall of the well casing. The tubular string B will thus be held in tension, which is a desirable condition when disposed in the well casing.

After the anchor A has been set in the well casing, should the tubular string B elongate for any reason (which might be due to an increase in its temperature, reciprocation of the deep well pump, or an increase in the hydrostatic head differential within the tubing string), the mandrel 10 will shift downwardly, carrying the expander 16 downwardly with it. Such downward movement of the expander will tend to release the slips 26 from the well casing. However, as the expander 16 moves downwardly, the spring 38, acting upon the slip ring 30 and slips 26 will shift the slips downwardly along the well casing. Any subsequent tendency of the tubing string B, mandrel 10 and expander 16 to shift upwardly will again promptly embed the slip wickers 29 in the wall of the well casing. In the event that further elongation of the tubing string B occurs, accompanied by corresponding downward movement of the mandrel 10 and expander 16, the spring 38 will cause the slips 26 to follow the expander in a downward direction, any tendency for the expander 16 to move upwardly immediately wedging it behind the slips 26 and embedding their wickers 29 in the wall of the well casing. Such downward feeding of the entire anchor A and upward wedging of the expander 16 behind the slips 26 can occur intermittently, the slips always following the downward movement of the expander 16 while remaining in engagement with the casing, such that upward shifting of the expander to a slight extent immediately wedges the slips 26 outwardly into anchoring engagement with the well casing C.

The entire anchor device A can be shifted downwardly within the well casing to a very substantial extent. The spring 38 is always available to cause the slips 26 to follow the downward motion of the expander 16. This is due to the fact that the drag device 42 is coupled to the mandrel 10 to move therewith. The drag device, by moving down with the body 10, will retain the compressive force in the spring 38, since it cannot shift away from the slip ring 30 to any substantial extent. In fact, downward movement of the drag device 42 toward the

slip ring 30 will further compress the spring 38, which additional spring compression will be lost as soon as the slips 26 shift downwardly to follow the downward motion of the expander 16. However, there is still a very substantial spring force available after the slips have followed the expander 16.

In the event that the anchor A is to be released from the well casing, it is merely necessary to turn the tubular string B and the mandrel 10 to the right. Such turning effort will be transferred through the keyway and key connection 36, 37 to the slip ring 30, to which the slips 26 and spring 38 are connected. In view of the frictional engagement of the drag device 42 against the wall of the well casing, the drag body 41 is prevented from turning. Accordingly, the right hand rotary motion of the left hand wound spring 38 within the drag body 41 will result in an upward feeding of the spring within the left hand helical groove 46 of the body 41, which feeding action will pull the slip ring 30 and the slips 26 upwardly relative to the body 10 and the expander 16. Because of the inclined tongue and groove slidable connection 60, 61 between the slips 26 and expander 16, such upward movement results in inward shifting of the slips to their retracted position, such as disclosed in FIG. 1. The anchor A can now be elevated by the tubing string B in the well casing C and removed completely therefrom, if desired. During the elevating movement the expander 16 cannot shift the slips 26 outwardly into engagement with the wall of the well casing, since the slips are connected to the body 10 for upward movement therewith through the spring 38 and drag body 41, whereas the expander is also connected to the body by the shear ring 22. Assurance is therefore had that the slips 26 will not be expanded inadvertently against the well casing during upward movement of the expander 16 therewithin.

In the event that the slips 26 cannot be freed from the well casing as a result of right hand rotation of the tubing string B and the mandrel 10, an upward pull can be taken on the tubing string and the mandrel, with the slips 26 embedded in the wall of the well casing. When such pull exceeds the shear strength of the ring 22, its inner portion 24 is sheared from the outer portion, freeing the mandrel 10 from the expander 16. The mandrel can now be moved upwardly, causing an upwardly facing shoulder 70 thereon to strike against the lower end of the slip ring 30, which will tend to pull the slips 26 upwardly relative to the expander 16. If such action does not free the slips 26, then the mandrel 10 can be moved downwardly to cause the shoulder 21 to engage the expander flange 20 and drive the expander downwardly relative to the slips 26, in order to shift the latter to a retracted position within the well casing. As soon as the wickers 29 become released from the well casing the expander will drop downwardly along the mandrel 10, such downward movement being accompanied by inward retraction of the slips 26, due to their inclined tongue and groove interconnection 60, 61 with the expander. The apparatus can now be elevated in the well casing and removed entirely therefrom.

From the foregoing description, it is apparent that a tubing anchor has been provided which will shift automatically downwardly to retain the tubing string in a tensioned condition as the tubing string elongates. The spring 38 insures the follow-up of the slips 26 with respect to the expander 16, the slips being held in engagement with the expander 16 and the well casing C at all times, in order that any upward moving tendency of the tubing string and the mandrel 10 will immediately result in reembedding of the slip members in the wall of the well casing. The apparatus is simple in construction, and is consequently relatively economical to manufacture. Its mode of operation is also relatively simple, requiring only rotation in a left hand direction to set the slips 26 against the casing, and rotation in a right hand direction to retract the slips from the casing. The entier anchor is short and compact, and is still capable of being released from the well casing under emergency conditions in the event that the slips 26 cannot be released as a result of rotation of the tubing string and the mandrel of the tool.

The inventor claims:

1. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means fixed to said body against longitudinal movement in both directions and adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit; means for moving said slip means and expander means longitudinally with respect to each other whereby said expander means expands said slip means against the well conduit; and means engaging said drag means and slip means to yieldably urge said slip means toward said expander means and maintain said slip means engaged with said expander means and conduit as said body moves said expander means in a direction away from said slip means after said slip means has been expanded against the well conduit.

2. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means fixed to said body against longitudinal movement in both directions and adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit; means for moving said slip means and expander means longitudinally with respect to each other whereby said expander means expands said slip means against the well conduit; and spring means engaging said drag means and slip means to urge said slip means toward said expander means and maintain said slip means engaged with said expander means and conduit as said body moves said expander means in a direction away from said slip means after said slip means has been expanded against the well conduit.

3. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means fixed to said body against longitudinal movement in both directions and adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means mounted on said body to move longitudinally therewith and frictionally engageable with the well conduit; means for moving said slip means and expander means longitudinally with respect to each other whereby said expander means expands said slip means against the well conduit; and spring means engaging said drag means and slip means to urge said slip means toward said expander means and maintain said slip means engaged with said expander means and conduit as said body moves said expander means in a direction away from said slip means after said slip means has been expanded against the well conduit.

4. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit and having a helical groove; helical spring means fitting in said groove and engaging said slip means; and means for relatively rotating said spring means and drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

5. An apparatus to be disposed within and anchored

to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means mounted on said body to move longitudinally therewith and frictionally engageable with the well conduit; said drag means having a helical groove; helical spring means fitting in said groove and engaging said slip means; and means for relatively rotating said spring means and drag means to feed said spring means along said drag means to shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

6. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit and having a helical groove; helical spring means fitting in said groove and engaging said slip means; and means connecting said spring means to said body, whereby rotation of said body rotates said spring means relatively to said drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

7. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means mounted on said body to move longitudinally therewith and frictionally engageable with the well conduit, said drag means having a helical groove; helical spring means fitting in said groove and engaging said slip means; and means connecting said spring means to said body, whereby rotation of said body rotates said spring means relative to said drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

8. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit and having an internal helical groove; helical spring means fitting in said groove and engaging said slip means; and means connecting said spring means to said body, whereby rotation of said body rotates said spring means relatively to said drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

9. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit and having a helical groove; helical spring means fitting in said groove and connected to said slip means; and means connecting said slip means to said body, whereby rotation of said body rotates said slip means and spring means relatively to said drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

10. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means mounted on said body to move longitudinally therewith and frictionally engageable with the well conduit, said drag means having a helical groove; helical spring means fitting in said groove and connected to said slip means; and means connecting said slip means to said body, whereby rotation of said body rotates said slip means and spring means relatively to said drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

11. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means mounted on said body to move longitudinally therewith and frictionally engageable with the well conduit; said drag means having an internal helical groove; helical spring means fitting in said groove and connected to said slip means; and means connecting said slip means to said body, whereby rotation of said body rotates said slip means and spring means relatively to said drag means to feed said spring means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

12. An apparatus to be disposed within and anchored to a well conduit in a well bore: a body; slip means on said body adapted to engage the well conduit to anchor the body therewithin; expander means on said body adapted to coact with said slip means to expand and hold said slip means against the well conduit; drag means frictionally engageable with the well conduit and having a helical groove; feeding means fitting in said groove and including a helical spring engaging said slip means; and means for relatively rotating said feeding means and drag means to shift said feeding means along said drag means and shift said slip means longitudinally with respect to said expander means and outwardly against the well conduit.

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