

Feb. 22, 1966

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3,236,309

RETRIEVABLE PACKER HOLDDOWN DEVICE

Original Filed Aug. 8, 1958

4 Sheets-Sheet 1

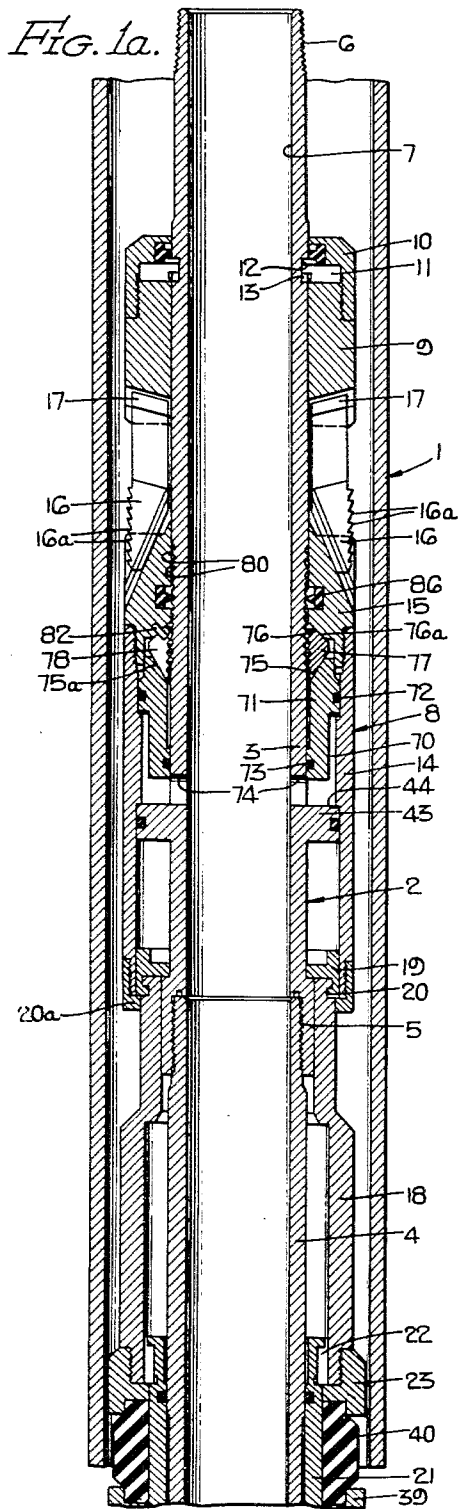
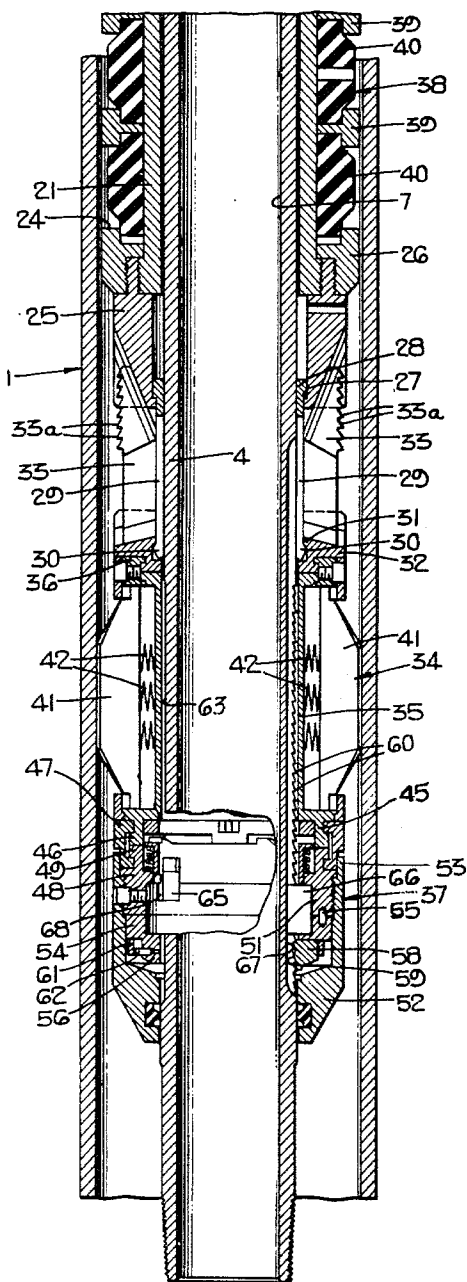


*Fig. 1b.*

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4 Sheets-Sheet 2

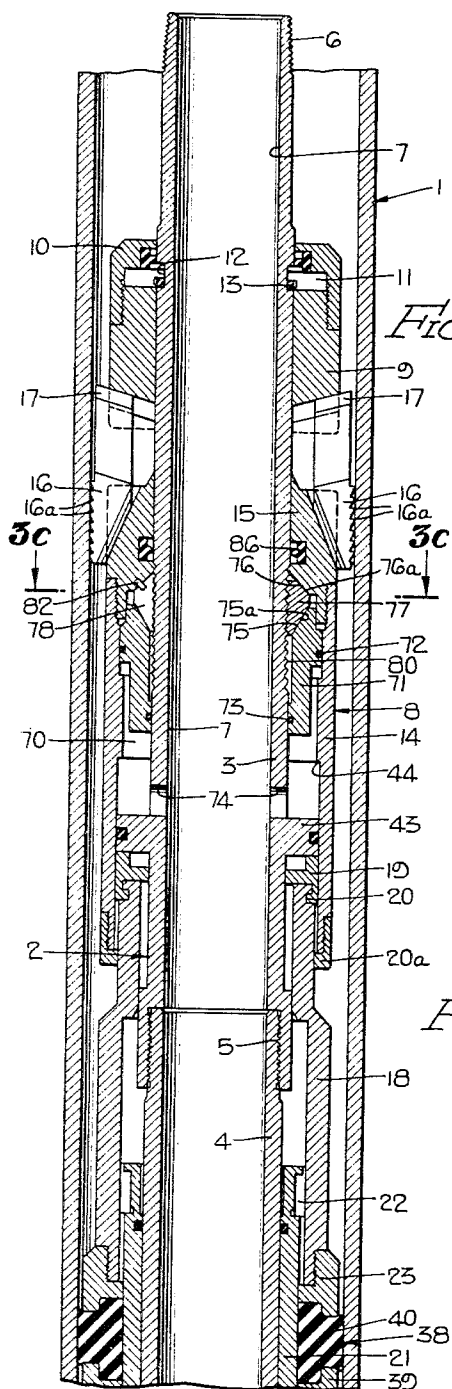


FIG. 2a.

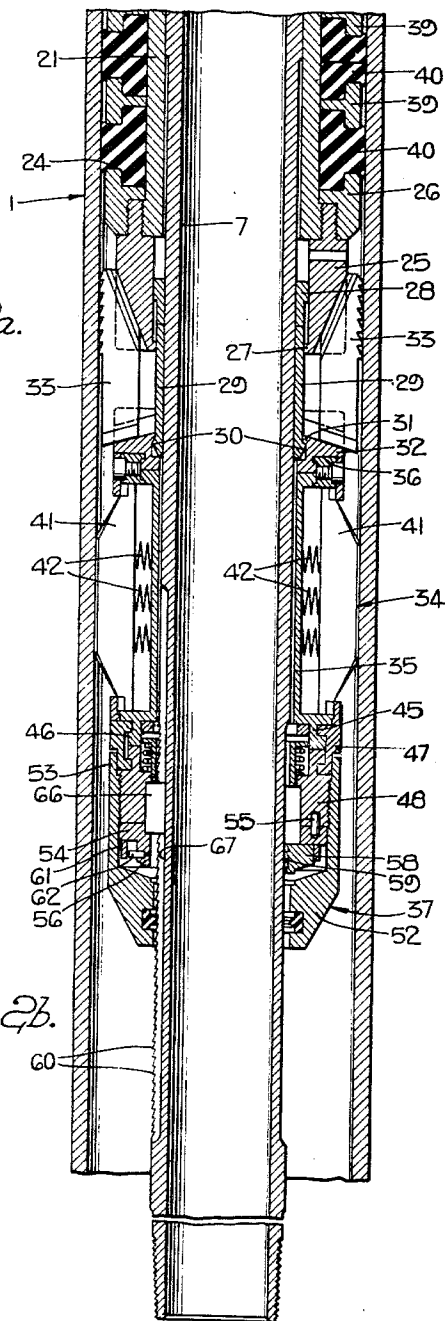


FIG. 2b.

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4 Sheets-Sheet 3

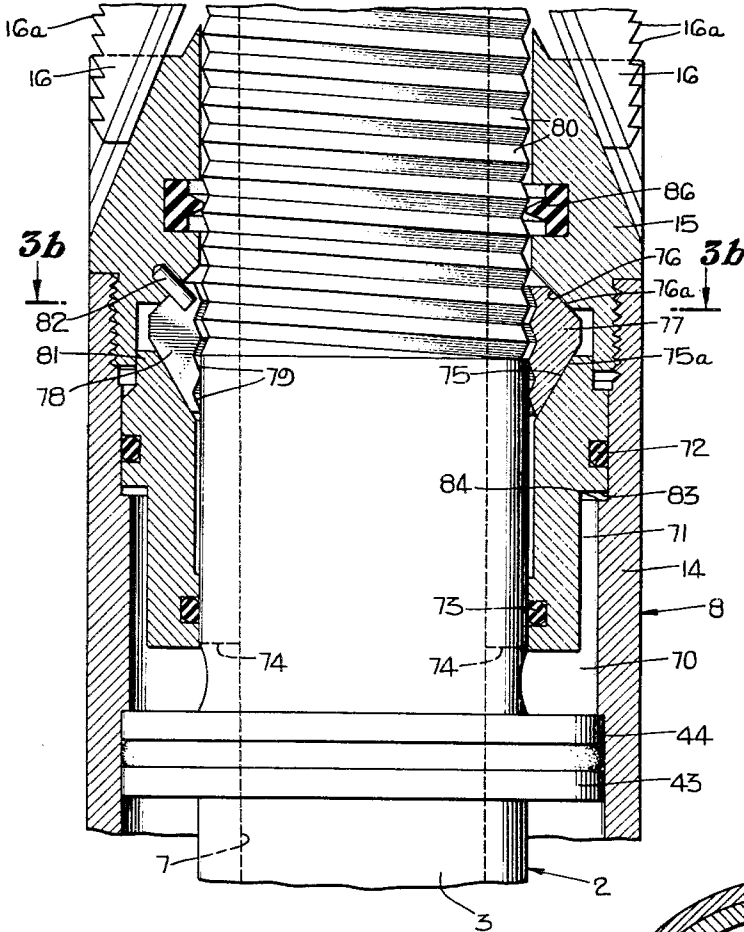


FIG. 3a.

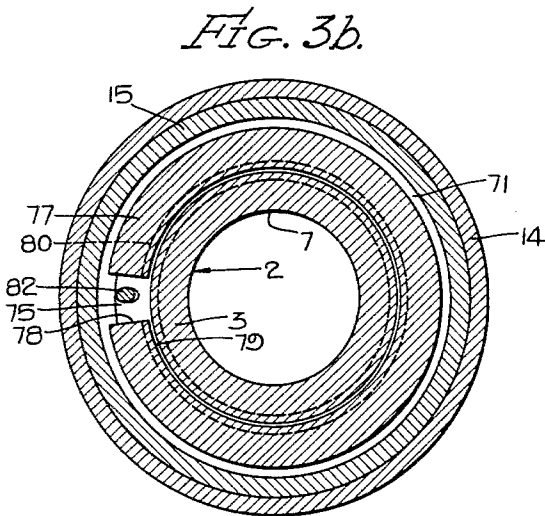


FIG. 3b.

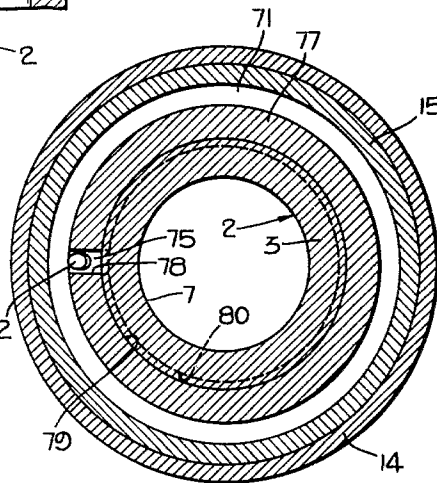


FIG. 3c.

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Original Filed Aug. 8, 1958

4 Sheets-Sheet 4

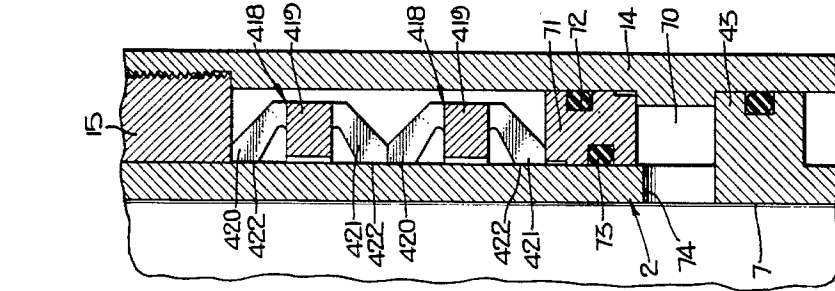


FIG. 7.

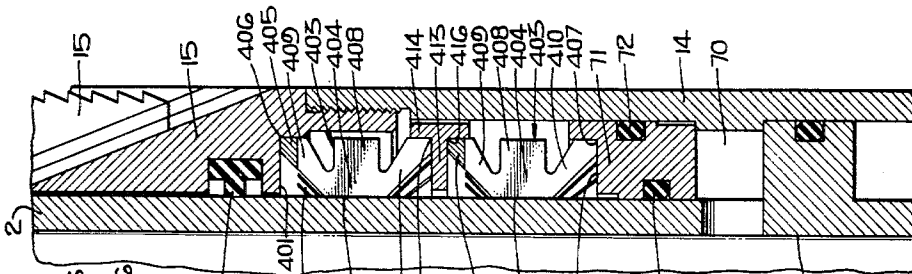


FIG. 6.

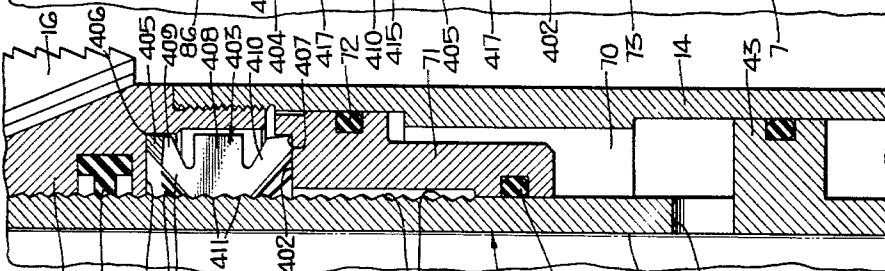


FIG. 4b.

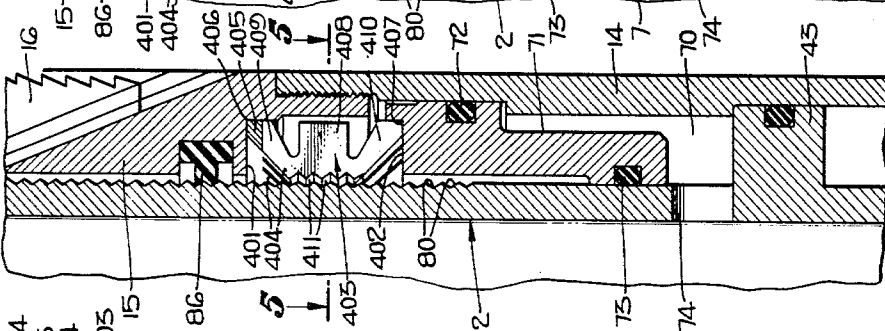


FIG. 4a.

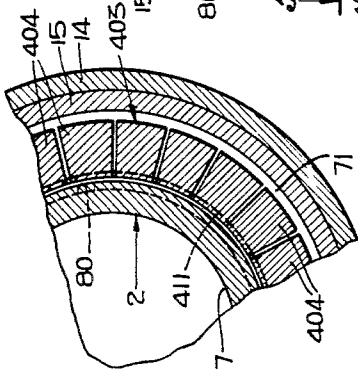


FIG. 5.

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3,236,309

## RETRIEVABLE PACKER HOLDDOWN DEVICE

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Original application Aug. 8, 1958, Ser. No. 754,002, now

Patent No. 3,094,169, dated June 18, 1963. Divided

and this application July 9, 1962, Ser. No. 223,571

24 Claims. (Cl. 166—120)

This application is a division of my copending application Serial No. 754,002 filed August 8, 1958, now Patent No. 3,094,169 granted June 18, 1963.

The present invention relates to well tools, and more particularly to improvements in well packers adapted to be run into a well on a tubing or pipe string and to pack-off the annulus between the running-in string and the casing during such fluid injection well treatments or operations as squeeze cementing, formation fracturing, acidizing, casing testing, or the like.

Among the primary objectives of the invention is the provision of an outstandingly versatile tool which is susceptible of a wide range of variation in the manner of its usage.

Well tools of the type here involved generally include a mandrel or tubular body adapted to be connected to a running-in string of tubing or pipe, anchor slips expansible into engagement with the well casing to anchor the tool, casing engaging friction means in the form of drag blocks or springs for effecting expansion of the slips responsive to axial movement of the mandrel; latch means for releasably securing the casing engaging friction means to the mandrel during running of the tool into the well, this latch means being releasable responsive to rotation of the running-in string and mandrel, and packer means expansible into engagement with the casing upon axial movement of the mandrel.

In tools of the aforementioned type wherein the casing engaging anchor slips and the packing elements are spaced axially of the tool, and particularly where the packing element is disposed above the slips, and the slips and packing element are expanded into engagement with the casing upon setting down or lowering of the running-in string, the packer rubber tends to be forced into eccentric relation to the casing resulting in inferior sealing with the casing well. Moreover, pressure in the well acting beneath the packer assembly tending to elevate the same in the casing, has a tendency to blow past the packing element if the latter is not centralized within the casing and uniformly in engagement with the casing. Accordingly, another object of the invention is to provide a packer assembly including hold-down slips mounted in axially spaced relation to the anchor slips, with the packing element disposed between the hold-down and anchor slips so that the tool is centralized in the casing by the spaced slips, and the packer rubber is accordingly maintained concentric in the casing and is capable of withstanding extremely high pressures therebelow.

In furtherance of the preceding objective, an additional object is to provide improved means for locking the hold-down slips, this locking means being responsive to hydraulic pressure resulting from the pumping of fluid down the running-in string and through the tubular mandrel. In this connection the mandrel is surrounded by a tubular member which defines, with the mandrel, a pressure chamber, in which is shiftably disposed an annular piston. The hold-down slips are set as a result of relative axial movement between the mandrel and the tubular member, and the locking means includes a contractible member disposed about the mandrel but adapted to be wedged or cammed, in one embodiment, into engagement with the mandrel so as to prevent movement of the mandrel in a direction to release the hold-down slips; in

other embodiments of the invention the locking means is so constructed as to be flexed as a result of fluid pressure in the pressure chamber so as to frictionally grip the mandrel, or so as to effect engagement of cooperative teeth or wickers on the element and the mandrel as a function of a resultant vector force. One important novel feature of the hold-down slip locking means is the provision of means whereby the lock may be positively released in the event that the annular piston in the pressure chamber should fail to permit disengagement of the locking element when pressure in the chamber is relieved.

Other objects and advantages of the invention will be hereinafter described or will become apparent to those skilled in the art, and the novel features thereof will be defined in the appended claims.

In the accompanying drawings:

FIGS. 1a and 1b are views in longitudinal section through a set-down type packer, made in accordance with the invention; FIG. 1b being a downward extension of FIG. 1a, certain of the parts being shown in elevation and a portion of the mandrel being broken away in FIG. 1b to more clearly show the control mechanism, the packer being in condition for running the same into a well or retrieval from the well;

FIG. 3a is an enlarged fragmentary view in longitudinal section with the mandrel in elevation, showing one form of the novel hold-down slip lock mechanism of the invention, the lock mechanism being disengaged as when the packer is being run into a well or retrieved therefrom;

FIG. 3b is a view in transverse section on a slightly reduced scale, as taken on the line 3b—3b of FIG. 3a;

FIG. 3c is a view similar to FIG. 3b, but showing the lock mechanism engaged with the mandrel, as taken on the line 3c—3c of FIG. 2a, on an enlarged scale;

FIG. 4a is a fragmentary view in longitudinal section through a modified form of hold-down slip lock mechanism, the lock mechanism being disengaged from the mandrel;

FIG. 4b is a view similar to FIG. 4a, but showing the lock mechanism engaged with the mandrel;

FIG. 5 is a fragmentary view in transverse section as taken on the line 5—5 of FIG. 4a;

FIG. 6 is a fragmentary view in longitudinal section through a further modification of the hold-down slip docking means, wherein a frictional lock is provided; and

FIG. 7 is a fragmentary view in a longitudinal section of still another modification of the hold-down slip lock mechanism.

Like reference characters in the several views of the drawings and in the following description designate corresponding parts.

Referring particularly to FIGS. 1a and 1b, well casing is generally designated at 1, and disposed in the casing is a packer assembly made in accordance with the invention. The packer, as illustrated, includes longitudinally extended tubular member or mandrel generally designated 2, which is comprised of an upper mandrel section 3, and a lower mandrel section 4, threadedly interconnected as at 5.

At its upper extremity, the mandrel 2 is provided with a thread 6, whereby the mandrel is adapted to be coupled to a running-in string of tubing or pipe upon which the packer may be lowered into the well casing 1, to be set during the performance of certain well treating operations such as squeeze cementing, formation fracturing, acidizing, casing testing, or the like. Extending through the mandrel 2 is a bore 7, which is the same size as the inside diameter of the running-in pipe or tubing, so that the present packer may be characterized as a "full-flow" tool which offers no restriction to the flow of fluid there-

through. In addition, by reason of the bore 7 being at least equal to the running-in tubing or pipe opening, certain through tubing wire line operations may be performed through the packer assembly. For example, perforating guns, formation testers and the like may readily pass downwardly through the packer bore 7.

Tubular means 8 is concentrically disposed about the mandrel 2 and includes a series of relatively axial movable telescopically interfitting tubular members. Uppermost of these tubular members is a slip ring 9, having a retainer cap 10 threadedly connected thereto, with a split retainer ring 11 confined between the cap 10 and the sleeve 9 and projecting radially inwardly into an annular groove 12 extending about the mandrel 2. The groove 12 has a greater axial extent than the split ring 11 so as to permit a limited amount of relative axial movement between the slip sleeve 9 and the mandrel 2 for assembly purposes as will hereinafter be more readily apparent.

A resilient ring 13 engages with the shoulder provided at the base of the groove 12 and with the inner surface of the split retainer ring 11, and normally biases the slip sleeve 9 upwardly with respect to the mandrel 2. Disposed below the slip ring 9 is a tubular housing 14 which is disposed about the mandrel 2 in spaced relation thereto. At its upper extremity the housing 14 is provided with, or has connected thereto, an expander cone 15 tapered towards the slip sleeve 9 and having slidably connected thereto, as by a dove-tailed fit, a series of circumferentially spaced tapered slips 16, the slips 16 also being provided with a dove-tailed connection, as at 17, to the lower extremity of the slip sleeve 9. Thus, expander cone 15 and slip ring 9 are interconnected by slips 16, and upon relative axial movement of the slip sleeve 9 and the expander 15, the slips 16 will be wedged outwardly into engagement with the casing 1, or retracted from engagement with the casing.

Disposed below the tubular housing 14 is a tubular connector sub 18, which is also disposed about the mandrel 2 for axial movement thereon and for rotative movement thereabout. The lower extremity of tubular housing 14 and the upper extremity of connector sub 18 are disposed in overlapped relation and are swivelly interconnected, as by means of a split swivel ring 19, engaged in a groove 20 in the connector sub 18, and engaged by a housing cap 20a which provides an inwardly projecting shoulder for limiting relative axial movement of the tubular housing 14 and the connector sub 18 in one direction.

The tubular means 8 further includes a packing element supporting sleeve 21, which is disposed about the mandrel 2 and projects upwardly into connector sub 18 at the lower extremity of the latter, the sleeve 21 being engaged at its upper extremity with a split ring 22 which shoulders with an annular abutment member 23, the latter being formed on, or connected to, the lower extremity of the connector sub 18, whereby relative axial movement of the connector sub 18 and the packing element supporting sleeve 21 is limited in one direction. At its lower extremity, the sleeve 21 is provided with a radially outwardly projecting flange 24, provided by the connection to the sleeve 21 of a downwardly tapered expander cone 25 and an abutment ring 26 which are threadedly interconnected.

It will be noted that the expander 25 extends about the lower mandrel section 4 in spaced relation thereto, and is provided with a radially inwardly projecting shoulder 27 with which is engaged the upper end of a tie sleeve 28, having a plurality of circumferentially spaced fingers 29 provided at their lower extremities with protuberances 30 for engagement beneath an inwardly projecting shoulder 31 of an anchor slip ring 32. Accordingly, the tie 28 interconnects the expander 25 and the anchor slip ring 32 against separation in an axial direction, but the expander 25 is free to move axially towards the slip ring 32, as will hereinafter more fully appear.

Shiftably interconnected with the expander 25 and with the slip ring 32, so as to be wedged outwardly into engage-

ment with the casing 1 and so as to be retracted from engagement with the casing, is a series of circumferentially spaced anchor slips 33 provided with dove-tailed connections to the expander 25 and the slip ring 32, respectively, at opposite ends of the slips 33. Depending from the slip ring 32, is casing engaging friction means, generally designated 34, and including a drag block carrier 35, which is connected to the slip ring 32 as by means of a swivel ring 36. Disposed beneath the drag block carrier 35 and interconnected therewith in a manner which will hereinafter be described, is controlled mechanism, generally designated 37.

Thus it will be seen that the tubular means 8 disposed about the mandrel 1 is constituted by a series of interconnected relatively axially movable elements comprising upper hold-down slip ring 9, expander 15, tubular housing 14, connector sub 18, packing element supporting sleeve 21, expander 25, tie 28, anchor slip ring 32 and drag block carrier 35.

In the illustrative embodiment a series of three vertically spaced packer rubbers are shown as making up a packing element 38, the packing element including gauge rings 39, 39 interposed between the independent rubber rings designated 40.

The abutment member 23 is slidably disposed upon the packing element supporting sleeve 21 for movement towards the flange 24, and as a result of such movement the packer rubbers 40 which are disposed between the abutment member 23 and the flange 24, will be axially loaded and caused to expand radially into engagement with the casing 1 in a conventional manner. Axial movement of the mandrel 2 within the tubular means 8 will also effect expansion of the anchor slips 33 into engagement with the casing prior to full expansion of the packer rubbers 40, in a manner which will hereinafter appear.

In order to effect the setting of the packer rubbers 40 and anchoring of the slips 33, the casing engaging friction means 34 includes a suitable number of friction drag blocks 41, shiftably disposed in windows in the drag block carrier 35 and resiliently biased into engagement with the casing 1 as by a number of springs 42. The drag blocks 41 are urged into engagement with the casing with such a force that sufficient friction exists between the drag blocks and the casing that as the mandrel 2 moves downwardly within the tubular means 8, the drag block carrier 35 will remain stationary in the casing while the elements of the tubular means 8, as previously described, telescope upon one another.

The mandrel 2 is provided with an outstanding annular flange 43 which is slidable within the tubular housing 14 between the swivel ring 19 and an internal shoulder 44 on the tubular housing 14. Movement of the mandrel 2 axially in one direction will effect engagement of the flange 43 with shoulder 44 so as to maintain the tubular means 8 stretched out to the limit as shown in FIGS. 1a and 1b.

Means are provided for releasably latching the tubular mandrel 2 and the tubular means 8 in the particular stretched out relationship shown in FIGS. 1a and 1b, so that the tool may be run into a well casing or retrieved therefrom. In this connection, the tubular means 8 is provided with a downward extension comprising the control mechanism 37 previously referred to.

Depending from the lower extremity of the drag block carrier 35, is a cylindrical extension 45 having a radial flange 46 to which is secured, as by means of a split swivel ring 47, an annular swivel adaptor 48 having at its upper end a radial flange 49 rotatably engaged with the flange 46 of the drag block carrier 35. It will be noted that the swivel ring 47 is provided with a pair of axially spaced internal radial flanges engaged above and below flanges 46 and 49 just referred to and securing the latter against axial separation while permitting free relative rotation.

Swivel adaptor 48 has a cylindrical skirt 51, to which is threadedly secured a control mechanism housing 52,

the latter having an axially extended skirt 53 surrounding the split swivel adaptor ring 47 so as to secure the latter against displacement. Disposed beneath the swivel adaptor 48 is a dog carrier ring 54 which is pinned to the swivel adaptor 48, as by a dowel 55.

Formed on the dog carrier 54 is a depending skirt 56 which is slotted or notched to accommodate a dog 58 which is in the form of an arcuate segment having internal wickers 59 thereon for engagement with wickers or threads 60 extending about the mandrel 2. An annular spring 61 embraces the skirt 56 on dog carrier 54, and resiliently retains the dog 58 in engagement with the mandrel 2. The spring 61 is preferably of a greater diameter than skirt 56 and is maintained in engagement with the dog 58 by means of a contact pin 62 projecting radially from the skirt 56 of dog carrier 54. The threads or wickers 60 are discontinuous, being interrupted by a longitudinally extended groove or clearance space 63, adapted to receive the dog 58 upon rotation of the mandrel 2 in a manner which will hereinafter be described.

Internally of the swivel adaptor 48 there is provided a radially inwardly directed stop lug or projection 65 which is disposed in the path of a drive key 66, the key 66 being disposed in an axially extended key slot 67 in the outer surface of the mandrel 2, the key 66 also being disposed within the annular space between the mandrel 2 and the swivel adaptor 48 and dog carrier 54.

As viewed in FIG. 1b, rotation of the mandrel 2 in a clockwise direction will bring key 66 into engagement with side face 68 of the stop projection 65, at which time the dog 58 will be disposed in the clearance space or slot 63 through the mandrel wickers 60, and the mandrel will accordingly be free to move downwardly through the tubular means 8 and the control mechanism 37. Thus the dog 58 and its related operating mechanism constitute means for releasably latching the mandrel 2 to the tubular assembly 8, so as to prevent relative axial movement therebetween as the tool is being run into a well. These and additional details of the control mechanism are shown and described in greater detail in said Patent No. 3,094,160.

When the mandrel has been freed for axial movement, then the running-in string may be set down, causing the mandrel to move downwardly with respect to the tubular means 8 to set the tool as shown in FIGS. 2a and 2b. Initial downward movement of the mandrel 2 will effect corresponding downward movement of the slip sleeve 9 and slips 16, which may be cammed outwardly into engagement with the casing 1 by the expander 15. However, the slips 16 are provided with upwardly facing wickers or teeth 16a, which will slide along the casing wall so that the slips 16 will impart downward movement to the expander 15 and consequently to tubular housing 14 which telescopes over the connector sub 18. Alternatively, friction between expander 15 and the mandrel may cause co-travel thereof, under which circumstances, the slips 16 will not be initially expanded but will remain in the same relative position as shown in FIG. 1a, as the slip ring 9, slips 16, tubular housing 14 and expander 15 move downwardly with the mandrel and the tubular housing 14 telescopes over connector sub 18. In either event, however, the slip sleeve 9, the expander 15 and tubular housing 14, will move with the mandrel 2 so far as necessary to enable engagement of the mandrel flange 43 with the swivel ring 19. Engagement of the flange 43 with swivel ring 19 will impart downward movement to the connector sub 18, which will be transmitted through packing element 38 to the lower expander 25 which will be forced downwardly relative to the anchor slips 33, thereby wedging the latter into engagement with the casing 1, since downward movement of the anchor slips 33 is resisted by the casing engaging friction means 34. Therefore, as a function of downward movement of the mandrel 2, the downwardly facing

wickers 33a of slips 33 will bite into the casing 1, thereby firmly anchoring the packing element supporting sleeve 21 against movement downwardly in the casing; whereupon continued downward movement of the mandrel 2 will cause axial loading and consequent radial expansion of the packer rubbers 40 into engagement with the casing 1, as the abutment member 23 telescopes along the packing element sleeve 21 to the position shown in FIG. 2a. Thus the anchor slips 33 and the packing element 38 will be firmly set in engagement with the casing.

When a packer having a packer rubber disposed above the anchor slips is secured in well casing by the setting down of the running-in string, the weight of the running-in string of pipe would ordinarily tend to cause the pipe string to bow into engagement with the casing wall, thus creating eccentric relationship of the packing rubbers within the casing. Moreover, high pressures in the well beneath the packer tend to elevate the packer assembly, and in the absence of a true concentric relationship of the packer rubbers in the casings, such high pressures tend to blow past the packer element. Therefore, in accordance with another of the salient features of the invention, novel hold-down slip locking means are provided whereby, as a function of the pressure of fluid being pumped through the mandrel 2, the hold-down slips 16 will be firmly locked in engagement with the casing 1 and, in addition, will centralize the mandrel or body 2 so that it is concentrically disposed within the casing 1, thus substantially increasing the effectiveness of the packer element as well as substantially extending its life.

In the illustrative embodiment, the tubular housing 14 is disposed in radially spaced relation to the upper mandrel section 3, so as to provide there between a pressure chamber 70, defined between the radial flange 43 on the mandrel and an axially movable annular piston 71 which is disposed in the space between the tubular housing 14 and the mandrel section 3, and respectively sealed thereto as by means of an O-ring or the like as at 72 and 73.

The mandrel section 3 is ported as at 74 so as to admit fluid under pressure into the pressure chamber 70. At its upper end, the piston 71 is provided with internal tapered wedging surface 75 which is preferably at an angle on the order of about 30°. Opposed to the wedging surface 75, the expander 15 is provided with a wedging surface 76 which is preferably at an angle on the order of about 45°. Disposed between the opposing wedging surfaces 75 and 76 is a resilient lock ring 77 which is split or slotted at one side, as at 78, and which has a normally relaxed diameter such that it freely permits passage of the mandrel 2 therethrough. The lock ring 77 is provided with an angularly disposed face 76a complementary to the wedging surface 76 of cone 15, as well as with an angularly disposed lower face 75a complementary to the wedging surface 75 of piston 71.

Internally of the lock ring 77 it is preferably provided with wickers 79 which, as best seen in FIG. 6a, in this embodiment of the invention, are preferably in the form of a uniform thread having a pitch on the order of 20°. The mandrel section 3 is provided with a complementary uniform thread 80, adapted to be engaged by the internally threaded lock ring 77 in a manner to securely lock the mandrel against upward movement.

Upon pressurizing the chamber 70 responsive to the pumping of well treating fluid downwardly through the mandrel 2, the piston 71 will be shifted towards the expander 15, lock ring 77 will resist constriction between wedge faces 75, 76 and consequently the tubular housing 14 and the expander 15 will be forced upwardly by pressure beneath piston 71, thus expanding slips 16 tightly into engagement with the casing. As pointed out above, it is possible that the slips 16 will upon pressurizing chamber 70 already be in engagement with the casing, in which event the force of engagement will be increased in proportion to the resistance of the lock ring 77 to constriction. When the slips 16 are firmly set, the complementary

wedging surfaces 75, 75a and 76, 76a, will flex the ring 77 and cause it to constrict about the mandrel section 3 so that the threads 79 of the lock ring 77 will be engaged with the thread 80 of the mandrel.

The upper extremity of the piston 71 is formed at 81 so as to closely fit within the lower extremity of the cone 15 so that the wedging section of the piston is firmly backed-up against deflection so as to assure positive locking engagement of the ring 77 with the mandrel.

For the purpose of description, the wickers 79 and 80 on the lock ring 77 of the mandrel section 3, respectively, have been referred to as having pitch angles of approximately 20°, while the cooperative wedge faces 75 and 75a have been referred to as being at an angle on the order of 30°, and the cooperative wedge faces 76 and 76a have been referred to as being at an angle on the order of 45°. These angles are referred to by way of illustration and not by way of limitation. However, it will be noted that as a result of the angles referred to, release of the lock ring 77 when pressure in the pressure chamber 70 is relieved will be assured upon upward movement of the mandrel 2 relative to the expander cone 15. Such release is assured by virtue of the fact that, as described, the 45° wedge surface 76 and the 20° pitch angle of the threads 79 and 80 provide a positive squeeze angle of 25°, tending to effect disengagement of the lock ring 77 from the mandrel.

However, since failure of the hold-down slips 16 to release from engagement with the casing 1, as a result of the lock ring 77 not freeing itself from the mandrel 2, when it is desired to retrieve the tool from a well, due to uncontrollable circumstances, would cause serious consequences, means are also provided for effecting a positive mechanical disengagement of the lock ring 77 from the mandrel 2. In this connection a pin or other projection carried by a non-rotatable part such as the expander cone 15 and, in the illustrative embodiment projecting from the wedging face 76, is disposed in the slot 78 of the lock ring 77 and the thread 80 is preferably of a left-hand lead. Accordingly, upon failure of the lock ring 77 to release, rotation of the mandrel 2 in a righthand direction will effect relative downward movement of the lock ring 77 by reason of the threaded engagement thereof with the lefthand threaded mandrel. Such movement of the lock ring 77 relative to the mandrel will force the piston 71 downwardly in the tubular housing 14 until an outstanding shoulder 83 on the piston engages an internal shoulder 84 on the tubular body 14. Following this, the complementary wedge faces 75, 75a and 76, 76a will be so spaced that the lock ring 77 is free of any wedging action and, accordingly, is free to assume a normal condition. In an aggravated case were the lock ring fails to disengage from the mandrel, the mandrel may be rotated to such an extent that the thread 80 thereon is completely removed from the lock ring 77, with the result that no further positive locking action will result.

In order to facilitate ease of operation of the hold-down slip mechanism, a seal 86 is provided between the inner surface of the expander cone 15 and the mandrel 2. A lip seal is herein illustrated, the purpose of which is to enable packing with a lubricant the space in which the lock ring 77 is disposed, so as to prevent the passage of well fluids into this space, and so as to maintain the parts freely movable.

Referring now to FIGS. 4a, 4b and 5, a modified hold-down slip operating and lock mechanism is shown, for use in lieu of the mechanism previously described and more particularly shown in FIGS. 3a and 3b. In FIGS. 4a, 4b and 5, as in the construction previously described, the mandrel is shown at 2, about which is disposed the tubular housing 14, having threadedly connected at its upper extremity an expander cone 15 for expanding slips 16 into engagement with the well bore defined by the casing. The mandrel 2 is provided with external wickers or threads, as at 80, and between the tubular housing 14

and the mandrel 2 there is a pressure chamber 70 communicating through port 74 with the opening through the mandrel and containing a piston 71. Projecting radially from the mandrel 2 is the flange 43 which is sealingly engaged with the inner periphery of the tubular housing 14.

In this modified construction the expander 15 has an internal radial shoulder 401, opposed by an end face 402 of the piston 71. Between the elements providing shoulder 401 and face 402 there is disposed a flexible locking member 403 comprising an annularly arranged series of flexible fingers 404 interconnected by a ring 405. The ring 405 seats in a corner 406 formed at the outer periphery of the radial shoulder 401, and the fingers 404 are engaged at their free extremities in a corner 407 formed at the outer periphery of end face 402 of piston 71. It will be noted that the fingers 404 comprise a massive central body 408, a portion 409 extending at an angle from the body towards the ring 405, and a portion 410 extending at an angle from the body into the corner 407 referred to above. As a result of this construction, axial loading of the fingers 404 will create a bending at the juncture of the portions 409 and 410 with the body 408, so that the central body 408 will shift radially inwardly into engagement with the mandrel 2 as a function of the resultant vector movement and force created upon such axial loading. Accordingly, the fingers 404 are each, in this embodiment, provided with wickers 411, complementary to the wickers 80 on the mandrel, for engagement therewith; whereby, as shown in FIG. 11b, when fluid under pressure enters the chamber 70, the piston 71 will be shifted upwardly within tubular housing 14, and when the expander 15 has shifted the slips 16 into firm engagement with the casing, further upward movement of the tubular housing 14 will be prevented, and fluid pressure acting on the piston 71 will effect locking engagement of the fingers 404 with the mandrel 2, thus the hold-down slips 16 will be expanded and locked in engagement with the casing.

Referring to FIG. 6, a further modification is shown, wherein the general construction is similar to that previously described, but wherein the piston 71 is foreshortened, so that between the end face 402 thereof and the shoulder 401 on expander 15, a pair of locking devices is accommodated. In order to provide an abutment surface for the fingers 404 of the compound locking devices of FIG. 13, an intermediate ring 413 having an axially extended outer peripheral flange 414 is interposed between the locking devices and provides a corner 415 and a corner 416, in which seat the flexible portion 410 of the upper locking device and the ring 405 of the lower locking device respectively.

In lieu of wickers on the locking fingers 404 in this modification, the mandrel 2 provides a smooth cylindrical surface, against which the central sections of the locking fingers 404 are frictionally engageable, and the locking fingers in lieu of wickers are also respectively provided with a smooth mandrel-engaging face 417.

In the use of the locking means shown in FIGS. 4a, 4b and 5, should piston 71 fail to release the locking fingers 404 from engagement with the mandrel due to the piston becoming sanded up in the piston chamber, rotation of the mandrel will effect disengagement of the locking fingers by reason of the helical disposition of wickers 80. In the modification of FIG. 6, however, rotation of the mandrel would not be required, since the mandrel may be forcibly shifted relative to the locking fingers 404 in this embodiment, by the imposition on the tubing string of a force greater than the frictional holding efforts of these locking fingers.

A further friction means for locking the hold-down slips in engagement with the casing is illustrated in FIG. 7, wherein friction elements are generally designated at 418 and include an annular rigid body 419, respectively hav-

ing flexible fingers 420 and 421 diverging from the outer periphery of the rings 419 towards the mandrel 2. In this embodiment, the inner extremities of the fingers 420 and 421 of the respective friction devices 418 are provided with friction surfaces 422 engageable with the smooth outer surface of the mandrel 2. The rigid bodies or rings 419 will resist circumferential expansion when the fingers 420 and 421 are loaded axially, and as a consequence, axial loading of these fingers will result in the application of a vector movement and holding force on the mandrel 2, whereby the expander 15 will be securely held in position as a result of fluid pressure in the chamber 70.

In view of the foregoing, it will now be recognized that the present invention provides an extremely versatile packer or other tool for use in wells wherein it is desired to control the setting of slip packer or other expansible mechanism in engagement with the well casing through manipulation of the running-in string of tubing, and that the objects and advantages stated at the commencement hereof have been fully accomplished.

While the specific details of several modifications of the invention have been herein shown and described, changes and alterations may be resorted to without departing from the spirit thereof as defined in the appended claims.

I claim:

1. In a well tool adapted to be run into a well bore on a running-in string and comprising a mandrel, friction means on said mandrel engageable with said well bore, said friction means and mandrel being relatively movable, means on said mandrel expansible into engagement with said well bore, means for expanding said expansible means upon movement of said mandrel relative to said friction means, and hold-down means carried by said mandrel and including anchor elements engageable with the well bore wall for retaining said tool in said well bore against upward movement in the well bore, said hold-down means including also a pair of opposed elements shiftable relatively one towards the other, said elements being disposed about said mandrel, and mandrel engaging means disposed about said mandrel between said elements engageable by said elements upon movement thereof one towards the other and shiftable laterally into contact with said mandrel for preventing movement of said mandrel, and means for effecting relative movement of said elements one toward the other.

2. A well tool as defined in claim 1, wherein said mandrel engaging means comprises a split ring normally loosely disposed about said mandrel, said ring having a wedge face opposed to one of said elements, said latter element having a complementary wedge face for constricting said split ring about said mandrel.

3. A well tool as defined in claim 1, wherein said mandrel engaging means comprises a member having a body portion and angularly projecting arm portions, said elements being engageable with said arm portions to cause deflection of certain of said portions into engagement with said mandrel.

4. A well tool as defined in claim 1, wherein said mandrel engaging means comprises a member having a body portion and angularly projecting arm portions, said elements being engageable with said arm portions to cause a resultant movement of said body portion into engagement with said mandrel upon movement of said elements towards one another.

5. A well tool as defined in claim 1, wherein said mandrel engaging means comprises a member having a body portion and arm portions projecting angularly from said body portion and diverging towards said mandrel for engagement therewith.

6. A well tool as defined in claim 1, wherein said mandrel engaging means comprises a plurality of mandrel engaging members disposed one above the other on said mandrel, each of said members having a body portion and arm portions projecting angularly from said body portion, said elements being engageable with one arm of each

of said members to cause deflection of certain of said portions of each member into engagement with said mandrel.

7. A well tool as defined in claim 1, wherein said mandrel engaging means comprises a plurality of mandrel engaging members disposed one above the other on said mandrel, an intermediate element interposed between said members, each of said members having a body portion and arm portions projecting from said body portion, said arm portions of each member being engaged with one of said opposed elements and with said intermediate element to cause deflection of certain of said portions into engagement with said mandrel.

8. A well tool as defined in claim 1, wherein said mandrel and said mandrel engaging means are provided with coengageable wickers.

9. A well tool as defined in claim 1, wherein said mandrel is provided with a thread, said mandrel engaging means having wickers engageable with said thread, and including means for retaining said mandrel engaging means against rotation upon rotation of said mandrel for forcing said elements apart upon rotation of said mandrel in one direction.

10. A well tool as defined in claim 1, wherein said mandrel and said mandrel engaging means are provided with coengageable smooth friction surfaces.

11. Apparatus for holding a well tool in a well bore, comprising a mandrel, a tubular housing disposed about said mandrel, said mandrel and said housing being relatively axially movable, well bore engaging anchor means including elements expansible into engagement with the well bore by relatively axial movement of said mandrel and said housing in one direction, and locking means for retaining said well bore engaging means engaged with the well bore, said locking means including a piston forming with said mandrel and said housing a pressure chamber having means for admitting fluid under pressure thereto, said piston being movable axially of said pressure chamber upon admission of fluid under pressure into said chamber, said housing and said piston having opposed portions, and a flexible locking element interposed between said piston and housing portions, said locking element being flexible for movement into engagement with said mandrel by movement of said opposed portions towards one another.

12. Apparatus for holding a well tool in a well bore, comprising a pair of coaxially arranged tubular members movable axially relative to one another, means for shifting said tubular members including a piston between said tubular members and defining therewith a pressure chamber having means for admitting fluid under pressure thereto, one of said tubular members having a portion opposed to said piston, said piston being movable toward said portion, and means disposed between said piston and said opposing portion for shifting said tubular members relatively axially and for locking said tubular members in a relatively shifted position upon the admission of fluid under pressure into said pressure chamber, and well bore engageable means carried by one of said tubular members, expansible into engagement with the well bore, and means carried by the other of said tubular members for expanding said well bore engageable means upon shifting of said tubular members as aforesaid.

13. Apparatus as defined in claim 12, wherein said locking means includes a flexible split ring normally disengaged from said tubular members, said piston and said ring having coengageable wedge surfaces for wedging said ring radially into locking engagement with one of said tubular members.

14. Apparatus as defined in claim 12, wherein said locking means includes a flexible split ring normally disengaged from said tubular members, said portion and said ring having coengageable wedge surfaces for wedging said ring radially into locking engagement with one of said tubular members, said last mentioned tubular member and said ring having coengageable wickers thereon.

15. Apparatus as defined in claim 12, wherein said locking means comprises a split ring adapted to be flexed radially into engagement with one of said tubular members, and means on said piston and on the opposing portion of said one tubular member for flexing said ring upon movement of said piston toward said opposing portion.

16. Apparatus as defined in claim 12, wherein said locking means comprises a split ring adapted to be flexed radially into engagement with one of said tubular members, and means on said piston and on the opposing portion of said one tubular member for flexing said ring upon movement of said piston toward said opposing portion, said ring and said one tubular member having coengageable wickers.

17. Apparatus as defined in claim 12, wherein said locking means comprises a split ring adapted to be flexed radially into engagement with one of said tubular members, and means on said piston and on the opposing portion of said one tubular member for flexing said ring upon movement of said piston toward said opposing portion, said ring having wickers thereon, said one tubular member having a thread engageable by said wickers, and means keying said ring to said one tubular member for effecting threaded movement of said ring upon relative rotation of said tubular members when said ring is engaged with said one tubular member.

18. Apparatus as defined in claim 12, wherein said locking means comprises a series of circumferentially spaced elements each having a body portion disposed adjacent to one of said tubular members and arm portions projecting at an angle from said body portion into engagement with the other tubular member, movement of said piston and said opposing portion of said one tubular member toward one another compressing said elements to effect radial expansion of said body and arm portions of said elements.

19. Apparatus as defined in claim 12, wherein said locking means comprises a series of circumferentially spaced elements each having a body portion disposed adjacent to one of said tubular members and arm portions projecting at an angle from said body portion into engagement with the other tubular member, movement of said piston and said opposing portion of said one tubular member toward one another compressing said elements to effect radial expansion of said body and arm portions of said elements, said body portion and the adjacent tubular member having coengageable wickers.

20. Apparatus as defined in claim 12, wherein said locking means comprises a member disposed at an angle between and engaged with said tubular members for creat-

ing a resultant vector force for locking said tubular members upon movement of said piston toward said opposed portion of said one tubular member.

21. Apparatus as defined in claim 12, wherein said locking means comprises a pair of members disposed at angles between and engaged with said tubular members and converging towards one of said tubular members for creating a compound resultant vector force for locking said tubular members upon movement of said piston towards said opposed portion of said one member.

22. Apparatus as defined in claim 12, wherein said locking means comprises a pair of members disposed at angles between and engaged with said tubular members and converging towards one of said tubular members for creating a compound resultant vector force for locking said tubular members upon movement of said piston towards said opposed portion of said one member, and a rigid element interposed between said pair of members and having means for preventing movement of said members towards the other of said tubular members.

23. Apparatus as defined in claim 12, wherein said locking means comprises an axially spaced set of circumferentially spaced locking elements each having a body portion and arm portions diverging from said body portion towards one of said tubular members, certain of said portions being engageable with one of said tubular members upon axial compression of said elements between said piston and said one tubular member.

24. Apparatus as defined in claim 12, wherein said locking means comprises an axially spaced set of circumferentially spaced locking elements each having a body portion and arm portions diverging from said body portion towards one of said tubular members, said body portion being engageable with one of said tubular members, and means rigidly backing up said arm portions whereby the body portion will be urged by vector force into holding engagement with said last mentioned tubular member upon movement of said piston toward the opposing portion of the aforesaid one tubular member.

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