

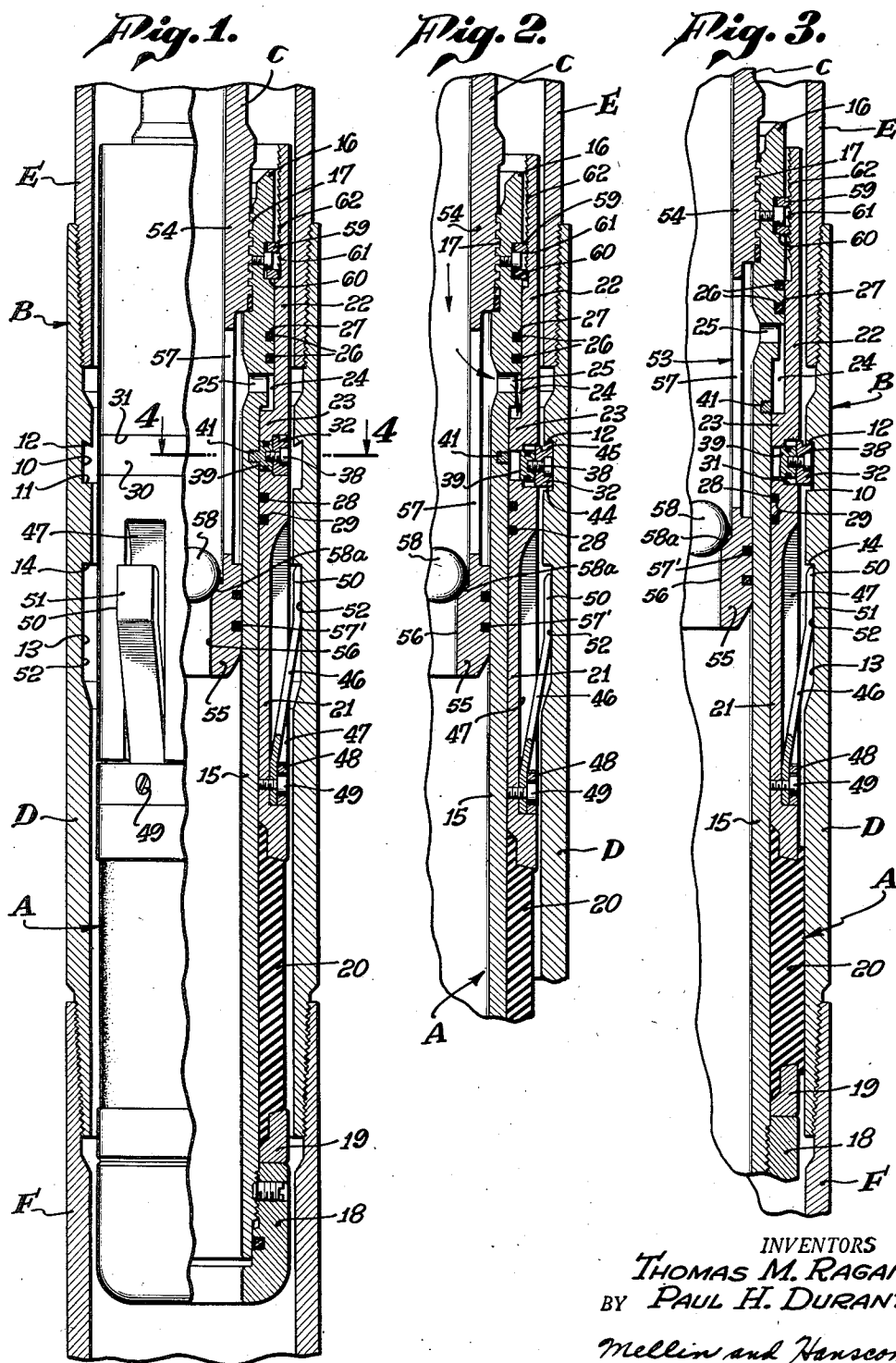
March 9, 1954

T. M. RAGAN ET AL
WELL PACKER APPARATUS

2,671,512

Filed July 12, 1948

4 Sheets-Sheet 1



INVENTORS
THOMAS M. RAGAN,
BY PAUL H. DURANT,
Mellin and Hanson
ATTORNEYS

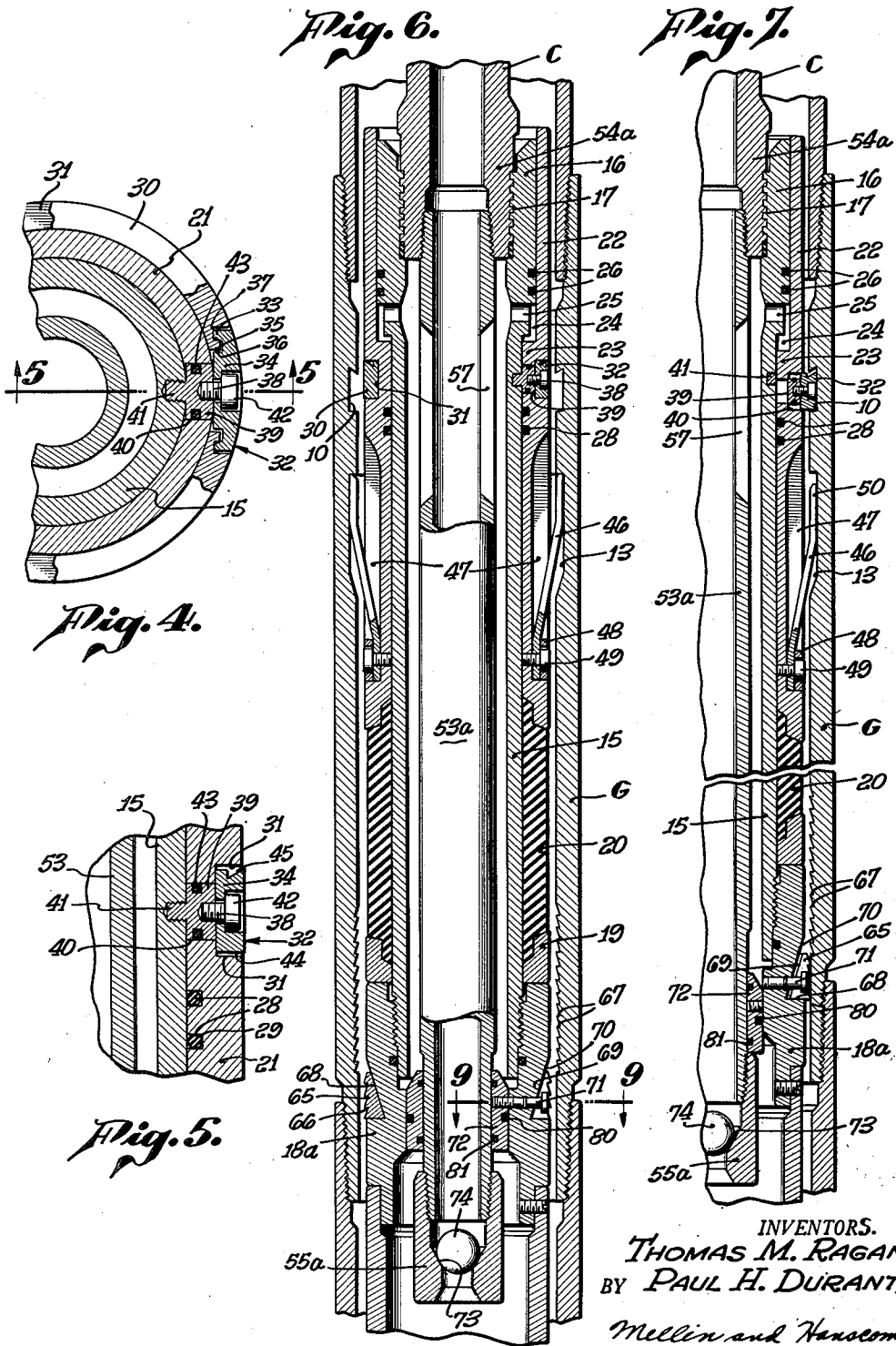
March 9, 1954

T. M. RAGAN ET AL
WELL PACKER APPARATUS

2,671,512

Filed July 12, 1948

4 Sheets-Sheet 2



INVENTORS.
THOMAS M. RAGAN,
BY PAUL H. DURANT,
Mellin and Hanson
ATTORNEYS

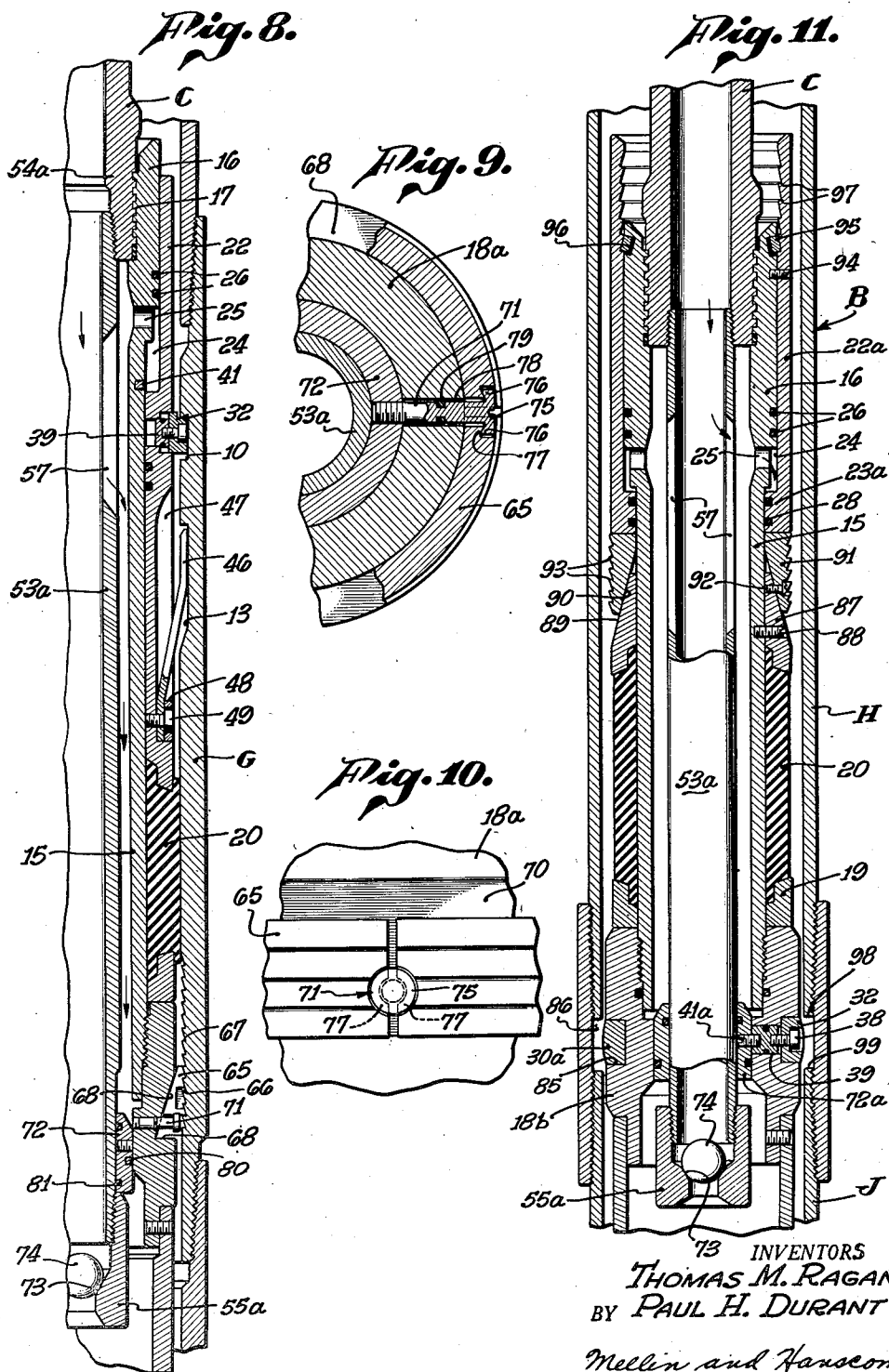
March 9, 1954

T. M. RAGAN ET AL
WELL PACKER APPARATUS

2,671,512

Filed July 12, 1948

4 Sheets-Sheet 3



INVENTORS
THOMAS M. RAGAN
BY PAUL H. DURANT

Mellin and Hanson
ATTORNEYS

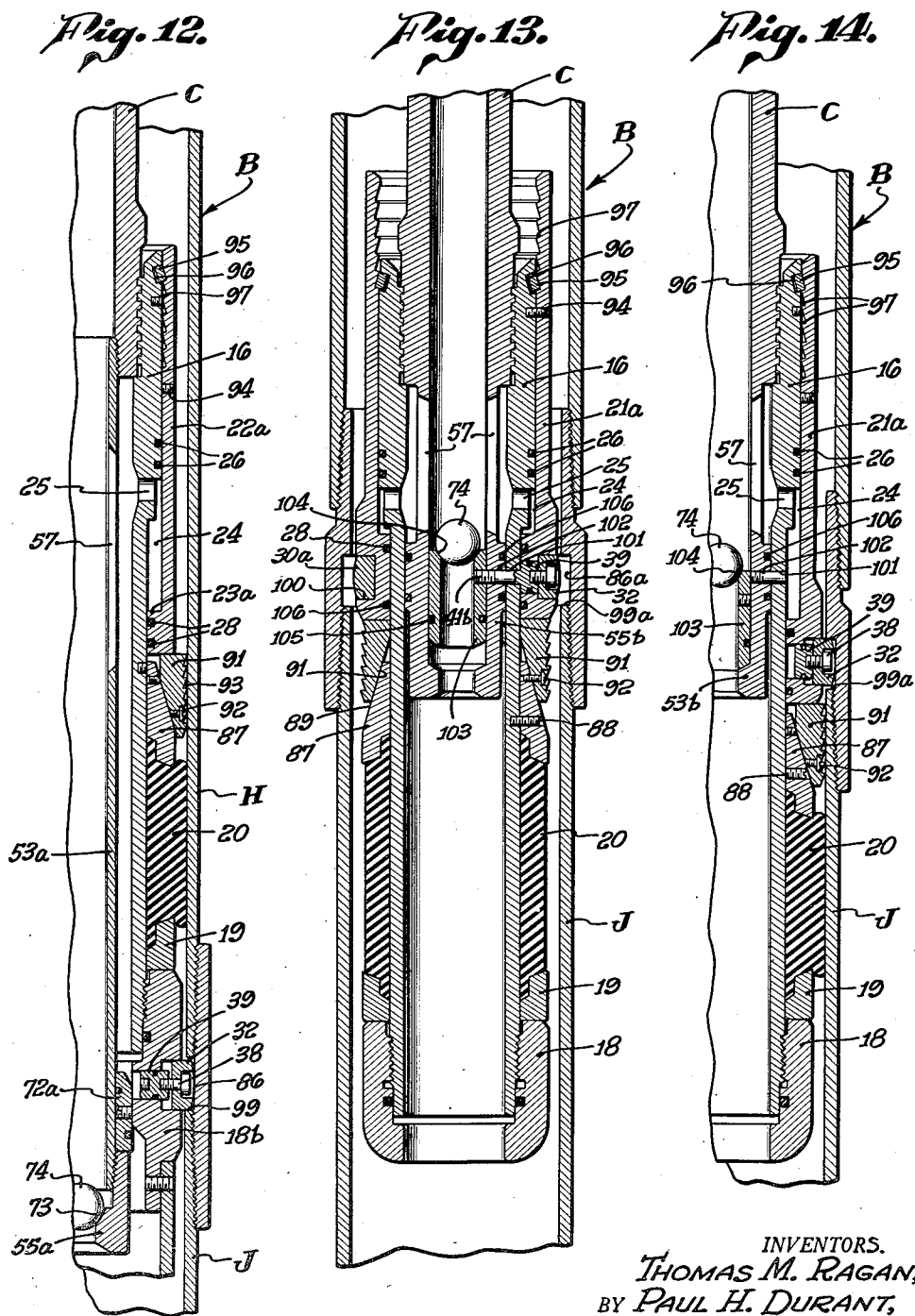
March 9, 1954

T. M. RAGAN ET AL
WELL PACKER APPARATUS

2,671,512

Filed July 12, 1948

4 Sheets-Sheet 4



INVENTORS.
THOMAS M. RAGAN,
BY PAUL H. DURANT,
Mellin and Hanscom
ATTORNEYS

UNITED STATES PATENT OFFICE

2,671,512

WELL PACKER APPARATUS

Thomas M. Ragan, Downey, and Paul H. Durant,
Temple City, Calif., assignors to Baker Oil
Tools, Inc., Vernon, Calif., a corporation of Cali-
fornia

Application July 12, 1948, Serial No. 38,266

23 Claims. (Cl. 166—12)

1

The present invention relates to subsurface well tools, and more particularly to well packers and anchors adapted to be coupled or anchored to a string of well casing, or similar conduit string, positioned in a well bore.

An object of the invention is to provide well tools embodying improved devices for anchoring the tools in well conduit strings.

Another object of the invention is to provide well packers capable of being anchored in packed-off condition in well conduits, and of withstanding high pressures and temperatures encountered in well bores.

A further object of the invention is to provide an improved setting mechanism for effecting shifting of normally retracted well tool anchoring elements into coupling engagement with well conduits, within which they may be positioned.

Still another object of the invention is to provide an improved lock mechanism for preventing longitudinal movement of a well tool body within a well conduit.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several forms in which it may be embodied. Such forms are shown in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, 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 view, partly in section and partly in elevation, of a well packer located within a well casing, to which it is to be anchored in packed-off condition, with the packer parts occupying their initial positions during running of the packer through the well casing;

Fig. 2 is a partial longitudinal section of the well packer, shown as anchored to the casing;

Fig. 3 is a view similar to Fig. 2, disclosing the packer anchored in packed-off condition within the casing;

Fig. 4 is a partial cross-section, on an enlarged scale, taken along the line 4—4 on Fig. 1;

Fig. 5 is a section taken along the line 5—5 on Fig. 4;

Fig. 6 is a longitudinal section, partly in elevation, of another embodiment of the invention, disclosing the packer with its parts in the initial position occupied by them while running the packer through the well casing;

2

Fig. 7 is a partial longitudinal section disclosing the well packer of Fig. 6 partly anchored in the well casing;

Fig. 8 is a view similar to Fig. 7 of the packer fully anchored in packed-off condition within the well casing;

Fig. 9 is an enlarged partial cross-section taken along the line 9—9 on Fig. 6;

Fig. 10 is a side elevation of part of the anchoring device, as seen from the right of Fig. 9;

Fig. 11 is a longitudinal section, partly in elevation, of still another embodiment of the invention, with the parts in retracted position for running the tool through a well casing;

Fig. 12 is a partial longitudinal section of the tool shown in Fig. 11, anchored in packed-off condition within the well casing;

Fig. 13 is a longitudinal section through still another form of the invention; and

Fig. 14 is a partial longitudinal section of the tool shown in Fig. 13, anchored in packed-off condition within the well casing.

In the form of invention disclosed in Figs. 1 to 5, inclusive, a well tool, such as a well packer A, is adapted to be run in a well casing B on the lower end of a tubular string C, and to be anchored in the well casing at a predetermined point.

Specifically, the packer A is to be anchored in a casing collar D, whose opposite ends are threadedly secured to upper and lower casing sections E, F.

The collar includes a lock groove 10 having a lower shoulder 11 and an upper shoulder 12 that is preferably inclined inwardly and downwardly for a purpose to be described hereinafter. The collar also includes a locating groove 13 for advising the operator at the top of the well bore that the well packer is at the predetermined point in the well casing. This groove 13 has an upper shoulder 14 for cooperating with well tool elements in a manner to be described hereinafter.

The well packer shown in Figs. 1 to 5, inclusive, includes a tubular body 15 having an upper head 16 threaded onto the tubular string C by means of a left hand threaded connection 17. An abutment and guide 18 is secured on the lower end of the body 15, and is engaged by a lower retainer 19 receiving the lower end of a packing sleeve 20, of rubber or other suitable material, surrounding the body. The upper end of the packing engages the lower retainer portion of a setting and anchoring sleeve 21 extending upwardly along the body and having an upper cylinder portion 22 slidable along the body head 16.

The setting sleeve also includes a shoulder or cylinder head portion 23 disposed below the body head 16, and on which fluid under pressure is adapted to act. This fluid can enter the cylinder space 24, formed between the sleeve 22 and the body 10, through a plurality of ports 25 disposed below the body head 16. Leakage of fluid in an upward direction along the cylinder 22 is prevented by one or more side seals 26 located in peripheral grooves 27 in the head 16 and engageable with the interior of the cylinder. Similarly, leakage of fluid in a downward direction between the body 15 and the setting sleeve 21 is prevented by one or more side seals 28 located in grooves 29 in the setting sleeve and engageable with the exterior of the body.

The setting sleeve 21 carries an anchoring device for preventing longitudinal movement of the tool in both directions within the well casing. This anchoring device consists of an inherently expandable lock ring or band 30 positioned within a lock groove 31 in the exterior of the sleeve and preferably above the seal rings 28 contained in the latter. This band 30 is split and is made of metal possessing spring-like characteristics, so that the band tends to expand inherently to a substantially greater effective diameter than the external diameter of the setting sleeve 21. However, the band is initially restrained in retracted position for confinement substantially entirely within its companion groove 31, and within the periphery of the setting sleeve 21, by a holding device.

The holding device (see Figs. 4 and 5) includes a retainer piece 32, which, in effect, forms a continuation of the band 30 when confined within the groove 31, in that its outer surface is arcuate to form a continuation of the band periphery. The retainer piece has inwardly directed flanges 33 on its outer ends spaced from its central portion 34 to define grooves 35 in which outwardly directed flanges 36 on the ends of the split band or ring are located. These latter flanges 36 also define grooves 37 with the main body of the band in which the retainer flanges are received. In effect, the flanges 33, 36 on the retainer and band form interlocking hooks, preventing outward expansion of the band 30 when the retainer piece 32 is located within the lock groove 31.

The retainer piece 32 is held in its inward position, holding the band 30 retracted within the groove 31, by a screw 38 threaded into a piston 39 slidable in a transverse cylinder bore 40 through the setting sleeve 21. This piston, in turn, has an inward extension 41 threaded into the packer body 15. It is evident that the piston screw 41 holds the piston 39 inwardly within its cooperable sleeve cylinder 40, and that the retainer screw 38, by being threaded into the piston, holds the retainer piece 32 inwardly, by virtue of engagement of the screw head 42 with the latter, thereby maintaining the flanges or hooks 33, 36 interlocked and the band 30 in retracted position.

The piston 39 is made of frangible material, so that the main portion of the piston may be sheared from its threaded portion 41 in effecting outward expansion of the lock ring or band 30 in the manner described below. Such outward expansion may be insured by providing a suitable packing ring 43 on the piston for sealing engagement with the transverse cylinder wall 40. The inner surface of this piston may also be subject to the pressure of fluid entering the cylinder space 24 through the ports 25, since such fluid

under pressure can pass downwardly from the cylinder space through the clearance space between the body 15 and setting sleeve 21.

The band 30 is adapted to expand outwardly into the lock groove 10 in the collar D. It is also adapted to cooperate with the groove shoulders 11, 12 in preventing movement of the setting sleeve 21 in both longitudinal directions. Accordingly, the lower surface 44 of the band is parallel to the lower groove shoulder 11, while the upper surface 45 of the band is tapered in the same direction as the upper groove shoulder 12, in order to interlock therewith, in view of the acute angle of which the upper corner of the band and the outer corner of the shoulder are formed.

In order to obtain outward expansion of the band 30 into the lock groove 10, it must be appropriately located with respect thereto. To accomplish this purpose, a plurality of circularly spaced leaf springs 46 are disposed within longitudinal grooves 47 in the setting sleeve 21 below the lock ring 30. The lower ends of these springs are secured to the sleeve 21 by an encompassing band 48 and by screws 49 extending through the band and the springs into the setting sleeve 21. The springs 46 extend upwardly, with their upper free ends 50 tending to expand inherently in an outward direction. The free arm portions 50 of the springs are engageable within the locating groove 13 and their upper terminals are adapted to engage the upper groove shoulder 14. When in this position, the outer surfaces 51 of the arms preferably have surface contact with the wall 52 of the groove 13, in order to increase the load-carrying capacity of the springs. These outer surfaces 51 are also longer than the usual coupling surfaces existing between adjacent casing sections forming the casing or conduit string, so that the springs cannot expand outwardly into such spaces and effect setting of the packer at an undesired point in the conduit string. The locating groove 13, however, is substantially longer than such leaf spring portions 50, to allow the springs to inherently expand outwardly and engage the downwardly facing shoulder 14.

The well packer A is threadedly attached to the running-in string C, with the band 30 held in retracted position, and with the packing 20 also in retracted position. The lower portion of the tubular running-in string C has a tubular extension 53 depending from its threaded section 54 and terminating in a head 55 closely fitting the inner wall of the body 15. This head has a central passage 56 therethrough, and may also have suitable sealing ring 57' in its exterior portion cooperable with the body wall, to prevent leakage between the head 55 and body 15.

The extension 53 has a plurality of ports 57 between its threaded portion 54 and head 55, to enable fluid from the tubing string C to pass through the body ports 25 and into the cylinder space 24.

The well packer A is lowered through the casing string B until it is located below the collar D, whereupon it may be elevated, preferably slowly, until the leaf springs 46 are disposed opposite the locating groove 13. The springs expand outwardly into this groove and engage the shoulder 14, thereby arresting upward movement of the well packer A and advising the well operator that the setting location of the packer has been reached (Fig. 1).

The leaf springs 46 and retracted band 30 are spaced from one another longitudinally, so that

the upper end 45 of the band is disposed slightly above the tapered lock groove shoulder 12 when the springs first engage the shoulder 14. Also, the length of the lock groove 10 is slightly greater than the length or height of the band 30. This disposition of parts is preferred, since it enables the screw 41 to be sheared hydraulically by downward movement of the setting sleeve 21, and, when sheared, the band 30 is disposed substantially centrally of the lock groove 10, and is capable of expanding thereinto.

Release and expansion of the band 30 is effected after the leaf springs 46 have engaged the collar shoulder 14 by pumping or dropping a tripping element 58, such as a ball, into the tubing string C until it engages a valve seat 59 in the head 55, closing the head passage 56 against downward flow of fluid. Fluid under pressure can then flow down through the tubing string C, and through the extension ports 57 and body ports 25 into the cylinder space 24, acting downwardly on the cylinder head portion 23 of the setting sleeve 21 and exerting sufficient force to shear the piston screw 41. When this screw is sheared, the band 30 can expand outwardly, forcing the retainer piece 32 outwardly into the groove 10 and disengaging the hooks 33, 36 from one another. Such disengagement is facilitated by inclining the inner surfaces of the retainer piece hooks or flanges 33.

As indicated above, the fluid under pressure moves the setting sleeve 21 downwardly sufficiently to shear the screw 41, which locates the band 30 opposite the lock groove 10 and allows the retainer piece 32 and band 30 to expand outwardly into this groove (Fig. 2). The inner portion of the band 30 still remains within the peripheral setting sleeve groove 31, the band serving to couple the setting sleeve 21 to the casing collar D.

It is apparent that downward movement of the sleeve 21 is resisted by engagement of the band 30 with the lower shoulder 11, whereas upper movement of the sleeve is resisted by engagement of the beveled surface 45 of the band with the upper groove shoulder 12. Upward movement may also be resisted by the leaf springs 46 engaging the locating groove shoulder 14.

In the event that the band 30 should not expand inherently out against the casing, because of the holding action of the retainer piece 32, the latter may be positively removed from its holding position by virtue of the fluid under pressure flowing through the clearance space between the body 15 and setting sleeve 22, and acting upon the inner end of the piston 39, forcing the latter positively outwardly and positively locating the retainer piece 32 within the groove 10. This insures the freeing of the retainer hooks 33 from the companion hooks 36 on the ends of the ring 30. The latter will then snap out into the lock groove 10.

After the packer or well tool A has been anchored to the well casing in the manner described, an upward pull can be taken on the tubing string C, to pull the body 15 upwardly within the setting sleeve 21, which cannot move in an upward direction. Such upward movement of the body moves the lower abutment 18 toward the setting sleeve 21, to foreshorten the packing 20 and expand it outwardly into leak-proof engagement with the collar or casing wall (Fig. 3).

After the packing 20 has been fully expanded against the casing B, upward movement of the

packer body 15 is prevented by the upward thrust being transmitted to the casing through the abutment 18, retainer 19, packing 20, setting sleeve 21 and band 30 or leaf springs 46, or both. Downward movement of the body 15 is prevented by providing a one-way latch device between the body and setting sleeve 21.

The one-way device may assume various forms. As specifically shown in the drawings, it consists of a split, inherently expansible ring 59 located within a peripheral groove 60 in the body head 16 and having downwardly facing peripheral ratchet teeth 61 engageable with companion upwardly facing ratchet teeth 62 in the upper end of the setting sleeve. This one-way ratchet device permits upward movement of the body 15 within the setting sleeve 21 without moving the latter, but couples the body directly to the setting sleeve upon downward movement of the former. Such downward movement, or force, is transmitted through the setting sleeve 21 to the lock ring or band 30 and against the lower lock groove shoulder 11 to the casing B.

The well packer apparatus A has thus been anchored in packed-off condition to the well casing B against longitudinal movement in both directions. The tubular string C may then be rotated to the right to unscrew its lower end 54 from the packer body 15, and the entire tubing string can then be withdrawn from the well casing.

Instead of hydraulically releasing the band 30 from its retracted position, it may be released mechanically by taking an upward strain on the tubing string C, after engagement of the leaf springs 46 with the locating groove shoulder 14. Such engagement prevents upward movement of the setting sleeve 21, whereupon an upward strain on the tubing string C and body 15 will effect shearing of the piston screw 41, and allow the band 30 to expand outwardly. However, this band will not be located completely opposite the lock groove 10, necessitating slight downward movement of the tubing string C which will be transmitted through the body 15 and latch ring 59 to the setting sleeve 21, shifting the latter downwardly until the released band 30 is opposite the lock groove 10. The band may now expand inherently into the lock groove.

In mechanically releasing the band 30, the packing 20 may have been expanded partially against the well casing B, depending upon the shear strength of the screw 41. After the band 30 has been positioned in the lock groove 10, a sufficient upward strain can be taken on the tubing string C and body 15 to insure full expansion of the packing sleeve 20 against the casing wall.

In the form of invention disclosed in Figs. 6 to 10, inclusive, a different kind of latch is provided for preventing downward movement of the body. This latch consists of a split, inherently expansible gripping band or ring 65 having downwardly facing wickers or teeth 66 adapted to engage companion upwardly facing wickers or teeth 67 formed in the collar G below its locating groove 13. The band is located within a groove 68 formed in the lower abutment 18a on the body 15, and has a tapered inner surface 69 inclined downwardly and inwardly for cooperation with a corresponding tapered surface 70 at the base of the groove. This latter surface tends to urge and hold the band 65 in an outward direction, when expanded into engagement with the collar teeth 67.

The band 65 is originally held in retracted position within the confines of its companion groove 68 by a holding member in the form of a piston 71 extending through the abutment 18a and threaded into an annular piston or sleeve 72 slidable along the inner wall of the abutment. The sleeve 72 is also slidable along a tubular extension 53a threaded into the lower end 54a of the tubular string and depending therefrom. This extension has a head 55a threaded on its lower end below the annular piston 72, which is provided with a valve seat 73 for a ball 74, or corresponding valve element.

The holding member 71 is made of frangible material, so as to be released from the annular piston. It is provided with a head 75 having oppositely directed hooks or wings 76 interlocking with companion hooks or wings 77 on opposite ends of the split, gripping band 65 (Figs. 9 and 10). It is evident that the threading of the holding member 71 into the annular piston 72 causes its hooks 76 to engage the band hooks 77 and hold the band in confined or retracted position within its groove 68.

The holding member 71 is also in the form of a transverse piston extending through a transverse cylindrical bore 78 in the abutment 18a, and may have a sealing ring 79 engageable with the wall of the cylinder to prevent leakage therebetween. The annular piston 72 is also provided with outer and inner side seals 86, 81 slidably engageable with the abutment 18a and the exterior of the extension 53a, to prevent leakage therebetween.

The apparatus disclosed in Figs. 6 to 10 is run in the well casing to a position below the grooved collar G, whereupon the tubing string C and packer are moved upwardly slowly until the locating springs 46 expand into the groove 13 and engage the groove shoulder 14. The ball 74 is dropped or pumped down into the tubing string, as before, until it engages the valve seat 73 in the head 55a. Pressure can then be applied to the fluid in the tubing string, such pressure being transmitted through the ports 57 in the extension, and through the body ports 25 to shift the setting sleeve 21 downwardly, shearing the piston screw 41 and allowing the lock band 30 to expand outwardly into a collar lock groove 10. Such fluid under pressure also passes downwardly through the annular space between the body 15 and extension 53a for action upon the annular piston 72, shearing the frangible holding device 71 and moving the piston 72 downwardly to an extent determined by its engagement with the upper end of the head 55a, which also allows the fluid pressure to enter the transverse cylinder 73 in the abutment.

Because of the inclined engagement between the hooks 76, 77 on the holding member 71 and on the toothed band 65, the inherent expansibility of the band 65 moves the device outwardly until the hooks 66, 67 disengage from each other allowing the band 65 to expand against the casing wall. If such release of the hooks does not occur as a result of the inherently expansive force of the band, pressure applied on the inner end of the piston 71 will forcibly move the holding device outwardly to a releasing position (Fig. 7).

The tubing string C and packer body 15 are then moved upwardly to compress the packing 20 between the setting sleeve 21 and abutment 18a and expand it outwardly against the casing B. Such upward movement also carries the toothed band 65 upwardly with the abutment to a posi-

tion opposite the ratchet teeth 67 in the collar, the band expanding outwardly into engagement with such teeth, and transmitting any downward force on the body 15 through the tapered abutment 18a and expanded band 65 to the collar G (Fig. 8).

It is apparent that the latch device 65, 71, disclosed at the lower portion of the form of invention depicted in Figs. 6 to 10, obviates the necessity for using a latch device between the body 15 and setting sleeve 21, as in the other form of the invention. Upward forces imposed on the body 15 are transmitted through the packing 20, setting sleeve 21 and lock band 30, or spring fingers 46, in the same manner as in the other form of the invention. Downward forces on the body 15 are transmitted through the abutment 18a and split latch band 65 directly to the casing.

In the embodiment of the invention illustrated in Figs. 11 and 12, an inherently expansible lock ring or band 30a is disposed in a peripheral groove 85 within the lower body abutment 18b, and is adapted to expand outwardly into a coupling space 86 between adjacent casing sections H, J, in order to obviate the necessity for providing a specially grooved collar in the casing string B.

The band 30a is essentially the same as described in the Figs. 1 to 6 form of the invention, being held in retracted position within its companion groove 85 in essentially the same manner. That is, a retainer piece 32 is hooked to the ends of the band, and is attached to a piston 39 by a screw 38. The piston extends through a transverse bore 86 in the abutment 18b, and is held initially in an inward position by a shear screw 41a threaded through an annular piston 72a slidable along the inner wall of the abutment and also along the extension 53a depending from the tubular string C.

A packing sleeve 20 is also provided around the body, with its lower end engaging a retainer ring 19 resting on the abutment 18b, its upper end being received within a tapered expander 87 initially secured to the body 15 by one or more shear screws 88. The outer surface 89 of this expander is inclined in an upward and inward direction for cooperation with correspondingly tapered surfaces 90 on the interior of segmental upper slips 91 held initially in retracted position by one or more shear screws 92 attaching them to the expander. These slips have upwardly facing wickers or teeth 93, cooperating with the expander 87 to hold the packing 20 in expanded condition against the casing wall.

Such expansion of the slips 91 may occur hydraulically through the provision of a cylinder on the body, having an upper skirt 22a slidable along the body head 16 and a lower head 23a disposed adjacent the slips. Fluid can enter the cylinder space 24 between the skirt or sleeve 22a and the body 15 through the body ports 25, leakage being prevented, as before, by suitable side seals 26, 28 on opposite sides of the cylinder space, provided on the body head 16 and on the cylinder head 23a. The cylinder is held initially in an upward position by one or more shear screws 94 threaded into the head 16.

In order to prevent return movement of the cylinder 22a, 23a, after it has been hydraulically shifted along the body 15, a one-way latch device is provided between the body head and cylinder. This device consists of a split, inherently expansible latch ring 95 disposed in a body head groove 96 and adapted to cooperate with upwardly

facing ratchet teeth 97 on the interior of the cylinder sleeve 22a. This latch device permits relative downward movement of the cylinder 22a, 23a along the body 15, but prevents its return or upward movement therealong.

The packer apparatus shown in Figs. 11 and 12 is run in the well casing with the parts disposed in retracted position, as illustrated in Fig. 11. When the approximate location in the casing string has been reached, at which the packer is to be anchored in packed-off condition, the tripping ball 74 is lowered through the tubing string until it engages the seat 73 in the extension head 55a, which prevents further downward passage of fluid through the extension 53a. The fluid in the tubing string C and apparatus may now be subject to pressure, such pressure passing through the extension ports 57 and body ports 25 into the cylinder space 24, and also passing downwardly through the annulus around the extension 53a for action upon the annular piston 72a.

The shear value of the piston screw 41a is less than the shear value of any of the other screws in the apparatus, which causes the piston screw to be disrupted first, allowing the annular piston 72a to be shifted downwardly, freeing the retainer piece 32, which expands outwardly under the influence of the inherently expansible band 30a, and also under the effect of the pressure acting upon the inner end of the transverse piston 39. The band 30a snaps outwardly until it engages the casing wall, whereupon the tubing string C and packer body 15 may be elevated slowly until the band 30a is disposed opposite a coupling space 86, which allows it to expand outwardly into such space and contact the upper and lower shoulders 98, 99 on the ends of the casing sections H, J. Such outward expansion precludes further upward or downward movement of the packer body 15 within the casing string, advising the operator at the top of the well bore that the packer is coupled to the well casing.

The pressure of the fluid is then increased to an extent sufficient to shear the cylinder screw or screws 94, and also the screws 88 holding the expander 87 to the body. These last-mentioned screws have a substantially lower shear value than the screws 92 holding the slips 91 to the expander, which causes the cylinder 22a, 23a to move downwardly, shifting the upper slips 91 and expander 87, as a unit, toward the lower abutment 18b and expanding the packing 20 outwardly against the casing.

The pressure of the fluid is increased to a further extent to shear the slip screws 92 and move the slips 91 downwardly along the tapered expander into anchoring engagement with the casing (see Fig. 12). During such downward movement of the cylinder, its teeth 95 ratchet over the split lock ring 95, which prevents return upward movement of the cylinder along the body.

It is evident that the apparatus disclosed in Figs. 11 and 12 is anchored to the well casing against movement in both longitudinal directions by the location of the expansible band 30a within a collar space or groove 86. It is also evident that the packing 20 is prevented from returning to its retracted position by the wedging action of the tapered expander 87 within the slips 91, whose tooth portions 93 dig into the casing wall and become firmly attached thereto.

The packer body is incapable of moving in either direction by the expanded lock band 30a. The packing 20 is held in a confined state by the

lock band and also by the upper slips 91. If desired, the split latch ring 95 and ratchet teeth 96 need not be used, since the packer will remain anchored in packed-off condition within the well casing in the absence of the latch ring and ratchet teeth. The ring 95 and teeth 96, however, still hold the packing 20 expanded, should the slips fail to become anchored to the casing.

In the form of the invention disclosed in Figs. 13 and 14, the expansible band 30a is held within a setting sleeve groove 100 in essentially the same manner as in the forms of invention shown in Figs. 1 to 10, inclusive. Instead of being threaded into a body, the piston screw 41b is extended through holes 101, 102 in the body 15 and in the head 55b in the lower end of the extension 53b for threaded reception within a sleeve 103 slidable within the head 55b. This sleeve has a seat 104 adapted to be engaged by a ball 74, or other valve element, and is also provided with a suitable side seal 105 engaging the inner wall of the head to prevent leakage therebetween.

The setting sleeve or cylinder 21a is secured initially to the body head 16 by one or more shear screws 94. The body head 16 and the cylinder sleeve may have a one-way latch device 95, 96 of the same form as described in connection with Figs. 11, 12.

Suitable side seals 26 are provided on the body head 16 for engagement with the cylinder sleeve, and suitable side seals 28 are also provided on opposite sides of the piston 39 for engagement with the outer surface of the body. These seals will allow the transverse piston 39 to be subjected to fluid pressure from within the body extension 53b. Similarly, seals 106 are provided on the extension head 55b on opposite sides of its hole or passage 102 to allow fluid under pressure to pass therethrough and act upon the piston 39.

Disposed below the cylinder head are a plurality of segmental slips 91 having tapered inner surfaces 90 inclined in a downward and outward direction for engagement with a companion tapered surface 89 on a conical expander 87 disposed around the body of the packer. The slips are held initially in retracted position by one or more shear screws 92 attached to the expander 87, while the expander is attached initially to the body by one or more shear screws 88. The upper end of a packing sleeve 20, encompassing the body 15, abuts the expander 87, with the lower end of the sleeve abutting a ring 19 resting upon an abutment 18 forming part of the body 15.

The well packer is secured on the lower end of a string of tubing C and is lowered through a well casing B until it is positioned approximately at the desired setting point in the casing. All of the parts occupy the relative position shown in Fig. 13, in which the lock band 30a, slips 91 and packing sleeve 20 are in retracted positions.

The tripping ball 74 is lowered through the tubing string until it engages the seat 104 in the sleeve 103, whereupon sufficient pressure can be built up in the tubing string for action downwardly upon the ball and sleeve to shear the piston screw 41b and shift the sleeve 103 downwardly to a position exposing the aligned holes 102, 101 in the extension head 55b and body 15. Such shearing action of the screw allows the band retainer 32 to move outwardly, this action being assisted, if need be, by fluid pressure passing through the aligned holes 102, 101 and acting upon the inner end of the piston 39, forcing the latter outwardly and positively shifting the retainer piece 32 in the same direction.

The tubing string C is then elevated or lowered, as desired, until the band 30a is opposite a casing coupling space or groove 86a into which the band will expand inherently and couple the sleeve 21a to the casing against movement in both longitudinal directions (see Fig. 14).

An upward strain may now be taken on the tubing string C to move the body 15 upwardly. Since the sleeve 21a cannot move in this direction, the slip screws 92 are first sheared, the expander 87 moving upwardly with the body to shift the slips 91 radially outward into anchoring engagement with the casing. A continuation of the upward strain, and increase in the upward force or pull on the tubing string or body, then shears the expander screws 93, moving the lower abutment 18 toward the expander 87. In view of the wedging engagement of the expander within the slips 91, it is prevented from moving upwardly. Accordingly, movement of the lower abutment toward the expander foreshortens the packing 20 and expands it outwardly into firm sealing engagement with the casing wall.

During upward movement of the body 15 within the cylinder setting sleeve 21a, the ratchet ring 95 moves upwardly along the companion ratchet teeth 96 in the sleeve. Downward movement of the body 15 within the sleeve is prevented by engagement of the latch ring 95 with the ratchet teeth 96, such downward movement or force being transmitted through the setting sleeve 21a to the band 30a, and from the band to the casing, by virtue of engagement of the band with the lower shoulder 99a at the end of the lower casing section J. Upward forces imposed on the packer body 15 are transmitted to the casing through the abutment 18, packing 20, expander 87 and segmental slips 91.

By providing shear screws 92 attaching the slips 91 to the expander 87 with a much greater shear value than the screws 93 securing the expander to the body 15, the expansible band 30a may be released by fluid pressure passing through the body ports 25 into the cylinder space 24. Such pressure will shear or disrupt the piston screw 41b adjacent the outer surface of the body 15 and will also shear the expander screws 93, the setting sleeve 21a moving downwardly during this action to a slight extent. However, insufficient pressure is applied to the fluid to shear the slip screws 92.

The band 30a is thus released and will expand outwardly against the casing wall, whereupon the tubing string C may be raised or lowered until the band snaps out into a collar groove or space 86a. Thereupon, an upward strain may be taken on the tubing string or body 15 to effect shearing of the slip screws 92 and outward expansion of the slips 91, as well as foreshortening and outwardly expanding the packing sleeve 20 into engagement with the casing.

The inventors claim:

1. In a well tool: a member adapted to be lowered in a well conduit positioned in a well bore; an outwardly expansible lock ring on said member disposed initially in a retracted position on said member; means engageable with said lock ring for expanding said lock ring outwardly into engagement with the well conduit to lock the member to the conduit; means releasably retaining said ring in such retracted position on said member and slidable transversely of and within said member to a position released from said ring to permit said ring to expand outwardly; and means for releasing said retaining means to

permit outward movement of said ring into locking engagement with said conduit.

2. In a well tool: a member adapted to be lowered in a well conduit positioned in a well bore; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the member to the conduit; means releasably retaining said ring in retracted position on said member and slidable transversely of and within said member to a position released from said ring to permit said ring to expand outwardly; and means for releasing said retaining means to permit outward movement of said ring into locking engagement with said conduit.

3. In a well tool: tubular means adapted to be lowered in a well conduit positioned in a well bore; an outwardly expansible lock ring on said means disposed initially in retracted position on said means; means engageable with said lock ring for expanding said lock ring outwardly into engagement with the well conduit to lock the tubular means to the conduit; means releasably retaining said ring in such retracted position on said tubular means and slidable transversely of and within said tubular means to a position released from said ring to permit said ring to expand outwardly; and hydraulically operable means for releasing said retaining means to permit outward movement of said ring into locking engagement with said conduit.

4. In a well tool: tubular means adapted to be lowered in a well conduit positioned in a well bore; a split, inherently expansible and outwardly movable lock ring on said means; means releasably retaining said ring in retracted position on said tubular means and slidable transversely of and within said tubular means to a position enabling said ring to expand outwardly; and hydraulically operable means for releasing said retaining means to enable outward movement of said ring into engagement with said conduit.

5. In apparatus of the character described: a well conduit having a groove therein; a member adapted to be lowered in said conduit; an outwardly expansible lock ring on said member; means for expanding said lock ring outwardly into said groove to lock the member to the well conduit; means releasably retaining said ring in retracted position on said member and slidable transversely of and within said member to a position released from said ring to permit said ring to expand outwardly; and means for releasing said retaining means to permit outward movement of said ring into said groove.

6. In a well tool: a member adapted to be lowered in a well conduit positioned in a well bore, said member having a peripheral groove therein; a split, inherently expansible and outwardly movable ring in said groove; means releasably interlocked with the end portions of said ring for holding said ring in retracted position within said groove; and means for releasing said holding means to enable said ring to expand outwardly.

7. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means on said body engageable with said ring for retaining said ring in retracted position on said member; and means re-

leasing said retaining means from said ring upon relative movement between said body and member to permit said ring to expand outwardly into locking engagement with the conduit.

8. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; frangible means extending into said body and engageable with said ring for retaining said ring in retracted position on said member; and means for disrupting said frangible means to permit said ring to expand outwardly into locking engagement with the conduit.

9. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means on said body engageable with said ring for retaining said ring in retracted position on said member; and means including instrumentalities on said tubular member engageable with said conduit for effecting release of said retaining means upon movement of said body and member relative to each other to permit outward expansion of said ring into locking engagement with the conduit.

10. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means on said body engageable with said ring for retaining said ring in retracted position on said member; and means for feeding fluid under pressure to said tubular member to shift said tubular member on said body and thereby effect release of said retaining means to permit outward expansion of said ring into locking engagement with the conduit.

11. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means on said body engageable with said ring for retaining said ring in retracted position on said member; and hydraulically operable means within said body for releasing said retaining means to permit outward expansion of said ring into locking engagement with the conduit.

12. In a well tool: tubular means adapted to be lowered in a well conduit positioned in a well bore; a lock ring on said means disposed initially in retracted position on said means; means engageable with said lock ring for expanding said lock ring outwardly into engagement with the well conduit to lock the tubular means to the conduit; means detachably secured to said lock ring to releasably retain said ring in such retracted position and movable within said member to a position permitting said ring to expand outwardly; and hydraulically operable means for releasing said retaining means to permit outward movement of said ring into locking engagement with said conduit.

13. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore;

a tubular member slidable on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means engageable with said ring for retaining said ring in retracted position on said member; means for releasing said retaining means to permit said ring to move outwardly into locking engagement with the well conduit; and lock means on said body adapted to engage said well conduit to prevent longitudinal movement of said body therewithin.

14. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member slidable on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock said member to the conduit; means engageable with said ring for retaining said ring in retracted position on said member; means for releasing said retaining means to permit said ring to move outwardly into locking engagement with the well conduit; an inherently expansible annulus on said body movable outwardly into engagement with the well conduit to lock the body to the well conduit; means engageable with said annulus for retaining said annulus in retracted position on said body; and means for releasing said annulus retaining means to permit said annulus to expand into locking engagement with the conduit.

15. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member slidable on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock said member to the conduit; means engageable with said ring for retaining said ring in retracted position on said member; means for releasing said retaining means to permit said ring to move outwardly into locking engagement with the well conduit; an inherently expansible annulus on said body movable outwardly into engagement with the well conduit to lock the body to the well conduit; means engageable with said annulus for retaining said annulus in retracted position on said body; and hydraulically operable means responsive to the pressure of fluid within said body for releasing said annulus retaining means to permit said annulus to expand into locking engagement with the conduit.

16. In a well tool: a body adapted to be lowered in a well conduit positioned in a well bore; an inherently expansible and outwardly movable lock ring on said body; means engageable with said ring for retaining said ring in retracted position on said body; and hydraulically operable means responsive to the pressure of fluid within said body for releasing said retaining means, allowing said ring to expand outwardly into engagement with said conduit.

17. In a well tool: a tubular member adapted to be lowered in a well conduit positioned in a well bore; an inherently expansible and outwardly movable split lock ring on said member; and means engageable with the ends of said split ring for retaining said ring in retracted position on said member, said means extending into said tubular member, said means comprising hydraulically operable instrumentalities within said member and subject to fluid pressure to release said retaining means from said ring.

18. In a well tool: a tubular member adapted to be lowered in a well conduit positioned in

a well bore; an inherently expansible and outwardly movable split lock ring on said member; means engageable with the ends of said split ring for retaining said ring in retracted position on said member; frangible means secured to said retaining means and extending into said member; and hydraulically operable means within said member secured to said frangible means.

19. In a well packer: a body adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body; an inherently expansible lock ring on said member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means engageable with said ring to retain said ring in retracted position on said member; means including instrumentalities on said member engageable with said conduit for effecting release of said retaining means to permit outward expansion of said ring into locking engagement with said conduit; and a packing on said body adapted to be compressed between said body and member upon relative movement between said body and member.

20. In a well tool: a member adapted to be lowered in a well conduit positioned in a well bore; an outwardly expansible lock ring on said member; means for expanding said lock ring outwardly into engagement with the well conduit to lock the member to the conduit; frangible means releasably retaining said ring in retracted position on said member and slidable transversely of and within said member to a position released from said ring to permit said ring to expand outwardly; and means for shearing said frangible means to release said retaining means and permit said ring to move outwardly into anchoring engagement with said conduit.

21. In a well tool: tubular means adapted to be lowered in a well conduit positioned in a well bore; an outwardly expansible lock ring on said means; means for expanding said lock ring outwardly into engagement with the well conduit to lock the tubular means to the conduit; frangible means engageable with said ring to retain said ring in retracted position on said means and slidable transversely of and within said member to a position of disengagement from

said ring; and hydraulically operable means for shearing said frangible means to release said frangible means from said ring to permit said ring to move outwardly into anchoring engagement with said conduit.

22. In a well tool: a body member adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body; an inherently expansible lock ring on said tubular member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; means on said body member engageable with said ring for retaining said ring in retracted position on said tubular member; and means for restraining movement of one of said members to permit said members to be moved with respect to each other to release said retaining means and permit said ring to move outwardly into locking engagement with the well conduit.

23. In a well tool: a body member adapted to be lowered in a well conduit positioned in a well bore; a tubular member movably mounted on said body member; an inherently expansible lock ring on said tubular member movable outwardly into engagement with the well conduit to lock the tubular member to the conduit; frangible means extending into said body member and tubular member and engageable with said ring for retaining said ring in retracted position on said tubular member; and means for restraining movement of one of said members to permit said members to be moved with respect to each other to disrupt said frangible means to allow outward expansion of said lock ring into locking engagement with the well conduit.

THOMAS M. RAGAN.
PAUL H. DURANT.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,178,844	Baker	Nov. 7, 1939
2,394,977	Boynton	Feb. 14, 1946
2,467,801	Baker	Apr. 19, 1949