Feb. 3, 1959 J. V. FREDD 2,871,947

LOCKING DEVICES FOR WELL TOOLS

Filed Oct. 21, 1954 3 Sheets-Sheet 1

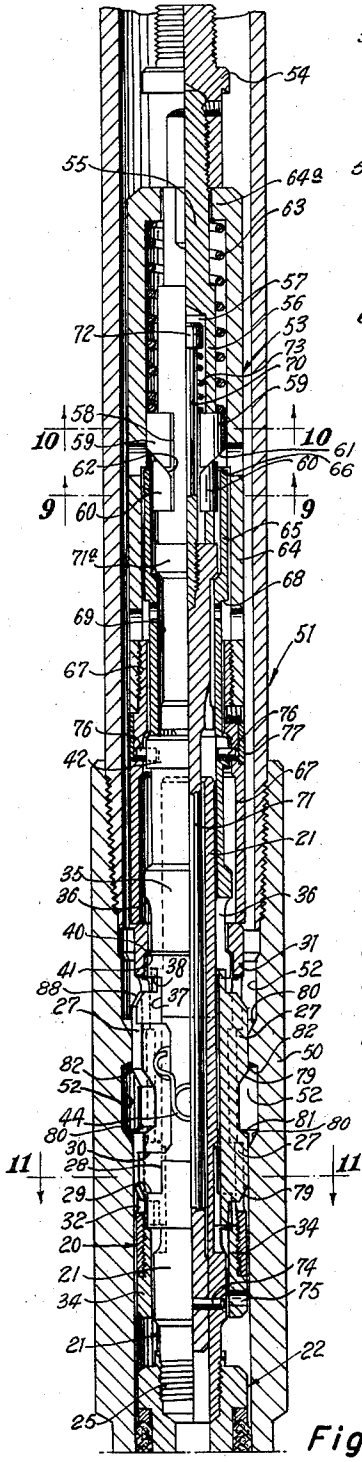


Fig. 1

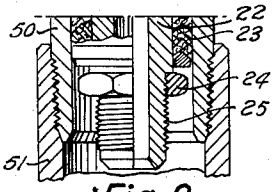


Fig. 2

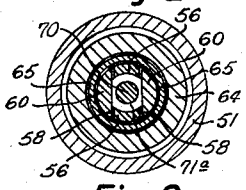


Fig. 9

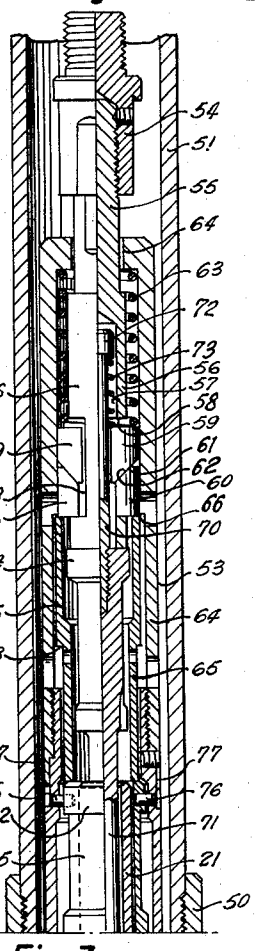


Fig. 3

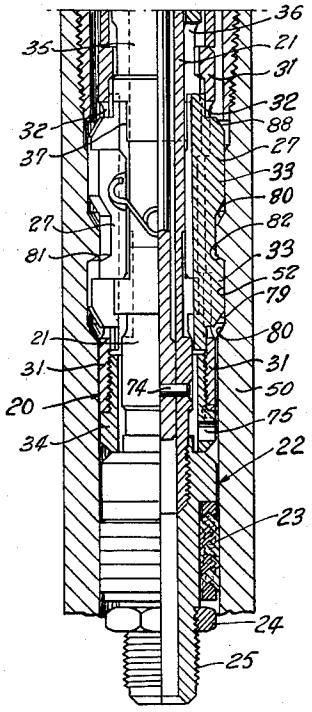


Fig. 4

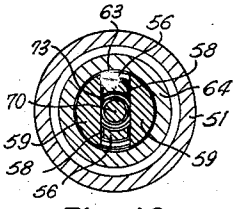


Fig. 10

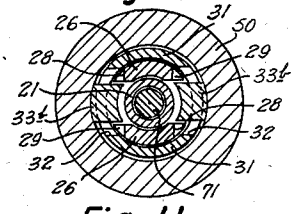


Fig. 11

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Feb. 3, 1959 J. V. FREDD 2,871,947

LOCKING DEVICES FOR WELL TOOLS

Filed Oct. 21, 1954 3 Sheets-Sheet 2

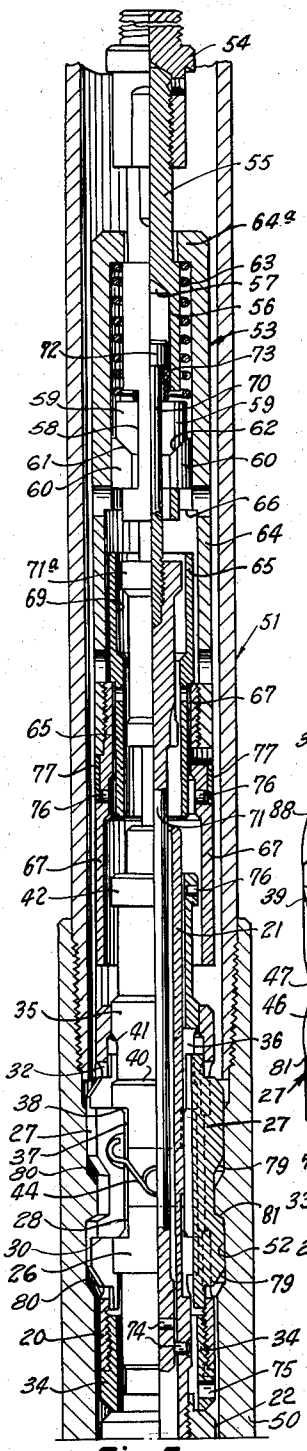


Fig.5

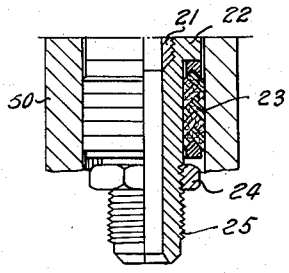


Fig. 6

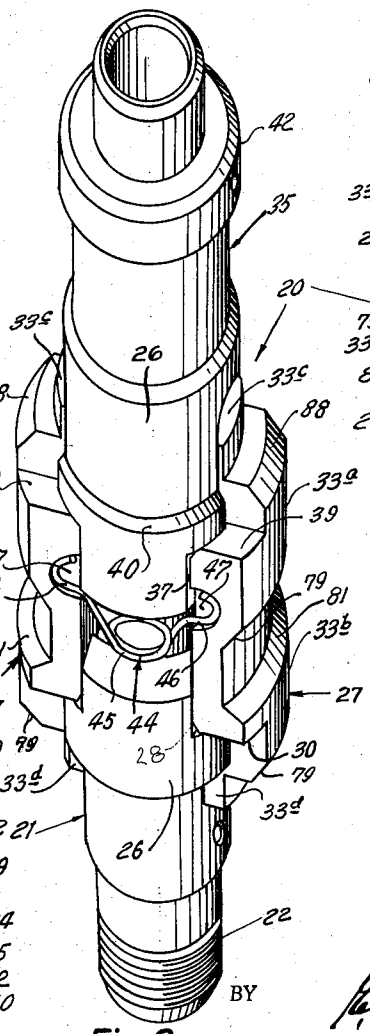


Fig.8

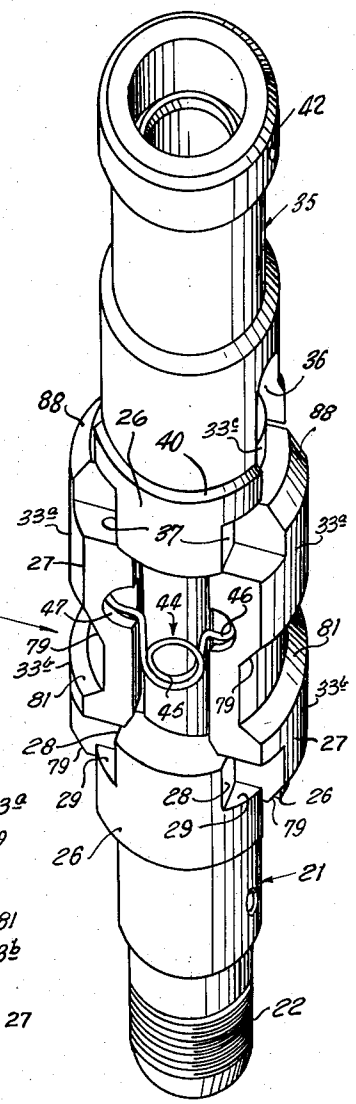


Fig.7

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Feb. 3, 1959 J. V. FREDD 2,871,947

LOCKING DEVICES FOR WELL TOOLS

Filed Oct. 21, 1954 3 Sheets-Sheet 3

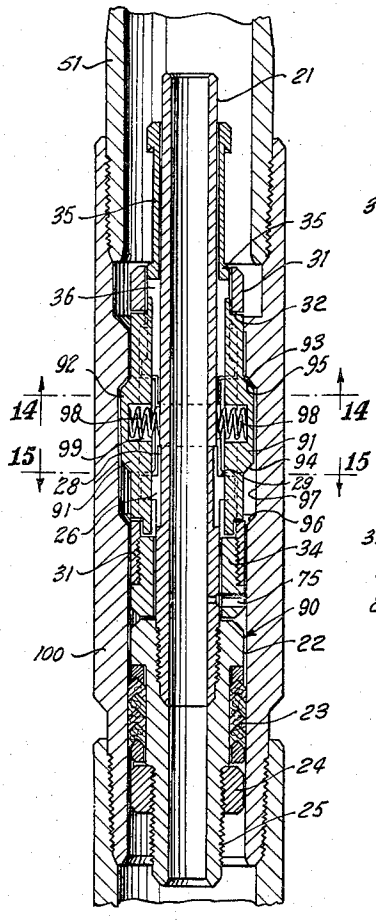


Fig. 13

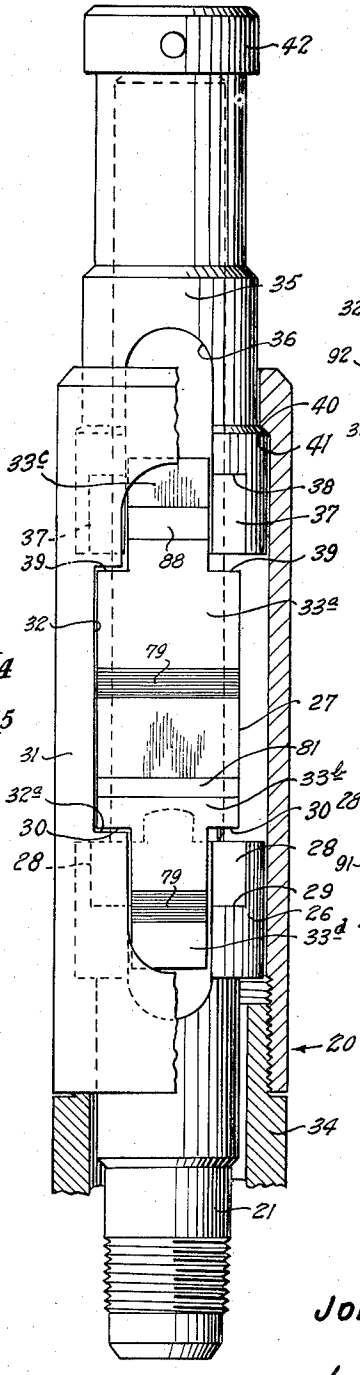


Fig. 12

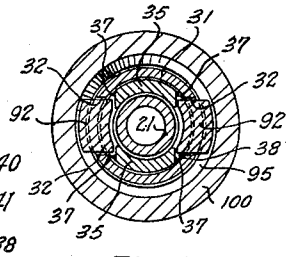


Fig. 14

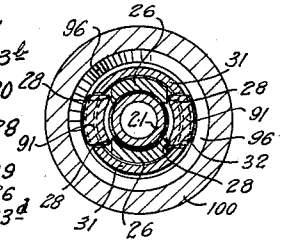


Fig. 15

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LOCKING DEVICES FOR WELL TOOLS

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Application October 21, 1954, Serial No. 463,721

14 Claims. (Cl. 166—219)

This invention relates to locking devices for well tools and more particularly to locking devices for removably locking well tools, such as plugs or chokes, in the well tubing or casing, or the like.

One object of this invention is to provide a new and improved locking device for locking well tools in selected positions in well tubing or casing, or the like.

Another object is to provide a new and improved locking device, of the type described, having locking means which are positively double locked to prevent either upward or downward movement of the locking device in the well conductors.

Still another object of the invention is to provide a new and improved locking device, of the type described, which may be selectively locked in and to any desired landing nipple of a plurality of landing nipples connected in and forming a part of the well tubing, casing, or the like.

A further object of the invention is to provde a new and improved locking device, of the type described, which may be releasably double locked in position in a selected landing nipple of a plurality of landing nipples forming a part of the well conductors.

A still further object of the invention is to provide a new and improved locking device, of the type described, which may be lowered into the well conductor, double locked in place in a landing nipple thereof, and removed therefrom by means of appropriate running and pulling tools which are moved and operated in the well conductor by means of a flexible line.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of devices constructed in accordance with the invention, and reference to the accompanying drawings thereof, wherein:

Figure 1 is a view, partly in elevation and partly in section, of the locking device and of a running tool by means of which the locking device is lowered through and locked in a well conductor, showing the operative components of the locking device and the running tool as they appear while the locking device is being lowered through the well conductor;

Figure 2 is a continuation of the view of Figure 1 showing the lower end of the locking device;

Figure 3 is a view, partly in elevation and partly in section, of the upper portions of the locking device and of the running tool, showing the locking device positioned in a selected landing nipple with the operative components of the running tool in appropriate positions to lock the locking device in the selected nipple upon further operation of the running tool;

Figure 4 is a continuation of the view of Figure 3 showing the lower portions of the locking device and of the running tool;

Figure 5 is a view, partly in elevation and partly in section, of the upper portion of the locking device and of the running tool, showing the operative components of the locking device and the running tool as they appear

immediately after the locking device has been double locked in position in the selected landing nipple of the well conductor and the running tool has been freed from the locking device for upward removal from the well;

Figure 6 is a continuation of the view of Figure 5 showing the lower portion of the locking device;

Figure 7 is a perspective view of the locking device, with a component thereof removed, showing the landing nipple engaging or locking keys free to move between retracted and expanded positions;

Figure 8 is a perspective view of the locking device, with a component thereof removed, showing the landing nipple engaging or locking keys thereof double locked in expanded locking positions;

Figures 9, 10 and 11 are horizontal cross-sectional views taken on the lines **9—9**, **10—10** and **11—11**, repectively, of Figure 1;

Figure 12 is a side view of the locking device, partly in elevation and partly in section, taken at substantially ninety degrees from the view of Figure 7;

Figure 13 is a sectional view of a modified form of the locking device showing it double locked to prevent both upward and downward movement in a landing nipple of a well tubing; and,

Figures 14 and 15 are horizontal cross-sectional views taken on the lines **14—14** and **15—15**, respectively, of Figure 13.

In the drawings, the numeral **20** designates generally a locking device, which includes a central tubular lock mandrel **21** having a threaded lower end to which a packing mandrel **22** is adapted to be secured. The packing mandrel carries a packing assembly **23** which is retained in place on said mandrel by a packing nut **24** threaded on the lower end **25** thereof. A suitable flow controlling or restrictive device, or other well tool may be connected to the threaded lower end **25** of the packer mandrel. If desired, any other suitable well device may be connected to the lower end of the lock mandrel in place of the packing mandrel and packing assembly.

The lock mandrel **21** is provided intermediate its ends with a pair of lateral opposed bosses **26** between which the lower ends of locking keys **27** are adapted to slide. Each boss **26** has its upper corners cut away to provide longitudinally disposed pairs of opposed lock shoulders or surfaces **28** on each boss, each lock shoulder having an upwardly facing stop shoulder **29** at its lower end. The inner surfaces of the locking keys may be engaged by the lock shoulders **28** of the bosses when the keys are expanded, which thus lock the keys in expanded positions, when the lock mandrel is in the raised position shown in Figures 5 and 8, and the stop shoulders **29** of the bosses may engage downwardly facing stop shoulders **30** of the keys to limit upward movement of the lock mandrel **21** relative to the locking keys.

The locking keys **27** are held in proper position on the lock mandrel by a tubular key retainer or cage **31** slidably mounted on the lock mandrel, the cage being provided with windows **32** through which the bosses **33***a* and **33***b* of each key protrude. An upper retaining flange **33***c* and a lower retaining flange **33***d* at the upper and lower ends, respectively, of each locking key engage the inner wall of the cage **31** at the upper and lower ends of the windows **32** to limit outward movement of the locking keys on the lock mandrel. A bushing **34** is threaded into the lower end of the cage **31** and limits downward movement of the lock mandrel with respect to the cage since the lower ends of the bosses **26** are engageable with the upper end of the bushing.

A lock sleeve **35** is slidably mounted on the lock mandrel and its lower portion extends between the lock man-

drel and the cage and is provided with a pair of slots **36** into which the upper ends of the locking keys extend. The lower portions of the lock sleeve on each side of the slots are cut away to provide longitudinally disposed lock shoulders **37**, which are adapted to abut the inner surfaces of the upper portion of the keys **27** to lock the keys in expanded positions when the lock sleeve is in the lower or locking position shown in Figures 5 and 8. Downwardly facing stop shoulders **38** are formed on the lock sleeve at the upper end of each lock shoulder **37**, and these stop shoulders are adapted to engage the upwardly facing stop shoulders **39** of the locking keys to limit downward movement of the lock sleeve on the lock mandrel.

The lock sleeve is provided near its lower end with an upwardly facing stop shoulder **40** which is adapted to engage an internal annular downwardly facing stop shoulder **41** within the upper portion of the bore of the cage **31** to limit upward movement of the lock sleeve with respect to the cage. The upper end of the lock sleeve is provided with an undercut external annular flange **42** which may be engaged by a suitable pulling tool.

The locking keys **27** are yieldably biased outwardly toward expanded positions by a pair of springs **44**. Each of the springs has a central coiled portion **45** which is disposed between the lower end of the lock sleeve and the upper end of the adjacent lock mandrel boss **26** and has curved outer ends **46** which are received in side recesses **47** of the keys.

It will be seen that when the lock mandrel **21** is moved upwardly relative to the key cage **31** and the locking keys **27** while the keys are in their expanded positions, the lock shoulders **28** of the lock mandrel bosses **26** engage the rear or inner surfaces of the lower portions of the keys to lock the keys against inward movement toward retracted position. The lock sleeve **35** may then be moved downwardly between the lock mandrel and the cage until the lock shoulders **37** of the lock sleeve engage the rear or inner surfaces of the upper portions of the locking keys to prevent inward movement of said keys toward retracted position. Thus, the keys are positively double locked in their expanded positions, and any fluid pressures or other forces acting on the locking device in either upward or a downward direction cannot dislodge the bosses **33***b* of the locking keys from their expanded positions wherein they are engaged in the internal locking groove **52** formed in the bore of a selected landing nipple **50** connected in the well tubing or conductor **51**, as will hereinafter more fully be explained.

The locking device is lowered into the well conductor or tubing **51**, which may include a plurality of vertically spaced landing nipples **50**, by means of a running tool **53** (Figure 1) on the lower end of a flexible line running and pulling mechanism (not shown) until a selected landing nipple located at the proper depth is reached. The running tool is then operated by jars imparted thereto through the flexible line mechanism to lock the locking device in the selected landing nipple.

The running tool **53** includes a top sub **54** having a threaded pin at its upper end by means of which it may be secured to the flexible line mechanism in the usual manner. An elongate core **55** connected at its upper end to the top sub has an enlarged lower portion **56** provided with a central bore **57** and a pair of opposed lateral windows **58** (Figure 3). A wedge member **59** and a catch lug **60** having wedge or beveled surfaces **61** and **62**, respectively, are disposed in each window **58** of the core. A tubular body **64** is movably mounted on the core and has an internal annular flange **64***a* at its upper end slidable on the core above the enlarged lower portion thereof, and a helical spring **63** surrounding the core is confined between the flange **64***a* and the upper ends of the wedge members **59**, whereby the spring biases the wedge members downwardly and the sleeve upwardly relative to the core. The action of the spring on the wedge members biasing the same downwardly tends to urge the lugs **60** outwardly of the windows **58** in the core, from the positions shown in Figure 1 to that shown in Figure 3, because of the action of the wedge surfaces **61** and **62**.

A tubular sleeve **65** movably mounted within the tubular body **64** holds the lugs **60** in retracted positions in its bore when said tubular sleeve is held in the raised position shown in Figure 1 by the engagement of its lower end with the upper end of the lock sleeve **35** of the locking device. Upward movement of the tubular sleeve within the tubular body is limited by an internal downwardly facing stop shoulder **66** formed in the bore of the tubular body and which engages the upper end of the tubular sleeve. Downward movement of the sleeve **65** is limited by the upper end of a skirt **67** which is threaded in the lower end of the tubular body and is adapted to engage a downwardly facing external annular stop shoulder **68** formed intermediate the ends of the tubular sleeve.

An elongate prong **71** having a head **71***a* at its upper end is slidable in the bore **69** of the tubular sleeve **65**, and a prong screw or extension **70** extends upwardly from the upper end of the prong and projects upwardly into the bore **57** of the core **55**. A spring **73** surrounds the prong extension and is confined between a flange **72** at the upper end of said extension and the upper ends of the wedge members **59**, whereby the spring biases the prong extension and prong upwardly toward the position shown in Figure 1. The prong extends downwardly into the tubular lock mandrel **21** of the locking device and has enlargement at its lower end which is secured to the lock mandrel by a shear pin **74**. The cage bushing **34** is provided with a hole **75** through which the shear pin **74** may be inserted into aligned holes in the lock mandrel and the lower end of the prong.

The lock sleeve **35** of the locking device is secured at its upper end to the skirt **67** by means of shear pins **76** disposed in aligned openings in the skirt and the flange **42** of the lock sleeve. A rotatable ring **77** mounted exteriorly of the upper portion of the skirt **67** is provided with a plurality of apertures (not shown) through which these shear pins may be inserted to connect the lock sleeve to the skirt and, thus, to the tubular body **64** of the running tool.

When it is desired to lock a well tool in a landing nipple **50**, or in a selected one of a plurality of landing nipples **50** connected in a well flow conductor or tubing string, the well tool is connected to the lower end of the lock mandrel **21** of the locking device. The locking device is then secured to the running tool by means of the shear pins **74** and **76**, so that the lock sleeve and the lock mandrel are held in their longitudinally separated positions shown in Figure 1, whereby the locking keys **27** of the locking device are free to move between retracted and expanded positions.

The running tool, locking device and well tool are then lowered into the well tubing. The locking keys **27** are yieldingly biased outwardly by the springs **44** whereby their downwardly facing beveled shoulders **79** will contact the upwardly facing beveled shoulders **80** of the landing nipples in passing therethrough. Since these shoulders are beveled, downward jars imparted to the running tool will cam the keys inwardly against the resistance of the springs **44** to permit the locking device to pass through all landing nipples until the selected landing nipple at the proper depth is reached and the bosses **33***b* of the keys are located in the annular groove **52** of the landing nipple at the selected depth.

An upward pull is then exerted on the running tool, causing the upwardly facing beveled shoulders **81** of the keys to contact the downwardly facing annular shoulder **82** at the upper end of the groove in the landing nipple. The relatively sharp angle of the shoulders **81** and **82** require a substantial force to move the locking keys upwardly from this position, and an upward pull on the run-

ning tool will move all other parts of the locking device upwardly with respect to the locking keys until the lock shoulders 28 of the lock mandrel 21 are lifted to a position between the inner surfaces of the locking keys, thus locking the keys expanded. A further upward pull will now cause the core 55 to move upwardly compressing the springs 63 and 73 since the lugs 60 are restrained against outward movement by the tubular sleeve 65. The strengths of the springs 63 and 73 are such that a lesser force is required to compress the springs 63 and 73 than is required to move the keys 27 inwardly against the resistance of the springs 44. The locking keys, being locked in expanded position, cannot move upwardly, and the lock mandrel 21 can move upwardly only until the stop shoulders 29 engage the shoulders 30 at the lower ends of the locking keys, whereby further upward movement of the lock mandrel is prevented. Similarly, the upper end of the packing mandrel 22 will engage the lower end of the bushing 34 at the lower end of the key cage 31 and the upwardly facing stop shoulders 32*a* in the lower portion of the windows 32 of the key cage will also engage the downwardly facing stop shoulders 30 of the locking keys to prevent upward movement of the packing mandrel, lock mandrel and key cage. The prong 71 being connected to the lock mandrel by the shear pin 74 is also held against further upward movement, but the spring 73 permits the core 55 to move further upwardly with respect to the prong and prong extension.

The shoulder 40 on the lock sleeve 35 engages the stop shoulder 41 in the key cage 31 to limit upward movement of the lock sleeve, since the bushing 34 at the lower end of the cage engages the lower ends of the bosses 26 on the lock mandrel to limit upward movement of the cage. Since the lock sleeve is connected to the tubular body 64 by the shear pins 76, upward movement of the tubular body is thus limited by such connection, and upward movement of the tubular sleeve 65 is likewise limited by virtue of its engagement with the shoulder 66 in the tubular body.

As the core 55 moves upwardly and compresses the springs 63 and 73, the lugs 60 are moved upwardly past the upper end of the tubular sleeve 65, which is held against upward movement by the stop shoulder 66 in the bore of the tubular body 64. When the lugs move above the upper end of the tubular sleeve, the spring 63 biases the wedge members 59 downwardly and the wedge surfaces 61 and 62 cam the lugs outwardly over the upper end of the tubular sleeve to the position shown in Figure 3.

When the lugs 60 move past the upper end of the tubular sleeve 65 and are freed to move outwardly, they overlie and abut the upper end of the tubular sleeve and thus hold the springs 63 and 73 in compression, the springs resisting downward movement of the prong 71 and the tubular body 64 and the skirt 67 carried by the tubular body. The lock sleeve 35 is still secured to the tubular skirt and the prong is still secured to the lock mandrel so that the operative elements of the running tool and the locking device are now in the positions shown in Figures 3 and 4.

Downward jars or blows are then imparted by the running tool mechanism to the core 55, such blows being transmitted through the wedge members 59 and the lugs 60 to the upper end of the tubular sleeve 65, causing said tubular sleeve to move downwardly relative to the tubular body 64 and the skirt 67. Since the lower end of the tubular sleeve engages on the upper end of the lock sleeve, the downward force applied to the tubular sleeve shears the pins 76 and the lock sleeve is moved downwardly relative to the skirt and the locking keys until the lock shoulders 37 of the lock sleeve are moved between the inner surfaces of the upper ends of the locking keys and thus double lock the locking keys in their expanded positions. Downward movement of the lock sleeve is limited by the engagement of the stop shoulders 38 on said sleeve with the shoulders 39 at the upper ends of the locking keys.

Upward jars are then imparted to the running tool causing the pin 74 to shear and thus free the running tool from the locking device. The running tool is then removed from the well tubing leaving the locking device, and the well tool it supports, double locked in position in the well tubing so that fluid pressure or other forces acting in either direction thereon cannot dislodge the locking device from the landing nipple. If the well fluid pressure exerts a downward pressure on the locking device, which could tend to move the lock mandrel downwardly out of locking position, the lock sleeve holds it in locking position. Conversely, if an upward force pressure is exerted on the locking sleeve which could tend to move the lock sleeve upwardly out of locking position, the lock mandrel holds the locking device in locking position. Furthermore, since the lock sleeve is slidable exteriorly on the lock mandrel and is not exposed to upward flow of fluids, which flow upwardly through the bore of the lock mandrel, the lock sleeve will not be affected by upward fluid flow or pressure differentials, so that both lock members, the mandrel and the sleeve, hold the keys in expanded locking position against displacement by upward fluid flow and pressure differentials.

When it is desired to remove the locking device and the well tool it supports, a suitable retrieving tool is lowered into the well conductor and employed first to impart downward jars or blows to the upper end of the lock mandrel 21, which now projects above the upper end of the lock sleeve, to drive said lock mandrel downwardly so that its locking shoulders 28 no longer engage the locking keys. The retrieving tool may then engage the flange 42 of the lock sleeve and an upward pull thereon may move the lock sleeve upwardly relative to the locking keys until its lock shoulders 37 are moved out of engagement therewith. The locking device is then pulled up and out of the well tubing, the downwardly and outwardly beveled upper shoulders 38 of the locking keys camming the keys inwardly upon meeting obstructions during upward movement of the locking device through the well tubing. It will be readily apparent that the locking device cannot be freed for removal until the lock mandrel has been moved downwardly, so that if a condition of pressure differential acting upwardly on the packing mandrel and lock mandrel exists, the tool cannot be accidentally released by pulling upwardly on the lock sleeve. This prevents "blow-outs" of the locking device and fouling of the flexible line running and pulling mechanism.

It will be seen that a new and improved double locking lock device for well tools has been illustrated and described which includes a central lock mandrel having locking bosses which engage locking keys mounted on the lock mandrel to lock the keys in expanded position upon upward movement of the lock mandrel with respect to the keys. It will be apparent that the locking keys are mounted on the lock mandrel for lateral movement between retracted and expanded positions and that biasing means, the springs 44, are provided to urge the locking keys toward the expanded positions. It will also be seen that a lock sleeve is provided which is slidably mounted on the lock mandrel for movement between the locking keys and the lock mandrel and that downward movement of the lock sleeve with respect to the lock mandrel causes the lock sleeve to engage the locking keys to lock them in the expanded positions. The double lock adds security to the installation in which the locking device is used, and prevents dropping of the device should upward pressure differential be sharply decreased or removed.

Moreover, it will be seen that a running tool has been provided for the locking device which includes a central prong 71 detachably secured to the lock mandrel, a tubular member which includes the tubular body 64 and the skirt 67 and which is detachably secured to the lock sleeve, and a tubular sleeve in the tubular member which

coacts with biasing springs 63 and 73 and the wedges 59 and lugs 60 to simultaneously hold both to locking mandrel and lock sleeve in their unlocked positions; and that upward force or jars imparted to the running tool when the locking keys are in expanded positions in a lock groove or recess of a landing nipple will first cause the lock mandrel to move upwardly with respect to the locking keys to lock the keys in the expanded positions, then downward jars or force applied to the running tool will cause the lock sleeve to become detached from the tubular member and move downwardly with respect to the locking keys to lock them in expanded positions; whereupon, upward force or jars applied to the running tool will detach the prong from the lock mandrel to free the running tool from the locking device, whereby the latter may be left in double locked position in the landing nipple while the running tool may be removed from the well tubing.

In Figures 13, 14 and 15 is illustrated a locking device 90 which differs from the previously described form of the locking device in that the locking keys 91 each have but a single laterally and outwardly extending boss 92 which extends through the windows 32 of the cage 31. The bosses of the locking keys have beveled upper shoulders 93 and lower shoulders 94 which engage the upper and lower annular shoulders 95 and 96 of the internal annular locking recess or groove 97 of the landing nipple 100. The annular locking recess 97 is of appropriate size and shape to receive the bosses 92 of the keys 91. The locking keys are biased outwardly toward expanded positions by coil springs 98 which are received in appropriate inner recesses 99 of the keys and bear against the lock mandrel and the keys. In all other respects the locking device 90 is identical to the locking device 20 and is operable in the same manner as the locking device 20 by a running tool of the same form as the running tool 53, like parts being given like numbers. No other description of the locking device 90 is therefore necessary.

It will thus be seen that locking devices have been shown and described which are adapted for use with a set of upwardly and downwardly facing stop shoulders in a flow conductor, preferably provided in a suitable landing nipple in the conductor string, and which may be lowered past a plurality of identical sets of stop shoulders, or landing nipples, and locked in locking engagement with any one of a plurality of sets of such stop shoulders. The position at which the devices are locked may be determined by locating the desired set of shoulders or landing nipples by means of a measuring apparatus of any well known type operating in association or connection with the flexible line running and pulling mechanism by means of which the locking device is lowered in the conductor.

Since the lower shoulders of the bosses on the locking keys are beveled, it will be seen that the locking device may be lowered past any number of sets of shoulders, or landing nipples, each having identical sets of stop shoulders, to a landing nipple located at a desired location in the conductor and in which it may be locked. As the downwardly facing stop shoulders are preferably inclined upwardly and inwardly at a rather abrupt angle with respect to the longitudinal axis of the conductor, preferably at an angle of less than forty-five degrees above a plane normal to the longitudinal axis of said conductor, and the upwardly facing stop shoulders on the bosses of the locking keys have a corresponding configuration, the upward movement of the keys with respect to the landing nipples will be somewhat more greatly restrained than the downward movement was. As has already been explained, the force of the springs biasing the locking keys outwardly, in cooperation with the abrupt shoulders in the conductor and on the bosses of the keys, is sufficient to restrain upward movement of the keys while the lock mandrel is moved upwardly to position the lock shoulders between the keys to positively lock the keys in stop shoulder engaging position, after which the other steps of locking the device may be carried out.

When the locking device is being removed from within the conductor, the device is lifted by engagement of the retrieving tool with the upper end of the lock sleeve, after the lock mandrel has been moved downwardly to its lowermost position to permit the locking keys to move inwardly. Thus, as downwardly facing stop shoulders in the conductor are engaged by the upwardly facing stop shoulders on the bosses of the locking keys, upward force applied to the lock sleeve will readily lift the keys past the stop shoulders, since the lock mandrel is not moved upwardly with respect to said keys, and they may move inwardly against the force of the springs so as to pass the downwardly facing stop shoulders.

Thus, the locking device may be lowered through a plurality of landing nipples to a selected landing nipple, locked therein positively against either upward or downward displacement by fluid pressure differentials, and may be removed upwardly from such position, all by means of suitable running and retrieving tools operated by means of a flexible line.

The foregoing description of the invention is explanatory only, and changes in the details of the constructions illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A well tool including: a lock mandrel; a tubular cage mounted on said mandrel for longitudinal movement thereon and having a plurality of windows; locking keys disposed in said cage and having bosses extending laterally outwardly through said windows, said keys being movable laterally between expanded positions remote from said lock mandrel and retracted positions adjacent said lock mandrel; means biasing said keys toward expanded positions; lock shoulders on said lock mandrel intermediate the ends thereof, said lock shoulders being disposed substantially normal to the direction of lateral movement of said keys and engageable with said keys upon longitudinal movement of said lock mandrel in said cage when said keys are in said expanded positions; a lock sleeve slidably mounted on said lock mandrel above said keys and between said lock mandrel and said cage and movable downwardly on said lock mandrel independently of movement of said mandrel from an upper unlocked position to a lower locking position, said lock sleeve having lock shoulders disposed substantially normal to the direction of lateral movement of said keys and engageable with said keys when said keys are in said expanded positions and said lock sleeve is moved downwardly with respect to said sleeve to lock said keys in said expanded positions; cooperable means on said lock mandrel and said keys limiting upward movement of said lock mandrel with respect to said keys; cooperable means on said lock sleeve and said keys limiting downward movement of said lock sleeve on said lock mandrel; cooperable means on said cage and said lock sleeve limiting upward movement of said lock sleeve on said lock mandrel; and cooperable means on said cage and said lock mandrel limiting upward movement of said cage on said lock mandrel.

2. A well tool including: a lock mandrel; a tubular cage mounted on said mandrel for longitudinal movement thereon and having a plurality of windows; locking keys disposed in said cage and having bosses extending laterally outwardly through said windows, said keys being movable laterally between expanded positions remote from said lock mandrel and retracted positions adjacent said lock mandrel; means biasing said keys toward expanded positions; a plurality of spaced laterally projecting bosses on said lock mandrel intermediate the ends thereof, said bosses providing lock shoulders engageable with said keys when said keys are in said expanded positions to lock said keys in said expanded positions upon longitudinal movement of said lock mandrel in said cage; and a lock sleeve

slidably mounted on said lock mandrel above said keys and between said lock mandrel and said cage and movable downwardly on said lock mandrel from an upper unlocked position to a lower locking position, said lock sleeve having a plurality of downwardly opening slots for receiving the upper ends of said keys, the sides of said slots forming lock shoulders engageable with said keys when said keys are in expanded position and said lock sleeve is moved downwardly to said locking position to lock said keys in said expanded positions.

3. A well tool including: a lock mandrel; a tubular cage mounted on said mandrel for longitudinal movement thereon and having a plurality of windows; locking keys disposed in said cage and having bosses extending laterally outwardly through said windows; said keys being movable laterally between expanded positions remote from said lock mandrel and retracted positions adjacent said lock mandrel; means biasing said keys toward expanded positions; a plurality of spaced laterally projecting bosses on said lock mandrel intermediate the ends thereof, said bosses providing lock shoulders engageable with said keys when said keys are in said expanded positions to lock said keys in said expanded positions upon longitudinal movement of said lock mandrel in said cage; and a lock sleeve slidably mounted on said lock mandrel above said keys and between said lock mandrel and said cage and movable downwardly on said lock mandrel from an upper unlocked position to a lower locking position, said lock sleeve having a plurality of downwardly opening slots for receiving the upper ends of said keys, the sides of said slots forming lock shoulders engageable with said keys when said keys are in expanded position and said lock sleeve is moved downwardly to said locking position to lock said keys in said expanded positions; said lock mandrel extending above said lock sleeve when said lock mandrel and said lock sleeve are in locking positions.

4. A well tool including: a lock mandrel; a tubular cage mounted on said mandrel for longitudinal movement thereon and having a plurality of windows; locking keys disposed in said cage and having bosses extending laterally outwardly through said windows, said keys being movable laterally between expanded positions remote from said lock mandrel and retracted positions adjacent said lock mandrel; means biasing said keys toward expanded positions; lock shoulders on said lock mandrel intermediate ends thereof, said lock shoulders being engageable with said keys upon longitudinal movement of said lock mandrel in said cage when said keys are in said expanded positions; a lock sleeve slidably mounted on said lock mandrel above said keys and between said lock mandrel and said cage and movable downwardly on said lock mandrel from an upper unlocked position to a lower locking position, said lock sleeve having lock shoulders engageable with said keys when said keys are in said expanded positions and said lock sleeve is moved downwardly with respect to said sleeve to lock said keys in said expanded positions; stop means limiting longitudinal movement of said lock mandrel relative to said keys between locking and unlocking positions; and stop means limiting movement of said lock sleeve relative to said keys between upper and lower positions; said lock mandrel extending above said lock sleeve when said lock mandrel and said lock sleeve are in locking positions.

5. A well tool including: a lock mandrel; a tubular cage mounted on said mandrel for longitudinal movement thereon and having a plurality of windows; locking keys disposed in said cage and having bosses extending laterally outwardly through said windows, said keys being movable laterally between expanded positions remote from said lock mandrel and retracted positions adjacent to said lock mandrel; means biasing said keys toward expanded positions; lock shoulders on said lock mandrel intermediate to ends thereof, said lock shoulders being engageable with said keys upon longitudinal movement of said lock mandrel in said cage when said keys are in said expanded positions; a lock sleeve slidably mounted on said lock mandrel above said keys and between said lock mandrel and said cage and movable downwardly on said lock mandrel from an upper unlocked position to a lower locking position, said lock sleeve having lock shoulders engageable with said keys when said keys are in said expanded positions and said lock sleeve is moved downwardly with respect to said sleeve to lock said keys in said expanded positions; cooperable means on said lock mandrel and said keys limiting upward movement of said lock mandrel with respect to said keys; cooperable means on said lock sleeve and said keys limiting downward movement of said lock sleeve on said lock mandrel; cooperable means on said cage and said lock sleeve limiting upward movement of said lock sleeve on said lock mandrel; and cooperable means on said cage and said lock mandrel limiting upward movement of said cage on said lock mandrel; said lock mandrel extending above said lock sleeve when said lock mandrel and said lock sleeve are in locking positions.

6. In combination, a well pipe having a plurality of spaced tubular landing sections connected therein at selected levels and each having an identical set of stop shoulders comprising an internal upwardly facing stop shoulder and an internal downwardly facing stop shoulder, and a device for releasably anchoring a well tool in a selected one of said landing sections including: a lock mandrel; locking means mounted on said mandrel biased for lateral movement to a locking position wherein said locking means is disposed to engage said upwardly and downwardly facing shoulders of each of said landing sections, said lock mandrel being movable longitudinally upwardly relative to said locking means and having a lock surface engageable with said locking means when said locking means is in locking position in any one of said landing sections to lock said locking means in said locking position; and a lock sleeve slidably mounted on said mandrel and slidable longitudinally thereon independently thereof, said lock sleeve having a lock surface engageable with said locking means when said locking means has been initially locked in locking position by said lock mandrel to additionally lock said locking means in said locking position.

7. A locking device for releasably anchoring a well tool in a selected one of a plurality of spaced tubular landing sections connected in a well pipe at selected levels in said well pipe and each having an identical set of stop shoulders comprising an internal upwardly facing stop shoulder and an internal downwardly facing stop shoulder, said downwardly facing stop shoulder being inclined inwardly and upwardly with respect to the longitudinal axis of said landing section at an angle of less than forty-five degrees with respect to a plane normal to such axis, and said upwardly facing shoulders being inclined inwardly and downwardly with respect to the longitudinal axis of said landing section at an angle of at least forty-five degrees with respect to a plane normal to such axis, and including a locking mechanism lowerable through all said landing sections and having outwardly biased lock means having projecting lock lugs thereon of a configuration conforming to the configuration of the stop shoulders of the landing sections and movable to locking engagement with said stop shoulders of each of said landing sections, and means on said locking mechanism operable to lock said device in a selected landing section against movement in either direction therefrom.

8. A well tool including: a lock mandrel; locking means having a laterally extending boss portion adapted to engage locking shoulders in a well conductor and mounted on said lock mandrel and movable laterally between projecting position remote from the lock mandrel and retracted position adjacent said lock mandrel; retaining means slidable longitudinally on said lock man-

drel and movably supporting and retaining said locking means on said lock mandrel; means biasing said locking means toward projecting position; said lock mandrel having means intermediate its ends providing a lock surface engageable with said locking means when said locking means is in projecting position to lock said locking means in such projecting position upon longitudinal movement of said lock mandrel relative to said locking means when said boss portion of said locking means is engaged with said locking shoulders; a lock sleeve slidably mounted on said lock mandrel above said locking means and movable downwardly thereon from an upper unlocking position to a lower locking position, said lock sleeve having means thereon providing a lock surface engageable with said locking means when said locking means is in projecting position and said lock sleeve is moved downwardly on said lock mandrel to said locking position to lock said locking means in said projecting position; stop means limiting longitudinal movement of said lock mandrel relative to said locking means between unlocking and locking positions; and stop means limiting movement of said lock sleeve relative to said locking means between said unlocking and locking positions.

9. The device of claim 8 and a running tool including means detachably secured to said lock mandrel and means separately detachably secured to said lock sleeve for holding said lock mandrel and said lock sleeve to maintain said lock surfaces out of engagement with said locking means.

10. A well tool including: a lock mandrel; locking means having a laterally extending boss portion adapted to engage locking shoulders in a well conductor and mounted on said lock mandrel and movable laterally between projecting position remote from the lock mandrel and retracted position adjacent said lock mandrel; retaining means slidable longitudinally on said lock mandrel and movably supporting and retaining said locking means on said lock mandrel; means biasing said locking means toward projecting position; said lock mandrel having means intermediate its ends providing a lock surface engageable with said locking means when said locking means is in projecting position to lock said locking means in such projecting position upon longitudinal movement of said lock mandrel relative to said locking means when said boss portion of said locking means is engaged with said locking shoulders; a lock sleeve slidably mounted on said lock mandrel in a position in which said locking means is disposed between said sleeve and said lock mandrel lock surface, said sleeve being movable on said mandrel from an unlocking position toward locking position engaging said locking means, said lock sleeve having means thereon providing a lock surface engageable with said locking means when said locking means is in projecting position and said lock sleeve is moved on said lock mandrel toward said locking means to said locking position to lock said locking means in said projecting position; stop means limiting longitudinal movement of said lock mandrel relative to said locking means between unlocking and locking positions; and stop means limiting movement of said lock sleeve relative to said locking means between said unlocking and locking positions.

11. A well tool including: a lock mandrel; a plurality of locking members each having a laterally extending boss portion adapted to engage locking shoulders in a well conductor and mounted on said lock mandrel and movable laterally between projecting position remote from the lock mandrel and retracted position adjacent said lock mandrel; retaining means slidable longitudinally on said lock mandrel and movably supporting and retaining said locking members on said lock mandrel; means biasing said locking members toward projecting position; said lock mandrel having means intermediate its ends providing a lock surface engageable with said locking members when said locking members are in projecting position to lock said locking members in such projecting position upon longitudinal movement of said lock mandrel relative to said locking members when said boss portions of said locking members are engaged with said locking shoulders; a lock sleeve slidably mounted on said lock mandrel above said locking members and movable downwardly thereon from an upper unlocking position to a lower locking position, said lock sleeve having means thereon providing a lock surface engageable with said locking members when said locking members are in projecting position and said lock sleeve is moved downwardly on said lock mandrel to said locking position to lock said locking members in said projecting position; stop means limiting longitudinal movement of said lock mandrel relative to said locking members between unlocking and locking positions; and stop means limiting movement of said lock sleeve relative to said locking members between said unlocking and locking positions.

12. The device of claim 11 and a running tool including: a prong extending downwardly into said lock mandrel; releasable means securing said prong to said lock mandrel; a tubular member telescoping over said lock sleeve and longitudinally movable with respect to said prong; releasable means securing said tubular member to said lock sleeve; and means between said prong and said tubular member permitting longitudinal movement therebetween whereby said tubular member and said prong may be successively detached from said tubular member and said lock mandrel respectively.

13. A well tool including: a lock mandrel; a tubular retaining cage slidable longitudinally on said mandrel and having a plurality of lateral windows; locking members each having a laterally extending boss portion slidably disposed in one of the windows of said cage and adapted to engage locking shoulders in a well conductor, said locking members being movable laterally between projecting position remote from the lock mandrel and retracted position adjacent said lock mandrel; said retaining cage movably supporting and retaining said locking members on said lock mandrel; means biasing said locking members toward projecting position; said lock mandrel having means intermediate its ends providing a lock surface engageable with said locking members when said locking members are in projecting position to lock said locking members in such projecting position upon longitudinal movement of said lock mandrel relative to said locking members when said boss portions of said locking members are engaged with said locking shoulders; a lock sleeve slidably mounted on said lock mandrel above said locking members and movable downwardly on said mandrel within said cage from an upper unlocking position to a lower locking position, said lock sleeve having means thereon providing a lock surface engageable with said locking members when said locking members are in projecting position and said lock sleeve is moved downwardly on said lock mandrel to said locking position to lock said locking members in said projecting position; stop means limiting longitudinal movement of said lock mandrel relative to said locking members between unlocking and locking positions; and stop means limiting movement of said lock sleeve relative to said locking members between said unlocking and locking positions.

14. As a sub-combination, a landing section comprising: a tubular member having means at its ends providing for connecting the same in a well string having a longitudinal bore therethrough; an internal annular flange in the bore of said member having an upwardly facing inclined shoulder thereon inclined downwardly and inwardly of the longitudinal axis of the housing and an angle of at least forty-five degrees with respect to a plane normal to such axis; said internal annular flange having a lower downwardly facing stop and lock shoulder inclined inwardly and upwardly with respect to the longitudinal axis of such member at an angle less than forty-five degrees with respect to a plane normal to such axis; the bore of said member below said internal annular

flange being reduced in diameter beginning at a point spaced a distance below said downwardly facing stop and lock shoulder, said reduced bore having at its upper end an upwardly facing shoulder inclined inwardly and downwardly with respect to the longitudinal axis of said member at an angle of at least forty-five degrees with respect to a plane normal to the longitudinal axis of said member, and a downwardly facing shoulder at the lower end of said reduced portion of the bore of said member inclined downwardly and outwardly with respect to the longitudinal axis of said member, the bore of said member being unrestricted below said reduced portion; the bore of the member between said flange and said reduced portion forming an internal annular locking groove in said member having the downwardly facing stop and lock shoulder inclined at an angle of less than forty-five degrees defining the upper limit of said groove and the upwardly facing downwardly and inwardly inclined shoulder at the upper end of the reduced portion of the bore defining the lower limit of said locking groove; said locking groove being adapted to receive the locking member of a removable well device for stopping and anchoring said well device in said landing section, said downwardly facing stop and lock shoulder at the upper end of said groove offering substantial resistance to upward movement of said lock member from said groove, said upwardly facing shoulders at the upper end of said flange and at the upper end of the reduced portion of the bore of said landing section providing camming surfaces facilitating passage of said locking member through said section, whereby said locking member may pass through the locking groove and through the locking section to permit said well tool to be movable therethrough to a position below said landing section.

References Cited in the file of this patent

UNITED STATES PATENTS

2,153,812	Newton	Apr. 11, 1939
2,221,204	Santiago	Nov. 12, 1940
2,380,022	Burt	July 10, 1945
2,383,453	Crickmer	Aug. 28, 1945
2,568,867	Otis	Sept. 25, 1951
2,673,614	Miller	Mar. 30, 1954
2,698,056	Marshall et al.	Dec. 28, 1954
2,698,663	Brown	Jan. 4, 1955