March 22, 1966 R. O. COX 3,241,616

ANCHORING MEANS FOR WELL TOOLS

Filed Dec. 20, 1962 3 Sheets-Sheet 1

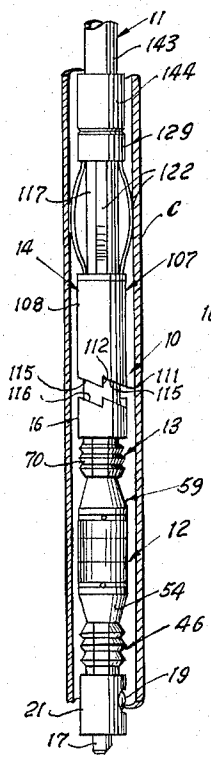


Fig. 1

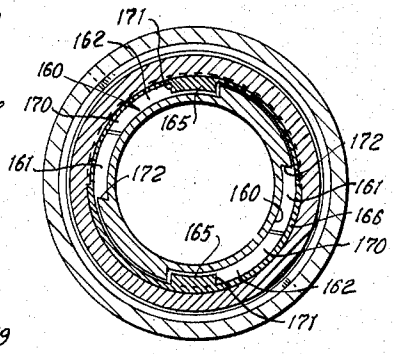


Fig. 6

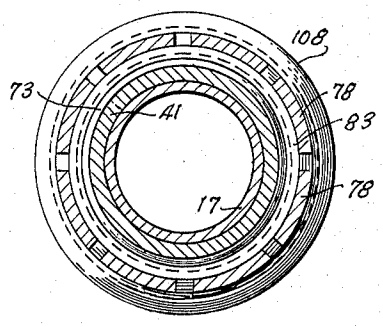


Fig. 7

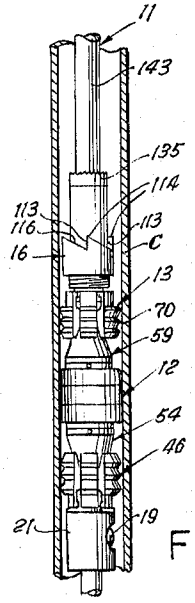


Fig. 2

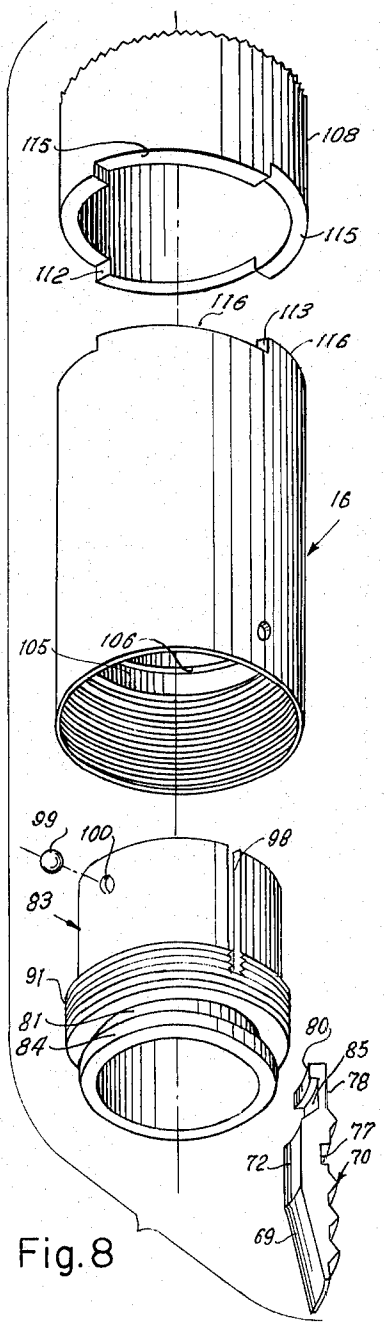


Fig. 8

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ANCHORING MEANS FOR WELL TOOLS

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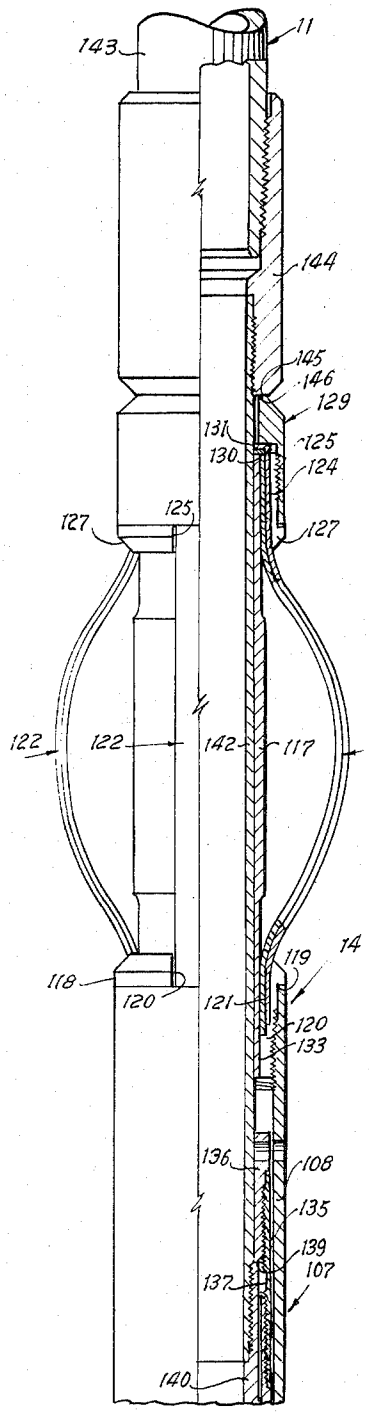


Fig. 3

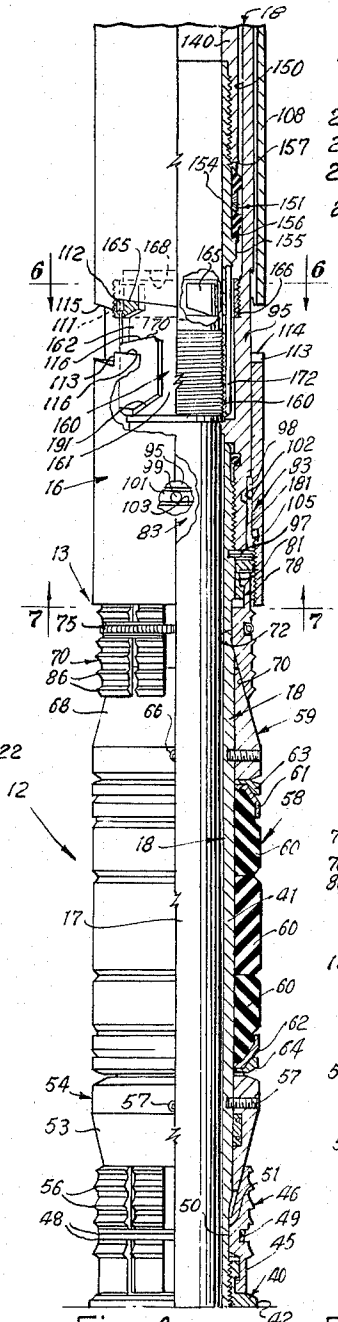


Fig. 4

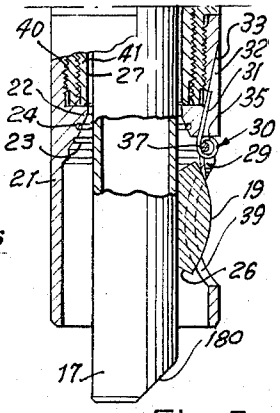


Fig. 5

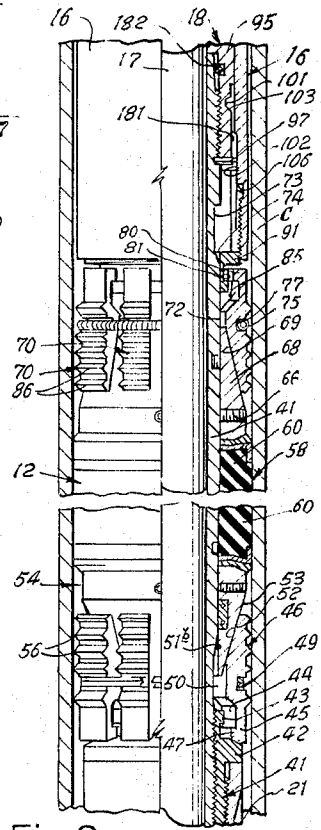


Fig. 9

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ANCHORING MEANS FOR WELL TOOLS

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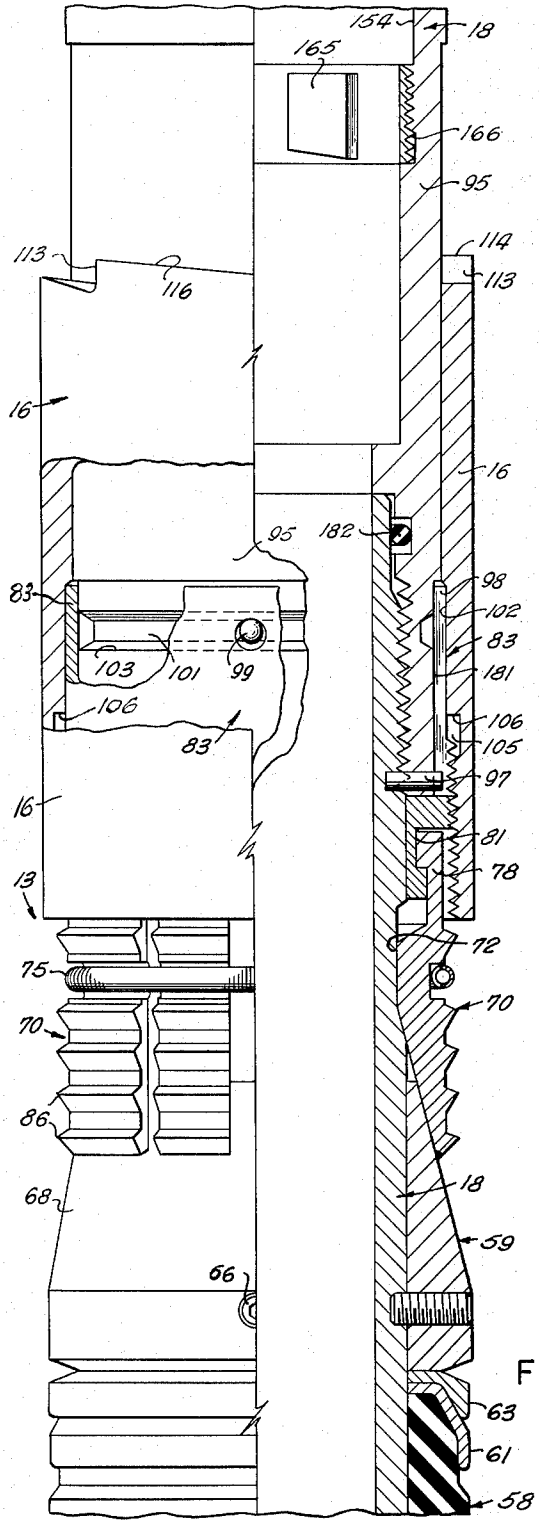


Fig. 10

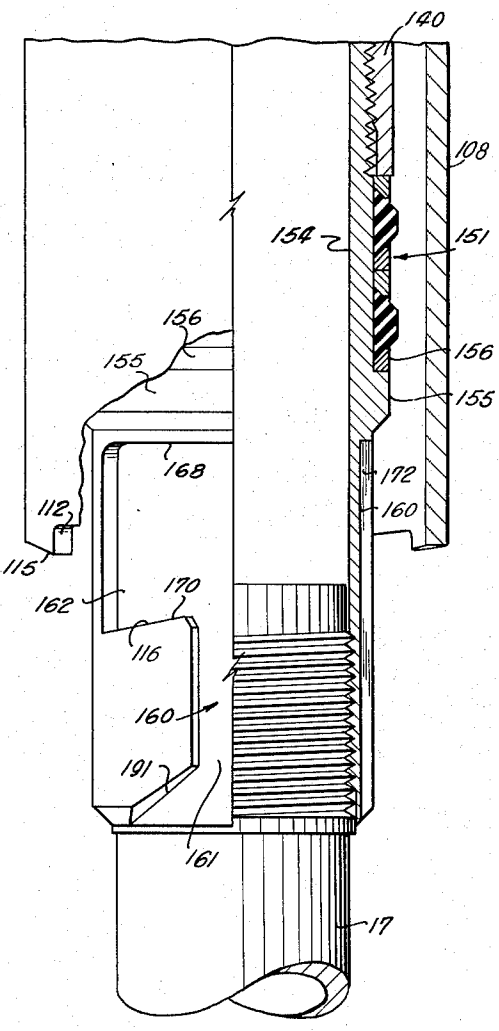


Fig. 11

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3,241,616

ANCHORING MEANS FOR WELL TOOLS

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Filed Dec. 20, 1962, Ser. No. 246,257
15 Claims. (Cl. 166—134)

This invention relates to well tools and more particularly to anchoring means for anchoring a well tool in a flow conductor and to a well packer provided with the anchoring means.

An object of this invention is to provide a new and improved anchoring means for well tools having outwardly expandable means for engaging the internal surfaces of a well flow conductor to anchor a well tool against movement in a predetermined direction in the well flow conductor wherein the anchoring device is provided with means for preventing accidental movement of the expandable means from retracted toward expanded position.

Another object is to provide a new and improved anchoring means provided with a locking means for holding the expandable means in retracted position and which is movable relative to the expandable means to release the expandable means for movement to expanded anchoring position, the locking means being movable to release the anchoring means only upon predetermined longitudinal and rotational movement of the well tool on which the anchoring means are mounted.

Still another object is to provide an anchoring means for a well tool wherein the locking means is mounted for rotatable movement relative to the well tool and wherein the well tool is provided with a releasing means engageable with the locking means upon predetermined longitudinal movement of the well tool in the well flow conductor for holding the locking means against rotation whereby rotation of the well tool causes the locking means to move to inoperative position and release the expandable means for outward movement toward expanded position.

A further object is to provide a new and improved anchoring means including a plurality of slips supported by a carrier mounted on a well tool and an expander for moving the slips to expanded position upon movement therebetween, the carrier being releasably connected to a locking sleeve telescoped over the slips and preventing outward movement of the slips toward expanded position, wherein the slip carrier and the well tool have cooperable means preventing movement of the slip carrier and therefore the slips relative to the slip expander until the locking means has been moved to its inoperative position out of telescoped relation to the slips.

A still further object is to provide a new and improved anchoring means wherein the slip carrier and the locking sleeve have coengageable means for preventing longitudinal movement of the slip carrier relative to the well tool until after the locking sleeve has been moved to inoperative position whereby subsequent upward movement of the well tool causes movement of the slip expander relative to the slips and their movement into expanded position.

Another object is to provide a well packer having anchoring means movable into expanded position and into engagement with the internal surface of a well flow conductor, such as the well casing, only upon predetermined sequential longitudinal, rotational and then longitudinal movement of the well tool in the well casing after the well packer has been moved to a desired position in the well casing and wherein the sealing means for sealing between the mandrel and the well casing are movable to expanded position only after the anchoring means has been moved into expanded position whereby accidental setting of the packer at an undesired location is prevented.

Still another object is to provide a well packer including a tubular member having means for releasably connecting the tubular member to a well flow conductor by means of which the well packer may be moved in a well casing and by means of which the tubular member may be moved longitudinally and rotated to cause a releasing means engageable with the well casing and mounted on the flow conductor to engage the locking sleeve and hold it against rotation when the flow conductor and the outer tubular member are rotated to move the locking sleeve to inoperative position, whereby the flow conductor is releasable from the tubular member of the well packer after the well packer has been anchored in the well casing for removal from the well leaving the well packer set in the well casing and then may subsequently be reintroduced into the well packer and again releasably secured thereto.

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

FIGURE 1 is a vertical schematic illustration of a well tool assembly including the well packer embodying the invention showing it as it is being moved downwardly through a well casing by means of a string of tubing provided with a releasing means for engaging the slip locking sleeve of the anchoring means of the well packer;

FIGURE 2 is a fragmentary, partly sectional view showing the well packer of FIGURE 1 in anchored operative position in the well casing and with a string of tubing connected thereto;

FIGURE 3 is a vertical partly sectional view showing the upper portions of the well tool assembly illustrated in FIGURE 1;

FIGURE 4 is a view similar to FIGURE 3 showing intermediate portions of the well tool assembly with some portions broken away;

FIGURE 5 is a view similar to FIGURE 4, showing the lower portion of the well tool assembly with some parts broken away;

FIGURE 6 is a horizontal sectional view taken on line 6—6 of FIGURE 4, showing the well tool assembly rotated substantially ninety degrees from the position thereof in FIGURE 4;

FIGURE 7 is a sectional view taken on line 7—7 of FIGURE 4;

FIGURE 8 is an exploded partly fragmentary view of the anchoring means and releasing means of the well packer illustrated in FIGURES 1 through 7;

FIGURE 9 is a fragmentary vertical partly sectional view, with some parts broken away, of the well packer showing the well packer in anchored operative position in a well casing;

FIGURE 10 is an enlarged view, partly in elevation and partly in section, of the upper portion of the well packer of FIGURE 4 with the operating tool assembly removed therefrom; and,

FIGURE 11 is an enlarged view, partly in elevation and partly in section, of the lower portion of the operating tool assembly of FIGURE 4.

Referring now to the drawings, the well tool assembly **10** which is movable through the casing C of a well includes a string of tubing **11** releasably connected to the well packer **12** provided with the anchoring means **13** embodying the invention. The string of tubing has a releasing means **14** engageable with the locking sleeve **16** of the anchoring means and an extension **17** which extends

through the mandrel **18** of the well packer **12** and holds open a flapper valve **19** mounted on the mandrel.

The mandrel **18** includes a bottom section **21** having an internal annular flange **22** whose downwardly and outwardly beveled annular seat surface **23** is provided with an annular groove in which is disposed an O-ring **24** or other suitable seal means which seals between the seat surface **23** and the annular beveled seat surface **26** of the flapper valve when the flapper valve is in an upper position closing the lower end of the longitudinal bore or passage **27** of the mandrel. One end portion **29** of the mounting and biasing spring **30** is rigidly secured to the flapper valve in any suitable manner and its other end portion **31** is received in a longitudinal outwardly opening slot **32** of the bottom mandrel section and bears against the surface **33** thereof. The intermediate coil portion **35** of the mounting and biasing spring is disposed about a mounting pin **37** rigidly secured in any suitable manner to the bottom mandrel section and extending across the lower end of the longitudinal slot **32**. The bottom section of the packer mandrel is provided with a lateral aperture **39** immediately below and communicating with the longitudinal slot into which outer portions of the flapper valve are received when it is moved to its lower open position by such means as the tubing extension **17**.

The upper end of the bottom mandrel section is threaded on an annular slip carrier **40** which in turn is threaded on the lower end of the intermediate or packing section **41** of the mandrel. The slip carrier has an intermediate external annular flange **42** which limits upward movement of the bottom mandrel section thereon and an upper annular flange **43** spaced above the intermediate annular flange receivable in the internal recessess **44** of the lower hook portions **45** of the lower slips **46**. The lower ends of the recesses of the slips are defined by the internal end flanges or hooks **47** of the slips. Longitudinal movement of the slips relative to the slip carrier is limited by the engagement of the hooks **47** of the slips with the external flanges of the slip carrier. The slips are releasably held in their retracted positions, illustrated in FIGURE 4, on the mandrel by the retainer wires **48** disposed in circumferentially extending external slots **49** of the slips. The retainer wires **48** may be soldered to one another and to the slips.

The slips have intermediate arcuate surfaces **50** which engage the external annular surface **51** of the packing mandrel section when the slips are in their retracted positions and upwardly and outwardly extending cam surfaces **52** which correspond in configuration to the upwardly and outwardly beveled upper shoulder **51***b* of the packing mandrel defining the upper end of the annular surface **51** and to the upwardly and outwardly beveled annular cam surface **53** of the lower slip expander **54** whereby the camming engagement between these cam surfaces when the slips move upwardly relative to the slip expander causes outward movement of the slips, the retainer wires **48** breaking to permit such outward movement of the slips into anchoring engagement with the internal wall surfaces of the well casing C. The slips have external downwardly facing serrations or teeth **56** which engage or grip the well casing to prevent downward movement of the mandrel in the well casing.

The lower slip expander is releasably secured on the packing mandrel section **41** by one or more shear screws **57** which extend through suitable threaded bores of the lower slip expander into suitable aligned external bores of the packing mandrel section.

The packing assembly **58** mounted on the packing mandrel section between the lower slip expander **54** and the upper slip expander **59** includes a plurality of annular resilient packing elements **60**, the resilient rings or annular shoes **61** and **62**, and the annular back-up rings **63** and **64**. The back-up and resilient rings are provided to help bridge the gap between the external surfaces

of the upper and lower slip expanders and the internal surfaces of the well casing to prevent extrusion of the resilient substance of the packing elements therebetween.

The upper slip expander **59** constitutes an element of the anchoring means **13** embodying the invention and is releasably secured to the packing mandrel section by one or more shear screws **66** which extend through suitable threaded lateral bores of the upper slip expander into suitable laterally outwardly opening bores of the packing mandrel section. The upper slip expander is identical in configuration with the lower slip expander and has an upwardly and inwardly beveled cam surface **68** engageable with the arcuate downwardly and outwardly extending lower inner cam surfaces **69** of the upper slips **70**. The intermediate arcuate surfaces **72** to the slips, when the upper slips are in their retracted positions on the packing mandrel section, engage the outer annular surface **73** provided by the external annular recess of the packing mandrel section whose lower end is defined by the downwardly and outwardly beveled annular shoulder **74**. The slips are resiliently held in their inner retracted positions with their intermediate surfaces **72** engaging the outer surface **73** of the packing mandrel section by a garter spring **75** disposed in the external circumferential grooves **77** of the slips.

The upper hook portions **78** of the upper slips have internal flanges or hooks **80** at their upper ends which are received in the external annular groove **81** of a tubular slip carrier **83** mounted on the packing mandrel section. The lower end of the external annular recess **81** of the upper slip carrier **83** is defined by the upper surface of the external annular flange **84** of the slip carrier which extends outwardly into the internal recesses **85** of the slips whose upper ends are defined by the internal flanges **80**. It will be apparent that the engagement of the hooks of the slips in the external recess of the slip carrier prevents longitudinal movement of the slips relative to the slip carrier when the slips are in their retracted positions and that the slips are biased toward and held in their retracted positions by the garter spring **75**. The slips have external upwardly facing serrations or teeth **86** which, when the slips are in their expanded positions, engage the internal surfaces of the well casing to anchor the mandrel against upward movement.

In order to prevent accidental outward movement of the slips, which might occur if the garter spring broke or by accidental engagement of the slips with any internal obstructions in the well casing, a locking sleeve **16** is threaded on the intermediate threaded portion **91** of the slip carrier of increased external diameter located immediately above the annular recess **81**. The lower end portion of the locking sleeve is telescoped downwardly over the upper hook portions of the slips. The upper portion of the slip carrier **83** of enlarged internal diameter extends over the lower portion of the seal section **95** of the mandrel threaded on the upper end portion of the packing mandrel section.

The slip carrier is held against rotational movement relative to the mandrel by a pin **97** whose inner end portion is rigidly secured in an outwardly opening bore of the packing mandrel section located below the lower end of the seal mandrel section and whose outer end portion extends outwardly into the longitudinal upwardly opening slot **98** of the slip carrier. The slip carrier is releasably held against longitudinal movement on the mandrel by a plurality of latch balls **99** movably disposed in the circumferentially spaced lateral apertures **100** of the slip carrier. The inner portions of the latch balls extend into the external annular latch recess **101** of the seal mandrel section and are held therein by the engagement of their outer surfaces with the internal surface **102** of the locking sleeve when the locking sleeve is in its lower operative or slip locking position illustrated in FIGURE 4 wherein its lower end portion extends about the upper hook portions of the slips and holds them against outward move-

ment. The lower annular shoulder **103** defining the lower end of the external latch recess **102** of the seal mandrel is beveled downwardly and outwardly and tends to cam the latch balls outwardly when an upward force is applied to the mandrel so that the latch balls will be moved outwardly into the internal annular recess **105** of the locking sleeve when the internal recess of the locking sleeve is in alignment with the apertures **100** of the slip carrier. The internal recess moves into alignment with the apertures **100** when the locking sleeve is rotated on the slip carrier by virtue of its threaded connection with such slip carrier to a position wherein its bottom edge is positioned above the upper ends of the hook portions of the upper slips. As the latch balls move outwardly in the apertures of the slip carrier out of engagement with the lower shoulder **103** of the packing mandrel section, their outer portions enter into the internal recess of the locking sleeve. The mandrel is then free to move upwardly relative to the slip carrier and at the same time the engagement of the outer portions of the balls with the annular downwardly facing shoulder **106** defining the upper end of the internal recess limits upward movement of the slip carrier relative to the locking sleeve.

It will therefore now be seen that if the locking sleeve is held against rotational movement but allowed to move longitudinally upwardly and the mandrel is rotated, the slip carrier will rotate relative to the locking sleeve until the locking sleeve moves upwardly on the slip carrier to its upper inoperative position on the slip carrier wherein the locking sleeve no longer prevents outward movement of the slips and wherein its internal annular recess is in alignment with the apertures **100** in which the latch balls are disposed. An upward movement of the mandrel relative to the slip carrier and the locking sleeve will now cause the latch balls to be moved outwardly into the internal annular recess **105** of the locking sleeve due to the camming engagement of the lower shoulder **103** of the seal section of the mandrel with the latch balls. Upward movement of the mandrel causes the cam surface **68** of the upper slip expander **59** to move the slips outwardly into anchoring engagement with the well casing. The slip carrier is held against upward movement in the well casing since the latch balls now engage the shoulder **106** of the locking sleeve and prevent upward movement of the slip carrier relative to the locking sleeve.

The locking sleeve may be held against movement relative to the mandrel by the releasing means **14** which includes a releasing sleeve **107** the bottom edge of whose lower section **108** is provided with a plurality of ratchet teeth **111** whose abrupt vertical shoulders or surfaces **112** are engageable with the vertical shoulders or surfaces **113** of similar teeth **114** on the upper edge of the lock sleeve. The camming engagement of the sloping shoulders **115** and **116** of the ratchet teeth **111** and **114**, respectively, permit rotation of the locking sleeve in a counterclockwise direction, as seen from above, if the releasing sleeve is movable upwardly even though held against rotation. The engagement of the vertical shoulders of the ratchet teeth, however, prevents clockwise rotation of the locking sleeve when the releasing sleeve is held against rotation even when it is movable upwardly.

The upper section **117** of the releasing sleeve has a lower integral external annular flange **118** threaded into the upper end of the lower section **108**. Downward movement of the upper section of the releasing sleeve relative to the lower section is limited by the engagement of the downwardly facing annular shoulder **119** of the external flange **118** with the upper end of the lower section.

The lower external flange **118** of the upper section has a plurality of longitudinal slots **120** into which extend the lower free vertical end portions **121** of the drag springs **122**. The upper end portions **124** of the drag springs extend into the longitudinal outwardly opening slots **125** of the upper integral external flange **127** at the upper end of the upper section and are clamped to the upper section by a retainer cap **129** threaded on the upper external flange **127** whose downwardly facing annular internal shoulder **130** clamps the inwardly extending end portions **131** of the springs against the upper annular end surface of the upper section of the releasing sleeve. The lower ends **121** of the drag springs slide freely on the external surfaces **133** defining the inner ends of the external lower flange of the upper section of the sleeve to permit deformation of the springs when the well packer is inserted into a well casing whose internal diameter is smaller than the span of the arcuate intermediate portions of the span when the springs are in undeformed condition. The intermediate portions of the drag springs therefore engage the internal surfaces of such well casing and yieldably resist both longitudinal and rotational movement of the releasing sleeve in the well casing.

The string of tubing **11** is releasably secured to the mandrel by means of a tension sleeve **135** threaded on the upper end of the seal section **95** of the mandrel and a stop ring **136** threaded into the upper end of the tension sleeve. The tension sleeve has an internal recess **137** to provide a circular section of decreased thickness and comparatively low mechanical strength. The downwardly facing annular end shoulder **139** of the stop ring is engageable by the external upwardly facing end shoulder of a connector sub **140** which constitutes a section of the string of tubing. The upper end portion of the connector sub is threaded on the lower end of the tubing section **142** on which the upper section of reduced internal and external diameter **117** of the releasing sleeve is slidable and its upper end is connected to the lower end of the usual section of tubing **143** by a suitable coupling **144** whose lower end portion is threaded on the upper end of the tubing section **142** and whose upper end is threaded on the lower end of the section **143** of the string of tubing **11**.

Upward movement of the releasing sleeve relative to the string of tubing and the mandrel is limited by the engagement of the upper annular end shoulder **145** of the retainer cap **129** with the downwardly facing annular shoulder **146** of the coupling **144** while downward movement of the releasing sleeve relative to the mandrel is limited by the engagement of the sloping shoulders of the ratchet teeth of the lower section of the relasing sleeve and of the locking sleeve.

The seal section **95** has an upper portion of enlarged internal diameter which provides an internal seal surface **150** engageable by the seal assembly **151** mounted on the latch section **154** of the string of tubing. The latch section **154** has an intermediate external annular flange **155** which provides an upwardly facing shoulder **156** which limits downward movement of the seal assembly **151** on the latch section. Upward movement of the seal assembly is prevented by the engagement of the downwardly facing annular end shoulder or surface **157** of the connector sub whose lower end portion is threaded on the upper end portion of the latch section. The latch section is provided with a pair of J-slots **160** each of which has a downwardly opening vertical portion **161** and an upper horizontal portion **162**. The inwardly extending latch lugs **165** of the lug ring **166** threaded in the seal section of the mandrel below the seal surface **150** are receivable in the J-slots. The engagement of the upper downwardly facing shoulders **168** of the latch section defining the upper ends of the J-slots with the upwardly facing shoulders of the latch lugs limits downward movement of the latch section **154** of the string of tubing relative to the seal mandrel section **95**. When the latch section is in the position relative to the packer mandrel **18** illustrated in FIGURE 4 with the lugs **165** disposed in the upper horizontal portions **162** of the J-slots, the engagement of the lower upwardly facing shoulders **170** of the latch section defining the lower ends of the horizontal portions of the J-slots limits upward

movement of the latch section relative to the seal mandrel section **95**. It will be apparent that when the string of tubing is rotated in a clockwise manner, as seen from above, the J-slots are moved to such positions that the vertical side shoulders **171** of the lugs **165** engage the shoulders **172** of the latch section defining one side of the longitudinal vertical portions of the J-slots to limit rotational movement of the latch section relative to the seal section while at the same time the lugs **165** are positioned in alignment with the longitudinal portions of the J-slots whereby the lugs do not prevent upward movement of the latch section relative to the seal mandrel section. The tension sleeve now prevents longitudinal upward movement of the string of tubing relative to the packer mandrel. If the bottom section of the well packer mandrel is provided with the flapper valve **19**, the tubing extension **17** is threaded into the lower end of the latch section **154** of the string of tubing and extends through the bottom mandrel section and holds the flapper valve in open position so that flow of fluids may take place through the string of tubing during movement of the well tool assembly **10** through a well casing. The tubing extension has a beveled cam surface **180** which facilitates opening and closing of the flapper valve **19** as the tubing extension **17** is moved downwardly or upwardly through the bottom mandrel section.

In use, when it is desired to move the well packer **12** into a well casing to a desired location in the well casing C and there anchor the well packer against movement in the well casing with the sealing elements thereof in expanded position sealing between the well packer mandrel and the well casing, the various elements of the well tool assembly **10** are connected to the string of tubing in the manner illustrated in FIGURES 3, 4 and 5. The tubing extension **17** holds the flapper valve open and fluids may flow through the string of tubing. The latch section **154** of the string of tubing is disposed in the seal mandrel section of the mandrel of the well packer with the lugs **165** in the horizontal portions **162** of the J-slots **160**. As the well tool assembly **10** is lowered into the well, the intermediate arcuate portions of the drag springs **122** engage the internal surfaces of the well casing and are deformed inwardly, the lower free end portions **121** of the springs sliding in the slots of the lower external flange **118** as required by such deformation. Downward movement of the releasing sleeve is resisted by the friction between the drag springs and the internal surfaces of the well casing and the releasing sleeve will therefore be caused to assume the upper position on the tubing section **142** wherein the upper end shoulder **145** of the retainer cap **129** engages the lower end shoulder **146** of the coupling **144**. As a result, during the downward movement the releasing sleeve is in its upper position on the string of tubing with the teeth **111** on its bottom edge spaced above the teeth **114** of the locking sleeve. The slips **70** of the upper anchoring means **13** are now held against outward movement toward expanded position by the garter spring **75**. In addition, since the slip carrier **83** is held against longitudinal movement on the mandrel **18** by the latch balls **99** whose inner portions are now disposed in the external latch recess **101** of the packing mandrel section and are held against outward movement therefrom by the internal lock surface **102** of the locking sleeve, the slip carrier **83** and the slips **70** supported thereby thus cannot be moved downwardly relative to the slip expander **59** and the slips cannot be moved to their expanded positions and into engagement with the well casing by any accidental jars imparted to the string of tubing. In addition, the lower portion of the locking sleeve disposed about the upper hook portions of the slips prevents their outward movement and holds their hooks in engagement with the flange **84** of the slip carrier. It will be apparent therefore that the slips are securely held against any accidental displacement or movement to expanded position at an undesired location in the well casing which would result in a premature setting of the well packer.

When the well packer has been moved to the desired location in the well casing C, the string of tubing is moved upwardly a limited distance until the ratchet teeth **111** of the releasing sleeve move into engagement with the ratchet teeth **114** of the locking sleeve **16**. A clockwise rotational movement, as seen from above, is then imparted to the string of tubing which moves the lugs **165** into engagement with the vertical shoulders **172** of the latch section of the string of tubing whereupon continued rotation of the tubing string also causes rotation of the mandrel of the well packer and of the slip carrier, since the slip carrier is held against rotational movement relative to the well packer mandrel by the pin **97**. The string of tubing is then rotated a predetermined number of times to cause the locking sleeve, which is now held against rotation due to the engagement of the teeth of the releasing and locking sleeves since rotation of the releasing sleeve is resisted by the engagement of the drag springs with the internal surfaces of the well casing, to move upwardly on the slip carrier due to the threaded engagement therebetween. The releasing sleeve of course moves upwardly against the resistance of the drag springs as the locking sleeve is moved upwardly by such rotational movement of the slip carrier. The locking sleeve is moved to its upper inoperative position by such predetermined rotation of the slip carrier wherein its lower edge is disposed above the upper ends of the slips and wherein the internal recess **105** thereof is moved into alignment with the apertures **100** of the slip carrier so that the latch balls may move outwardly into the internal recess. The mandrel is now moved upwardly and the shoulder **103** of the latch recess **102** cams the latch balls outwardly out of the latch recess and into the internal recess of the locking sleeve. Upward movement of the slip carrier is now resisted by the frictional engagement of the bow springs with the internal surfaces of the well casing due to the engagement of the latch balls with the downwardly facing shoulder **106** of the locking sleeve since inward movement of the latch balls is now prevented by their engagement with the external surface **181** of the seal mandrel section **95** below the latch recess thereof.

When an upward force is therefore now exerted on the string of tubing, the well packer mandrel will move upwardly relative to the locking sleeve and to the slip carrier. Such upward movement of the mandrel now moves the slip expander **59** upwardly relative to the now stationary slips **70** and moves the slips outwardly against the resistance of the garter spring **75** until the serrations or teeth of the slips engage the internal wall surface of the casing and their outward movement is stopped. Upward movement of the slip expander is arrested when the slips are in fully expanded anchoring positions and continued upward movement of the string of tubing now causes the shear screw **66** to shear or fail. The upper annular end surface of the lower slip expander **54** then engages the lower back-up ring **64** and, as upward movement of the well packer mandrel continues, causes the packing elements **60** of the packing assembly **58** to be compressed and moved to expanded position, since upward movement of the packing elements is limited by the engagement of the lower annular end surface of the now stationary upper slip expander **59** with the upper back-up ring **63**. The compression of the resilient packing elements now causes them to expand outwardly and sealingly engage the internal surfaces of the well casing. The resilient rings **62** and **61** and the back-up rings **63** and **64** are deformed to bridge the gap between the outer surfaces of the slip expanders and the well casing and thus prevent extrusion of the resilient substance of the packing elements therepast. Further upward movement of the lower slip expander is arrested when the packing assembly is fully expanded and the continued upward

movement of the well packer mandrel then causes the shear screws **57** to fail or shear. Such continued further upward movement of the well packer mandrel now causes the lower slips **46** to move upwardly relative to the now stationary lower slip expander and the engagement of the cam surfaces **52** and **53** thereof causes the slips to be moved outwardly, the wires **47** which up to now have held the lower slips in retracted positions breaking due to the outward force exerted thereon. The well packer mandrel is moved upwardly until the lower slips are moved to fully expanded position and an anchoring engagement with the internal surfaces of the well casing and prevent any further upward movement of the well packer mandrel since their lower ends engage the upwardly facing shoulder of the intermediate flange **42** of the lower slip carrier **40**. The upper slips now prevent upward movement of the mandrel and the lower slips now prevent downward movement of the mandrel and also hold the upper and lower slip expanders against upward or downward movement on the mandrel and thus maintain the packing elements in their expanded positions sealing between the well packer mandrel and the well casing. The mandrel is now anchored against movement in either longitudinal direction in the well casing and the well may be placed in production, the well fluids flowing from below the well packer through the open lower end of the extension **17**, the latch mandrel **154**, the connector sub **140** and the connecting section **142**, which constitute sections of the string of tubing, since the seal means carried by the latch mandrel sealingly engage the seal surface **150** of the seal mandrel section **95** and the O-ring **182** seals between the seal and packing mandrel sections **95** and **42**.

If it is now desired to withdraw the string of tubing from the well, an upward forward pull is imparted to the string of tubing of sufficient force to cause the tension sleeve to fail or rupture at its line of mechanical weakness provided by the internal recess **137** thereof. Once the tension sleeve fails, the string of tubing may be withdrawn upwardly from the well casing leaving the well packer in place since the long vertical portions of the J-slots of the latch section **154** are now aligned with the lugs **165** and the latch section can move freely upwardly therepast. As the tubing extension moves out of the bottom sub, the flapper valve **19** of course will move to its closed position closing the lower end of the packer mandrel and prevents upward flow therethrough.

If it is then desired to reintroduce the string of tubing into the well to resume production of well fluids from below the well packer, the latch section and the extension **17** are secured to the lower end of the string of tubing. The releasing sleeve **107** and the connection section **142** are not installed on the string of tubing since the packer is already in anchored operative position in the well casing. As the lower end of the tubing extension **17** moves downwardly into and through the well packer mandrel its beveled cam shoulder **180** engages the flapper valve and moves it to open position. Further downward movement of the string of tubing then causes the long vertical sections **161** of the J-slots **160** to move past the lugs **165**, the string of tubing being rotated as required to orient the downwardly opening longitudinal portions of the J-slots with the lugs. The upwardly beveled shoulders **191** of the latch section aid in such orientation of the latch sections relative to the lugs.

When the latch mandrel has moved to its lowermost position with the horizontal portions **162** of the J-slots in alignment with the lugs, the string of tubing is rotated in a counter-clockwise manner to cause the lugs to be disposed in the horizontal sections of the portions of the J-slots whereby the engagement of the lugs with the upper and lower shoulders **168** and **170** of the latch section then limits longitudinal movement of the string of tubing relative to the packer mandrel. The seal assembly **151** now seals between the seal section of the well packer mandrel and the latch section so that all flow of fluids must take place through the open lower end of the tubing extension **17**.

The string of tubing may of course thereafter be again disengaged from the packer mandrel by rotating it in a clockwise manner to align the longitudinal portions of the slots with the lugs and then lifting the string of tubing for upward removal from the well.

If the packer mandrel is not provided with a means for closing the lower end of the bore of the mandrel, such as the flapper valve **19**, the tubing extension **17** is obviously not needed and is therefore not secured to the latch section. If it is desired that the string of tubing not be latched to the mandrel, the latch section may be replaced by any suitable nipple or section carrying a seal means, such as the seal means **151**, to engage the seal surface **150** of the seal section **95** of the packer mandrel to seal between the string of tubing and the mandrel when the string of tubing is inserted or telescoped into the well packer mandrel.

The well packer is preferably made of drillable or millable substances so that it may be removed from the well casing, after the string of tubing has been removed therefrom, in the usual well known manner, by means of a suitable milling tool or drill bit lowered into the well on a string of tubing.

The improved anchoring means **13** embodying the invention permits the well packer to be anchored and set in place in a well casing upon a very small short longitudinal movement of the string of tubing, e.g., four or five inches, and the well packer may therefore be set very accurately at a predetermined depth or location in the well casing.

It will now be seen that a new and improved anchoring means **13** for well tools, such as the illustrated and described well packer, includes a plurality of slips and a slip expander mounted on a supporting means of a well tool, such as the mandrel **18** of the well packer, the slips and the expander having coengageable means, such as the cam surfaces **68** and **69** thereof, for moving the slips to expanded positions, that the slips are supported by a slip carrier and that a locking sleeve is provided which is engageable with the slips to prevent their outward movement toward expanded position until after a predetermined movement of the locking sleeve relative to the slips.

It will further be seen that the supporting means, the slip carrier and the locking sleeve are provided with cooperable latch means for holding the slip carrier, and therefore the slips carried thereby, against longitudinal movement on the supporting means and relative to the slip expander except upon predetermined longitudinal and rotational movement of the supporting means relative to the locking sleeve whereby the locking sleeve not only prevents outward movement of the slips but also longitudinal movement of the slips relative to the expander means.

It will further be seen that the anchoring means embodying the invention includes a releasing means having means engageable with the well casing or other flow conductor into which the well tool provided therewith is inserted for engaging the locking means and holding it against rotation upon longitudinal movement of the supporting means of the well tool in a predetermined longitudinal direction in the well casing whereupon the rotation of the supporting means in a predetermined direction causes the locking sleeve to move to an inoperative position relative to the slip carrier releasing the slips for outward movement toward expanded position and the latching means to release the slip carrier for longitudinal movement on the supporting member relative to the slip expander and simultaneously prevents longitudinal movement of the slip carrier relative to the locking sleeve in such predetermined longitudinal direction.

It will further be seen that the releasing means is mounted on the string of tubing for limited longitudinal movement relative thereto and is provided with means engageable with the internal surfaces of a well casing or other flow conductor in which the well tool is insertable for yieldably resisting movement of the releasing means through the well casing, the locking sleeve and releasing means having coengageable means for preventing rotation of the locking sleeve after the coengageable means have been engaged by a limited longitudinal movement of the supporting means when the releasing means is in one extreme longitudinal position on the string of tubing and held against rotational movement in the well casing by the means engageable with the well casing.

It will further be seen that the releasing means and the locking sleeve constitute a clutch or ratchet mechanism which causes rotation of the locking sleeve only upon a predetermined longitudinal movement in a predetermined direction of the two relative to one another and upon subsequent rotational movement of the supporting means in a predetermined direction so that the well tool will be anchored and set in a well casing or other flow conductor only at a predetermined location and upon intentional predetermined longitudinal and rotational movement of the means by which a well tool is lowered into a well.

It will further be seen that the new and improved well packer includes a mandrel having a seal surface engageable with a seal means carried by a string of tubing telescopable thereinto for sealing therebetween, that the packer mandrel is provided with upper and lower anchoring means disposed on opposite sides of a packing or sealing assembly **58**, and that each anchoring means includes a slip expander and a plurality of slips movable thereby into expanded position upon longitudinal movement of the slips relative to the expander.

It will further be seen that the mandrel of the well packer and the string of tubing may be provided with latch means, such as the lugs **165** and the J-slots **160**, for releasably latching or securing the string of tubing to the packer mandrel and that the upper anchoring means, the sealing means and the lower anchoring means are sequentially moved to their expanded operative positions after the upper slips of the upper anchoring assembly have been released for movement to expanded position by the locking sleeve upon upward longitudinal movement of the string of tubing in the well casing.

It will further be seen that the packer mandrel may be considered to be a section of the string of tubing which is secured thereto and that when the string of tubing is telescoped in the mandrel a sealing means sealing therebetween causes all fluid flowing through the string of tubing to flow through the lower open end thereof.

It will further be seen that the connection of the packer mandrel to the means by which it is lowered into the well by means of the tension sleeve **135** insures that the well packer is properly anchored and set since a predetermined upward force must be exerted on such means to cause the tension sleeve to rupture to release such means from the packer mandrel and permit its removal from the well which cannot be exerted until the anchoring and sealing means of the well packer are in properly expanded anchoring and sealing engagement with the well casing.

The foregoing description of the invention is explanatory only, and changes in the details of the construction 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 is claimed and desired to be secured by Letters Patent is:

1. A well packer including: a tubular mandrel; sealing means carried by said mandrel for sealing between the mandrel and a well casing in which it is positionable; anchoring means disposed on the mandrel at opposite ends of said sealing means expandable outwardly of said mandrel for engaging the well casing to anchor the mandrel in the well casing, one of said anchoring means having locking means cooperable therewith when in an operative position relative thereto for holding said one of said anchoring means against outward movement relative to said mandrel, said locking means being movable by predetermined rotational movement of said mandrel relative to said locking means to an inoperative position wherein said one of said anchoring means is free to move outwardly; and releasing means connected with said mandrel and movable longitudinally relative to said mandrel, said releasing means having means yieldably engageable with a well casing for yieldably resisting movement of said releasing means in the well casing, said releasing means and said locking means having cooperable means coengageable upon predetermined longitudinal movement of said mandrel relative to said releasing means for holding said locking means against rotation relative to said mandrel whereby said predetermined rotational movement of said mandrel relative to said locking means causes said locking means to move longitudinally of said mandrel to said inoperative position.

2. A well packer including: a tubular mandrel, said mandrel being releasably connectable to a means for moving the mandrel through a well casing; sealing means carried by said mandrel for sealing between the mandrel and a well casing in which it is positionable; anchoring means disposed on said mandrel at opposite ends of said sealing means expandable outwardly of said mandrel for engaging the well casing to anchor the mandrel in the well casing, one of said anchoring means having locking means cooperable therewith when in an operative position relative thereto for holding said one of said anchoring means against outward movement relative to said mandrel, said locking means being movable by predetermined rotational movement of said mandrel relative to said locking means to an inoperative position wherein said one of said anchoring means is free to move outwardly; and releasing means connected with said mandrel and movable a limited distance longitudinally relative to said mandrel, said releasing means having means yieldably engageable with a well casing for yieldably resisting movement of said releasing means in the well casing, said releasing means and said locking means having cooperable means coengageable upon predetermined longitudinal movement of said mandrel relative to said releasing means for holding said locking means against rotation relative to said mandrel whereby said predetermined rotational movement of said mandrel causes said locking means to move longitudinally of said mandrel to said inoperative position.

3. A well packer including: a tubular mandrel; first expandable means mounted on said mandrel for outward movement relative thereto into expanded anchoring engagement with a flow conductor in which the well packer is positionable; first expander means on said mandrel engageable with said first expandable means for moving said first expandable means toward expanded position upon movement of said first expander means in a predetermined longitudinal direction relative to said expandable means; carrier means movably mounted on said mandrel supporting said first expandable means against longitudinal movement relative to said mandrel and said first expander means; locking means connected to said carrier means and engageable with said first expandable means when in an operative position for preventing outward movement of said first expandable means toward expanded position, said locking means and said carrier means having cooperable means for moving said locking means to an inoperative position to permit movement of said first expandable means to expanded position upon rotation of said carrier means relative to said locking means, said carrier means and said mandrel having latch means holding said carrier means against movement relative to said mandrel when said locking means is in said operative position and releasing said carrier means for movement relative to said

mandrel when said locking means is moved to said inoperative position, said first expander means being releasably secured to said mandrel against movement relative thereto; sealing means mounted on said mandrel; a second expandable means mounted on said mandrel for outward movement relative thereto into expanded anchoring engagement with a well flow conductor; second expander means releasably secured to said mandrel engageable with said second expandable means for moving said second expandable means toward expanded position upon movement of said second expander means in a direction opposite said predetermined direction relative to said second expandable means, said sealing means being disposed between said first and second expander means whereby movement of said mandrel in said predetermined direction after said first expandable means has moved into expanded anchoring engagement with a flow conductor causes said sealing means to be expanded into sealing engagement with the well flow conductor and said second expandable means to be moved outwardly to expanded anchoring engagement with the well flow conductor.

4. A well packer including: a tubular mandrel; first expandable means mounted on said mandrel for outward movement relative thereto into expanded anchoring engagement with a flow conductor in which the well packer is positionable; first expander means on said mandrel engageable with said first expandable means for moving said first expandable means toward expanded expanded position upon movement of said first expander means in a predetermined longitudinal direction relative to said expandable means; carrier means movably mounted on said mandrel supporting said first expandable means against longitudinal movement relative to said mandrel and said first expander means; locking means connected to said carrier means and engageable with said first expandable means when in an operative position for preventing outward movement of said first expandable means toward expandable position, said locking means and said carrier means having cooperable means for moving said locking means to an inoperative position to permit movement of said first expandable means to expanded position upon rotation of said carrier means relative to said locking means, said carrier means and said mandrel having latch means holding said carrier means against movement relative to said mandrel when said locking means is in said operative position and releasing said carrier means for movement relative to said mandrel when said locking means is moved to said inoperative position, said first expander means being releasably secured to said mandrel against movement relative thereto; sealing means mounted on said mandrel; a second expandable means mounted on said mandrel for outward movement relative thereto into expanded anchoring engagement with a well flow conductor; second expander means releasably secured to said mandrel engageable with said second expandable means for moving said second expandable means toward expanded position upon movement of said second expander means in a direction opposite said predetermined direction relative to said second expandable means, each of said expander means being releasably secured to said mandrel and releasable for movement relative to said mandrel upon the exertion of a predetermined force on said mandrel in said predetermined direction after said first expandable means is expanded and said mandrel is moved in said predetermined direction to expand said sealing means into sealing engagement with said well flow conductor and to move said second expandable means into expanded position.

5. A well packer including: a tubular mandrel; first expandable means mounted on said mandrel for outward movement relative thereto into expanded anchoring engagement with a flow conductor in which the well packer is positionable; first expander means on said mandrel engageable with said first expandable means for moving said first expandable means toward expanded position upon movement of said first expander means in a predetermined longitudinal direction relative to said expandable means; carrier means movably mounted on said mandrel supporting said first expandable means against longitudinal movement relative to said mandrel and said first expander means; locking means connected to said carrier means and engageable with said first expandable means when in an operative position for preventing outward movement of said first expandable means toward expanded position, said locking means and said carrier means having coengaged means for moving said locking means to an inoperative position to permit movement of said first expandable means to expanded position upon rotation of said carrier means relative to said locking means, said carrier means, said mandrel and said locking means having cooperable latch means holding said carrier means against movement relative to said mandrel and permitting movement of said carrier means relative to said locking means when said locking means is in said operative position, said latch means permitting movement of said mandrel in said predetermined direction relative to said carrier means and preventing movement of said carrier means in said predetermined direction relative to said locking means when said locking means is in said inoperative position, said first expander means being releasably secured to said mandrel against movement relative thereto; sealing means mounted on said mandrel; a second expandable means mounted on said mandrel for outward movement relative thereto into expanded anchoring engagement with a well flow conductor; second expander means releasably secured to said mandrel engageable with said second expandable means for moving said second expandable means toward expanded position upon movement of said second expander means in a direction opposite said predetermined direction relative to said second expandable means, said sealing means being disposed between said first and second expander means whereby movement of said mandrel in said predetermined direction after said first expandable means has moved into expanded anchoring engagement with a flow conductor causes said sealing means to be expanded into sealing engagement with the well flow conductor and said second expandable means to be moved outwardly to expanded anchoring engagement with the well flow conductor.

6. The well packer of claim 4 wherein said latch means comprises movable means mounted on said carrier means for movement in a direction perpendicular to said predetermined direction between inner and outer position; stop means on said mandrel engageable with said movable means when said movable means is in said inner position; and surface means on said locking means engageable with said movable means holding said movable means in said inner position when said locking means is in said operative position, said surface means on said locking means being out of engagement with said movable means when said locking means is in said inoperative position whereby said movable means is free to move from said inner position to said outer position.

7. The well packer of claim 5 wherein said latch means comprises movable means mounted on said carrier means for movement in a direction perpendicular to said predetermined direction between an inner position and an outer position; stop means on said mandrel engageable with said movable means when said movable means is in said inner position; surface means on said locking means engageable with said movable means holding said movable means in said inner position when said locking means is in said operative position, said surface means being out of engagement with said movable means when said locking means is in said inoperative position whereby said movable means is free to move from said inner position to said outer position; and stop means on said locking means engageable with said movable means preventing movement of said carrier means in said one direction relative

to said locking means when said movable means are in said outer position.

8. Anchoring means for a well tool having a supporting means including: expandable means mounted on said supporting means for outward movement relative thereto into expanded anchoring engagement with a flow conductor in which the well tool is positionable; expander means on said supporting means engageable with said expandable means for moving said expandable means toward expanded position upon longitudinal movement of said supporting means in a predetermined direction relative to said expandable means, carrier means movably mounted on said supporting means and supporting said expandable means; locking means connected to said carrier means and having means adapted to engage said expandable means when said locking means is in an operative position on said carrier means to prevent movement of said expandable means toward expanded positions, said locking means and said carrier means having cooperable means for moving said locking means longitudinally relative to said carrier means to an inoperative position to permit movement of said expandable means to expanded position upon rotation of said carrier means relative to said locking means.

9. Anchoring means for a well tool having a supporting means including: expandable means mounted on said supporting means for outward movement relative thereto into expanded anchoring engagement with a flow conductor in which the well tool is positionable; expander means on said supporting means engageable with said expandable means for moving said expandable means toward expanded position upon longitudinal movement of said supporting means in a predetermined direction relative to said expandable means; carrier means movably mounted on said supporting means and supporting said expandable means; and locking means connected to said carrier means and having means adapted to engage said expandable means when said locking means is in an operative position on said carrier means to prevent movement of said expandable means toward expanded positions, said locking means and said carrier means having coengageable means for moving said locking means longitudinally relative to said carrier means to an inoperative position to permit movement of said expandable means to expanded position upon rotation of said carrier means relative to said locking means, said locking means including latch means engageable with said supporting means and said carrier means preventing longitudinal movement of said carrier means relative to said supporting means when said locking means is in said operative position.

10. Anchoring means for a well tool having a supporting means including: expandable means mounted on said supporting means for outward movement relative thereto into expanded anchoring engagement with a flow conductor in which the well tool is positionable; expander means on said supporting means engageable with said expandable means for moving said expandable means toward expanded position upon longitudinal movement of said supporting means in a predetermined direction relative to said expandable means; carrier means movably mounted on said supporting means and supporting said expandable means; and locking means connected to said carrier means and having means adapted to engage said expandable means when said locking means is in an operative position on said carrier means to prevent movement of said expandable means toward expanded positions, said locking means and carrier means having coengageable means for moving said locking means longitudinally relative to said carrier means to an inoperative position to permit movement of said expandable means to expanded position upon rotation of said carrier means relative to said locking means, said locking means including latch means engageable with said supporting means and said carrier means preventing longitudinal movement of said carrier means relative to said supporting means when said locking means is in said operative position, said locking means having means coengageable with said latch means preventing movement of said carrier means relative to said locking means in said predetermined direction when said locking means is in said inoperative position.

11. Anchoring means for a well tool having an elongate supporting means including: a carrier mounted thereto; expandable means supported by said carrier for outward movement relative thereto into expanded position; expander means releasably secured to said supporting means and engageable with said expandable means for moving said expandable means toward expanded anchoring position on longitudinal movement of said supporting means in one predetermined longitudinal direction relative to said expandable means; a locking sleeve connected to said carrier and adapted to engage expandable means when said locking means is in one extreme longitudinal operative position on said carrier to prevent movement of said expandable means toward expanded position, said locking sleeve and said carrier having coengageable means for moving said locking sleeve in said one direction to a second extreme inoperative position relative to said carrier upon predetermined rotation of said carrier relative to said locking sleeve, said supporting means and said carrier having coengageable means preventing rotational movement of said carrier relative to said supporting means, said carrier having a portion thereof extending between said locking sleeve and said supporting means and provided with a lateral aperture; latch means disposed in said aperture for movement between inner and outer portions, said supporting means having an external recess and said locking sleeve having an internal recess longitudinally spaced from one another when said locking sleeve is in said operative position, said latch means being in said inner position and extending into said external recess of said supporting means to prevent longitudinal movement of said carrier on said supporting means when said locking sleeve is in said operative position, said locking sleeve having means engageable with said latch means holding said latch means in said inner position when said locking sleeve is in said operative position, said internal recess of said sleeve being aligned with said aperture of said carrier when said locking sleeve is in said inoperative position on said carrier whereby said latch means is movable in said aperture from said inner position to said outer position to free said carrier for longitudinal movement relative to said supporting means, said locking sleeve having means engageable with said latch means when said latch means is in said outer position limiting movement of said carrier in said one direction relative to said locking sleeve whereby movement of said supporting means in said one direction when said locking sleeve is in said inoperative position and held against movement in said one direction causes said expander means to move said expandable means into expanded position.

12. The anchoring means of claim 11, wherein said supporting means has releasing means carried thereby for limited longitudinal movement relative thereto, said releasing means having means engageable with internal surfaces of a flow conductor when the well tool is inserted therein for yieldably resisting movement of said releasing means relative to the conductor, said locking sleeve and said releasing means having means coengageable upon movement of said support means in said one direction relative to said releasing means for preventing rotational movement of said locking sleeve relative to said releasing means.

13. A well packer including: an elongate tubular mandrel; normally retracted upper slips mounted on said mandrel adapted to anchor said mandrel to a conduit string against longitudinal movement in said string; first expander member on said mandrel movable with respect to said upper slips to expand said slips outwardly to engagement with said conduit; a lower set of slips on said mandrel in normally retracted position and adapted to be moved to expanded position to anchor said man-

drel in said conduit string against longitudinal movement therein; a second expander member on said mandrel movable with respect to said lower set of slips to expand said slips outwardly into locking engagement with said conduit; packing means on said mandrel between said upper and lower sets of slips and said expander members in a normally retracted position and movable to expanded position upon expansion of said first set of slips into engagement with said conduit and subsequent movement of said lower set of slips said second expander member and said packing means toward said first expander member and upper set of slips; a locking sleeve telescoped over a portion of said upper set of slips while said upper set of slips are in retracted position and adapted to hold said slips against movement outwardly toward expanded position, and means on said mandrel and engageable with said locking sleeve and adapted to move said locking sleeve longitudinally relative to said upper set of slips in a direction away from said slips upon rotation of said mandrel relative to said locking sleeve to permit said slips to move outwardly from retracted to expanded position.

14. A well packer including: an elongate mandrel having a pair of longitudinally spaced sets of normally retracted expansible gripping slips mounted thereon; expander means on said mandrel movable with respect to said slips to expand said slips outwardly relative to said mandrel; packing means on said mandrel between said sets of slips and expander means and adapted to be distorted into expanded sealing position by movement of said sets of slips and said expander means toward each other; a locking sleeve carried by said mandrel and telescoping a portion of one of the sets of slips on said mandrel when said slips are in retracted position and adapted to prevent movement of said one set of slips from retracted position to expanded position; and means on said mandrel and engageable with said locking sleeve for moving said locking sleeve longitudinally relative to said one set of slips out of telescoping position with respect to said one set of slips upon rotation of said mandrel relative to said locking sleeve to permit said one set of slips to move outwardly from retracted to expanded position.

15. A well packer including: an elongate tubular mandrel; a lower set of slips and expander means; an upper set of slips and expander means; packing means disposed on said mandrel between said sets of slips and expander means in unexpanded position and adapted to be compressed between said sets of slips and expander means from such normally retracted to an expanded position on movement of said slips and expander means toward each other; a locking sleeve on said mandrel and movable longitudinally with respect thereto, said locking sleeve having a portion thereof telescoped over a portion of one of the sets of slips when said slips are in retracted position adapted to prevent movement of said one set of slips outwardly from retracted to expanded position by the expander means associated therewith; and means on said mandrel having screw threaded engagement with said locking sleeve for moving said locking sleeve longitudinally of said mandrel from telescoping position with respect to said one set of slips to a non-telescoping position with respect to said one set of slips when said mandrel is rotated with respect to said sleeve, whereby said sleeve is moved from telescoping position to non-telescoping position with respect to said one set of slips.

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CHARLES E. O'CONNELL, *Primary Examiner.*