United States Patent

Tamplen

[15] **3,670,821**

[45] **June 20, 1972**

[54] LOCKING DEVICE AND METHOD AND APPARATUS FOR EMPLACING SAME

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[21] Appl. No.: **99,762**

[52] **U.S. Cl.** **166/315**, 166/125, 166/217

[51] **Int. Cl.** **E21b 43/00**, E21b 23/00

[58] **Field of Search** 166/123, 125, 216, 217, 315

[56] **References Cited**

UNITED STATES PATENTS

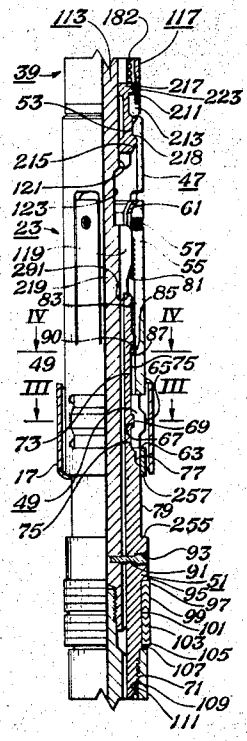
2,798,559	7/1957	Fredd	166/125
2,976,931	3/1961	Daffin	166/217
3,079,996	3/1963	Tamplin	166/125
3,090,438	5/1963	Raulins	166/125
3,207,222	9/1965	Tamplin	166/123
3,430,699	3/1969	De Cuir	166/217
3,507,329	4/1970	Stone, Jr.	166/217

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[57] **ABSTRACT**

A locking device and method and apparatus for emplacing same within tubing in a well characterized by having locking dogs that are run into the well retracted; and that are operable into a no-go position at a desired depth for thereafter stopping the locking device at the top of a restricted portion such as a nipple; and that can be locked into a recess such as defined by a landing nipple or a collar immediately above the restricted portion. Both the running tool employed in emplacing the locking device, and the locking device, can be armed into the no-go position but cannot be inadvertently locked in the tubing until the locking dogs encounter the restricted portion. Also disclosed are specific and preferred structural embodiments wherein the running tool and the locking device are armed and the locking device locked and left in the tubing by reciprocal movement of the tool in the tubing in conjunction with energy stored in a spring and without the use of complicated electric motors, hydraulic connections or the like.

27 Claims, 20 Drawing Figures



PATENTED JUN 20 1972

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SHEET 1 OF 4

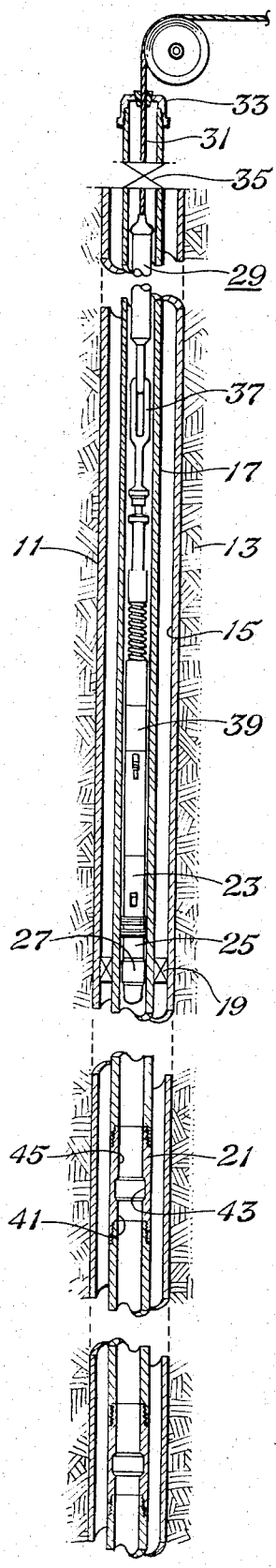


Fig. 1

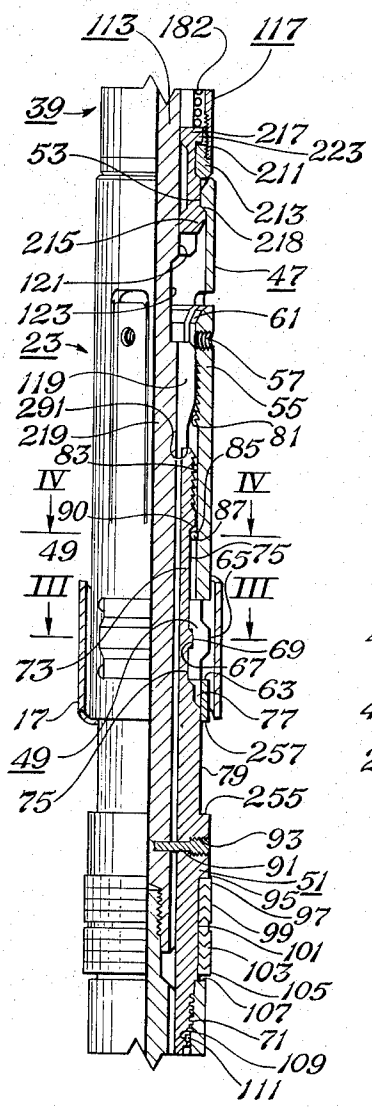


Fig. 2b

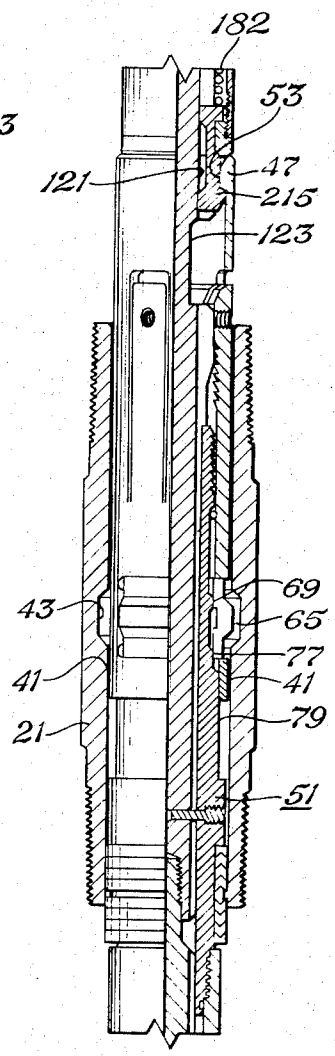


Fig. 5b

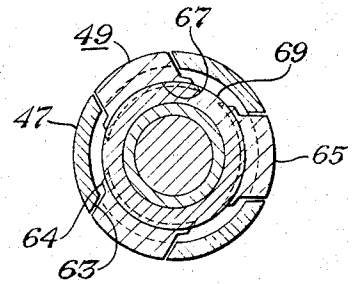


Fig. 3

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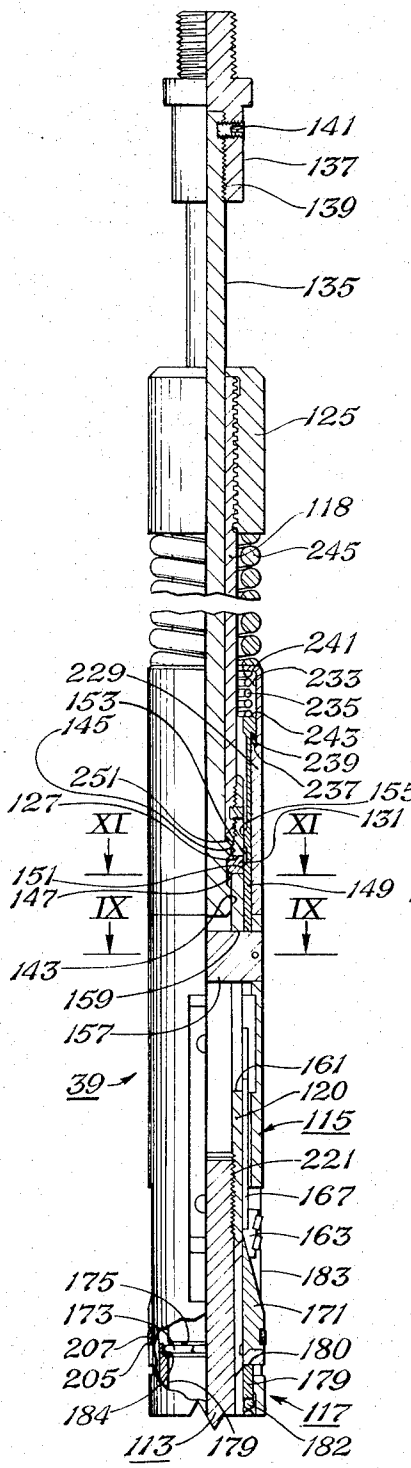


Fig.2a

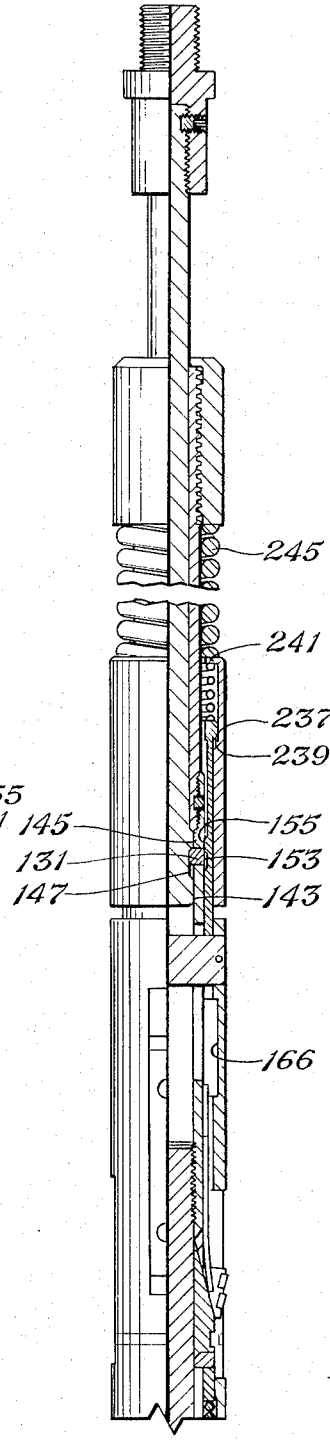


Fig.5a

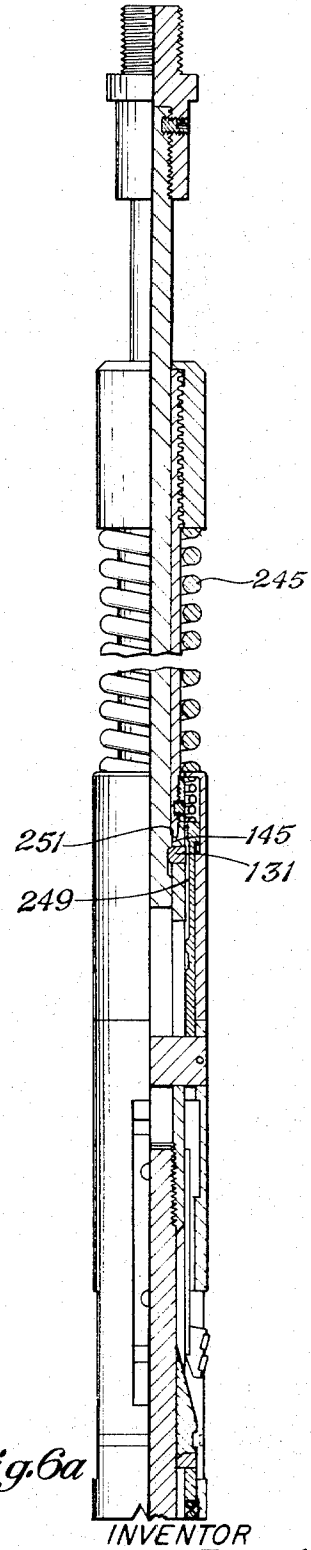


Fig.6a

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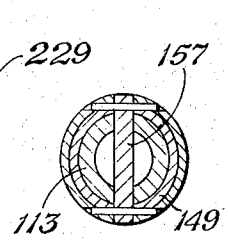


Fig. 9

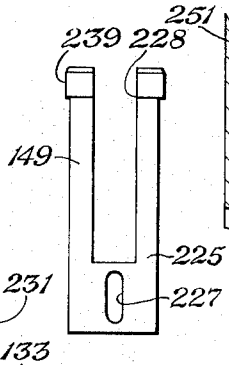


Fig. 10

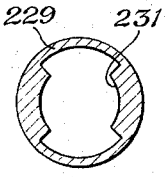


Fig. 11

Fig. 12

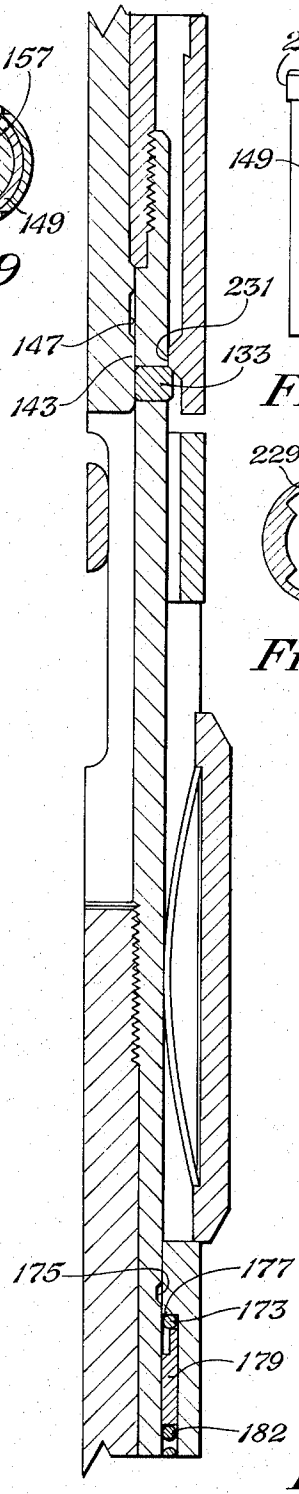


Fig. 13

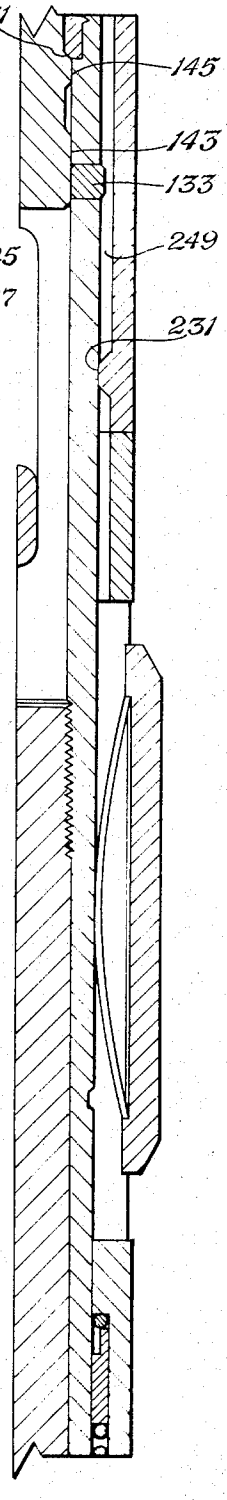


Fig. 14

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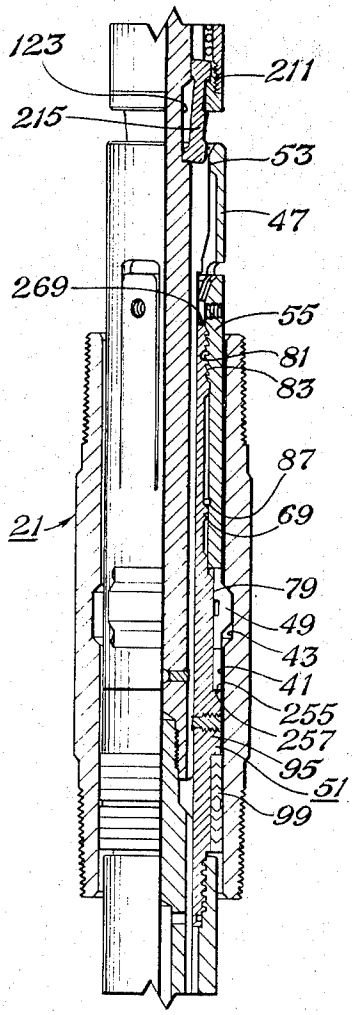


Fig. 6b

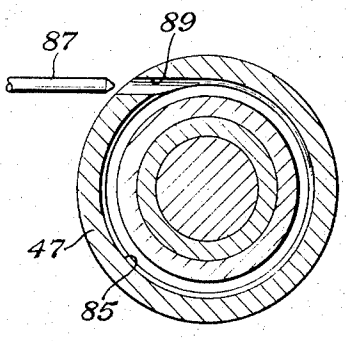


Fig. 4

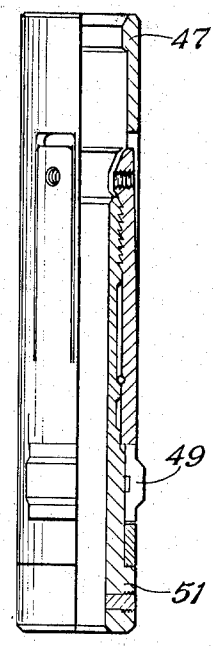


Fig. 15

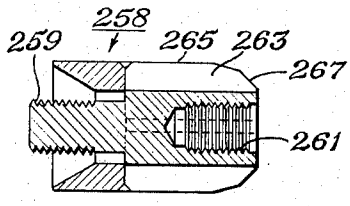


Fig. 17

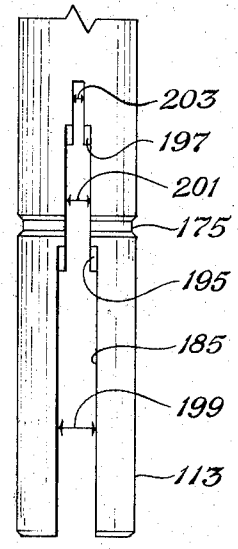


Fig. 8

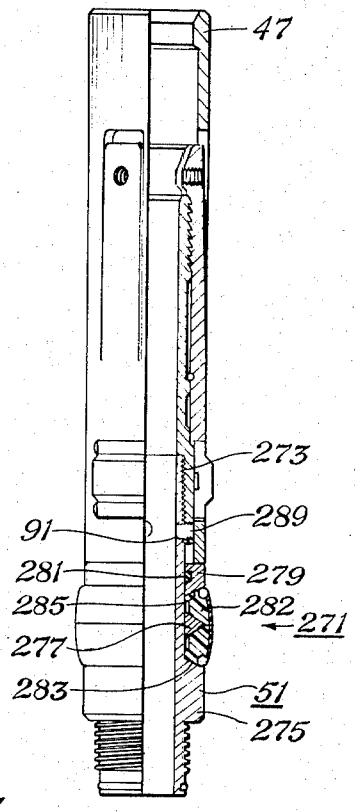


Fig. 16

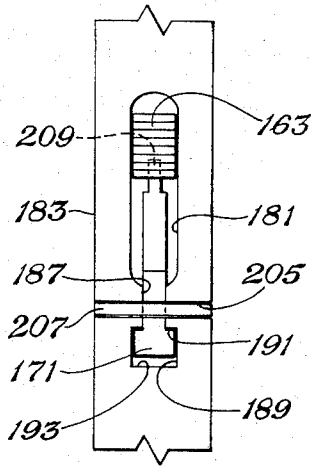


Fig. 7

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LOCKING DEVICE AND METHOD AND APPARATUS FOR EMPLACING SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates broadly to well tools such as are employed in oil and gas wells. More particularly, this invention relates to a locking device, and to method and apparatus for its emplacement in tubing in a well penetrating subterranean formations; the locking device being operable to hold in place a variety of compatible accessories; such as, pressure equalizing devices and flow control devices.

2. Description of the Prior Art

In early oil field technology, the accessories such as downhole controls and tools were incorporated directly into the tubing string. Repair or change of accessories required pulling the tubing string, a costly and undesirable process. The ingenuity of the engineers and operating personnel was taxed to find ways of affixing the accessories in the tubing such that the accessories would be retained in place with sufficient force to withstand a differential pressure thereacross without being blown up or down the hole, and without leaking; yet be removed and either replaced or moved to a higher or lower depth in the tubing. Many and varied were the devices attempted. Finally, landing nipples were incorporated in the tubing string at a plurality of locations; such as, between zones likely to be productive. These landing nipples usually incorporated a restricted portion, or bore, of restricted diameter less than the diameter of the tubing, and conventionally had a recess of a diameter larger than the diameter of the tubing above the restricted portion. With this structure, locking mandrels could be emplaced in the tubing string. Ordinarily, the locking mandrels were run into the well on running tools. In the combination of the locking mandrel and the running tool, a complex feeler apparatus was employed for determining the restricted portion and the recess; and the locking mandrel attempted to be moved such that suitable locking dog means could be emplaced in the recess. In the early models this was a time consuming and costly operation and left emplaced in the well expensive equipment in the locking mandrel. Moreover, the apparatus could not be relied upon to function after years of being exposed to the products in the well. The products were usually corrosive, and frequently contained sour, or sulfur-containing, compounds.

Improved construction was effected when locking mandrels were developed that could be armed by being moved downwardly through the restricted portion such that when pulled upwardly they could be locked into the recess. Such locking mandrels were not totally satisfactory in solving all the problems, however, since they would be armed after being passed through a first portion of restricted diameter and could not thereafter be emplaced in lower nipples. Other nipples having a restricted portion were incorporated into the tubing string. The collar with which the nipple was connected into the tubing string would define a recess above the restricted portion. Use of these other nipples and collar recesses for emplacing locking devices has been needed but has not been available heretofore.

Experience has indicated that it is desirable that a locking device, or lock mandrel, and the method and apparatus for emplacing it in the tubing, or conduit, in a well penetrating subterranean formations provide the following features, either separately or in combination:

1. a tool, including a running tool and a locking device, that is able to move the locking device to any depth through any number of restrictions in the tubing, and then be armed such that, if interrogated by the operator, it will apprise him as to whether or not it is armed; and it will determine and signal to the operator when it encounters a restricted portion and should be moved into the locked position;

2. both the running tool and the lock mandrel are operable in response to relative longitudinal movement between parts thereof so that greater force can be employed in effecting operation, regardless of the length of time the locking device may have been emplaced in the well;

3. a running tool and locking device that can be run through a series of identical bore nipples and, at the operator's command above a particular nipple, locate and set on that particular nipple;

4. the running tool and the locking device that are operable into the armed and no-go position in the tubing without having to go through a restricted diameter for arming;

5. a locking device that will locate and lock in any nipple means on the market as well as any restricted nipple with a collar recess above for utmost flexibility and lessened costs for warehousing different types of locking devices and running tools;

6. a locking device that can be operated into locking or no-go positions in the well without complex accessories, such as electronic or hydraulic power means;

7. a locking device that will set on a restricted portion such as a nipple from above, and will prevent inadvertent locking, as by having an expander mandrel that moves upwardly to lock only after setting on the restricted portion;

8. a locking device, including an expander mandrel, that is of simple construction with the smallest possible number of parts for greater reliability and lower expense, since it will be left in the well;

9. a locking device that will hold pressure in either direction and permit its retrieval in either direction after unlocking has been accomplished;

10. a locking device wherein the packing, if employed, has to be moved downwardly against pressure before the locking device can be unlocked, thereby virtually eliminating the danger of the locking device being blown up the tubing during unlocking;

11. a locking device that can be moved in either direction through a restricted nipple during retrieval without the mandrel being moved into the locked position; and

12. a locking device that can pass small restricted bores, but that will locate a larger intermediate bore and expand an expansible packing to seal in an intermediate bore.

The structures of the prior art have not provided these desirable features.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial side elevational view, partly in section, illustrating a locking device and running tool combination in situ in a well penetrating subterranean formations, in accordance with one embodiment of this invention.

FIGS. 2*a* and 2*b* are partial side elevational views, partly in section, showing the upper and lower portion of the locking device and the running tool therefor with the locking dog means retracted into the running position for being run in the well.

FIG. 3 is a horizontal cross sectional view taken on the lines III—III of FIG. 2*b*, showing the locking dog means disposed in their respective window means.

FIG. 4 is a horizontal cross sectional view taken along the lines IV—IV of FIG. 2*b*, showing how an assembly retainer means is inserted intermediate the expander mandrel and the tubular housing.

FIGS. 5*a* and 5*b* are partial side elevational views, partly in section, illustrating the running tool and the locking device in the armed and no-go position with the locking dog means partially extended, just before being set on a restricted portion in the tubing.

FIGS. 6*a* and 6*b* are partial side elevational views, partly in section, illustrating the locking device in the locked position with the locking dog means fully extended and the running tool being pulled free of the locking device.

FIG. 7 is a partial side elevational view showing the slip means and the slip expander means.

FIG. 8 is a partial side elevational view of the body means of the running tool, showing the slots and ramps whereby the slip expander means may be dropped toward the center of the tool to prevent subsequent expansion of the slips into engagement with the tubing.

FIG. 9 is a horizontal cross sectional view taken along the lines IX—IX of FIG. 2*a*, showing the cross member for transferring jarring force between elements of the running tool.

FIG. 10 a a partial side elevational view of a top portion of the retainer means of the embodiment of FIG. 2*a* for operating in conjunction with the trigger lug means.

FIG. 11 is a horizontal cross sectional view taken along the lines XI—XI of FIG. 2*a*, showing the cross section of the tubular release housing that operates in conjunction with the trigger lug means and the top portion of drag means.

FIG. 12 is a partial cross sectional view, rotated 90° from the cross sectional view of FIG. 2*a*, showing a portion of the drag means and the trigger lug means in the running position.

FIG. 13 is a partial cross sectional view, rotated 90° from the cross sectional view shown in FIG. 5*a*, showing a portion of the drag means and the trigger lug means in the no-go position.

FIG. 14 is a partial cross sectional view, rotated 90° from the cross sectional view of FIG. 6*a*, showing the drag means and the trigger lug means in the retrieving position.

FIG. 15 is a partial side elevational view, partly in section, illustrating another embodiment of the locking device.

FIG. 16 is a partial side elevational view, partly in section, illustrating still another embodiment of the locking device.

FIG. 17 is a side elevational view of an adapter for pulling the locking device.

DESCRIPTION OF PREFERRED EMBODIMENTS

It is a primary object of this invention to provide a locking device and method and apparatus for emplacing it in a tubing and to thereby provide the desirable features enumerated hereinbefore, which were unattainable before this invention.

Other specific objects are implicit in the structural features of the locking device, of the running tool and of the combination of locking device and running tool, as well as in the method steps, delineated hereinafter.

The following descriptive matter describes a preferred embodiment of this invention; namely, a locking device and running tool for use in its emplacement down-hole in a well penetrating subterranean formations. Accordingly, the terms "upward" and "downward" are employed in their relative context for that environment. This invention may be useful in other environments in a position other than the vertical position. In such eventuality, the terms conveying the same relative direction with respect to the position of the elements would be substituted for upward and downward.

Referring to FIG. 1, well **11** will have been completed in a bore hole penetrating subterranean formations **13**. For example, casing **15** may have been cemented in place in the bore hole by conventional cement circulation techniques, leaving a cement sheath (not shown) around the casing. Inside casing **15** is suspended tubing **17**. The annulus between tubing **17** and casing **15** may be separated into a plurality of zones by one or more packers **19** sealingly emplaced therebetween. Tubing **17** may have a landing nipple **21** for receiving suitable down-hole equipment.

As illustrated, a locking device, or lock mandrel, **23** having a pressure equalizing device **25** and a flow control valve **27** attached thereto is being lowered into the well. A preferred form of the pressure equalizing device **25** is described and claimed in my co-pending application entitled "Pressure Equalizing Device," filed Mar. 21, 1970, Ser. No. 22,881. Any other down-hole tools such as the control valve alone may be emplaced in landing nipple **21** via the locking device **23**. The locking device **23**, on a conventional wireline tool string **29** is suspended and operated from the surface via wireline **31**. Insertion of the locking device and tool string is made through suitable lubricator **33** and valves **35** if the well is pressurized. The wireline tool string **29** includes jars **37** for jarring upwardly or downwardly for effecting the requisite force to move the respective elements with respect to each other, as described more clearly hereinafter. The wireline tool string **29** also includes running tool **39** for effecting relative positions of the locking device as delineated hereinafter.

The landing nipple **21**, forming a preferred seat for the locking device, comprises a restricted portion **41** of a first diameter smaller than the diameter of the tubing. Immediately thereabove, the landing nipple has a recess portion **43** of a diameter larger than the diameter of the tubing for locking of the locking dog means of the locking device thereinto. Conventional landing nipples **21** also have an intermediate portion **45** of diameter intermediate that of the restricted portion and the diameter of the tubing. One of the advantages of the locking device of this invention, however, is that it does not require the landing nipple per se but can set in a collar recess atop any restricted portion, or restricted bore such as formed by any other nipple means.

The locking device **23**, FIG. 2*b*, comprises the major elements of tubular housing **47**, locking dog means **49**, and expander mandrel **51**. The tubular housing **47** has an internal shoulder means **53** disposed at its upper end. As illustrated, the internal shoulder means **53** is an internal fishing neck. Such an internal fishing neck arrangement is advantageous, since it not only affords an interconnecting internal shoulder means, but also a fishing neck onto which a fishing tool can be connected for applying a greater pulling force than with a fishing tool connected with an external fishing neck. A plurality of collet fingers **55** are formed from a portion of the wall of the tubular housing **47**. The collet fingers **55** are biased inwardly; although, as illustrated, they are retained at the same diameter of the tubular housing **47** by a mandrel adapter therewithin. The collet fingers **55** have threaded apertures **57** for receiving suitable threaded means such as bolts of an exterior expander ring for drawing the collet fingers outwardly to facilitate assembly. Although the upper end of the collect fingers **55** flex inwardly or outwardly, the lower end is fixed and forms part of the wall of tubular housing **47**. Each collet finger has an inclined, or frusto-conical, portion **61** facilitating the insertion of a suitable expander element such as an adapter on a pulling tool.

The tubular housing **47** has window means **63** disposed adjacent its lower end for receiving the locking dog means **49**.

The locking dog means **49**, FIGS. 2*b* and **3**, are disposed in the window means **63** and are movable laterally of the tubular housing **47** into a retracted position, a no-go position protruding slightly through the window means; and a locked position protruding through the window means and lockingly engaging a recess in the landing nipple or tubing. A dog retainer means comprising lip **64** prevents passage of the locking dog means **49** completely through the window means **63** as the locking dog means are moved outwardly to their respective positions. The locking dog means **49** are reversible to minimize error in assembly. That is, they are symmetrical with respect to a horizontal plane through their midpoint. The raised portion **65** of the locking dog means **49** is narrow so as to lock within a collar recess in collar-type tubing, or conduit. An interior annular groove **67** is cut in the center of the dogs to receive a no-go ridge **69**, serving as part of a no-go portion on the expander mandrel **51**. The use of a groove and ridge enables expanding the dogs into a no-go position with the shortest possible relative longitudinal movement between the expander mandrel **51** and the tubular housing **47**, as explained in more detail hereinafter. The locking dog means **49** may be preformed for the particular size conduit and locking devices in which they will be employed. It is frequently advantageous to have the raised portion **65** somewhat thicker than desirable and machine the raised portion **65** to the exact dimensions desired with the locking dog means supported in their respective no-go and locked positions by the particular expander mandrel with which they will be employed. For example, they may be machined to a diameter in the range of 1.885–1.889 to form a no-go diameter when the landing nipple **21** has an intermediate portion **45** of a diameter of 1.890 inch and a restricted portion of a diameter of 1.875 inch; as employed with 2.710 outside diameter landing nipples.

The expander mandrel **51** has a connection means such as threaded connection **71** disposed at its lower end for connection with a tool such as an equalizing device to be supported

thereby. The mandrel **51** also has an internal portion **73** that is disposed within the tubular housing **47** and reciprocally movable along the longitudinal axis thereof. The internal portion **73** has a retraction portion **75** of fully reduced diameter for supporting the locking dog means in a retracted position. The internal portion **73** also has a no-go portion **77**, including ridge **69**, of intermediate diameter for supporting the locking dog means **49** in a no-go position. As illustrated, and as indicated hereinbefore, the retraction portion **75** and the no-go portion **77** and **69** each comprise two longitudinal sections of the same respective diameters, with at least one section of the other portion disposed therebetween for facilitating movement of the locking dog means into the no-go position with the shortest possible relative longitudinal movement between the tubular housing **47** and the expander mandrel **51**. For example, as can be seen by referring to FIG. **5***b*, the locking dog means **49** can be expanded into a no-go position by moving the expander mandrel **51** with respect to the tubular housing only the longitudinal length of the ridge **69** to move it beneath one end of the locking dog means **49**, the other section of the no-go portion **77** being moved beneath the other end of the locking dog means. The ends of the locking dog means **49** are cammed out simultaneously and held parallel thereby to form the no-go feature. The internal portion **73** also has a locking portion **79** for supporting the locking dog means in a locked position. As can be seen from a comparison of FIGS. **2***b*, **5***b*, and **6***b*, the retraction portion **75**, the no-go portion **77** and **69**, and the locking portion **79** are positionable to support the locking dog means in their respective positions in response to longitudinal movement of the expander mandrel **51** along the longitudinal axis of the tubular housing **47**. The locking portion **79** of the expander mandrel is also employed herein as a guide for the lower end of the tubular housing **47**.

A locking means is provided intermediate the collet fingers and the expander mandrel for releasably retaining the same in the locked position with the locking portion of the expander mandrel being retained supporting the locking dog means in their locked position. Specifically, the locking means comprises nonhelical teeth **81** formed on the interior of the collet fingers and nonhelical teeth **83** formed on the exterior of the expander mandrel. As can be seen in FIG. **6***b*, the nonhelical teeth **81** and **83** co-engage to lock the expander mandrel in its upper, or locked position as long as the inwardly biased collect fingers **55** are not forced outwardly. The locked position is, however, releasable by insertion of a suitable expander element to forece the inwardly biased collet fingers **55** outwardly and disengage the respective teeth **81** and **83**.

An assembly retainer means is provided intermediate the expander mandrel **51** and the tubular housing **47** for preventing inadvertent disassembly. As illustrated in FIGS. **2***b* and **4**, an internal groove **85** is formed on the interior of tubular housing **47** for receiving retaining wire **87**. The retaining wire **87** is inserted through tangential aperture **89**. As the retaining wire **87** is driven into the tangential aperture **89**, groove **85** guides it around the expander mandrel and the expander mandrel bends the retaining wire into a curl. The retaining wire **87** is then sawed off flush with the outside of the tubular housing **47**. The retaining wire **87** is readily removed with a punch and pliers. Shoulder **90** on the expander mandrel **51** engages the retaining wire **87** when the expander mandrel is in its lowermost position; as when being run into the well or when the locking device is being retrieved, with the expander mandrel supporting additional tools thereon; to prevent the internal portion **73** from being pulled downwardly out of tubular housing **47**. Conversely, ridge **69** may engage the retainer wire **87** to limit upward travel of the expander mandrel as illustrated in FIG. **6** *b;* although, ordinarily, other shoulders are employed for this purpose, as indicated hereinafter.

An attachment means is provided for releasably attaching the locking device to a running tool. Specifically, an aperture **91** having a threaded outer portion **93** is employed for the insertion of a shear pin therewithin. The shear pin in then bradded into the threaded section **93** and conformed to the outer surface of the expander mandrel. In this way the outer portion of the shear pin is retained by the threaded section even though it has been sheared from the inner portion which is removed with the running tool. Since complete forming between the shear pin and the threaded portion **93** is not achieved, the pieces of the sheared pin can be driven out with very little effort and the shear pin apertures **91** employed repeatedly.

As illustrated in FIG. **2**b, a seal means is disposed about the lower portion of the locking device for sealingly engaging the locking device and an internal surface of the conduit forming tubing in the well. Specifically, the expander mandrel **51** has an enlarged portion **95** against which a seal support **97** abuts. Suitable resilient seal means such as vee packing **99** is emplaced adjacent the seal support. If desired, a center seal shaper **101** and lower inversely mounted vee packing **103** may be employed for sealing regardless of the direction in which the pressure differential acts across the seal. A bottom seal support **105** retains the elements of the seal means together, since its downward movement is prevented by the top **107** of any tools mounted on connection threads **71**. A groove **109** and an O-ring **111** may be employed for sealing between the exterior of the expander mandrel and the interior of the tool supported thereby.

The running tool **39**, FIGS. **2***a* and **2***b*, for emplacing the locking device **23** in a conduit such as tubing in the well includes the major structural assemblies of elongate body means **113**, drag means **115**, and retainer means **117**.

As illustrated, the elongate body means **113** includes three portions threadedly coupled together; an upper portion **118**, a middle portion **120**, and a lower portion **219**. The body means **113** has a plurality of different levels **121** and **123** disposed opposite the internal shoulder means **53** to provide different sized openings intermediate the body means **113** and the internal shoulder means **53**.

The body means **113** has an end flange means **125** disposed at its upper end for engaging a biasing means. End flange means **125** is in reality a spring nut that may be tightened to compress a biasing means such as a spring. The body means **113** has disposed on its periphery at a at a first longitudinal location at least one radially extending first window means **127**. Preferably, there are at least a pair of window means **127** diametrically opposite each other. The body means **113** also has disposed on its periphery at a second longitudinal location at least a second radially extending window means **129**, FIG. **12**.

A first trigger lug means **131** is disposed in each of the window means **127**. A second trigger lug means **133**, FIG. **12**, is disposed in the second window means **129**. The respective trigger lug means are reciprocally movable in their respective window means laterally of the elongate body means **113**.

A release rod member **135** is slidably disposed within the upper portion **118** of body means **113** and connected at its upper end with an adapter **137** for being connected with the remainder of the wireline tool string **29**. The connection may be by way of a threaded connection **139** and set screw **141**. The release rod member **135** has an enlarged bottom portion **143** disposed at its lower end. The release rod member **135** also has an enlarged shoulder portion **145** disposed adjacent the enlarged bottom portion with a recess portion **147** therebetween. The enlarged shoulder portion **145** engages, at its lower edge, the upper edge portion of the first trigger lug means **131** when the first trigger lug means is extended inwardly into its holding position. The enlarged bottom portion **143** supports the second trigger lug means **133**, FIG. **12**, extended outwardly into its holding position when the tool is in the running position. The recess portion **147** is movable to release the second trigger lug means **133** after the first trigger lug means **131** is released.

The drag means **115** is disposed peripherally about the body means **113** and freely movable longitudinally of the body means. The drag means **115** has a portion that is adapted to frictionally drag on the inner wall of the conduit so as to bias

the portion of the drag means toward its extreme position in a direction opposite to the direction of movement of the running tool **39** along the longitudinal axis of the conduit. By reverse or upward movement of the running tool **39**, the drag means may be employed for effecting operation of the expander mandrel and the locking dogs into the armed and no-go position through relative downward movement of the drag means along the longitudinal axis of the body means, as will be described in more detail hereinafter. Specifically, the drag means **115** includes a top portion **149** having an internally protruding first shoulder means **151** for maintaining the first trigger lug means **131** protruding inwardly to its holding position engaging the enlarged shoulder **145** of the release rod member **135** for preventing relative downward movement of the release rod member with respect to the body means **113**. The top portion **149** has a recess portion **153** contiguous the first shoulder **151** for releasing the first trigger lug means after the locking dog means of the locking device in a no-go position have encountered a restricted portion **41** in tubing **17**. A second shoulder, or cam, **155** is disposed contiguous the top side of the recess portion **153** for retaining the first trigger lug means **131** protruding inwardly to its holding position after the running tool and the locking device are moved to the armed and no-go position and before the locking dog means have encountered the portion of restricted diameter in the conduit.

The drag means **115** also includes a fixed member that is slidable longitudinally of the body means between stops. Specifically, FIG. **9** illustrates the cross member **157** disposed in its slot. Cross member **157** is slidable longitudinally of the body means **113**. It passes through slots **227** of the top portion **149** and slip housing **183** for fixedly but removably retaining them together as an entity, as described with respect to FIG. **10** hereinafter. The cross member **157** is movable in its slot **158**, FIG. **12**, longitudinally of the body means to solidly engage the body means at the top and bottom stops **159** and **161** for transmitting respective upwardly and downwardly directed jarring forces. The respective jarring forces may be transmitted to jar the respective seal means, or other portions of the tools through tight, or closely fitting, diameters by means of the cross member **157**, without risking deforming other parts of the tool.

The drag means **115** also includes slip means **163** retained therewithin and adapted to be moved outwardly to engage an inner surface of the tubing. The drag means also includes drag shoe means **165**, FIG. **12**, retained within the drag means and biased outwardly for frictionally dragging on the inner walls of the tubing. The drag shoe means have laterally protruding ears that are retained within the recess **166**, FIG. **5***a*, to retain the drag shoe means within the drag means. As indicated hereinbefore, the dragging biases the drag shoe means toward its extreme position in a direction opposite to the direction of movement of the running tool along the longitudinal axis of the tubing. In fact, a single tubular sleeve is employed in forming the arms **167**, on which the slip means **163** are mounted and the biasing spring **169** for the drag shoe means. The biasing spring **169** and the arms **167** on the single tubular sleeve constrain the drag shoe means and the slips to move as a unit longitudinally of the body means **113**.

A slip expander means **171** and biased lock means are disposed adjacent each other on the body means **113**. The lock means comprises a lock ring **173** held inwardly to engage an annular groove **175** on the exterior of the body means **113** and a shoulder **177**, FIG. **12**, for preventing relative longitudinal movement between the body means and the drag and retainer means until released. Specifically, the lock ring **173** is retained in the locked position by an annular cylindrical member **179** that is biased upwardly by spring **182**. As illustrated in FIG. **7**, the slip means **163** are disposed in diametrically opposed slots **181** that are machined or otherwise formed into the sides of the slip housing **183** of the drag means **115**. These slots **181** are in line with the cross pin slot **158**, FIG. **12**, and with slots **185** in the body means **113**, FIG. **8**. The lower end of slot **181** has a reduced section **187** and a squared out section **189** below the reduced section to form a tee slot. Deposited within this tee slot and slidable longitudinally between shoulders **191** and **193** are the slip expander means **171**. The slip expander means **171** also move laterally in the slots **185**, FIG. **8**, by camming up and down camming shoulders **195** and **197** of slots **185**. As can be seen in FIG. **8**, the slots **185** in the middle portion **120** of the body means have three widths **199**, **201**, and **203**. Intermediate the ramps **195** and **197**, the groove **175** is disposed for receiving the segments of the lock ring **173**, which is lockingly held in place by an annular recess portion **184** of an annular cylindrical member **179**.

The annular cylindrical member **179**, FIGS. **2***a* and **12**, abuts the slip expander means **171** such that when the slip means **163** are engaged with the internal wall of the conduit and an upward pull given the running tool **39**, the slip expander means **171** will move the cylindrical member **179** downwardly. Downward movement of the cylindrical member **179** frees the segments of the lock ring **173** from cylindrical recess **184** for allowing relative longitudinal movement between the body means, and the drag means and the retainer means for arming the running tool and moving the locking device into the no-go position, as will become apparent hereafter. The annular cylindrical member **179** has two slots **180**, FIG. **2***a*, cut at its upper end to saddle around the lower end of the slip expander means **171**. The cylindrical member **179** synchronizes the slip expander means **171**, and the spring **182** continually biases the cylindrical member **179** and the slip expander means **171** upwardly. The upward biasing of the cylindrical member **179** is stopped by the shoulder **177**, FIG. **12**, inside the slip housing **183**. The upward biasing of the slip expander means **171** is limited by the shoulder **191** in the tee slots of the slip housing **183**, FIG. **7**. The annular cylindrical member **179** has a cylindrical recess **184** at its upper end which extends over the locking segments of lock ring **173** when the locking segments are in the groove **175**. But when the cylindrical member **179** is forced downwardly by the slip expander means **171**, the segments of the locking ring will be permitted to expand outwardly, thus escaping from groove **175** on the body means **113**. Once the locking ring segments have escaped from groove **175**, the spring **182** will bias the cylindrical member **179** upward, holding the segments of the locking ring **173** against shoulder **177**, as illustrated in FIG. **13**. When groove **175** is again moved under the segments of the lock, or locking, ring **173**, the lock ring **173** will automatically be forced back into and locked within groove **175**, provided no downward force is applied to slip expanders **171**. The slip housing **183** has an external groove **205** about its periphery wherein retainer band **207** fits for retaining the slip expander means **171** in place before arming. The upper end **209** of the slip expander means **171** is retained underneath the lower end of the slip means **163**. The lower end of slip housing **183** is provided with an internal thread **211** for receiving a lower spring retainer **213** of the retainer means.

The retainer means **117** is disposed longitudinally on the body means **113** for keeping the tubular housing **47** spaced with respect to drag means **115** and for releasing the tubular housing **47** therefrom. The retainer means **117** includes a release means **215**. The release means **215** engages the retainer means at one end **217** and is disposed intermediate the internal shoulder means **53** of the locking device and the level **121** of the body means. The release means **215** thus serves to hold the tubular housing **47** in fixed relationship with the retainer means and allow restricted relative longitudinal movement of the body means **113** and the expander mandrel **51** with respect thereto to move the locking dog means **49** from the retracted position to the no-go position. The release means **215** permits complete disengagement and unrestricted longitudinal movement when moved to the second level **123** of the body means **113**. More specifically, the retainer means **117** is disposed about the body means **113** for retaining the locking device in a running position until an upward force is exerted on the running tool sufficient to move the drag shoe

means **165** downward and to set the slip means in engagement with the internal wall of the conduit and to release the lock means. The release means **215** are in effect retainer dogs that are retained and guided within slots **185**, FIG. **8**. The lower enlarged end **218** of the release means **215** is movable laterally within slots **185**. Ordinarily, however, longitudinal motion of the body means **113** is restricted to prevent freeing the one end **217** from the retainer means within the lower spring retainer **213** and spring **182**.

The lower spring retainer **213** has two slots **223** at its upper end for receiving the one end **217** of the release means **215**. The slots are deep enough to prevent the spring **182** from biasing against the upper end of the release means **215**. Also the release means **215** being in slots **185** of the body means **113** and extending laterally outward into slots **223** of the lower spring retainer **213** prevent the lower spring retainer **213** from rotating relative to the slip housing **183**.

A mandrel adapter **119** is disposed on the lower portion **219** of the body means **113**. The lower portion **219** of the body means **113** may be attached, as by threaded connection **221**, to the remainder of the body means for supporting the mandrel adapter. Rotation is prevented by a suitable pin means (not shown) through the skirt of the body means **113** containing slot **185**, and the lower portion **219**. Two diametrically opposite bypass slots traverse the length of the mandrel adapter **119**, as indicated by the lack of sectioning in FIG. **2***b*, to permit fluids to flow therepast.

The top portion **149** of the slip housing **183** has an external configuration as illustrated in FIG. **10**. The lower end **225** of the top portion **149** is disposed within the upper end of the slip housing **183**. As indicated with respect to FIG. **9**, the top portion **149** is fixedly but removably connected with the slip housing **183** by the cross member **157** passing through the slots **227** in the lower end **225** of the top portion **149**. The top portion **149** is movably disposed around the upper end of the body means **113** and more particularly over the trigger lug means **131** and **133**. The interrelationship between the internal configuration comprising annular shoulders **151** and **155**, recess **153**, and the trigger lug means **131** and **133** is described hereinbefore and their interaction is described in the Operation section.

A tubular release housing **229** is disposed about the upper end of the drag means and specifically, around the outside of the top portion **149**. The tubular release housing is slidable longitudinally of the body means **113**, and has two internal lugs **231**, FIG. **12**, which work within the slots **228** in the top portion **149**, FIG. **10**, to control the amount of movement that can occur between the body means **113** and the release housing **229**. Specifically, the internal lugs **231** protrude through the slots **228** and engage, or collide, with the second trigger lug means **133** during operation of the tool. The tubular release housing **229** has an enlarged internal diameter portion **233** at its upper end for receiving the upper, colleted end of the top portion **149** and a biasing means such as spring **235**. The tubular release housing **229** also includes an interiorly protruding annular bottom shoulder **237** at the bottom of the enlarged internal diameter portion **233** for engaging an enlarged exteriorly protruding annular upper shoulder **239** of the top portion **149** for limiting the expanding longitudinal movement between the top portion **149** and the tubular release housing **229**. The tubular release housing **229** has an end flange **241** extending annularly inward toward the body means **113**. The compressed spring **235** extends intermediate and rests upon the inwardly extending annular flange **241** of the tubular release housing **229** and the uppermost end **243** of the top portion **149** for effecting relative longitudinal movement between the drag means and the tubular release housing once the lock means has been released. When the spring **235** is allowed to expand and effect relative longitudinal movement between the drag means and the tubular release housing, the running tool is armed and the respective upper shoulder **239** and the bottom shoulder **237** are moved into engagement with each other, as illustrated in FIG. **5***a*.

A second biasing means such as spring **245** is disposed intermediate the end flange **241** of the tubular release housing **229** and the end flange means **125** of the body means **113** for effecting relative longitudinal movement therebetween for arming the running tool after the locking means is released.

OPERATION

In operation, the locking device is assembled by the insertion of the locking dog means **49** within window means **63**; insertion of the internal portion **73** of the expander mandrel within the tubular housing **47**; and insertion of the retaining wire **87** therebetween, as described hereinbefore with respect to FIG. **4**. Suitable down-hole tools will have been attached to the lower end of the expander mandrel, as indicated hereinbefore. Before further assembly by attaching the running tool, the spring nut **125** thereon is loosened to release the compressive force on the springs and facilitate assembly. Then the lower portion **219** of the running tool **39** is inserted within the expander mandrel until the top of the expander mandrel engages the bottom shoulder **291** of the mandrel adapter **119**. To facilitate insertion, an expander ring with suitable screws or bolts may be employed to expand the collet fingers **55** outwardly through engagement with threaded apertures **57**. The shear pin apertures **91** are aligned and the shear pin installed through shear pin aperture **91**. The shear pin will be bradded into the threaded section **93** for retention therewith. Thereafter, the collet fingers are released and allowed to frictionally engage mandrel adapter **119**.

The running tool is thus inserted downwardly within the locking device sufficiently to emplace the release means **215** intermediate the internal shoulder means **53** and the body means **113**; for example, at innermost level **123**. The body means is moved downwardly with respect to the release means **215** to emplace the outermost level **121** therebeneath. The release means **215** then engages the internal shoulder means **53** of the locking device, with the top of the tubular housing **47** held against the lower spring retainer **213**. Thus, the locking device is retained on the running tool in the running position with the locking dog means **49** retracted. The collet fingers **55** are expanded by the mandrel adapter **119**. The segments of the locking ring **173** are forced into the groove **175** of the body means **113** for preventing any relative longitudinal movement between the elements of either the running tool or the locking device until the locking ring **173** is released. The slip expander means **171** are expanded onto the outer surface of the body means **113**. The elements of the running tool are moved so that, as illustrated in FIG. **2***a*, the respective first trigger lug means **131** are trapped inside the internal annular shoulder **151** to expand inwardly into their holding position engaging the enlarged shoulder portion **145** of the release rod member **135**. The second trigger release means **133** are forced outwardly by the enlarged bottom portion **143** of the release rod member **135** into their holding position so as to engage the internal lugs **231** of the tubular release housing **229** when the lock means is released. The spring nut **125** is tightened, compressing the spring **245**; which also compresses spring **235**, until the lower end of the tubular release housing **229** abuts the upper end of the slip housing **183**. The locking device and the running tool are connected in the running position as illustrated in FIGS. **2***a* and **2***b*, to a conventional wireline tool string **29**. They are lowered through appropriate valves and lubricators into the well, as illustrated in FIG. **1**.

As the running tool is lowered into the well, the friction between the drag shoe means and the tubing wall will cause the drag shoe means to move to the upper end of the window **247**, FIG. **12**. This movement also retracts the slip means **163**.

Downward jarring such as necessary to pass through tight spots can be accomplished without releasing the tool because the first trigger lug means are being held within recess portion **147** and engaging enlarged shoulder portion **145**. When the tools have been lowered to a point below any landing nipples that are not to be set in and above the landing nipple in which

it is desired to set the locking device, the tool string is picked up. While the operation will be described hereinafter with respect to a landing nipple, it is to be remembered that any nipple means having a restricted portion of restricted internal diameter and a recess such as defined by a collar thereabove, may be set in. As the tool string is picked up, the drag shoe means **165** will move downwardly, with respect to the body means **113**, in windows **247**; and, thereby, force the slip means **163** upon the slip expander means **171**. The slip means **163** will engage the tubing wall and oppose the upward force on the wireline. Consequently, a downward force will be generated with respect to the cylindrical member **179** encountering the expander means **171**. The relatively downwardly acting force is applied on the slip expander means **171** and the annular cylindrical member **179** disposed about and retaining the lock ring **173** engaging groove **175**. When sufficient force is supplied to compress the bottom spring **182**, the annular cylindrical member **179** will be moved downwardly, releasing the segments of the locking ring **173** from the groove **175** of the body means **113**. Once the segments of the locking ring **173** are released, the spring **245** will begin moving the body means **113** and the retainer means **117** with respect to each other. Specifically, spring **245** moves the body means **113** upwardly, and the retainer means **117** and the drag means **115**, including the slip housing **183**, downwardly until the internal lugs **231** of the tubular release housing **229** are stopped by the second trigger lug means **133**, as illustrated in FIGS. **5***a*, **5***b* and **13**. Spring **245** is now being held from expanding by the tubular release housing **229** and the engagement between the second trigger lug means **133** and the internal lugs **231**. The spring **235** also expands and forces the slip housing unit **183** downwardly until upper shoulder **239** engages bottom shoulder **237** of the tubular release housing **229**, FIG. **5***a*. The cam or shoulder **155** is moved downwardly over the first trigger lug means **131** to retain it in recess portion **147**, still preventing the release rod member **135** from moving downwardly with respect to the body means **113**.

As this relative longitudinal movement between the retainer means **117** and the body means **113** is effected, the slip expander means **171** cam down ramp surfaces **195** and **197**, FIG. **8**, and come to rest in slots **185** of the body means **113**. This camming inwardly of the slip expander means **171** throws the slip means **163** out of service such that they cannot be expanded again, even though the drag shoe means **165** move downwardly within the windows **247**. This inward camming of the slip expander means **171** and the release of the slip means **163** releases the force opposing the upward pull on the tool and signals to the operator at the surface that the running tool has been armed and that the locking device has been moved to the no-go position. Should the operator have any doubts, he may attempt to pull the tool upwardly again. In the event the catching and releasing was effected by a force other than the arming of the running tool, the slips will engage upon the subsequent upward movement of the tool, as described hereinbefore. If the running tool has in fact been armed, the slips will not engage and the operator can be certain that he has effected the arming of the running tool and the movement of the locking dog means into their no-go position for encountering the restricted portion of the landing nipple.

The running tool and the locking device is then lowered into position wherein the raised portion **65** of the locking dog means **49**, in the no-go position, as illustrated in FIG. **5***b*, will engage the restricted portion **41** of the landing nipple **21** and stop further downward movement of the tubular housing **47**. Even though armed, the running tool and locking device can be jarred through tight spots, such as jarring the tight packing into the nipple without tripping the tool into the locked position until the locking dog means **49** engage the restricted portion **41**. As can be seen, the stopping of the downward movement of the tubular housing **47** also stops the downward movement of the retainer means **117** and the drag means **115**, including the slip housing **183**. Further downward jarring will compress spring **235**, causing the body means **113** to move downwardly relative to the slip housing **183**. As the body means **113** moves downwardly with respect to slip housing **183**, the first trigger lug means **131** will be moved from shoulder means **155** into recess **153**, permitting the first trigger lug means to move outwardly.

Once the first trigger lug means **131** is allowed to move outwardly, it allows passage downwardly of the enlarged shoulder portion **145** of release rod member **135**. As the release rod member **135** is moved downwardly, the recess portion **147** is moved behind second trigger lug means **133**. Thus, the second trigger lug means **133** is allowed to move inwardly and thereby release internal lugs **231** of the tubular release housing **229**.

When the tubular release housing **229** has its internal lugs **231** freed, the spring **245** ordinarily will move the body means **113** upwardly with respect to the tubular release housing and the retainer means until the locking device is moved into the fully locked position as shown in FIG. **6**b. In the event that the spring does not effect the fully locked position, the fully locked position may be effected by jarring upwardly.

After the trigger lug means are moved laterally to allow the body means to be moved upwardly with respect to the retainer means and the tubular housing **47** of the locking device, the innermost level **123** is moved beneath the release means **215**, allowing the release means **215** to move inwardly. The inward movement of the release means **215** from its retaining position, as indicated in FIG. **5***b*, to its releasing position, as indicated in FIG. **6***b*, disengages the internal shoulder means **53** of the tubular housing **47** of the locking device. The disengagement of the release means **215** from shoulder means **53** frees the tubular housing **47** and allows it to remain locked in recess portion **43** of the landing nipple **21** with its seal means, including vee packing **99**, sealingly engaging the internal wall **41** of the restricted portion of the landing nipple **21**. Thereafter, the locking portion **79** of the expander mandrel **51** may be pulled upwardly behind the locking dog means **49** to expand them outwardly into their locked position. As the expander mandrel is pulled upwardly, the mandrel adapter **119** is withdrawn upwardly, permitting the collet fingers **55** to spring inwardly; and, consequently, the nonhelical teeth **81** and **83** coengage to retain the expander mandrel in the locked position, supporting the locking dog means in their locked position. The top shoulder **255** of the enlarged portion **95** will encounter the bottom **257** of the tubular housing **47**, and ridge **69** will encounter retaining wire **87** to stop upward movement of the expander mandrel and oppose the force necessary to shear the shear pin holding the expander mandrel to the lower portion **219** of the running tool.

The spring **245** will not, however, shear the shear pin. The shear pin is sheared by additional upward jarring. As can be seen in FIGS. **6***a*, **6***b* and **14**, illustrating the retrieving position, the first and second trigger lug means **131** and **133** are moved upwardly into the enlarged cylindrical portion **249** of the top portion **149**, thereby permitting the first and second trigger lug means **131** and **133** to expand outwardly. The outward expansion of the first and second trigger lug means allows the enlarged bottom portion **143** of the release rod member **135** to return back to its original position with its enlarged shoulder portion **145** engaging a lower shoulder **251** of body means **113**, FIG. **6***a*. In this way, the upward jarring force may be transferred to the body means **113**. The outward movement of the first and second trigger lug means **131** and **133** likewise leaves the release rod member **135** free to move downwardly to cross member **157** for downward jarring. Thus, it can be seen that the upward jarring force is transmitted from the release rod member **135** to the body means **113** for completing any incomplete locking and shearing the shear pin; whereas the downward jarring force is transmitted from the release rod member to the cross member **157** and thence via the slip housing **183** directly to the tubular housing **47** without tending to unlock the locking device. Consequently, an operator may jar in both directions without adversely affecting the locking and shearing operation.

When the shear pin is sheared, the running tool is retrieved, as illustrated in FIGS. 6*a*, 6*b* and 14. Thereafter, the running tool is retrieved from the well and the locking device with its appended well tools remains locked in the landing nipple 21.

The locking device may be pulled with a conventional pulling tool. Ordinarily, a conventional pulling tool adapted for pulling an internal fishing neck will be employed. For example, an adapter 258, such as shown in FIG. 17, is attached to the bottom of a conventional tool; for example by threaded connection 259 with the conventional tool. The adapter 258 has an internal threaded section 261 at its lower end for receiving any desired appropriate additional tools; such as the equalizing prong for operation of a pressure equalizing device. Such an equalizing prong is described in my copending patent application Ser. No. 22,881, referenced hereinbefore. The adapter 258 is also provided with a bypass slot 263 to permit fluid to bypass the adapter in either direction. With the pulling tool properly assembled, the combination tool is lowered into the well and the appended tools are properly operated; for example, an equalizing valve may be opened by downward jarring and the pressure allowed to equalize. Further downward jarring will force the adapter 258 downwardly within collet fingers 55, thereby expanding the collet fingers outwardly. This outward expansion of the collet fingers 55 will disengage the teeth 81 and 83. As the adapter 258 is moved further downwardly, the inclined portion 61 of the collet fingers will move up on the surface 265 of the adapter 258, thereby providing the correct expansion of the collet fingers 55. Further downward movement of adapter 258 will cause the shoulder 267 to abut the upper end shoulder 269 of the expander mandrel and to begin to apply downward force on the expander mandrel.

Of course, if a pressure differential exists from the bottom of the locking device, this pressure differential will be working against the entire area of the vee packing in the seal means and the closed control (not shown). This pressure differential will prevent the force of the jars, acting through the pulling tool and the adapter 258, from moving the expander mandrel 51 downwardly relative to the locking dog means 49 until equalization of pressure across the locking device has been accomplished. The adapter 258 is long enough that the dogs of the pulling tool are not permitted to engage the internal shoulder 53, or internal fishing neck, inside the tubular housing 47 until the expander mandrel can be moved downward relative to the tubular housing 47. Therefore, the pulling tool assembly can be withdrawn from the locking device at any time prior to full pressure equalization and thereby re-engage the locking teeth 81 and 83 of the locking device. Also, if pressure equalization fails to occur, the pulling tool assembly with adapter prong can be withdrawn, leaving the locking device locked as before.

Jarring downwardly is suspended until pressure equalizing has been effected. Thereafter, further downward jarring will move the expander mandrel with its vee packing downward relative to the landing nipple 21, tubular housing 47, and the locking dog means 49; which are still expanded into the recess of the landing nipple. When the expander mandrel 51 has moved down approximately one-half inch, the pulling tool dogs will engage beneath the internal shoulder 53 on the main housing, thus attaching the pulling tool to the locking device. Further downward jarring will move the expander mandrel and the vee packing downwardly into a position illustrated in FIG. 2*b* with the locking dog means 49 in the fully retracted position. Further downward jarring will result in the locking device being moved downwardly below the restricted portion of the nipple means. However, if upward jarring is begun, the pulling tool dogs will move back up to engage the internal shoulder means 53 and the locking device can be pulled upwardly out of the landing nipple. It can be seen that once the expander mandrel has been moved down to release the locking dog means, the locking device can be moved out of the landing nipple in either direction.

Moreover, it can be seen that the locking device can be moved in either direction through other restricted portions, or restricted bores of landing nipples within a tubing string without again going to the locked position.

If a pressure differential exists from the top of the tool downwardly, it is recommended that an equalizing prong be run without the pulling tool and adapter. After equalizing has occured, the pulling tool and adapter may be employed to pull the locking device on a second trip into the well.

In any event, the locking device with the pulling tool assembly may be brought to the surface to complete the pulling operation.

GENERAL

Several variations may be made in the construction of the locking device without departing from the basic invention. Referring to FIG. 15, the same basic locking device including the tubular housing 47 and the expander mandrel 51 is employed with the exception that the seal means and the lower connection means have been removed. The locking device illustrated in FIG. 15 may be employed as a nipple stop to prevent other tools from falling below a nipple in which this lock is set. Such a nipple stop may be advantageously employed, for example, to protect expensive downhole equipment during workover operations. Also, it may be used to support other devices such as pack-off anchors which are set above a nipple but spaced a given distance from a nipple. A locking device similarly constructed to the one illustrated in FIG. 15 may also be employed for locating at the top of a nipple such as a polished nipple. A polished nipple has a restricted portion of restricted diameter, but has no internal recess portion. In such a locking device, the locking dog means 49 have a slightly larger outside diameter for locking within a collar recess immediately above the polished nipple.

Another embodiment is illustrated in FIG. 16. FIG. 16 employs the same basic tubular housing 47 and construction of the internal portion of the expander mandrel 51. The expander mandrel 51, however, has an expandable-type seal element 271. As illustrated, the expander element is a single piece element but, if desired, two cups face-to-face with an expander ring therebetween can be employed. Several expanding type elements are known in the art and can be employed. As illustrated, the expander mandrel 51 has been separated as at thread 273 to minimize variations and cost; and achieve better outside diameter control immediately above and below the expander seal element 271. Also the threaded connection 273 enables attaching various sub-assemblies and lower thread adaptations while using the same basic upper sections of the locking device. Included in the illustrated sub-assembly is expander mandrel extension 275 with the seal element 271, and a seal element expander 277 and an element back-up 279. The element back-up 279 has an internal seal 281 sealingly engaging the expander mandrel extension 275. The seal element back-up 279 0 canted surface, or shoulder, 285 adjacent the resilient seal member 282 of expandable seal element 271. The bottom shoulder 283 is canted, also. The resilient seal member of the expander seal element also has matching canted shoulders for being forced outwardly under a compressive force between the canted shoulders 283 and 285.

A shear pin retainer ring 289 is also employed for retaining the shear pin after shearing. The shear pin apertures 91 are moved up higher on this locking device in order to keep the shear pin apertures 91 above the seal element 271, thereby removing these holes from the pressure chamber below the seal element 271. It is noteworthy that the threaded connection 273 is also above the seal element 271 and therefore out of the pressure chamber also. The variation in location of the shear pin apertures 91, requires an additional set of matching apertures on the lower portion 219 of the running tool.

As can be seen, the different types of locking devices are operated in essentially the same manner described hereinbefore, whether or not a seal means is emplaced thereon. If an

expander seal means is employed, the upper back-up element will ultimately rest against the tubular housing **47** while the lower canted shoulder moves toward the tubular housing **47** as the expander mandrel is moved upwardly to compress the seal outwardly into engagement with the internal wall of the conduit.

All of the variations of this locking device can be equipped with a set of locking dog means having different sizes of outside diameters of the dogs so as to permit the dogs, while in the no-go position, to pass through certain restricted bores and land on top of yet further restricted portions of internal diameter. Also, the locking device can be equipped with locking dog means that will seek out an intermediate restricted bore above a yet further restricted portion in the no-go position. The locking device itself may be sized to fit different sizes of tubings or conduit in the well. Moreover, the diameter difference between the no-go shoulders and the locking diameter of the expander mandrel can be varied to obtain maximum or minimum engagement of the locking dog means into a locking recess or tubing collar.

The embodiments herein have been described and illustrated with respect to a landing nipple having a nominal diameter the same as the diameter of the tubing. With such landing nipples, as well as with collar recesses, the diameter of the recess means is larger than the diameter of the tubing. If desired, reduced landing nipples having a nominal diameter smaller than the diameter of the tubing may be employed. With reduced landing nipples, as with any other nipples, the recess means must be larger than the restricted bore on which the locking device is to locate to be set. If the locking device is to hold pressure in from below, it is necessary that there be an internal bore having an internal diameter less than that of the recess means thereabove, whether it be the tubing, an intermediate portion of a landing nipple or other restricted bore.

The respective embodiments also have been illustrated with one each dog, slip, slip expander and drag shoe employed respectively in the release means **215**, the slip means **163**; the slip expander means **171**, and the drag shoe means **165**. Preferably, a plurality of each are disposed uniformly about the periphery of the running tool. For example, three each may be disposed about the periphery of the body means at 120° apart.

The locking device of this invention has the flexibility of being locked into a landing nipple and run into the well with the tubing string, if desired. It may then be retrieved or moved to a different depth as described hereinbefore. Thus, it can be seen that the invention provides a locking device and a running tool for its emplacement in a well that obviates the disadvantages of the prior art; and provides the objects enumerated hereinbefore; and that, particularly, provides the desirable features enumerated hereinbefore. Specifically, the invention provides: (1) a tool that is able to move, and a locking device that can be lowered, to any depth through any number of restrictions in a tubing and then be armed such that, if interrogated by the operator, it will apprise him as to whether or not it is armed; and it will determine and signal to the operator when it encounters a restricted portion and should be moved into the locked position; (2) a running tool and a locking device that are operable in response to relative longitudinal movement between parts thereof so that a greater force can be employed in effecting operation of the parts regardless of the length of time the locking device may have been emplaced in the well; (3) a running tool and locking device that can be run through a series of identical restricted bore nipples and, at the operator's command above a particular nipple, locate and set on that particular nipple; (4) a running tool and a locking device that are operable into the armed and no-go position without having to go through a restricted diameter for arming; (5) a locking device that will locate and lock in any nipple means on the market as well as any restricted nipple with a collar recess above it for utmost flexibility and lower costs in having to warehouse different types of locking devices and running tools; (6) a locking device that can be operated into locking or no-go positions in the well without complex accessories; (7) a locking device that will set on the restricted portion of restricted diameter from above and have the expander mandrel move upwardly to lock only after setting on the restricted portion, thereby preventing inadvertent locking; (8) a locking device with the simplest possible construction for lower expense and greater reliability, and with only relatively inexpensive equipment being left in the well; (9) a locking device that will hold pressure in either direction and permit its retrieval from a nipple means in any direction after unlocking has been accomplished; (10) a locking device wherein the packing, if employed, has to be moved downwardly against pressure before the lock mandrel can be unlocked, thereby virtually eliminating the danger of the locking device being blown up the tubing during unlocking; (11) a locking device that can be moved in either direction through a restricted nipple during retrieval without the mandrel being moved into the locked position; and (12) a lock mandrel that can pass small restricted bores but will locate a larger intermediate bore and expand an expansible packing to seal in an intermediate bore.

Although the invention has been described with a certain degree of particularity, it is understood that the present disclosure is made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention.

What is claimed is:

1. A method of emplacing a locking device in a conduit in a well penetrating subterranean formations comprising the steps of:

a. emplacing in said conduit in said well a nipple means having a restricted portion having an internal diameter less than the diameter of said conduit, and thereby defining a recess means above said restricted portion; said recess means having an internal diameter greater than the diameter of said restricted portion;

b. running through said conduit downwardly into said well a locking device with locking dog means retracted into a retracted position until at a depth below any higher nipple means and any other restricted diameters and above said nipple means;

c. thereupon operating said locking dog means into a no-go position with locking dog means protruding outwardly to define an outside diameter greater than the internal diameter of said restricted portion and less than the internal diameter of said conduit;

d. lowering said locking device farther downwardly until said locking dog means in said no-go position encounters said restricted portion of said nipple means; and

e. expanding said locking dog means outwardly into said recess means to a locked position having an outside diameter greater than the inside diameters of said restricted portion, and removably locking said locking dog means into said locked position.

2. The method of claim **1** wherein said locking device is run into said well on a running tool having slips and said operating of said locking dog means into a no-go position in accordance with step (c) is effected by exerting on a body means of said running tool an upward force sufficient to set said slip means in engagement with an internal wall of said conduit and to release a lock means; the releasing of the lock means allowing a bias means to move a no-go portion of intermediate diameter of an expander mandrel behind said locking dog means to move them into the no-go position and thereby arm said running tool for moving said locking dog means to the locked position; and wherein said expanding of said locking dog means outwardly into said locked position in accordance with step (e) is effected by exerting a downward force on said body means of said running tool after said locking dog means in said no-go position have engaged said restricted portion in said nipple means and stopped downward movement of a housing of said locking device, the downward force being sufficient to

release a trigger lug arrangement that allows said body means of said running tool to be biased upwardly to move said expander mandrel with which it is connected upwardly to expand said locking dog means into said locked position and releasably lock said expander mandrel in said locked position; and wherein said body means of said running tool is thereafter pulled upwardly to complete any incomplete lock and to effect release of said locking device therefrom and leave said locking device locked in said conduit; and said running tool is withdrawn from said well.

3. The method of claim 2 wherein once said slips set and sufficient force is exerted upwardly to release said lock means and said bias means moves said no-go portion relative to said locking dog means, said slips are automatically dropped out of engagement with said internal wall of said conduit to release said running tool and thereby signal to the operator that said locking dog means are in the no-go position and said running tool is armed.

4. The method of claim 3 wherein said slips remain out of engagement as long as said running tool is in said well so that the operator can check that said running tool is in the armed position without setting the slips, and said locking dog means cannot inadvertently be moved to the retracted position and said running tool cannot inadvertently be disarmed.

5. The method of claim 1 wherein said locking dog means are reversibly held in said locked position, and said locking dog means are retracted and said locking device is retrieved from said nipple by movement in either direction without again locking.

6. The method of claim 1 wherein an internal bore having an internal diameter less than said internal diameter of said recess means is defined above said recess means; and said locking dog means are expanded into said locked position to an outside diameter greater than said internal diameter of said internal bore.

7. A locking device for locking tools within a conduit at a location defined by a portion of restricted diameter and a recess thereabove for receiving locking dog means comprising:

a. a tubular housing having an internal shoulder means disposed at its upper end; having a plurality of inwardly biased collet fingers disposed adjacent its upper end; and having a window means disposed adjacent its lower end for receiving locking dog means;

b. locking dog means disposed in said window means; said locking dog means being movable laterally of said tubular housing into a retracted position, a no-go position protruding slightly through said window means; and a locked position protruding through said window means and lockingly engaging said recess in said conduit;

c. dog retainer means for preventing passage of said locking dog means completely through said window means;

d. an expander mandrel having a connection means at its lower end for connection with a tool to be supported thereby; and having an internal portion disposed within said tubular housing and reciprocally movable along the longitudinal axis thereof; said internal portion having a retraction portion of fully reduced diameter for supporting sad locking dog means in a retracted position; a no-go portion of intermediate reduced diameter for supporting said locking dog means in a no-go position; and a locking portion for supporting said locking dog means in a locked position; said retraction portion, said no-go portion, and said said locking portion being positionable to support said locking dog means in response to longitudinal movement of said expander mandrel along the longitudinal axis of said tubular housing;

e. locking means intermediate said collet fingers and said expander mandrel for releasably retaining same in said locked position;

f. assembly retainer means intermediate said expander mandrel and said tubular housing for preventing inadvertent disassembly thereof; and

g. attachment means for releasably attaching said locking device to a running tool.

8. The locking device of claim 7 wherein a seal means is disposed on an external surface of said locking device above said connection means for sealingly engaging said locking device and an internal surface of said conduit.

9. The locking device of claim 7 wherein said locking dog means have an outside no-go diameter in said no-go position that is greater than said restricted diameter and less than the diameter of said conduit, and have an outside locked diameter in said locked position that is greater than said no-go diameter.

10. The locking device of claim 9 wherein an internal bore of a diameter intermediate that of the recess means and the portion of restricted diameter is included above said recess means; and wherein said locking dog means have said outside diameter in said locked position that is less than the diameter of said recess means and is also greater than said internal bore thereabove.

11. The locking device of claim 7 wherein said locking dog means have an outside diameter in said no-go position that is greater than said restricted diameter which is defined by a nipple means emplaced at a depth where said locking device is to be set in a conduit; and said locking dog means have an outside diameter in said locked position larger than the diameter of said conduit and smaller than a diameter of a collar for said conduit so as to lock in a collar recess immediately above said nipple means.

12. The locking device of claim 7 wherein said expander mandrel is connected at its lower end with an expander mandrel extension that has an expansible seal means thereon; said seal means having an internal seal portion for sealingly engaging the expander mandrel extension, and being disposed intermediate the lower end of said tubular housing and a shoulder portion on said expander mandrel extension for being expanded outwardly into sealing engagement with an internal surface of said conduit in response to relative motion that tends to compress said seal means between said expander mandrel extension and said tubular housing.

13. The locking device of claim 12 wherein said seal means includes an expander element disposed intermediate the upper and lower surfaces of said resilient seal for effecting outward expansion of said resilient seal; said attachment means comprises a shear pin; and said expander mandrel extension includes a shear pin retainer ring adjacent said shear pin for retaining the shear pin in place once said locking device is sheared from a running tool.

14. The locking device of claim 7 wherein said locking means is releasable by expanding said collet fingers outwardly and said locking dog means are thereafter retractable whereby said locking device may be retrieved from its recess and restricted portion by movement in either direction and brought to the surface.

15. A well tool comprising:

a. a locking device for locking tools within a conduit at a location defined by a portion of restricted diameter and a recess thereabove for receiving locking dog means including:

i. a tubular housing having an internal shoulder means disposed at its upper end; having a plurality of inwardly biased collet fingers disposed adjacent its upper end, and having a window means disposed adjacent its lower end for receiving locking dog means;

ii. locking dog means retained within said tubular housing and disposed in said window means; said locking dog means being movable laterally of said tubular housing into a retracted position, a no-go position protruding slightly through said window means; and a locked position protruding through said window means and lockingly engaging said recess in said conduit;

iii. an expander mandrel having a connection means at its lower end for connection with a tool to be supported thereby; and having an internal portion disposed within said tubular housing and reciprocally movable along the longitudinal axis thereof; said internal portion having a retraction portion of fully reduced diameter for

supporting said locking dog means in a retracted position; a no-go portion of intermediate reduced diameter for supporting said locking dog means in a no-go position; and a locking portion for supporting said locking dog means in a locked position; said retraction portion, said no-go portion, and said locking portion being positionable to support said locking dog means in response to longitudinal movement of said expander mandrel along the longitudinal axis of said tubular housing;

iv. locking means intermediate said collet fingers and said expander mandrel for releasably retaining same in said locked position; and

v. assembly retainer means intermediate said expander mandrel and said tubular housing for preventing inadvertent disassembly thereof;

b. a running tool for emplacing said locking device in a conduit in said well, including:

i. an elongate body means having a plurality of different levels disposed opposite said internal shoulder means of said locking device to provide different size openings intermediate said body means and said internal shoulder means;

ii. drag means disposed peripherally about said body means and having a drag shoe means that is freely movable longitudinally of said body means; said drag shoe means being adapted to frictionally drag on the inner wall of said conduit so as to bias said drag shoe means toward its extreme position in a direction opposite to the direction of movement of said running tool along the longitudinal axis of said conduit for effecting operation of the expander mandrel and locking dogs into a no-go position through respective movement along the longitudinal axis of said body means;

iii. retainer means on said body means keeping said tubular housing and said expander mandrel in a running position with said locking dog means retracted until said drag shoe means is moved longitudinally to effect movement of said locking dog means into said no-go position; said retainer means including a release means engaging said retainer means and disposed intermediate said internal shoulder means of said locking device and said body means so as to restrict relative longitudinal movement between said tubular housing and said expander mandrel from said retracted position to said no-go position at a first level on said body means and to permit complete disengagement and unrestricted longitudinal movement at another of said levels on said body means; and

iv. mandrel adapter connected with said body means; and

c. complete attachment means releasably connecting said running tool with said expander mandrel of said locking device whereby said expander mandrel can be drawn upwardly to lock said locking dog means into said locked position before said running tool is released from said expander mandrel.

16. The well tool of claim **15** wherein said locking means intermediate said collet fingers and said expander mandrel comprise non-helical and co-engaging teeth on said collet fingers and on said expander mandrel.

17. The well tool of claim **15** wherein said drag means includes slip means in operable to move said slip means onto a slip expander means for setting said slip means into engagement with the internal wall of said conduit.

18. A running tool for emplacing in a conduit in a well a removable locking device having an expander mandrel that is movable longitudinally thereof and having outwardly expanding locking dog means, said running tool comprising:

a. an elongate body means having at least one radially extending window means disposed about its periphery at a first longitudinal location and at least one radially extending window means disposed about its periphery at a second longitudinal location; and having disposed at its lower end different levels that are respectively positionable beneath a release means for releasing and holding an internal shoulder means of a locking device; said elongate body means having an end flange means disposed at its upper end;

b. first trigger lug means disposed in said window means at said first longitudinal location;

c. second trigger lug means disposed in said window means at said second longitudinal location;

d. release rod member slidably disposed within said body means and having an enlarged bottom portion, an enlarged shoulder portion adjacent said enlarged bottom portion, and a recess portion therebetween; said enlarged shoulder portion engaging the upper portion of said first trigger lug means when said first trigger lug means is extended inwardly into its holding position; and said enlarged bottom portion supporting said second trigger lug means extended outwardly into its holding position; said recess portion being movable to release said second trigger lug means after said first trigger lug means is released;

e. drag means slidably disposed about said body means and including;

i. an internally protruding shoulder for maintaining said first trigger lug means protruding inwardly to its holding position engaging said enlarged shoulder of said release rod member for preventing relative downward movement of said release rod member with respect to said body means; and a contiguous recess portion for releasing said first trigger lug means after locking dog means of a locking device in a no-go position have encountered a portion of restricted diameter in said conduit;

ii. a rigid member that is rigidly attached to said drag means and is slidable longitudinally of said body means between stops;

iii. slip means retained therewithin and adapted to be moved outwardly to engage an inner surface of said conduit; and

iv. drag shoe means retained therewithin and biased outwardly for frictionally dragging on the inner walls of said conduit and biasing said drag shoe means toward its extreme position in a direction opposite to the direction of movement of said running tool along the longitudinal axis of said conduit; said drag shoe means being freely movable longitudinally of said body means and said drag means and connected with said slip means so as to effect concurrent movement longitudinally of said body means;

f. slip expander means and biased lock means disposed adjacent each other on said body means; said slip expander means being slidably carried by said body means and said drag means and operable to expand said slip means outwardly for engaging said internal wall of said conduit in response to downward movement of said drag shoe means; and, in response to upward pull against said slip means, to release said lock means and thereby release said body means for relative longitudinal movement with respect to said drag means;

g. retainer means disposed about said body means for retaining a tubular housing and an expander mandrel of a locking device in a running position with locking dog means retracted until an upward force is exerted on said running tool sufficient to move said drag shoe means downwardly to set said slip means in engagement with the internal wall of said conduit and to release the lock means; the releasing of the lock means allowing a biasing means to move a no-go portion of intermediate diameter of an expander mandrel behind said locking dog means to move them into a no-go position and thereby arm said running tool for moving said locking dog means to the locked position; said retainer means including release means engaging said retainer means; said release means having a retaining end portion for being disposed inter-

mediate an internal shoulder means of a locking device and said body means so as to prevent movement between said internal shoulder means and said retainer means until said body means has its outermost level moved from beneath said release means and after the innermost level of said body means is positioned beneath said release means permit complete disengagement of said release means from an internal shoulder of any locking device connected thereonto;

h. tubular release housing disposed about the upper end of said drag means and having internal lugs for engaging said second trigger lug means when said second trigger lug means is extended outwardly into its holding position for limiting movement of said tubular release housing until said second trigger lug means is released; said tubular release housing having a bottom shoulder engaging an upper shoulder on said drag means for limiting relative movement therebetween in one direction, having an intermediate internal shoulder for engaging an external upper shoulder on said drag means for limiting said relative movement in the opposite direction, and having an end flange extending annularly inward to said body means;

i. biasing means intermediate said end flange of said tubular release housing and said end flange means of said body means for effecting relative longitudinal movement therebetween for arming said running tool after said lock means is released; and

j. biasing means intermediate said end flange of said tubular release housing and the uppermost end of said drag means for effecting relative longitudinal movement therebetween for arming said running tool after said lock means is released.

19. The running tool of claim **18** wherein said elongate body means has a collet expander mandrel affixed adjacent its bottom end for expanding collet fingers in a locking device.

20. The running tool of claim **18** wherein said slip expander means are mounted adjacent respective ramp and groove means such that upon effecting of relative movement between said drag means and said body means said slip expander means are moved down said ramp into said groove means for releasing and preventing resetting of said slip means;

whereby an operator at the surface is advised by the sudden release of force of the slips opposing his upward pull that said relative movement, which effects the arming of the running tool and movement of locking dog means of a locking device into the no-go position, has been effected.

21. The running tool of claim **18** wherein said rigid member is a cross member that solidly engages said body means at said stops for transmitting respective upwardly and downwardly directed jarring forces.

22. A running tool for emplacing in a conduit in a well a removable locking device having an expander mandrel that is movable longitudinally thereof and having outwardly expanding locking dog means, said running tool comprising:

a. an elongate body means having disposed at its lower end an insertion portion of reduced cross sectional dimensions for inserting within a removable locking device; said insertion portion having a plurality of different levels comprising an innermost portion and an outermost portion for providing different size openings intermediate said body means and an internal shoulder means of a locking device;

b. drag means disposed peripherally about said body means and having a drag shoe means that is freely movable longitudinally of said body means; said drag shoe means being adapted to frictionally drag on the inner wall of said conduit so as to bias said drag shoe means toward its extreme position in a direction opposite to the direction of movement of said running tool along the longitudinal axis of said conduit to effect operation of an expander mandrel and locking dogs of a locking device into a no-go position through respective movement of said drag means along the longitudinal axis of said body means;

c. retainer means on said body means for keeping a tubular housing and an expander mandrel of a locking device spaced relative to each other in a running position with said locking dog means retracted until said drag means is moved longitudinally to effect movement of said locking dog means into said no-go position; said retainer means including a release means engaging said retainer means and having one end disposed adjacent said different levels of said insert portion of said body means for being disposed intermediate and engaging said outermost portion and an internal shoulder means so as to restrict relative longitudinal movement between said housing and said expander mandrel from said retracted position to said to said no-go position and for being moved to said innermost portion for disengagement from said internal shoulder means of a locking device; and

d. attachment means for releasably connecting said running tool with an expander mandrel of a locking device whereby said expander mandrel can be drawn upwardly to lock said locking dog means into their locked position before said running tool is released from said expander mandrel.

23. The running tool of claim **22** wherein said insert portion of said body means includes two different levels comprising an innermost portion and an outermost portion, said outermost portion and said release means coacting to engage an internal shoulder means of a locking device for preventing movement of said internal shoulder means with respect to said retainer means of said running tool; and said innermost portion allowing disengagement of said release means from said internal shoulder portion of a locking device when moved beneath said release means; wherein a lock means is provided for locking said running tool together and preventing relative longitudinal movement between said retainer means and said body means until unlocked; and wherein slip means and slip expander means are provided for expanding said slips outwardly into engagement with an internal wall of said conduit in response to upward movement of said running tool, said slip expander means being adapted to effect unlocking of said lock means in response to an upward force against said slip means; and wherein a biasing means is provided for effecting relative longitudinal movement between said body means and said retainer means for effecting movement of locking dog means of a locking device into a no-go position in response to the upward force and the unlocking of said lock means.

24. The running tool of claim **23** wherein a release rod member and a tubular release housing are annularly disposed with respect to said body means and wherein trigger lug means are disposed intermediate said release rod member and said tubular release housing and through a tubular portion of said body means for restricting relative longitudinal movement between said release rod member and said body means until after locking dog means of a lock mandrel have encountered a restricted diameter in said conduit; said trigger lug means, said release rod member, and said tubular release housing thereafter coacting under a downward force to allow said release rod member and said body means to be released and pulled upwardly with respect to said retainer means for locking said locking dog means in said locked position and moving said innermost portion of said different levels beneath said release means for releasing said release means from said internal shoulder means of a locking device; whereby said locking dog means may be moved into the locked position and an expander mandrel of a locking means moved longitudinally therebehind into the locked position and locked within a housing of a locking device, and said body means thereafter released via said attachment means from said expander mandrel of a locking device and said running tool pulled from the well.

25. The running tool of claim **24** wherein said trigger lug means comprise a first trigger lug means and a second trigger lug means and a top portion of said drag means is interposed intermediate said tubular release housing and said release rod member and movable longitudinally of said body means; said

top portion having a pair of internally protruding shoulder portions with a recess portion therebetween; said first trigger lug means being held in engagement with an enlarged shoulder of said release rod member by one of said internal shoulder portions of said top portion for controlling longitudinal movement of said release rod member with respect to said body means, and being positioned in said recess portion for releasing said release rod member; and wherein movement of said release rod member allows said second trigger lug means to move inwardly to release said tubular release housing, thereby releasing said biasing means for effecting relative longitudinal movement sufficient to initiate the movement of said locking dog means into said locked position.

26. The running tool of claim **23** wherein said lock means comprise a plurality of lock ring segments disposed about said body means and retained in engagement with a groove means on said body means and an annular recess portion of an annular cylindrical member; wherein a lock biasing means is disposed intermediate said annular cylindrical member and said body means so as to bias said annular cylindrical member toward said lock ring segments; said annular cylindrical member being disposed contiguous said slip expander means so as to compress said lock biasing means and release said lock ring segments in response to sufficient upward force on said body means against said slip means when said slip means are expanded outwardly on said slip expander means and engaged with a conduit to hold said slip expander means and said annular cylindrical member stationary in said conduit.

27. The running tool of claim **26** wherein said annular cylindrical member is movable upwardly by said lock biasing means when said biasing means of claim **20** has its biasing force removed to facilitate re-attaching another locking device at the surface and said lock ring segments are automatically moved back into engagement with said groove means and said annular recess portion of said annular cylindrical member; and said slip expander means are automatically biased upwardly within their slots.

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