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Dallas

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(54) **LOCKDOWN MECHANISM FOR WELL TOOLS REQUIRING FIXED-POINT PACKOFF**

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(52) **U.S. Cl.** **166/77.51**; 166/341; 166/382
(58) **Field of Search** 166/77.51, 348, 166/341, 338, 351, 381, 383, 382

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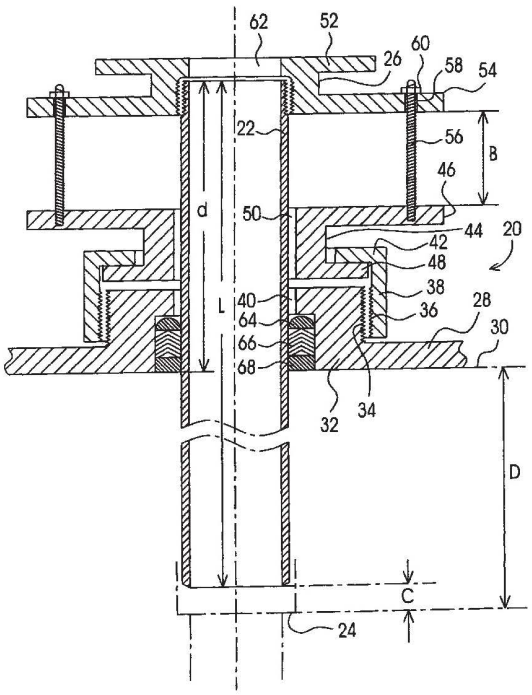
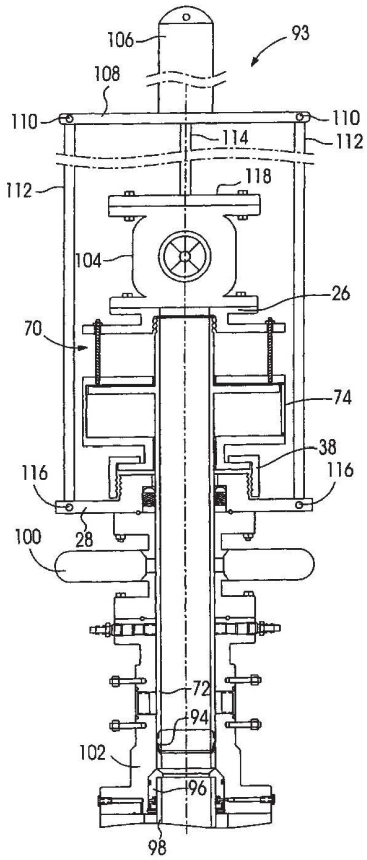
(57) **ABSTRACT**

An apparatus for securing a mandrel of a well tool in an operative position in which the mandrel is packed off against a fixed-point in the well is described. The apparatus includes a mechanical lockdown mechanism to secure the tool to the wellhead and maintain the mandrel in proximity to the fixed-point for packoff, and a mechanical or a hydraulic mechanism to move the mandrel into the operative position while the mechanical lockdown mechanism is in a lockdown position. A second mechanical locking mechanism is provided to ensure the mandrel is maintained in the operative position in the event that hydraulic pressure is lost. The invention provides a mechanism to lock down well tools requiring fixed-point packoff in a well and advantageously improves the range of adjustment of the lockdown mechanism so that the length of a mandrel may be less precisely matched to a distance from a top of the wellhead to the fixed-point in the well.

27 Claims, 9 Drawing Sheets





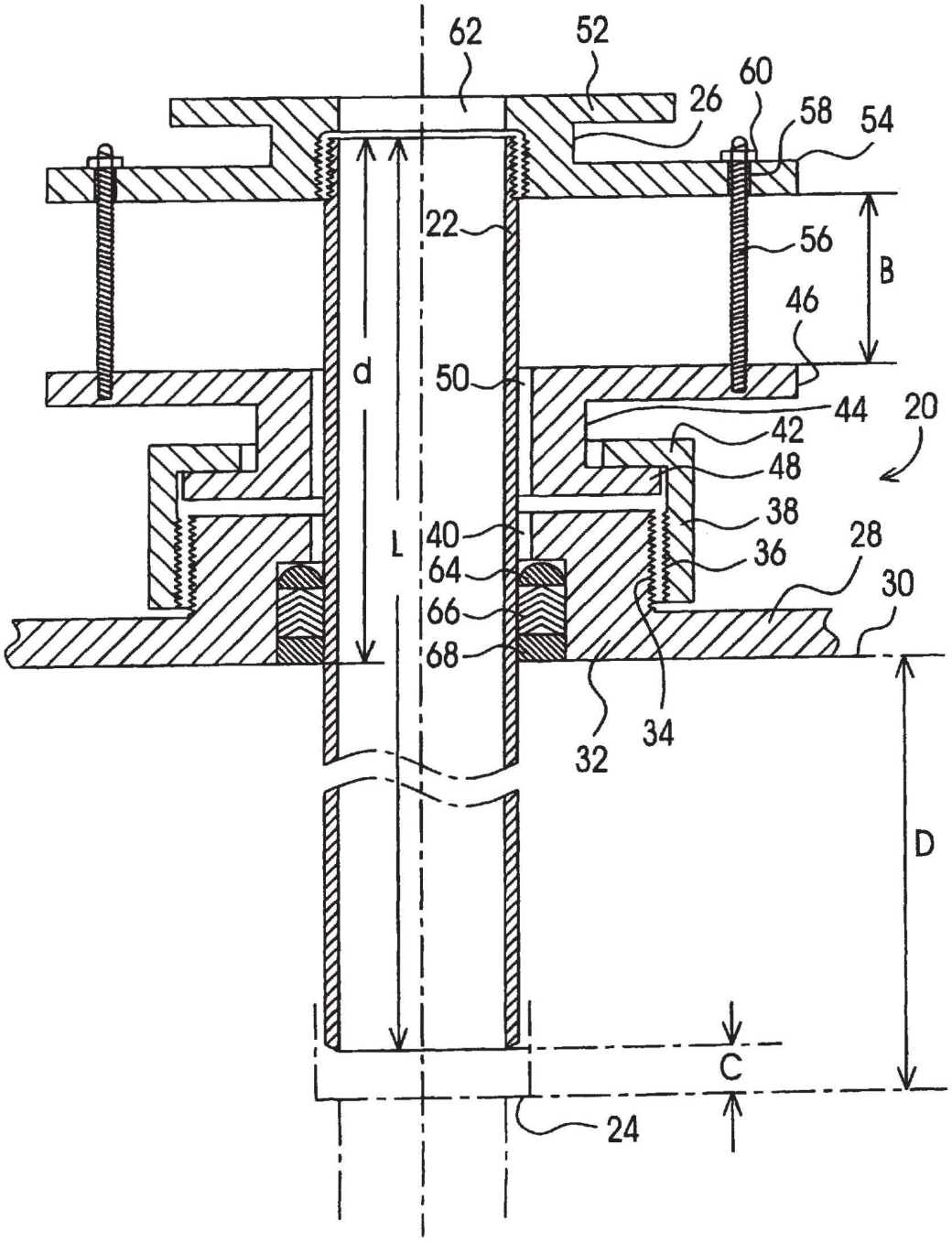

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FIG. 1

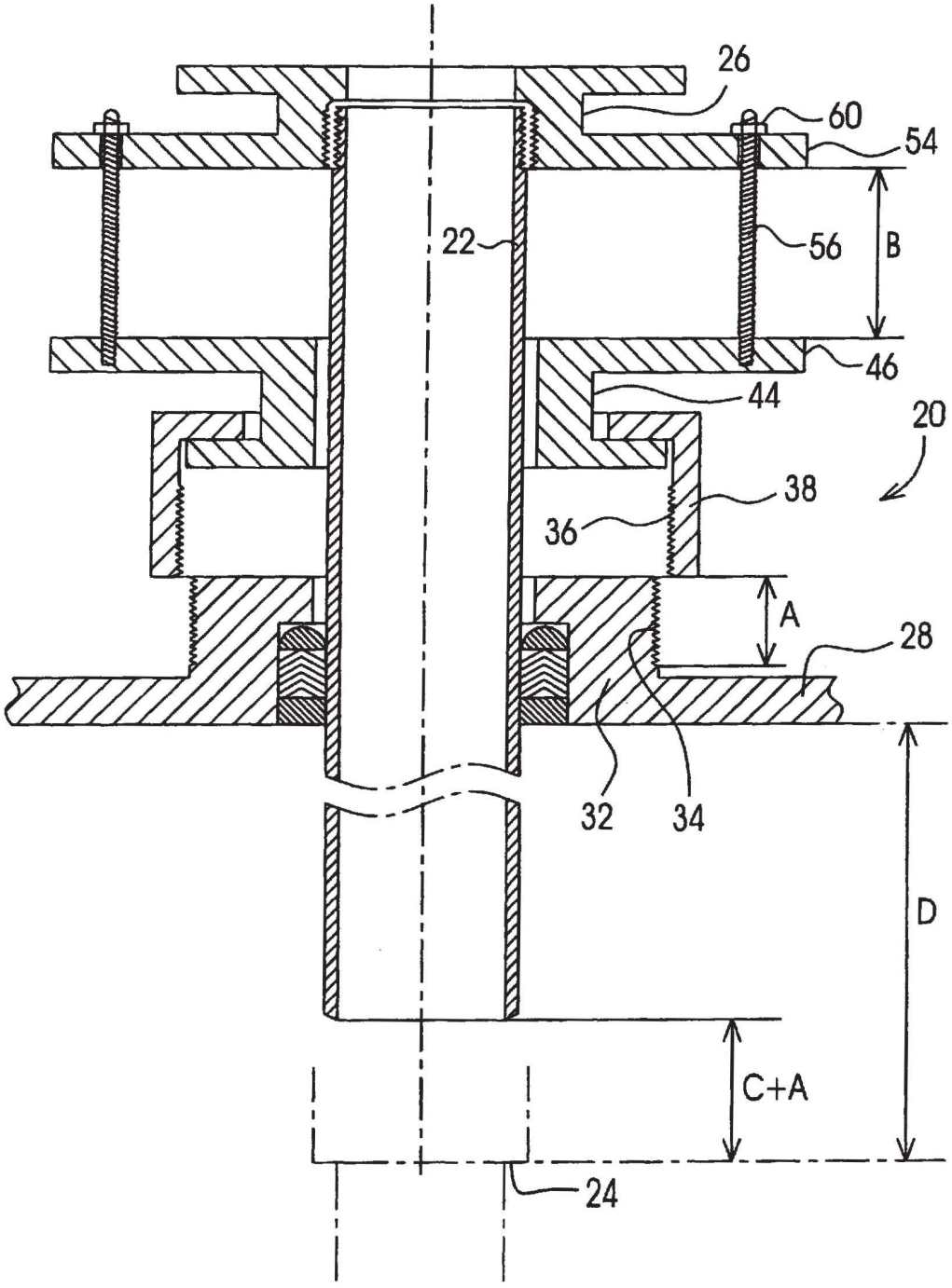

FIG. 2

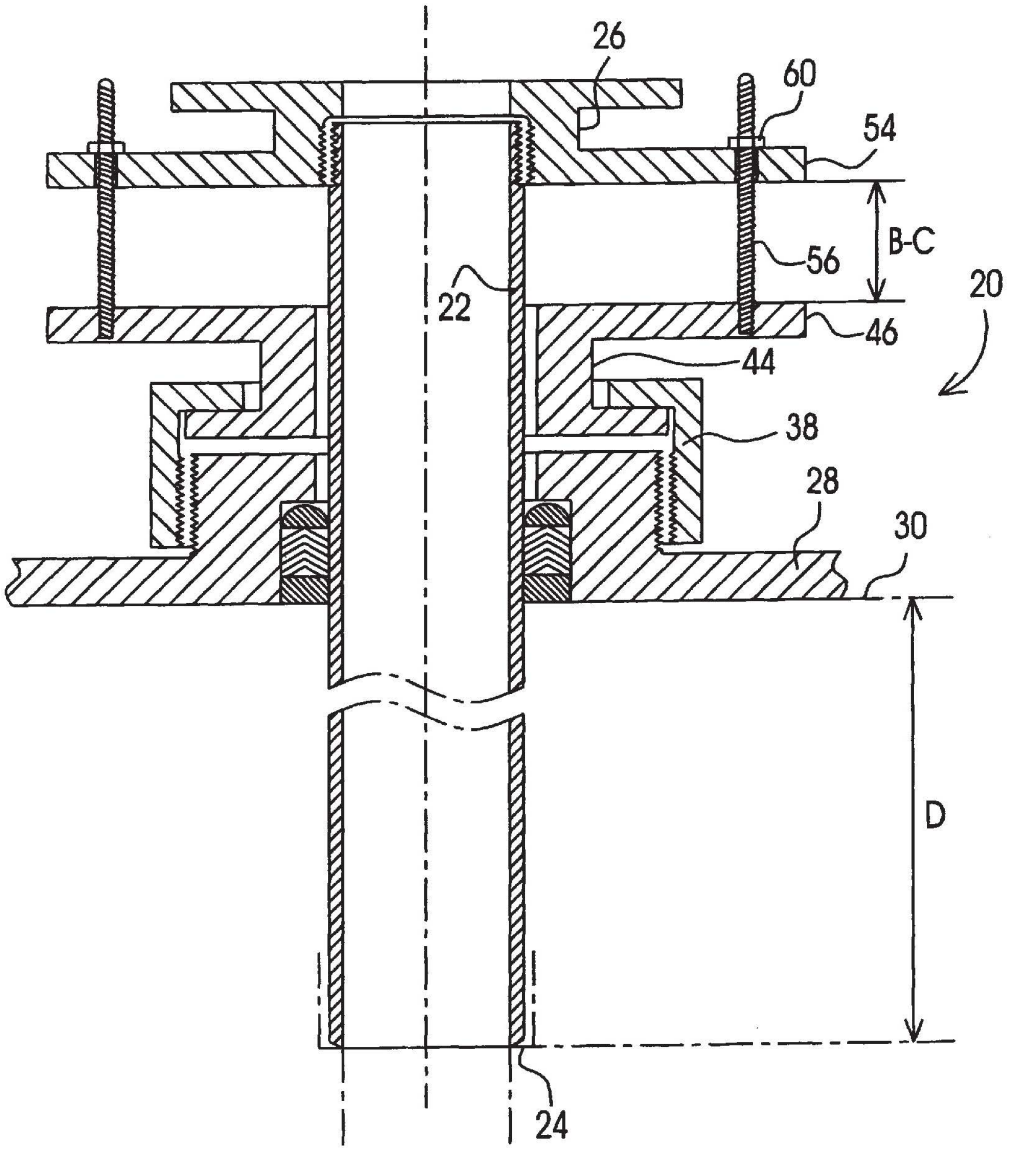

FIG. 3

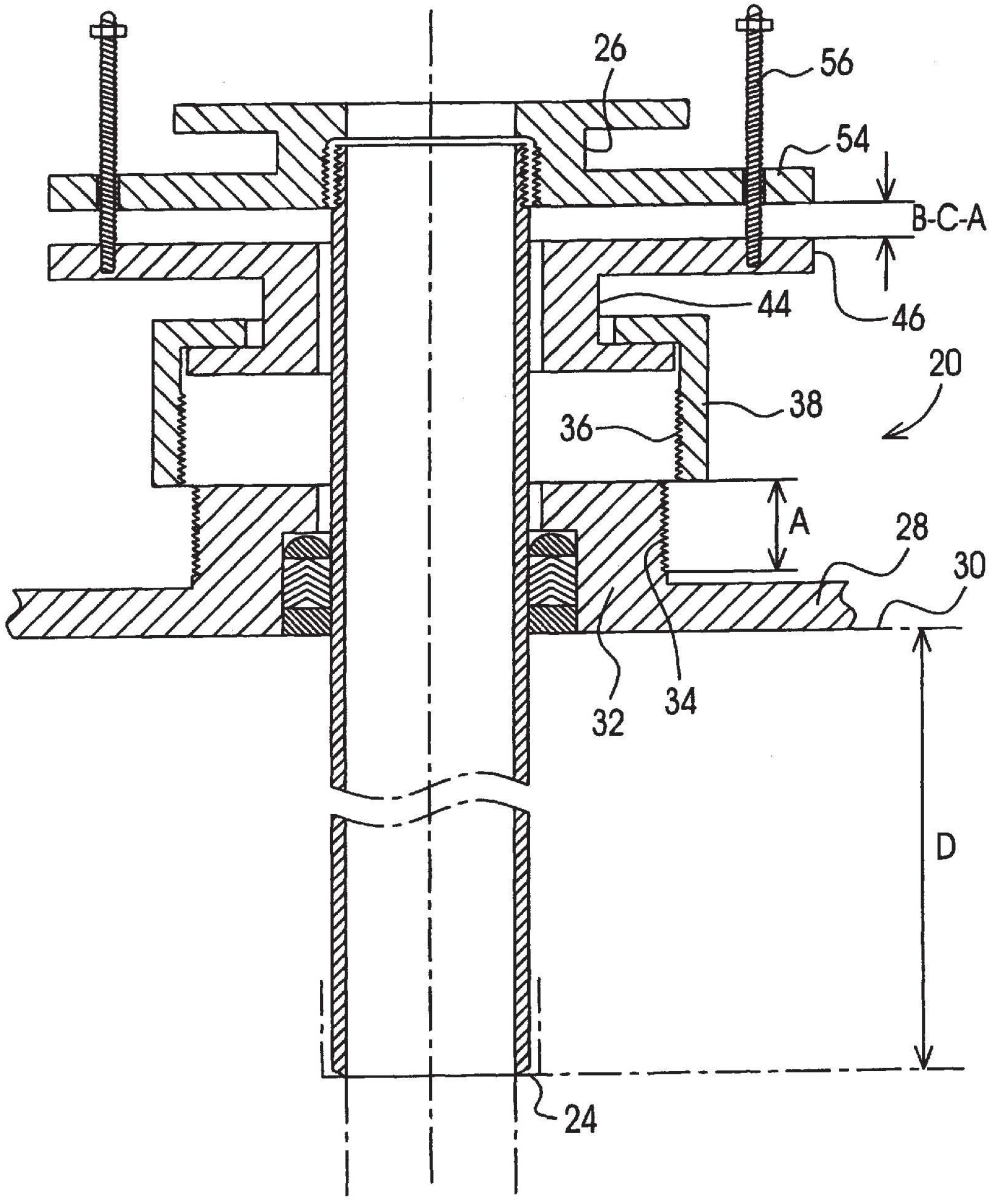

FIG. 4

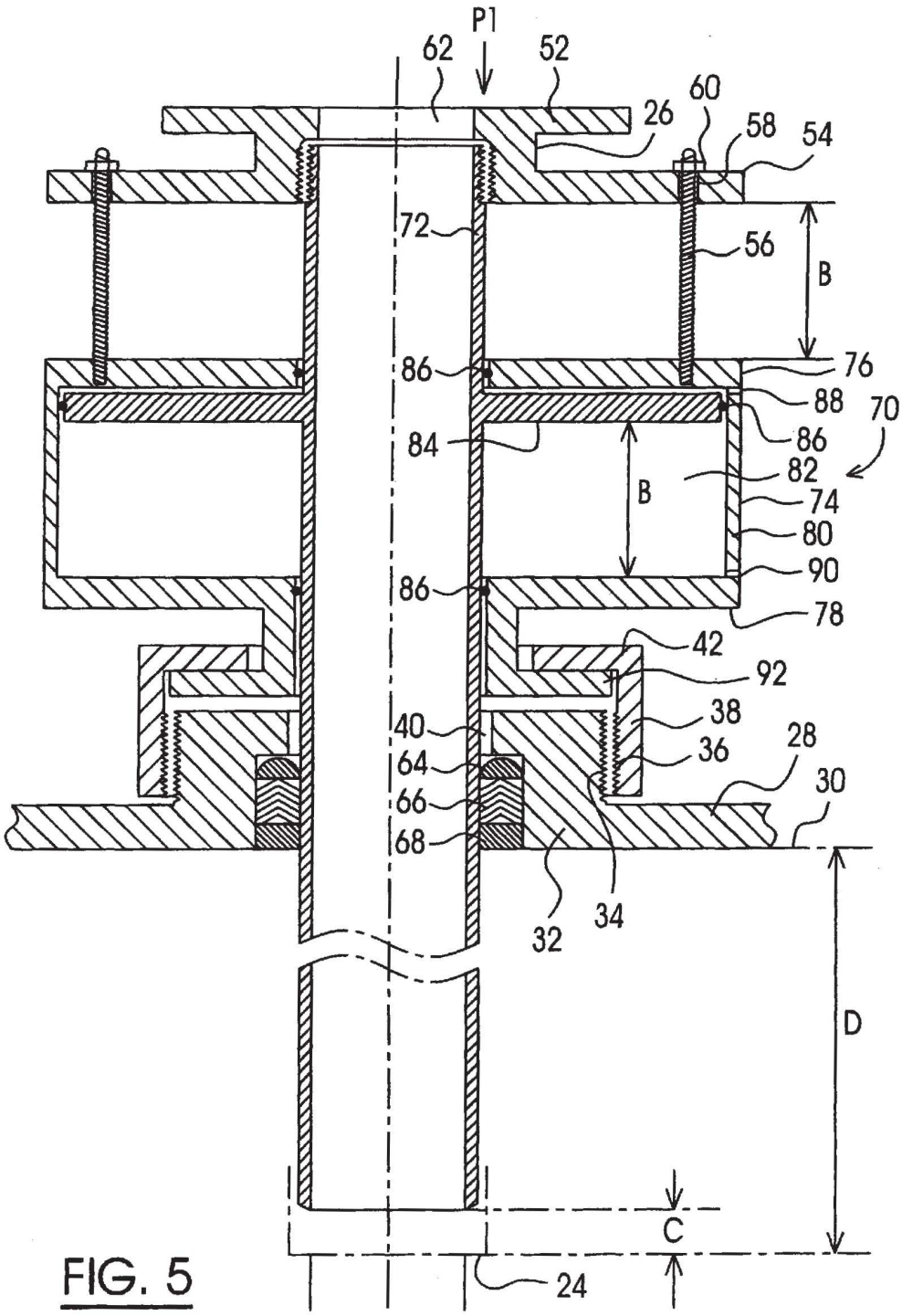
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FIG. 5

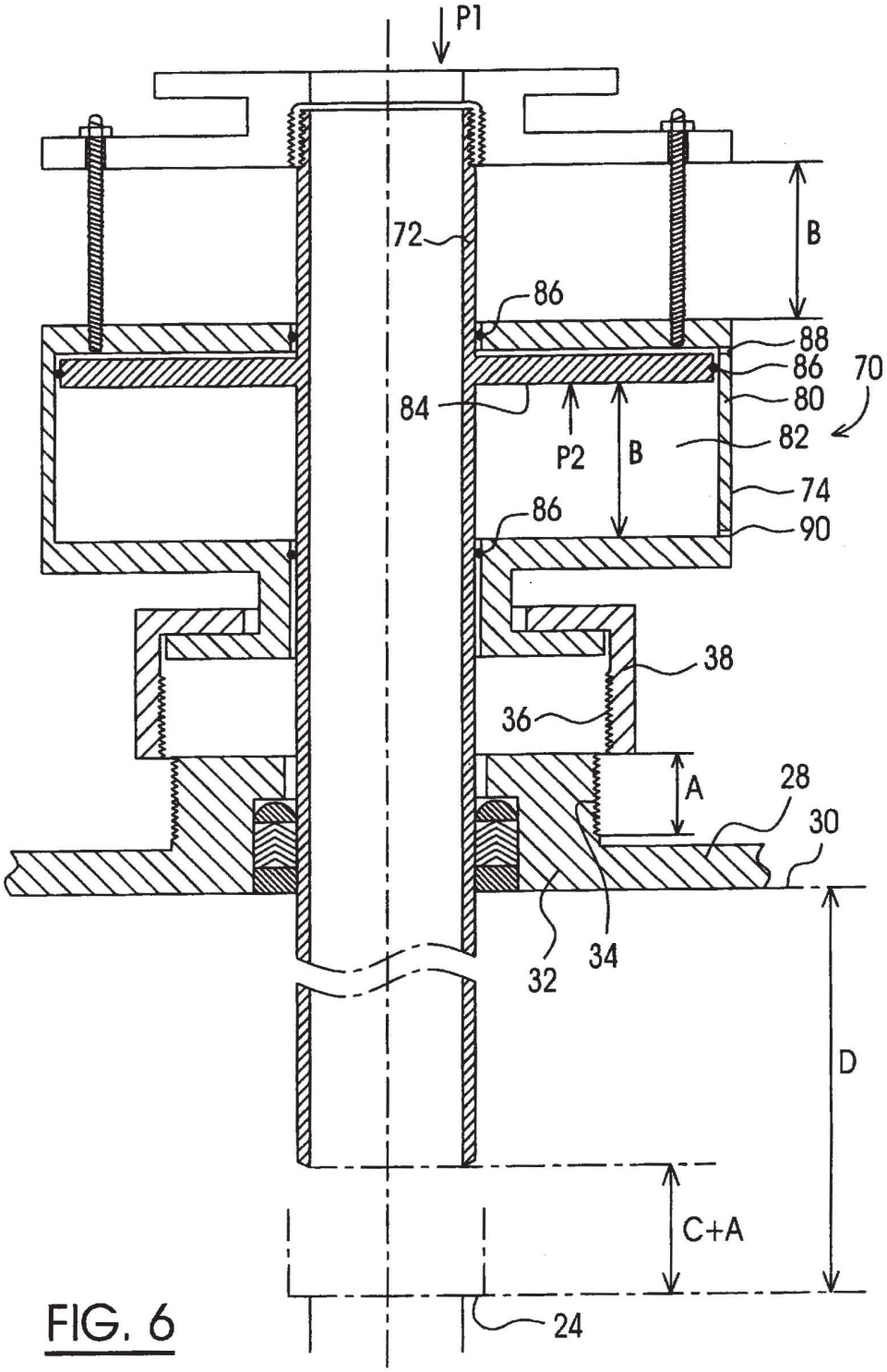

FIG. 6

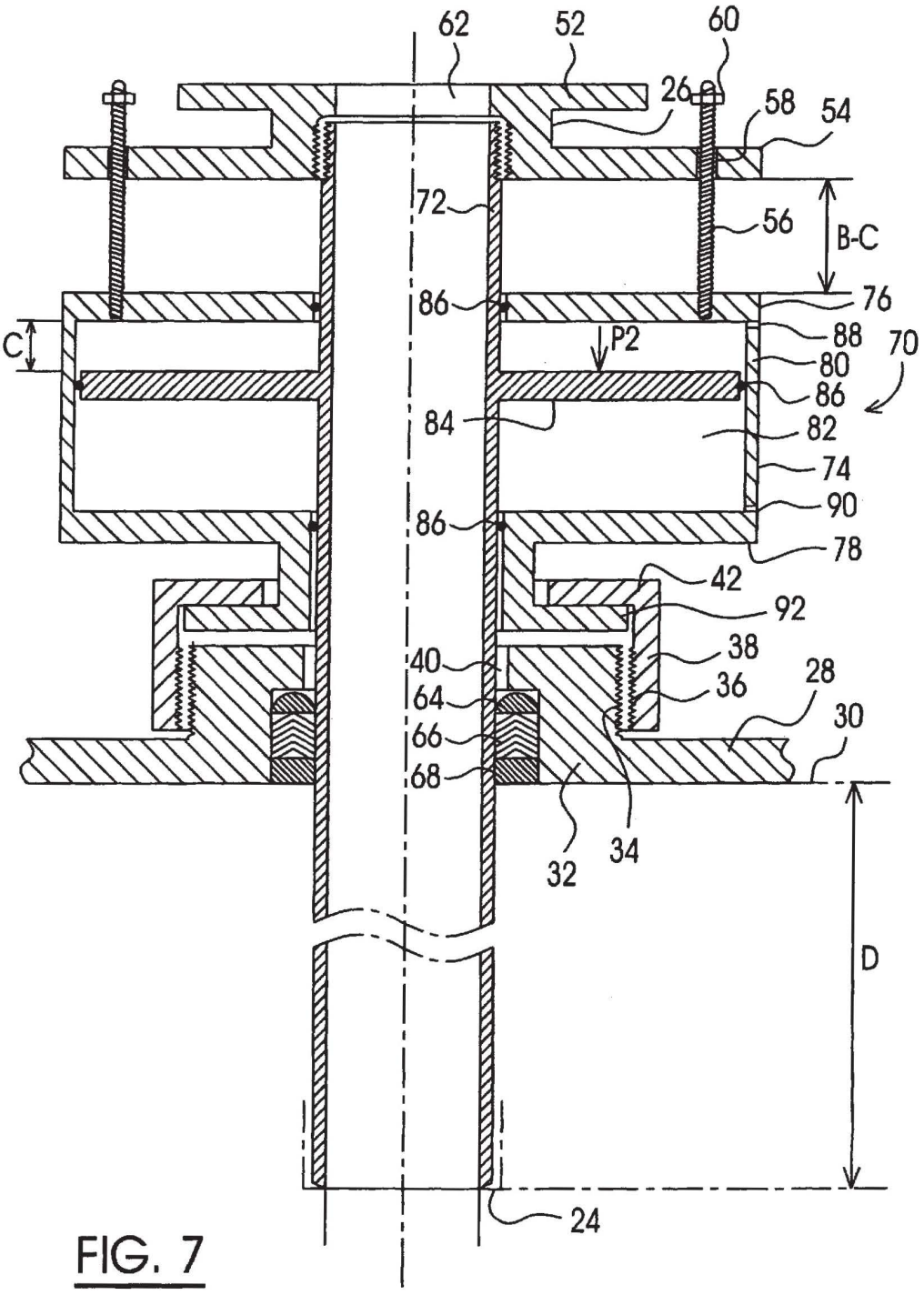
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FIG. 7

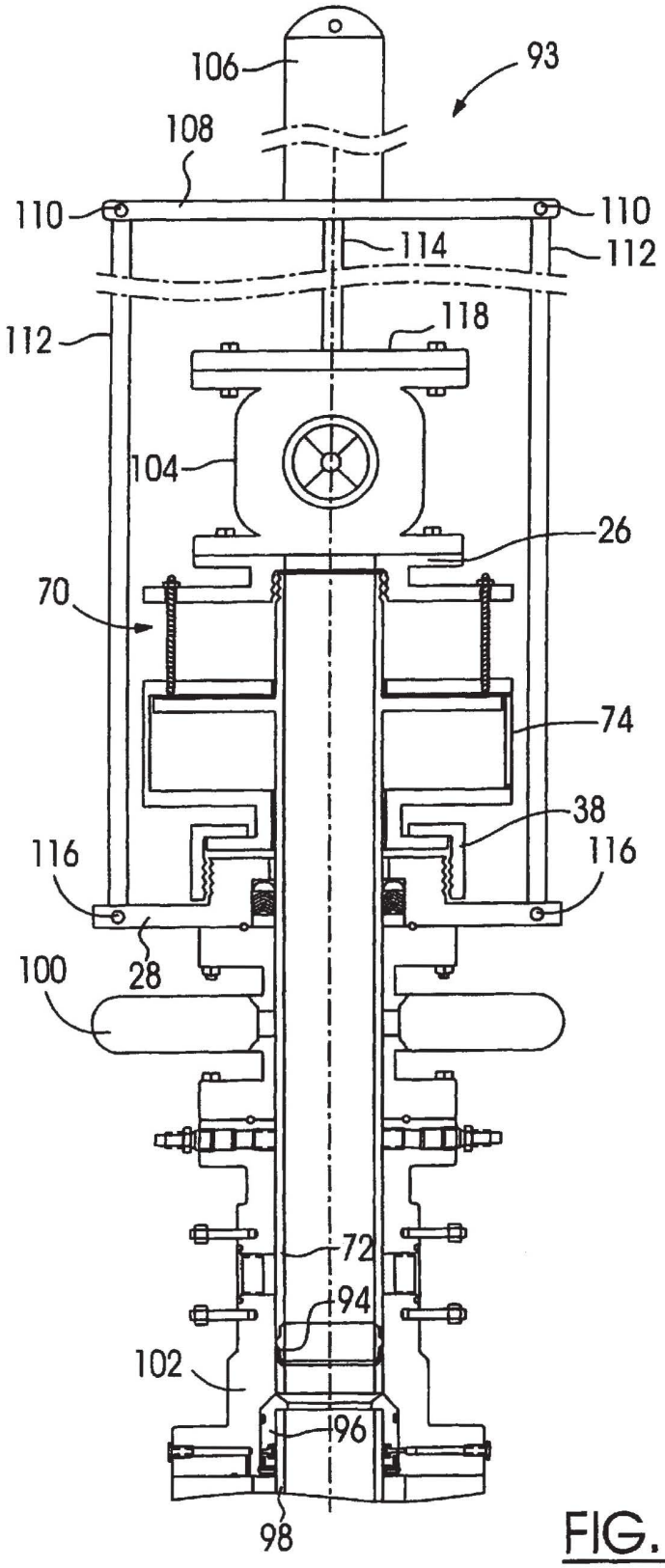
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FIG. 8

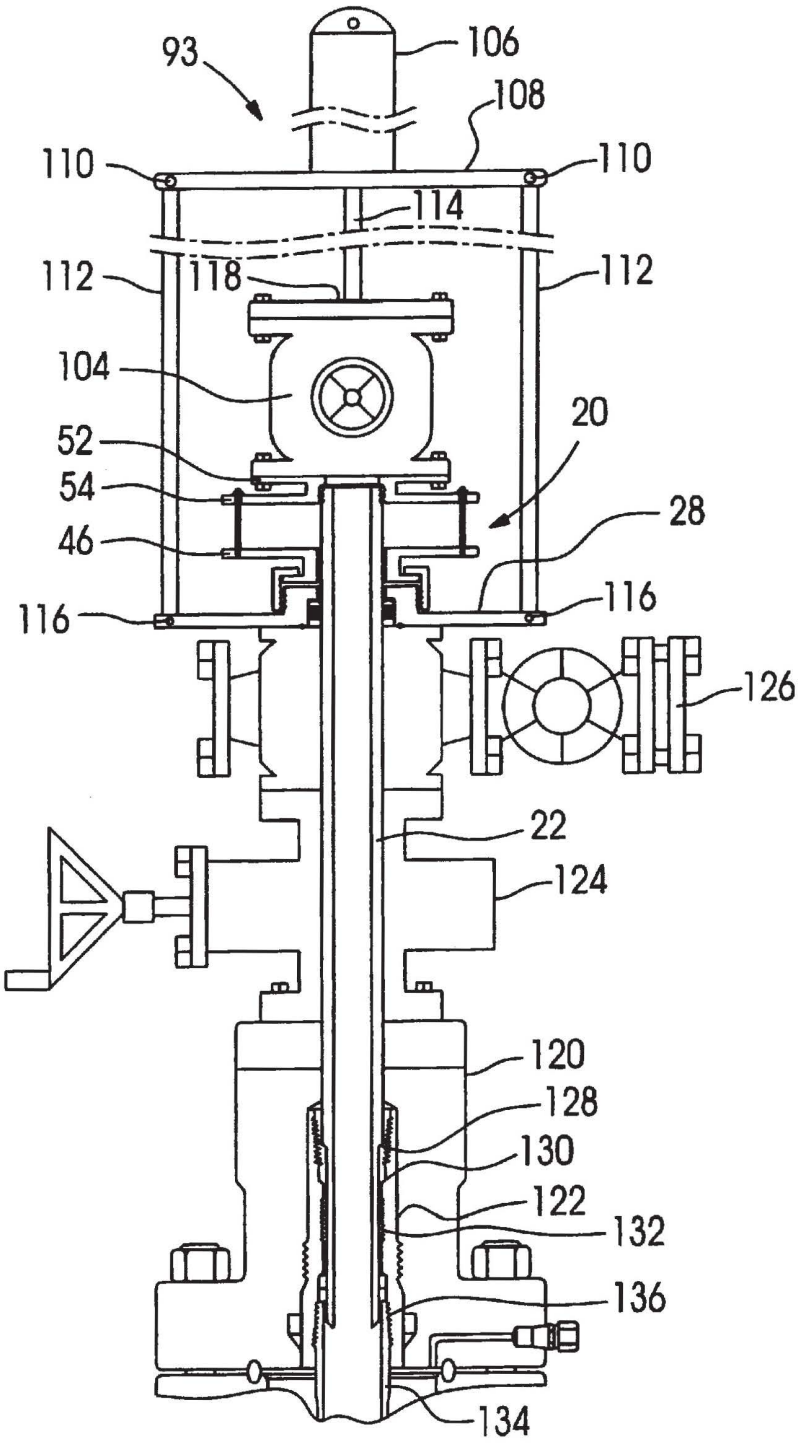
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FIG. 9

LOCKDOWN MECHANISM FOR WELL TOOLS REQUIRING FIXED-POINT PACKOFF

TECHNICAL FIELD

The present invention relates to equipment for servicing oil and gas wells and, in particular, to an apparatus and method for securing a mandrel of a well tool in an operative position in which the mandrel is packed-off against a fixed-point in the well.

BACKGROUND OF THE INVENTION

Most oil and gas wells eventually require some form of stimulation to enhance hydrocarbon flow and make or keep them economically viable. The servicing of the oil and gas wells to stimulate production requires the pumping of fluids under high pressure. The fluids are generally corrosive and abrasive because they are frequently laden with corrosive acids and abrasive proppants such as sharp sand. Consequently, such fluids can cause irreparable damage to wellhead equipment if they are pumped directly through the spool and the various valves that make up the wellhead. To prevent such damage, wellhead isolation tools have been used and various configurations are well known in the art.

A general principle of wellhead isolation in the prior art is to insert a mandrel of the tools through the various valves and spools of the wellhead to isolate those components from the elevated pressures and the corrosive and abrasive fluids used in the well treatment to stimulate production. A top end of the mandrel is connected to one or more high pressure valves through which the stimulation fluids are pumped. A packoff assembly is usually provided at a bottom end of the mandrel for achieving a fluid seal against the inside of the production tubing or casing so that the wellhead is completely isolated from the stimulation fluids. The length of the mandrel need not be precise because the location of the packoff assembly in the production tubing or casing is immaterial so long as the mandrel is inserted into the production tubing or casing and a fluid tight seal is achieved between the production tubing or casing and the packoff assembly.

However, a packoff affixed to a bottom end of the mandrel which seals against the inside of the production tubing or casing, limits the internal diameter of the mandrel and, consequently, the flow rate at which stimulation fluids may be pumped into the well. To overcome this problem, applicant invented an improved mandrel for a wellhead isolation tool described in co-pending U.S. patent application Ser. No. 08/837,574 which was filed on Apr. 21, 1997 and entitled APPARATUS FOR INCREASING THE TRANSFER RATE OF PRODUCTION STIMULATION FLUIDS THROUGH THE WELLHEAD OF A HYDROCARBON WELL. The apparatus described in that patent application includes a mandrel for a wellhead isolation tool and a tubing hanger for use in conjunction with the mandrel. The mandrel includes an annular seal bonded to an outside wall above the bottom end of the mandrel. The annular seal cooperates with a sealing surface in the top end of the tubing hanger to isolate the wellhead equipment from high pressures and corrosive and abrasive materials pumped into the well during a well treatment to stimulate production. The novel construction of the mandrel and the tubing hanger eliminates the requirement for a packoff assembly attached to the bottom of the mandrel and thereby permits the mandrel to have a larger internal diameter for increasing the transfer rate of the production stimulation fluids through the wellhead. The axial length of the sealing surface in the tubing hanger available for packoff is limited and, therefore, the length of the mandrel is determined, to a large extent, by a distance from the top of the tubing hanger to the top of the wellhead.

Applicant describes another improved mandrel for a wellhead isolation tool in U.S. patent application Ser. No. 09/356,231 which was filed on Jul. 16, 1999 and entitled WELLHEAD ISOLATION TOOL AND METHOD OF USING SAME, which is incorporated herein by reference. The wellhead isolation tool includes a mandrel that is inserted into a wellhead. The mandrel is seated against an annular step above back pressure valve threads in a tubing hanger to isolate the pressure sensitive components of the wellhead from fluid pressure used in the well treatment and has a lower section extending past the back pressure valve threads and tubing threads into the tubing to protect the threads from washout. The annular step above the back pressure valve threads in the tubing hanger is a fixed-point for packoff of the mandrel and, therefore, a length of the mandrel is determined by the distance from the annular step to the top of the wellhead and a lockdown mechanism for securing the wellhead isolation tool to the wellhead preferably provides a range of adjustment to compensate for variations in the position of the top end of the mandrel when the mandrel is packed off in different wellheads.

Another example of a well tool in an operative position in which the mandrel of the well tool is packed-off against a fixed-point in the well is described in Applicant's U.S. Pat. No. 5,819,851 which issued on Oct. 13, 1998 and is entitled BLOWOUT PREVENTER PROTECTOR FOR USE DURING HIGH PRESSURE OIL/GAS WELL STIMULATION. The blowout preventer protector described in that patent includes a mandrel that is forcibly reciprocatable in an annular cavity of a spool. The mandrel is stroked down through a blowout preventer and packed off at the bottom end against a bit guide that is attached to a top end of the casing to protect the blowout preventer from exposure to fluid pressure as well as abrasive and corrosive well stimulation fluids. The bit guide attached to the top end of the casing provides a fixed-point for packoff of the mandrel.

It is apparent from the examples described above that, as a result of new tools being invented and new technology being developed, there is a need for a lockdown mechanism for securing a well tool requiring a fixed-point packoff in an operative position in the well.

The blowout preventer protector described in U.S. Pat. No. 5,819,851 includes a mandrel that is integrally incorporated with a hydraulic setting tool. The mandrel is not separable from the hydraulic setting tool and the setting tool is used to hydraulically lock the mandrel in an operative position. The mandrel. can be secured at any location within the annular cavity by maintaining the hydraulic pressure in the annular cavity after the mandrel is packed-off against the bit guide. The stroke of the hydraulic setting tool is used for inserting the mandrel through the blowout preventer, and also provides compensation for variations in a distance from the bit guide to the top of the blowout preventer when the mandrel is inserted through different wellheads. The blowout preventer protector is widely accepted in the industry and the hydraulic setting tool is very convenient for securing a mandrel of a well tool in the operative position requiring fixed-point packoff in the well. However, the setting tool must be fairly long to provide sufficient stroke. Furthermore, the setting tool is not removable from the mandrel during a well treatment to stimulate production. Consequently, the blowout preventer protector has a high profile. A well tool with a high profile is not convenient because access to

equipment mounted thereto, such as a high pressure valve, is impeded by the height of the valve above ground. In addition, a hydraulic lockdown mechanism is considered less secure than a mechanical lockdown mechanism. The hydraulic lockdown mechanism is dependent on maintenance of the hydraulic fluid pressure in the setting tool. Since fluid pressure may be lost for a variety of reasons, persons in the industry are generally less inclined to endorse or accept a hydraulic lockdown mechanism.

A mechanical lockdown mechanism having a range of adjustment is used for the well tools described in Applicant's co-pending U.S. patent application filed on Jun. 23, 1999 and the application filed on Jul. 16, 1999 referenced above. The mechanical lockdown mechanism described in the above two patent applications is for securing a mandrel of well tools in an operative position requiring fixed-point packoff in the well, and provides a broad range of adjustment to compensate for variations in the height of different wellheads to which the well tool is mounted. The mechanical lockdown mechanism includes a base member that is adapted to be mounted to a top of the wellhead, the base member having a central passage to permit the insertion and the removal of the mandrel. The passage is surrounded by an integral sleeve having an elongated spiral thread for engaging a lockdown nut that is adapted to secure the mandrel in the operative position. The spiral thread on the integral sleeve and the lockdown nut have a length adequate to ensure safe operation at well stimulation fluid pressures. At least one of the spiral threads on the integral sleeve and the lockdown nut has a length adequate to provide a significant range of adjustment to compensate for variation in a distance between the top of the wellhead and the fixed-point for packoff in the well when the tool is mounted to different wellheads. The mechanical lockdown mechanism is separated from the hydraulic setting tool and, therefore, permits the setting tool to be removed from the well tool after the mandrel is locked down in the operative position. The tools therefore provide a low profile to facilitate well stimulation operations. The advantages also include the security of a mechanical lockdown mechanism. Therefore, there exists a need for a lockdown mechanism for securing a mandrel of a well tool in an operative position requiring fixed-point packoff in the well which provides a broader range of adjustment while ensuring a secure mechanical lockdown for maximum security.

SUMMARY OF THE INVENTION

It is a primary object of the invention to provide a lockdown mechanism for securing a mandrel of a well tool in an operative position in which the mandrel is packed-off against a fixed-point in the well.

It is another object of the invention to provide a lockdown mechanism for securing a mandrel of the well tool in an operative position requiring fixed-point packoff in the well, the lockdown mechanism having a low profile for easy access to a high pressure valve during use while the tool is in the operative position.

It is a further object of the invention to provide a lockdown mechanism for securing a mandrel of the well tool in an operative position requiring fixed-point packoff in the well which is convenient to use.

It is yet a further object of the invention to provide a lockdown mechanism for securing a mandrel of a well tool in an operative position requiring fixed-point packoff in the well which combines a hydraulic lockdown mechanism with a mechanical lockdown mechanism.

In accordance with one aspect of the invention, there is provided an apparatus for securing a mandrel of a well tool in an operative position requiring fixed-point packoff in the well, comprising a first and a second lockdown mechanism arranged so that the mandrel is locked in the operative position only when both the first and the second lockdown mechanisms are in respective lockdown positions; the first lockdown mechanism adapted to detachably maintain the mandrel in proximity to the fixed-point packoff when in the lockdown position, the first lockdown mechanism including a base member for connection to a wellhead of the well and a locking member for detachably engaging the base member; and the second lockdown mechanism having a range of adjustment adequate to ensure that the mandrel can be moved into the operative position and locked down in the operative position while the first lockdown mechanism is in the lockdown position.

The second lockdown mechanism preferably comprises a first member connected to the mandrel and a second member connected to the locking member of the first lockdown mechanism, the first and second members being linked to permit movement with respect to each other within the range of adjustment.

In accordance with one embodiment of the invention, the second member of the second lockdown mechanism includes at least one threaded bolt connected at a fixed end to the locking member of the first lockdown mechanism and the first member of the second lockdown mechanism has at least one bore to permit the at least one threaded bolt to pass therethrough without resistance, the at least one threaded bolt being prevented from being withdrawn from the bore by a lock nut which is adapted to be rotated from a free end of the threaded bolt towards the fixed end to lock the second lockdown mechanism in the lockdown position.

In accordance with another embodiment of the invention, the first member of the second lockdown mechanism includes a piston fixed to the mandrel and the second member of the second lockdown mechanism includes a cylinder connected with the locking member of the first lockdown mechanism, the piston being adapted to be reciprocated within the cylinder using fluid pressure.

In accordance with another aspect of the invention, there is provided an apparatus used for securing a mandrel of a well tool in an operative position in which the mandrel is packed off against a fixed-point in the well, comprising a mechanical lockdown mechanism for detachably securing the well tool to a wellhead of the well and maintaining the mandrel in proximity to the fixed-point for packoff, the mechanical lockdown mechanism including a base member for connection of the wellhead and a locking member for detachably engaging the base member; a hydraulic mechanism including a cylinder and a piston which may be reciprocated within the cylinder using fluid pressure, the cylinder being connected to the locking member of the mechanical lockdown mechanism and the piston being fixed to the mandrel of the tool so that the mandrel may be moved to and maintained in the operative position by injecting fluid pressure into the cylinder while the mechanical lockdown mechanism is in a lockdown position. The hydraulic mechanism preferably comprises a mechanical locking mechanism to ensure the mandrel is maintained in the operative position in the event that the fluid pressure is lost.

The invention provides a lockdown mechanism with a greater range of adjustment for securing a mandrel of a well tool in an operative position requiring fixed-point packoff in the well, in comparison with prior art lockdown mecha-

nisms. Consequently, the length of a mandrel may be less precisely matched to a distance from the fixed-point for packoff to the top of the wellhead. Other features and advantages will become apparent given the preferred embodiments which are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be further explained by way of example only and with reference to the following drawings, in which:

FIGS. **1** to **4** illustrate cross-sectional views of an apparatus in various working positions in accordance with a preferred embodiment of the invention;

FIGS. **5** to **7** illustrate cross-sectional views of an apparatus in various working positions in accordance with another preferred embodiment of the invention;

FIG. **8** is a schematic diagram of the apparatus shown in FIG. **5** mounted to a blowout preventer through which a mandrel is to be stroked and secured in an operative position in which the mandrel is packed off against a bit guide mounted to a top of a casing of the well; and

FIG. **9** is a schematic diagram of the apparatus shown in FIG. **1** mounted to a wellhead through which a mandrel is to be stroked and secured in an operative position in which the mandrel is packed off against an annular step in a tubing hanger of the wellhead.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. **1** shows a cross-sectional view of a first lockdown mechanism **20** for securing a mandrel **22** of a well tool in an operative position in which the mandrel **22** is packed off against a fixed-point **24** in the well. The fixed-point for packoff may be a bit guide mounted to the top of a casing, as shown in FIG. **8**, an annular step above back pressure valve threads of a tubing hanger, as shown in FIG. **9**, or any other type of fixed-point location used for packoff in a wellhead, a casing, a tubing or a downhole tool. For the purpose of convenient description, the mandrel is assumed to be packed off against a fixed packoff point at the bottom of FIGS. **1** through **7**.

The apparatus **20** includes a mandrel head **26** connected to a top end of the mandrel **22** and a base plate **28** mounted to a top of the wellhead, which is indicated by line **30**. The mandrel head **26** is separable from the base plate **28** to permit the mandrel **22**, which is connected to the mandrel head **26**, to be inserted through the base plate **28** into the wellhead until the mandrel **22** reaches a fixed-point **24** for packoff. In different wellheads, a distance "D" from the fixed-point **24** for packoff to the top of the wellhead may vary. Although a length "L" of the mandrel **22** may be adjusted by the insertion of extension sections, as described in Applicant's co-pending patent applications, it is not practical to provide a large number of extension sections, each having a different length to permit mandrels to be assembled to precisely match the distance "D" of each wellhead. A distance "d" from a top of the wellhead **30** to a top end of the mandrel **22** is a constant when the mandrel **22** is locked down to the base plate **28** by a first locking member **38**, as shown in FIG. **1**. Consequently, a range of adjustment "B" is provided by a second locking member such that "B" is greater than a distance "C" between a bottom end of the mandrel **22** and the fixed packoff point **24** when the mandrel **22** is locked down to the base plate **28**, as shown in FIG. **1**.

The base plate **28** is preferably a circular disc which includes an integral concentric sleeve **32** perpendicular to the base plate **28**. A spiral thread **34** on the exterior of the integral sleeve **32** mates with a complementary spiral thread **36** on an interior surface of a lockdown nut **38**. The base plate **28** and the integral sleeve **32** include a central passage **40** to permit the mandrel **22** to pass through. The lockdown nut **38** includes a top wall **42** for rotatably retaining a connector **44**. The connector **44** is a cylindrical body with an upper flange **46** and a lower flange **48** which engages the top wall **42** of the lockdown nut **38**. A central passage **50** through the connector **44** permits the mandrel **22** to fully pass through. The mandrel head **26** is a cylindrical body with an upper flange **52** for connection of equipment, such as a high pressure valve, and a lower flange **54** which is adjustably linked to the connector **44**. The adjustable link between the connector **44** and the mandrel head **26** is provided by at least two threaded bolts **56** which extends through at least two respective bores **58** in the lower flange **54**. The threaded bolts **56** are connected at their fixed ends to the upper flange **46** of the connector **44**. Nuts **60** at a free end of each bolt **56** prevents the bolt from being withdrawn from the flange **54**. The bore **58** has an internal diameter slightly larger than an external diameter of the bolt **56** to permit the bolt **56** to pass therethrough without resistance. The threaded bolt **56** has an adequate length to permit the range "B" of movement of the mandrel head **56** relative to the connector **44**.

When the lockdown nut **38** is locked to the integral sleeve **32** by the engagement of threads **34**, **36** and the mandrel head **26** is moved towards or away from the connector **44** within the range "B", the mandrel can be packed off against a fixed-point for packoff. Therefore, when the mandrel **22** may be used with wellheads having different configurations and the distance D from the fixed-point **24** for packoff to the top of the wellhead indicated by line **30** varies by a distance "C" that is not greater than the range of adjustment "B", that is, $0 \leqq C \leqq B$, the apparatus **20** is adapted to be locked down in the operative position in which a bottom end of the mandrel **22** is packed off against the fixed-point **24** for packoff.

As will be understood by those skilled in the art, in order to safely restrain fluid pressure during a well treatment to stimulate production, the number of the threaded bolts **56**, nuts **60** and bores **58** is generally more than two. The bolts **56** are circumferentially spaced from each other, the number of each being dictated by the fluid pressures to be restrained and the quality of materials used. The periphery of the lower flange **54** of the mandrel head **26** extends beyond the flange **52** of the mandrel head **26** so that the upper flange **52** does not interfere with the threaded bolts **56** as the mandrel head **26** is moved towards the connector **44**. The mandrel head **26** has a central passage **62** in fluid communication with the mandrel **22**. The passage **62** has a diameter not smaller than the internal diameter of the mandrel **22** for a full access to the mandrel. A spiral thread is provided at the lower end of the central passage **62** for connection of the threaded top end of the mandrel **22**. A sealing mechanism (not shown) is provided in the threaded connection between the top end of the mandrel **22** and the mandrel head **26** to prevent well fluids from escaping to atmosphere. The central passage **40** through the base plate **28** has a recessed lower region for receiving a steel spacer **64** and packing rings **66** preferably constructed of brass, rubber and fabric. The steel spacer **64** and packing rings **66** define a passage of the same diameter as the periphery of the mandrel **22**. The steel spacer **64** and the packing rings **66** are removable and may be interchanged to accommodate different sizes of mandrel **22**. The steel spacer **64** and the packing rings **66** are retained in the recessed region by a retainer nut **68**. The combination of the

steel spacer **64**, packing rings **66** and the retainer nut **68** provide a fluid seal to prevent the passage to atmosphere of well fluids between the exterior of the mandrel **22** and the interior of the wellhead when the mandrel **22** is inserted into the wellhead.

FIG. **2** shows a cross-sectional view of the apparatus **20** in a working position in which the nuts **60** are at the free end of the threaded bolts **56** and the lockdown nut **38** is disengaged from the base plate **28**. In this condition, the base plate **28** can be mounted on the top of the wellhead while the other parts of the apparatus **20** are connected to the top end of mandrel **22** and are moved with the mandrel **22** when the mandrel **22** is inserted into the wellhead by a setting tool, which will be described in more detail with reference to FIGS. **8** and **9**. When the apparatus **20**, except for the base plate **28**, is moved downwardly as the mandrel **22** is inserted through the wellhead, the upper flange **46** of the connector **44** is spaced from the lower flange **54** of the mandrel head **26**, as shown in FIG. **2**. For safe engagement to restrain the high fluid pressures during a well treatment to stimulate production, threads **34–36** are engaged a distance "A" by rotating the lockdown nut **38**. At this stage, the bottom end of the mandrel **22** is still above the fixed-point **24** for packoff by the distance "C", as shown in FIG. **1**. After the lockdown nut **38** is fully engaged as shown in FIG. **3**, the mandrel **22** is further stroked down until the bottom end of the mandrel **22** packs off against the fixed-point **24**. The nuts **60** are then rotated down against the lower flange **54** of the mandrel head **26** to prevent a fluid seal on the lower end of mandrel **22** (not shown) from being forced away from the fixed-point **24** for packoff after the setting tool is removed from the wellhead and pressurized fluids are injected into the well.

Alternatively, the mandrel **22** with connected mandrel head **26** may be stroked downwardly without engaging the lockdown nut **38** with the base plate **28** as shown in FIG. **4** until the bottom end of the mandrel **22** is packed off in an operative position against the fixed-point **24** for packoff. The lockdown nut **38** is then rotated to engage the threads **34** on the integral sleeve **32**. The final locked position is the same as shown in FIG. **3**. Therefore, the nuts **60** are turned down against the lower flange **54** of the mandrel head **26** to lock the apparatus **20** in the operative position.

FIG. **5** is a cross-sectional view of an apparatus **70** in accordance with another preferred embodiment of the invention. The apparatus **70** includes a mandrel head **26** threadedly connected to a top end of the mandrel **72** and a base plate **28** adapted to be mounted to the top of the wellhead, indicated by line **30**. The mandrel head **26**, base plate **28** and other parts indicated by reference numerals corresponding to those shown in FIG. **1** are respectively identical to the corresponding parts of the apparatus **70**. The principal difference is that the apparatus **70** includes an integral hydraulic cylinder **74** in place of the connector **44** of the apparatus **20**. The hydraulic cylinder **74** includes upper and lower walls **76**, **78** which respectively surround the mandrel **72**. The cylinder **74** further includes a sidewall **80** which defines an annular cavity **82**. A piston **84** is fixed to the mandrel **72**. O-ring seals **86** are provided respectively between the piston **84** and sidewall **80**, upper wall **76** and the lower wall **78** and the exterior surface of a mandrel **72** to permit introduction of pressurized hydraulic fluid into the annular cavity **82** to induce movement of the piston **84**. The hydraulic fluid is injected, as required, through an upper port **88** and drained through a lower port **90**, and vice versa. The piston preferably has a stroke about equal to the distance "B", to match the functional length of the threaded bolts **56**. The threaded bolts **56** are connected at their fixed ends to the upper wall **76**. The cylinder **74** further includes a connecting flange **92** connected to but spaced from the lower wall **78** for rotatable engagement with the top wall **42** of the lockdown nut **38**.

FIG. **6** is a cross-sectional view of the apparatus **70** shown in FIG. **5** with the piston **84** at the top of cylinder **74**, and the lockdown nut **38** disengaged from the integral sleeve **32** of the base plate **28**. As described above, the base plate **28** is mounted to the top of the wellhead before the mandrel **72** is inserted into the wellhead. The mandrel **72** is stroked down under a force **P1** exerted by a setting tool, as will be described below with reference to FIGS. **8** and **9**. The piston **84** is maintained at a top of the hydraulic cylinder by a force **P2** exerted by pressurized hydraulic fluid trapped in the cylinder. The lockdown nut **38** is turned down to its locked position as shown in FIG. **5**. The bottom end of the mandrel **70** is then a distance "C" above the fixed-point **24** for packoff.

After the lockdown nut **38** is fully engaged with the base plate **28**, the setting tool is removed from the wellhead and the well tool is left unobstructed for access. Pressurized hydraulic fluid is injected into the upper port **88** of the cylinder **74** while the hydraulic fluid below the piston **84** is drained from the lower port **90** so that the mandrel **72** is forced downwardly to packoff against the fixed-point **24** under a force **P2** exerted on the piston **84** by the pressurized hydraulic fluid, as shown in FIG. **7**. The mandrel head **26** is thus forced downwardly over the distance "C" so that the space between the mandrel head **26** and the upper wall **76** of the cylinder **74** is reduced to B-C. The mandrel **72** is locked down in its operative position by the hydraulic force **P2**. To ensure that the mandrel is secured in the operative position, the nuts **60** are turned down against the lower flange **54** of the mandrel head **26**.

FIG. **8** shows an example of the use of the apparatus **70** shown in FIG. **5**, using a hydraulic setting tool **93** to insert the mandrel **72** to an operative position for a well treatment to stimulate production. In this example, the mandrel **72** is used to protect a blowout preventer **100** and includes a packoff assembly **94** that is packed-off against a top of a bit guide **96** mounted to a top of a casing **98**, as described in Applicant's co-pending patent application filed Jun. 23, 1999. The hydraulic setting tool **93** illustrated in FIG. **8** is also described in Applicant's U.S. Pat. No. 4,867,243 which issued on Sep. 19, 1989 and is entitled WELLHEAD ISOLATION TOOL AND SETTING TOOL AND METHOD OF USING SAME, which is incorporated herein by reference. The blowout preventer **100** is connected to the well casing **98** by various spools, such as a tubing head spool **102**, for example. The blowout preventer **100** and the tubing head spool **102** are wellhead equipment that is well known in the art and their construction and function do not form a part of this invention. The blowout preventer **100** and the tubing head spool **102** are, therefore, not described. The apparatus **70** is supported on a top of the blowout preventer by mounting the base plate **28** in a fluid tight relationship to the top flange of the blowout preventer **100**. Mounted above the apparatus **70**, is a high pressure valve **104** which is used for fluid flow control during a well treatment to stimulate production and, also used to prevent well fluids from escaping to the atmosphere from the top of the mandrel **72**. The high pressure valve **104** is typically a hydraulic valve well known in the art. The hydraulic setting tool **93** includes a hydraulic cylinder **106** which is mounted to a support plate **108**. The support plate **108** includes a central passage (not shown) to permit a piston rod **114** of the hydraulic cylinder **106** to pass through the support plate **108**. The support **108**

also includes at least two attachment points **110** for attachment of respective hydraulic cylinder support rods **112**. The spaced apart attachment points **110** are preferably equally spaced from the central passage to ensure that the hydraulic cylinder **106** and the piston rod **114** align with the blowout preventer **100**. The hydraulic cylinder support rods **112** are respectively attached at their lower ends to corresponding attachment points **116** on the base plate **28**. As is apparent, the base plate **28** and the support plate **108** have a periphery that extends beyond the wellhead to provide enough radial offset of the cylinder support rods **112** to accommodate the high pressure valve **104**, the mandrel head **26** and the cylinder **74**. The support rods **112** are identical in length. The support rods **112** are attached to the respective spaced apart attachment points **110**, **116** on the support plates **108** and the base plate **28** by means of threaded fasteners or pins (not illustrated). The piston rod **114** is attached to the top of the high pressure valve **104** by a connector **118** so that a force can be applied to stroke the mandrel **72** down through the wellhead.

After the mandrel **72** is stroked downwardly to an extent that the packoff assembly **94** is in proximity to the bit guide **96**, and the lockdown nut **38** is turned down to its locked position, as illustrated in FIG. **8**, the setting tool **93** including the hydraulic cylinder **106**, support plate **108**, cylinder support rods **112** and the connector **118** are removed. The packoff assembly **94** on the bottom of the mandrel **72** is then stroked further down until it is packed off against the bit guide **96** by injecting pressurized fluid into the top port **88** of the hydraulic cylinder **74**, as illustrated in FIG. **7**.

FIG. **9** shows an example of the use of the apparatus **20**, shown in FIG. **1**, using the hydraulic setting tool **93** to insert the mandrel **22** to an operative position for a well treatment to stimulate production. In this example, the wellhead is constructed in a well known manner from a series of valves and related flanges. The wellhead schematically illustrated in FIG. **9** includes a tubing spool **120** which receives and supports a tubing hanger **122**. Connected by flange connections to the top of the tubing spool **120**, are valves **124** and **126**. The purpose of the two valves **124** and **126** is to control the flow of hydrocarbons from the well. The apparatus **20** is mounted above the wellhead, that is, atop the valve **126**. The mandrel **22** is inserted through the wellhead into the operative position in which an elastomeric seal (not shown) on a sealing shoulder **128** is seated against an annular step **130** located above back pressure valve threads **132** of the tubing hanger **122** while a lower section of the mandrel **22** enters the top of the tubing **134** to protect the back pressure valve threads **132** and tubing threads **136**, as described in Applicant's co-pending patent application filed Jul. 16, 1999. The annular step **130** of the tubing hanger **122** is the fixed-point **24** for packoff in the well. The distance from the annular step **130** to the top of the valve **126** may vary in different wellheads and, therefore, the apparatus **20** is used to provide a broad range of adjustment to compensate for variations to ensure that the mandrel **22** can be locked down in the operative position. After the setting tool **93** is mounted to the base plate **28** in the same way as described with reference to FIG. **8**, the steps described with reference to FIGS. **1** to **4** are followed to lock the mandrel **22** in the operative position in which the elastomeric seal on the sealing shoulder **128** of the mandrel **22** is packed-off against the annular step **130**.

The two examples described with reference to FIGS. **8** and **9** are for the purpose of illustration of the invention only and do not limit the applications of the invention. For example, the two embodiments described above may be used interchangeably. Likewise, other setting tool known in the art may be used in conjunction with the apparatus **20** or **70** for inserting the mandrel through the wellhead into proximity of the operative position. For example, a setting tool described by McLeod in U.S. Pat. No. 4,632,183 and entitled INSERTION DRIVE SYSTEM FOR TREE SAVERS which issued on Dec. 5, 1984, the entire specification which is incorporated herein by reference, may be used. Another type of setting tool which may also be used to insert the mandrel in proximity to the operative position is described by Bullen in U.S. Pat. No. 4,241,786, entitled WELLTREE SAVER which issued on May 2, 1979 and is also incorporated herein by reference.

It should also be understood that the apparatus described above can be used to lock down other types of tools which must be packed-off against a fixed-point in a well and is not limited to use with the mandrels described above.

Modifications and improvements to the above-described embodiments of the invention may become apparent to those skilled in the art. The foregoing description is intended to be exemplary rather than limiting. The scope of the invention is therefore intended to be limited solely by the scope of the appended claims.

What is claimed is:

1. An apparatus for securing a mandrel of a well tool in an operative position requiring fixed-point packoff in the well, comprising:

a first and a second lockdown mechanism arranged so that the mandrel is locked in the operative position only when both the first and the second lockdown mechanism are in respective lockdown positions;

the first lockdown mechanism adapted to detachably maintain the mandrel in proximity to the fixed-point packoff when in the lockdown position, the first lockdown mechanism including a base member for connection to a wellhead of the well and a locking member for detachably engaging the base member; and

the second lockdown mechanism having a range of adjustment adequate to ensure that the mandrel can be moved into the operative position and locked down in the operative position while the first lockdown mechanism is in the lockdown position.

2. An apparatus as claimed in claim **1** wherein the second lockdown mechanism comprises a first member connected to the mandrel and a second member connected to the locking member of the first lockdown mechanism, the first and the second members being linked to permit movement with respect to each other within the range of adjustment.

3. An apparatus as claimed in claim **2** wherein the base member of the first lockdown mechanism includes a central passage to permit insertion of the mandrel down through the wellhead, and an elongated spiral thread for engaging a complementary spiral thread of the locking member.

4. An apparatus as claimed in claim **3** wherein the base member includes a base plate having an elongated sleeve perpendicular to the base plate, an interior of the sleeve forming the central passage and an exterior of the sleeve forming the elongated spiral thread, the base plate being adapted to be detachably mounted to a top of the wellhead of the well.

5. An apparatus as claimed in claim **2** wherein the second member of the second lockdown mechanism includes at least one threaded bolt connected at a fixed end to the locking member of the first lockdown mechanism and the first member of the second lockdown mechanism has at least one bore to permit the at least one threaded bolt to pass through without resistance, the at least one threaded bolt

being prevented from being withdrawn from the bore by a lock nut which is adapted to be rotated from a free end of the threaded bolt towards the fixed end to lock the second lockdown mechanism in the lockdown position.

6. An apparatus as claimed in claim **5** wherein a length of the threaded bolt determines the range of the adjustment.

7. An apparatus as claimed in claim **6** wherein the first member of the second lockdown mechanism includes a flange having a central passage, the flange being connected in a fluid sealing relationship with a top end of the mandrel, the central passage being in fluid communication with the mandrel.

8. An apparatus as claimed in claim **2** wherein the first member of the second lockdown mechanism includes a piston fixed to the mandrel and the second member of the second lockdown mechanism includes a cylinder connected with the locking member of the first lockdown mechanism, the piston being adapted to be reciprocated within the cylinder using fluid pressure.

9. An apparatus as claimed in claim **8** wherein a maximum stroke of the piston within the cylinder determines the range of adjustment of the second lockdown mechanism.

10. An apparatus as claimed in claim **8** wherein the second lockdown mechanism comprises a mechanical locking mechanism adapted to ensure the mandrel is maintained in the operative position in the event that the fluid pressure is lost.

11. An apparatus as claimed in claim **10** wherein the mechanical locking mechanism includes at least two threaded bolts connected at a fixed end to the cylinder and at a free end to a flange connected to the mandrel, the flange having at least two bores to permit the at least two threaded bolts to pass through without resistance, the at least two threaded bolts being prevented from being withdrawn from the bore by a lock nut which is adapted to be rotated from the free ends of the threaded bolts towards the fixed ends to lock the second lockdown mechanism in the lockdown position.

12. An apparatus as claimed in claim **11** wherein a length of the threaded bolts is determined by the maximum stroke of the piston within the cylinder.

13. An apparatus as claimed in claim **12** wherein the flange of the mechanical locking mechanism includes a central passage, the flange being connected in a fluid sealing relationship with a top end of the mandrel and the central passage being in fluid communication with the mandrel.

14. An apparatus used for securing a mandrel of a well tool in an operative position in which the mandrel is packed off against a fixed-point in the well, comprising:

a mechanical lockdown mechanism for detachably securing the well tool to a wellhead of the well and maintaining the mandrel in proximity to the fixed-point for packoff, the mechanical lockdown mechanism including a base member for connection to the wellhead and a locking member for detachably engaging the base member;

a hydraulic mechanism including a cylinder and a piston which may be reciprocated within the cylinder using fluid pressure, the cylinder being connected to the locking member of the mechanical lockdown mechanism and the piston being fixed to the mandrel of the tool so that the mandrel may be moved to and maintained in the operative position by injecting fluid pressure into the cylinder while the mechanical lockdown mechanism is in a lockdown position.

15. An apparatus as claimed in claim **14** wherein a maximum stroke of the piston determines a maximum range of the proximity enabled when the mechanical lockdown mechanism is in the lockdown position.

16. An apparatus as claimed in claim **15** wherein the hydraulic mechanism comprises a mechanical locking mechanism adapted to ensure the mandrel is maintained in the operative position in the event that the fluid pressure is lost from the hydraulic cylinder.

17. An apparatus as claimed in claim **16** wherein the mechanical locking mechanism includes at least two threaded bolts connected at fixed ends to the cylinder and at free end to a flange connected to the mandrel, the flange having at least two bores to permit the at least two threaded bolts to pass through without resistance, the at least two threaded bolts being prevented from being withdrawn from the bores by lock nuts which are adapted to be rotated from the free ends of the threaded bolts towards the fixed ends to ensure the tool is locked in the lockdown position.

18. An apparatus as claimed in claim **17** wherein a length of the threaded bolt is determined by the maximum stroke of the piston.

19. An apparatus as claimed in claim **18** wherein the flange of the mechanical locking member includes a central passage, the flange being connected in a fluid sealing relationship to a top end of the mandrel and the central passage being in fluid communication with the mandrel.

20. An apparatus as claimed in claim **14** wherein the base member of the mechanical lockdown mechanism includes a central passage to permit insertion of the mandrel down through the wellhead, and an elongated spiral thread for engaging a complementary spiral thread of the locking member.

21. An apparatus as claimed in claim **20** wherein the base member includes a base plate having an elongated sleeve perpendicular to the base plate, an interior of the sleeve forming the central passage and an exterior of the sleeve forming the elongated spiral thread, the base plate being adapted to be detachably mounted to a top of the wellhead of the well.

22. A method for lockdown of a mandrel of a well tool in an operative position in which the mandrel is packed off against a fixed-point in the well, comprising steps of:

a) mounting above a wellhead of the well an apparatus for securing the mandrel of the well tool in the operative position, comprising a first and a second lockdown mechanism arranged so that the mandrel is locked in the operative position only when both the first and second lockdown mechanisms are in respective lockdown positions; the first lockdown mechanism being adapted to detachably maintain the mandrel in proximity to the fixed-point for packoff, and including a base member for connection to a top of a wellhead of the well and a locking member for detachably engaging the base member; and the second lockdown mechanism having a range of adjustment to ensure that the mandrel can be moved into the operative position and locked down in the operative position while the first lockdown mechanism is in the lockdown position;

b) after inserting the mandrel through the wellhead into proximity to the fixed-point in the well, engaging the locking member of the first lockdown mechanism with the base member so that the mandrel is only moveable within the range of adjustment;

c) moving the mandrel into the operative position if the mandrel is not yet packed off against the fixed-point; and

d) locking the second lockdown mechanism in the lockdown position.

23. A method as claimed in claim **22** wherein step (d) includes a step of locking a first member of the second

lockdown mechanism relative to a second member of the second lockdown mechanism, the first member being connected to the mandrel and the second member being connected to the locking member of the first lockdown mechanism, the first and second members being adapted to permit movement with respect to each other within the range of adjustment when the respective first and second members are in an unlocked condition.

24. A method as claimed in claim **22** wherein the second lockdown mechanism comprises a hydraulic cylinder connected to the locking member of the first lockdown mechanism and a piston connected to the mandrel and adapted to be reciprocatable within the hydraulic cylinder, and step (c) is completed by injecting pressurized fluid into the hydraulic cylinder to move the piston.

25. A method as claimed in claim **24** wherein step (d) further includes a step of maintaining fluid pressure in the hydraulic cylinder.

26. A method as claimed in claim **25** wherein step (d) further includes a step of locking a mechanical locking mechanism included in the second lockdown mechanism in a lockdown position to ensure the mandrel is secured in the operative position in the event that the fluid pressure is lost.

27. A method as claimed in claim **26** wherein the mechanical locking mechanism includes a flange connected to a top of the mandrel and at least two threaded bolts connected at fixed ends to the cylinder, the flange having at least two bores to permit the at least two threaded bolts to pass through without resistance, the at least two threaded bolts being prevented from being withdrawn from the bores by nuts which are adapted to be rotated from the free ends of the threaded bolts towards the fixed ends to lock the second lockdown mechanism in the lockdown position.

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