July 22, 1969 J. H. CURRENT ET AL 3,456,723

HYDRAULICALLY SET WELL PACKER

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Fig. 1

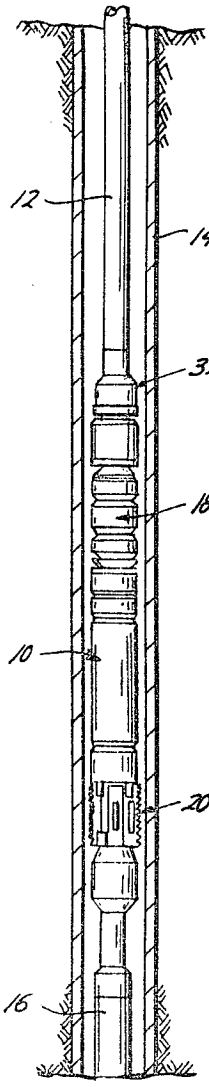


Fig. 2A

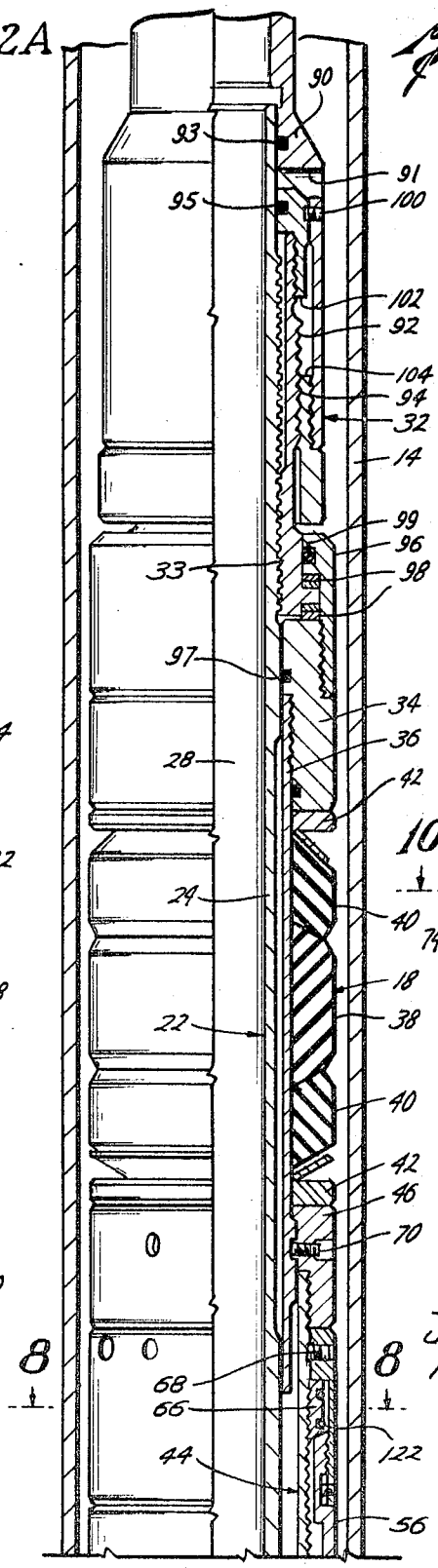
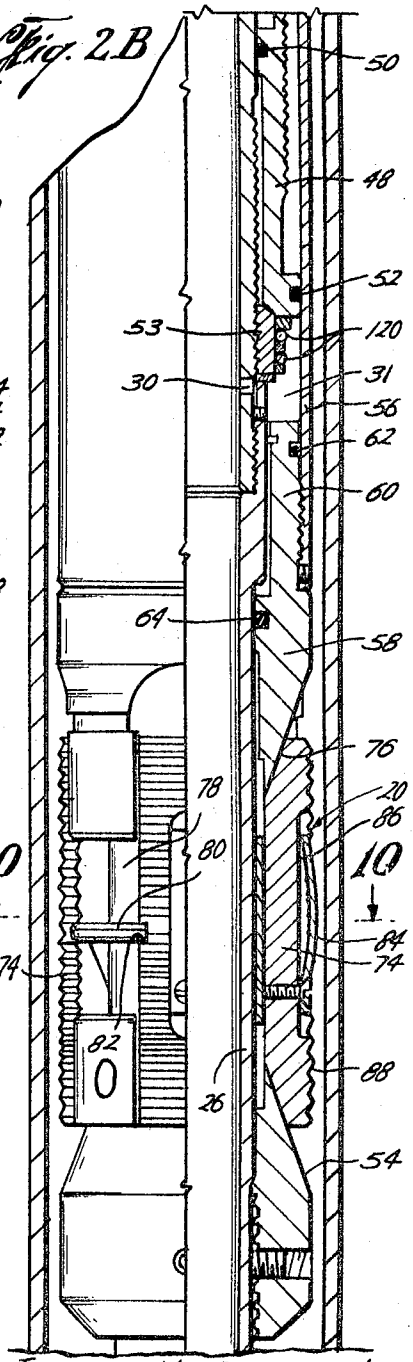


Fig. 2B



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HYDRAULICALLY SET WELL PACKER

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Fig. 3A

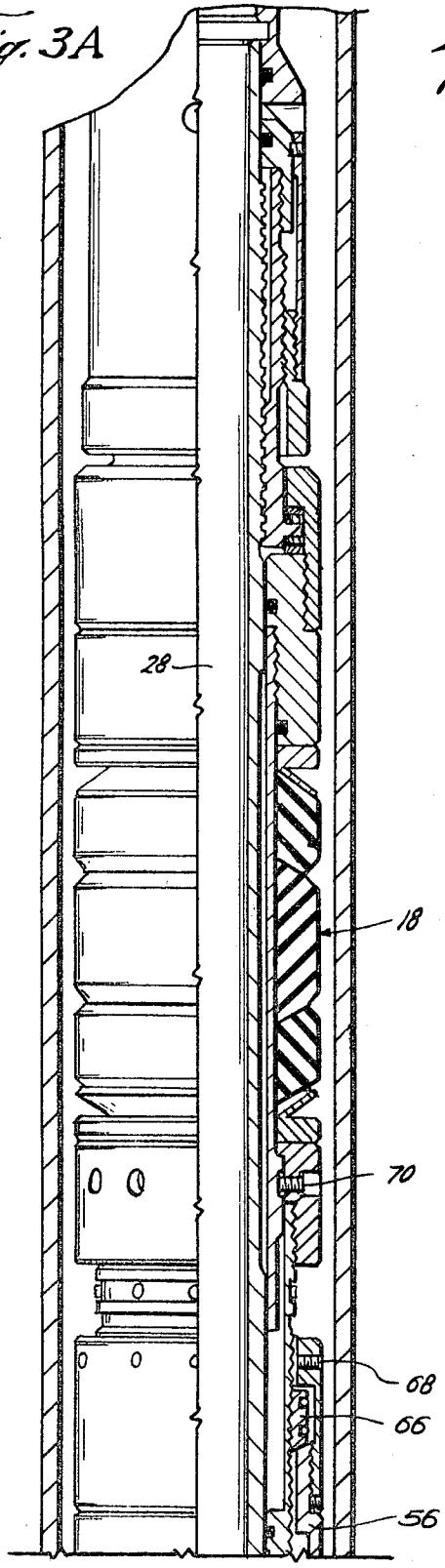
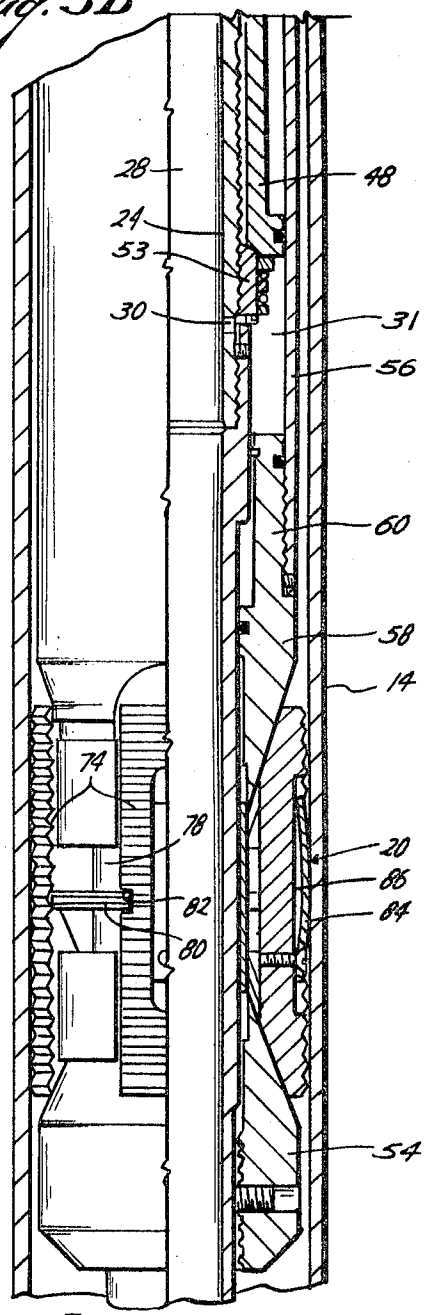


Fig. 3B



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July 22, 1969 J. H. CURRENT ET AL 3,456,723

HYDRAULICALLY SET WELL PACKER

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Fig. 4A

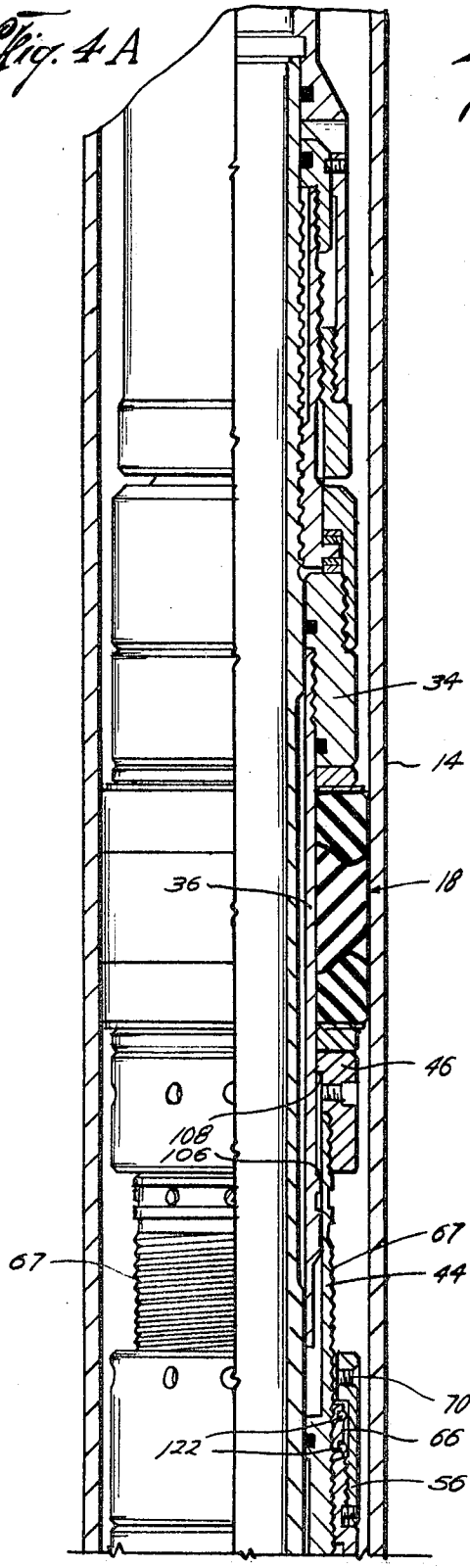
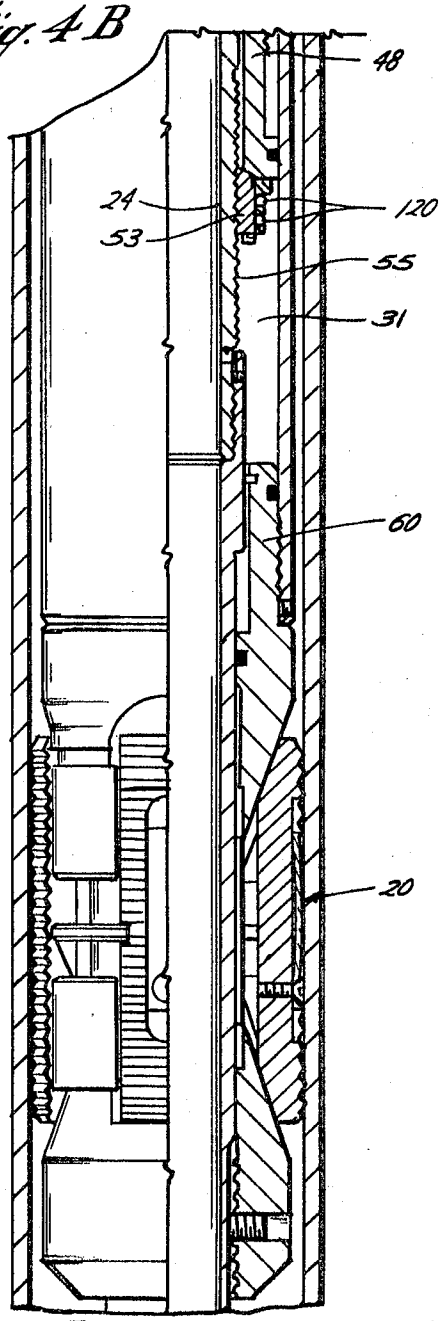


Fig. 4B



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Fig. 5A

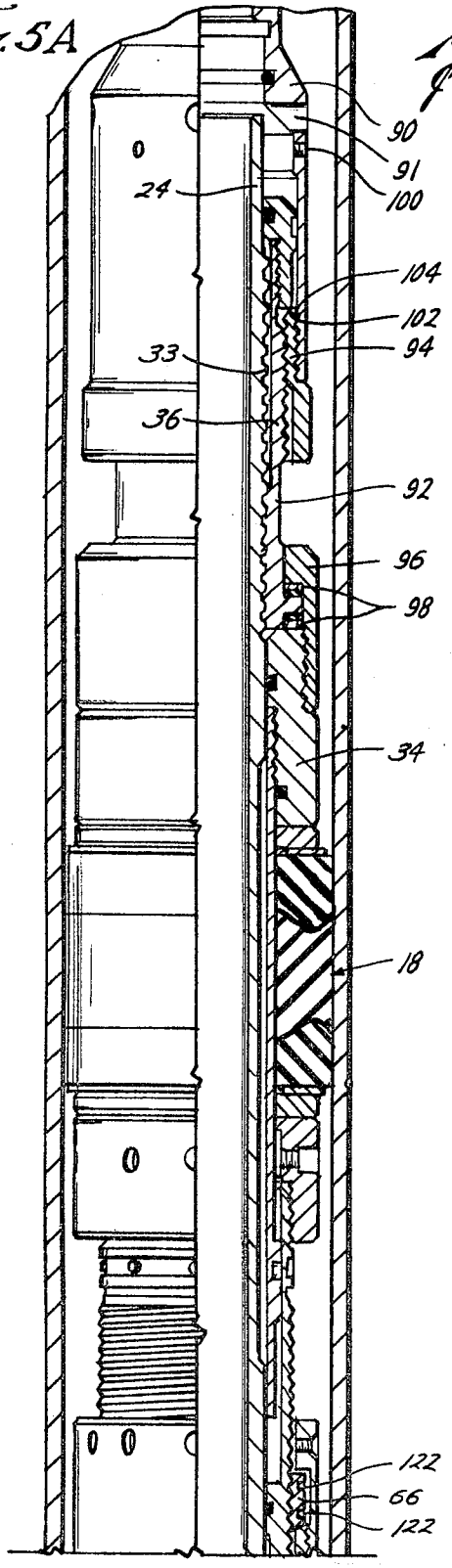
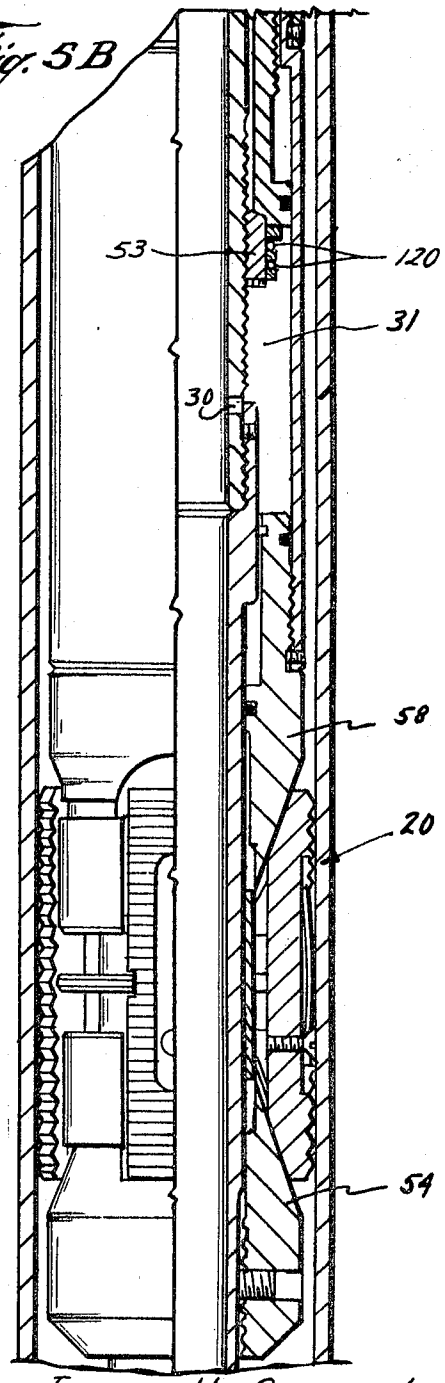


Fig. 5B



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HYDRAULICALLY SET WELL PACKER

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Fig. 6A

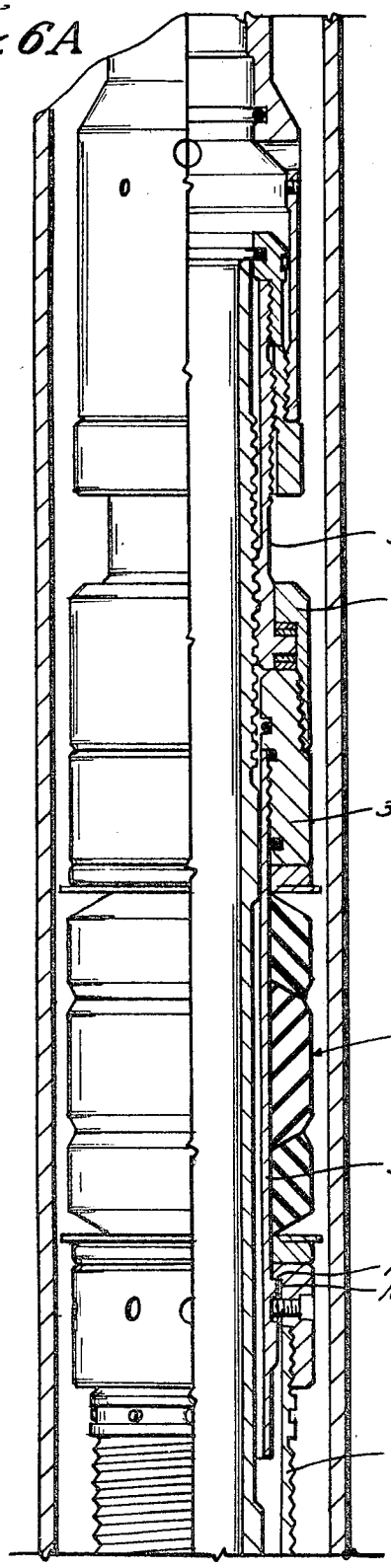
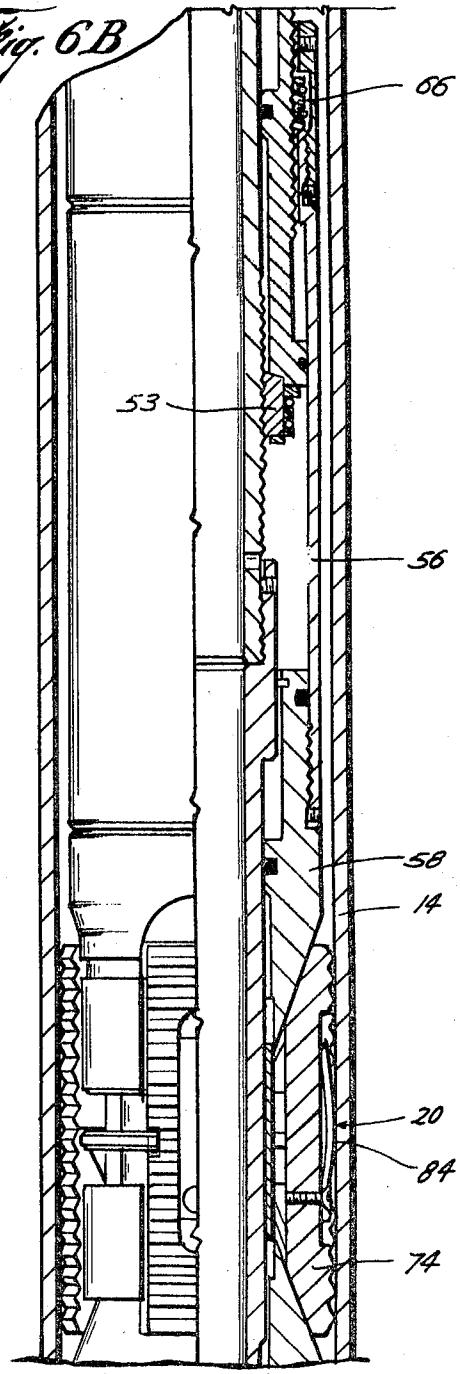


Fig. 6B



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HYDRAULICALLY SET WELL PACKER

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Fig. 7A

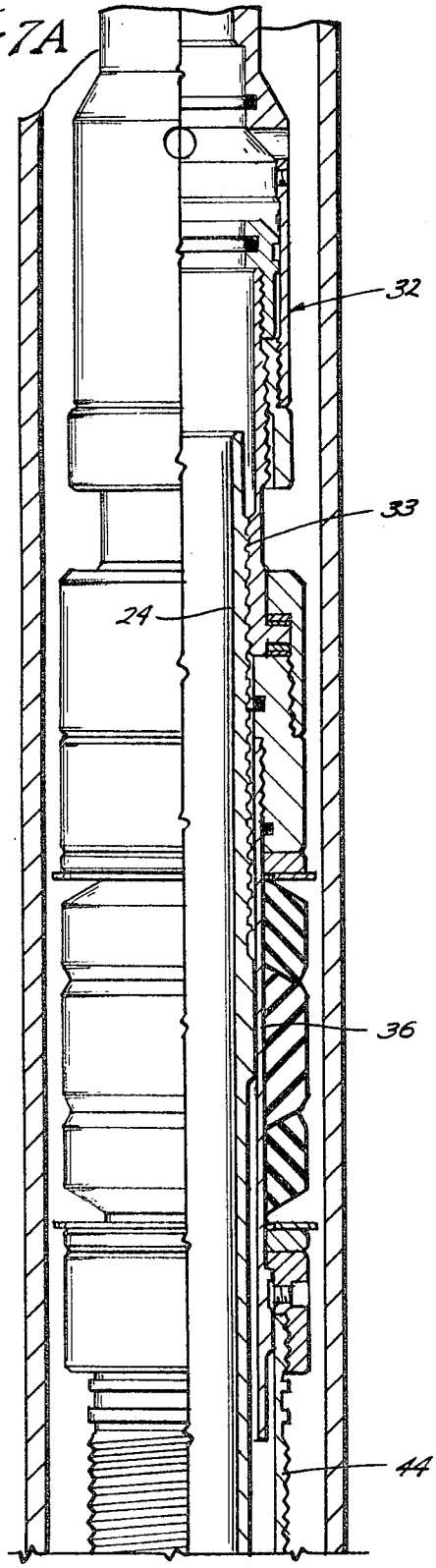
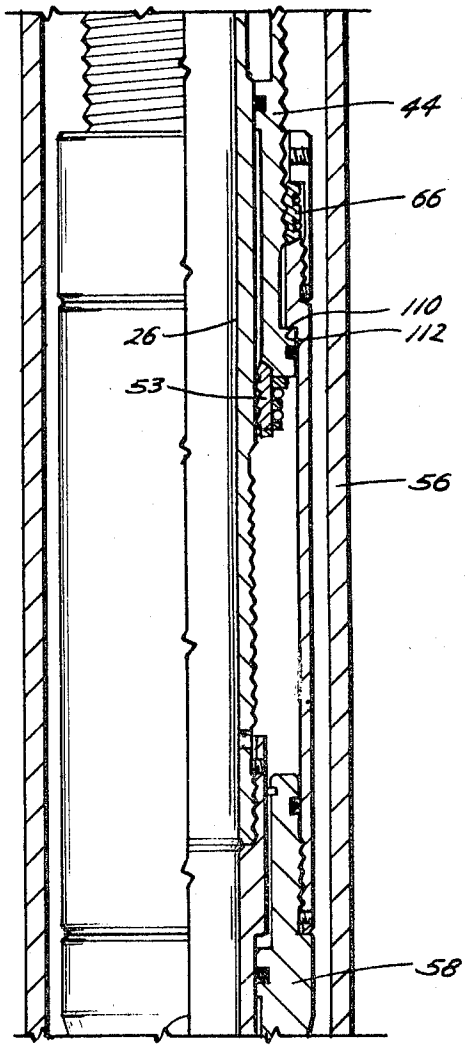


Fig. 7B



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July 22, 1969 J. H. CURRENT ET AL 3,456,723

HYDRAULICALLY SET WELL PACKER

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Fig. 7C

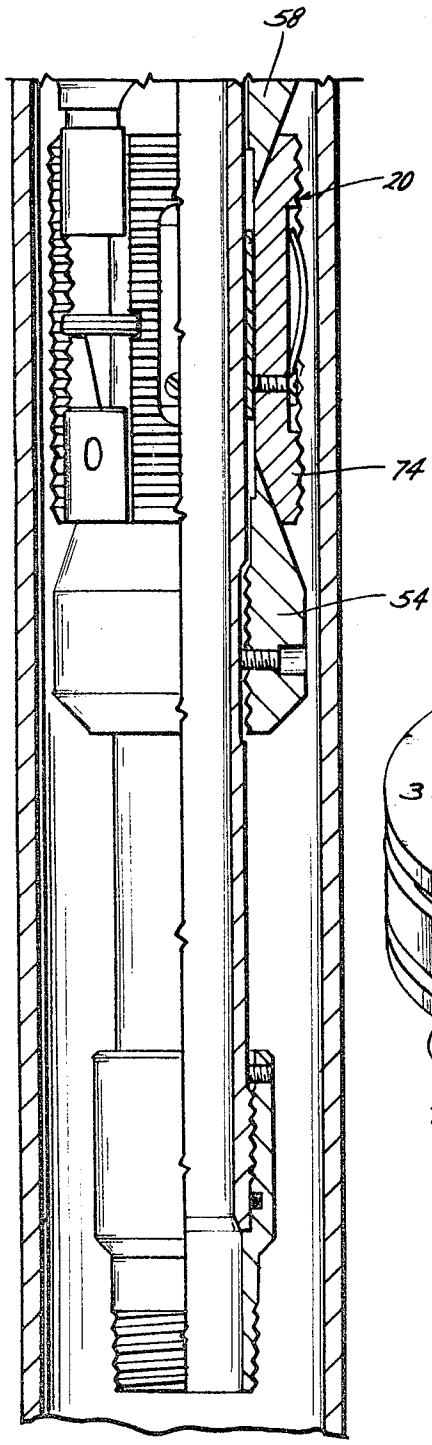


Fig. 8

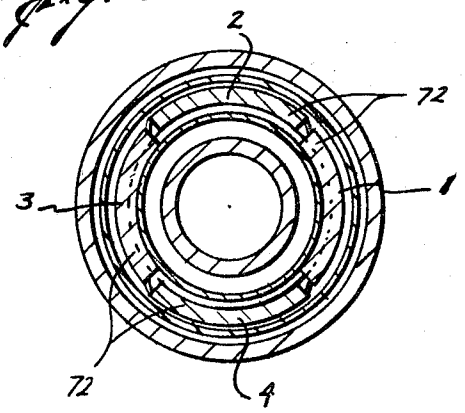
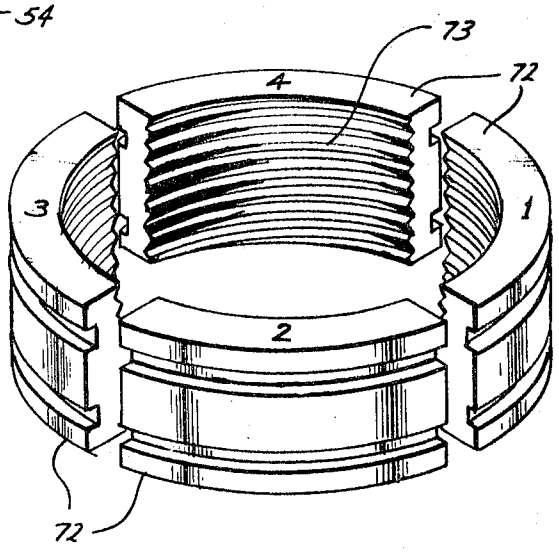


Fig. 9



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Fig. 10

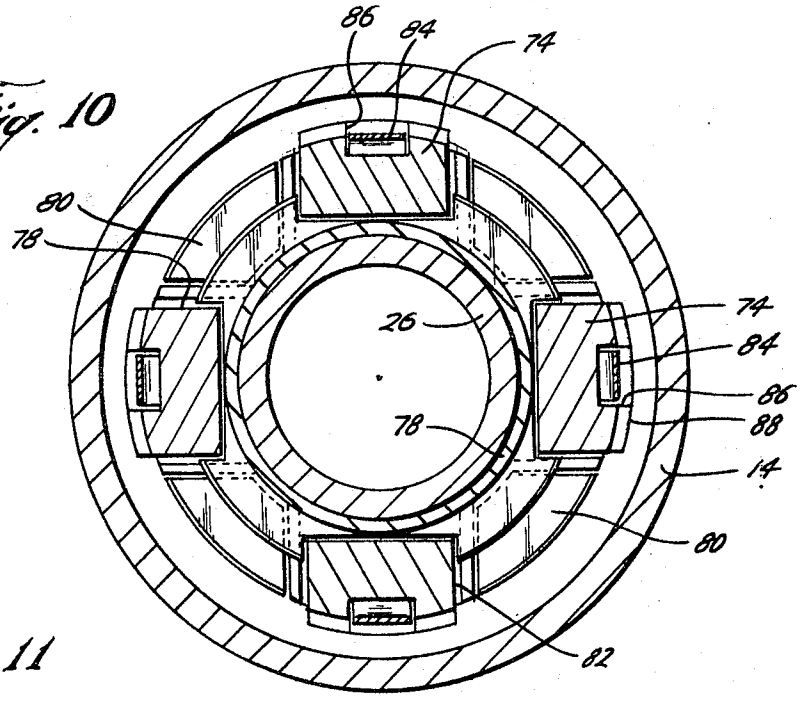


Fig. 11

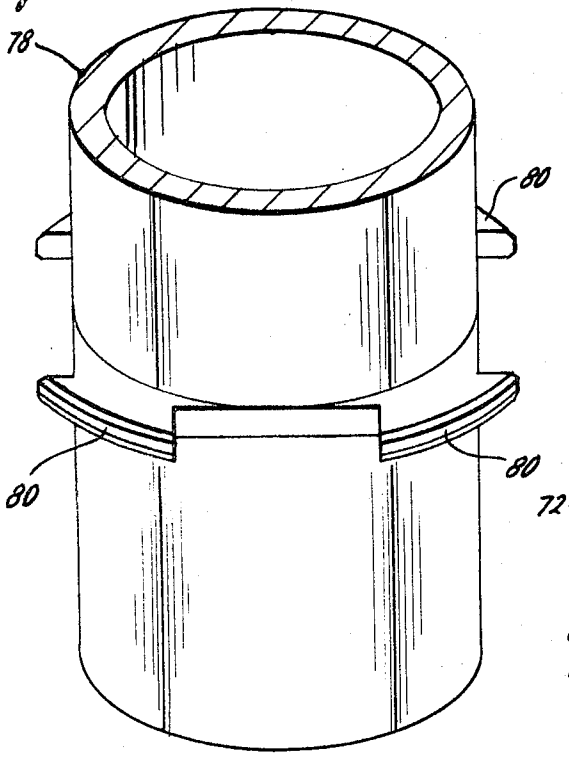
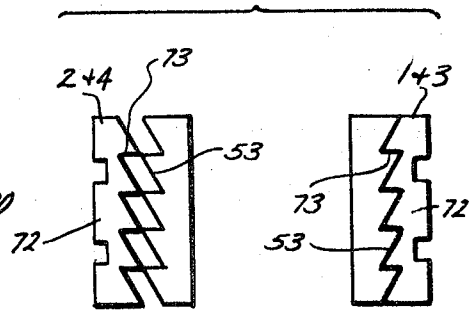


Fig. 12



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United States Patent Office 3,456,723 Patented July 22, 1969

3,456,723

HYDRAULICALLY SET WELL PACKER

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Filed June 30, 1967, Ser. No. 650,423
Int. Cl. E21b 33/12, 23/06
U.S. Cl. 166—120 20 Claims

ABSTRACT OF THE DISCLOSURE

A well packer hydraulically set by the sequential operation of opposed pistons and provided with one-way clutches whereby the well packer may be set hydraulically without moving the tubing string. A centering sleeve for maintaining the slip segments parallel to the sleeve. A spring recessed in each slip segment to retract the slip segments from the well conduit. A one-way clutch with an external helical thread having a plurality of mating ratchet segments which are positioned about the external helical thread in reverse consecutive rotational position. An equalizing port and sealed thread in a packer releasing sub for easily releasing the packer.

BACKGROUND OF THE INVENTION

The present invention relates to a well packer that is to be set in a conduit disposed in a well bore having a hydraulically set packer seal and slips, and which is retrievable therefrom.

While packers in the prior art are available in which the packer seal and the slips are hydraulically set, the present packer is an improvement in that the tubing string neither moves upwardly or downwardly due to the setting forces created by the hydraulic setting pressure, neither compressive or tensional forces in the tubing string will cause the packer seal to move after it has been set, the seal will remain in its fully set position regardless of differential pressures above and below the set packer and the packer seal is maintained in a set position regardless of any movement of the slips. The present invention is also directed to various other improvements such as a slip guide insuring that the slips are moved in unison while they are being expanded and retracted, improved one-way ratchet clutches which will reduce breaking of the clutch teeth and which reduce the distance of ratching, an improved releasing sub in which is provided an equalizing port for balancing the internal and external pressure in the packer seal at the time of release and which is provided with release threads which are sealed off from contamination so that they will readily release when it is desired to retrieve the packer and slip segment springs which are positioned to prevent undesired wear when the packer is being moved downhole.

SUMMARY OF THE INVENTION

The present invention relates to a well packer adapted to be set in a conduit disposed in a well bore and which is provided with a mandrel and initially retracted packing seal means and slips surrounding the mandrel in which hydraulic means are provided for setting the seal and the slips in which a one-way clutch is provided between the mandrel and a packer seal expanding sleeve and a one-way clutch is provided between the slip expanding sleeve and a seal expanding sleeve in which the hydraulic pistons are actuated without moving the mandrel, and in which the packer seal will remain in its expanded and sealed position in spite of compressive or tensional forces in the tubing string acting on the mandrel in spite of differential pressures about the packer and independently from the packer slips.

Another object of the present invention is the provision of a releasing sub in a well packer having an equalizing port for equalizing the pressure inside and outside the mandrel when the releasing sub is longitudinally moved upwardly from the mandrel and providing seal means between the releasing sub and the mandrel initially blocking off the equalizing port.

Still a further object of the present invention is the provision of an improvement in a releasing sub in a well packer which threadably engages the mandrel for release therefrom by right hand rotation to release the packer in which seal means seal off the threaded connection between the sleeve and the mandrel to prevent entry of well fluid to the connection so that the connection will remain free and easily operable after an extended period of time.

Still a further object of the present invention is the provision of an improvement in a slip assembly in which a plurality of slip segments are connected at each end by dovetail shaped coacting engaging surfaces, and in which a centering sleeve is slidably positioned between the mandrel and the segments and slidable coacting engaging elements are provided on the sleeve and each segment and positioned transversely of the sleeve for maintaining the segments parallel to the sleeve so that slip segments are expanded outwardly and retracted inwardly in unison.

Still a further object of the present invention is the improvement in a slip assembly in a well packer in which a spring is provided recessed in a slot in the face of each slip element with the spring extending outwardly on the segment further than the outer surface of the segment so as to engage the conduit in which the packer is set and act to provide a torsional restraint to retract the segments from their conduit engaging position on release of the packer, but in which the springs extend outwardly less than the internal diameter of the conduit so as not to engage the conduit when the packer is initially moved into position and thereby avoid becoming worn and weakened.

Another object of the present invention is the provision of an improved one-way ratchet clutch for use between two members in a well packer and having an external helical thread on one member and a plurality of ratchet segments connected to the other member which have, when positioned in one consecutive rotational position to each other an internal helical thread on said segments adapted to fully mate with the external helical thread, but which are positioned about the external helical thread in the reverse consecutive rotational position thereby insuring that at least some of the ratchet segments will be in substantial gripping position with the external helical threads at all times.

Other and further objects, features and advantages will be apparent from the following description of a presently preferred embodiment of the invention given for the purpose of disclosure and taken in conjuction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the attached drawings, like character references refer to like parts throughout the several views which are as follows:

FIGURE 1 is an elevational view of the well packer of the present invention in position being lowered in a conduit in a well bore,

FIGURE 2A is an enlarged cross-sectional view of the upper portion of the present invention with the parts in position as the packer is being lowered into the well bore,

FIGURE 2B is a continuation of FIGURE 2A, showing the lower portion of the packer,

FIGURE 3A is an elevational view, partly in cross-section, of the top portion of the packer of the present invention shown in position in a well conduit with the slips in a set position,

FIGURE 3B is a continuation of FIGURE 3A showing the lower portion of the packer,

FIGURE 4A is an elevational view, partly in cross-section, of the top portion of the packer of the present invention shown in position in which the slips and the packer seal are set in position,

FIGURE 4B is a continuation of FIGURE 4A showing the lower portion of the packer,

FIGURE 5A is an elevational view, partly in cross-section, illustrating the top portion of the packer of the present invention in position in which the releasing sub has been rotated to equalize the pressure inside and outside of the packer,

FIGURE 5B is a continuation of FIGURE 5A showing the lower portion of the packer,

FIGURE 6A is an elevational view, partly in cross-section, illustrating the top portion of the packer of the present invention in which the releasing assembly has been backed off from the packer so that the packer seal may retract,

FIGURE 6B is a continuation of FIGURE 6A showing the lower portion of the packer,

FIGURE 7A is an elevational view, partly in cross-section, illustrating the top portion of the packer of the present invention in a fully retracted position,

FIGURE 7B is a continuation of FIGURE 7A illustrating the middle portion of the packer,

FIGURE 7C is a continuation of FIGURES 7A and 7B showing the lower portion of the packer,

FIGURE 8 is a cross-sectional view taken along the line 8—8 of FIGURE 2A,

FIGURE 9 is an enlarged perspective view showing the conventional positioning of the clutch elements of FIGURE 8,

FIGURE 10 is an enlarged cross-sectional view taken along line 10—10 of FIGURE 2B,

FIGURE 11 is an enlarged perspective view of the slip centering guide of the present invention, and

FIGURE 12 is a schematic elevational cross-sectional view of the clutch elements of FIGURE 8.

Referring now to the drawings, and particularly to FIGURE 1, the packer of the present invention is generally indicated by the numeral **10**, and is shown being lowered into position on a pipe or running in string **12** in a conduit **14** such as a casing in a well bore. In order to actuate the packer **10** by hydraulic fluid, a suitable plugging tool **16** is connected to the lower end of the packer **10** to block the bottom of the running in string **12** and the packer **10** so that hydraulic pressure may be applied therein. The tool **16** may be, by way of example, a Camco PE–500 pump out plug which is conventional and no further description is believed necessary.

The packer **10** includes the usual packing sealing means or packer seal generally indicated by the numeral **18** and a slip assembly generally indicated by the numeral **20**, both of which are shown in their retracted position in FIGURES 1, 2A and 2B as the packer **10** is being lowered to the desired location in the casing **14**.

Referring now to FIGURES 2A and 2B, the packer **10** includes a mandrel **22** which for convenience includes an upper portion **24** and a lower portion **26** secured together to provide an internal passageway **28** in communication with the pipe or running in string **12** for receiving hydraulic fluid to set the packer and includes at least one port **30** for passage of the hydraulic pressure for setting the slip assembly and the packer seal means **18**.

The packing seal means **18** may include a suitable and conventional packer seal element **38**, back up seal rings **40**, and expander rings **42** all of which are conventional and no further description is believed to be necessary.

A top releasing assembly is generally indicated by the numeral **32** and is threadably secured to the upper mandrel **24** by a left-handed thread connection **33** and includes an upper abutment **34** for engaging the top of the packer seal means **18** and a releasing sleeve **36** slidably mounted between the mandrel **24** and the packing seal means **18**, and will be more fully described hereinafter.

A lower slip cone **54** is provided secured to the mandrel **26** and positioned against the lower end of the slip assembly **20**. A hydraulically actuated slip expanding means which includes slip setting sleeve **56** is provided above the slip assembly **20** and includes an upper movable slip cone **58** and a piston **60** defined by seals **62** and **64** and is exposed to hydraulic pressure in a chamber **31** which communicates with port **30** for actuation of the piston **60** for expanding the slip assembly **20** outwardly and into engagement with the casing **14**.

A hydraulically actuated packer seal expanding means which includes packing seal setting sleeve **44** the upper end **46** of which is positioned adjacent the bottom of the seal means **18**, and the lower end of which is provided with a piston **48** formed between seals **50** and **52**. The piston **48** is exposed to hydraulic pressure in the chamber **31** for movement upwardly against the packer seal means **18** for setting the seal.

A one-way clutch **66**, which will be more fully described hereinafter, is provided between the sleeve **56** and the sleeve **44** allowing downward movement of the sleeve **56** when hydraulic pressure is applied to the piston **60** to allow the slip assembly **20** to be expanded outwardly and to allow the sleeve **44** to move upwardly relative to the sleeve **56** for preventing upward movement of the sleeve **56** relative to the sleeve **44** thereby locking the slip assembly **20** in its expanded position.

A one-way clutch **53**, which would be more fully described hereinafter, is provided between the sleeve **44** and the mandrel **24** allowing movement upwardly of the sleeve **44** to expand the packer seal **18**, but preventing downward movement of the sleeve **44** thereby locking the packer seal **18** into an expanded position when actuated.

Thus, with the temporary plugging tool **16** in place at the bottom end of the packer **10** (FIGURE 1), and with hydraulic pressure applied through the pipe **12** to the passageway **28**, hydraulic fluid will flow through the port **30** and be applied against both of the opposing pistons **48** and **60**. A first releasable holding means such as a shear pin **68** is provided connected between the slip setting sleeve **56** and the seal setting sleeve **44** to prevent actuation of the slip setting sleeve **56** until a predetermined hydraulic setting pressure has been applied after the packer has been desirably positioned in the well conduit **14**. A second releasable holding means or shear pin **70** is provided between the seal setting sleeve **44** and the releasing sleeve **36** to prevent actuation of the sleeve **44** until a predetermined hydraulic pressure has been applied in the chamber **31**. The shear pin **68** shears first allowing the slip setting sleeve **56** to move downwardly carrying the upper slip cone **58** to expand the slip assembly **20** into setting engagement with the conduit **14** after which the shear pin **70** is sheared, allowing the upward movement of the seal setting sleeve **44** to compress and/or displace the seal means **18** by the end **46** against the abutment **34** and sleeve **36** and expand the packer seal means outwardly into a sealing relationship with the conduit **14**. It is noted that the one-way ratchet clutch **66** allows the slip setting sleeve **56** to move downwardly relative to the seal setting sleeve **44**, and it is noted that both the one-way clutches **53** and **66** allow the packer seal setting sleeve **44** to move upwardly relative to both the mandrel **24** and the slip setting sleeve **56**, and that upon a stoppage of hydraulic pressure to the chamber **31**, the packer seal **18** and the slip assembly **20** will remain in a set position by the action of the clutches **53** and **66**.

The setting of the slip assembly **20** is best seen in FIGURES 3A and 3B wherein fluid pressure is applied to the internal passageway **28**, through the port **30** and against the packer seal setting piston **48** and the slip setting piston **60**. Upon predetermined hydraulic pressure shear pin **68** will be sheared, and the slip setting piston **60** and sleeve **56** and will move downwardly actuating slip cone **58** toward the lower cone **54** to move the slip assembly **20** out-

wardly and downwardly into engagement with the conduit wall **14**.

As best seen in FIGURES 4A and 4B, the pressure in chamber **31** continues to build up, and since piston **60** is now in a fixed position, the pressure acts against the packer seal setting piston **48** until shear pin **70** shears thereby moving the packer seal setting sleeve **44** upwardly pushing end **46** against the seal means **18** compressing and/or displacing it against the abutment **34** and sleeve **36** and outwardly into engagement with the well conduit **14** to provide a seal.

The one-way clutches **66** and **53** allow relative movement between the seal setting sleeve **44** and the slip setting sleeve **56** and between the packer seal setting sleeve **44** and the mandrel **24**, respectively, and act to hold the setting sleeves **44** and **56** and thus the packer means **18** and the slip assembly **20** in an expanded set position. Thus in FIGURES 4A and 4B, the packer **10** is in a fully set position.

It is to be noted that the running in pipe **12**, as the packer **10** is hydraulically set, neither moves upwardly or downwardly due to setting forces created by hydraulic pressure and thus does not cause undesired buckling of the pipe **12**. Once the packer **10** has been set, it is also noted that pressure differentials either above or below the packing means **18** will not cause any relaxation of the seal **18**. Furthermore, weight may be imposed upon the pipe **12** or it may be pulled in tension after the packer is set and the compressive or tensional forces will not cause the seal **18** to relax or leak. That is, the packer means **18** and the slip assembly **20** are held in a fully set position and locked therein by the interlocking relationships between the mandrel **22**, the lower cone **54**, the slip assembly **20**, the upper cone **58**, the slip setting sleeve **56**, clutch **66**, clutch **53**, seal setting sleeve **44**, packing means **18**, the upper abutment **34** and the top sub **32**. The packing seal means **18** is capable of storing a great amount of energy to maintain a high sealing relationship with the conduit **14** and the packer will maintain this seal in a compressed condition. That is, the seal means **18** is maintained in a compressed position independently of the slip assembly **20** and forces acting against the packer will not release the seal means.

After the packer **10** is set the hydraulic pressure in the passageway **28** is removed. This may be done by increasing the hydraulic pressure to blow out the temporary plugging tool **16** (FIGURE 1) or other conventional methods. In any case, it is important that the one-way clutches **53** and **66** maintain the packer **10** in a fully set position independently of other moving parts so as to maintain the sealing relationship of the packer to the conduit **14**. Another of the features of the present invention is the provision of an improved ratchet one-way clutch such as the one-way clutches **53** and **66**. Referring now to FIGURE 9, a conventional ratchet clutch is provided by providing a plurality of ratchet segments **72** having an internal helical thread **73** which coacts with an external helical thread to provide uni-directional ratchet movement. Thus referring to FIGURES 4A and 4B the ratchet segments of clutch **53** would coact with the helical thread **55** on the mandrel **24**, and the ratchet segments of one-way clutch **66** would coact with the helical thread **67** on the packer seal setting sleeve **44**. The rachet segments are urged into engagement with the coacting external helical threads by yieldable retaining means or springs. Thus ratchet segments of clutch **53** are urged into engagement with thread **55** by garter springs **120**, and the rachet segments of clutch **66** are urged into engagement with thread **67** by garter springs **122**. Such a one-way clutch is conventional. That is, again referring to FIGURE 9, the ratchet segments **72** are conventionally manufactured with a helical thread **73** and are conventionally mounted about an external helical thread in the same consecutive rotational position as numbered **1, 2, 3, 4** in a clockwise position as shown such that the helical threaded segments **72** are in continuous alignment. However, such conventional ratchets when actuated may stop with the crest of the external helical threads with which they coact and then when the hydraulic pressure is released the coacting helical interior and exterior threads may skip several threads or may break several threads before gripping thereby providing a release in the setting force of either the seal means **18** or the slip assembly **20** where it would be undesirable and could result in the packer failing to function. Even if the mating internal and external helical threads were not set in a crest to crest position, they would likely be set in an intermediate or non-mating position which would allow some relaxing of the setting mechanism on release of hydraulic pressure which is undesirable.

The improved ratchet clutch of the present invention is provided by positioning the segments **72** as manufactured and numbered **1, 2, 3, 4** in FIGURE 9, in a counterclockwise numbered direction in position as shown in FIGURE 8 in a counterclockwise numbered position **1, 2, 3 4**. Such positioning of the ratchet segments **72** will insure that at least one or more of the segments **72** will be in a closely engaging position with the mating external helical thread with which they coact thereby overcoming the disadvantages mentioned. That is, reversal of the direction of positioning the segments **72** will not prevent mating with the external helical thread, but will merely cause some of the segments to be shifted vertically so that one or more will always be in a near clutch holding position.

Thus, referring to FIGURE 12, even though ratchet segments **72** which are in numbered position **2** and **4** are in a crest position in relationship to helical threads **55**, it is noted that segments **72** at positions **1** and **3** are in a fully engaged position and thus the one-way ratchet is engaged. From FIGURE 12 it is noted that at no time would all of the segments **72** be in a crest to crest relationship with the thread **55** and thus could not skip. Furthermore, even if all of the threads of the segments **72** were in intermediate positions relative to the thread **55**, the clutch would relax or release no more than one-half of the threads width thereby minimizing release.

Referring now to FIGURES 2B, 3B, 6B, 7C, 10 and 11, various improvements in the slip assembly **20** are provided. A plurality of slips **74**, here shown as four, which are held in place by coacting angled dove-tail shaped engaging surfaces **76** on the end of each slip **74** and the lower slip cone **54** and the upper movable slip cone **58** whereby the slips **74** may be moved radially outwardly into engagement with the wall of the conduit **14**. Thus as the upper movable slip cone **58** is moved downwardly toward the lower slip cone **54** by the action of the hydraulic piston **60** the slips **74** will be moved downwardly and outwardly so that the slip teeth **88** grippingly engage pipe **14**.

However, it is important that the slips **74** move downwardly and outwardly in unison and on release transverse both upwardly and inwardly in unison and parallel to each other and the mandrel **26**. Without this uniformity of movement, one slip **74** may transverse ahead of another slip and cause frictional binding in the dove-tailed coacting engaging surfaces **76** which will bind and prevent the entire slip assembly **20** from functioning. A centering sleeve **78** is provided which is slidably mounted between the mandrel **26** and the slips **74**. Slidably coacting engaging means are provided on the sleeve **78** and the slips **74** such as ears **80** on the sleeve **78** and the coacting slots **82** on the slips **74**. Thus, as the slips **74** move outwardly, inwardly, downwardly, or upwardly, the centering sleeve **78** is slidably moved along the mandrel **26** and the slip segments **74** are able to move inwardly and outwardly on the ears **80** to maintain the slips parallel to each other and thus move in unison without cocking or binding in the dove-tail slots. In addition, the centering sleeve insures centering of the packer in the conduit when the slips are set.

Another feature of the slip assembly **20** is the provision of energy storing means such as springs **84** provided in recess slots **86** in the face of each of the slip segments **74**. The springs **84** extend outwardly in their extended or uncompressed position a radial distance from the packer further than the outward surface or teeth **88** on the slips **74**. However, the springs **84** extend outwardly less than the internal diameter of the conduit **14** and thus do not engage the conduit when the packer is initially moved into setting position, and thus the springs are not weakened by frictional contact and wear upon running the packer **10** to its setting location. The springs **84** serve no function during the setting operation and as shown in FIGURE 3B are compressed into the recessed slots **86** when the slip assembly **20** is set. However, when the packer is released as will be more fully described hereinafter, the energy storing means or springs **84** act as torsional restraints against which the releasing sub **32** operates to fully retract the slip assembly **20** out of engagement with the interior wall of the conduit **14**.

Referring now to FIGURES 1, 2A and 2B, the top releasing assembly **32**, which is connected to the upper mandrel portion **24** includes a top sub **90** connected to an unloader sleeve **92** by a left handed thread connection **94** which is in turn connected to the left hand threaded connection **33**, a bearing housing **96**, bearings **98**, the housing **96** being connected to the abutment **34** and the releasing sleeve **36**. The top sub **90** is connected to the pipe or running in string **12** by any suitable connection (not shown) such as a conventional box and pin connection. A shear pin **100** is provided between top sub **90** and the unloader sleeve **92**. An equalizing port **91** is provided in the top sub **90** and as shown in the running in position in FIGURE 2A, is sealed by seal **93** preventing commmunication at this time between the well fluids and/or gases inside and outside of the packer **10**.

It is also noted that in the running in position the seals **95**, **97** and **99** seal off the threaded connection **33** and the bearings **98** from contamination with well fluids inside or outside of the packer so that the threaded connection **33** may be packed with grease and thus even though the packer remains in a set position in the well bore for an extended period of time, the threaded connection **33** will not become frozen but will remain operable for release of the packer.

As previously mentioned, the packer is shown in its set position in FIGURES 4A and 4B. When it is desired to release the packer **10**, the pipe or running in string **12** is rotated in a right-hand direction shearing the shear pin **100** allowing rotation of the top sub **90** relative to the unloader sleeve **92** through the left-handed thread connection **94** moving the equalizing port **91** upwardly past the top end of the mandrel **24** thereby providing a fluid communication between the inside and outside of the packer **10** and thus above and below the packer seal means **18**, as best seen in FIGURES 5A, to equalize any differential pressure that may exist above and below the seal means **18**. Further right-hand rotation of the top sub **90** will bring coacting engaging shoulders **104** and **102**, which are on the top sub **90** and the unloader sleeve **92** respectively, into engagement whereby further right-hand rotation of the top sub **90** will unthread the threaded connection **33** by rotating unloader sleeve **92** which may be more easily rotated because of the bearings **98**, even though the sealing energy stored in the packing means **18** presses against the abutment **34** and the unloader sleeve **92** through bearings **98**.

As best seen in FIGURE 6A, as the unloader sleeve **92** moves upwardly it carries the housing **96** and the abutment **34** upwardly away from the seal means **18** to release the setting force on the seal means **18** allowing the seal **18** to resiliently retract away from the sealing relationship with the interior of the wall **14**.

Thus the right-handed rotation of the pipe **12** and the releasing assembly **32** has now retracted the packer seal **18** and is ready to release the slip assembly **20**. As the right-hand rotation is continued carrying the abutment **34** upwardly, the releasing sleeve **36** is slidably carried upwardly until an engaging shoulder **106** on the releasing sleeve **36** engages a shoulder **108** on the seal setting sleeve **44**. Continued right-hand rotation of the pipe **12** and releasing assembly **32**, as best seen in FIGURES 6A, 6B, 7A, 7B, and 7C will continue with rotation of the releasing assembly **32** and movement upwardly relative to the mandrel **24** through the threaded connection **33** moving the releasing sleeve **36** upwardly which now carries the seal setting sleeve **44** upwardly as the one-way clutch **53** ratchets upwardly against the mandrel **24**, and the seal setting sleeve **44** ratchets upwardly past the one-way clutch **66**. Upward movement of the seal setting sleeve **44** continues until coacting mating shoulders **112** and **110** (FIGURE 7B) on the packer setting sleeve **44** and on the slip setting sleeve **56**, respectively, are engaged. Continued upward movement of the sleeve **44** and thus the sleeve **56** carries the upper movable slip cone **58** away from the lower slip cone **54** to allow the slips **74** to be retracted away from the interior wall of the conduit **14**.

It is to be noted that as the right-handed rotation continues carrying the slip setting sleeve **56** upwardly, the springs **84** act against the inside of conduit **14** to provide a torsional restraint so the slips may be mounted to a retracted position. Since the right-hand rotation for releasing the packer acts against the engagement of the slip assembly **20** with the conduit **14** further releasing of the slip setting sleeve **56** and retraction of the slip segments **74** would not occur once the slip segments have backed away from the interior wall of the conduit **14** in the absence of the springs **84**. Also, it is obvious that the internal diameter of the conduit **14** is not sized exactly the same throughout its entire length. Therefore, in the absence of the springs **84**, the slips **74** would retract only a small distance, and when the packer was being longitudinally withdrawn upwardly throughout the conduit **14**, the slips **74** would encounter other sections of a smaller diameter and would lock into position causing possible damage and would again require that the packer be released from its set location by further right-hand rotation. However, the springs **84** act as bow strings aganist which the right-hand rotation of the releasing sub **32** may continue for carrying the releasing sub assembly **32**, the slip setting sleeve **56**, and the upper cone **58** upwardly, in order that the slips **74** may be retracted a sufficient distance to clear any variations in the internal diameter of the conduit **14** and thus the packer may be lifted to the surface of the well bore clear of the conduit.

In operation, the packer **10** is connected to a pipe running in string **12** and includes provision of a suitable plugging tool **16** (FIGURE 1) connected to and closing the bottom thereof to allow a hydraulic pressure to be built up internally of the running in string **12** and in the internal passageway **28** of the packer **10**. The packer **10** is lowered to the desired setting location in the conduit **14**, a plug is provided and pressure is applied down the tubing string **12** from the surface which pressure passes through port **30** into the chamber **31** and applies a hydraulic force against the opposing packer seal setting piston **48** and slip setting piston **60**. Initially, shear pins **68** and **70** prevent movement of the piston **48** and **60**. Upon a predetermined hydraulic pressure, the first shear pin and/or pins **68** shear allowing the slip setting piston **60** to move downwardly moving the upper slip cone **58** and moving the upper slip cone **58** toward the lower slip cone **54** and moving the slips **74** out into a gripping relationship with the interior wall of the conduit **14**. Because of the centering sleeve **78** the slips will move in unison without any cocking and inadvertent locking ac-

tion and will centralize the packer. Once the slip assembly is set, further downward movement of the slip setting piston **60** is prevented and the second shear pin and/or pins **70** shear allowing the packer seal setting piston **48** to move upwardly and the seal setting sleeve **44** through end **46** pushes the packer seal means **18** against the upper abutment **34** which is fixed to set the packer seal in a sealing relationship between the interior wall of the conduit **14** and the exterior surface of releasing sleeve **36**. The sleeves **44** and **56** now hold the seal means **18** and the slip setting assembly **20** in a set position through the one-way clutches **53** and **66**. And the setting pressure may be removed and the packer will remain in its set position.

When it is desired to release the packer the string **12** is rotated to the right shearing pin **100** and allowing the top sub **90** to rotate upwardly until the equalizing port **91** is above the upper end of mandrel **24** to equalize any differential pressure above and below the packing means **18**. Further right-hand rotational movement carries the unloading sleeve **92** upwardly along with the abutment **34** to release the setting pressure in the seal means **18** and the seal is able to retract from the wall of the conduit **14**.

Further rotational movement of the releasing sub assembly **32** will also carry the releasing sleeve **36** upwardly which will engage the packer seal setting sleeve **44** which in turn will engage and carry the slip setting sleeve **56** upwardly to move the setting cone **58** away from the lower cones **54** allowing the slips **74** to be retracted from engagement with the interior wall of the conduit. The packer is then in a fully released position as best seen in FIGURES 7A, 7B, and 7C and may be longitudinally lifted and removed from the conduit **14**.

The present invention, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned as well as others inherent therein. While a presently preferred embodiment is given for the purpose of disclosure, numerous changes in the details of construction and arrangement of parts may be made which will readily suggest themselves to those skilled in the art and which are encompassed within the spirit of the invention and the scope of the appended claims.

We claim:

1. In a well packer adapted to be set in a conduit disposed in a well bore having a mandrel, an initially retracted packing seal means surrounding the mandrel, an abutment above and adjacent the seal means, a slip means surrounding said mandrel and positioned below said packing seal means, means for expanding the slip means into engagement with the conduit, the improvement comprising,

packing seal expanding means surrounding said mandrel for moving away from the slip means and toward the packing seal means for expanding said packer seal means into engagement with the conduit,

one-way clutch means between the mandrel and said packer seal expanding means allowing one-way movement of the packer seal expanding means toward the packer seal means whereby the seal means can be held in an expanded position independently of the slip means,

means about the mandrel longitudinally movable relative to the mandrel for relatively moving the abutment and the packer seal expanding means away from each other for releasing the packer seal means, and

means for retracting the slips from engagement with the conduit.

2. A well packer adapted to be set in a conduit disposed in a well bore comprising,

a mandrel,

an initially retracted packing seal means surrounding said mandrel,

abutment means connected to the mandrel on one side of the packer seal means preventing movement of the packer seal means in the direction of said abutment during and after expansion of said seal means but movable for releasing the packer,

slip means surrounding said mandrel,

hydraulic actuated slip expanding means surrounding the mandrel for moving away from said packing seal means and toward said slip means expanding said slip means into engagement with said conduit,

one-way clutch means connected to the slip expanding means for allowing one-way movement of the slip expanding means to move toward the slip means,

hydraulic actuated packing seal expanding means surrounding said mandrel for moving away from said slip means and toward said packing means for expanding said packer means into engagement with said conduit,

one-way clutch means connected to the packer expanding means for allowing one-way movement of the packer seal expanding means toward the packer seal means,

means about the mandrel longitudinally movable relative to the mandrel for relatively moving the abutment and the packer seal expanding means away from each other for releasing the packer seal means, and

means for retracting the slips from engagement with the conduit.

3. A well packer adapted to be set in a conduit disposed in a well bore comprising,

a mandrel,

an initially retracting packing seal means surrounding said mandrel,

abutment means connected to the mandrel on one side of the packer seal means preventing movement of the packer seal means in the direction of said abutment during and after expansion of said seal means but movable for releasing the packer,

slip means surrounding said mandrel and positioned below said packing seal means,

hydraulically actuated packer seal expanding means surrounding the mandrel for moving away from said slip means and toward said packing seal means for expanding said packer seal means into engagement with said conduit,

one-way clutch means between the mandrel and said packer seal expanding means allowing one-way movement of the packer seal expanding means toward the packer seal means,

hydraulically actuated slip expanding means surrounding said mandrel and a portion of the packer seal expanding means,

one-way clutch means between the slip expanding means and said packer expanding means allowing one-way movement of the slip expanding means toward said slip means,

means connected to the packer expanding means preventing setting of the packing means until the slip means have been set,

means about the mandrel longitudinally movable relative to the mandrel for relatively moving the abutment and the packer seal expanding means away from each other for releasing the packer seal means, and

means for retracting the slips from engagement with the conduit.

4. The apparatus of claim **3** including,

an abutment member surrounding the mandrel and positioned against the packing means,

a sleeve threadably engaging the mandrel for release therefrom by right hand rotation, said sleeve engaging said abutment member whereby said abutment member may be moved away from the packing means for release thereof, and

seal means sealing off the threaded connection between the sleeve and the mandrel for preventing the entry of well fluid to the connection.

5. The apparatus of claim 3 wherein said slip means includes,
a plurality of slips surrounding the mandrel,
dove-tailed shaped coacting engaging surfaces on each end of the segments and the supporting means at each end of the segments,
a centering sleeve slidably positioned between the mandrel and the segments,
slidable coacting engaging means on the sleeve and each slip positioned transversely of the sleeve for maintaining the slips parallel to the sleeve as the slips are expanded outwardly and retracted inwardly.

6. The apparatus of claim 3 wherein the slip means includes,
a plurality of slips surrounding the mandrel,
each of said slips having an energy storing means extending outwardly from the slips further than the outer surface of said slips, but said energy storing means extending outwardly less than the internal diameter of the conduit so as not to engage the conduit when the packer is initially moved into the conduit.

7. The apparatus of claim 3 wherein the one-way clutch between the mandrel and said packer seal expanding means includes,
an external helical thread on the mandrel,
a plurality of ratchet segments having when positioned in one consecutive rotational position to each other an internal helical thread on said segment sized to mesh with said external helical thread, but which are positioned about the external helical thread in a reverse consecutive rotational position, and
yieldable retaining means about said segments yieldably urging said segments into engagement with the external helical thread.

8. The apparatus of claim 3 including,
a releasing sub movably connected to the mandrel for releasing the packing seal means, and
a releasing sleeve connected to the releasing sub and adapted to engage the packer expanding means and release the slip expanding means.

9. The apparatus of claim 8 including,
an equalizing port in the releasing sub for equalizing the pressure inside and outside said mandrel and thus on either side of the packing seal means when the releasing sub is longitudinally moved upwardly from the mandrel, and
seal means between the releasing sub and the mandrel initially blocking off the equalizing port.

10. A well packer adapted to be set in a conduit for closing a well bore comprising,
a mandrel,
an initially retracted packing seal means surrounding said mandrel,
slip means surrounding said mandrel and positioned below said packer seal means,
hydraulically actuated packer seal expanding means surrounding the mandrel for expanding said seal means into engagement with said conduit,
one-way clutch means between the mandrel and said seal expanding means allowing one-way movement of the seal expanding means in a direction to expand the seal means,
hydraulically actuated slip expanding means surrounding said mandrel and a portion of the seal expanding means,
one-way clutch means between the slip expanding means and said seal expanding means allowing one-way movement of the seal expanding means in a direction to expand the slip means,
releasable holding means connected to the slip expanding means for preventing setting of the slip means until a predetermined hydraulic pressure has been applied against the slip expanding means,
means connected to the packer seal expanding means preventing setting of the seal expanding means until the slip means have been set,
coacting shoulders between the seal expanding means and the slip expanding means positioned so that when the seal expanding means is lifted sufficiently the shoulders will contact and the slip expanding means will disengage the slip means, and
a releasing sub movable connected to the mandrel and engageable with the packer expanding means for releasing the packer seal means and the slip means when longitudinally moved relative to the mandrel.

11. A well packer adapted to be set in a conduit disposed in a well bore comprising,
a mandrel,
an initially retracted packing seal means surrounding said mandrel,
slip means surrounding said mandrel and positioned below said packing seal means,
an abutment member surrounding the mandrel against which the top of the packing seal means is engaged,
a seal expanding sleeve surrounding the mandrel for movement toward said packing means for expanding said packing seal means into engagement with the conduit,
one-way clutch means between the mandrel and said packer expanding sleeve allowing one-way movement of the packer expanding sleeve upwardly,
a slip expanding sleeve surrounding said mandrel and a portion of the seal expanding sleeve,
one-way clutch means between the slip expanding sleeve and the seal expanding sleeve allowing one-way movement of the slip expanding sleeve downwardly,
opposing pistons inside of said slip expanding sleeve and surrounding said mandrel, one of which is connected to the slip expanding sleeve and one of which is connected to the seal expanding sleeve,
releasable holding means connected to the slip expanding sleeve for preventing the setting of the slip means until a predetermined pressure is applied against the opposing pistons, and
means connected to the seal expanding sleeve preventing setting of the packer means until the slip means have been set, and
a releasable sub connected to said abutment and engageable with the seal expanding sleeve for releasing the packing seal means and the slip means.

12. In a well packer having an initially retracted packing seal means and initially retracted slip means surrounding a mandrel and adapted to be set in a conduit in a well bore, the improvement in a releasing assembly comprising,
an abutment member surrounding the mandrel against which the packing seal means is engaged,
an unloader sleeve threadably engaging the mandrel and engaging the abutment member,
a top sub threadably engaging the unloader sleeve,
coacting shoulders on the unloader sleeve and on the top sub whereby rotating the top sub will rotate the unloader sleeve after engagement of the coacting shoulders,
an equalizing port in the top sub for equalizing the pressure inside and outside said mandrel when the top sub is longitudinally moved away from the mandrel before releasing the energy stored in the seal means,
seal means between the top sub and said mandrel initially blocking off the equalizing port,
seal means sealing off the threaded connection between the unloader sleeve and the mandrel.

13. In a well packer having an initially retracted packing means and initially retracted slip means surrounding a mandrel and adapted to be set in a conduit in a well bore, the improvement in a slip assembly comprising,
a plurality of unitary slips surrounding the mandrel,
wedge shaped slip supporting means on each end of

the segments which when moved relative to each other expand the slips outwardly into engagement with the conduit,

dove-tail shaped coacting engaging surfaces on each end of the slips and on the supporting means at the end of the slips,

a centering sleeve slidable at all times relative to and surrounding the mandrel,

engaging means on the sleeve and each slip for maintaining the longitudinal movement of all of the unitary slips in unison as the segments are moved outwardly and inwardly.

14. In a well packer having a packing means and a plurality of slip segments mounted on a mandrel and adapted to be set in a conduit in a well bore, the improvement in a slip assembly comprising,

wedge shaped slip supporting means on each end of the slips which when moved toward each other expand the slips outwardly into engagement with the conduit,

each of said segments having an energy storing means in the outer face thereof, said energy storing means in its expanded position extending outwardly from the segments further than the outer surface of said slips so as to engage the conduit so the supporting means can be moved away from each other, but said energy storage means extending outwardly less than the internal diameter of the conduit when the packer is initially moved into the conduit.

15. In a well packer having a packing means and a plurality of unitary slips surrounding a mandrel and adapted to be set in a conduit in a well bore, the improvement in a slip assembly comprising,

wedge shaped slip supporting means on each end of the slips which when moved toward each other will expand the slips in unison outwardly into engagement with the conduit,

dove-tailed shaped coacting engaging surfaces on each end of the slips and the supporting means at the end of the slips,

a centering sleeve slidably positioned between the mandrel and the slips,

slidable engaging means on the sleeve for maintaining the slips parallel to the sleeve as the slips are expanded outwardly and inwardly,

each of said slips having a spring which in their expanded position extending outwardly from the slips further than the outer surface of said slips but said springs extending outwardly less than the internal diameter of the conduit when the packer is initially moved into the conduit.

16. In a well packer having seal means and a plurality of slip segments mounted on a mandrel and adapted to be set in a conduit in a well bore, the improvement in a one-way clutch for holding one member of the packer relative to another member while permitting one-way movement in the second direction comprising,

an external helical thread on one of said members,

a plurality of ratchet segments connected to the other member, having when positioned in one consecutive rotational position to each other an internal helical thread on said segments, but which are positioned about the external helical thread in a reverse consecutive rotational position, and

yieldable retaining means about said segments yieldably urging said segments into engagement with the external helical thread.

17. A well packer adapted to be set in a conduit exposed in a well bore comprising,

a mandrel,

an initially retracted seal means surrounding said mandrel,

slip means surrounding said mandrel and positioned below said seal means,

said slip means including,

a plurality of slips surrounding the mandrel,

wedge shaped slip supporting means on each end of the slips which when moved toward each other move the slips outwardly into engagement with the conduit,

dove-tail shaped coacting engaging surfaces on each end of the slips and the supporting means at the end of the slips,

a centering sleeve slidably positioned between the mandrel and the slips,

slidable engaging means on the sleeve and the slips for maintaining the slips parallel to the sleeve as the slips are expanded outwardly and inwardly,

each of said slips having a spring receiving slot in the space thereof,

a spring in each slot, said spring in its expanded position extending outwardly from the slips further than the outer surface of such slip, but said springs extending outwardly less than the packer is initially moved into the conduit,

a releasable sub including,

an abutment member surrounding said mandrel and positioned about the packing means,

an unloader sleeve threadably engaging the mandrel and engaging the abutment member,

a top sub threadably engaging the unloader sleeve,

coacting shoulders on the unloader sleeve and on the top sub whereby rotating the top sub will rotate the unloader sleeve after engagement of the coacting shoulders,

an equalizing port in the top sub which equalizes the pressure inside and outside said mandrel when the top sub is longitudinally moved away from the mandrel,

seal means between the top sub and said mandrel initially blocking off the equalizing ports,

seal means sealing off the threaded connection between the unloader sleeve and the mandrel,

a seal expanding sleeve surrounding the mandrel for movement toward said packing means for expanding said packing means into engagement with the conduit,

one-way clutch means between the mandrel and said seal expanding sleeve allowing one-way movement of the seal expanding sleeve upwardly,

a slip expanding sleeve surrounding said mandrel and a portion of the seal expanding sleeve,

one-way clutch means between the slip expanding sleeve and the seal expanding sleeve allowing one-way movement of the slip expanding sleeve downwardly,

each of said one-way clutch means including,

an external helical thread,

a plurality of ratchet segments having when positioned in one consecutive rotational position to each other, an internal helical thread on said segment sized to match the said external helical thread, but which are positioned about the external helical threads in a reverse consecutive rotational position, and

yieldable retaining means about said segments yieldably urging said segments into engagement with the external helical thread,

hydraulic means connected to said slip expanding sleeve and said packer expanding sleeve for movement of said sleeve oppositely to each other,

means connected to the seal expanding sleeve preventing setting of the seal means until the slip means have been set.

18. A well packer adapted to be set in a conduit disposed in a well bore comprising,

a mandrel,

an initially retracted packing seal means surrounding said mandrel,

abutment means connected to the mandrel on one side of the packer seal means preventing movement of the packer seal means in the direction of said abutment during and after expansion of said seal means but movable for releasing the packer,

slip means surrounding said mandrel and positioned below said packing seal means,

packer seal expanding means surrounding the mandrel for moving away from said slip means and toward said packing seal means for expanding said packer seal means into engagement with said conduit,

one-way clutch means between the mandrel and said packer seal expanding means allowing one-way movement of the packer seal expanding means toward the packer seal means,

slip expanding means surrounding said mandrel and a portion of the packer seal expanding means,

one-way clutch means between the slip expanding means and said packer expanding means allowing one-way movement of the slip expanding means toward said slip means,

means about the mandrel longitudinally movable relative to the mandrel for relatively moving the abutment and the packer seal expanding means away from each other for releasing the packer seal means, and

means for retracting the slips from engagement with the conduit.

19. A well packer adapted to be set in a conduit disposed in a well bore comprising,

a mandrel,

an initially retracted packing seal means surrounding said mandrel,

abutment means connected to the mandrel on one side of the packer seal means preventing movement of said packer seal means in the direction of said abutment during and after expansion of said seal means, but movable for releasing the packer,

slip means surrounding said mandrel and positioned on the second side of said packing seal means preventing either upward or downward movement when engaged with the conduit,

packer seal expanding means surrounding the mandrel and moving away from said slip means and toward said packing seal means for expanding said packer seal means into engagement with said conduit,

one-way clutch means between the mandrel and said packer seal expanding means allowing one-way movement of the packer seal expanding means toward the packer seal means,

slip expanding means surrounding said mandrel and a portion of the packer seal expanding means,

one-way clutch means between the slip expanding means and said packer expanding means allowing one-way movement of the slip expanding means toward said slip means,

means about the mandrel longitudinally movable relative to the mandrel for relatively moving the abutment and the packer seal expanding means away from each other for releasing the packer seal means, and

means for retracting the slips from engagement with the conduit.

20. The apparatus of claim **19** wherein the slip means are positioned below the packing seal means.

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