United States Patent

Dean

[15] **3,667,543**

[45] **June 6, 1972**

[54] RETRIEVABLE WELL PACKER

[72] Inventor: **Michael R. Dean,** Houston, Tex.

[73] Assignee: **Baker Oil Tools, Inc.,** Commerce, Calif.

[22] Filed: **May 22, 1970**

[21] Appl. No.: **39,637**

Related U.S. Application Data

[62] Division of Ser. No. 15,403, Mar. 2, 1970, Pat. No. 3,580,332.

[52] **U.S. Cl.** **166/125,** 166/134

[51] **Int. Cl.** **E21b 33/12**

[58] **Field of Search** 166/123, 124, 125, 134

[56] **References Cited**

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Primary Examiner—James A. Leppink

Attorney—Bernard Kriegel

[57] **ABSTRACT**

A retrievable well packer to be lowered in a well casing and having a main body with expanders and initially retracted slips thereon for anchoring the body to the well casing, and also an initially retracted packing thereon expandable against the casing, the slips and packing being expanded by moving the body upwardly and a device downwardly along the body, the upward force and movement of the body being transmitted to the slips and packing by a structure releasably locked to the body, such structure being released from the body when the well packer is to be retrieved to enable the body to be moved upwardly of the slips, expanders and packing to effect retraction from the casing of such slips and packing.

33 Claims, 29 Drawing Figures

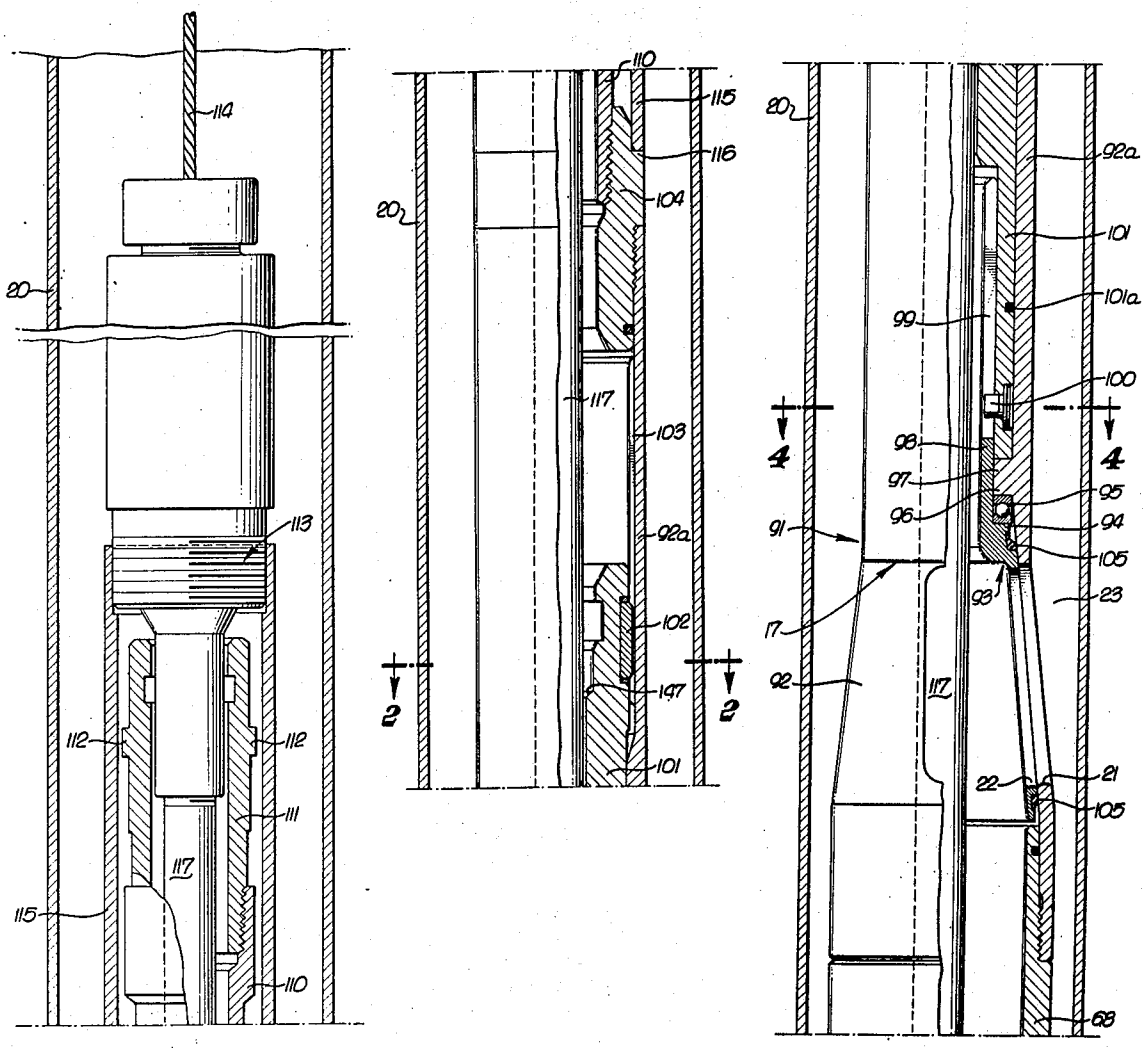


FIG. 1a.

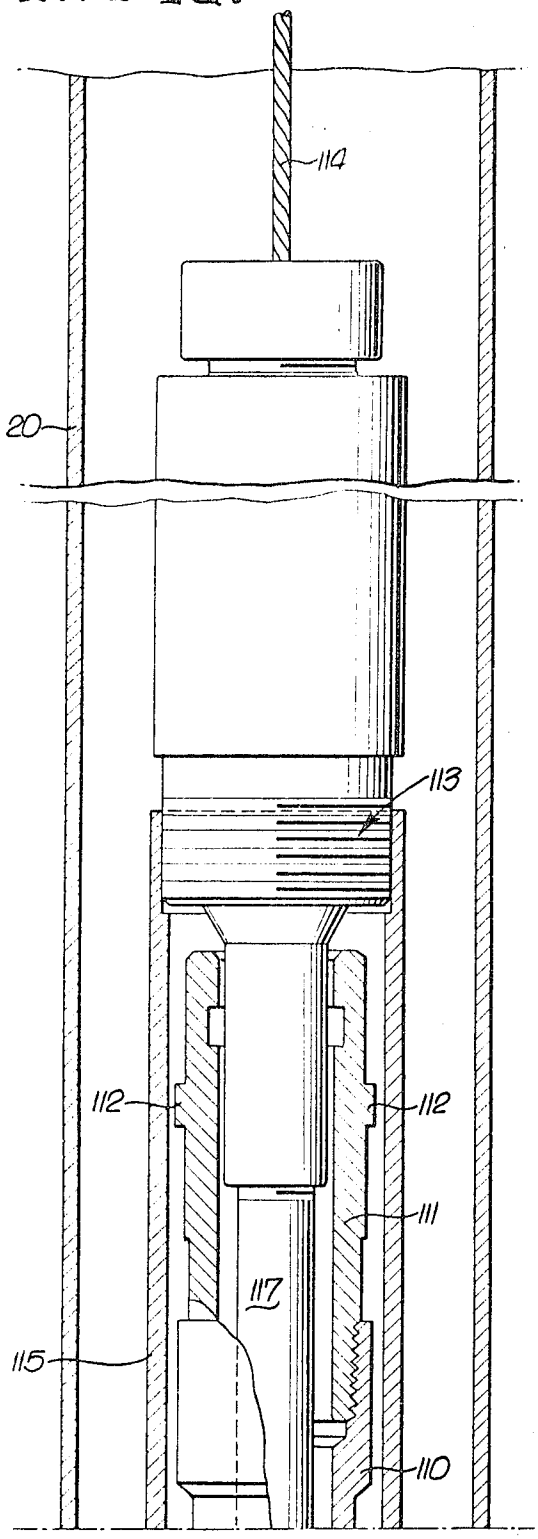
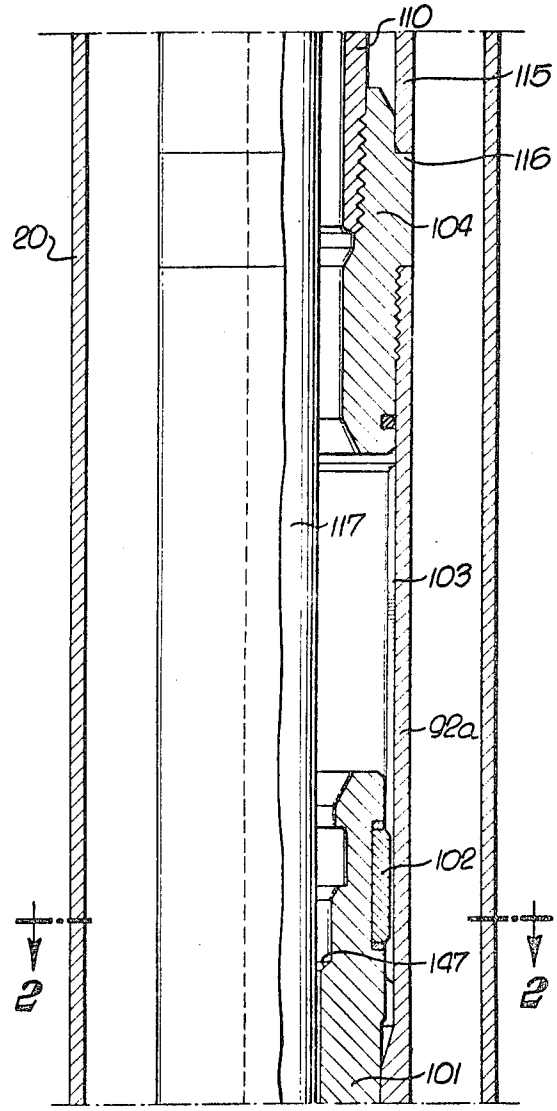


FIG. 1b.



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MICHAEL R. DEAN

BY Bernard Kriegel

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FIG. 1c.

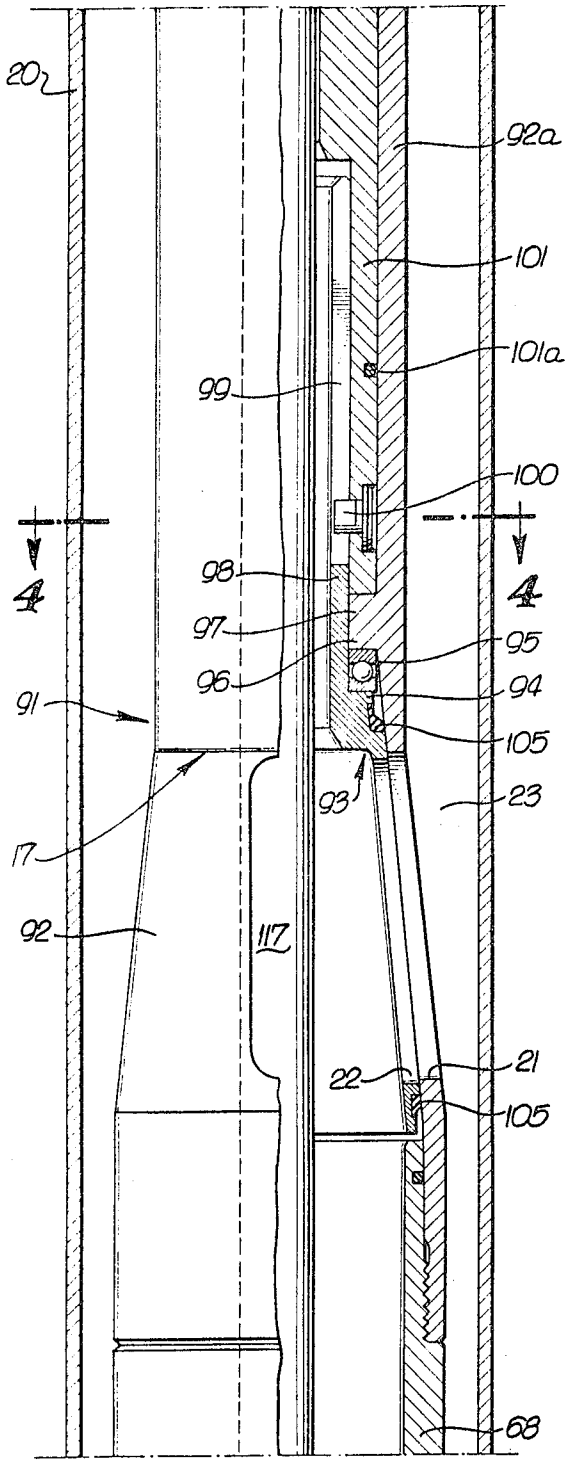


FIG. 2.

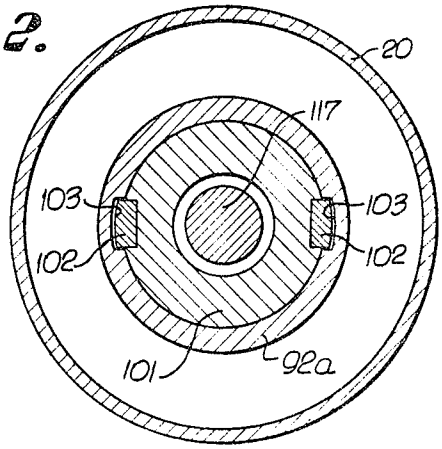


FIG. 3.

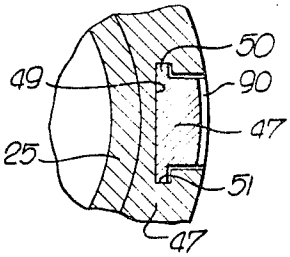
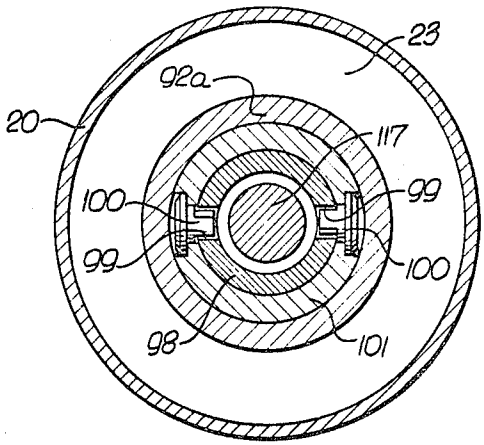


FIG. 4.



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MICHAEL R. DEAN

BY Bernard Kriegel

ATTORNEY

FIG. 1d.

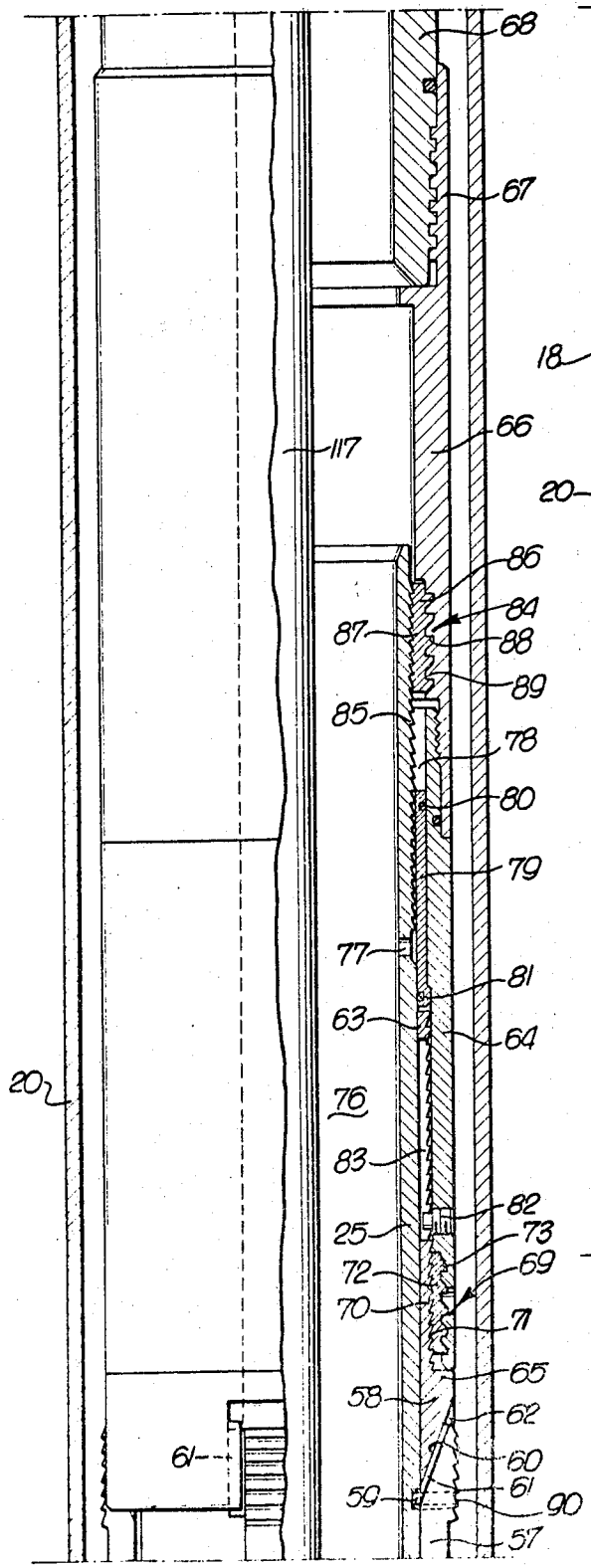
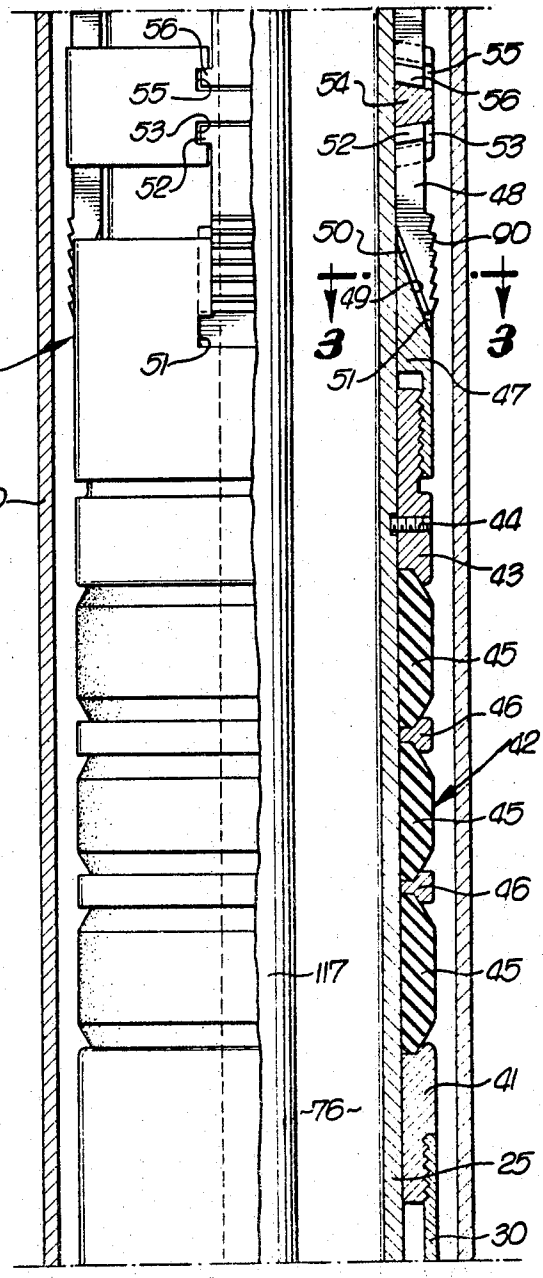


FIG. 1e.



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MICHAEL R. DEAN

By Bernard Kriegel

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FIG. 1f.

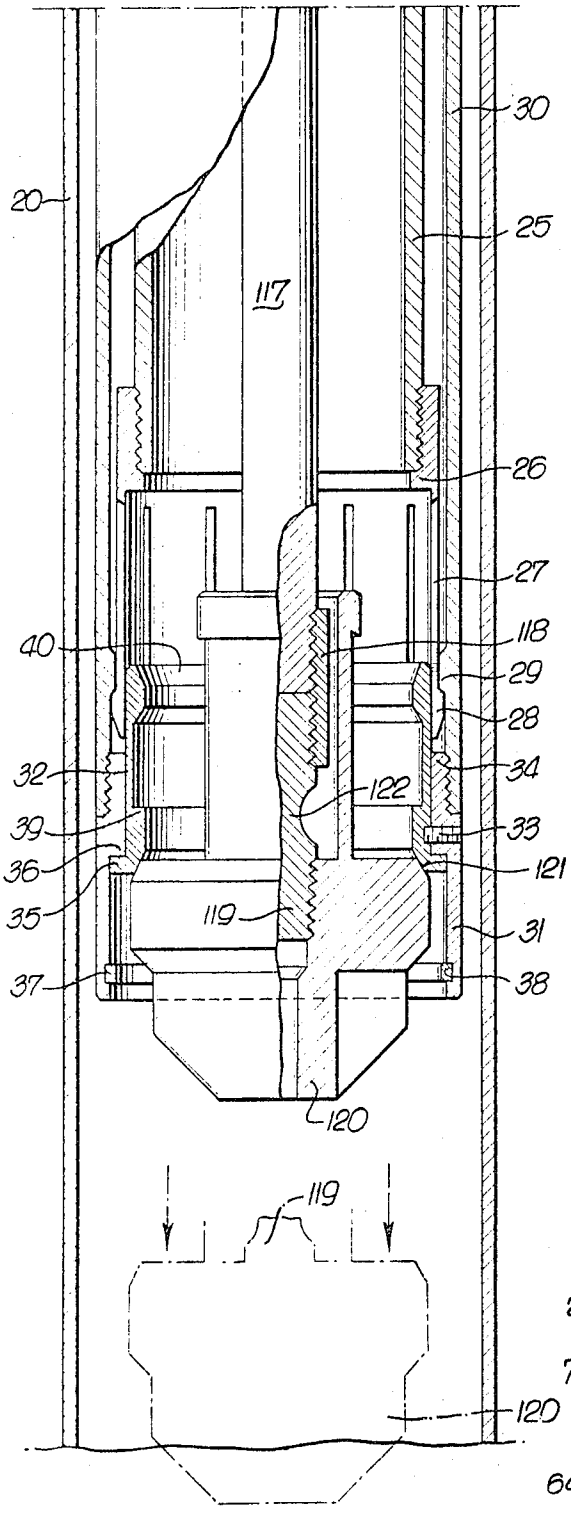


FIG. 5a.

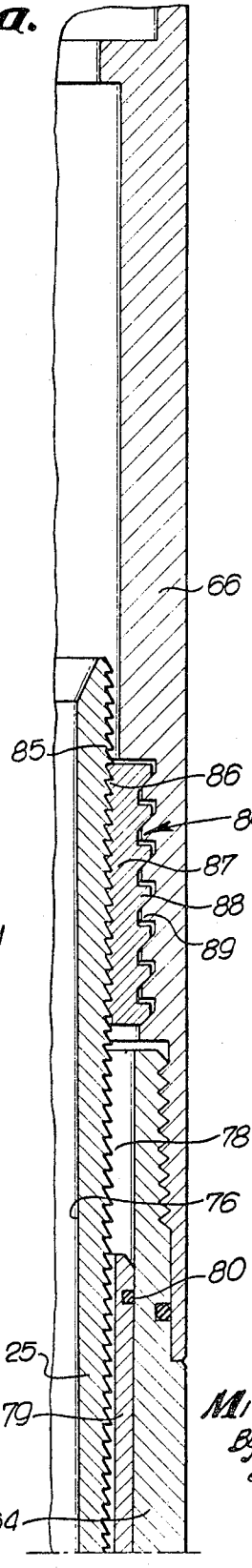
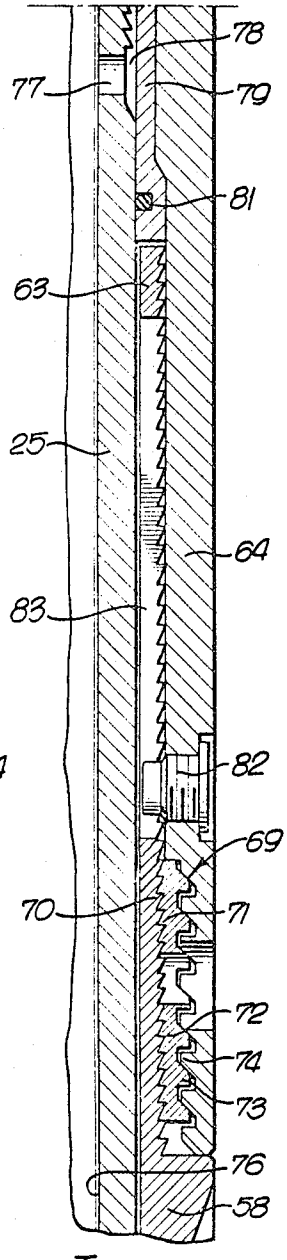


FIG. 5b.



INVENTOR

MICHAEL R. DEAN

By Bernard Kriegel

ATTORNEY

FIG. 6a.

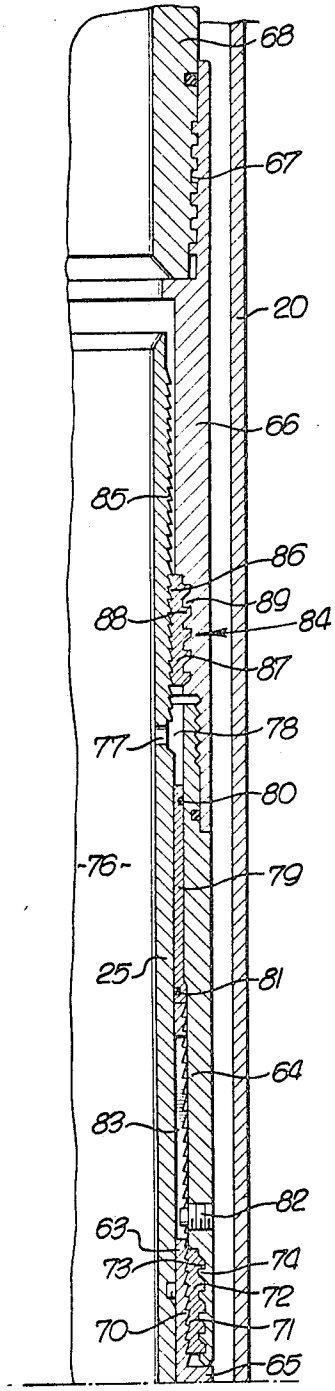


FIG. 6b.

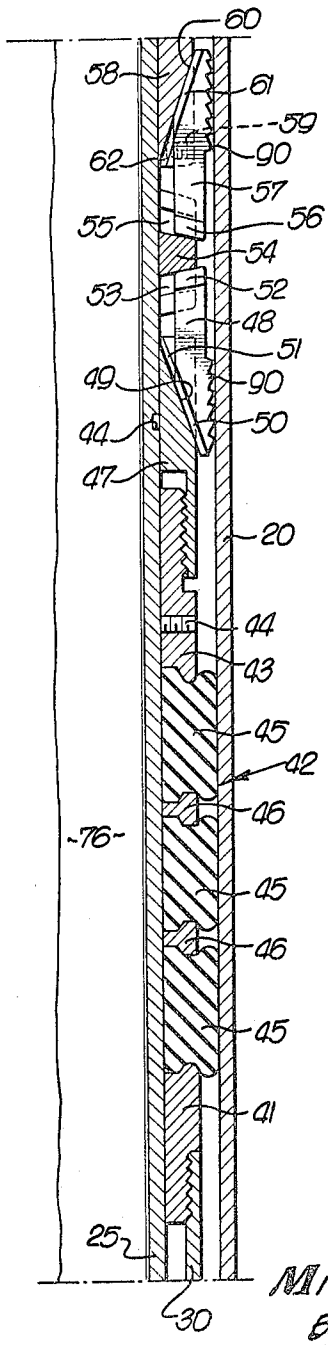
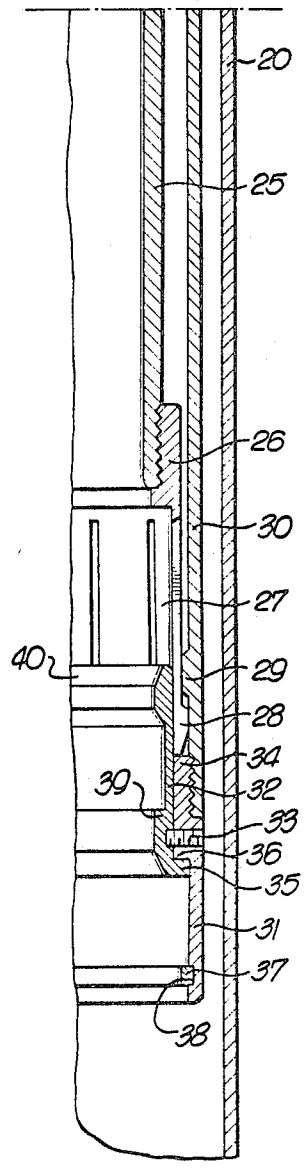


FIG. 6c.



INVENTOR

MICHAEL R. DEAN

By Bernard Kriegel

ATTORNEY

FIG. 7.

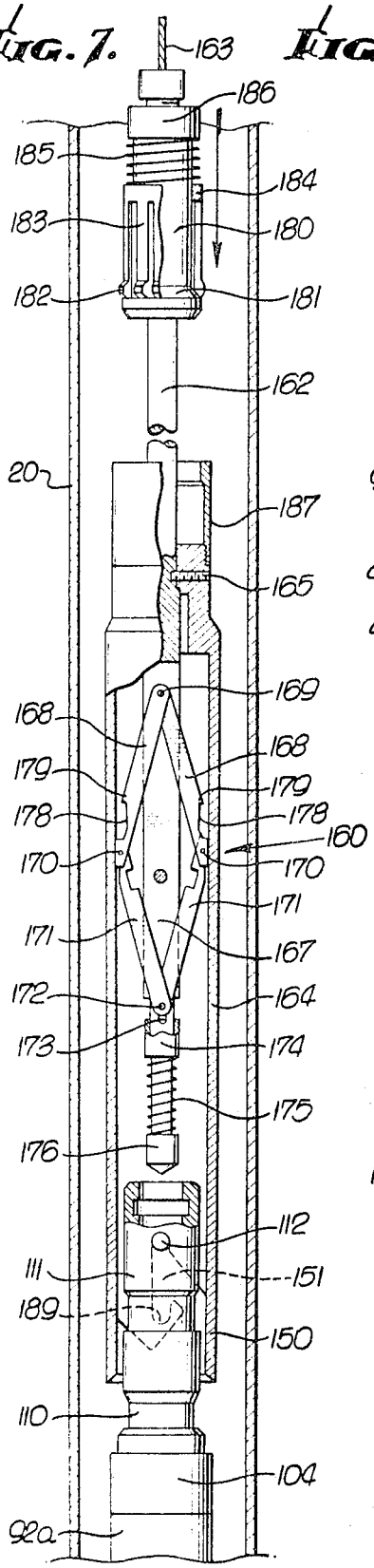


FIG. 12.

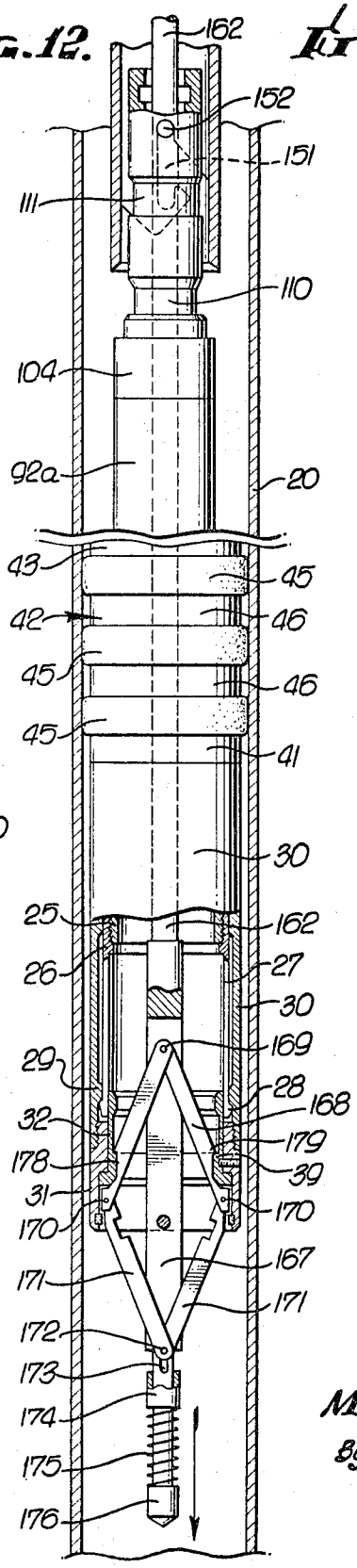
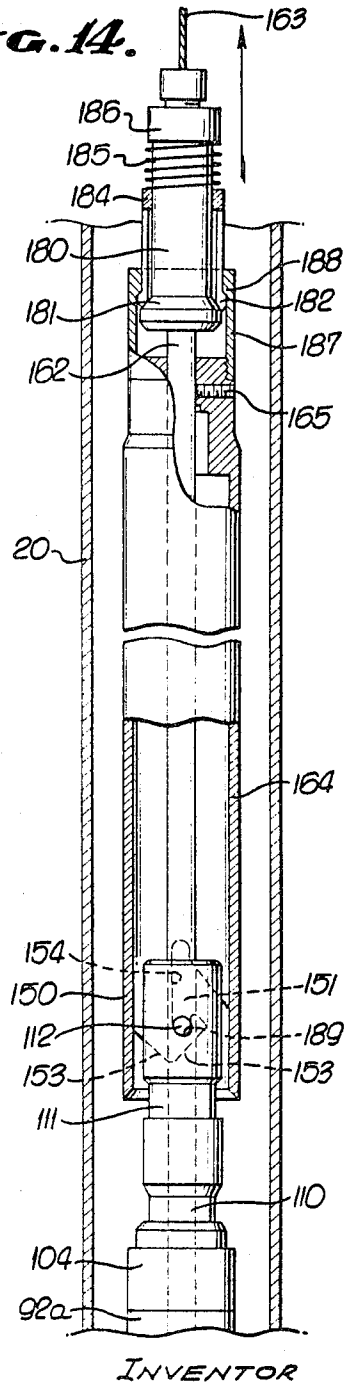


FIG. 14.



INVENTOR

MICHAEL R. DEAN

By Bernard Kriegel

ATTORNEY

FIG. 8.

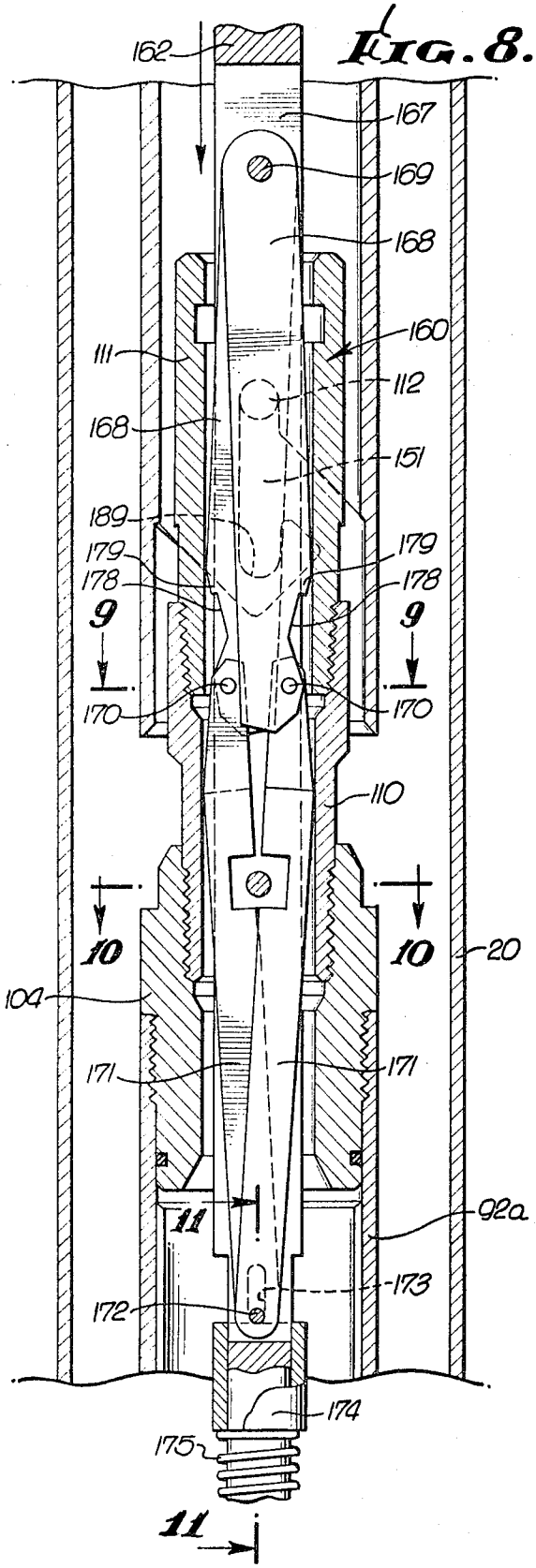


FIG. 9.

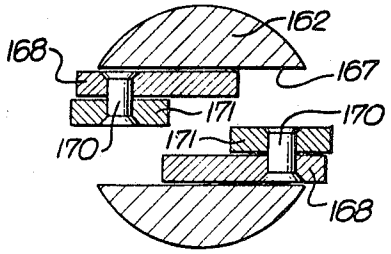


FIG. 10.

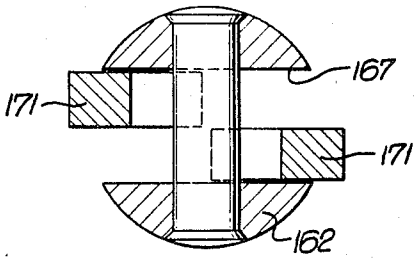
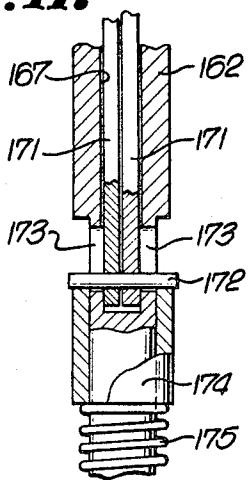


FIG. 11.



INVENTOR

MICHAEL R. DEAN

By Bernard Kriegel

ATTORNEY

FIG. 13a.

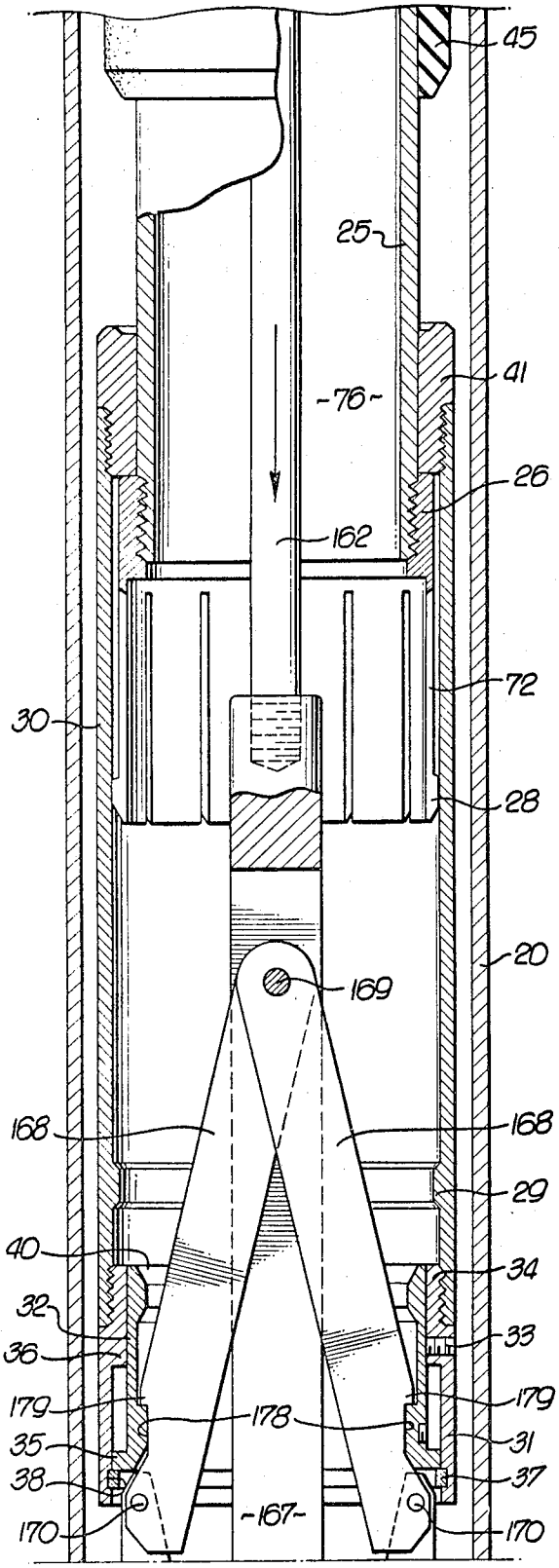
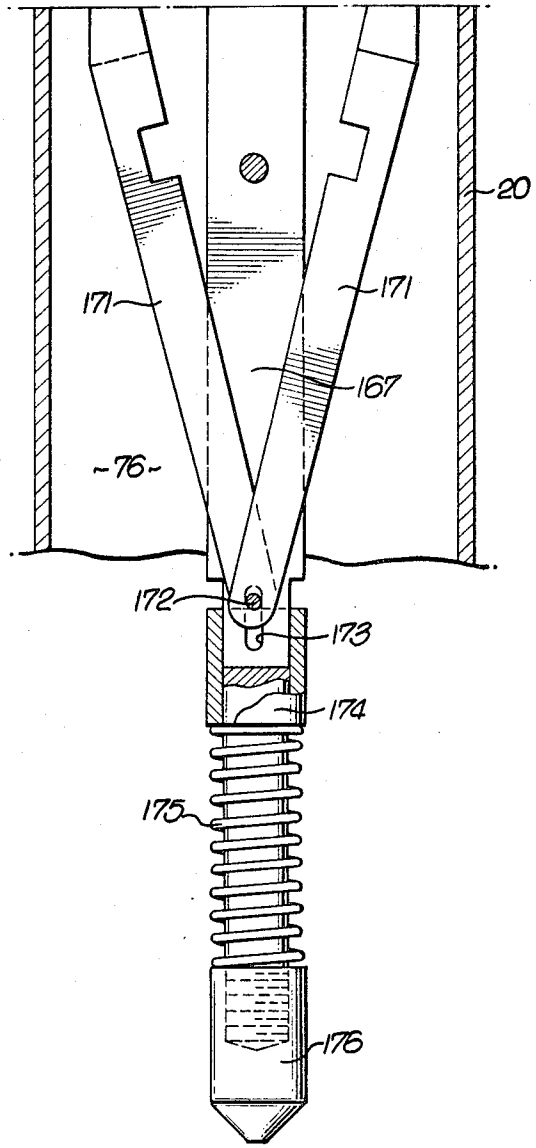


FIG. 13b.



INVENTOR

MICHAEL R. DEAN
By Bernard Kriegel
ATTORNEY

FIG. 15a.

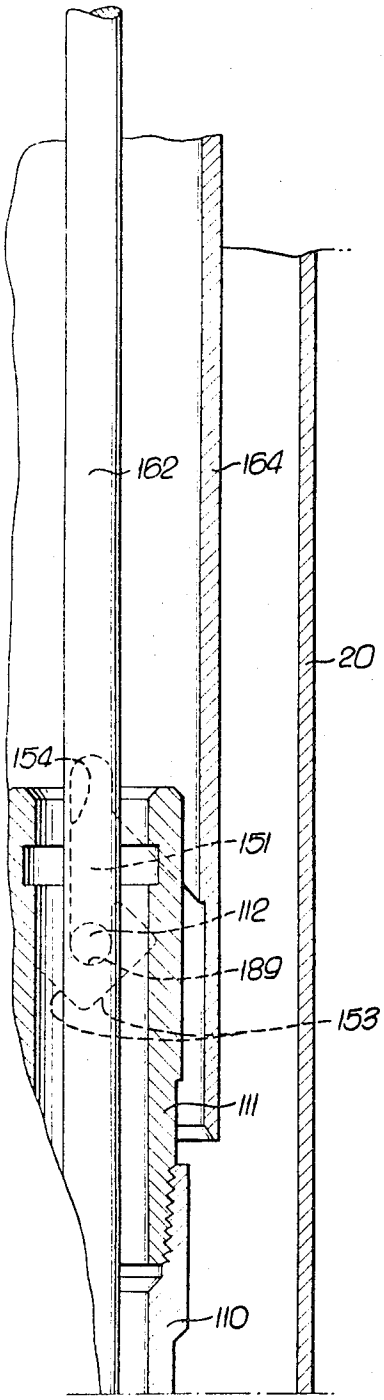


FIG. 15b.

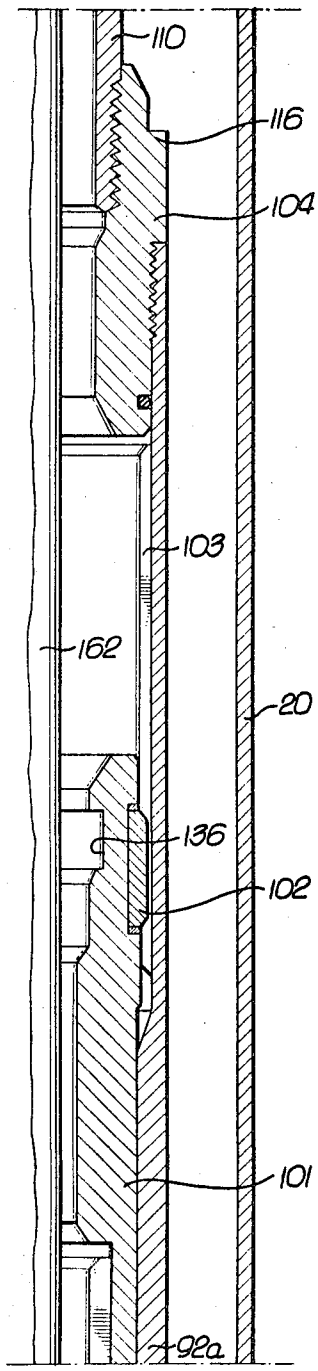
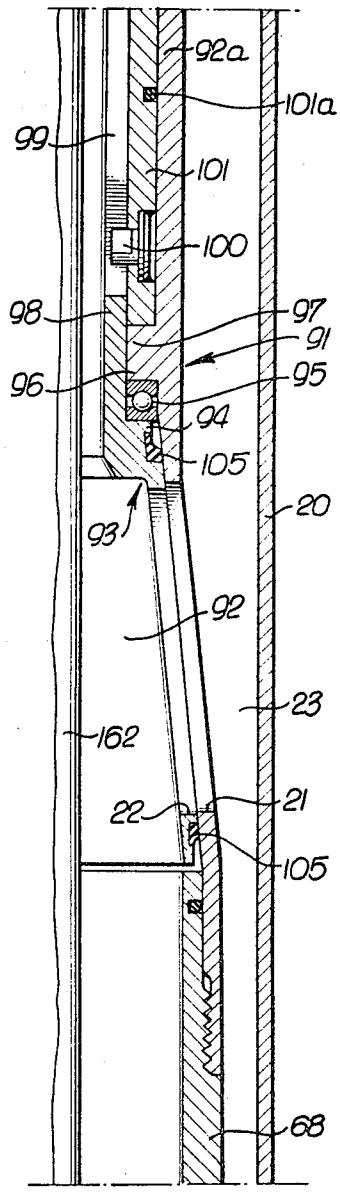


FIG. 15c.



INVENTOR

MICHAEL R. DEAN

By Bernard Kriegel

ATTORNEY

FIG. 15d.

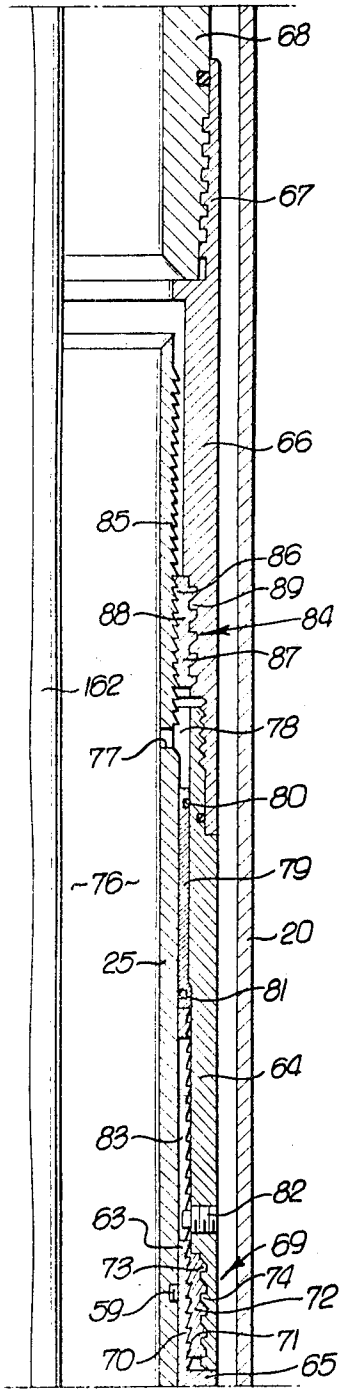


FIG. 15e.

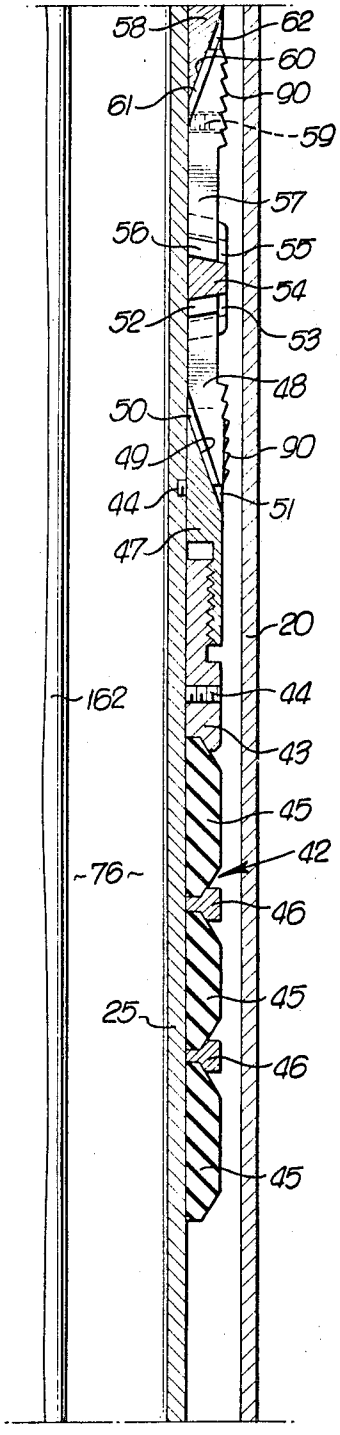
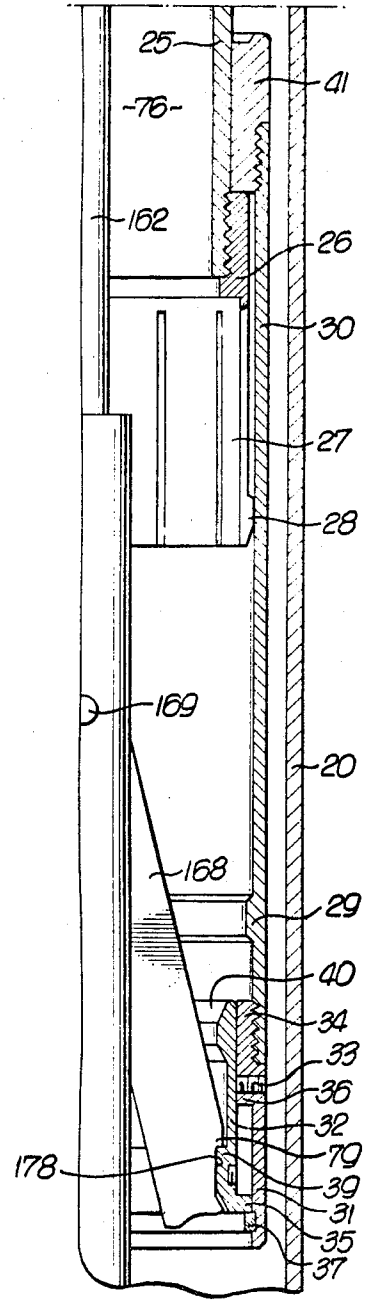


FIG. 15f.



INVENTOR

MICHAEL R. DEAN

By Bernard Kriegel

ATTORNEY

RETRIEVABLE WELL PACKER

RETRIEVABLE WELL PACKER

This application is a division of application, Ser. No. 15,403, filed Mar. 2, 1970, for "Apparatus for Controlling Fluid Flow From Gas Storage Wells and Reservoirs", now U.S. Pat. No. 3,580,332, patented May 25, 1971.

The present invention relates to subsurface well bore apparatus, and more particularly to subsurface well packers of the retrievable type.

Prior well packers, particularly those used in the production of fluid from a well bore or storage reservoir, could not be run in the well casing and also retrieved therefrom without the necessity for first "killing" the well; that is, filling the well bore with heavy drilling mud, or the like. The "killing" of a well is costly and is associated with the possibility of damage to the well bore. The inability to retrieve the well packer is occasioned, to some extent, by the necessity for effecting a turning effort or rotation to the packer body in securing release of the packer slips and packing from the well casing. Such action requires the use of a tubing string connected to the packer body, or other packer part, in order that turning effort can be imparted to the packer through the tubing string.

Prior packers of the retrievable type have relatively restricted passage areas therethrough which greatly limit the volume of fluid, such as gaseous fluids, that can flow therethrough in a relatively unrestricted manner. It is desirable for a well packer used in connection with the flow of gas from a gas storage reservoir to have a large passage area, so that gas can be withdrawn at very high rates during peak operating periods.

By virtue of the present invention, a well packer apparatus is provided having a large passage area therethrough. Moreover, the well packer can be run in and retrieved from the well casing without "killing" the well and under safe conditions. Such conditions are obtainable since the well packer can be lowered and removed from the well casing through use of wireline equipment, such as an electric wireline, piano wireline, or sand line, the packer being lowered into the well casing through use of a known type of lubricator at the top of the well bore, which permits the lowering of the well packer, its setting in the well casing, and its release and retrieval therefrom to take place with the well under fluid pressure.

An object of the present invention is to provide a well packer capable of being anchored in packed-off condition in the well casing against movement in both longitudinal directions, the slips and packer parts being set firmly against the well casing by virtue of straight-line longitudinal forces imposed upon the body of the packer and its surrounding parts, the slips and packing also being released and retracted from the well casing by virtue of a straight-line longitudinal movement imposed upon the body of the packer and its surrounding parts.

More specifically, an object of the invention is to provide a well packer which is anchored against longitudinal movement in both directions in the well casing as a result of taking an upstrain on the body of the tool, the well packer also being released from the well casing by the taking of an upstrain on the body of the tool.

A further object of the invention is to provide a well packer having slips and expanders for anchoring the packer against movement in both directions in a well casing, which embodies a device subject to well fluid pressure that prevents looseness from developing in the slips, and holds them anchored against the well casing.

Another object of the invention is to provide a retrievable well packer embodying slips capable of anchoring the casing against movement in both longitudinal directions as a result of longitudinal force imposed upon the body of the tool, which is transmitted to the slips surrounding it, and in which the well packer is released by disconnecting or uncoupling the body of the tool from at least a portion of the slips and packing structure surrounding it, which permits the body of the tool to be moved longitudinally relative thereto, in order to effect retraction of the slips and packing from the well casing, and withdrawal of the well packer through the casing to the top of the well bore.

This invention possesses many other advantages, and has other purposes which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense.

Referring to the drawings:

FIGS. **1***a*, **1***b*, **1***c*, **1***d*, **1***e* and **1**f together constitute a combined side elevational view and longitudinal section through a safety valve and well packer apparatus, being lowered in a casing on a wireline, and with the packer parts in their initial retracted positions, FIGS. **1***b*, **1***c*, **1***d*, **1***e* and **1***f* being lower continuations of FIGS. **1***a*, **1***b*, **1***c*, **1***d* and **1***e*, respectively;

FIG. **2** is a cross-section taken along the line **2—2** on FIG. **1***b*;

FIG. **3** is a fragmentary cross-section taken along the line **3—3** on FIG. **1***e*;

FIG. **4** is a cross-section taken along the line **4—4** on FIG. **1***c*;

FIGS. **5***a* and **5***b* together constitute a partial longitudinal section through the upper portion of the packer apparatus on an enlarged scale, primarily illustrating the ratchet type lock mechanisms embodied in the well packer, FIG. **5***b* being a lower continuation of FIG. **5***a*;

FIGS. **6***a*, **6***b* and **6***c* together constitute a quarter longitudinal section through the lower packer portion of the apparatus, illustrated as anchored in packed-off condition in the well casing, FIGS. **6***b* and **6***c* being lower continuations of FIGS. **6***a* and **6***b*, respectively;

FIG. **7** is a view of the apparatus with a packer releasing and retrieving tool lowered into engagement with the apparatus;

FIG. **8** is an enlarged longitudinal section of the packer releasing portion of the releasing and retrieving tool, with its releasing dogs in contracted condition and passing through the upper portion of the apparatus;

FIG. **9** is an enlarged cross-section taken along the line **9—9** on FIG. **8**;

FIG. **10** is an enlarged cross-section taken along the line **10—10** on FIG. **8**;

FIG. **11** is a fragmentary section taken on the line **11—11** on FIG. **8**;

FIG. **12** is a combined side elevational view and longitudinal sectional illustrating the releasing mechanism in condition for releasing the well packer;

FIGS. **13***a* and **13***b* together constitute an enlarged longitudinal section, with parts shown in side elevation, of the releasing mechanism after having released the well packer parts, FIG. **13***b* being a lower continuation of FIG. **13***a*;

FIG. **14** is a longitudinal section, with parts shown in side elevation, of the upper portion of the retrieving tool in condition for retrieving the well packer and safety valve from the well casing;

FIGS. **15***a*, **15***b*, **15***c*, **15***d*, **15***e* and **15***f* are quarter longitudinal sections through the well packer and safety valve, with the well packer parts retracted from the well casing and with the entire apparatus in condition for elevation through and from the well casing, FIGS. **15***b*, **15***c*, **15***d*, **15***e* and **15***f* being lower continuations of FIGS. **15***a*, **15***b*, **15***c*, **15***d* and **15***e*, respectively.

As illustrated in the drawings, a well packer **18** can be lowered in a well casing **20** (well bore) and anchored therein in packed-off condition against movement in both longitudinal directions. It includes a main or tubular body **25** (FIGS. **1***d*, **1***e*, **1***f*), the lower end of which is threadedly secured to a body latch sleeve **26** having a plurality of depending spring-like arms **27** terminating in lateral outward directed latch fingers

28 adapted to be disposed under an inwardly directed circumferential shoulder or flange 29 integral with a thrust sleeve 30, the lower end of which is threadedly secured, below the latch fingers, to a lower thrust sleeve section 31 (FIG. 1*f*). A retainer sleeve 32 is disposed within the upper portion of the extension 31, being held initially in a position closely behind the latch fingers 28 by a shear screw 33, in order to retain the latch fingers under the thrust sleeve shoulder 29. The body latch sleeve 26 can only move to a limited distance downwardly along the thrust sleeve 30 by engagement of its latch fingers with the upper end 34 of the thrust sleeve extension 31. Upward force imposed upon the retainer sleeve 32 is transmitted from its lower flange 35 to a downwardly facing shoulder 36 on the extension sleeve 31, with which it is in engagement when the shear screw 33 is intact. The upper ends of the latch fingers 28 and their companion shoulder 29 are inclined in a downward and outward direction so that an upward pull taken on the body 25 and its latch sleeve 26 will tend to cam the latch fingers 28 laterally inwardly from engagement with the shoulder or flange 29. However, such action cannot occur so long as the retainer sleeve 32 is located behind the latch fingers.

Shearing of the screw 33 by imposing a downward force on the retainer sleeve 32 will enable the latter to shift downwardly to a position below the latch fingers 28, allowing the latter to shift laterally inwardly. The extent of downward movement of the retainer sleeve 32 is limited by its engagement with a split stop ring 37 confined within an internal groove 38 in the extension member 31. Such downward movement is obtained as a result of engagement of a tool part, described hereinbelow, with an upwardly facing shoulder 39 in the retainer sleeve, the tool being guided into the sleeve by a downwardly tapering upper surface 40 on the retainer sleeve.

The upper end of the thrust sleeve 30 is threadedly secured to a lower abutment ring 41 slidably mounted on the periphery of the body 25 (FIG. 1*e*). This abutment ring engages the lower end of a packing assembly 42, the upper end of which contacts an upper abutment ring 43 initially secured to the body 25 by a shear screw 44. As specifically illustrated, the packing assembly 42 includes a plurality of elastomer packing elements 45 engaging the upper and lower abutments 43, 41 and separated by metallic spacer sleeves 46. Relative movement of the upper and lower abutments 43, 41 toward each other will compress the packing elements 45 and expand them outwardly into firm sealing engagement with the wall of the well casing 20 and the periphery of the body 25.

The upper abutment 43 is threadedly secured to a lower expander 47 engaging initially retracted lower slips 48 adapted to be expanded outwardly upon relative downward movement of the lower slips along the lower expander, by virtue of slidable engagement of the inner downwardly and outwardly inclined inner surfaces 49 on the slips with companion tapered surfaces on the lower expander. Relative separating movement between the lower slips 48 and lower expander 47 will cause retraction of the lower slips because of opposed side tongues 50 on the lower slips engaging in companion grooves 51 in the lower expander (FIG. 3), the tongues and grooves being inclined in the same direction and to the same extent as the expander surfaces 49. The upper ends of the lower slips 48 are formed as T-shaped heads 52 radially slidable in companion slots 53 in a slip ring 54.

The upper end of the slip ring 54 has similar T-shaped slots 55 receiving the lower T-shaped heads 56 of a plurality of circumferentially spaced upper slips 57 engageable with an upper expander 58 initially secured to the body by a shear screw 59 when the slips 48, 57 and packing assembly 42 are in retracted position (FIG. 1*d*). The inner surfaces 60 of the slips 57 are inclined in an upward and outward direction, engaging companion surfaces in the upper expander 58, such that relative longitudinal movement toward each other between the upper expander and upper slips will effect radial outward expansion of the upper slips against the well casing 20. Similarly, relative longitudinal separating movement between the upper expander and upper slips will effect retraction of the upper slips toward the packer body 25 because of the inclined side tongues 61 on the upper slips received within companion grooves 62 in the upper expander, the tongues and grooves being inclined to the same extent as the expander surfaces 60 on the upper expander and slips.

The expander 58 has an extension sleeve 63 integral therewith and extending upwardly therefrom, which is slidable along the periphery of the body 25. This extension sleeve is connected to a connector sleeve 64 extending upwardly from the expander 58 and encompassing the extension sleeve, the lower end of the connector sleeve engaging an upwardly facing shoulder 65 on the upper expander. The upper end of the connector sleeve is threadedly secured to a connector sub 66 having an upper left-hand threaded box 67 threadedly secured to a valve body section 68 disposed therewithin. The upper expander 58, although initially engaged by the lower end of the connector sleeve 64, is movable downwardly to a small extent relative to the latter by virtue of a one-way or ratchet interconnection 69 therebetween (FIGS. 1*d*, 5*b*). Thus, the expander extension sleeve 63 has a plurality of upwardly facing ratchet teeth 70 on its periphery engaging companion downwardly facing ratchet teeth 71 on a split lock ring 72 having external cam teeth 73 thereon engaging companion internal cam teeth 74 in the connector sleeve 64. Thus, the extension sleeve 63 and upper expander 58 can move downwardly relative to the connector sleeve 64 by virtue of ratcheting of the extension sleeve through the lock ring 72. However, the teeth 70, 71 will coengage to prevent upward or return movement of the extension sleeve and upper expander relative to the connector sleeve 64, the cam teeth 73, 74 on the exterior of the lock ring 72 and the connector sleeve 64 forcing the internal ratchet teeth 71 of the lock ring laterally inwardly to retain them meshed with the external ratchet teeth 70 on the extension sleeve. The specific one-way connection between the connector sleeve 63 and extension sleeve 64 forms no part of the present invention, being illustrated and described in U.S. Pat. No. 3,311,171, to which attention is directed.

The extension sleeve 63 and upper expander 58 are urged in a downward direction by fluid pressure internally of the central passage 76 through the body 25, the fluid passing through side ports 77 in the body into an annular space 78 between the body and the connector sleeve, acting upon the upper end of an annular piston 79 disposed in such space, this piston having an upper side seal ring 80 engaging the inner wall of the connector sleeve 64 and a lower internal side seal ring 81 engaging the periphery of the body 25 below the port 77. Thus, fluid under pressure will act over the upper end area of the piston 79 and urge it in a downward direction against the extension sleeve 63, urging the upper expander 58 downwardly of the body 25 and the connector sleeve 64. Relative rotation between the connector sleeve 64 and the expander extension sleeve 63 is prevented by a torque pin 82 threaded in the connector sleeve and received within a longitudinal slot 83 in the extension sleeve.

As described hereinbelow, the packing assembly 42 and the upper and lower slips 48, 57 are expanded outwardly to set the well packer as a result of moving the packer body 25 upwardly and the connector sub 66 and connector sleeve 64 downwardly. Such relative movement is permitted by a one-way or ratchet device 84, but return relative movement is prevented (FIGS. 1*d*, 5*a*). As disclosed, the upper portion of the body 25 above its port 77 is provided with circumferential ratchet teeth 85 extending therealong that face in a downward direction, which are adapted to mesh with companion upwardly facing ratchet teeth 86 on a split upper lock ring 87 having external circumferential cam teeth 88 engaging companion cam teeth 89 in the connector sub 66. Thus, the body 25 can move upwardly and ratchet through the lock ring 87, but its downward movement is prevented by coengagement of the ratchet teeth 85, 86 and the bearing of the inclined faces of the cam teeth 88, 89 against one another, urging and retain-

ing the lock ring **87** in its lateral inward direction to hold the ratchet teeth fully meshed.

The well packer **18** is lowered to its desired setting location in the casing **20**, whereupon, as described hereinbelow, a downward force is imposed on the connector sub **66** and connector sleeve **64**, the body **25** being shifted in an upward direction, such upward movement being transmitted to the thrust sleeve **30**. Such upwardly and downwardly directed forces will shear the pin **59** securing the upper expander **58** to the body and the upper abutment **43** to the body, the upper expander **58** being shifted downwardly and the lower abutment **43** being shifted upwardly. This action effects downward movement of the upper expander within the upper slips **57** and relative upward movement of the lower expander **47** within the lower slips **48** to expand both upper and lower slips radially outwardly until their wickers or teeth **90** engage and are embedded firmly in the well casing **20**. Upon anchoring of the upper slips **57** against the casing, the upper expander **58** cannot move downwardly to any further extent, which is also true of the anchoring of the lower slips **48** against the well casing preventing further upward movement of the lower expander **47**. Accordingly, the lower packing abutment **41** then moves upwardly toward the upper packer abutment **43** to shorten the packing assembly **42** and expand the packing elements **45** outwardly into sealing engagement with the wall of the well casing **20** and periphery of the packer body **25**. During setting of the tool, the body **25** ratchets relatively upwardly through the upper lock ring **87**. However, when full setting has been achieved, the body cannot shift downwardly and thereby release the slips and packing assembly, because of the interengagement between the ratchet teeth **85**, **86**, which lock the body to the connector sub **66** against downward movement with respect thereto.

The packer **18** is disclosed as being attached through the left-hand threaded interconnection **67** to a lower valve body section **68**, the upper end of which is threadedly secured to an upper valve body section **91** having a plurality of elongate, circumferentially spaced ports **21** through an upwardly tapering or converging section **92** thereof (FIG. 1*c*). The small diameter portion of the tapered valve body section is laterally spaced from the wall of the casing **20** to a considerable extent, providing a large annular space **23** therebetween, the valve body portion **92***a* being of cylindrical form above the small end of its frusto-conical or tapered portion. A plug valve **93** is rotatably mounted within the frusto-conical portion **92** of the valve body, having elongate ports **22** extending therethrough conforming in number, shape and spacing with the body ports **21** so that the alignment between the plug valve ports **22** and the body ports **21** provides a large flow area for gas therethrough from the packer body **25**, through the lower valve body section **68** and into the relatively large area annulus **23** between the upper cylindrical body portion **92***a* and the well casing **20**. Downward movement of the plug valve **93** is limited by its engagement with the upper end of the lower valve body section **68**; whereas, its upward movement is prevented by its upwardly facing shoulder **94** bearing against the lower end of a suitable thrust bearing **95** that engages a downwardly facing shoulder **96** on an internal flange **97** provided in the cylindrical valve body portion **92**. A cylindrical plug valve extension **98** extends upwardly from its tapered portion, such extension having a pair of opposed inclined cam slots **99** therein in which pins **100** are received carried by and extending inwardly from a longitudinally slidable sleeve **101** which is prevented from rotating by one or a plurality of keys **102** thereon riding in longitudinal keyways **103** within the upper portion of the cylindrical valve body extension **92***a* (FIG. 1*b*). The slidable sleeve **101** is adapted to occupy a lower position in engagement with the flange **97**, at which time its cam pins or followers **100** are disposed in the lower portions of the inclined cam slots **99**, the plug body **93** then being disposed in the position in which its ports **22** are aligned with the body ports **21**. Upward shifting of the slidable sleeve **101**, which is prevented from rotating by reception of its keys **102** within the keyways **103**, carries the follower pins **100** upwardly in the inclined cam slots **99** and turns or rotates the plug valve body **93** so that, when the slidable sleeve **101** is in its uppermost position in engagement with a top sub **104** threadedly secured to the upper end of the valve body **92**, the plug valve ports **22** are completely out of alignment with the body ports **21**, the valve **17** then being in a closed position. A side seal ring **101**a on the sleeve **101** engages the body portion **92**a to prevent leakage therebetween.

As specifically illustrated and described in the above-identified application, the cam slots **99** are inclined circumferentially so that a full stroke of the slidable sleeve **101** from its lowermost to its uppermost position will turn the valve body **93** 54 degrees, since there are four ports **22** and **21** in the plug valve member **93** and in the surrounding body portion **92**. The ports **22**, **21** are illustrated as aligned, the valve being in a fully opened condition. Turning the plug valve member **93** by 45° through shifting the sleeve **41** upwardly will fully disalign the ports and close the valve.

To prevent fluid leakage between the plug valve **93** and the surrounding body **92**, the plug valve has upper and lower circumferential seal rings **105** mounted thereon above and below its ports **22** sealingly engaging the inner wall of the plug body portion **92** above and below its ports **21**. The plug body also has longitudinal seals (not shown) mounted thereon between its ports **22** and extending from the upper to the lower seals **105**, so as to provide a seal completely around each plug body port **22**, to prevent fluid from flowing through the plug body ports **22** and around the plug body exterior into the valve body ports **21** when the valve **17** is in the closed condition.

The valve body **91**, **68** may be considered as forming an upper extension of the connector sub **66** and connector sleeve **64**, for the purpose of running the well packer **18** in the casing, setting the packer therein, and releasing and withdrawing the well packer from the well casing. The top sub **104** secured to the upper valve body section **92***a* is threadedly secured to a coupling **110**, which is, in turn, threadedly attached to a seal nipple **111** having a pair of opposed radial lock pins **112** projecting therefrom. As specifically illustrated, the well packer and valve mechanism connected thereto is run in the well casing by means of a setting tool **113** secured to a wireline **114** extending to the top of the well bore. The setting tool is of a known type, for example, being of the specific type illustrated in U.S. Pat. No. 2,640,546, in which its upper end is secured to the wireline. The setting tool includes a setting sleeve **115** surrounding the seal nipple **111** and coupling **110**, with its lower end engaging an upwardly facing shoulder **116** on the top sub **104**. This setting sleeve is shifted downwardly as a result of operation of the setting tool **113**. The setting tool also includes a tension rod **117** that extends through the seal nipple **111**, coupling **110**, top sub **104**, slidable sleeve **101**, plug body **93**, valve body **91**, **68** and packer body **25**, its lower end being threaded to a coupling **118**, which is, in turn, threaded onto a tension release stud **119** threadedly secured to an abutment **120** underlying and engaging a downwardly facing shoulder **121** of the retainer sleeve **32**. The release stud **119** has a weakened section **122** at which it can pull apart when a certain predetermined setting force has been imposed on the well packer.

In a known manner, described in the above U.S. Pat. No. 2,640,546, the setting tool **113** is actuated, after lowering of the packer and valve apparatus to the position in which the well packer is to be set within the casing. The setting force developed in the tool shifts the setting sleeve **115** downwardly and pulls upwardly on the tension rod **117**. Downward force on the setting sleeve is then transmitted through the top sub **104** and valve body **91**, **68** to the connector sub **66** and the connector sleeve **64**, shearing the screw **59** and shifting the upper expander **58** downwardly. At the same time, the upward motion and force on the tension rod **117** is being exerted through the release stud **119**, abutment **120**, and retainer sleeve **32** on the thrust member **31**, **30**, shifting the thrust sleeve **30** upwardly and causing the upper end **34** of the sleeve

extension 31 to engage the latch fingers 28 and shift the sleeve 26 and the body 25 upwardly. Upward movement of the thrust sleeve 30 and downward movement of the connector sleeve 64 effect outward expansion of the upper and lower slips 57, 48 and of the elastomer packing elements 45 against the well casing 20, in the manner described above, the packer then being in its set condition as illustrated in FIGS. 6*a*, 6*b* and 6*c*. As the force developed in the setting tool increases, the slips are anchored more firmly against the well casing and the packing elements 45 are forced to a greater extent into sealed relation against the casing 20 and the packer body 25. The force eventually exceeds the strength of the release stud 119 at its weakened section 122, pulling the stud apart at that point, which allows the lower portion of the stud and the abutment 120 to drop down in the well bore. The wireline 114 can now be elevated to remove the setting tool 113 from the anchored packer 18 and valve mechanism 17 thereabove, leaving the bore of the packer and of the valve body unobstructed, the packer then being in the condition shown in FIGS. 6*a*, 6*b*, 6*c*.

The apparatus disclosed can be used with other equipment, as disclosed and described in the above parent application. In the event the packer is to be retrieved, such other equipment is first removed, leaving the passages through the safety valve 17 and packer 18 open and capable of receiving a packer releasing and retrieving mechanism, as disclosed in FIGS. 7 to 15, inclusive. This mechanism includes an elongate mandrel 162, the upper end of which is secured to a wireline running string 163, by means of which the packer releasing and retrieving mechanism is lowered in the well casing 20. A housing 164 surrounds the mandrel, its lower end being provided with J-slots 151 of the same configuration as the tubing string J-slots, so that the lower portion of the housing can be piloted over the seal nipple 111 and become coupled thereto. This housing is releasably secured to the mandrel 162 by a shear pin 165, such that engagement of the upper end of the housing slots with the lock pins 112 will allow a downward jarring force to be imposed on the extension mandrel 162 to shear the pin 165 and release the mandrel from the housing 164, permitting the mandrel to move downwardly therethrough.

The extension mandrel 162 has an elongate slot 167 extending therethrough in which a scissors-type linkage is received. An upper pair of links 168 is disposed in the mandrel slot, being pivotally mounted on the mandrel by a hinge pin 169. The lower ends of these upper links are connected by pins 170 to the upper ends of a pair of lower links 171, whose lower ends are pivoted together by a hinge pin 172 extending through an elongate slot 173 in the mandrel. A ring 174 is slidably mounted on the lower portion of the mandrel 162, engaging the pin 172 and being urged upwardly of the mandrel by a compression spring 175 surrounding the mandrel and bearing against a lower guide 176 secured to the mandrel. The spring forces the sleeve 174 upwardly, urging the lower ends of the lower links 171 upwardly, and, because of the pin connection 170 with the upper links 168, tends to separate such pin connections 170 of the upper and lower links with respect to one another. Such separating action is prevented initially by the encompassing retrieving tool housing 164. However, after shearing of the pin 165 and lowering of the mandrel 162 within the housing, the links 168, 171 are removed therefrom, collapsing together in passing through the seal nipple 111, coupling 110, top sub 104, slidable sleeve 101 and rotary plug valve 93 into the packer body 25, which is of a much larger inside diameter than the parts thereabove. Accordingly, the spring 175 then shifts the lower ends of the lower links upwardly and spreads out their pin connected portions 170, as shown in FIG. 12.

The upper links 168 have recesses 178 therein above their pin connections 170 with the lower links 171, the upper ends of the recesses providing downwardly facing dogs 179 which are adapted to engage the upwardly facing shoulder 39 of the retainer sleeve 32, for the purpose of releasing the latter from the thrust sleeve extension 31, as described below.

To the upper end of the extension mandrel 162 is secured a retrieving body 180 having a downwardly and outwardly inclined holding surface 181 adapted to engage the lower ends of fingers 182 at the bottom end of spring-like arms 183 forming part of a collet latch sleeve 184 surrounding the body. A compression spring 185 surrounds the body 180 and engages an upper stop ring 186 on the body and the latch sleeve 184, tending to urge the collet latch sleeve downwardly so as to slide its fingers 182 downwardly along the holding surface 181. The retrieving latch mechanism is adapted to pass into an upper extension sleeve 187 secured to the retrieving tool housing 164, the fingers 182 and holding portion 181 of the body moving into the extension, with the fingers disposed under an extension shoulder 188. Accordingly, upward movement of the extension mandrel 162 and its body 180 will bring the holding surface 181 behind the fingers 182 and urge and hold them outwardly in position under the shoulder 188, whereby upward movement of the wireline 163 will exert an upward pull on the housing 164, and, through the lower ends 189 of the J-slots 151 at the lower portion of the housing, pull upwardly upon the seal nipple 111, coupling 110, top sub 104, valve body 91, connector sub 66, connector sleeve 64 and upper expander 58.

With the passages through the safety valve 17 and packer 18 open, the packer releasing and retrieving tool 160 is lowered on the wireline 163 in the well casing. The lower housing portion 164 of the retrieving tool moves over the seal nipple 111 and the inclined walls 153 of the J-slots 151 will cause the J-slots to assume an appropriate retrieving position, as determined by engagement of the upper ends of the inclined J-slot walls with the release studs or pins 112, as disclosed in FIG. 7. A downward jarring force is now imposed on the wireline to shear the pin 165, which will cause the mandrel 162 to move downwardly through the housing 164, carrying its linkage 168–170 with it, the linkage and mandrel passing through the seal nipple 111, top sub 110, slidable sleeve 101, plug body 93, lower portion 68 of the valve body, and connector sub 66 into the passage 76 through the main body 25, the scissors-like links 168, 171 then being expanded outwardly by the spring 175, the lower links 171 shifting through the packer retainer sleeve 32, but the dogs 179 expanding outwardly into the retainer sleeve above its shoulder 39 and coming to a stop in engagement with such shoulder, as disclosed in FIG. 12. A downward jarring force is now imposed through the wireline 163 on the extension mandrel 162, which will act through the links 168 and their dog portions 179 on the retainer sleeve 32 to shear the pin 33 securing it to the thrust sleeve extension 31, driving the retainer sleeve downwardly until it engages the stop ring 37, at which time the upper end of the retainer sleeve is disposed below the latch fingers 28, freeing the latch sleeve 26 from the thrust sleeve 30. Downward movement of the extension mandrel 162 moves the body 180 at its upper portion and the fingers 182 of the collet latch 184 into the housing extension 187, at which the extension mandrel 162 becomes coupled to the housing 164. At this time, the dogs 179 will have driven the thrust sleeve shoulder 29 past the latch fingers 28, the lower abutment 41 on the thrust sleeve engaging the upper end of the body latch sleeve 26, as disclosed in FIGS. 13*a*, 13*b*.

An upward pull can now be taken on the wireline 163, which, through the body 180 and upper collet sleeve 184, will exert an upward pull on the housing 164 and seal nipple 111 connected thereto by engagement of the lower ends of the J-slot portions 154 with the lock pins 112 (FIG. 14). The upward force and pull is transmitted from the seal nipple through the coupling 111, top sub 110 and valve body 91 to the connector sub 66 and connector sleeve 64, pulling the upper expander 58 upwardly and effecting retraction of the upper slips 57, because of the tongue and groove interconnection 61, 62 therebetween. Upon dropping away of the lower abutment 41 from the packing assembly 42, the latter will inherently contract from the casing, relieving the upwardly directed force on the lower expander 47. Accordingly, retraction of the upper

expander **58** and the upper slips **57** will then cause their upward movement and upward movement of the slip ring **54** and of the lower slips **48** relative to the lower expander **47**, effecting retraction of the lower slips because of their tongue and groove interconnection **50**, **51** with the lower expander. During such retracting movement as a result of upward shifting of the upper expander **58** with respect to the lower expander **47**, the body **25** is moving upwardly with the connector sub **66** because of the ratchet lock **84**. However, such upward movement of the body **25** does not adversely effect the retraction of the packing elements **45** and of the upper and lower slips **57**, **48**, since the body is free to move upwardly with respect thereto because of the large longitudinal space that existed between the lower abutment **41** and the lowermost packing element **45** upon release of the thrust sleeve **30** from the collet latch **26** and its dropping down to place the lower abutment **41** upon the upper end of the collet sleeve (FIG. **13a**). The safety valve **17** and packing assembly **18** can now be elevated by the wireline **163** and removed from the casing to the top of the well bore, the parts being in the relative positions shown in FIGS. **14** to **15***f*, inclusive.

The foregoing sequence of operation can take place without "killing" the well. The tubing string **16** is run in the well casing and connected to the apparatus, and is also removed from the well casing, only when the packer **18** is set and the safety valve **17** is in its closed condition. The packer and valve combination is run in the well casing and removed therefrom under pressure controlled conditions, as through use of a lubricator (not shown) of a known arrangement at the top of the well, which is readily permitted because of the use of wirelines.

It is, accordingly, apparent that a well packer has been provided which can be run in the well casing, anchored in place, and released and withdrawn from the well casing, without the necessity for "killing" the well. The well packer can be set through use of wireline equipment and is released also through the use of wireline equipment, the top of the well casing being closed during such operations through use of a known lubricator in conjunction with the wireline. The well packer has a passage **76** of very large cross-sectional area provided because of the structural arrangement between the body of the well packer and the parts that surround it. Any looseness that tends to develop in the well packer is compensated for by the one-way lock device **84**, which will permit the body **25** to move upwardly with respect to the surrounding slips, but prevent the body from moving downwardly from this new position, and also by virtue of the fact that the pressure within the packer passage can act in a downward direction over the sleeve **79** to shift the extension sleeve **63** and the upper expander **58** downwardly to insure the retention of the expander **58** wedged tightly behind the upper slips **57**. Such downward movement of the upper expander **58** can occur because of the one-way lock ring device **69** that allows the expander to shift downwardly relative to the connector sleeve **64**. The body of the well packer is positively coupled to the thrust sleeve **30**, so as to transmit the upward force of the body of the packer to the retracted parts that surround it, securing packer setting. Yet the body of the packer can still be moved upwardly in effecting release of the well packer from the well casing because of unlocking of the body from the thrust sleeve **30**, which results from the downward shifting of the retainer sleeve **32** from its position behind the latch fingers **28**. The well packer can be wireline operated both in connection with its setting and in connection with its retrieval, the upwardly and downwardly holding packer slips preventing up and down movement of the packer body relative to the well casing, holding it anchored against such movement at all times, except for such movement that automatically occurs in the event of extrusion of the packing material around the upper and lower abutments **43**, **41**.

I claim:

1. In subsurface apparatus adapted to be set in a well bore: a body; normally retracted means on said body; means for expanding said normally retracted means laterally outwardly against the wall of the well bore; a coupling releasably securing said body to said expanding means for transmitting longitudinal non-rotary relative motion of said body to said expanding means to effect lateral outward expansion of said normally retracted means; means for retaining said coupling in its coupled relation; said retaining means being shiftably carried by one of said body and said expanding means for movement from its retaining position to enable said coupling to be released and said normally retracted means to return from its expanded position to its retracted position.

2. In apparatus as defined in claim **1**; and means for shifting said retaining means from its retaining position.

3. In apparatus as defined in claim **1**; and means movable within said body into engagement with said retaining means for shifting said retaining means from its retaining position.

4. In apparatus as defined in claim **1**; said normally retracted means comprising packing means expandable into sealing engagement with the wall of the well bore.

5. In apparatus as defined in claim **1**; said normally retracted means comprising anchoring means expandable into anchoring engagement with the wall of the well bore.

6. In apparatus as defined in claim **1**; said normally retracted means comprising packing means expandable into sealing engagement with the wall of the well bore; said normally retracted means further comprising anchoring means expandable into anchoring engagement with the wall of the well bore.

7. In apparatus as defined in claim **1**; said normally retracted means comprising anchoring means expandable into anchoring engagement with the wall of the well bore to prevent movement of said body in both longitudinal directions.

8. In apparatus as defined in claim **1**; said normally retracted means comprising packing means expandable into sealing engagement with the wall of the well bore; said normally retracted means further comprising anchoring means expandable into anchoring engagement with the wall of the well bore to prevent movement of said body in both longitudinal directions.

9. In subsurface apparatus adapted to be set in a well bore: a body; normally retracted means on said body; means for expanding said normally retracted means laterally outwardly against the wall of the well bore comprising an upper structure above said normally retracted means and shiftable relatively downwardly along said body and a lower structure below said normally retracted means and shiftable relatively upwardly toward said upper structure; a releasable coupling for transmitting non-rotary relative upward movement of said body to said lower structure to effect relative upward movement of said lower structure toward said upper structure and expansion of said normally retracted means; means for retaining said coupling in its coupled relation; said retaining means being shiftably carried by one of said body and said lower structure for movement from its retaining position to release said coupling and said body from said lower structure to allow said upper and lower structures to move relatively away from each other and said normally retracted means to return from its expanded position to its retracted position.

10. In apparatus as defined in claim **9**; frangible means securing said retaining means in its retaining position; and means for exerting a force on said retaining means disruptive of said frangible means and for shifting said retaining means from its retaining position.

11. In apparatus as defined in claim **9**; frangible means securing said retaining means in its retaining position; and means movable within said body into engagement with said retaining means to disrupt said frangible means and shift said retaining means from its retaining position.

12. In apparatus as defined in claim **9**; and one-way lock means between said body and upper structure permitting upward movement of said body with respect to said upper structure but locking said body to said upper structure against downward movement relative thereto.

13. In apparatus as defined in claim 9; said normally retracted means comprising packing means between said structures and expandable into sealing engagement with the wall of the well bore upon relative movement of said structures toward each other.

14. In apparatus as defined in claim 9; said normally retracted means comprising expander means and slip means engaging said expander means and expandable into anchoring engagement with the wall of the well bore upon relative movement of said structures toward each other.

15. In apparatus as defined in claim 9; said normally retracted means comprising packing means, expander means and slip means, said packing means and slip means being expandable against the wall of the well bore upon relative movement of said structures toward each other.

16. In apparatus as defined in claim 9; said normally retracted means comprising packing means, expander means and slip means, said packing means and slip means being expandable against the wall of the well bore upon relative movement of said structures toward each other; frangible means securing said retaining means in its retaining position; means movable within said body into engagement with said retaining means to disrupt said frangible means and shift said retaining means from its retaining position; and one-way lock means between said body and upper structure permitting upward movement of said body with respect to said upper structure but locking said body to said upper structure against downward movement relative thereto.

17. In subsurface apparatus adapted to be set in a well bore: a body; normally retracted packing means on said body; anchoring means on said body at one end of said packing means comprising an expander and normally retracted slips engaging said expander; a first structure on said body at the opposite end of said packing means; a second structure engageable with said anchoring means and shiftable relatively toward said first structure to expand said packing means and slips toward the wall of the well bore; a releasable coupling for transmitting longitudinal non-rotary movement of said body to one of said structures to effect relative movement of said structures toward each other and expansion of said slips and packing means; means for retaining said coupling in its coupled relation; said retaining means being shiftably carried by one of said body and said one of said structures for movement from its retaining position to release said coupling and said body from said one of said structures to allow said structures to move relatively away from each other and said packing means and slips to return from their expanded positions to retracted positions.

18. In apparatus as defined in claim 17; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward movement of said body to said one of said structures.

19. In apparatus as defined in claim 17; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward movement of said body to said one of said structures; and one-way lock means between said body and said other of said structures permitting upward movement of said body with respect to said other of said structures but locking said body to said other of said structures against downward movement relative thereto.

20. In apparatus as defined in claim 17; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward movement of said body to said one of said structures; and one-way lock means between said body and said other of said structures permitting upward movement of said body with respect to said other of said structures but locking said body to said other of said structures against downward movement relative thereto; frangible means securing said retaining means in its retaining position; and means movable within said body into engagement with said retaining means to disrupt said frangible means and shift said retaining means from its retaining position.

21. In apparatus as defined in claim 17; and fluid pressure responsive means acting on said expander for retaining said expander wedged behind said slips and said slips anchored to the wall of the well bore.

22. In apparatus as defined in claim 17; and fluid pressure responsive means acting on said expander for retaining said expander wedged behind said slips and said slips anchored to the wall of the well bore; and one-way lock means between said second structure and expander permitting movement of said expander in one longitudinal direction relative to said second structure but preventing movement of said expander in the opposite longitudinal direction relative to said second structure.

23. In subsurface apparatus adapted to be set in a well bore: a body; normally retracted packing means on said body; anchoring means on said body at one end of said packing means comprising an upper expander, a lower expander and normally retracted slips engaging said expanders; a first structure on said body at the opposite end of said packing means; a second structure engageable with said anchoring means and shiftable relatively toward said first structure to expand said packing means and slips into engagement with the wall of the well bore to secure said apparatus in packed-off relation in the well bore against movement in both longitudinal directions; a releasable coupling for transmitting longitudinal non-rotary movement of said body to one of said structures to effect relative movement of said structures toward each other and expansion of said slips and packing means; means for retaining said coupling in its coupled relation; said retaining means being shiftably carried by one of said body and said one of said structures for movement from its retaining position to release said coupling and said body from said one of said structures to allow said structures to move relatively away from each other and said packing means and slips to return from their expanded positions to retracted positions.

24. In apparatus as defined in claim 23; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward relative movement of said body to said one of said structures.

25. In apparatus as defined in claim 23; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward relative movement of said body to said one of said structures; and one-way lock means between said body and said other of said structures permitting upward movement of said body with respect to said other of said structures but locking said body to said other of said structures against downward movement relative thereto.

26. In apparatus as defined in claim 23; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward relative movement of said body to said one of said structures; and one-way lock means between said body and said other of said structures permitting upward movement of said body with respect to said other of said structures but locking said body to said other of said structures against downward movement relative thereto; frangible means securing said retaining means in its retaining position; and means movable within said body into engagement with said retaining means to disrupt said frangible means and shift said retaining means from its retaining position.

27. In apparatus as defined in claim 23; wherein said packing means is located below said anchoring means; said one of said structures being located below said packing means

and said other of said structures above said upper expander; said coupling transmitting upward relative movement of said body to said one of said structures.

28. In apparatus as defined in claim 23; wherein said packing means is located below said anchoring means; said one of said structures being located below said packing means and said other of said structures above said upper expander; said coupling transmitting upward relative movement of said body to said one of said structures; frangible means securing said retaining means in its retaining position; and means movable within said body into engagement with said retaining means to disrupt said frangible means and shift said retaining means from its retaining position.

29. In apparatus as defined in claim 23; wherein said packing means is located below said anchoring means; said one of said structures being located below said packing means and said other of said structures above said upper expander; said coupling transmitting upward relative movement of said body to said one of said structures; frangible means securing said retaining means in its retaining position; and means movable within said body into engagement with said retaining means to disrupt said frangible means and shift said retaining means from its retaining position; and one-way lock means between said body and said other of said structures permitting upward movement of said body with respect to said other of said structures but locking said body to said other of said structures against downward movement relative thereto.

30. In apparatus as defined in claim 1; actuating means movable through the well bore for shifting said retaining means from its retaining position, said actuating means including means adapted for connection to the subsurface apparatus for withdrawal of said apparatus from the well bore.

31. In apparatus as defined in claim 1; actuating means movable through the well bore and within said body into engagement with said retaining means for shifting said retaining means from its retaining position, said actuating means including means adapted for connection to the subsurface apparatus for withdrawal of said apparatus from the well bore.

32. In apparatus as defined in claim 9; actuating means movable through the well bore and within said body into engagement with said retaining means for shifting said retaining means from its retaining position, said actuating means including means connectible to said upper structure for elevating said upper structure with respect to said lower structure and withdrawing said apparatus from the well bore.

33. In apparatus as defined in claim 17; wherein said one of said structures is located below said packing means and anchoring means and said other of said structures is located above said packing means and anchoring means; said coupling transmitting upward movement of said body to said one of said structures; actuating means movable through the well bore and within said body into engagement with said retaining means for shifting said retaining means from its retaining position, said actuating means including means connectible to said other of said structures for elevating said other of said structures with respect to said one of said structures to effect retraction of said slips and withdrawal of said apparatus from the well bore.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,667,543 Dated June 6, 1972

Inventor(s) MICHAEL R. DEAN

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 14: cancel "54" and substitute --45--.

Signed and sealed this 9th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents