Dec. 17, 1968 M. L. CROW ETAL 3,416,608

RETRIEVABLE WELL PACKER

Filed June 27, 1966 3 Sheets-Sheet 1

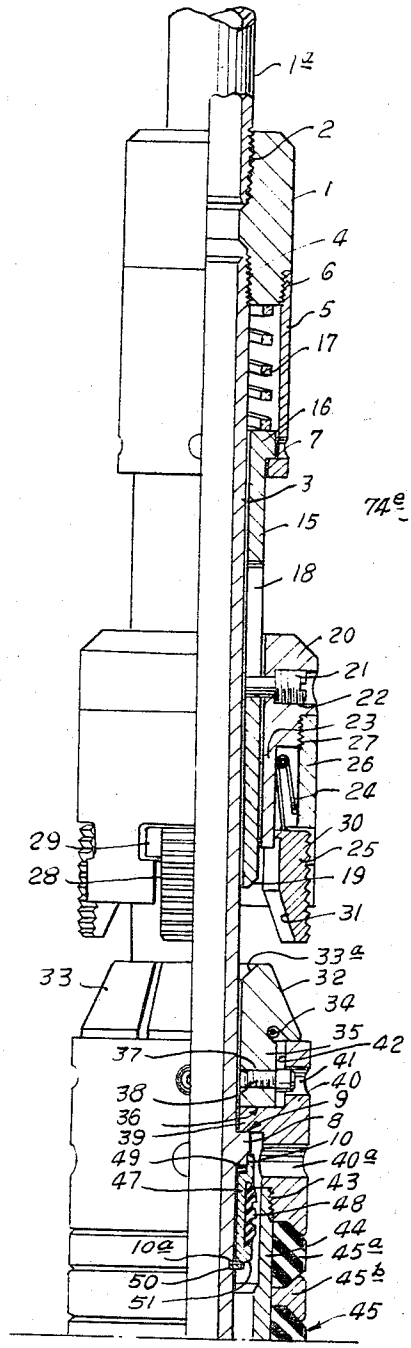


Fig. I

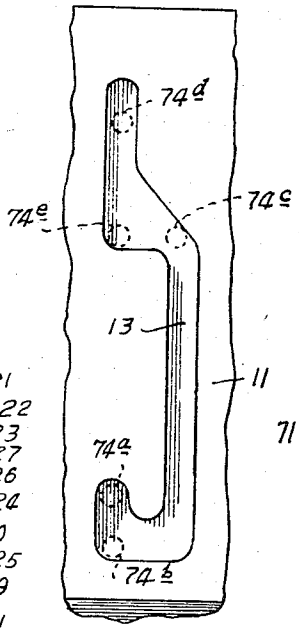


Fig. II

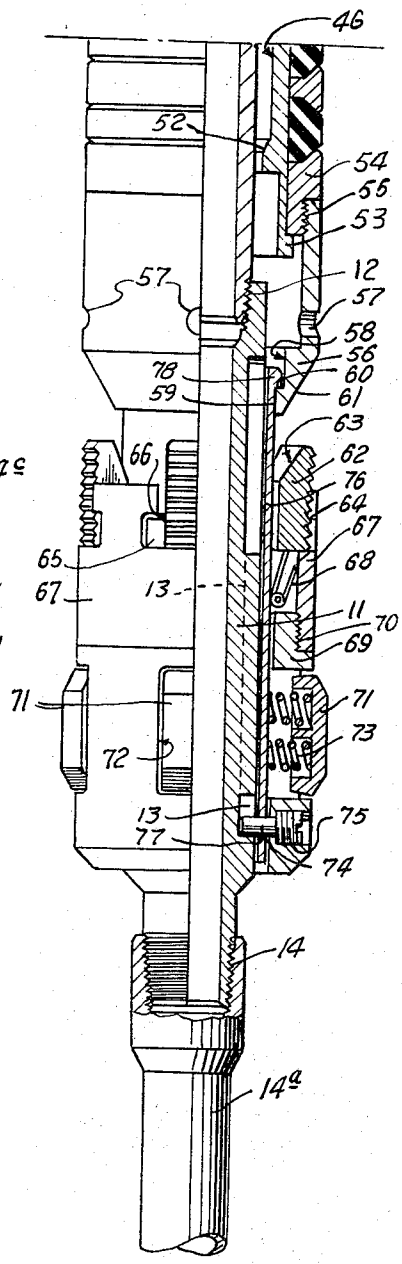


Fig. I-A

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RETRIEVABLE WELL PACKER

Filed June 27, 1966 3 Sheets-Sheet 2

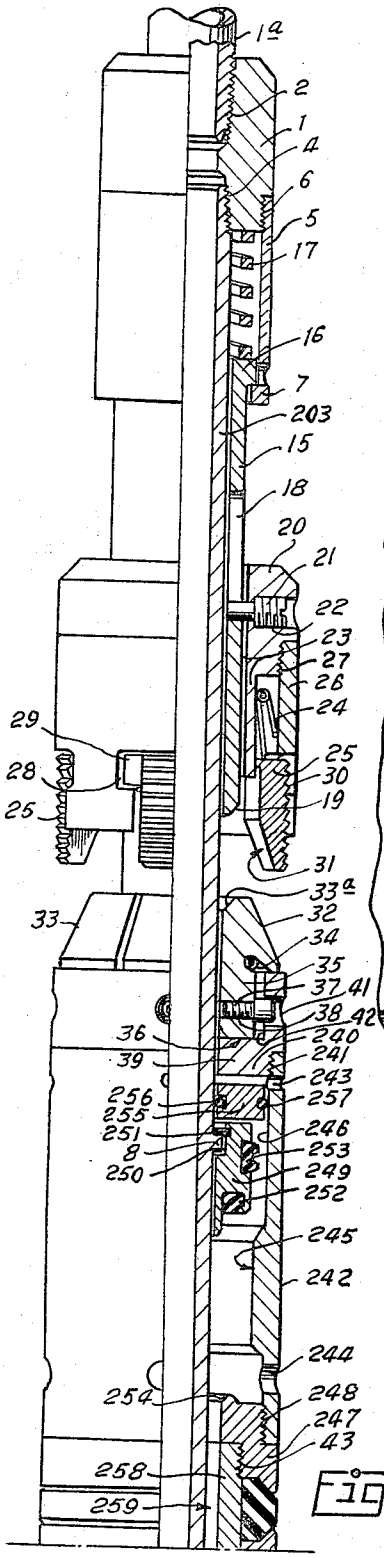


Fig. III

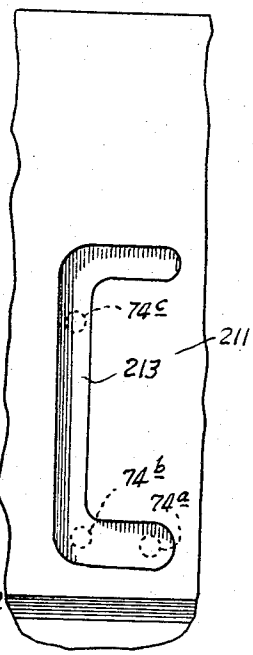


Fig. IV

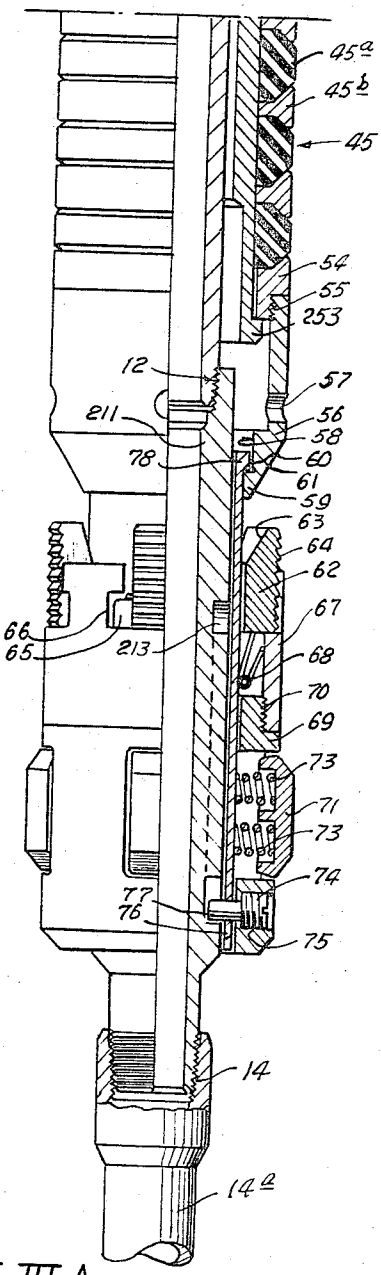


Fig. III-A

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RETRIEVABLE WELL PACKER

Filed June 27, 1966 3 Sheets-Sheet 3

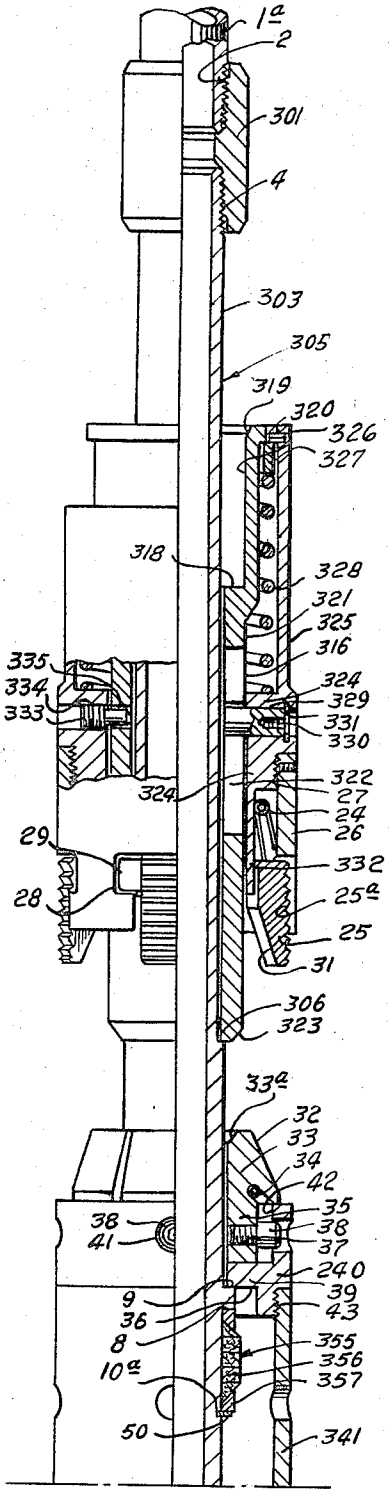


Fig. V

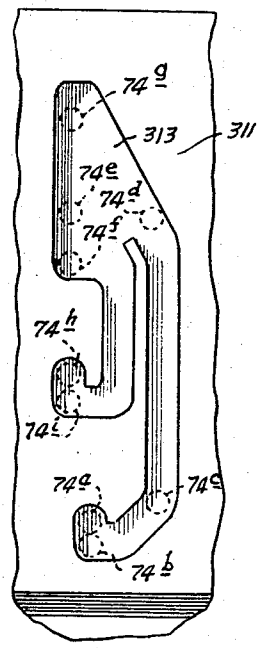


Fig. VI

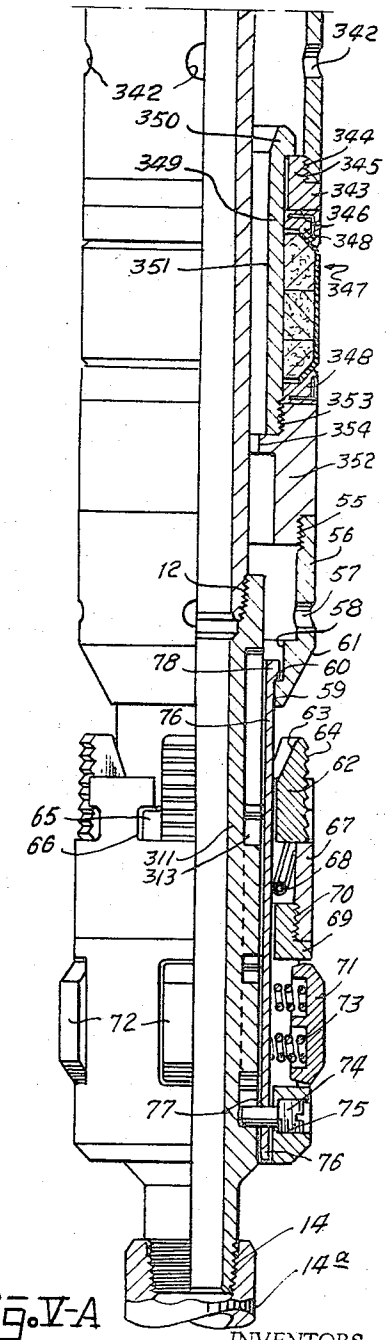


Fig. V-A

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United States Patent Office 3,416,608 Patented Dec. 17, 1968

3,416,608

RETRIEVABLE WELL PACKER

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Filed June 27, 1966, Ser. No. 560,756
8 Claims. (Cl. 166—129)

ABSTRACT OF THE DISCLOSURE

A retrievable packer for use in a well bore. A mandrel extends through the packer and is coupled with a lower anchoring mechanism adapted when actuated to hold the packer against downward movement in the well bore. An upper anchoring mechanism for the packer includes a setting sleeve that is carried by the mandrel and arranged to engage segmented expanders which are in turn engaged by upper slips upon relative movement between the mandrel and the segmented expanders. The slips are moved radially by such engagement to retain the packer against upward movement in the well bore. A deformable packing element, located between the anchoring mechanisms, forms a fluid-tight seal with the well bore. Valve means is provided in the packer to control flow of fluid through a by-pass passageway located between the packing element and the mandrel.

This invention is concerned with a mechanically anchored retrievable well packer arranged to be anchored and set in the casing of a well and is particularly concerned with such a well packer which is anchored to hold against pressure from both above and below.

Among the objects of the invention are the following:

A mechanically anchored retrievable well packer which may be anchored to hold against pressure from both above and below.

A mechanically anchored retrievable well packer which has a fluid circulation passage therethrough between the packer rubber and the mandrel with seal means carried on the mandrel to close said passage when the packer is set.

Such a well packer which compensates for pressure fluctuations above and below same to provide a tighter seal between the packer rubber and the casing.

Such a packer construction wherein the slips and setting heads at each end thereof are positively held out of contact while the packer is being lowered to prevent premature setting of the packer.

Such a packer construction wherein the packer may be moved into setting position by a slight rotation of the tubing string.

A packer construction of the type indicated wherein an additional compression in the packing rubber and tension in the tubing string may be attained after the packer is set by a simple upward movement of the tubing string.

A packer construction of the type indicated which may be placed in retrievable position by simple rotation of the tubing string in the appropriate direction.

A packer construction of the type indicated wherein the tubing string may be set in tension, compression, or may be allowed to remain in neutral position, as elected.

A packer construction of the type indicated wherein the by-pass through the packer may be opened to permit circulation therethrough while the packer is set.

A packer construction of the type indicated wherein by simply reversing a J-slot body the J-slot therein may be reversed to thereby reverse the direction of rotation of the tubing required for setting and retrieving the packer.

A general object of the invention is to provide a simple, trouble-free, compact mechanically held, retrievable packer which is versatile in its operations for carrying out all completion and remedial operations in a well.

Summary of the invention

The foregoing objects are accomplished by the invention which provides an improved packer for use in a well bore and includes: a tubular mandrel; packer support means surrounding the mandrel and releasably attached thereto; a packer sleeve encircling the mandrel in spaced relationship thereto; a resilient packing element disposed on the sleeve adapted to be deformed into sealing engagement with the wall of the well bore; ports above and below the sleeve providing a by-pass passage between the sleeve and mandrel; anchoring means disposed above and below the packing element arranged to be moved into holding engagement with the wall of the well bore; and seal means carried by the mandrel for engaging the sleeve to close the by-pass passage.

Other and further objects of the invention will become apparent upon reading the detailed specification hereinafter following and by referring to the drawings annexed hereto.

A suitable form of the invention is shown in the attached drawings wherein:

FIGS. I and I–A are a quarter sectional elevational view of a preferred form of the packer as it would appear in unset condition;

FIG. II is a side elevational view of the J-slot employed with the preferred form of FIGS. I and I–A;

FIGS. III and III–A are a quarter sectional elevational view of a modified form of packer construction as it would appear in unset condition;

FIG. IV is a side elevational view of the J-slot employed with the modified form of FIGS. III and III–A;

FIGS. V and V–A are a quarter sectional elevational view of another modified form of packer construction as it would appear in an unset condition; and

FIG. VI is a side elevational view of a J-slot employed with the form shown in FIGS. V and V–A.

Numeral references are employed to indicate the various parts shown in the drawings and like numerals indicate like parts throughout the various figures of the drawings.

Description of form shown in FIGS. I, I–A and II

Referring to the preferred form of FIGURES I and I–A there is a top connection **1** which is adapted for connection to a tubular production string **1***a* by the threads **2** and for attachment to a mandrel **3** at the mating threads **4**. The top connection **1** is further adapted for connection to a recovery ring **5** by the mating threads **6**, said recovery ring **5** having an inwardly projecting portion at the lower end thereof providing an upwardly facing shoulder **7**.

The mandrel **3** has an outwardly extending annular portion **8** which presents an upwardly facing shoulder **9** and which has a reduced diameter **10**.

The mandrel **3** is further adapted for connection to a J-slot body **11** at the companion threads **12**.

A profile or slot **13** is milled, cast, or fabricated on the exterior surface of the J-slot body **11** (see FIGURE II). The J-slot body **11** is adapted for connection to a lower tubular string **14***a* by the companion threads **14**.

There is a setting sleeve **15** slidably arranged around the mandrel **3**. The downward motion of sleeve **15** with respect to mandrel **3** is limited by the engagement of an outwardly extending portion **16** on the setting sleeve **15** with the upwardly facing shoulder **7** on the recovery ring **5**. A slip take-up spring **17** is positioned between the upper end of the setting sleeve **15** and the lower end of the connection **1** and is encircled by the recovery ring **5**.

The setting sleeve **15** has one or more longitudinal slots **18** provided through the wall thereof for the purpose hereinafter mentioned.

The setting sleeve **15** is terminated at its lower end by a tapered surface **19**.

A slip rest **20** carries a pick-up pin **21** which is rigidly attached thereto by the companion threads **22**. The slip rest **20** further includes a reduced diameter portion **23** encircling the setting sleeve **15** which is arranged to carry upper slip springs **24** thereabout and to limit the inward travel of a multiplicity of upper toothed slips **25** when said upper slips are in a retracted or relaxed position. An upper slip housing **26** is attached to the slip rest **20** by the mating threads **27** and has a multiplicity of open-ended T-slots **28** formed through the wall thereof.

The upper slips **25** are suspended by the open-ended T-slots **28** by an outwardly projecting portion **29** which prohibits axial motion of the upper slips **25** with relation to the upper slip housing **26**, but allows radial motion therebetween.

The upper slips **25** have toothed serrations **30** on the outer periphery thereof adapted for penetrating engagement with the inner wall of a casing when the packer is in an operating or set position. An outwardly and downwardly tapered surface **31** is adapted for engagement and co-action with an upwardly and inwardly tapered surface **32** on a multiplicity of upper head expander segments **33**.

The upper head expander segments **33** are carried in a collapsed position around the mandrel **3** and urged thereto by a spring **34** encircling same. Downwardly depending portion **35** has a downwardly facing end **36** and threaded bores **37** by which segment retainer screws **38** are affixed to each of the said upper head segments **33**.

The downwardly facing ends **36** of the upper head segments **33** abut an inwardly extending portion **39** on a head cage **40** which is supported by the upwardly facing shoulder **9** of the outwardly extending portion **8** of mandrel **3**. The head cage **40** has a multiplicity of bores **41** through the wall thereof adapted to receive the segment retainer screws **38** and co-acting therewith to position the upper head segments **33** to permit radial movement and to prevent axial movement in respect to head cage **40**. The head cage **40** has a counterbore **42** therein which allows radial motion of the upper head segments **33** in respect to head cage **40**.

The head cage **40** has threads **43** therein adapted for rigid attachment of a packing sleeve **44** around which is carried a resilient packing element **45**.

The packing element **45** can be any of many configurations. It may be of a one piece elastic sleeve or of multiple segments **45***a* of elastic material (as shown), spaced by metallic rings **45***b*, or it may be specifically designed for high temperature application, or of a composition designed to be efficient in any of numerous environmental surroundings.

The head cage **40** also has a multiplicity of circulation ports **40***a* formed through the wall thereof.

The packing sleeve **44** has a reduced sealing bore **46** adapted for sealing engagement with a mandrel seal assembly consisting of a mandrel seal body **47**, a mandrel seal **48**, of resilient composition, and an inner sealing O-ring **49**. The mandrel seal assembly is carried by the mandrel **3** in a fixed position between the reduced portion **10** of the outwardly extending portion **8** of mandrel **3** and a mandrel seal lock ring **50** carried in the groove **10***a* about the mandrel **3**. The mandrel seal body **47** has a downwardly facing tapered surface **51** thereon which coacts with an upwardly facing tapered surface **52** in the packing sleeve **44** to transfer downward forces due to weight or compression of the upper tubular string **1***a* from the mandrel **3** to the packing sleeve **44** and thence to the entire packer assembly. The packing sleeve **44** further has an outwardly extending portion **53** adapted for co-action with a lower thimble **54** having mating threads **55** thereon for rigid attachment thereto of a lower expander head **56**.

The lower expander head **56** has circulation ports **57** through the wall thereof, a counterbore **58**, and an inwardly extending portion **59** which presents an upwardly facing shoulder **60**. There is a downwardly and inwardly facing taper **61** on the outer surface of the lower head **56**.

A multiplicity of lower slips **62** have upwardly and outwardly facing tapers **63** therein adapted for co-action, when set, with the taper **61** on the lower head **56** to expand the slips to cause outer teeth **64** to penetrate the casing wall. The slips have outwardly projecting portions **65** thereon which are carried in open-ended T-shaped slots **66** formed in a lower slip housing **67** in non-rotatable, non-axial movement with relation thereto, but which allows radial movement of the slips relative to said lower slip housing **67**. The lower slip springs **68** are carried in the lower slip housing **67** and are adapted to urge the lower slips **62** into a retracted position. The lower slip housing **67** is rigidly attached to an anchor cage **69** by the mating threads **70**. The anchor cage **69** carries a multiplicity of friction pads **71** in slots **72** formed in the wall of the anchor cage. Friction pads **71** are urged outwardly into frictional engagement with a casing by a multiplicity of friction pad springs **73** positioned therebehind.

The anchor cage **69** carries a gudgeon pin **74** attached rigidly in the wall thereof by the mating threads **75**. Pin **74** extends inwardly through a hole **77** through the wall of recovery sleeve **76** and extends into engagement with the profile or slot **13** (FIGURE I–A) of the J-slot body **11**.

The recovery sleeve **76** extends above the hole **77** therein and supports thereabout the friction pad springs **73** and the lower slip springs **68**. Furthermore, the recovery sleeve **76** has an outwardly extended portion **78** at the upper end thereof which is adapted to contact the upwardly facing internal shoulder **60** of the lower head **56** to limit the relative axial movement therebetween.

Operation of form shown in FIGS. I, I–A and II

Referring to FIGURES I and I–A, the packer is shown in the running-in position except that the gudgeon pin **74** assumes a position **74***a* as shown in FIGURE II.

The packer is attached to the tubular production string **1***a* by the threads **2**. Accessories, as required by the particular installation, are suspended to the packer by the lower threads **14**.

The anchor cage **69**, the lower slip housing **67**, and the lower slips **62**, urged into a collapsed position by the lower slip springs **68**, are led into the hole by the gudgeon pin **74** in position **74***a*. Likewise, the recovery sleeve **76** is pulled into the hole by the gudgeon pin **74**, and the outwardly extending portion **78** of the recovery sleeve **76**, acting against the upwardly facing shoulder **60** of the lower head **56**, pulls the lower head **56** and lower thimble **54** into the hole. Contact between the lower thimble **54** and the outwardly extending portion **53** of the packing sleeve **44** similarly leads the elements thereabove into the hole. The head cage **40**, being attached to the packing sleeve **44** at the mating threads **43**, is also led into the hole.

The upper head expander segments **33**, are in a collapsed position and are urged inwardly by the head segment spring **34**, and carried into the hole by inter-engagement of the segment retainer screws **38** in the holes **41** of the head cage **40**.

The setting sleeve **15** is urged into extended position by the slip take-up spring **17** and is carried into the hole by the mandrel **3** with the pick-up pins **21** in the slip rest **20** engaging the slot **18** of the setting sleeve **15**. The upper slips **25** are carried into the hole in a collapsed position and are maintained in collapsed position by the upper springs **24** engaged therewith.

It will be noted that, except for a minor possible movement represented by the difference between positions **74***a* and **74***b* in profile slot **13**, the entire packer mechanism is carried into the hole in a rigidly connected extended position between the engagement of the gudgeon pin **74**

in position 74*a* and the inwardly extending portion 39 of the head cage 40 resting on the upwardly facing shoulder 9 of the outwardly extended portion 8 of the mandrel 3. The upper slips 25 and associated structures are limited in downward telescoping movement by the recovery ring 5 attached to the top connection 1. There are positive gaps between the tapered surfaces 31 of the upper slips 25 and tapered surfaces 32 of the upper expander head segments 33, and the tapered surfaces 63 of the lower slips 62 and the surface 61 of the lower expander head 56. The limited movement permitted by positions 74*a* (running position) and 74*b* (retrieving position) of gudgeon pin 74 in slot 13 cannot close either of the gaps.

It should also be noted that turbulent fluid flow due to excessive running-in speed or the presence of foreign objects, such as scrap metal, sand, etc., cannot cause any element of this packer structure to move upwardly into premature setting position.

It will be noted also that in the unset or running-in position as shown in FIGURES I and I–A, there is an unrestricted and adequate bypass of fluid through the ports 57 in lower head 56 and, through the sealing bore 46 of the packing sleeve 44, outwardly into the casing annulus through the ports 40*a* in the head cage 40. Inasmuch as all elements are locked rigidly in unset position, this circulation passageway cannot be inadvertently closed or pumped closed due to movement of any element under excessive speed of running-in or fluid velocity created by the circulation process.

The setting procedure has also been simplified by the construction, as follows:

When setting depth has been reached, a slight upward movement of the tubing string places the gudgeon pin 74 in the position 74*b*. Rotation to the right of the tubing string simultaneously with a lowering of the tubing string will place the gudgeon pin 74 in position 74*c* where a slight rotation to the left of the tubing string will allow the gudgeon pin to assume the position 74*d* or 74*e*. While the downward motion of the tubing string has been occurring, the anchor cage and lower slip assemblies are held immovable in respect to the casing by the friction pads 71, and the lower slips 62 and their tapered surface 63 have contacted the lower head 56 and the corresponding tapered surface 61. The lower slips 62 are thereby forced outwardly into engagement with the casing.

Simultaneously, the downwardly facing taper 19 of the setting sleeve 15 has been forced into engagement with the upwardly facing tapers 33*a* on the upper head expander segments 33, and has been forced underneath said upper head segments 33, causing them to expand outwardly to setting position. The upper slips 25 through engagement of their tapered surface 31 with the tapered surfaces 32 of the upper head segments 33 are forced downwardly and outwardly into engagement with the casing wall. Further downward movement of the mandrel assembly to the position 74*d* of gudgeon pin 74 will move the mandrel seal 48 into sealing engagement with the seal bore 46 in the packing sleeve 44 and ultimate contact will be made between the downwardly facing surface 51 of the mandrel seal body 47 and the upwardly facing tapered surface 52 of the packing sleeve 44. Additional downward movement of the mandrel assembly will result in a compressive force being applied to the packing element 45 and the upper slips 25 will be ratcheted downwardly by the expansive force of the slip take-up spring 17. This maintains the upper slips 25 in a position to immediately engage and anchor against the casing to prevent upward movement upon relaxation of the downward force or reversal of the downward motion.

In installations where there is adequate tubing weight available to give the degree of compression on the packing element 45 required, the packer is now in a set position with the bypass tightly closed by the mandrel seal 48 in the lower portion of the seal bore 46 of the packing sleeve 44.

However, when the packer is set in relatively shallow holes, where adequate tubing weight is not present, or under design considerations where tension in the tubing string is desired, the packer can be set in tension. The necessary tension can be obtained by lifting the tubing string. Upward movement of the tubing string causes the gudgeon pin 74 to assume the tension position 74*e* in profile slot 13 (FIGURE II). Further upward movement of the tubing places the tubing in tension and adds further compressive forces to the packing element 45. When the gudgeon pin 74 is in position 74*e*, the mandrel seal 48 has been moved up but remains in sealing engagement with the upper portion of the sealing bore 46 in the packing sleeve 44 to maintain the by-pass closed.

Release and retrieval of the packer is simply and efficiently performed as follows:

If the gudgeon pin 74 is in position 74*d* in Profile 13 of the J-slot body 11, a simultaneous pick-up of the tubing string and right hand rotation thereof will result in the gudgeon pin being placed in position 74*c*. If the gudgeon pin is originally in position 74*e*, simple right hand rotation will likewise place it in the position 74*c*.

Further upward movement of the tubing string and mandrel assembly will result in movement of the gudgeon pin 74 to retrieval position 74*b* in profile slot 13.

Concurrently with this upward motion of the tubing string, the setting sleeve 15 will be picked up by engagement of the shoulder 7 on the recovery ring 5 with the outwardly extending portion 16 on the setting sleeve 15 and removed from behind the upper head segments 33, allowing the upper head segments to collapse inwardly, removing the upper slips 25 from engagement with the casing. Then the pick-up pin 21 in the slip rest 20 will engage the lower end of slot 18 and the upper slip housing 26 and slip rest 20 will be moved upwardly. This results in the upper slips 25 being removed from any possibility of re-engagement with the upper head segments 33 which would cause setting of the slips and difficulty in the retrieving cycle.

The upward movement of the tubing string and mandrel assembly also moves the mandrel seal 48 upwardly out of engagement with the sealing bore 46 of the packing sleeve 44, and allows pressure equalization across the packing element 45 and by-pass of fluid.

Ultimately, the shoulder 9 on the outwardly extended portion 10 of the mandrel 3 will engage and transfer the pick-up force to the inwardly extending portion 39 of the head cage 40. Further upward motion will cause the outwardly extending portion 53 of the packing sleeve 44 to engage the lower thimble 54 and by virtue of engaging threads 55 will move the lower head 56 up out of engagement with the lower slips 62. This motion also results in room for the packing element 45 to relax out of sealing engagement with the casing.

Engagement of the inwardly extending portion 59 on the lower head 56 with the outwardly extending portion 78 on the recovery sleeve 76 will result in a pick-up of the anchor cage 69 and the rigidly attached lower slip housing 67 which carries the lower slips 62 in collapsed position due to the inward urging of slip springs. This is accomplished by virtue of the co-action of the hole 77 in the recovery sleeve 76 with the gudgeon pin 74 extending therethrough and being threadably engaged with the anchor cage 69.

It should be noted that in the retrieving position, the packing element 45 has been provided room for relaxation, the circulation passageway has been opened, the non-engagement gaps between the upper slips and the upper head segment and the lower slips and lower head segments have been re-established and the several elements of the packer assembly have been locked in extended position between the outwardly extending por-

tion 8 of the mandrel 3 and the gudgeon pin 74, now in position 74*b* in the profile 13 (FIGURE II).

Description of form of FIGURE III, III–A and IV

In the modified form shown in FIG. III, III–A and IV, common elements and functional portions thereof are given the same numeral references as in FIG. I and I–A and the physical and functional description of said elements are found in the description of FIG. I and I–A.

The upper top connection 1, the recovery ring 5, the slip take-up spring 17, the setting sleeve 15, the slip rest 20, the pick-up pin 21, the upper slip spring 24, the upper slip housing 26, the upper slips 25, the upper expander segments 33, and the segment retainer screws 38, are all functional portions of the modified form as described herein.

A mandrel 203 is attached to the top connection 1 by the mating threads 4 and extends downwardly through the packer assembly. The mandrel has an outwardly extending shoulder 8 and is connected by the mating threads 12 to a tubular J-slot body 211.

A profile or slot 213 is milled, cast or fabricated on the exterior surface of the J-slot body 211 (FIG. IV) and is adapted for connection to a lower tubular string 14*a* by the tubing threads 14.

A head cage 240, has an inwardly extending portion 39, against which the upper expander head segments 33 abut. There is also a multiplicity of lateral bores 41 provided through the wall of head cage 240 and said cage has a counterbore 42 therein.

The head cage 240 is further adapted by the mating threads 241 for rigid attachment to tubular valve housing 242. Valve housing 242 has equalizing ports 243 through the wall thereof at the upper end thereof, and circulation ports 244 through the wall thereof near the lower end thereof. The lower portion of the valve housing 242 has a primary reduced sealing bore 245 therein and a secondary sealing bore 246 in the upper portion thereof. The seal housing 242 is rigidly attached to a seal support ring 247 by the companion threads 248.

A mandrel seal body 249 is secured in non-sealing engagement around the mandrel 203. The mandrel seal body 249 has an undercut portion 250 thereon adapted to receive the outwardly extending annular shoulder 8 of the mandrel 203 and is rigidly locked thereto by a snap ring 251 carried in an appropriate groove provided in the wall of body 249. The mandrel seal body 249 further carries on its lower end a primary face seal 252 composed of elastic sealing material which may be molded rigidly therewith, or it may be adapted for replacement, as required. The mandrel seal body 249 also carries thereabout a secondary peripheral seal 253 composed of resilient material which may be moulded thereto or may be snapped into place in the groove in which it is carried for replacement, to engage the primary seal bore 245 of the seal housing 242 when the mandrel 203 is lowered relative to said seal housing 242 when the packer is set as hereinafter described.

The seal support ring 247 has an upwardly protruding annular valve seat 254 on the upper end which is adapted to sealingly engage the primary face seal 252 when the mandrel has been lowered relative to the seal housing 242, as will be described hereinatfer.

When the packer is in the running or retrieving position, as shown in FIGS. III and III–A there is a floating piston 255 carried around the mandrel 203 and above the mandrel seal body 249. The floating piston 255 is adapted for slidable sealing engagement with the mandrel 203 by the resilient O-ring 256, carried in an appropriate groove on the inner side thereof, and for slidable sealing engagement with the secondary sealing bore 246 of the seal housing 242 by the resilient O-ring 257, carried in an appropriate groove thereabout.

The seal support ring 247 is adapted to apply a compressive force on a packing element, indicated generally as 45, and is rigidly attached to a packing sleeve 258 by the mating threads 43. The packing element, as shown, is made up of alternate resilient rings 45*a* and rigid rings 45*b*. An annular communication passageway 259 is formed by the interior bore of the packing sleeve 258 and the outer diameter of the mandrel 203. The passage 259 is open when the mandrel seal body 249 and the mandrel 203 are in the upper position, as shown in FIGS. III and III–A but is closed when the primary face seal 252 engages the annular valve seat 254 of seal support ring 247.

The packing sleeve 258 has an outwardly extending portion 253 engageable with support member 54, the function of which is described in connection with similar structure in FIGS. I and I–A.

The lower expander head 56 is connected by threads 55 to the support members 54 and associated lower slip and anchor structures are carried on the exterior of the J-slot body 211, all as previously described in the embodiment shown in FIGS. I and I–A.

Operation of form shown in FIGURES III, III–A and IV

Following is a description of the operation of the modified form of FIGURES III, III–A and IV.

The packer is made up on the upper production tubing 1*a* by the threads 2, as usual, and the necessary accessories, required by the particular installation are suspended below the packer by the threads 14.

In the running cycle, the gudgeon pin 74 is in position 74*a*, as shown in FIGURE IV. It should be noted that the entire packer assembly is held in an extended unset condition similar to that of the embodiment described in relation to FIGURES I and I–A, between the gudgeon pin 74 in position 74*a* in slot 213 and the inwardly extended shoulder 39 of the head cage 240 which is arranged to abut the floating piston 255, which in turn is arranged to abut the mandrel seal body 249. The mandrel seal body 249 is locked in a non-movable position with relation to the mandrel of 203 by the snap ring 251. The upper slips 25 and associated structures are held in an inward position out of engagement with the casing by the pick-up pin 21 disposed in the lower portion of the slot 18 in the wall of the setting sleeve 15, which is in its maximum downward position due to the engagement of outwardly extending portion 16 of setting sleeve 15 and the upwardly facing shoulder 7 of the recovery ring 5.

When the predetermined depth in the well for setting has been reached, the upper tubing string 1*a*, the mandrel 203 and J-slot body 211 are rotated to the left to place the gudgeon pin 74 in position 74*b* (FIG. IV). The tubing string, mandrel 203, and J-slot body 211 can now be lowered to set the packer exactly as previously described in connection with the embodiment shown in FIGURES I and I–A. The gudgeon pin 74 assumes a position approximately at 74*c* when the packer is set.

The differences in structure and function of this modified embodiment contrasted to the first embodiment described are as follows:

The primary face seal 252 and the secondary peripheral seal 253, carried by the mandrel seal body 249 are rigidly attached to the mandrel 203 and are free for reciprocal motion inside of the valve housing 242. The primary face seal 252 may move downwardly and contact the valve seat 254 which, co-acting therewith, establishes a fluid tight relationship therebetween when the weight of the tubing string is applied. Simultaneously, the secondary peripheral seal 253 enters into and engages the primary reduced seal bore 245 of the valve housing 242 in fluid tight relationship. Since the mandrel seal body 249, with the primary face seal 252 and the secondary peripheral seal 253, is carried in non-sealing engagement around the mandrel 203, the pressures encountered from below the packer will be communicated through said non-sealing engagement and will reflect downwardly on the

area determined by the difference in areas of the seal bore **245** and the valve seat **254**, thereby creating a downwardly acting force due to the pressure underneath the packer which holds the mandrel and its rigidly attached mandrel seal assembly in sealing engagement and effectively blocks circulation through the circulation ports **244**. The pressure from beneath the packer which establishes this balanced valve mechanism comes through the ports **57** in the lower head **56** and is carried upwardly through the interior of the packing element **45** through the communication passageway **259** defined by the interior bore of the packing sleeve **258**. This action, by proper selection of the two respective diameters, effectively creates an over balanced pressure which generates a downward force maintaining a fluid tight seal regardless of the magnitude of the pressure underneath the packer.

The floating piston **255** with its asociated O-rings **256** and **257** reacts to the direction of the differential in pressure existing between the annulus below the packer and the annulus above the packer. When the pressure below the packer is greater than the pressure above the packer the floating piston **255** remains in the upper position and effectively seals against communication from below the packer with the pressure outside of the packer through the equalizing ports **243**. The force generated by the differential against the floating piston will be resisted by the inwardly extending portion **39** of the head cage **240** and transferred into the casing through the upper head segments **32** and slips **25** when the packer is set. However, when the pressure above the packer is greater than the pressure below the packer, the floating piston **255** will be moved downwardly against the mandrel seal body **249**, still effectively blocking communication through the equalizing port **243** with the area below the seal and at the same time exerts a downward force on the mandrel seal body **249** which is transferred to the mandrel **203** through the snap ring **251** and shoulder **8** on the mandrel **203**.

The foregoing describes the running and operation of the packer by this modified embodiment under usual conditions.

However, there are times, dependent on the actuation and function of accessory tools run below when right hand rotation offers the most efficient and useful method of actuating the setting mechanism. By virtue of the C shape profile slot **213** in J-slot body **211**, the body **211** may be reversed to permit setting by right hand rotation. To permit reversal of body **211** the threads **14** must be made as box threads identical with the mating threads **12**. With the body **211** constructed in this manner, reversal of direction in the actuating rotation of the tubing string can be accomplished by simply removing the J-slot body **211**, inverting the body **211** and reassembling it with the mandrel **203**. Right hand rotation of the tubular string and the mandrel assembly will then actuate the packer and place it in position for setting, as above described.

Retrieval of the packer for reworking or for other purpose, is obtained by simple upward pull on the production string and the mandrel assembly. The mandrel seal body **249**, and its associated seals, is pulled upwardly out of sealing engagement with the valve seat **254** and the force of said upward pull is transmitted through the floating piston **255** into the inwardly extending portion **39** of the head cage **240**. The upper slips and associated assemblies are moved up free of the expander heads **33** by the slot **18** in setting sleeve **15** contacting the pin **21** as described in the operation of the preferred embodiment, shown in FIGURES I and I–A, and all associated structures are retrieved from the hole as hereinbefore described. When the lower head **56** has been picked up and moved from beneath the lower slips **62**, said lower slips, lower slip housing **67**, anchor cage **69**, and connected parts are brought out of the hole suspended on the gudgeon pin **74** in position **74***b* or, after appropriate rotation of the tubing string, in the position **74***a* (FIG. IV).

Description of form shown in FIGURES V, V–A, and VI

A description of the modified form shown in FIGS. V, V–A and VI is as follows:

An upper connection **301** is adapted for connection to an upper tubing string **1***a* by the threads **2** and is further adapted for connection to the mandrel **303** by the mating threads **4**.

The mandrel **303** has a section of reduced diameter **305** terminated by an upwardly facing shoulder **306**. An enlarged annular portion **8** on the mandrel **303** presents an upwardly facing shoulder **9**. A snap ring groove **10***a* is provided in mandrel **303** in which a snap ring **50** is disposed for the purpose hereinafter mentioned. The mating threads **12** are adapted for connection to a J-slot body **311**. The outer surface of the J-slot body **311** is milled to provide a J-slot profile or slot **313** (see FIG. VI) and has threads **14** thereon adapted to connect the packer to a lower production string **14***a*.

A setting sleeve **316** has a counterbore **317** therein terminating in an upwardly facing shoulder **318** at the lower end thereof and a tapered surface **319** at the upper end thereof. There is also an outwardly extending flange **320** at the upper end of sleeve **316** and a reduced diameter portion **321** thereon having one or more milled slots **322** formed therein. The sleeve **316** terminates in a tapered surface **323** at the lower end thereof. A slip rest **324** has an upwardly extending shell-like portion **325**. The upwardly extending shell-like portion **325** of the slip rest **324** has an interiorly cut annular groove to receive a slip spring snap ring **326**, which retains therein a spring stop ring **327** which retains therein a take-up spring **328**. Said take-up spring **328** rests on a shoulder in the slip rest **324**. The slip rest **324** has one or more lateral bores **329** in the wall thereof adapted to receive one or more pick-up pins **330** which are retained in the slip rest **324** by a snap ring **331** positioned in an appropriate groove. The pick-up pins **330** extend through the slip rest **324** and are located in the slots **322** in the wall of setting sleeve **316**.

The slip rest **324** has a depending portion **332** which is adapted to give interior support to a multiplicity of upper slips **25** and a like number of upper slip springs **24**. The upper slip housing **26** depends from the slip rest **324** and is attached thereto by the mating threads **27**.

The slip rest **324** also carries one or more shear pins **333** attached rigidly thereto by the mating threads **334** and extending into matching holes **335** in the wall of setting sleeve **316**. The axial position established between the slip rest **324** and the setting sleeve **316** by the shear pins **333** is such that the pick-up pins **330** are initially located in the medial portion of the slots **322** in the setting sleeve **316**. Such is a temporary position and exists only in the original running-in position and set position. When the packer is set as hereinafter described and the shear pins **333** are sheared, they serve no further useful function.

The description and function of the upper slip housing **26**, the upper slip segments **25**, the slip springs **24**, the upper head segments **33**, the segment retainer screws **38**, are identical to the function of said parts heretofore described in previous embodiments.

The head cage **240** is identical in structure and function to the head cage **240** shown in FIGURE III and similar in function but different in structure from the head cage **40** shown in FIGURE I, heretofore described.

A spacer collar **341** has a multiplicity of circulation ports **342** through the wall thereof, and is attached at the upper end to the head cage **240** by the mating threads **43**, and at the lower end to an upper thimble **343** by the mating threads **344**. The upper packing support thimble **343** has an upwardly extending portion **345** and a lower face **346** adapted to apply compressive force to a resilient packing element **347**. The packing element may be of

standard construction, as is well known in the art, or of special construction for high temperature application (as shown), and has packer retaining rings **348** at each end thereof.

The packing element **347** is carried by and supported about a packing sleeve **349** having an outwardly extending annular portion **350** adapted for engagement with the upwardly extending portion **345** of the upper thimble **343**. The packing sleeve **349** also has a sealing bore **351** on the interior thereof and is connected to a lower thimble **352** by the mating threads **353**.

The lower packer support thimble **352** has an inwardly extending annular portion **354** therein and is attached by the mating threads **55** to the lower expander head **56**.

The lower expander head **56** encircles the J-slot body **311**, and associated structures are carried on the exterior of the J-slot body **311**, all as previously described in the embodiment shown in FIGURES I and I–A.

A resilient mandrel seal assembly **355** is carried about the mandrel **303** between the outwardly extending annular portion **8** and the snap ring **50**. The mandrel seal assembly is adapted, when the mandrel is lowered in relation to the packing sleeve **349**, to come into sealing engagement with the seal bore **351** of the packing sleeve **349**. When high temperature conditions are expected, the mandrel seal assembly **355** is constructed of rings of thermal packing **356** positioned between spacers **357** at each end thereof. When normal temperature ranges are expected, the mandrel seal assembly can be identical with that shown in FIGURE 1.

Operation of form shown in FIGURES V, V–A and VI

The embodiment shown in FIGURES V and V–A and VI is fixedly attached to the tubular production string **1***a* by the tubular threads **2**. Any tubing, tail pipe, tools, etc., necessary for the particular installation design are carried below the packer by the threads **14**.

With the friction pads **71** in frictional engagement with the casing (not shown), the anchor cage **69** and lower slips **62** are led into the hole as the tubing string is lowered. Note that there is a gap between the lower slips **62** and the lower expander head **56** which would still exist although the gudgeon pin **74** assumes the position **74***a* in the J-slot profile **313**.

The recovery sleeve **76**, being fixed to the anchor cage **69** by the gudgeon pin **74** which extend through of the hole **77**, is similarly led into the hole. Engagement of the outwardly extended portion **78** on the sleeve **76** with the shoulder **60** on the lower head **56**, leads lower head **56**, the lower thimble **352**, the packing sleeve **349** and the packing element **347** into the hole. The outwardly extended shoulder **350** on the packing sleeve **349** abuts the upwardly extended portion **345** of the upper thimble **343** and leads the upper thimble **343**, the spacer collar **341**, and the head cage **240** into the hole. Connection of the segment retainer screws **38** with the upper expander head segments **33** and the engagement of the screws **38** with the head cage **240** pulls the segments **33** into the hole.

The upper slips **25**, the upper slip housing **26**, the slip rest **324**, settting sleeve **316** and pick-up pins **330** are carried into the hole on the mandrel **303** between the shoulder **306** on the mandrel **303** and the upper connection **301**.

The upper slip assembly including the slip rest **324** and the upper slips **25** are disengagably held in the position shown in FIG. V by the shear pin **333** protruding into the hole **335** in the setting sleeve **316**. This arrangement remains during the original running-in operation, but the shear pin **333** is sheared when the packer is set.

It may be seen from the above that unintentional setting cannot occur during running-in since the lower slips **62** and head **56** are held in an extended position between the pin **74** and the annular portion **8** on the mandrel **303**. The upper slips **25** are held in an extended position relative to segments **33** by contact of the shoulder **306** with the lower end of the sleeve **316**. The only collapsing movement possible is a relatively small movement represented by the difference in the positions **74***a* and **74***b* of gudgeon pin **74** in J-slot profile **313** (FIGURE VI).

When the predetermined vertical position of the packer in the well bore has been reached, the tubing string, carrying the J-slot body **311**, is picked up slightly moving pin **74** to position **74***b*. The tubing string is then simultaneously rotated clockwise and lowered to place the gudgeon pin **74** in position **74***c* in the J-slot profile **313**. The tubing, mandrel, and J-slot body can then be lowered through the exterior parts of the packer which are held in relatively non-movable position by the friction pads **71** in engagement with the casing.

Further downward movement of the tubing and associated assemblies will result in the following:

The lower expander head **56** will be lowered until the tapered surfaces **61** thereof comes in contact with tapered surface **63** of the lower slips **62**, causing outward expansion of lower slips into engagement with the casing. Further downward movement will result in engagement of the tapered surfaces **323** of setting sleeve **316** with the tapered surface **33***a* in the upper head segments **33**. Further downward movement of the mandrel **303** will cause the upper connection **301** to enter the counterbore **317** of the setting sleeve **316** and apply downward force on the setting sleeve **316** by contact between the upper connection **301** and the upwardly facing shoulder **318** of the setting sleeve **316**. This will cause the setting sleeve **316** to be inserted behind the upper head segments **33** causing them to expand radially. After the segments **33** are expanded, the inner surfaces **31** on the upper slips **25** engage the tapered surfaces **32** on the segments, placing the upper slips **25** in position for engagement with the casing. Further force of downward movement will be transferred from the setting sleeve **316** to the inwardly extended portion **39** of the head cage **240**, causing compression of the packing element **347** into sealing engagement with the casing. Simultaneously, the upper slips **25** will ratchet downwardly with some degree of compression in the slip take-up spring **328** due to contact between the slip take-up ring **327** and the outwardly extending flange **320** of the setting sleeve **316**. This downward ratcheting of the upper slip assembly will keep the upper slips **25** in position for immediate anchoring engagement of the teeth thereon with the casing when downward movement ceases, or is reversed.

Simultaneously with the above described movement, the gudgeon pin **74** has assumed a position at or above the position **74***d* in the J-slot profile **313** and the J-slot body **311** can be rotated to locate the pin **74** in the position **74***e* in J-slot profile **313**. In this position further expanding force on the packing element **347** can be applied by upward motion of the mandrel **303**, causing the gudgeon pin **74** to assume a position **74***f*, thereby applying further compressive force to the packing element **347** by tension on the tubing string. However, if sufficient tubing weight is available, the tubing string can be lowered to further compress the packing element by placing the gudgeon pin **74** in position **74***g* whereby further compressive force on the packing element **347** can be applied through the upper connection **301**, the setting sleeve **316**, the head cage **240**, the spacer collar **341** and upper thimble **343**.

Also simultaneously with the above described setting movement, the mandrel seal **355**, carried by the mandrel **303** enters the seal bore **351** of the packing sleeve **349**, thereby effectively closing the commuincation passageway consisting of the ports **57** in the lower head **56**, the entire area of the bore of **351** in the packing sleeve **349** and the ports **342** in the spacer collar **341**.

By proper rotation of the J-slot profile **313**, and upward movement of the J-slot body **311**, the gudgeon pin **74** can be placed in position **74***h* or **74***i*. During such upward motion of the mandrel **303** the mandrel seal assembly **355** moves clear of the sealing bore **351** in the packing sleeve **349**, re-establishing communication from below the packing element **347** through the ports **57**, through the space between the inwardly lower head **56** in the extended portion **354** of the lower thimble **352** and the mandrel **303** through the sealing bore **351** of the packing sleeve **349**, outwardly through the ports **342** of the spacer collar **341** to the annulus between the tubing and casing above the packing element **347**. The gudgeon pin **74** will assume the position **74***h* if compressive forces exist in the tubing string or the position **74***i* if tensile forces exist in the tubing string above the packer.

The by-pass communication through the packer can be reclosed by proper rotation and lowering of the mandrel **303** to cause the gudgeon pin **74** to reassume either the position **74***g* or **74***f*, which positions are determined by the existence of either compressive forces or tensile forces in the tubing string above the packer.

During either the opening or closing actions of the packer by-pass, described above, the packer remains in a set condition with the sealing element **347** in sealing engagement with the casing.

For retrieval, the tubing string, mandrel and J-slot body **311** are rotated and manipulated to place the gudgeon pin **74** in position **74***a* or **74***b*, and the tubing string is picked up. When the tubular string is picked up, the shoulder **306** on the mandrel **303** engages and picks up the setting sleeve **316** which, in turn, picks up the slip rest **324**, the upper slip housing **26** and the upper slips **25** by engagement of the pick-up pin **330** in the slot **322** of the setting sleeve **316**. This action pulls the setting sleeve **316** from underneath the head segments **33** which are now free to collapse under urging of the head segment spring **34** and the upper slips **25** are pulled free from the head segments **33** and are free to collapse under the urging of the slip springs **24**. The outwardly extended portion **8** on the mandrel **303** then contacts the inwardly extended portion **39** of the head cage **240** and thereby picks up the head cage, the spacer collar **341**, upper thimble **343**, packing sleeve **349**, lower thimble **352** and the lower head **56**, re-establishing the gap between the surface **61** of said lower head **56** and the surfaces **63** in the lower slips **62**. In such extended position, the packing element **347** is free to relax out of sealing engagement with the casing. The inner seal assembly, consisting of the mandrel seal **355** is picked up by the snap ring **50** on the mandrel **303** and moved out of sealing engagement with the seal bore **351** of the packing sleeve **349**. This movement re-establishes the by-pass through the packer, as described hereinbefore.

It will be observed that in all forms described above the force generated by pressure from both above and below the set packer acts across the mandrel seal and is transferred by the mandrel to the upper and lower anchors through the resilient packer to thereby compensate for variations in pressure above and below the packer.

It will be understood that other and further forms of our invention may be made without departing from the spirit and scope of the appended claims.

Having described our invention we claim:

1. In a well packer, including: a packer assembly; upper and lower slip and slip expander members on the packer assembly; said upper expander members comprising a plurality of separate segments with said upper slips contacting outer surfaces thereon; a mandrel extending through said packer assembly; releasable attachment means between said mandrel and said packer assembly, whereby said mandrel can be disengaged from said packer assembly and moved axially with relationship thereto; a tubular setting sleeve slidably disposed upon said mandrel and arranged to be moved downwardly with said mandrel to contact said segments to move said segments outwardly to expand said slips; spring means to resiliently urge said segments and upper slips downwardly; a packer support sleeve carried by said packer assembly in spaced relationship to said mandrel; port means above and below said packer support sleeve providing a by-pass between said packer support sleeve and said mandrel; and seal means carried by said mandrel arranged to be moved with said mandrel into sealing engagement with the bore of said packer sleeve to close the by-pass when the packer is set.

2. In a well packer arranged to be set in a well casing, a tubular mandrel; a packer assembly including, a tubular body surrounding the mandrel in spaced relationship thereto; upper anchoring means including, expansible slips above the tubular body, and lower anchoring means including expansible slips below the tubular body; releasable attachment means between the packer assembly and the mandrel; a setting sleeve carried by the mandrel above the upper slips; a plurality of expander segments surrounding the mandrel behind the upper slips, the lower end of the setting sleeve being arranged to engage and move outwardly the expander segments; co-acting tapered surfaces on the expander segments and upper slips arranged to move the slips outwardly into anchoring engagement with the well casing; a lower expander head suspended to the tubular body arranged to be moved into engagement with the lower anchoring means to expand same outwardly; packing means slidably carried about the tubular body arranged to be expanded into sealing engagement with a surrounding casing; said setting sleeve being arranged to move downwardly with the mandrel when the mandrel is disengaged from the packer assembly; port means above and below the packing means communicating with the bore of the tubular body providing a by-pass passage between the mandrel and the tubular body; and seal means carried about the mandrel movable into the bore of the tubular body to close the by-pass passage when the mandrel is disengaged and moved with relation to the packer assembly.

3. The combination called for in claim **2** with the addition of piston means in the tubular body above the seal means on the mandrel arranged to exert downward force upon the seal means in response to pressure from above the packer after the packer is set.

4. The combination called for in claim **2** wherein the seal means includes a seal element on the lower face thereof arranged to seal against a sealing surface projecting from the inner side of the by-pass passage which seal element is pressed downwardly against the said sealing surface by pressure from below the packer after it is set.

5. The combination called for in claim **2** wherein the means for releasably attaching the mandrel to the packing assembly comprises a co-operating J-slot and gudgeon pin connection located below the lower anchoring slips.

6. The combination called for in claim **5** wherein the J-slot includes an upwardly facing surface and a downwardly facing surface whereby force can be exerted against the gudgeon pin in two directions.

7. The combination called for in claim **5** wherein the J-slot includes spaced downwardly facing and upwardly facing surfaces at the upper and lower ends thereof and upwardly and downwardly facing surfaces intermediate the first mentioned upwardly and downwardly facing surfaces whereby the gudgeon pin may be moved to said intermediate surfaces to permit the by-pass to be opened and closed while the packer is set.

8. The combination called for in claim **5** wherein the J-slot is C shaped whereby it can be reversed to reverse the required rotation of the tubing string to engage and disengage the mandrel from the packer assembly.

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