United States Patent [19]

Ellis

[11] **3,851,706**

[45] **Dec. 3, 1974**

[54] **WELL PACKER AND RETRIEVER**

[75] Inventor: **Gary D. Ellis**, Dallas, Tex.

[73] Assignee: **Dresser Industries, Inc.**, Dallas, Tex.

[22] Filed: **Oct. 15, 1973**

[21] Appl. No.: **406,764**

Related U.S. Application Data

[62] Division of Ser. No. 307,696, Nov. 17, 1972, Pat. No. 3,818,987.

[52] **U.S. Cl.** **166/178**

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

[58] **Field of Search** 294/86.25; 81/3; 166/178, 166/123

[56] **References Cited**

UNITED STATES PATENTS

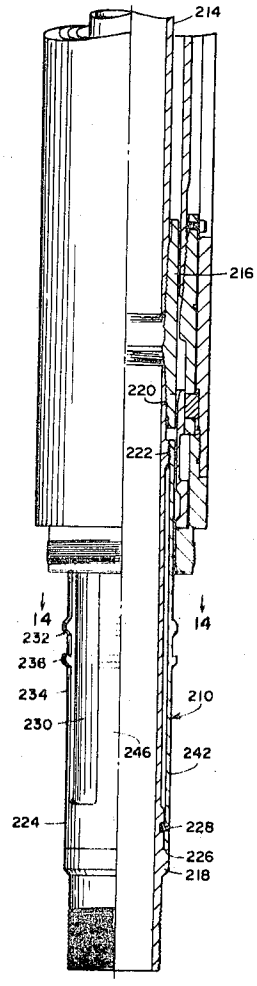
2,595,563	5/1952	Brown et al.	166/178 X
2,671,640	3/1954	Baker	166/178 X
3,023,811	3/1962	Green	166/178
3,054,454	9/1962	Evans	166/178

Primary Examiner—David H. Brown
Attorney, Agent, or Firm—Roy L. Van Winkle; Michael J. Caddell

[57] **ABSTRACT**

A well packer to be set in a casing has a cylindrical mandrel with a resilient packer unit encircling the mandrel which is radially expandable into contact with the casing when longitudinally compressed. A drive cylinder is secured to the mandrel below the packer unit to support the unit. A lower cylinder encircles the mandrel to bear against the top of the packer unit and is freely movable longitudinally on the mandrel. A hollow cylindrical bidirectional grip has beveled generally parallel ends with toothed shoulders adjacent to opposite extremities of the beveled ends. The grip is mounted on the mandrel and bears on the lower cylinder as to be tilted into engagement with the casing but normally is resiliently biased toward an untilted attitude. An upper cylinder encircles the mandrel and is slidably positioned thereon above the grip. Forces acting upward on the mandrel and downward on the upper cylinder apply a setting force to the grip which force is transmitted through the packer unit whereby the grip tilts toward and becomes wedged between opposite sides of the casing as the packer unit is forced into casing contact to seal the annulus between the mandrel and the casing.

1 Claim, 16 Drawing Figures



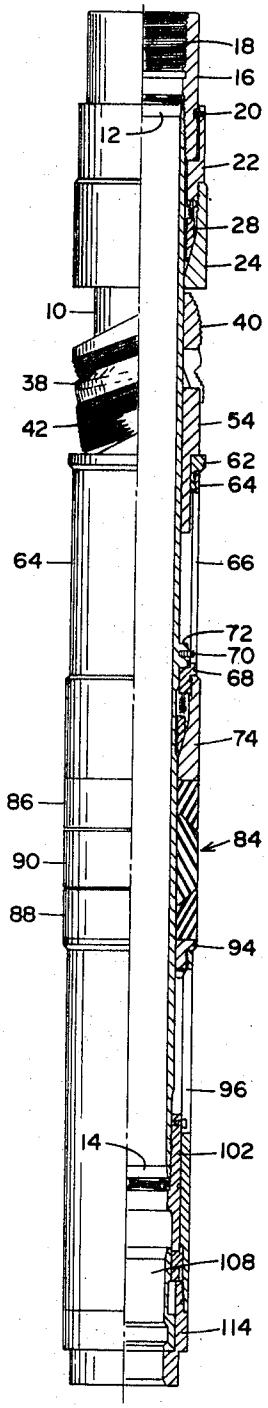

18
16
20
12
22
28
24
10
40
38
42
54
62
64
64
66
72
70
68
74
86
84
90
88
94
96
14
102
108
114

FIG. 1

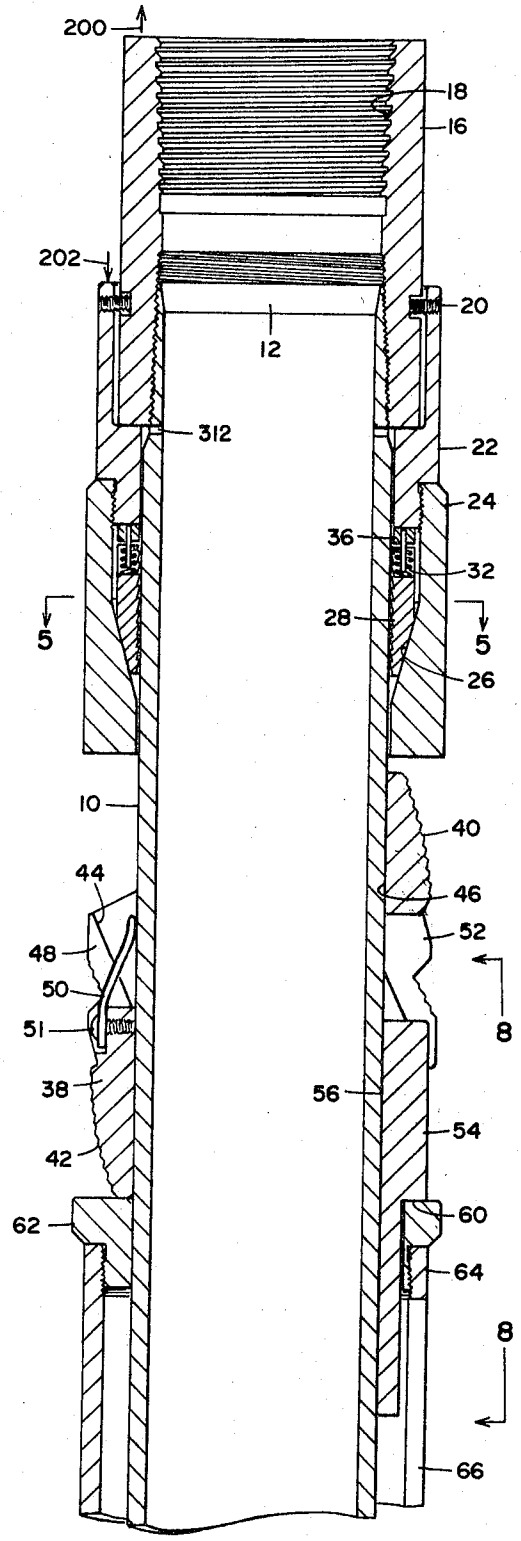

200
18
16
202
20
12
312
22
24
36
32
5
28
5
26
10
40
44
46
52
48
8
50
51
38
56
54
42
62
60
64
8
66

FIG. 2

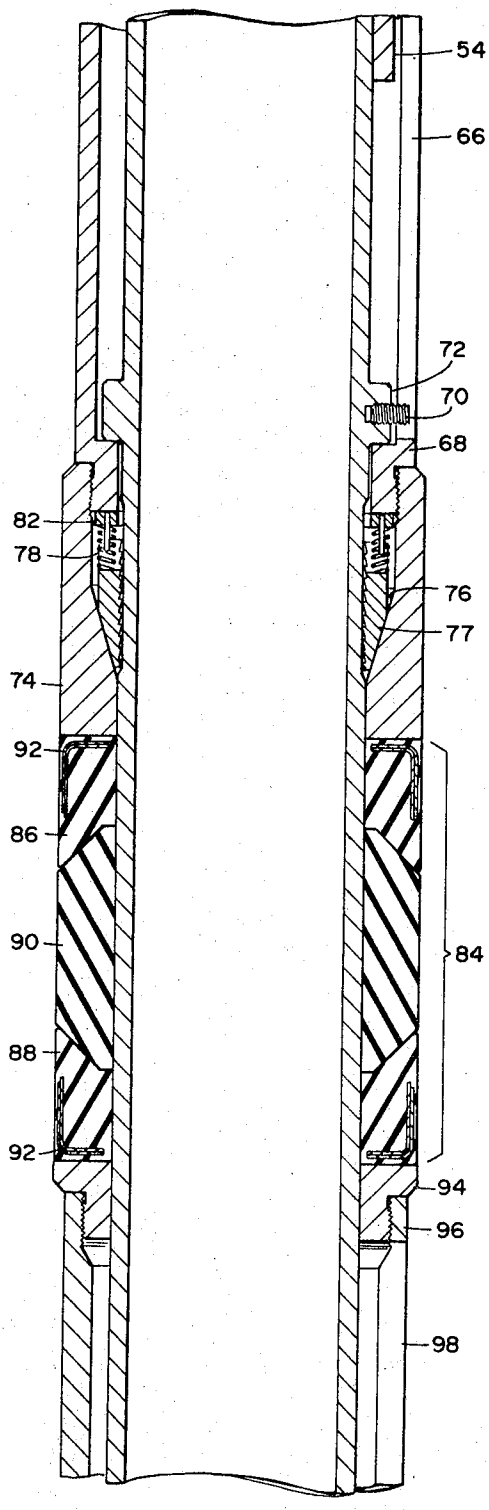

54
66
72
70
68
82
78
76
77
74
92
86
90
84
88
92
94
96
98

FIG. 3

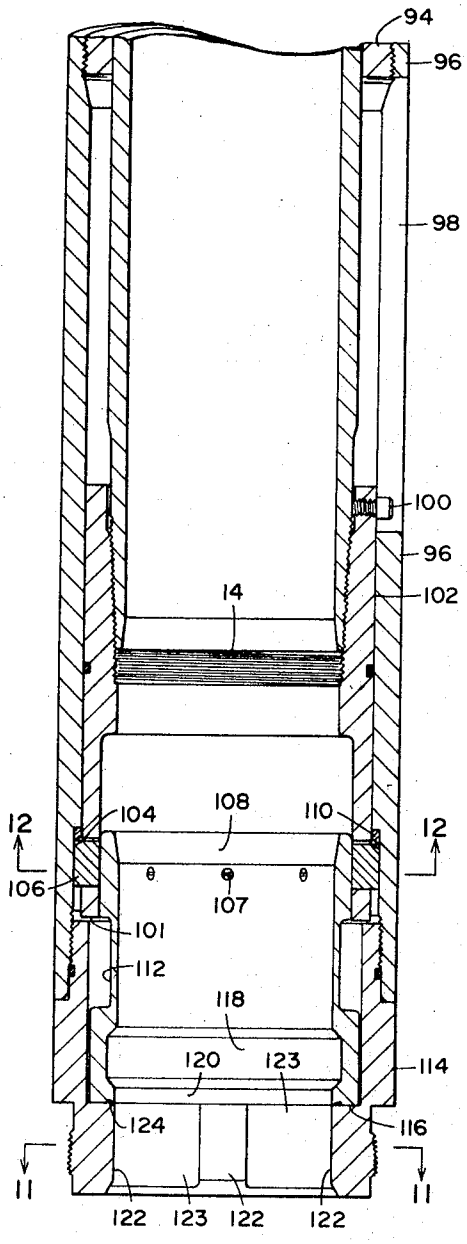

94
96
98
100
96
102
14
12
104
108
110
12
106
107
101
112
118
120
123
114
124
116
11
11
122
123
122
122

FIG. 4

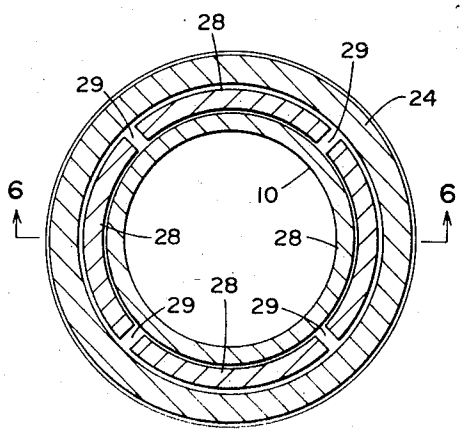


FIG. 5

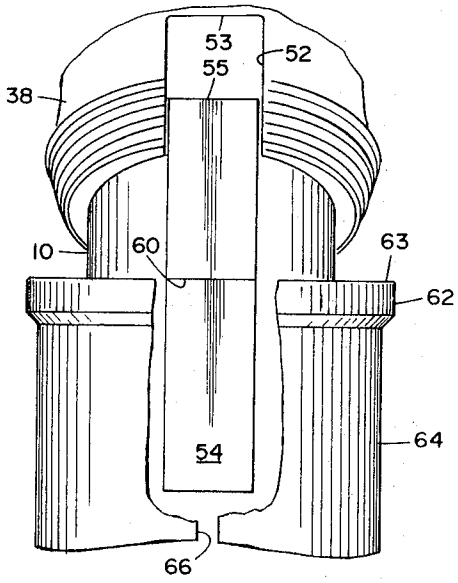


FIG. 8

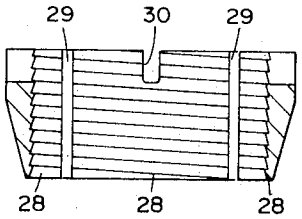


FIG. 6

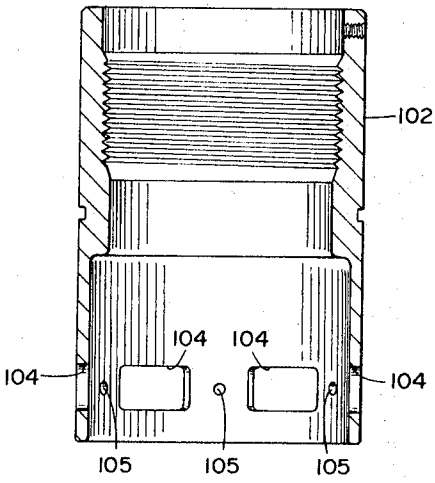


FIG. 9

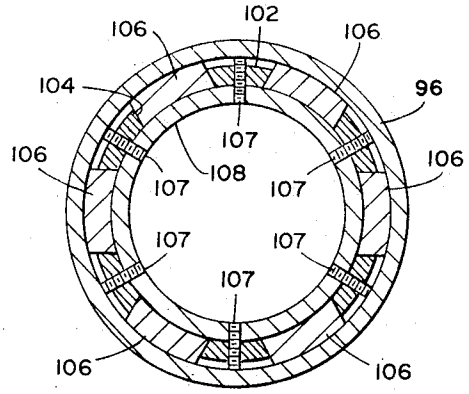


FIG. 12

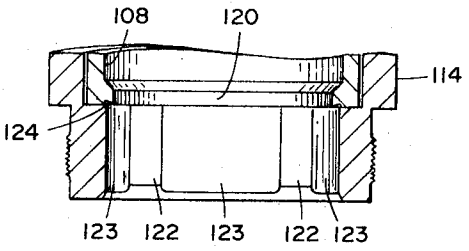


FIG. 10

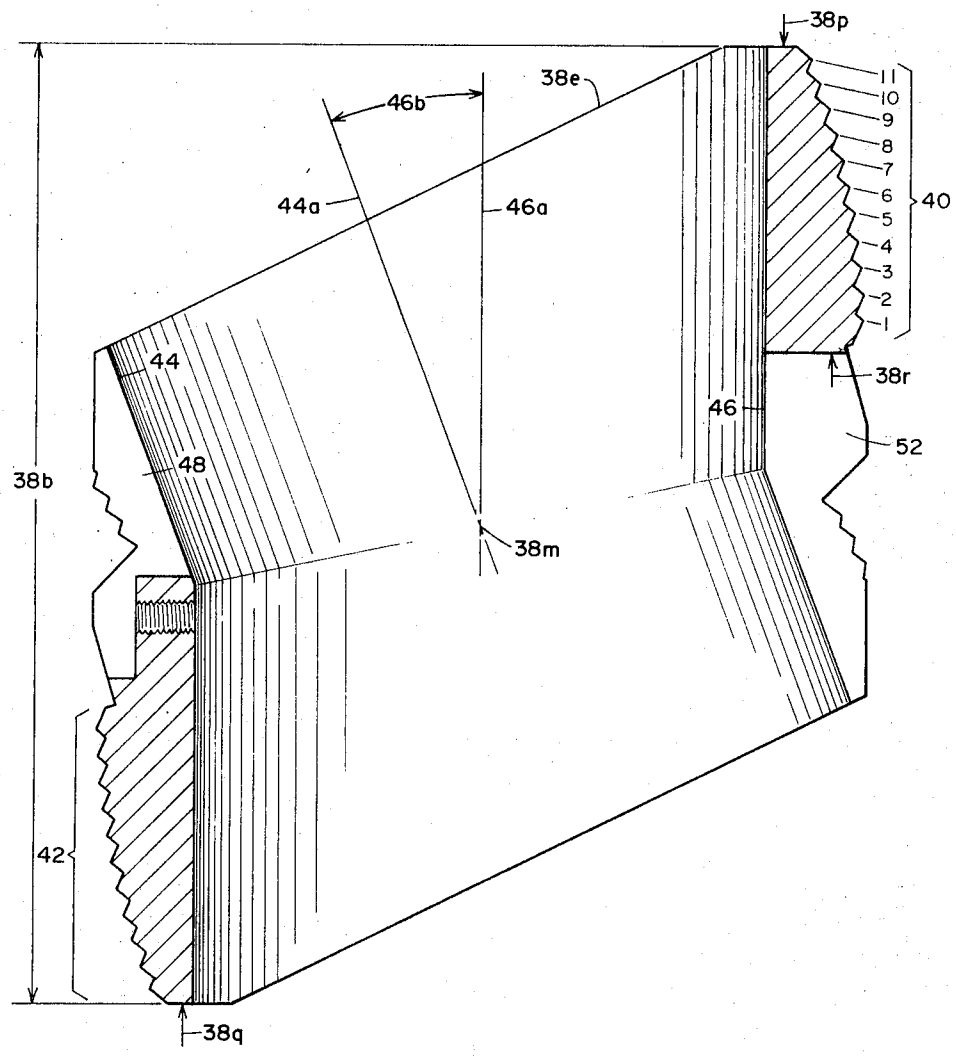
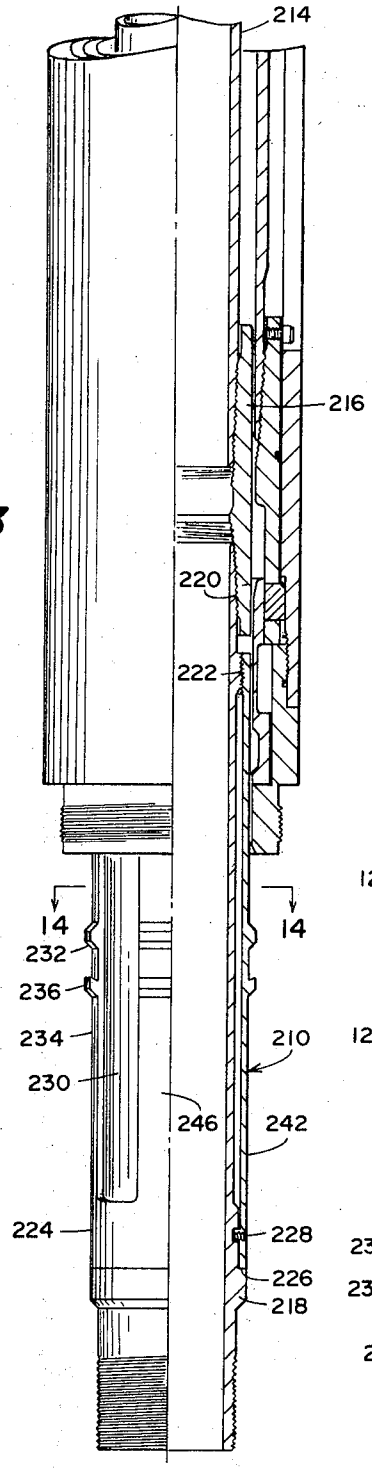

38p
38e
46b
44a
46a
11
10
9
8
7
6
5
4
3
2
1
40
44
38r
46
52
48
38b
38m
42
38q

FIG. 7

FIG. 13



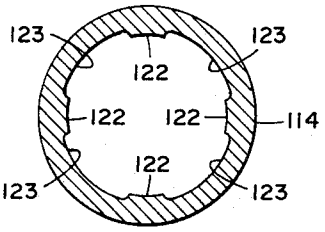


FIG. 11

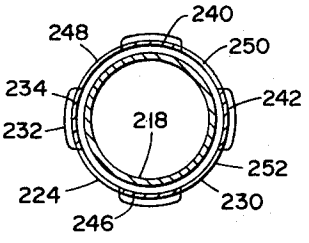


FIG. 14

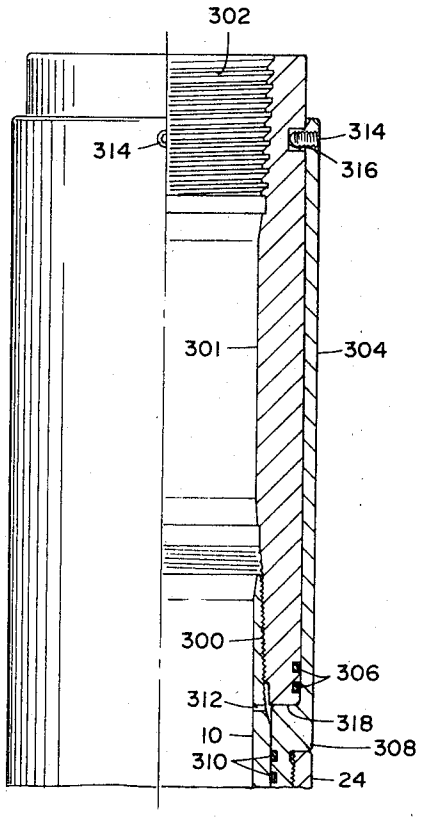

302
314
314
316
301
304
300
306
312
318
10
308
310
24

FIG. 15

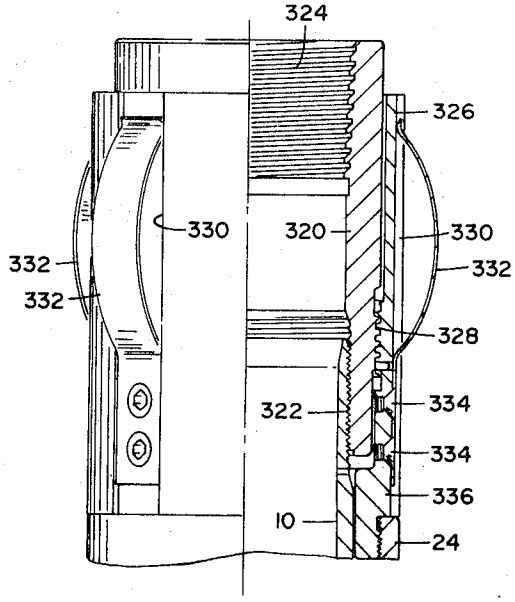

324
326
330
320
330
332
332
332
328
322
334
334
336
10
24

FIG. 16

WELL PACKER AND RETRIEVER

This is a division of application Ser. No. 307,696 filed Nov. 17, 1972, now U.S. Pat. No. 3,818,987.

This invention relates to tools for oil wells and the like, and more particularly to a well packer and a retrieving system therefor.

A packer is used in oil and gas operations to seal the zone above the packer from the zone below the packer in a well bore. For example, after a well casing has been set and the well has been logged to define the features of significance in the strata through which the well bore extends, a packer is then lowered into the well and located at a selected depth. For casing perforating and testing of a zone spanned by stratum of interest, one packer may be positioned at the top of the zone and another well packer may be positioned at the bottom of the zone. This isolates the zone for testing production after perforation. Packers are also used in cementing and fracturing operations and the like.

Heretofore, pneumatic, hydraulic, and mechanical packers have been used. The first two may be likened to an inflated ring using as a pressurized fluid either air or liquid. Mechanical packers are set in place by the mechanical displacement of packing components as distinguished from use of a pressurized medium.

One of the requirements of a satisfactory well packer is to be able to set it securely at a desired depth. When a packer is no longer needed, it must be removed. A retrieving system is desired that will facilitate removal of the packer in a relatively simple operation without loss of the packer or without damage to casing.

The packer of the present invention is an improvement over the packer disclosed in U.S. Pat. No. 3,548,936. It has a bidirectional grip to hold the packer in place opposing equally both upward and downward directed forces. Further, the packer of the present invention is provided with structure for mechanically unsetting the bidirectional grip to release the packer.

More particularly, in accordance with the invention there is provided a packer with a cylindrical mandrel encircled by a resilient packer unit which is radially deformable into contact with well casing when longitudinally compressed. A drive cylinder is secured to the mandrel below said packer unit to support the packer unit. A spacer encircles the mandrel to bear against the top of the packer unit and is movable longitudinally on the mandrel. A hollow cylindrical grip having beveled generally parallel ends with toothed shoulders adjacent to opposite extremities of the beveled ends is mounted on the mandrel and bears on the spacer as to be tilted into engagement with the casing but normally is resiliently biased toward an untilted attitude. An upper cylinder encircles the mandrel and is slidably positioned thereon above the grip whereby forces acting upward on the mandrel and downward on the upper cylinder apply a setting force to the grip which force is transmitted through the packer unit to tilt and wedge the grip between opposite sides of the casing as the packer unit seals the annulus between the mandrel and the casing. Wedge retainer means between the upper cylinder and mandrel permits downward movement and prevents upward movement of the upper cylinder with respect to the mandrel thereby locking the packer in set configuration.

In a further aspect of the invention, a downward opening slot opposite the lower toothed shoulder of the grip receives the end of a grip release bar supported on the spacer. A release lug on the surface of the mandrel below the bar cooperates with a releasable means coupling the mandrel and spacer which permits limited upward movement of the mandrel relative to the spacer for releasing the grip from the set configuration by driving the bar by the mandrel lug against the end of the slot in the grip.

In a further aspect of the invention, release structure is provided wherein a movable captured shear resistant element in recesses near the bottom of the packer spans a common boundary between the mandrel and drive cylinder. An insert cylinder supported by the mandrel has an outward facing peripheral groove dimensioned to accommodate the shear resistant element and normally is restrained with its groove below the bottom of the element to maintain capture of the element. Bottom structure secured to the drive cylinder supports the insert cylinder and has vertical internal ribs circumferentially arrayed below the insert cylinder of internal diameter about the same as the internal diameter of the insert cylinder and separated by vertical recesses. A tubing operated hook insertable down through said mandrel may engage the bottom of the insert cylinder only when aligned with the recesses to move the insert cylinder groove into registration with the shear resistant element, releasing the mandrel from the drive cylinder followed by release of the tool upon upward movement of the mandrel.

For a more complete understanding of the invention and for further advantages thereof, reference may now be had to the following description taken with the accompanying drawings, in which:

FIG. 1 is a partial cross section of a packer for mechanically setting a bidirectional grip in a casing;

FIG. 2 is an enlarged longitudinal cross section of the upper portion of the packer of FIG. 1;

FIG. 3 is a similar section of the middle portion of the well packer of FIG. 1;

FIG. 4 is a similar section of the lower portion of the well packer of FIG. 1;

FIG. 5 is a transverse sectional view of a well packer taken along the line 5—5 of FIG. 2;

FIG. 6 is a longitudinal sectional view of a split ring retainer only as taken along line 6—6 of FIG. 5;

FIG. 7 is a longitudinal sectional view of the grip 38 of FIGS. 1 and 2;

FIG. 8 is a partial view of the side of the well packer showing the grip release lug;

FIG. 9 is a longitudinal sectional view of the lock body of FIG. 4;

FIG. 10 is a longitudinal cross-sectional view of the lower end of the packer guide body and dog retainer of FIG. 4;

FIG. 11 is a transverse cross-sectional view of the guide body taken along line 11—11 of FIG. 4;

FIG. 12 is a cross-sectional view taken along line 12—12 of FIG. 4;

FIG. 13 is a longitudinal partial cross-sectional view of the lower end of the packer with a retriever in position to engage the packer to unseat the packer;

FIG. 14 is a transverse sectional view taken along line 14—14 of FIG. 13;

FIG. 15 is a partial sectional view of a hydraulic setting adapter; and

FIG. 16 is a partial sectional view of a mechanical setting adapter.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. 1–8 illustrate a well packer embodying the present invention wherein a hollow cylindrical mandrel 10 extends the length of the packer from the upper end 12 to the lower end 14. A top connection 16 is threaded onto end 12. Top connection 16 has internal threads 18 for receiving a tool setting mechanism (not shown).

A mandrel slip retainer 22 is mounted concentric with the mandrel 10. Retainer 22 is pinned to the top connection 16 by means of shear screws 20. Below retainer 22 and threadedly engaged therewith is a mandrel slip housing 24 having a cone-shaped inner wall 26.

An annular chamber is formed by the wall 26 and the outer surface of the mandrel 10. In this chamber is a split ring retainer wedge 28. Wedge 28 may slide downward along mandrel 10 freely but will oppose movement upward. Each segment of wedge 28 is spring biased downward by springs 32 which engage wedge 28. Springs 32 bias wedge 28 and are positioned on guide pins which are press fitted into a mandrel slip ring 36.

As shown in FIG. 5, the mandrel 10 is cylindrical as is the housing 24. However, wedge 28 is made up of arcuate segments mounted in the annulus between mandrel 10 and housing 24. Each segment of wedge 28 extends over an angle of almost 90°, leaving relatively small slots 29 between the confronting edges.

As best shown in FIG. 6, wedge 28 is internally grooved or threaded presenting sharp upfacing edges to engage mandrel 10. Each element of wedge 28 has a slot 30 in the upper surface thereof to receive a spring such as spring 32.

Immediately below the housing 24 is a bidirectional grip 38 which encircles mandrel 10. A first set of teeth 40 is located on an upper shoulder of grip 38. A second set of teeth 42 is located on a lower shoulder. Grip 38 is hollow having an axial bore 46 and an offset bore 44. Bores 44 and 46 are of the same diameter and are sized to accommodate mandrel 10. The bores are blended to permit tilt or rotation of grip 38 about an axis perpendicular to the axis of mandrel 10 and perpendicular to the plane which is common to the axes of bores 44 and 46.

In the preferred form, grip 38 will have the configuration as generally illustrated in FIG. 7. It will be noted that the axis 46*a* of bore 46 is offset by an angle 46*b*, preferably of the order of about 20°, from the axis of the bore 44. Bores 46 and 44 are of sufficient diameter for free movement of grip 38 from one extreme to the other as limited by the offset between bores 44 and 46.

The sets of teeth 40 and 42 each comprises eleven courses numbered 1–11, FIG. 7. The teeth are cut transverse to an axis which lies between axes 44a and 46a.

Teeth 40 and 42 are each formed on a curved shoulder so that the grip 38 will accommodate or be workable in casings having internal diameters over some predetermined limited range. For example, in a packer where the length 38*b* of a grip 38 was of the order of 7 inches, a grip constructed as shown in FIG. 7 was suitable for use in casing of internal diameter from about 6.4 inches to about 6.1 inches. As the grip 38 pivots or tilts about its central axis 38*m*, one of the teeth in set 40 and one of the teeth in set 42 will make initial contact with the casing wall. The tooth, or teeth, which engage the wall will do so with approximately the same angle above the tooth as below the tooth relative to the casing wall. Adequate force is applied so that the teeth actually penetrate to a degree the casing wall so that several teeth generally are called into play. They resist movement of grip 38 about equally in both the upward and downward direction.

Both ends of grip 38 are of the same configuration. Sets of teeth 40 and 42 generally are on opposite sides of the grip 38.

Teeth 40 may be cut spirally on the upper end of grip 38 or as parallel grooves. Grip 38 will tilt or pivot about the center line 38*m* in response to the couple represented by arrows 38*p* and 38*q* applied as housing 24 and shoulder converge.

Grip 38 may be unset by application of a force represented by arrow 38*r*.

Grip 38 has a vertical upfacing slot 48 immediately above the teeth 42. A retaining spring 50 is secured in slot 48 by screw 51 to maintain the grip 38 in the unset position illustrated in FIGS. 1 and 2.

A downwardly facing release slot 52 is provided immediately below the teeth 40 and diametrically opposite slot 48.

A grip release lug 54, FIG. 2, extends up into the bottom of slot 52. The inner surface 56 of lug 54 is formed with the same radius as the outside of mandrel 10. Release lug 54 has an intermediate downward facing shoulder 60 in contact with the upper surface of a lower head ring 62.

As best shown in FIG. 8, the slot 52 has a width approximately one-third the diameter of the mandrel 10. The lug 54 normally rests on the upper surface 63 of head ring 62. However as will later be explained, lug 54 is driven upward so that the top 55 of lug 54 engages the upper end 53 of slot 52 to rotate or tilt grip 38 back into an orientation such that the bore 46 is parallel to mandrel 10.

Head ring 62 threadedly engages an elongated spacer collar 64. A longitudinal slot 66 extends lengthwise of collar 64 to a point just above its lower threaded section 68.

A set screw 70 is threaded into a radial lug 72 formed on the outer surface of the mandrel 10. The head of screw 70 is positioned in longitudinal slot 66 to prevent rotation of the mandrel after the packer is set. Such rotation would be undesirable in any operation requiring application of rotational forces to the top of mandrel 10.

The lower end 68 of collar 64 is coupled by threads to a second mandrel slip housing 74. The configuration of housing 74 is similar to housing 24. It has a cone-shaped inner wall 76 which forms an annular space with the outer wall of the mandrel 10. Within this annular space is a split ring wedge 77 arranged in a manner similar to wedges 28, FIG. 2. Wedge 77 restricts upward movement of housing 74 with respect to the mandrel 10.

In FIG. 3 only two of the elements of wedge 77 are shown. The elements of wedge 77 are biased by means of springs 78 with the springs guided on pins inserted into a slip ring 82.

A packer unit 84 encircles mandrel 10 immediately below housing 74. Packer unit 84 in this embodiment

comprises two end rings 86 and 88 and a center ring 90. Rings 86, 88 and 90 are made of an elastomer such as rubber, synthetic rubber or other material compatible with the environment. The opposite ends of rings 86 and 88, respectively, are provided with flanged metal stiffening rings 92. The center ring 90 has tapered upper and lower ends that mate with reverse tapers of the confronting ends of rings 86 and 88.

A thimble 94 concentric with the mandrel 10 supports the bottom of ring 88. Threaded onto the bottom of thimble 94 is a dog housing 96 having a longitudinal slot 98 extending from thimble 94 to a point about half way down the length of the housing 92.

The head of a lock screw 100 extends into slot 98. Screw 100 is supported by a lock body 102 which is threaded onto the lower end 14 of the mandrel 10. Housing 96 is concentric with lock body 102 with sliding clearance therebetween. Screw 100 in slot 98 prevents rotation between the housing 96 and lock body 102.

FIG. 9 is a longitudinal sectional view of lock body 102. A plurality of circumferentially spaced windows 104 are located near the lower end thereof. Body 102 is formed with a cylindrical re-entrance passage therethrough with the windows 104 being in the lower large diameter portion. The upper end is internally threaded to receive the lower end 14 of mandrel 10. In the form illustrated in FIG. 9, four windows 104 are shown, there being six windows total in body 102. In the bars between windows 104 are threaded holes 105 which receive shear screws 107.

Referring again to FIG. 4, each window 104 will contain a locking dog 106. In this embodiment, six locking dogs are employed. Each locking dog 106 has a partially beveled upper surface. The outer curved surface of dog 106 mates with the inner surface of dog housing 96. The inner surface of dog 106 is curved to mate with the outer surface of a dog retainer 108. Each locking dog 106 is provided with its upper outer beveled edge to mate with the bottom beveled edge of a dog housing insert ring 110. The beveled surfaces cooperate as will later be explained in order to retrieve the packer.

Dog retainer 108, FIG. 4, includes central outward facing groove 112. Groove 112 faces the inner wall of a guide body 114. Dog retainer 108 is supported on a shoulder 116 of the guide body 114. At the lower end of retainer 108 is an inward facing groove 118. Groove 118 has upper and lower beveled ends. A lip 120 is located at the bottom of retainer 108 for use in retrieving the packer.

FIG. 10 is a longitudinal sectional view of the lower portion of body 114. FIG. 11 is a transverse sectional view of the lower end of body 114. Four circumferentially spaced guide fingers 122 in the form of longitudinal interior ribs are shown in FIGS. 4, 10 and 11 as being integral with the lower end of body 114. The inner surfaces of fingers 122 are curved on a diameter slightly smaller than the inner diameter of the lip 120, FIG. 4. Between adjacent guide fingers 122 is a slot 123, the diameter of which is equal to the inner diameter of the lip 120.

In FIG. 10, the longitudinal sectional view of the lower ends of retainer 108 and guide body 114 are rotated 45° from the section of FIG. 4. This shows lip 120 overlapping the top of the slots 123 between fingers 122. Lip 120 is undercut to provide a downward facing upward and outward sloping shoulder 124. In FIG. 11 fingers 122 alternate with grooves 123. The lip 120, FIGS. 4 and 10, overlaps grooves 123 because it is of diameter equal the diameter of the inner surfaces of the fingers 122.

As shown in FIG. 12, the dog housing 96 encircles lock body 102 inside of which is located the dog retainer 108. Shear screws 107 secure dog retainer 108 to lock body 102.

SETTING THE PACKER — WIRE LINE

The packer illustrated in FIGS. 1–11 may be set mechanically, hydraulically or by wire line.

The structure shown in FIGS. 1–12, and particularly the top connection 16 as mounted in this system is particularly adaptable for wire line setting. More particularly, a wire line pressure setting assembly (not shown) is fitted onto the top connection 16 by way of an adapter (not shown). The packer is then lowered into the borehole to the desired depth on a wire line and there actuated.

Such setting assemblies in general are well known. A suitable setting assembly is the Baker Wire Line Pressure Setting Assembly, Product No. 437–02 manufactured and sold by Baker Oil Tools of Los Angeles, Calif. With such assembly, there will be employed the well-known Guiberson B-Adapter Kit manufactured and sold by Guiberson of Dallas. Tex. Such kit would include a 35,000 lb. shear ring. Such units have long been used in oil well operations.

The pressure setting assembly and the Adapter Kit above identified serve to apply an upward force in the direction of arrow 200, FIG. 2, to the top connection 16 and at the same time by way of a sleeve (not shown but which extends down over top connection 16 as a part of the adapter kit) to apply a downward force as represented by arrow 202 to the top of the mandrel slip retainer 22.

By way of brief explanation, such pressure setting assemblies are adapted to be actuated by an electrical signal on the supporting wire line which leads from the surface. Such signal detonates a suitable explosive or combustible material to produce gas pressure in a piston chamber. The chamber and piston are connected as to apply the upward force 200 and the downward force 202. Such forces cause screws 20 to shear. Once screws 20 are severed, mandrel 10 tends to move upward while retainer 22 and housing 24 tend to move downward. The lower end of housing 24 engages the upper end of grip 38 at a point adjacent to the top of threads 40. Since mandrel 10 is connected to lock body 102 and, by way of dogs 106 to dog housing 96, upward movement of mandrel 10 results in application of a force represented by arrow 38*q*, FIG. 7. This force is transmitted from dog housing 96 by way of thimble 94, bottom packer ring 88, packer ring 90, packer ring 86, mandrel slip housing 74, collar 64 and lower head 62. The lower head 62 bears against the bottom of the grip 38 adjacent threads 42. As housing 24 and the lower head 62 move toward each other, grip 38 is rotated, overcoming the force of spring 50 so that the teeth in both sets 40 and 42 engage the casing wall on opposite sides of the casing and at opposite ends of grip 38.

As motion in the direction of arrows 200 and 202 continues, the casing will oppose significant further rotation of the grip 38. However, continued motion of mandrel 10 upward relative to housing 24 causes packer unit 84 to bulge outward into sealing contact

with the wall of the casing. As the casing further limits distortion in the rubber elements, progressively increasing force is applied to the grip **38** to partially embed the teeth in the walls of the casing.

Distortion of the rubber elements continues until the pressure in the pressure setting assembly reaches a predetermined level. As above indicated, a shear ring employed in the Adapter Kit controls this level. In the example given, a 35,000 pound shear ring was specified. In such case when the pressure in the pressure setting assembly reaches 35,000 p.s.i. thus determining the magnitude of forces **200** and **202**, the shear ring in the adapter kit fails, releasing the pressure setting assembly and the adapter kit from the top connection **16**. The pressure setting assembly and the adapter kit may then be withdrawn from the well.

Upon release of the pressure setting assembly and adapter kit, the mandrel **10** tends to move downward relative to housing **24**. Such movement is immediately arrested by the wedges **28** and **77**. Wedge **77** separately locks packer unit **84** in the set configuration in order to avoid any release of the packer unit **84** as might otherwise occur if the downhole pressure on the packer exceeded the setting pressure (35,000 pounds in the example) and were then released. Such excess pressure would pivot grip **38** to a greater angle. Removal of such excess pressure would then release to some degree packer unit **84** in the absence of wedge **77**.

With the wire line removed, the operator is then free to conduct such tests as may be appropriate or other operations desired in connection with the packer set at the desired depth.

SETTING THE PACKER — HYDRAULICALLY

The packer may be set hydraulically by use of the adapter unit shown in FIG. **15**. In this embodiment, the mandrel **10** is secured by threads **300** into the bottom of an adapter collar **301** which has threads **302** in the upper end thereof for coupling collar **301** to tubing (not shown). A cylinder **304** encompasses the collar **301**. O-rings **306** in grooves on the outer surface and near the lower end of collar **301** provide a pressure seal between the outside of the collar **301** and the inner wall of the cylinder **304**. The bore in cylinder **304** is reentrant with the smaller diameter portion **308** fitting closely around the outside of mandrel **10**. O-rings **310** in grooves on the inner wall of the small diameter portion **308** provide a pressure seal between mandrel **10** and portion **308**. Mandrel slip housing **24**, shown in detail in FIG. **2**, threadedly engages the bottom of portion **308**.

Ports **312** extend laterally through the wall of mandrel **10** adjacent the bottom of threads **300**.

Shear screws **314** extend through the upper end of cylinder **304** into a groove **316** in the region of threads **302** on collar **301**.

In setting the tool hydraulically, the lower end of the packer is provided with an expandable or relievable valve generally in the manner described in connection with FIG. **16***c* of U.S. Pat. No. 3,548,936.

With the lower end of the mandrel **10** closed by such valve means, pressure applied through the tubing connected at threads **302** will be exerted through ports **312**. As the pressure builds up, shear screws **314** part permitting the surfaces **318** to part, thus causing mandrel **10** to move upward and housing **24** to move downward. By this means the packer will be set with the wedges **28** and **77** providing restraint in the set configuration when the pressure in the tubing is relieved. The tubing and the valve at the lower end of the mandrel may then be removed in a conventional manner for use of the packer.

SETTING THE PACKER — MECHANICALLY

The packer may be set mechanically by use of the adapter shown in FIG. **16**. In this embodiment, an adapter **320** is secured to mandrel **10** by the threaded section **322**. Adapter **320** has threads **324** in the upper end thereof for coupling to tubing to be used in the setting operation. An anti-rotation sleeve **326** is connected to adapter **320** by a limited threaded section **328**. More particularly, a short length of the outer surface of adapter **320** is provided with external threads which mate with internal threads about midway the length of sleeve **326**. The exterior of sleeve **326** has a plurality of longitudinal grooves **330** extending from near the bottom to the top thereof. Bow springs **332** are mounted in grooves **330** by means of screws **334**. Screws **334** are located near the bottom of sleeve **326**. The upper portion of the bore of sleeve **326** is slightly larger in diameter than the crown of the threads **328** on the adapter **320** so that sleeve **326** may pass freely down over thread section **328** when the threads are disengaged. The bore in sleeve **326** is reentrant having a smaller diameter portion **336** at the lower end which is provided with threads to which the upper end of housing **24** is secured.

In operation the packer is lowered into the borehole on the end of tubing (not shown) coupled to threads **324**. When at desired depth, the tubing is rotated to disengage threads **328** on adapter **320** from mating threads on sleeve **326**. The tendency of sleeve **326** to rotate with adapter **320** is opposed by the frictional engagement of the bow springs **332** with the wall of the casing.

When threads **328** become disengaged, upward movement of the tubing carrying adapter **320** and mandrel **10** with it will take place relative to sleeve **326**. Springs **332** oppose upward movement of sleeve **326** to the extent that the force of spring **50**, FIG. **2**, is overcome, tilting grip **38** into engagement with the casing wall. Further upward force supplied to the tubing will then embed the grip **38** in the casing and seal packer unit **84** against the casing wall.

RETRIEVING THE SET PACKER

After the packer has been set and the desired operations have been conducted in the well, it is often desired to release the packer and retrieve it from the well.

The packer shown in FIGS. **1–11** may be retrieved by applying an upward force on grip **38** as represented by arrow **38***r*, FIG. **7**, by use of a packer retriever **210**, FIG. **13**.

Packer retriever **210** is shown in FIG. **13** in position preparatory to being latched onto the packer and is secured to the lower end of tubing **214**.

Retriever **210** includes an upper collar **216** which is threaded at the upper end to engage tubing **214**. Collar **216** is internally threaded at its lower end to receive a retriever mandrel **218**. Retriever mandrel **218** has a first set of threads **220** at the upper end thereof which are served into the lower end of the collar **216**. A second set of threads **222** are positioned below threads

220 and are of larger diameter than threads 220. A slotted sleeve 224 is telescoped downward over retriever mandrel 218. The upper end of the sleeve 224 is internally threaded on an internal shoulder to be served onto thread 222. Thus, there is an annulus between mandrel 218 and sleeve 224. Sleeve 224 extends downward onto shoulder 226. A screw 228 is employed to lock the sleeve 224 and prevent rotation relative to mandrel 218.

Sleeve 224 has four longitudinal slots such as the slot 230. The slots extend substantially the entire length of the sleeve 224 with ribs therebetween. Ribs 234, 242 and 246 are shown in FIG. 13. A central transverse guide lug 232 is formed on the outer surface of the rib 234. A hook 236 is formed on rib 234 below lug 232. Hook 236 is upwardly and outwardly beveled. The upper and lower surfaces of lug 232 are beveled towards the rib 234.

FIG. 14 illustrates the relationship between retrieving mandrel 218 and sleeve 224. Rib 234 occupies about one-eighth of the circumference of sleeve 224. As viewed in FIG. 14, the upper surface of the lug 232 extends radially outward from rib 234. In a similar manner, ribs 240, 242 and 246 form parts of the sleeve 224. Ribs 234, 240, 242 and 246 are centered at 90° intervals about sleeve 224. Slot 230 extends substantially the length of the sleeve 224 between ribs 242 and 246. Similarly, slots 248, 250 and 252 are located between the remaining ribs.

The outer diameter of lugs 232 and hooks 236 is greater than the inner diameter of lip 120, FIG. 4. It will be appreciated that ribs 234, 240, 242 and 246 will flex inwardly under the weight of the tubing 214 to be forced downward through the dog retainer 108 and through the lower end of the guide body 114.

To release the packer, the tubing 214, FIG. 13, is drawn upward. If lugs 232 and the hooks 236 are in angular positions such that as they move upward they register with the slots 123, FIGS. 10 and 11, then lug 232 will snap outward into the groove 118 and the hook 236 will engage lip 120.

Referring to FIG. 4, the application of a force to lip 120 will shear screws 107, releasing retainer 108 from its position at the bottom of lock body 102. Upward movement upward of the entire packer, however, is foreclosed by the fact that the grip 38 is set in the casing. Thus, when retainer 108 is freed by shearing screws 107, it may move upward freely until the shoulder at the bottom of groove 112 engages the lower end 101 of lock body 102. Further upward movement tends to raise dogs 106 upward. As a result, dogs 106 are forced inward into the groove 112 by the cooperation between the upper grooved edge of the dogs 106 and a downward beveled edge of the ring 110. Dogs 106 move inward a distance sufficient for the outer surface of the dogs to clear the inner wall of the dog housing 96. In such position, mandrel 10, lock body 102, dog retainer 108 and dogs 106 may then move upward relative to housing 96. Further upward movement permits the shoulder on lug 72 to move upward into engagement with the lower end of the grip release lug 54. As lug 54 then moves upward, the upper end thereof travels to the end of slot 52 and engages the grip 38 to rotate it counterclockwise and thereby release it from the set position. When this is done, the packer elements are free to resume their unset configuration and the packer may be retrieved or withdrawn from the hole supported on the tubing.

The construction of the retriever 210 and the ribs and grooves in body 114 provides for selective retrieval. FIG. 14 shows that the lugs such as lug 232 occupies about one-eighth of the circumference of the sleeve 224. From FIGS. 4, 10, 11 and 12 it will be apparent that the ribs 122 occupy substantial portions of the circumference of the guide body 114, each less than one-eighth thereof. The dimensions are such that with random orientation, hook 236 will, on the average, engage lip 120 about one out of every four times the retriever 210 is drawn upward through the lower end of the packer assembly.

Thus, in retrieving the packer, the procedure is to lower the retriever 210 until hook 236 passes below the edge of lip 120. Thereafter, the tubing 214 is raised. Increase in weight on the tubing, as conventionally measured at the drilling floor, will reveal to the operator whether or not lip 120 has been engaged by hook 236. If there is no buildup of weight as the hook 236 passes the location of lip 120 and retrieval is desired, then the tubing string is rotated, lowered and again raised. The procedure is repeated until a weight indicator signals the fact that the packer has been engaged. Thereafter, such force is applied through the tubing as to shear screws 107. The packer may then be withdrawn from the borehole and the shear pins again installed to place the packer in condition for another cycle of use.

It may be that the tubing and retrieving tool are to be removed without releasing the packer. This may be done when desired. More particularly, if the weight on the tubing when raised indicates the retriever 210 is hooked in the packer, the tubing may be lowered, rotated and again raised. Three out of four times, the retriever will not hook the packer, thus permitting selective retrieval operations.

The packer and retrieving system above described has significant capability in that the same structure may be set in the well by all three of the methods, i.e., wire line, hydraulic and mechanical. In addition, the packer is selectively retrievable regardless of which method of setting is utilized.

Further, a single grip serves to resist substantially equal forces from both uphole and downhole. Further, the packer is selectively retrievable by reason of the geometric relationship between the ribs 122 and recesses 123, FIG. 11, and the hooks 236, FIG. 14. Selective retrievability is an attribute that is important in well operations.

The foregoing description has been specific as to a single embodiment of the invention. It will be understood that modifications may be made, departing from the specific structure here shown while embodying the invention. More particularly, while six dogs 106 are shown in FIG. 12 and six windows are provided in insert cylinder 102, different numbers and different sizes of dogs may be employed. Dogs 106 preferably are made of specially hardened steel to avoid deformation due to the high forces supplied thereto during the setting operation. In addition, the ring 110 is of similar hardened steel material so that when the dogs 106 are to be forced into recess 112, a distance sufficient for the dogs to clear the inner wall of the drive cylinder, the transfer can be accomplished without distorting the shape of the dogs 106 or the ring 110.

While the packer element 84 has been illustrated and described as comprising the three rings 86, 88, and 90, it will be appreciated that a single resilient ring or band of unitary character may be employed in place of the three rings 86, 88 and 90 for distortion upon axial compression into sealing contact with the casing wall.

Further, the teeth 40 and 42 formed on grip 38 are on curved shoulders in the zones adjacent to the opposite extremities of the beveled ends of the grip 38. The sets of threads are located at diametrically opposed zones on the grip. The teeth are shaped as to resist movement relative to the casing once this grip 38 engages the casing, preferably engaging the casing about equilaterally, i.e., the angle between the tooth surface and casing wall above a tooth is about equal to the corresponding angle below the tooth.

In one aspect the packer comprises the cylindrical mandrel 10 encircled by resilient packer unit 86, 88 and 90 which is radially deformable into casing contact when longitudinally compressed. Drive cylinder 96 secured to mandrel 10 below packer unit 86, 88, 90 supports the packer unit. Spacer 64 encircles the mandrel and bears against the top of the packer unit while movable longitudinally on the mandrel. Grip 38 responds to the couple 38*q*, 38*p*, FIG. 7, between spacer 64 and upper cylinder 22, 24 to tilt into engagement with the casing although normally resiliently biased toward an untilted attitude. The couple is produced by forces acting upward on mandrel 10 and downward on cylinder 22, 24 to set grip 38. This force is transmitted through packer unit 86, 88, 90 to tilt and wedge grip 38 between opposite sides of the casing as the packer unit seals the annulus between mandrel 10 and the casing. Wedge retainer 28 between cylinder 22, 24 and mandrel 10 permits downward movement and prevent upward movement of cylinder 22, 24 with respect to mandrel 10.

Once set, grip release bar 54, supported by spacer 64, extends into the mouth of slot 52. Lug ring 72 on the surface of mandrel 10 serves to drive bar 54. The releasable coupling between mandrel 10 and drive cylinder 96, when actuated, permits upward movement of mandrel 10 relative to cylinder 96 whereupon mandrel 10 may drive bar 54 by lug ring 72 against the end of slot 52.

Movable captured shear resistant dogs 106 nested in recesses in the bottom of the packer span a boundary common to mandrel 10 and drive cylinder 96. Insert cylinder 108 is supported by mandrel 10. Cylinder 108 has outward facing peripheral groove 112 dimensioned to accommodate dogs 106 and normally to restrain them so long as groove 112 is positioned below dogs 106 and maintain the capture thereof. Structure 114 supports insert cylinder 108 from drive cylinder 96. Vertical internal ribs 122 in structure 114 are circumferentially arrayed below cylinder 108 and are of internal diameter about the same as the internal diameter of insert cylinder 108 and are separated by vertical recesses 124.

Tubing controlled hooks 236, FIG. 13, are insertable down through mandrel 10. Hooks 236 may engage the bottom of insert cylinder 108 only when aligned with recesses 123 to move groove 112 of cylinder 108 into registration with dogs 106 thereby to release mandrel 10 from drive cylinder 96.

Having described the invention in connection with certain specific embodiments thereof, it is to be understood that further modifications may now suggest themselves to those skilled in the art and it is intended to cover such modifications as fall within the scope of the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. Release means for a well packer set in a casing with a hollow cylindrical mandrel extending through a resilient packer unit which is radially forced into contact with said casing by longitudinal compression between a drive cylinder secured to said mandrel below said packer unit wherein a hollow cylindrical grip having beveled generally parallel ends with toothed shoulders adjacent to opposite extremities of said beveled ends is tilted into wedging engagement with said casing by a force transmitted from said packer unit by a cylindrical spacer engaging the bottom of said grip which comprises:

a. means to release said drive cylinder from said mandrel, and

b. structure including means on said mandrel to apply an upward force to the bottom of said grip at a location directly beneath the upper of said shoulders upon upward movement of said mandrel relative to said grip to release said grip.

* * * * *