United States Patent [19]

Jett

[11] **3,851,707**

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

[54] **UNI-DIRECTIONAL UNITARY ANCHOR SLIP**

[75] Inventor: **Marion Barney Jett,** Seagoville, Tex.

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

[22] Filed: **Nov. 2, 1973**

[21] Appl. No.: **412,239**

[52] **U.S. Cl.** **166/212,** 166/134

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

[58] **Field of Search** 166/206, 212, 216, 217, 166/214, 120, 134, 136, 189

[56] **References Cited**

UNITED STATES PATENTS

2,638,851	5/1953	Soberg et al.	166/136
3,416,610	12/1968	Prescott	166/206 X
3,548,936	12/1970	Kilgore	166/217 X
3,687,196	8/1972	Mullins	166/217
3,714,984	2/1973	Read	166/206 X
3,731,740	5/1973	Douglas	166/120
3,735,814	5/1973	Tucker	166/217
3,739,849	6/1973	Meripol	166/216
3,779,314	12/1973	Read	166/216
3,804,164	4/1974	Ellis	166/120

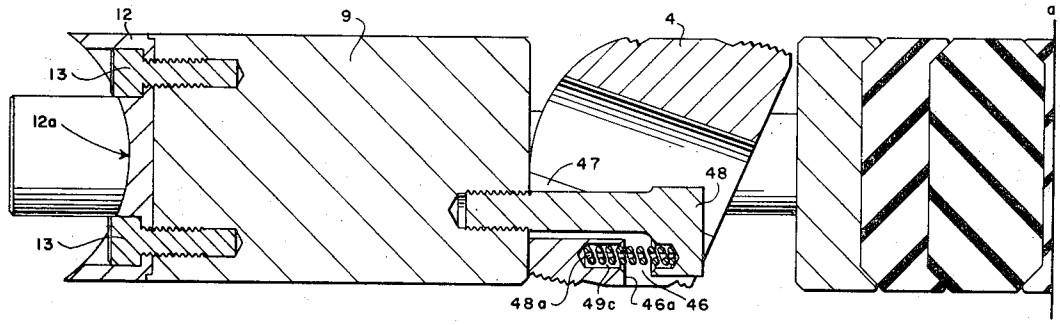
Primary Examiner—David H. Brown

Attorney, Agent, or Firm—Michael J. Caddell

[57] **ABSTRACT**

An improved unitary anchor slip utilizes a partially flat, partially curved abutment surface for allowing pivoting, setting, and later dislodgement of the slip in the casing, said abutment surface eliminating the need for pivot pins, supporting sleeves and pivot clearances with the improved unitary anchor slip.

7 Claims, 36 Drawing Figures



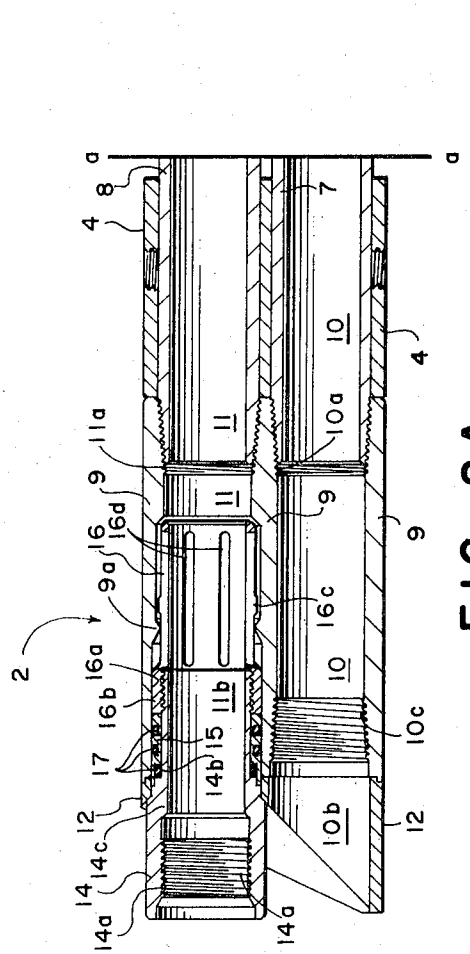


FIG. 2A

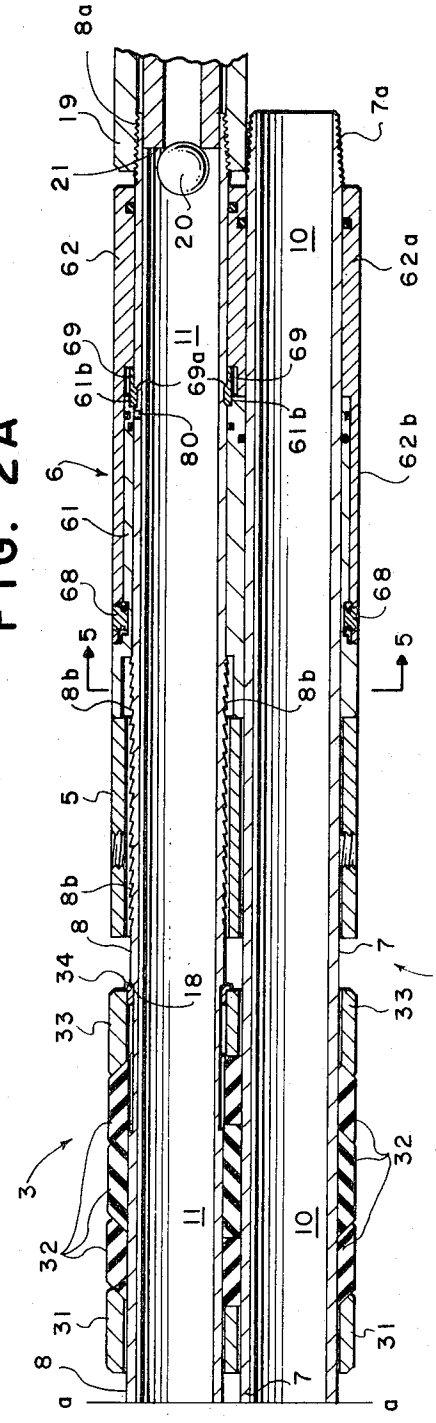


FIG. 2B

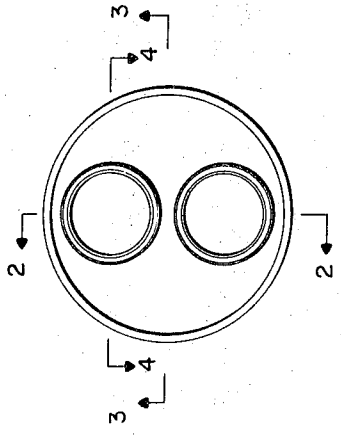


FIG. 1

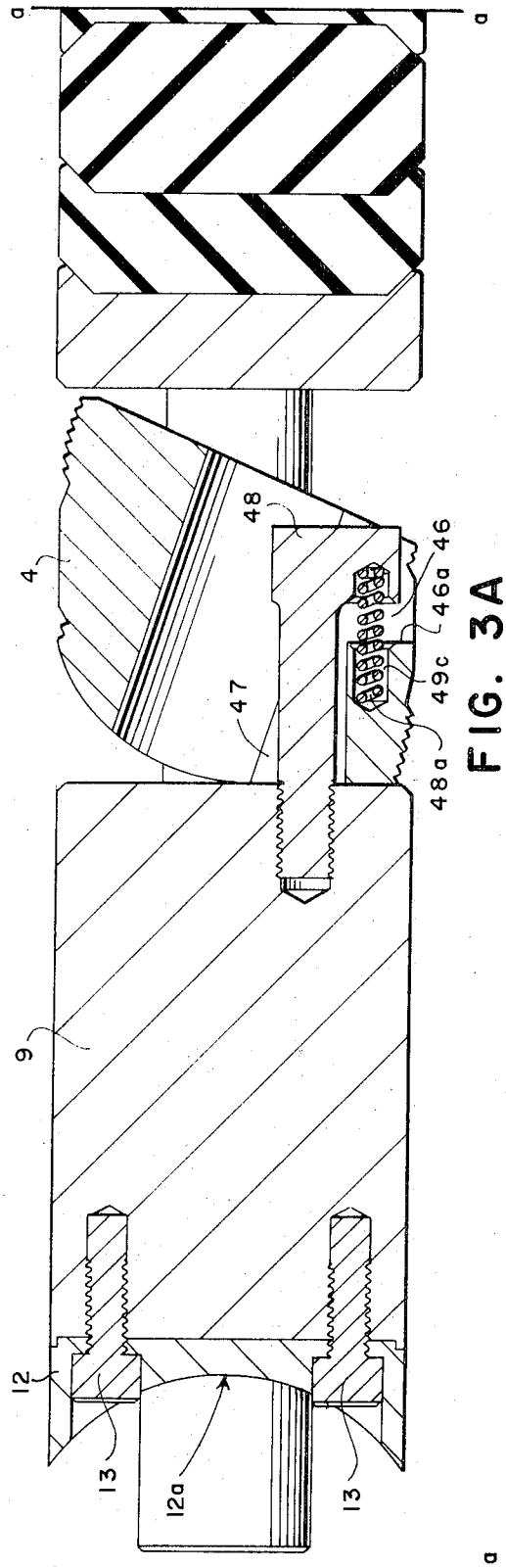

a
a
4
48
46
46a
49c
47
48a
9
12
13
12a
13

FIG. 3A

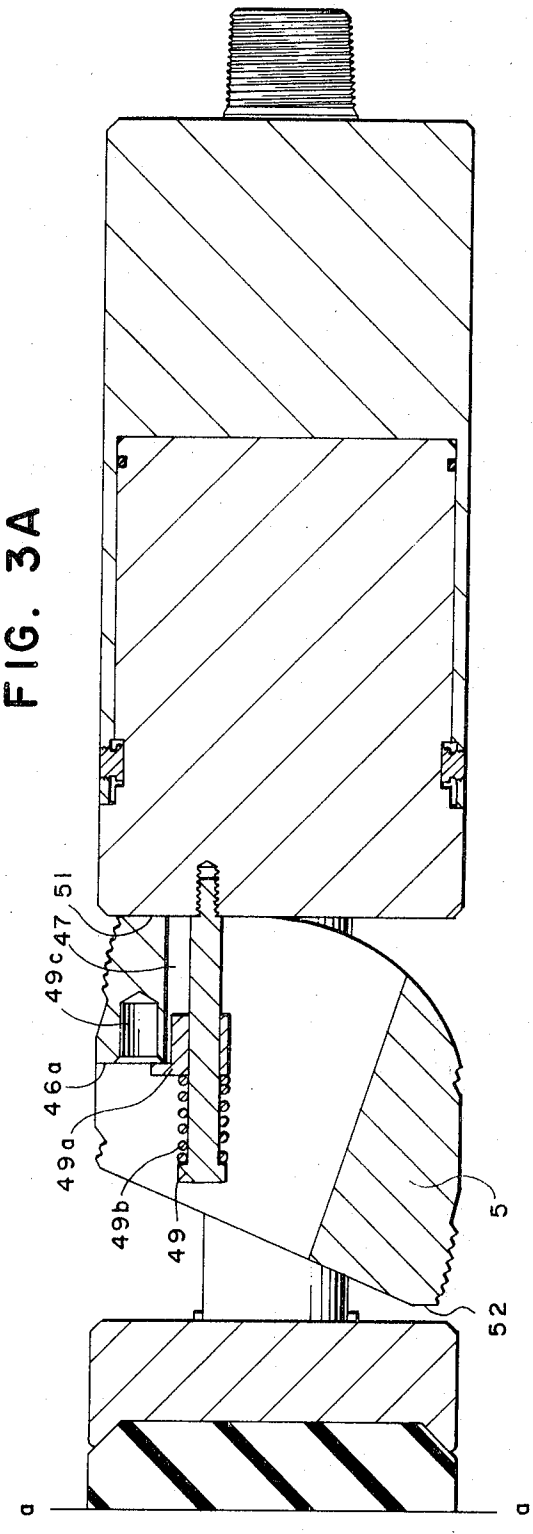

51
47
49c
46a
49a
49b
49
5
52
a
a

FIG. 3B

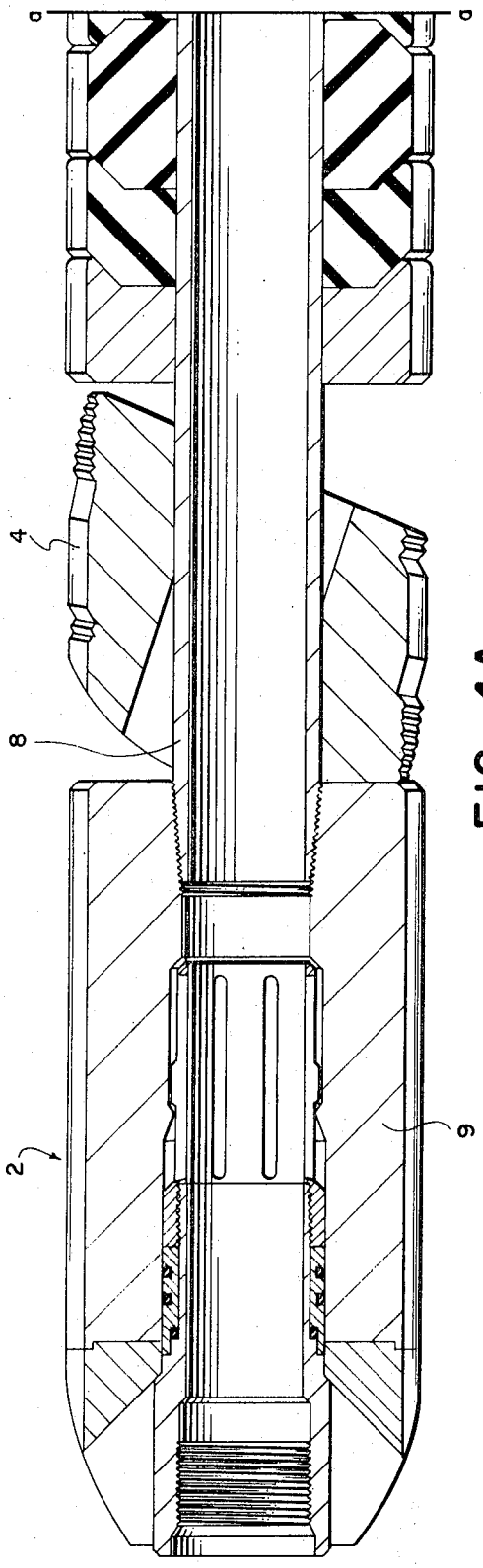


FIG. 4A

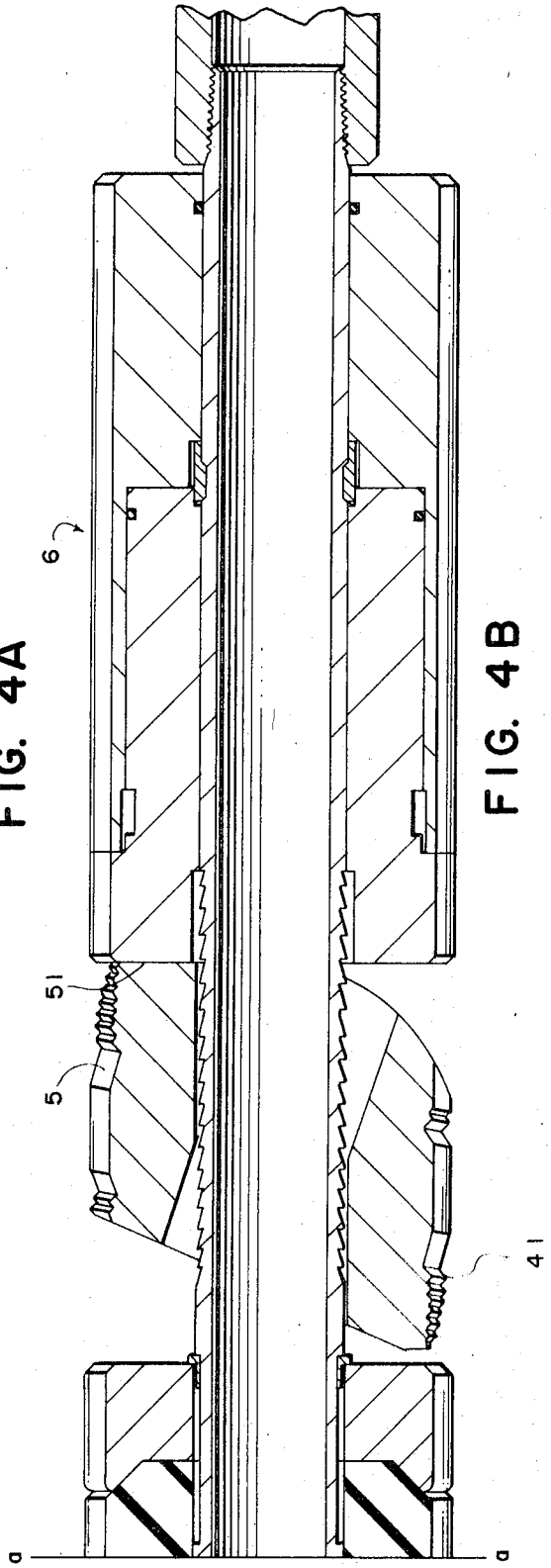


FIG. 4B

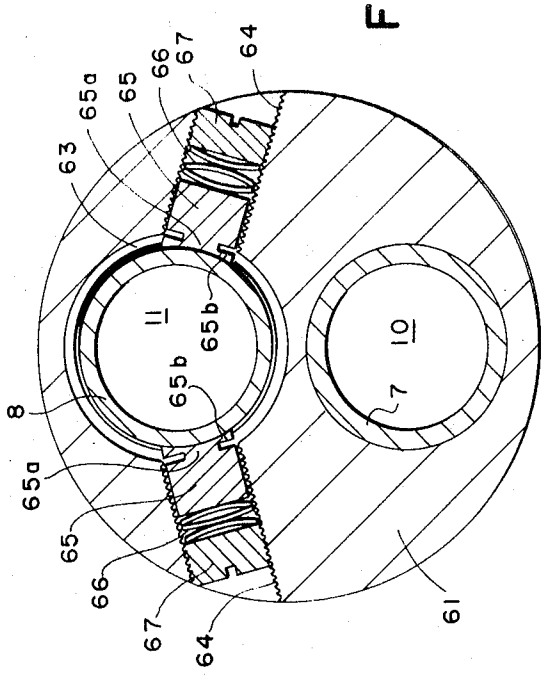


FIG. 5

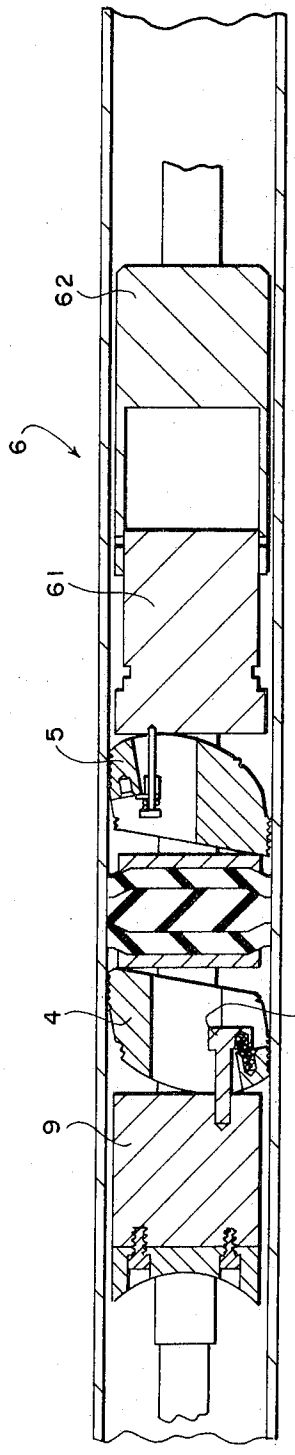


FIG. 8

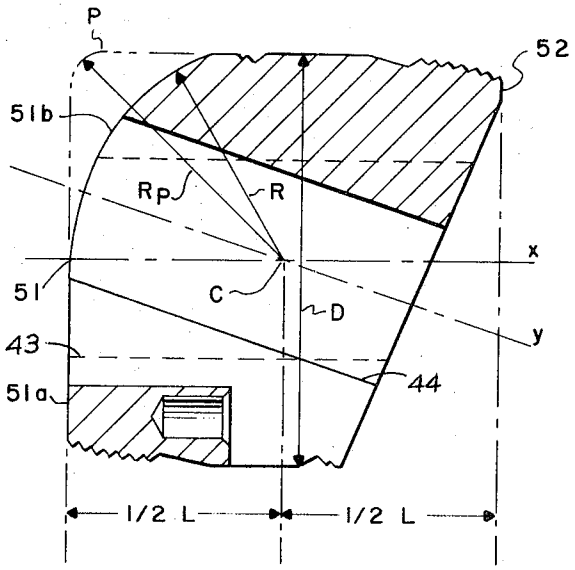
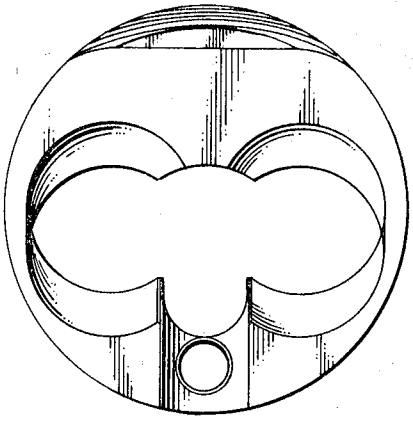


FIG. 6

FIG. 7



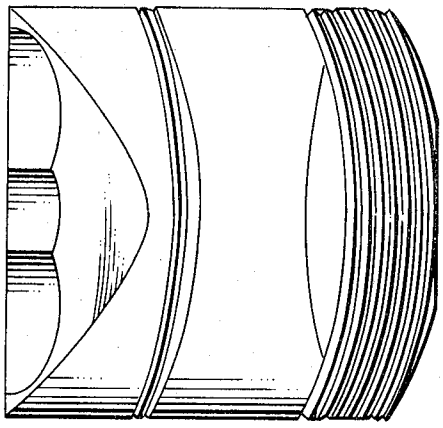


FIG. 7A

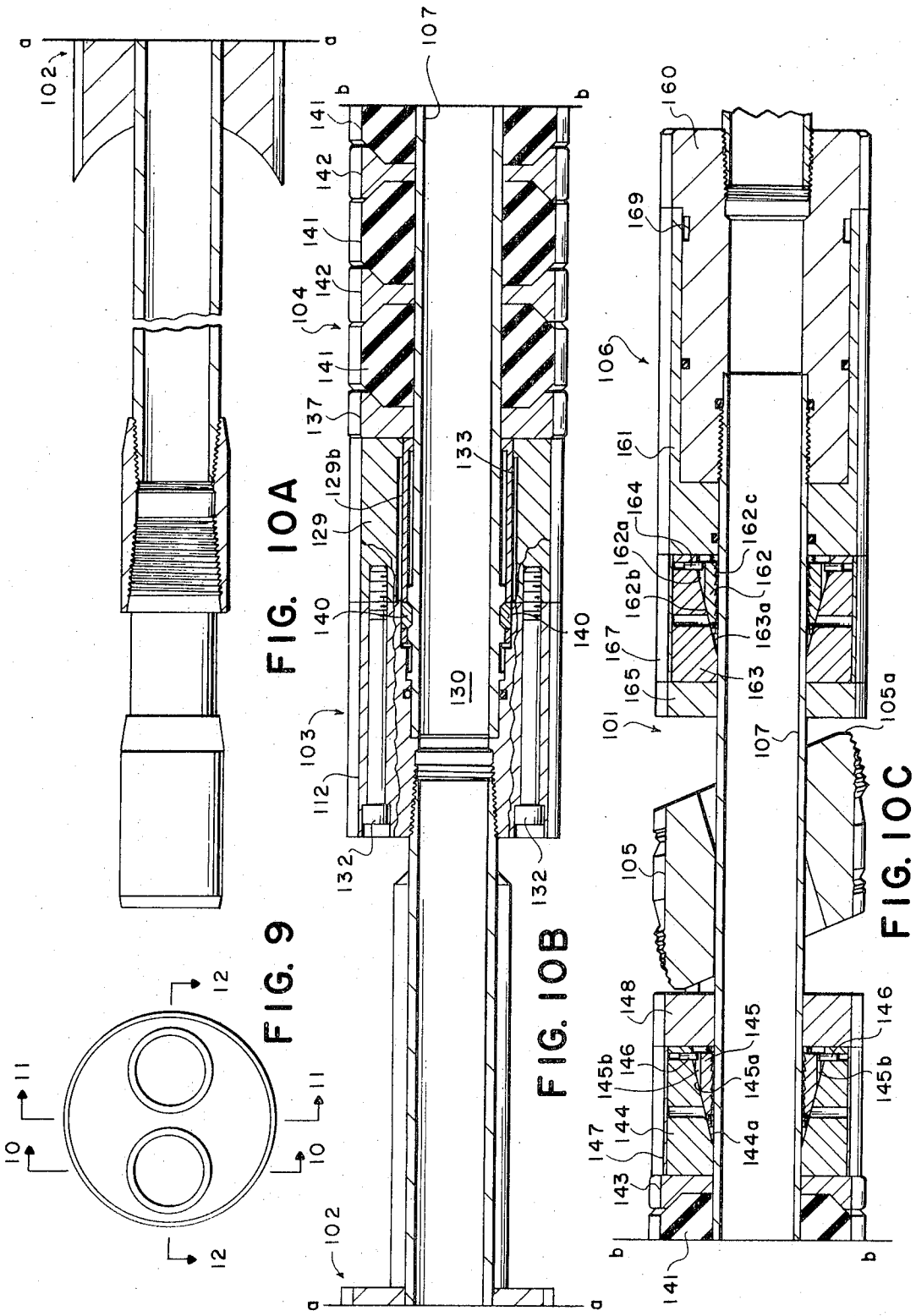


FIG. 10A

FIG. 10B

FIG. 10C

FIG. 9

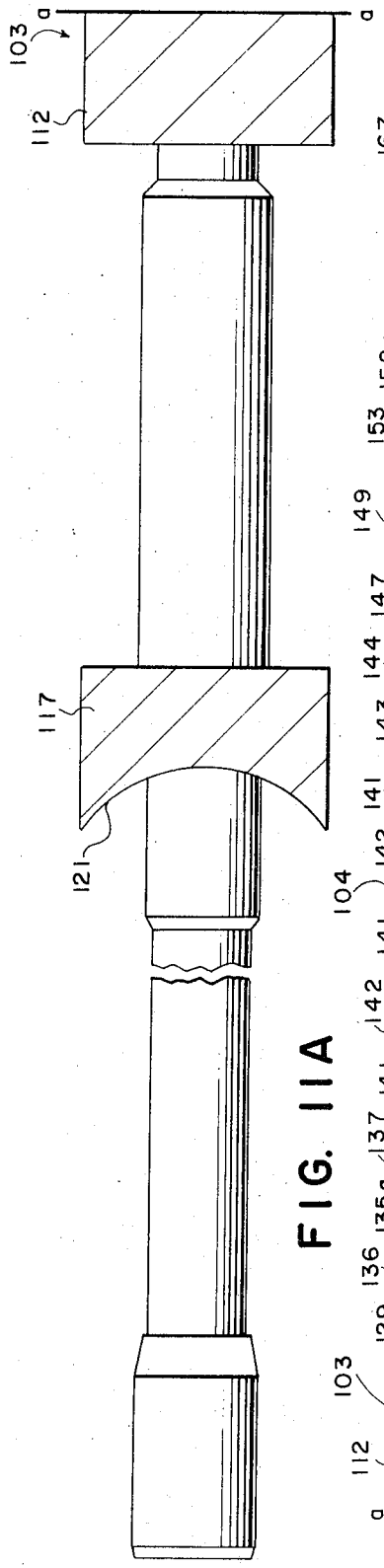


FIG. IIA

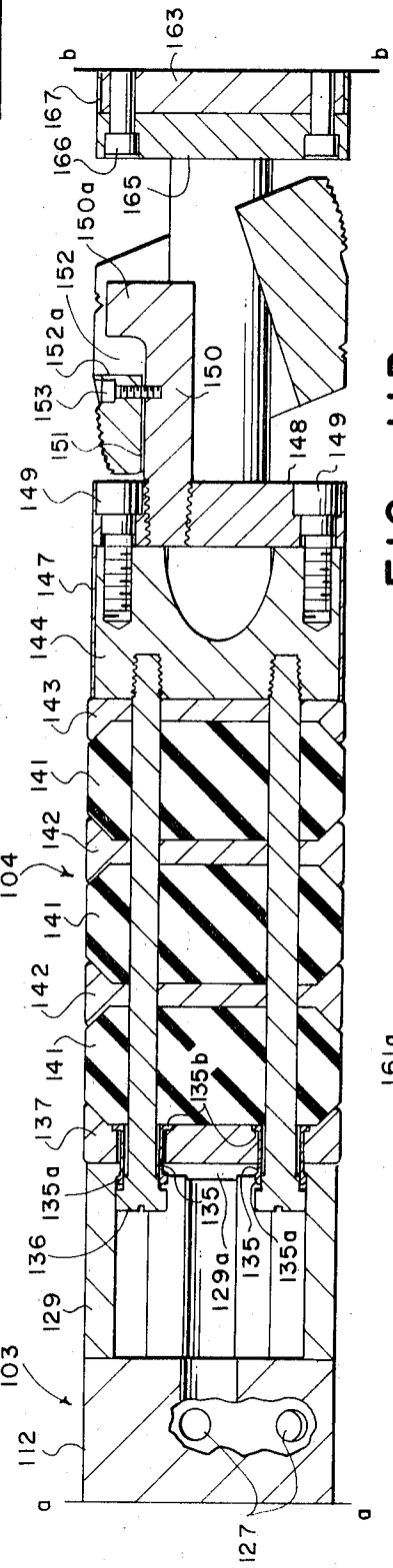


FIG. IIB

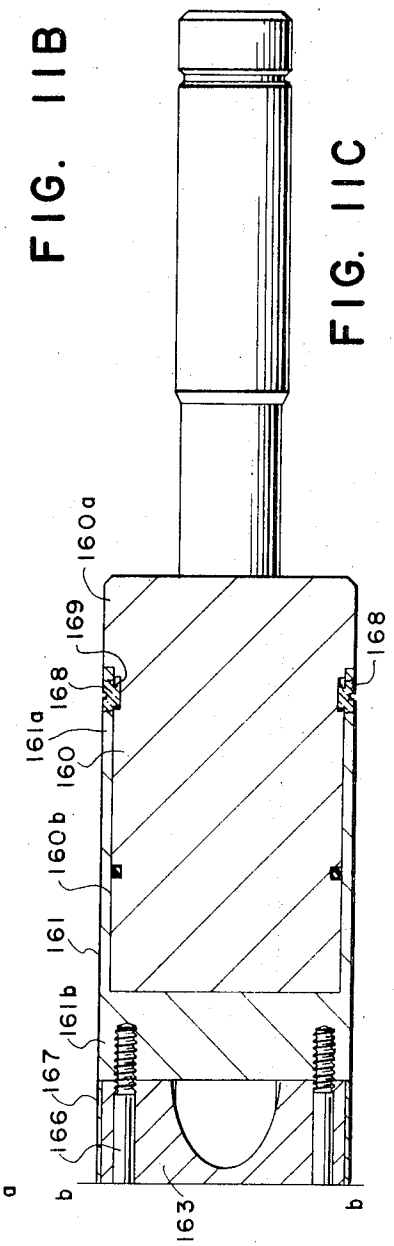


FIG. IIC

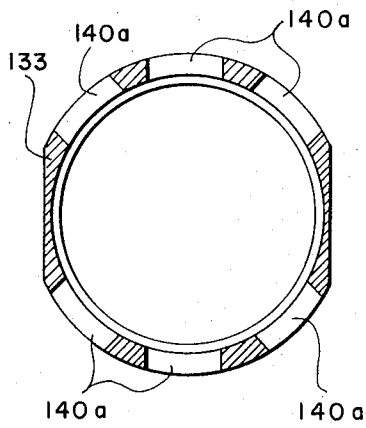


FIG. 11D

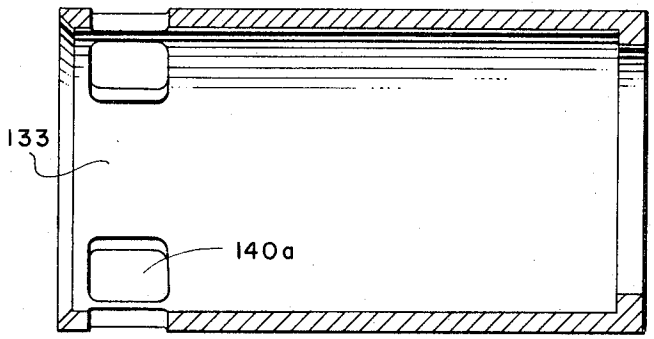


FIG. 11E



FIG. 11F

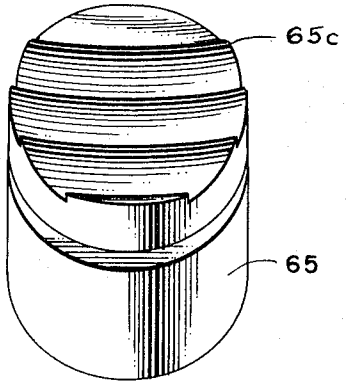


FIG. 13

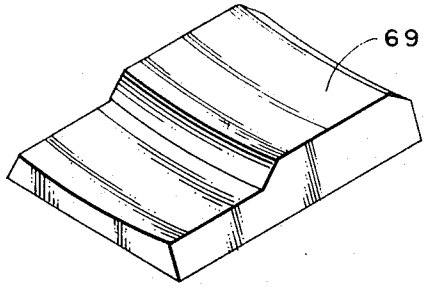


FIG. 14

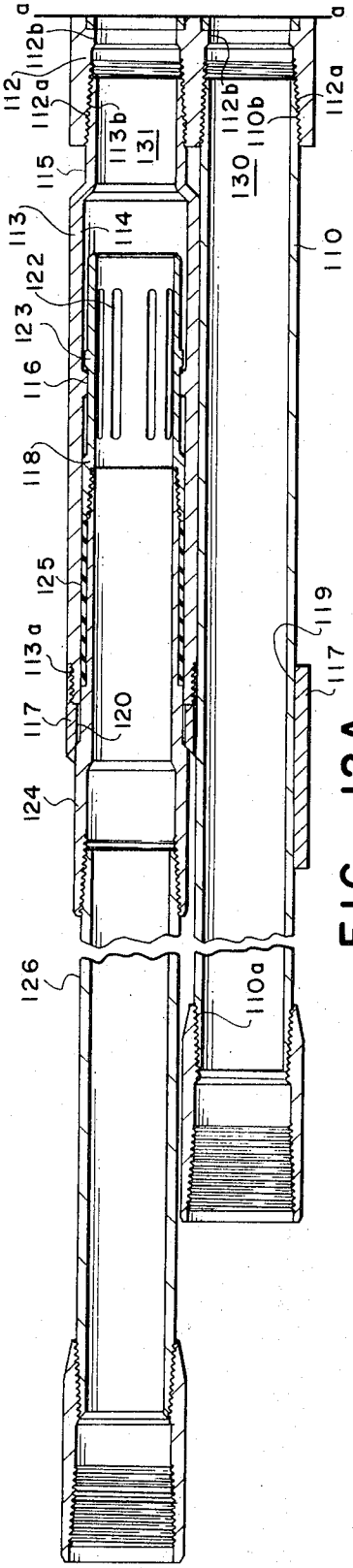


FIG. 12A

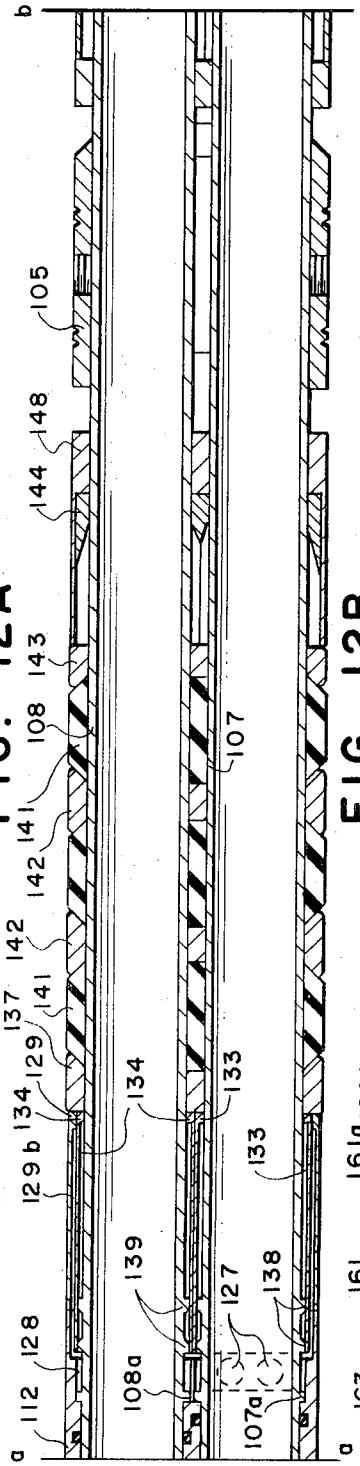


FIG. 12B

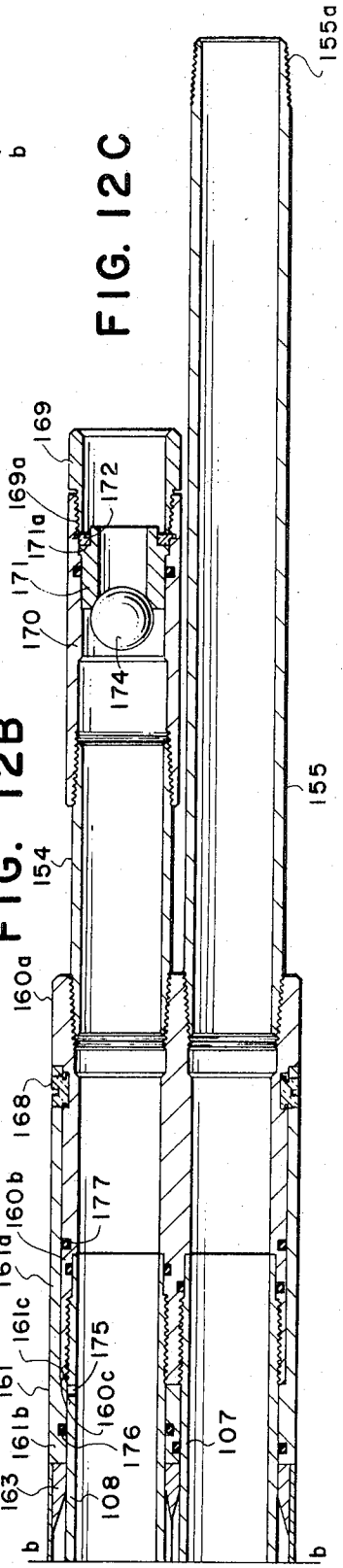


FIG. 12C

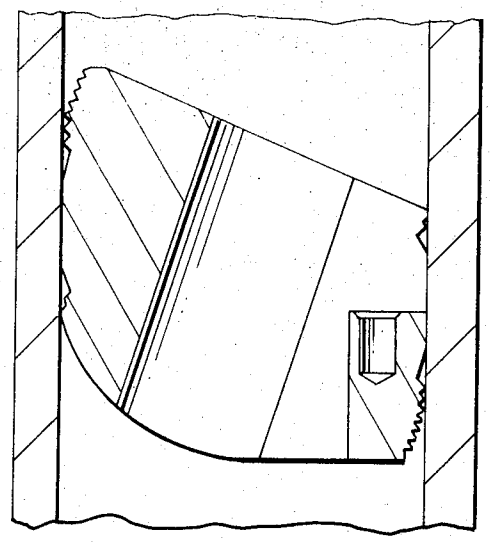


FIG. 15A

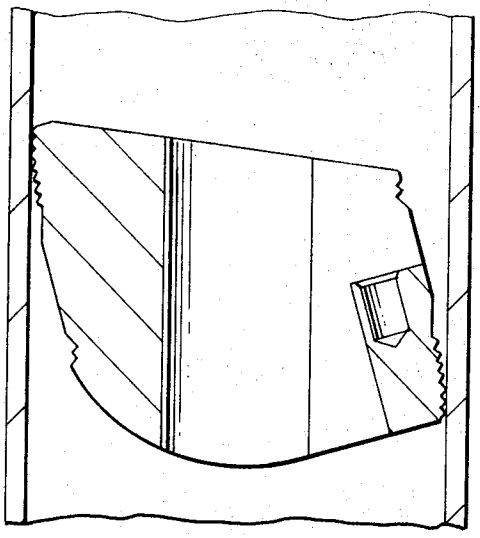


FIG. 15B

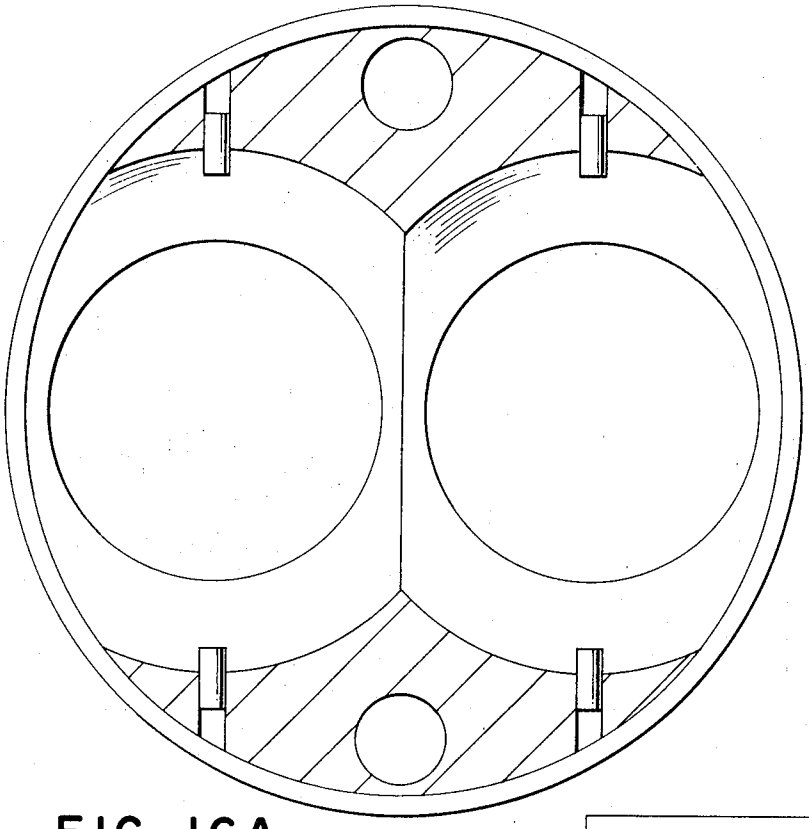


FIG. 16A

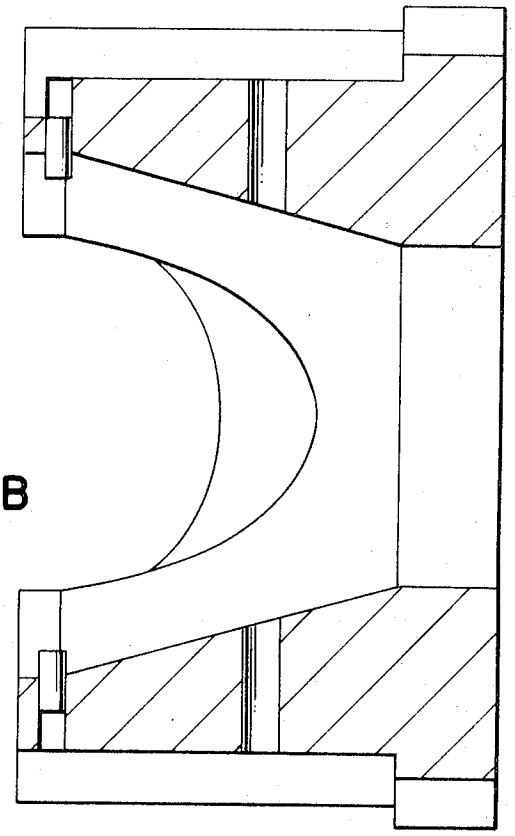


FIG. 16B

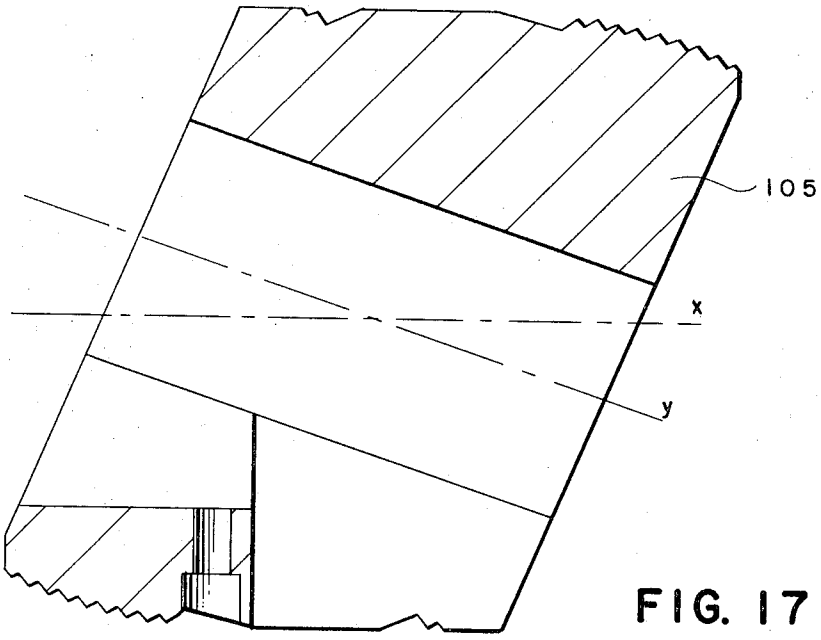


FIG. 17

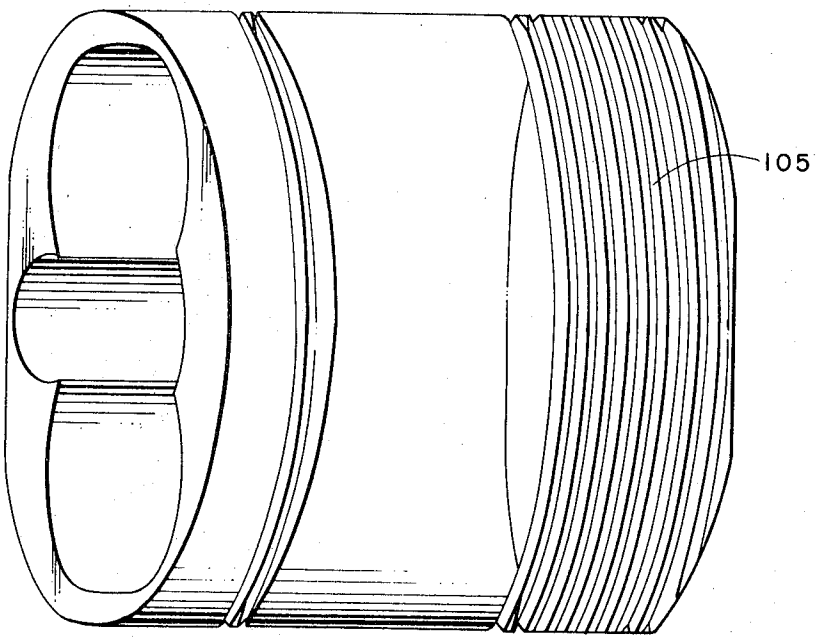


FIG. 18

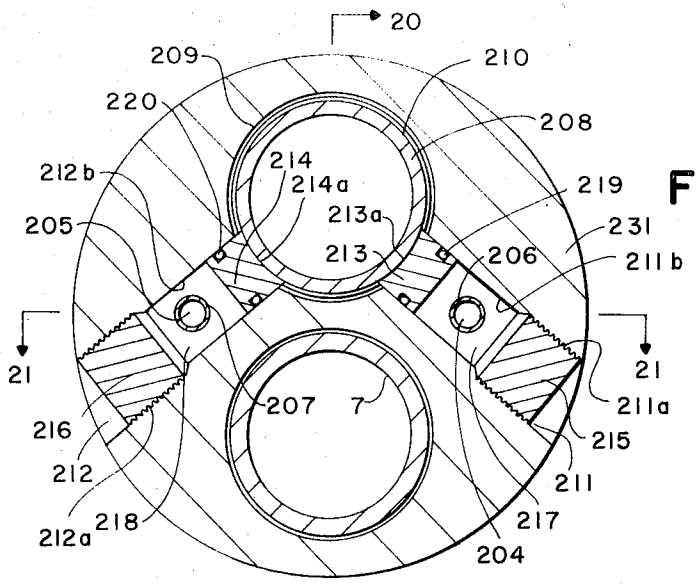


FIG. 19

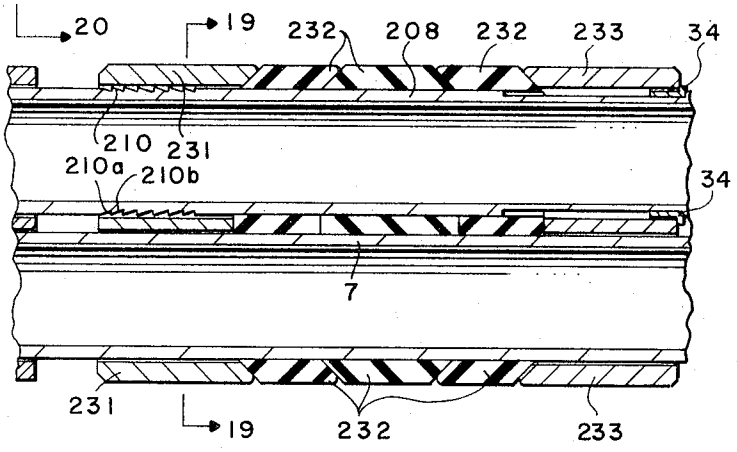


FIG. 20

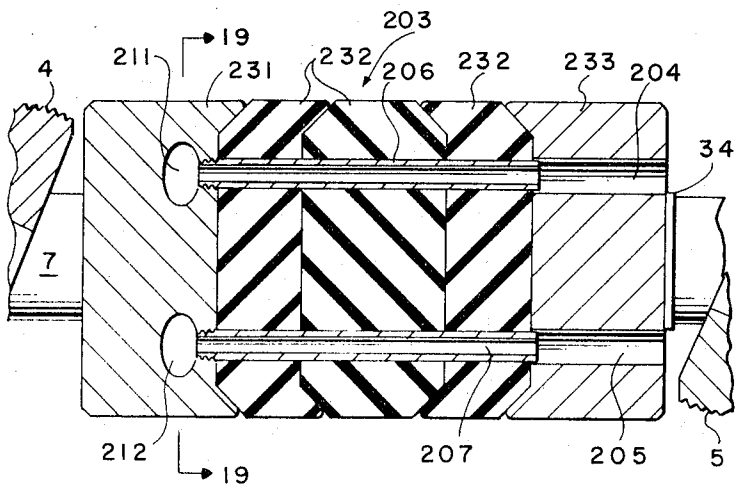


FIG. 21

UNI-DIRECTIONAL UNITARY ANCHOR SLIP

BACKGROUND OF THE INVENTION

Often during the producing life of an oil well it becomes desirable or necessary to produce from two or more different underground formations penetrated by the wellbore. This is commonly achieved through the use of packer assemblies containing two or more strings of conduit passing therethrough.

An example of such apparatus is shown in U.S. Pat. No. 2,965,173 in which a packer apparatus having dual conduit strings passing side-by-side therethrough has located on its outer surface resilient sealing cups having outwardly flared ends which are moved into sealing engagement by fluid pressure differentials above and below the cups.

Other types of multi-string packers include the inflatable or "bladder" type such as disclosed in U.S. Pat. No. 2,991,833 and the hydraulically actuated, compressible element, multi-string packer such as disclosed in U.S. Pat. No. 3,167,127. All known multi-string packers using mechanical anchors to lock the assembly to the casing wall utilize the wedge-type slip segments having teeth which are cammed or wedged into contact with the casing wall by the action of a wedging mandrel being forced inside the slip segments forcing them outwardly into contact with the casing. Other known types of slips include the hydraulic button type which are spring-retained radial pistons slidably located in the wall of the packer body and actuated outwardly against the spring retainer by hydraulic force applied from inside the packer assembly. An example of the button type slips is shown in U.S. Pat. No. 3,311,169.

The dual-string or dual-conduit packers normally are used with a standard single string packer located on the tubing string below the dual-packer, which tubing string communicates with a lower formation below the standard packer and is connected to one conduit in the dual packer and from there to a tubing string passing to the surface. The second formation is normally located between the standard packer and the dual packer and can be produced through the second conduit passing through the dual packer and communicating with a second tubing string extending to the surface.

The disadvantages of the prior art dual string packers are their complexity, extended length, and the tendency of the wedge-type slips to become disengaged by shifting or stretching of the tubing and/or casing during the production life of the packer.

These and other disadvantages of prior devices are overcome by the present invention which comprises a dual string packer having simplified design, shortened length, and highly efficient tubular unitary slip means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of the dual packer assembly;

FIGS. **2A** and **2B** comprise a lateral cross-sectional view of the assembly taken at line **2—2** of FIG. **1**;

FIGS. **3A** and **3B** comprise a lateral cross-sectional view of the assembly along line **3—3** of FIG. **1**;

FIGS. **4A** and **4B** comprise a lateral cross-sectional view of the assembly taken along line **4—4** of FIG. **1**;

FIG. **5**, shows an axial cross-sectional view of the assembly taken at line **5—5** of FIG. **2**;

FIG. **6** is a cross-section side view of the improved unitary tubular slip;

FIG. **7** is a top view of the improved unitary slip;

FIG. **7***a* is a side view of the improved unitary slip;

FIG. **8** illustrates a cross-sectional view of the apparatus in its engaged position;

FIG. **9** illustrates the top view of an alternate embodiment of the apparatus;

FIGS. **10A** through **10C** comprise a cross-sectional view of the embodiment of FIG. **9** taken at line **10—10** in FIG. **8**;

FIGS. **11***a* through **11***c* are cross-sectional views of the embodiment of FIG. **9** taken at line **11—11**;

FIG. **11***d* is a cross-sectional axial view of a key retaining sleeve;

FIG. **11***e* is a side cross-sectional view of a key retaining sleeve;

FIG. **11***f* is an axial end view of a retaining key;

FIGS. **12A** through **12C** comprise a cross-sectional view of the embodiment of FIG. **9** taken at line **12—12** of FIG. **9**;

FIG. **13** is an isometric view of the shearable ratchet pins;

FIG. **14** is an isometric view of one of the setting cylinder releasing keys in the piston assembly;

FIGS. **15***a* and **15***b* are schematic cross-sectional views of the gripping teeth on the anchor slip;

FIGS. **16***a* and **16***b* show axial and radial cross-sectional views of the wedge-cone heads disassembled from the apparatus;

FIG. **17** illustrates a cross-sectional view of the slip of the second embodiment;

FIG. **18** shows a side view of the slip of FIG. **17**;

FIG. **19** is an axial cross-sectional view of a mandrel locking assembly;

FIG. **20** is a lateral cross-sectional side view of the mechanism of FIG. **19** taken at line **20—20**;

FIG. **21** is a lateral cross-sectional top view of the mechanism of FIG. **19** taken at line **21—21**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment of the invention is illustrated in FIGS. **1** through **5** in which a packer assembly **1** is comprised of an upper mandrel assembly head **2**, resilient packer assembly **3**, upper slip **4**, lower slip **5**, and piston assembly **6**, all mounted more or less in encircling relationship about primary mandrel **7** and secondary mandrel **8**.

The upper mandrel assembly head consists of an integral cylindrical mandrel head **9** having longitudinal parallel bore passages **10** and **11** passing therethrough having internal threaded sections **10***a* and **11***a* in which are threadedly engaged the cylindrical tubular elongated mandrels **7** and **8**. A receiver collar **12** is connected by bolts **13** to mandrel head **9** and has bore passages **10***b* and **11***b* coinciding and axially aligned with passages **10** and **11** of head **9**. Collar **12** has a concave cupped upper surface **12***a* arranged to guide a tubing string connector **14** into bore **11***b* of the assembly. Mandrel head **9** further has a threaded internal section **10***c* adapted to receive a section of conduit or tubing in threaded engagement therein.

Tubular mandrels **7** and **8**, fixedly attached by threaded connection to head **9**, extend in parallel relationship to the longitudinal axis of the packer assembly **1** and generally parallel to the well-bore and have bot-

tom threaded sections 7*a* and 8*a* extending downward out of the piston assembly 6 whereby either or both may be threadedly engaged into a lower tubing string extending downward into the wellbore.

Slidably mounted on mandrels 7 and 8 are, in descending order, the upper unitary slip 4, upper packer head 31, one or more resilient packer elements 32, and lower packer head 33. Upper and lower packer heads 31 and 33 are metal cylindrical plates having a cupped surface on one side and having two axial bores therethrough for receiving mandrels 7 and 8.

Resilient packer elements 32 are made of a resilient material such as synthetic rubber and are generally cylindrical, with dual bore passages passing axially therethrough to snugly receive mandrels 7 and 8. Packer elements 32 are located in close fitting relationship with each other and with the cupped surfaces of plates 31 and 33. A flanged retainer ring 34 abutting an external shoulder 18 on mandrel 8 limits downward movement of the resilient packer assembly 3 on the mandrels by also abutting the lower surface of lower head 33.

Lower unitary slip 5 is located on the mandrels in encircling relationship about the mandrels and slidably mounted thereon; slip 5 is similar to slip 4 but is mounted on the mandrels in an inverted orientation to slip 4.

Piston assembly 6 is mounted on mandrels 7 and 8 in encircling relationship and consists of cylindrical setting piston 61 and cylindrical setting cylinder 62. Setting piston 61 is a substantially solid cylindrical piece having dual axial bore passages therethrough to receive mandrels 7 and 8 and an upper annular space 63 around mandrel 8. Referring to FIG. 5, setting piston 61, as shown in cross-section, has a plurality of transverse lateral cylindrical bore passages 64 intersecting the longitudinal axis of bore passage 11 and having internal helical threads. Shearable cylindrical ratchet pins 65 are slidably located in passages 64 and are urged into engagement with mandrel 8 by the expansive forces of leaf, helical, or belleville springs 66 which are held in compression against pins 65 by abutting engagement with threaded plugs 67 which are snugly secured into threaded passages 64.

Pins 65 have a reduced section 65*a* designed to shear at a predetermined load and a toothed ratchet head 65*b* having a curved face adapted to match the curvature of mandrel 8, with a plurality of cammed teeth 65*c* thereon designed to match and engage external annular teeth 8b formed on mandrel 8. FIG. 13 illustrates a second view of the shearable ratchet pins showing the relationship of the teeth 65*c* on ratchet head 65*b*. The teeth 8*b* and those on head 65*b* are arranged to allow upward movement of the pins on mandrel 8 but prevent downward movement of the pins and thus prevent downward movement of piston 61. The cammed faces of teeth 8*b* and 65*c* allow the piston 61 to move upward by camming the pins back against the springs 66, compressing them and allowing the ratchet teeth to slide over one another. Upon attempted downward movement of piston 61 on mandrel 8 the perpendicular faces of teeth 65*c* abut the perpendicular faces of teeth 8*b* and prevent the backward motion. Further operation and function of the ratcheting arrangement will be described in connection with operation of the entire packing assembly.

Setting cylinder 62 is a cylindrical element having a substantially solid lower section 62*a* and an upwardly extending outer collar 62*b* passing exteriorly around piston 61. Lower section 62*a* is solid except for two longitudinal bore passages therethrough which receive in snug slidable relationship the mandrels 7 and 8. Cylinder 62 is temporarily attached to piston 61 by means of a plurality of shear pins 68 passing through upper collar 62*b* in threaded engagement therewith and seating in exterior channel 61*a* passing circumferentially around piston 61.

Setting cylinder 62 is temporarily attached to mandrel 8 by means of a plurality of curved locking keys 69 having inwardly projecting shoulder 69*a* thereon for engaging a matching exterior channel in mandrel 8. Keys 69 are held inward by overlapping abutment of annular shoulder 61*b* on the lower end of piston 61. The keys, by abutment with the grooved channel in mandrel 8, the lower end of piston 61, and the upper end of solid end 62*a* of cylinder 62 temporarily prevent any sliding motion of the piston assembly 6 with respect to mandrels 7 and 8. One or more ports 80 are located through the wall of mandrel 8 to communicate with the area between piston 61 and cylinder end 62*a* from bore 11 to release keys 69 in a manner which will be more fully described in relation to the operation of this tool.

At the lower end of mandrel 8 on external threaded end 8*a* is a standard threaded collar 19 attached thereto containing a valve seat 21 for receiving a fluid valve member such as a ball or plug, arranged to selectively close passage 11 to fluid flow through mandrel 8 and alow fluid pressure to be applied through ports 80.

Referring specifically to FIGS. 2 and 4, the tubing string connector 14 is more particularly described as a cylindrical tubular upper sleeve 14*c* having internal threads 14*a* for engaging a standard conduit section and an annular external depression 14*b* for receiving a seal carrier ring 15. A lower spring collet sleeve 16 is threadedly attached at 16*a* to the upper sleeve 14*c* and has collar 16*b* thereon for abutting and retaining carrier ring 15 which has a plurality of circular seals 17 thereon for sealing engagement between connector 14 and head 9.

Collet sleeve 16 is temporarily restrained in head 9 by the abutment of annular exterior shoulder 16*c* with interior annular projection 9*a* in head 9. Removal of shoulder 16c upward past projection 9*a* can be accomplished by application of a predetermined lifting force which causes inward deflection of the shoulder 16*c* and allows it to move upward past projection 9*a*. Deflection inward of shoulder 16*c* is made possible by the forming of several longitudinal slots 16*d* in collet sleeve 16 thereby lending flexibility to the metal remaining in the areas between the slots. The amount of lifting force required to move collet sleeve 16 out of head 9 can be adjusted as desired by the number and/or width of slots 16*d* and/or the angle of engagement between 16*c* and 9*a*.

Referring now to FIGS. 6, 7, 7*a*, 15*a*, and 15*b*, a more detailed description of the improved unitary slip members can be given. Each slip 4 and 5 comprises a generally cylindrical gripping unit having on the extended outer reaches of opposing sides a plurality of teeth 41 curved about the slip body with an axis of curvature at an angle to the central longitudinal axis of the slip member. The teeth are also arranged so that the intersection of a plane passing through the slip longitudinal

axis with the teeth extreme outer tips would circumscribe a curve as shown in FIGS. 15*a* and 15*b*. This is to allow the use of this apparatus in casings having varying inner diameters and obviates the need for a separate set of unitary slips for each weight rating of casing. In smaller ID casings, as shown in FIG. 15*a*, i.e., those of heavier weight, the two sets of teeth near the center of the slip, having the shortest distance between them will contact the casing wall with greatest area contact; while in larger ID, lighter weight casing as shown in FIG. 15*b*, the teeth at the two outer ends of the slip will contact the casing due to the greater distance between the upper outer teeth and the lower outer teeth.

The curved boundary tooth profile as shown in FIGS. 15*a* and 15*b* allows this versatility of use by providing greater tooth-casing wall contact area regardless of which teeth are called upon to anchor the packer assembly.

Looking at FIGS. 6, 7 and 7*a*, it is clear that each unitary slip has a dual-axis bore passage for each mandrel to pass therethrough. One axis of each bore passage generally parallels the central longitudinal axis of the slip and the other axis is located at an angle thereto in the same plane.

In FIG. 6, the intersecting bore passages are illustrated more clearly and their longitudinal axes are designated as X—X and Y—Y. This view is taken from the side with the two mandrels lying in line with one another so that only one can be seen in cross section. The axis X—X defines bore passages 43 which are shown by the dashed lines in the figure. When the slip is oriented so that the mandrels occupy these bore passages, the gripping teeth are at their innermost orientation, out of contact with the casing wall.

When the slip has been rotated to bring the passages 44 into fitting relationship with the mandrels, then the gripping teeth are at their outermost extension from the mandrels and can engage the casing wall. Bore passages 44 are shown by the solid lines in the figure.

The angle between axes X—X and Y—Y can be from 5 ° up to about 35° but preferably is around 18 to 20°.

Referring specifically to FIG. 6, a significant improvement in the unitary anchor slip 5 is illustrated in the cross-sectional view which shows the abutment surface 51. This surface is at the opposite end of the slip from abutment edge 52 and provides a dual purpose surface on the slip.

Rotation of the slip into casing engagement is achieved by moving an abutment means such as piston 61 against compound surface 51 which moves the slip along the mandrel until abutment edge 52 encounters an opposing abutment surface. The resultant effect is a rotational moment established in the slip from the reactant force on edge 52. This is aided by abutment forces introduced into the slip from surface 51.

Surface 51 has been termed a dual or compound surface. This is because of the flat portion 51*a* and the tangentially curved section 51*b* joining the flat surface. The curve of surface 51*b* is preferably on a radius R substantially equivalent to ½L where L is the axial length of the slip along axis X—X. The curved surface is tangential to flat surface 51*a* at the point where axis X—X intersects the end of the slip at surface 51.

The slip is arranged to pivot about a point C located at the intersection of axes X—X and Y—Y at a distance of approximately ½ of the slip length L from surface 51.

A phantom line P is drawn on the slip at the edge containing surface 51*b* to indicate the construction of the prior art slip means. Such a slip is disclosed in U.S. Pat. No. 3,739,849 to Robert B. Meripol. While the slip of that disclosure is a significant improvement over the art, the existence of the extended shoulder P requires significant additional apparatus in the packer on which it is used.

Primarily a significant clearance must be maintained with the prior art slip between the slip in its unset position and the lower abutment means to allow pivoting of the slip into casing engagement position. This is because the radius Rp is considerably greater than the distance ½L and therefore a minimum clearance equivalent to Rp-R must be maintained below the flat surface of the prior art slip to allow it to rotate into the set position.

To maintain the clearance and also to support the slip in a rotatable position and allow a moment force to be applied to abutment surface 52 without driving the slip downward on the abutment surface, the prior art slip was necessarily supported by pivot pins at C which passed through the slip and were engaged in an inner support sleeve. The downward force at 52 was countered by the oppositely reacting upward force of the pins on the slip which set up the desired rotational moment. The inner sleeve and the pins also served to hold the slip up off of the lower abutment means so that it could be pivoted. The inner sleeve and pivot support pins are illustrated in FIG. 1 of the aforementioned Meripol patent and designated therein as 20 and 34 respectively. The clearance under the slip is not illustrated in that figure since the slip has been rotated to the engaging position.

The improved slip of this invention eliminates the need for the supporting sleeve, the pivot pins, and the pivot clearance necessary to the prior art device.

Since the radius of the curvature of surface 51*b* about the pivot center C is equivalent to the distance of surface 51*a* from C, it is obvious that the slip 5 can be pivoted about C in the same space as that occupied by the slip in the unset position. This eliminates the need for the support sleeve, the pins, and the clearance below surface 51. Furthermore surface 51 may remain in constant abutment with adjacent abutment means to provide the necessary rotational moment from forces on surface 52 which further obviates the need for support pins at C.

Another advantage of the improved slip is in the guaranteed setting of the slip. In the aforementioned patented slip, should the clearance below the slip ever be decreased due to stretching of the parts, accumulated debris in the clearance area, failure of one or more of the parts, or incorrect assembly of the tool during manufacture, to the point where the clearance is substantially less than the amount Rp-½L, it is clear that edge P will abut the lower surface or the debris in opposition to the setting forces at edge 52 and the desired rotational moment about C will be cancelled.

This situation is non-existent since the slip can rotate without the needed clearance and due to the simplicity of having no pins, nor sleeves; and incorrect assembly and part failure are almost absolutely eliminated.

One further advantage of the improved slip is that, when used as the lower slip, should it become lodged

in the casing to the point that the releasing spring 49*b* hereinafter described is insufficient to rotate it out of engagement, dislodgement can be accomplished by merely bumping upward on the slip with the lower abutment means. Since some point on the curved surface 51*b* will be located directly below C and will receive the upward abutment it is clear that no rotational moment will be introduced into the slip, and the simple upward driving force, in addition to the disengaging force of the releasing spring 49*b* will dislodge the slip from the casing. The upper surface 52 will of course be free from abutment during this releasing step.

Although the slip 5 has been described above, it is emphasized that slip 4 is identical to slip 5 and operates in the same manner, and the above description appertains thereto as well. Thus it can be seen that these two side-by-side dual bore passages and the compound curved-flat abutment surface 51 allow the unitary slip to pivot about the two parallel mandrels 7 and 8 from a non-engaging position to a casing contact position without any interference between the slips and the mandrels.

Each slip also has a releasing slot 46 as shown in FIG. 3 which runs partially the length of the slip and passes through the wall thereof in a plane perpendicular to the plane of the two dual-axis bore passages and the central slip axis. A third bore passage 47 passes from the inner terminal wall 46*a* of the slot 46 through the slip to the opposite end. The cross-sectional view of FIG. 3 reveals the purpose of slot 46 and passage 47 to be for the location of the threaded L-shaped releasing lug 48 and release spring 48*a* in the upper slip 4; and in the lower slip 5, retaining bolt 49, flanged bolt collar 49*a*, and coil spring 49*b*. A spring cavity 49c is formed in each slip and a spring cavity 48*b* is formed in the L-shaped bolt to receive coil spring 48*a*. Lug 48 passes through passage 47 and is threadedly secured into the lower end of head 9. Likewise, bolt 49 passes through passage 47 of the lower slip 5 and is threadedly secured to the upper end of setting piston 61.

In FIGS. 2 through 5 the packer assembly is illustrated in its unset orientation with the mandrels 7 and 8 lying in bore passages 43 parallel to the central longitudinal axis. In FIG. 8 the packer apparatus has been activated and expanded into sealing and anchoring engagement with the casing wall. In this position, the slips have been rotated to bring the mandrels into the second bore passages 44 at the angle to the longitudinal bore passages 43 mentioned above.

OPERATION OF THE PREFERRED EMBODIMENT

In a typical use of the described apparatus in a dual zone formation the apparatus is interconnected into a tubing production string by threaded connection of threads 10*c* and 7*a* to mating threads of standard tubing sections. The string will have a standard packer located in the string below this apparatus capable of sealing off the annulus between the tubing and the casing at the predetermined desired time.

The tubing string with the standard packer and the packer apparatus 1 is lowered into the well until the lower packer passes the upper producing formation and is situated between the two subject formations. The packer apparatus 1 will be located above the upper producing formation.

By appropriate means, such as manipulation of the tubing or hydraulic pressure applications, the lower packer is set in the casing. Alternately, the lower packer may be set by wireline or other means before the primary and secondary tubing strings are lowered into the hole and then the primary string can be "stung" into the lower packer. The second production string may then be lowered down the well with the connector sleeve 14 threadedly attached at the lower end. When the string has been lowered sufficiently, the sleeve 14 will engage head 9 and snap into place. The second string will then be sealingly communicating with mandrel 8 via bore 11 of head 9.

A sealing ball or plug 20 is dropped run in on a wireline, or pumped into the secondary tubing string to seal on seat 21 and allow fluid pressure to be applied to the fluid in the secondary string and act through bore 11 and ports 80 against the lower end of the setting piston 61. When sufficient pressure has been reached in bore 11, piston 61 will shear pins 68 and move upward against the lower edge 51 of lower slip 5 sliding the slip upward until upper abutment edge 52 of the slip contacts the lower edge of lower head 33. Movement upward of piston 61 on mandrel 8 is allowed by the ratcheting action of ratchet pins 65 over mandrel teeth 8b which ratchet mechanism simultaneously prevents downward movement of piston 61 on mandrel 8 under normal operating conditions.

As piston 61 moves upward in response to hydraulic pressure acting upward, the upward force is transferred to lower slip 5, and from slip 5 to packer elements 3 and into the upper slip 4. This abutment of the slips with the packer assembly serves to rotate the slips into contact with the casing simultaneously with compression of the packer elements 32. Thus, continued application of hydraulic pressure of sufficient magnitude for a short period of time will set the two unitary slips into the casing and will expand the resilient packer elements outward into sealing engagement with the casing as shown in FIG. 8.

Upon release of hydraulic pressure in bore 11, the resilient packer elements will attempt to expand longitudinally and contract radially. This will provide a constant upward force on slip 4 and a constant downward force on slip 5 maintaining them engaged in the casing. Also, ratchet pins 65 will maintain mandrel 8 telescoped within piston 61 thereby preventing the packer from unsetting should mandrel 8 try to move upward in the wellbore for any reason.

Should it become desirable to unseat the packer apparatus 1, this can be done selectively by applying an upward force on mandrel 7 and thus on mandrel 8 sufficient to shear pins 65 through their reduced area 65*a*. In order to prevent a bending or collapsing of shear head 65*b* along the gap at 65*a*, a relatively soft filler material such as lead or plastic can be filled in the gap at 65*a* to absorb the bending moment and insure proper shearing of the pins.

Upon shearing pins 65 mandrels 7 and 8 move upward with respect to the slips 4 and 5 and packer assembly 3. Releasing lug 48 will move upward and work through spring 48*a* to pivot upper slip 4 back to its non-engaging position, also pulling it upward off of the packer assembly 3, allowing the resilient packer elements to contract to their normal unseated orientation. Continued upper movement of the mandrels 7 and 8 will disengage the lower head 33 from abutment shoul-

der 52 of slip 5 allowing disengagement of the lower slip from the casing. Coil spring 49*b* will then expand against slip 5, thereby pivoting slip 5 into its retracted position. The packer assembly 1 is now completely unset and may be removed from the hole. The secondary tubing string may be removed from passage 11 before or after unsetting the packer assembly 1, or may be removed from the hole with the primary string if desirable.

MANDREL LOCKING MEANS FOR HIGH WELL PRESSURES

Occasionally the apparatus of this invention must be used in a well having extremely high formation pressures or used in treatments of wells whereby fluids under high pressure must be pumped into the well formations through this apparatus.

For instance, pressures below the above described packer assembly may reach the range of 5,000 PSI or higher, and in this range a considerable upward force is exerted by the fluid upon the conduit strings in the wellbore, creating a buoyancy effect on the packer mandrels tending to drive them upward through the packer assembly resulting in unsetting of the slips and consequently the packer elements. This buoyancy effect is termed the "piston" or "end area" effect.

To avoid this tendency towards disengagement of the slips caused by the pipe buoyancy, a special locking mechanism is provided which is actuated by pressure below the packer elements and serves to lock the mandrels in the packer assembly.

Referring to FIGS. 19, 20, and 21 the locking mechanism is illustrated. FIG. 19 is an axial view in cross-section taken at line 19—19 of FIG. 20. In the modified embodiment, the packer assembly 3 of FIGS. 1–4 is replaced by the modified locking packer assembly 203. Packer assembly 203 consists essentially of an upper head 231, resilient packer elements 232 and lower head 233, all encircling mandrel 7 and modified mandrel 208.

Modified mandrel 208 is substantially similar to mandrel 8 except for the existence of a plurality of tooth ridges 210 formed in the outer surface of the mandrel. Each ridge 210 has an abrupt upper face 210*a* and a sloping lower face 210*b*. The angle that face 210*a* makes with a plane normal to the tubular axis of mandrel 208 is preferably about ten degrees but may vary from 1 to 40° depending upon the amount of restraining force desired. The angle of face 210*b* with face 210*a* may be from 130° to about 50° with a preferable angle of around 90 degrees. Ridges 210 preferably circle mandrel 208 entirely but this is not absolutely essential.

The packer assembly 203 contains two fluid bore passages 204 and 205 passing through lower head 233, resilient packer elements 232, and part of the way into upper head 231. The bore passages generally run parallel to the mandrels 7 and 208 and communicate with the formation annular area below the packer assembly 203.

Rigid tubes 206 and 207 line the bores through the resilient elements 232 to prevent collapse and closure of the passages upon compression and deformation of the resilient packer elements.

The bore passages 204 and 205 intersect pin channels 211 and 212 passing from the longitudinal bore passage 209 in head 231 containing mandrel 208, going radially outward from mandrel 208 through head 231 and through the outer surface of the head.

The radial passages 211 and 212 contain outer threaded portions 211*a* and 212*a* and smooth piston sections 211*b* and 212*b*. The radial passages preferably are of a cylindrical configuration for ease and convenience of manufacture but may be of any reasonable configuration.

Located slidably in piston sections 211*b* and 212*b* of the radial passages are locking pistons 213 and 214 having curved toothed faces 213*a* and 214*a*. The teeth on these faces match and complement the teeth of mandrel 208 so that full surface contact between the two sets of teeth will occur. The radius of curvature of faces 213*a* and 214*a* is substantially equal to that of the outer surface of mandrel 208.

Threaded sections 211*a* and 212*a* contain threaded plugs 215 and 216 snugly engaged therein in sealing contact, which plugs, in conjunction with pistons 213 and 214, serve to form hydraulic expansion chambers 217 and 218 in each radial passage. Circular seals 219 and 220 in the outer wall of pistons 213 and 214 serve to prevent leakage of fluid from the expansion chambers into the mandrel bore passages 209.

Operation of the locking mechanism is automatic when this modified embodiment of packer mechanism 203 is installed in the previously described packer apparatus 1, and consists of hydraulic pressure from the annular area below the packer mechanism 203 communicating through bores 204 and 205 and into pressure actuation chambers 217 and 218. The pressure is prevented from moving radially outward by plugs 215 and 216 and therefore it acts inwardly against the pistons 213 and 214 driving them against the mandrel teeth 210 thereby gripping the mandrel 208 and holding it in the packer assembly 203.

Since the packer anchors 4 and 5 are normally released by pulling upward on the tubing strings and thus on the mandrels, the angle of faces 210*a* on the mandrel teeth should be around 5 to 15° to allow upward movement of the mandrels upon application of external lifting force on the mandrels. Also, the pressure area of piston faces 213 and 214 may be designed so that the gripping force of the piston teeth on the mandrel teeth is just equal to or slightly greater than the buoyant upward force on the mandrels so that little additional upward lifting of the mandrels is required to wedge the piston teeth out of engagement with the mandrel teeth when unsetting the packer to remove it from the wellbore.

It should be noted that the back or lower edges 210*b* of the mandrel teeth are at a relatively flat angle compared to the upper faces 210*a* so that movement of the upper head upward on the mandrels is hardly impeded.

In addition to the hydraulic force on pistons 213 and 214 it is clear that any known spring means such as coil springs could be compressed and placed in chambers 217 and 218 to supplement the actuating pressure.

ALTERNATE EMBODIMENTS

Referring now to FIGS. 9 through 12 and 16 through 18, an alternate embodiment of the invention is disclosed which utilizes a single unitary slip or anchor capable of anchoring the assembly in the casing against upward and downward forces and pressures.

The packer apparatus **101** essentially comprises upper connector assembly **102**, upper head asembly **103**, packer assembly **104**, unitary slip **105** and piston assembly **106**.

The upper connector assembly **102** features a primary tubing receiver **110** which is an elongated tubular member having external threads **110***a* and **110***b* at its upper and lower ends and containing a connector collar **111** threadedly attached to threads **110***a* and arranged to be interconnected into a standard tubing string. Tubing receiver **110** is threaded into upper head **112** which also receives in threaded engagement a tubular elongated secondary tubing string receiver **113**. Head **112** is primarily a cylindrical member having dual bore passages passing there-through oriented substantially parallel with the central longitudinal axis of the cylindrical member. The upper portions of the dual bore passages have internal threads **112***a* for receiving tubular sections **110** and **113**.

Tubular receiving member **113** has an enlarged chamber area **114** attached to a standard tubular section or neck **115** and containing an annular inwardly projecting shoulder **116**. Threadedly attached to the upper end of member **113** at threads **113***a* and slidably encircling member **110** is upper receiver dish **117** which is a generally cylindrical section having a concave upper face **121** and dual bore passages **119** and **120** to receive member **110** and the secondary tubing string collet sleeve **118**. Collet sleeve **118** is a tubular member having an annular shoulder **123** sized to abut shoulder **116** and be retained thereby. Longitudinal slots **122** are formed through the wall to give the remainder of the sleeve flexibility and allow shoulder **123** to flex inward and traverse shoulder **116**. A cylindrical, tubular seal carrier collar **124** is threadedly attached to sleeve **118** and contains seal elements **125** encircled thereon to seal against bore **114** of receiver **113**. A standard length of tubing **126** can be threadedly attached into collar **124**.

Upper head **112** contains inner annular abutment ridges **112***b* in bore passages **130** and **131** to receive in snug fitting relationship the primary and secondary mandrels **107** and **108** which mandrels are elongated cylindrical tubular members extending substantially through the entire tool.

Each mandrel **107** and **108** has an annular exterior shear shoulder **107***a* and **108***a* for abutment with and selective shear means for shear screws **127** which project through the wall of head **112** and into the shear chamber **128** formed between head **112**, shoulders **107***a* and **108***a* and mandrels **107** and **108**.

A cylindrical abutment shell **129** is secured to head **112** by threaded bolts **132** passing through the head and threadedly engaging shell **129** as shown in the discontinuous cross-sectional view of FIG. **9**. This cross section must be shown in broken or discontinuous section in order to show the bolts since a normal cross section at line **10—10** of FIG. **9** would not clearly show them.

Located axially within shell **129** are two parallel locking-key retainer sleeves **133** and **134** which are relatively thin cylindrical sleeves having flats milled along diametrically opposing sides and placed side by side slidably telescoped over mandrels **107** and **108**. The milled sides are shown in cross section in FIG. **12** and the normal sides are shown in FIG. **10**. FIG. **11***d* shows a cross-sectional axial view of one of the key-retaining sleeves **133** and **134**, and FIG. **11***e* shows a cross-sectional axial view of a sleeve.

Shell **129** also consists of a thick wall area and a thin wall area as shown in FIGS. **11** and **12**. The narrowed walls of shell **129** and of sleeves **133** and **134** are to allow side by side placement of the two mandrels **107** and **108** within the dimensions of the sleeves and the shell. Shell **129** has at its lower end an inwardly projecting flange **129***a* through which pass locking collet sleeves **135** and packer assembly bolts **136** concentrically located within sleeves **135**.

Sleeves **135** each have a small spring lip **135***a* on the outer edge of the upper end for engaging flange **129***a* and an outer abutment flange **135***b* at the lower end for abutment and retention of upper packer plate **137** to head **112**. This prevents head **112** from floating upward on bolts **136** away from plate **137** and prematurely shearing of screws **127** while going in the hole with the tool.

Key-retaining sleeves **133** and **134** are arranged so that slots in the sleeves are located directly over parallel, exterior circumferential ridges **138** and **139** on mandrels **107** and **108**. Retaining keys **140** are snugly fitted within the slots and abut the mandrels between the ridges as shown in FIG. **9**. This arrangement temporarily locks the mandrels to the upper head assembly **103** by means of keys **140**, ridges **138** and **139** and sleeves **133** and **134** and allows the operator to pick up on the string and reciprocate it to dislodge sediment or other material which may be binding between the tool string and the casing while going in the hole. This protects shear pins **127** from premature shearing. Keys **140** are held within the slots in sleeves **133** and **134** by abutment with the inner wall of the lower extending portion of head **112**. FIGS. **11***a* – **11***c* gives views of the sleeves and keys disassembled from the apparatus for a better understanding of their structure.

The resilient packer assembly is located slidably about the mandrels **107** and **108** below upper packer plate **137** and consists of resilient packer elements **141**, rigid spacer plates **142** and lower packer plate **143**.

A dual wedge-cone head **144** is abutted against lower plate **143** in encircling relationship about mandrels **107** and **108** and wedge anchors **145**. Anchors **145** are wedge shaped inserts having a plurality of angled gripping teeth on their inner surface contacting the outer wall of the mandrels.

Movement upward of the anchor inserts **145** on the mandrels is possible because of the angle of the upper faces of the wedge teeth but movement downward on the mandrels is prevented by the perpendicular teeth face projecting into the mandrel surface and also because of the wedging force inward imposed by the action of the wedge-cone head **144**. It is clear that the angled inner surface **144***a* of head **144**, acting on the angled outer surface **145***a* of the anchor **145** as the anchor moves upward, will result in a pressing inward of the anchor insert upon the mandrel it contacts thereby preventing downward movement of the mandrel. A more detailed view of the dual wedge-cone head **144** is shown in FIGS. **16***a* and **16***b*.

Guide pins **146** project through head **144** and into slots **145***b* formed in the outer portion of wedge inserts **145** to prevent the anchors from rotating around on the mandrel and getting out of optimum gripping position which is with each anchor diametrically opposed to another anchor about the mandrel.

A thin cylindrical retaining sleeve **147** snugly encircles head **144** and abuts lower plate **143** and cylindrical anchor cap **148** which is slidably aligned on mandrels **107** and **108** and fixedly secured to wedge head **144** by threaded bolts **149.**

Bolts **136** also pass through the resilient packer assembly **137, 141, 142, 143** and bolt into head **144** thereby joining together the entire packer assembly **103.**

A dogleg bolt **150** is threadedly engaged in cap **148** and extends through a grooved channel **151** in slip **105** with a dogleg extension **150***a* extending radially outward into opening **152** in slip **105.** The dogleg extension is designed to be able to abut upper shoulder **152***a* in opening **152** and apply upward force to the releasing side of slip **105.**

A shear screw **153** passes through slip **105** and is engaged in bolt **150** to prevent premature setting of the slip and also allow a certain preselected amount of compression be applied to the resilient elements **141** before the unitary slip **105** is anchored in the casing.

Located concentrically about the lower portion of mandrels **107** and **108** is the piston assembly **106** which comprises a cylindrical elongated piston **160** having a cylindrical lower head **160***a* threadedly attached to bottom tubing adapters **154** and **155** and a reduced diameter upper head **160***b* threadedly attached to the lower ends of mandrels **107** and **108.** Also in the piston assembly **106** is a piston cylinder **161** having a skirt **161***a* passing slidably and concentrically over upper head **160***b* and also having an upper head **161** abutting the upper head **160***b* of piston **160.** A wedge assembly similar to that at **144** and **145** is also slidably located in the piston assembly **106** and consists of a plurality of wedge anchors **162** slidably and wedgedly held in a dual conical wedge head **163** with guide pins **164** passing through head **163** and engaging in slots **162***a* located in anchors **162.** Anchors **162** have a conical wedge surface **162***b* along their outer periphery for camming engagement with conical inner surface **163***a* of head **163** and further have gripping ratchet teeth **162***c* on their inner surfaces for one-way gripping of mandrel **107.** It is clear that anchors **162** will allow upward movement of cylinder **161** with respect to mandrel **107** but will prohibit its return movement downward.

Wedge head **163** is fixedly secured to piston cylinder **161** by means of assembly cap **165** and bolts **166** passing through cap **165** and threadedly engaging head **161***b*. A thin cylindrical sleeve **167** is snugly fitted over head **163** to prevent contamination and sediment from entering the wedging assembly. A more detailed view of head **163** can be obtained in FIGS. **16***a* and **16***b*. Shearable screws **168** pass threadedly through lower skirt **161***a* and engage in an annular channel **169** formed in piston **160** and serve to temporarily attach cylinder **161** to piston **160** to prevent premature setting from transient pressure variations or from existing hydrostatic pressure in the casing or tubing string.

A fluid pressure actuating valve seat collar **170** is threadedly attached to the lower end of adapter **154** and contains a valve seat **171** secured sealingly therein by an annular retainer ring **172** abutting a lower shoulder **170***a* of the collar **170** and an upper shoulder **169***a* of retaining sleeve **169** which is screwed into collar **170** to clamp ring **172** in place. A circular seal **173** is located between valve seat **171** and collar **170** and sealingly engages both elements. A ball valve or other suitable valve element **174** is retained at the surface while the tool is interconnected in the tubing string and lowered in the hole and the valve can be dropped through the tubing to seat in valve seat **171** when it is desirable to actuate the packer assembly. Alternatively, the valve seat collar could be attached to the other tubing string at threads **155***a* and this string could be utilized to actuate the packer, providing sufficient porting, is formed in the mandrel communicating with the piston and cylinder assembly. Also, a wireline plug could be utilized instead of ball valve **174.**

OPERATION OF THE ALTERNATE EMBODIMENT

The packer assembly **101** is threadedly interconnected in the primary production string via threads **110***a* on tubing receiver **110** and threads **155***a* on tubing adapter **155.**

A standard single packer may be located on the primary string attached to threads **155**a of adapter **155** and extending below packer assembly **101.** Normally the single packer is located between the two subject formations and packer assembly **101** is situated above the uppermost formation.

When the tubing string has been lowered sufficiently far into the hole to properly position the lower packer and packer assembly **101,** the lower packer is set by manipulating the string or by hydraulic actuation or the lower packer may have been previously set by wireline or other methods.

A secondary tubing string **126** containing collet sleeve **118** and seal collar **124** at the lower end is lowered into the hole to contact the curved upper face **121** of dish **117** and be guided into sealed communication with bore passage **131** inside secondary mandrel **108.**

A valve element **174** can then be dropped or pumped down the secondary tubing string or lowered on a wireline to seal in valve seat **171** thereby sealing off the secondary bore passage to fluid flow and allowing the operator at the surface to apply fluid pressure to the secondary string.

Actuation of the packer is achieved by the application of fluid pressure through the secondary string which pressure is contained by valve **174** and allowed to exit through one or more ports **175** through the wall of mandrel **108.**

The fluid pressure then acts upward against inner differential pressure shoulder **161***c* of cylinder **161,** is prevented from leaking upward around the shoulder by circular seal **176** between cylinder **161** and mandrel **108** and also acts downward on differential pressure area **160**c on the uppermost end of upper head **160***b*, leakage downward being prevented by circular seal **177** between cylinder **161** and piston upper head **160***b*. Similar circular seals are located between mandrel **107** and cylinder **161.**

The resulting hydraulic force between the two differential pressure areas drives the piston outwardly from the cylinder, shearing screws **168,** simultaneously moving the cylinder and wedge assembly into abutment with the lower edge **105***a* of slip **105,** shearing slip shear screw **153** and pivoting the slip into anchoring contact with the casing wall. As hydraulic force drives the cylinder upward, setting the slip in the casing, it also drives the piston downward pulling the mandrels downward

through the slip and applying longitudinal compressive forces on the resilient packer elements.

Downward axial force from the mandrels **107** and **108** is transferred to the resilient packer elements by means of abutment of retaining keys **140** with mandrel ridges **138** and **139** and key-retaining sleeves **133** and **134**. The relationship between these elements is more clearly shown in FIGS. **10**, **11***a*, **11***b* and **11***c*.

The downward force transferred from mandrels **107** and **108** to sleeves **133** and **134** moves downward against packer plate **137** and thence into packer assembly **104** compressing it longitudinally and forcing it outward against the casing wall in sealing contact. The wedge anchors **145** and **162** maintain the telescoped position of cylinder **161** and piston **160** and also maintain the compressed orientation of packer assembly **104**.

Cylinder **161** thus is locked tightly up against the bottom of slip **105** which has been fully pivoted into casing engagement position; and the packer assembly **104** is locked tightly down on top of slip **105**, thereby resulting in the slip being completely locked in gripping position with the coincidental result of full expansion of the resilient packer elements **141** radially outward against the casing wall.

It should be noted that shear pins **127** have continued to maintain upper head **112** located over retaining keys **140** thereby keeping them in place in slots **140***a* of sleeves **133** and **134**. Very little force is felt by the shear pins up to this point since the hydraulically actuated forces are transferred through the mandrels, keys **140**, sleeves **133** and **134** and into head **137** bypassing head **112**.

The utility of pins **127** becomes clear when describing the method of unsetting the packer apparatus for removal from the well. This is accomplished by picking up on the primary tubing string which results in imposing an upward force on head **112** threadedly attached to the tubing string via tubing receiver **110**. Head **112** then moves upward on the mandrels until shear pins **127** abut annular shear shoulders **107***a* and **108***a*. Then a sufficient upward force on the tubing string will shear pins **127** across the shear shoulder and head **112** will move upward sufficiently to allow keys **140** to be wedged outward into the annular space **129***b* between head **129** and sleeves **133** and **134**. This releases sleeves **133** and **134** from the mandrels and allows upward movement of the sleeves, head **129**, the packer assembly **104** and wedge head **144** via bolts **132** and bolts **136**.

Movement upward of head **129** allows the resilient packer elements to contract radially to their uncompressed state thereby unseating the packer assembly **104** from the casing. Upward movement of wedge head **144** acting through bolts **149** also pulls upward with it anchor cap **148** and the threadedly engaged dogleg bolt **150**. The dogleg extension **150***a* contacts the upper outer edge of slip **105** and pulls it upward thereby pivoting it out of contact with the casing wall and releasing its grip. The apparatus is now completely free of the casing and, after unsetting of the lower single packer, the string can be pulled from the well.

Although certain preferred embodiments of the present invention have been herein described in order to provide an understanding of the general principles of the invention, it will be appreciated that various changes and innovations can be effected in the described multi-string packer apparatus without departure from these principles. For example, it would be possible to utilize hydraulic actuation through the primary tubing string rather than the secondary string as shown. All modifications and changes of this type are deemed to be embraced by the spirit and scope of the invention except as the same may be necessarily limited by the appended claims or reasonable equivalents thereof.

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

1. A unitary well tool anchor slip for ahchoring a well tool or well packer in the casing of an oil well, said slip comprising:

a generally cylindrical tubular member having a dual axis bore passage therethrough;

a plurality of gripping teeth having a curved boundary profile, said teeth being located on one side of said member near one end;

a second plurality of gripping teeth having a curved boundary profile, said second plurality of teeth located on the opposite side of said member near the opposite end;

an abutment shoulder located at one edge of one end of said member, said member end having a canted surface leading away from said abutment shoulder; and,

a compound abutment surface on the member end opposite said abutment shoulder, said compound surface having a flat surface extending from the central cylindrical axis to the edge of said member containing said gripping teeth and a radially curved surface extending from said central axis to the opposite edge of said member end.

2. The anchor slip of claim **1** wherein said dual axis bore passage is arranged to contain a plurality of tubular mandrels therein and is further adapted to pivot about said mandrels on dual axes, with the first of said dual axes substantially coinciding with the central, longitudinal cylindrical axis of said anchor slip, and said second axis beng canted from said first axis at an angle of from 5 to 45°, with a preferable angle of about 18°.

3. The anchor slip of claim **2** wherein said member has a pivoting center of rotation along the central, longitudinal cylindrical axis of said member and located at a distance of one-half of the cylindrical length of said member from said flat surface, and the radius of curvature of said radially curved surface is equivalent to one-half the cylindrical length of said member, with said curved surface being tangent to said flat surface at said central cylindrical axis.

4. The anchor slip of claim **3** wherein said member further comprises a longitudinal slot passing through one side of said member from the inner bore to the outer surface thereof and extending only partially along said one side of said member; said slot arranged adjacent to a cylindrical spring slot formed into the remaining portion of said member wall and aligned substantially parallel with the central cylindrical axis of said member.

5. A uni-directional gripping member for use on one or more conduit strings in a wellbore, said gripping member adapted for gripping the wellbore in one direction of longitudinal movement of said member and further adapted to allow non-gripping movement of the

member in either longitudinal direction in the wellbore comprising:

a generally cylindrical tubular member having a first bore passage passing longitudinally there-through generally parallel to the longitudinal central axis thereof and adapted to receive said one or more conduit strings in slidable relationship;

a second bore passage passing through said member and intersecting said first bore passage at an angle thereto, whereby said member can be pivoted on said conduits from a well-bore non-engaging position to a wellbore contact position whereby diametrically opposite edges of said member contact the wellbore simultaneously;

gripping teeth on said member along said diametrically opposite edges of said member, said teeth arranged to contact and grip the wellbore upon pivoting of said member on said conduit string;

a canted face on one end of said member, said face having an abutment surface thereon along the outer edge of said member arranged to abut a flat surface on said conduit string and introduce rotational moments in said member; and,

a dual surface end on said member opposite said canted face end, said dual surface end having a flat surface normal to the central cylindrical axis of said member and a curved surface tangent to said flat surface at said central axis said curved surface being on the same side of said member as said abutment surface but longitudinally spaced therefrom, and said curved surface having a radius of curvature equal to the distance from the point of said tangency to the pivot center of said member.

6. The gripping member of claim **5** wherein said member has a cylindrical length which is substantially greater than the diameter of the wellbore and a cylindrical diameter smaller than the diameter of the wellbore, with said curved surface having a center of curvature coinciding with the pivot center of said member, said pivot center lying on the central, cylindrical longitudinal axis of said member and being a distance of one-half the cylindrical length of said member from said point of tangency.

7. The gripping member of claim **6** wherein said first and second bore passages are each adapted to receive two parallel, spaced apart, conduit strings and said second bore passage intersects said first bore passage at an angle of from 5 to 45°, with a preferable angle of from 16 to 20°.

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