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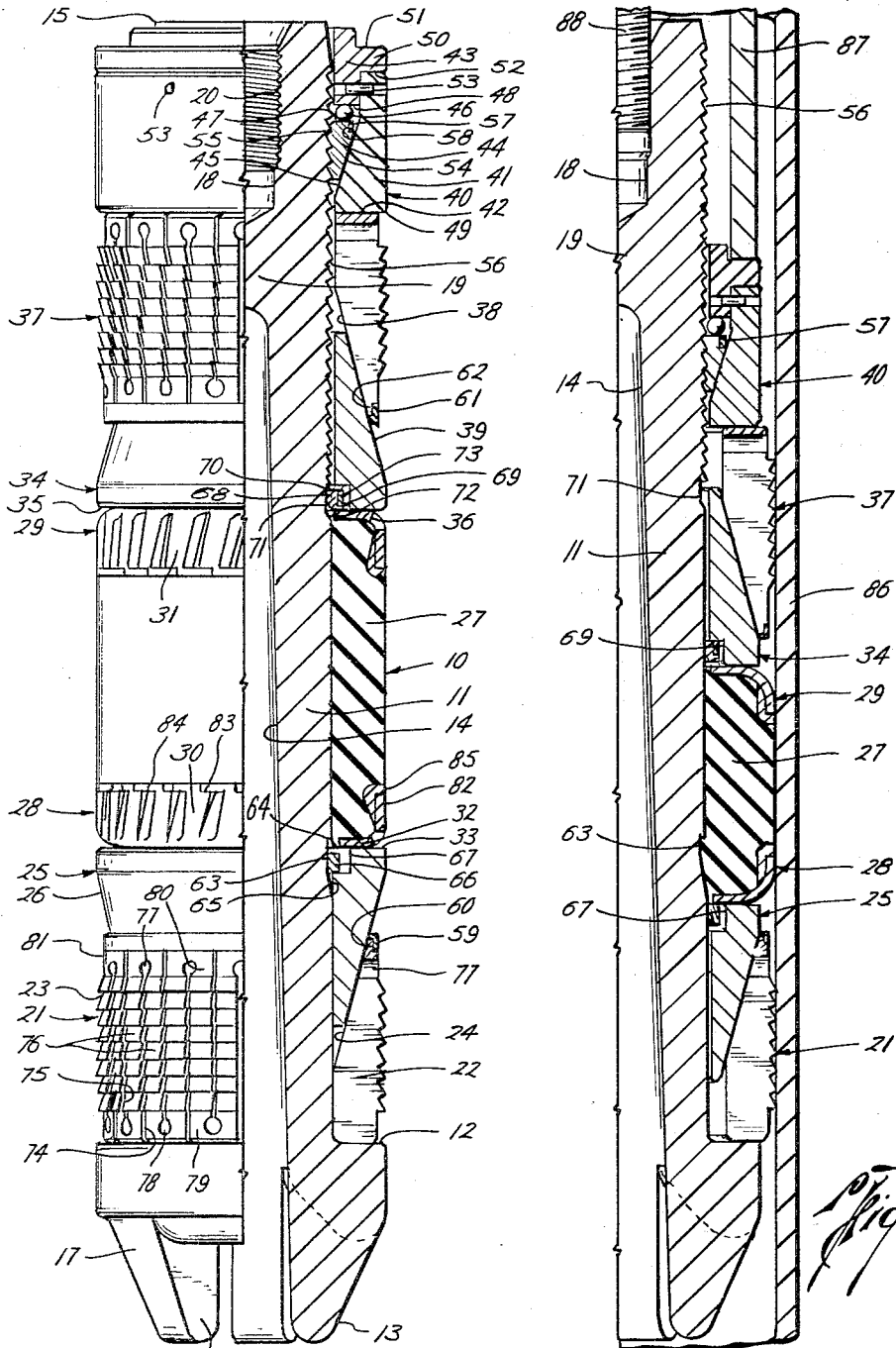


Fig. 1

Fig. 2

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NON-RETRIEVABLE BRIDGE PLUG

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This invention relates to bridge plugs for use in well bores, and, more particularly to bridge plugs which are designed to be set permanently in place within a cased well bore.

It often becomes necessary to isolate or bridge-over a well bore. In such cases, it is customary to lower a bridge plug into the well bore to the desired depth and then expand the plug into place by use of a setting tool. The plug has upper and lower anchor means and, once set, will remain fixed against pressure differentials in either direction.

In general, such bridge plugs basically consist of a central body or mandrel carrying upper and lower sets of normally retracted casing-gripping slips or anchoring devices slidably arranged on upper and lower slip-expanding devices or expanders. The expanders, in turn, are slidably mounted on the mandrel and longitudinally spaced from one another by a normally relaxed pliant or elastomeric packing element or sleeve. The mandrel, slips, expanders and packing element are so arranged that relatively movable members of a setting tool produce a relative axial movement to expand the packing element between the expanders and wedge the slips into anchoring engagement with the wall of the well bore. A locking device, usually called a body lock, is customarily employed to permanently lock the parts in a set position.

Heretofore, it has been conventional to utilize various arrangements of frangible members, such as shear pins, for holding the expanders and slip elements fixed relative to one another and to the mandrel in an inoperative first position to allow the bridge plug to be positioned in a well bore. These shear members are generally arranged in such a manner that, as the forces applied by the setting tool increase, the members will fail in a particular order to release the various elements in accordance with a predetermined sequence of operation.

Conventional shear pins have not been entirely satisfactory for several reasons. For example, when a large number of bridge plugs are being mass-produced, it is difficult to drill holes for receiving shear pins in the separated members with sufficient precision that the holes will be accurately aligned when the members are assembled. Accordingly, it is customary to assemble the members, drill the necessary holes, and then disassemble the members to remove burrs and the like before reassembling and inserting the pins.

Furthermore, it is not uncommon for the sudden shock, which is imparted to a bridge plug when a shear member fails, to crack a cast component of the bridge plug. It has also been found that a shear member will sometimes break irregularly and leave a projection which retards or even prevents free movement of the elements after they are supposed to be free.

It is, therefore, an object of the present invention to provide a reliable bridge plug assembly in which shear pin connections are eliminated.

This and other objects of the present invention are obtained by bridge plug assemblies which include, among other things, various embodiments of new and improved restraining members.

The bridge plug of the present invention includes a central mandrel carrying at each end thereof opposed sets of integral expansible slip members operatively engaged with frusto-conical slip expanders. An elastomeric pack-

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ing sleeve element is disposed between the opposed slips and expanders with each end being bonded to and confined within an expansible anti-extrusion ring which positively prevents cold-flow or extrusion of the packing element after it has been sealingly engaged between the mandrel and casing.

The slip expanders are initially held in an inoperative position by the novel expansible rings of the present invention. These rings are tightly fitted in circumferential grooves around the mandrel and engaged with the slip expanders. At least one of these expansible rings and both slip members are encircled with expansible bands of predetermined strengths for releasably holding these members in their initial positions to allow the various members of the bridge plug to be selectively operated in response to setting forces of predetermined magnitudes. Consequently, these expansible rings and bands replace the various shear-member arrangements commonly employed heretofore.

A body lock arrangement is provided for maintaining the members in their operative positions after the setting tool has been disengaged.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation together with further objects and advantages thereof, may best be understood by way of illustration and example of certain embodiments when taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates one embodiment of a bridge plug, partly in section, employing one arrangement of the novel expansible rings or bands of the present invention; and

FIG. 2 is a partial view showing the bridge plug of FIG. 1 set into sealing and anchoring engagement with a well casing.

Turning now to FIG. 1, one embodiment of a bridge plug 10 constructed in accordance with the principles of the invention is shown with a portion thereof in section for purposes of greater clarity. The mandrel 11 is an elongated cylindrical member having an enlarged-diameter frusto-conical portion at its lower end which provides an upwardly facing shoulder 12 and a converging nose 13. The lower end of nose 13 defines the outer opening of a blind axial bore 14 which extends upwardly along the axis of the mandrel 11 for a substantial distance toward the upper end 15 of the mandrel for a reason which will be subsequently explained in detail. A series of slots or gaps 16 provided in the frusto-conical nose 13 form a plurality of equally spaced lugs 17 thereon, each of which are rounded at their outermost end. At the opposite or upper end 15 of mandrel 11, a second blind axial bore 18 is provided which extends downwardly along the axis of the mandrel but is terminated short of the upper end of axial bore 14 so as to form a solid bridge 19 between the two bores. Internal threads 20 within axial bore 18 provide a means for attaching the mandrel to a conventional setting tool in the well-known manner.

A lower expansible slip member 21, as will be later described, is slidably disposed around the mandrel with its lower end 22 in engagement with the upwardly facing shoulder 12 of nose 13. Downwardly directed wickers or teeth 23 are provided around the outer surface of the slip with the internal bore 24 of the slip being tapered and diverging outwardly and upwardly.

A lower slip-expanding member 25 is slidably disposed around mandrel 11 with its outer surfaces 26 complementarily tapered and engaged with the inner tapered surface 24 of the lower expansible slip 21.

An elastomeric packing sleeve 27, which has its ends bonded to oppositely directed lower and upper anti-extrusion rings 28, 29, respectively, and confined within the fingers 30, 31, of the rings 28, 29, is slidably dis-

posed around the mandrel 11 with the base portion 32 of lower anti-extrusion ring 28 resting on the upwardly facing end 33 of lower expander 25. An upper expander 34, identical to but oppositely directed from the lower expander 25, is slidably disposed around mandrel 11 with the downwardly facing end 35 of the expander 34 resting on the base portion 26 of the upper anti-extrusion ring 29. An upper slip 37, identical to but oppositely directed from lower slip 21, is slidably disposed around mandrel 11 with its inner tapered surface 38 engaged over the complementarily tapered inwardly and upwardly converging surface 39 of upper expander 34.

An actuating and locking assembly 40, slidably disposed around the upper end 15 of mandrel 11, is arranged to engage upper slip member 37 as the mandrel moves upwardly therethrough and includes a ratchet-lock arrangement which prevents the mandrel from being forced downwardly after the bridge plug is set. The outer members of the assembly 40 include a tubular mandrel-locking sleeve 41 engaged around the upper end 42 of upper slip member 37 and fastened at its upper or opposite end to the bottom of an annular setting-tool adapter head 43. The inner members of the locking assembly 40 include a slidable annular ratchet cone or body lock 44 received within and cooperatively engaged with a complementarily tapered inner recess 45 of mandrel-locking sleeve 41. An O-ring 46 is disposed around mandrel 11 and engaged between the upper end 47 of body lock 44 and the lower end 48 of adapter head 43 for a reason which will be subsequently explained in detail.

Mandrel-locking sleeve 41 is a tubular member having a cylindrical outer surface and an axial bore which is uniformly tapered, as shown at 45, for at least a portion of its length so as to diverge outwardly and upwardly toward the upper end of the locking sleeve to receive body lock 44. The lower end 49 of mandrel-locking sleeve 41 is engaged with the upper end 42 of upper slip member 37.

The setting-tool adapter head 43 is slidably disposed around the upper end 15 of mandrel 11 and is provided with a circumferential flange 50 which projects radially outwardly to form an upwardly facing shoulder 51 sized and adapted for engagement with the sleeve member of a conventional setting tool (not shown) in the well-known manner and a downwardly facing shoulder 52 engaged with the upper end of mandrel-locking sleeve 41. Adapter head 43 is attached to the upper end of locking sleeve 41 by either complementary threads or pins 53.

The body lock 44 is an annular split cone nut received within mandrel-locking sleeve 41 and having an internal bore of a uniform diameter and a downwardly converging tapered outer surface 54 complementary to the inner tapered surface 45 of mandrel-locking sleeve 41. The inner bore of body lock 44 is provided with a plurality of upwardly facing ratchet teeth 55 complementarily engaged with a plurality of downwardly facing ratchet teeth 56 around the upper end of mandrel 11. A continuous ring or lock band 57 of a ductile material, such as brass, is received in a peripheral groove 58 around body lock 44. This lock band 58 is proportioned to restrain the expansion of body lock 44 over ratchet teeth 56 of mandrel 11 which prevents relative movement of the elements, such as might occur while connecting the setting tool to the bridge plug, until a substantial force is applied to the bridge plug 10 by the setting tool. When such a substantial force is applied, the ductile ring or lock band 57 is stretched, preferably beyond its elastic limit, as body lock 44 expands over ratchet teeth 56 for the first time. Once band 58 stretches, the body lock 44 is thereafter free and the inherent resilience of the body lock then permits it to alternately expand and contract as it ratchets downwardly over ratchet teeth 56 until ratchet teeth 55, 56 finally engage in the set position of the bridge plug.

The O-ring 46, which is a resilient energy-storing mem-

ber, is disposed between the lower end 48 of the adapter head 43 and the upper end 47 of the body lock 44 to hold the body lock engaged with the locking sleeve 41 and advance the body lock along the mandrel during the setting operation.

A continuous ring or stop band 59 of a ductile material, such as brass, is received in a peripheral groove 60 around the upper end of the lower slip member 21. This ductile ring 59 provides an additional restraining influence to that provided by the inherent resiliency of the lower slip member so the lower slip member will remain contracted despite accidental application thereon of forces of a magnitude less than those applied by the setting tool when the slip member is deliberately set. Although it is preferable that stop band 59 be at the thinner edge of the slip, it would be equally feasible to position it elsewhere around the slip.

It should be noted also that hydrodynamic forces tending to expand lower slip 21 whenever the contracted bridge plug is being pulled upwardly in a fluid-filled hole will also be effectively resisted by stop band 59. Similarly, should lower slip 21 be engaged by an obstruction or projection within the well casing as the bridge plug is being lowered therein, the restraining influence of stop band 59 prevents the lower slip member 21 from expanding and sliding upwardly over lower expander 25.

A second stop band 61 like band 59 is placed in a peripheral groove 62 around the lower end of upper slip 37. This stop band 61 serves the same function as stop band 59 on the lower slip 21 in addition to controlling the order in which the various elements are set.

In addition to initially preventing premature expansion of the slip members, it has also been found that as they stretch, stop bands 59, 61 continue to exert a uniform restraint as a slip member expands which ensures that the slip segments move outwardly in unison. Thus, it will be appreciated that all slip segments will contact the casing at substantially the same time to centralize the bridge plug as well as to ensure that the outwardly directed forces applied against the casing will be substantially equally spaced.

Should the lower slip member 21 or the lower expander 25 encounter an obstruction as the bridge plug is being lowered, it will be appreciated that there will be an upwardly directed force tending to foreshorten the packing sleeve 27 which could, in some instances, expand the sleeve sufficiently to allow it to drag along the inner wall of the well casing. Thus, to avoid any upward movement of lower expander 25 relative to mandrel 11, a circumferential groove 63 is formed around mandrel 11 to provide a downwardly facing shoulder 64 at the upper end of the groove with a downwardly and outwardly diverging beveled or tapered portion 65 at the other end thereof. A resilient or yieldable split stop-ring 66 is received within an annular recess 67 formed in the upwardly facing end of lower expander 25. This lower stop ring 66 is engaged with the upper shoulder 64 of circumferential groove 63 to prevent lower expander 25 from being accidentally forced upwardly. On the other hand, in the normal setting operation, when mandrel 11 is pulled upwardly relative to lower expander 25 with sufficient force, the beveled surface 65 of groove 63 will expand lower stop-ring 66 sufficiently to allow it to ride freely down the mandrel. Groove 63 could also be extended downwardly a sufficient distance to eliminate beveled surface 65 and ring 66 would then merely ride down the groove 63 without expanding. Thus, it will be appreciated that mandrel 11 can be moved upwardly relative to lower expander 25 when stop ring 66 is expanded, but lower expander 25 cannot be moved upwardly relative to mandrel 11.

A second split stop-ring 68 is received within an annular recess 69 around the lower end of the upper expander 34 and engages a downwardly facing shoulder 70 formed at the upper end of a peripheral groove 71 around the mandrel 11 at this point. Shoulder 70 will prevent upward

movement of upper stop-ring 68 and packing element 27 relative to the mandrel 11; but as the mandrel begins to travel upwardly, upper stop-ring 68 will be expanded outwardly in the same manner as lower stop-ring 66 by a beveled surface 72 at the lower end of groove 71 to allow the mandrel 11 to move freely upwardly. A continuous stop-ring band 73 of ductile material, such as brass, disposed around the outer periphery of upper stop-ring 68 prevents the stop-ring from expanding upon an accidental engagement of the upper expander 34 or slip member 37 with an obstruction whenever the bridge plug is being pulled out of a well while in its contracted position. It will be appreciated that if stop-ring 68 were free to expand, such accidental engagement could move the upper expander 34 downwardly to expand ring 68 over beveled surface 72 and force the packing sleeve 27 outwardly and into possible engagement with the side of the casing. As in the case of the lock band 57 and the slip stop bands 59, 61, stop-ring band 73 is made of a particular strength so as to require a substantial force to expand upper stop-ring 68, which force is still somewhat less than the required force applied by the setting tool to set the bridge plug 10.

The relative strength of stop-ring band 73 with respect to that of slip stop bands 59, 61 can be predetermined to vary the order of operation as will be subsequently explained in detail.

Each of the expansible slip members 21, 37 is an integral cylindrical member having a series of wickers or teeth, as at 23, disposed around its outer surface and a central bore which diverges outwardly toward one end to form a uniformly tapered inner surface, as at 24. The slip members 21, 37 are made readily expansible by a series of longitudinal slots 74, 75 cut radially through the wall at regular intervals around each member to form a plurality of sectorial segments 76. The slots 74, 75 are conversely alternated with one another so that slots 74 extend from one end of the member and terminate at radially directed bores 77 near the opposite end of the member. The intermediate slots 75 are similarly formed but extend from the opposite end of the member to their terminus at similar radially directed bores 78 near the first end of the member. Accordingly, segments 76 are interconnected only by a series of alternated webs 79, 80 of equal cross-sectional area which respectively join one end of a particular segment to the corresponding end of the adjacent segment on one side and join the opposite end of that particular segment to the corresponding end of the adjacent segment on the other side thereof. Thus, it will be appreciated that upon application of an outwardly directed force, this alternate arrangement of slots will permit circumferential expansion of the slip member as the several segments move apart circumferentially and radially outwardly with the connecting webs acting somewhat as pivots.

At the leading edge or thinner end 81 of the slip member, a peripheral groove, such as at 60, is provided to receive the ductile stop bands 59, 61 previously described above.

The anti-extrusion rings 28, 29 preferably used in the present bridge plug 10 are integrally formed, cup-shaped, expansible members, with each having an annular base portion, as at 32, and a circumferentially expansible skirt portion, as at 82, extending upwardly around the periphery of the base portion 32.

The skirt portion 82 is readily expansible by virtue of the several imbricated finger-like segments, as at 30, which are twisted slightly about their central axes and symmetrically arranged relative to one another so that one edge of each segment slightly overlaps the outer face of the segment adjacent that edge, and the opposite edge of each segment slightly overlaps the inner face of the segment adjacent that opposite edge. The outer or free end of each segment has an upwardly facing shoulder 83 on that edge which overlaps the outer face of the segment

adjacent that edge and a tab portion 84 on the opposite edge which overlaps the inner face of the segment adjacent that opposite edge. Each tab portion 84 is bent radially outwardly over the shoulder 83 of the segment adjacent thereto.

As illustrated, the ends of the elastomeric packing element 27 are received within and contained by the cup-like anti-extrusion rings 28, 29. It is preferable, but not essential, that the packing element 27 be bonded to the base and skirt portions of the anti-extrusion rings.

Thus, it will be appreciated that when the packing element 27 is foreshortened as it is being displaced into engagement with the casing, radial forces will be applied uniformly in all directions against the inside of the anti-extrusion rings by virtue of the well-known tendencies of elastomeric materials to behave substantially as relatively non-compressible fluids. Accordingly, as these forces increase, the skirt portion 82 will begin expanding radially outwardly.

The radial movement will continue until the peripheral surface 85 of the outer tips of the finger-like segments firmly engage the inner wall of the casing 86.

In FIG. 2, the bridge plug 10 of FIG. 1 is partially shown as it will appear when set in place within a casing 86. The outer sleeve 87 (partially shown) of a conventional setting tool (not shown) has been engaged with the upwardly directed shoulder 51 of setting-tool adapter head 43 and a conventional shear stud 88 (partially shown) connected to the inner mandrel (not shown) of the setting tool. Mandrel 11 has been pulled upwardly while the outer sleeve 87 was forced downwardly to set the bridge plug 10, with the stud 88 subsequently shearing to disengage the setting tool whenever the applied forces reached the shear point of stud 88.

It will be appreciated that when the bridge plug is set and the setting tool has been disengaged, upwardly directed forces on the bridge plug will be carried by the upper slips 37 and that the mandrel 11 cannot move upwardly without tending to set the packing element 27 and upper slips even more tightly. On the other hand, only the effectiveness of body lock 44 prevents downwardly directed forces from forcing the mandrel 11 downwardly through the packing element 27. Thus, it is important that ratchet teeth 55, 56 be held in firm engagement.

This firm engagement is ensured by the wedging action provided by tapered surfaces 45, 54 on locking sleeve 41 and body lock 44, respectively. Downwardly directed forces imposed on the mandrel 11 will act through ratchet teeth 55, 56 and tend to drive body lock 44 downwardly, which tendency will cause body lock 44 to be wedged inwardly to engage ratchet teeth 55, 56 even more tightly.

When the setting tool is operated and as the mandrel 11 first begins to travel upwardly, ratchet teeth 56 on the mandrel will slide under ratchet teeth 55 on body lock 44 to cam that member outwardly and stretch lock band 57. Accordingly, as soon as lock band 57 is sufficiently stretched, body lock 44 is thereafter free to expand and contract; and each time the body lock expands over ratchet teeth 56, it will tend to slide relatively upwardly along the tapered surface 45 of locking sleeve 41 which is held by setting tool sleeve 87 acting through the adapter head 43. As body lock 44 begins to slide upwardly, however, O-ring 46 is compressed and then will expand to drive the body lock 44 downwardly to force body-lock ratchet teeth 55 back into engagement with the ratchet teeth 56 around the mandrel. This alternate compression and expansion of O-ring 46 accordingly drives body lock 44 downwardly while preventing any "backlash" or retrograde movement upwardly. It will be appreciated, therefore, that body lock 44 will be sequentially driven over the lowest ratchet teeth 56 on the mandrel that it can engage and that packing element 27 can not relax.

When the bridge plug is firmly anchored into sealing engagement with the casing 86, the upwardly directed setting force on the mandrel will finally increase sufficiently to fracture shear stud 88, which allows the setting tool to be retrieved in the well-known manner.

As previously mentioned, various operational sequences can be obtained by varying the relative strength of the stop-ring band 73 with respect to that of the slip stop bands 59, 61. Furthermore, the strength of slip stop bands 59, 61 can also be varied with respect to one another. Thus, these bands eliminate the need for shear pin members as employed in prior art devices, and may be used wherever shear pins appear.

If, for example, stop-ring band 73 is made weaker than the slip stop band 61, as the setting tool applies an upwardly directed force on the mandrel and a downwardly directed force on adapter head 43, mandrel 11 will not begin moving upwardly until the forces have reached a predetermined magnitude sufficient to stretch stop-ring band 73 and allow upper stop ring 68 to be expanded over bevel 72 of groove 71. Whenever the upper stop ring 68 expands, lower stop ring 66 is also simultaneously expanded over beveled surface 65 to free the mandrel for upward travel. Thus, it will be appreciated that once the mandrel is freed, the oppositely directed forces applied by the setting tool will then be imposed against the bases of the slip members 21, 37 to begin forcing them over their respective expanders 25, 34. It is preferred to make slip stop bands 59, 61 of sufficient strength to allow the packing element 27 to be at least almost fully seated against the casing before the stop bands 59, 61 stretch sufficiently to allow the slips 21, 37 to expand and engage the casing. It would be equally feasible, of course, to make one of the slip stop bands slightly stronger than the other if it were preferred that one slip member be set against the casing before the other slip member is set.

The preferred arrangement, however, is to make stop-ring band 73 somewhat stronger than the slip stop band 61. With this arrangement, the mandrel 11 will initially be held fixed relative to the upper expander 34 which will allow the upper slip member 37 to be driven downwardly over upper expander 34 whenever the applied forces have reached a sufficient magnitude to stretch slip stop band 61. After the upper slip member 37 has been fully expanded into anchoring engagement with the casing, whenever the upwardly directed setting force on the mandrel 11 has increased sufficiently, stop-ring band 73 will stretch to allow upper stop ring 68 and lower stop ring 66 to ride up onto their respective beveled surfaces 72, 65 and free the mandrel 11 relative to the expanders 25, 34. The continuing upwardly directed setting force will then move the mandrel upwardly with the still-fixed lower slip member 21 and lower expander 25 forcing packing element 27 against the firmly held upper expander 34 until the packing element is fully displaced into sealing engagement with casing 86.

It is optional whether lower slip stop band 59 is stronger than the force required to displace or expand packing element 27 into sealing engagement, but it is preferred to make it so to allow the packing element to be substantially displaced before the lower slip 21 is fully expanded against the casing 86 to minimize the dragging of that slip member against the casing wall.

It is also within the scope of the present invention to use the split-ring and stop band arrangement of the present invention to hold a slip member fixed relative to its expander. This arrangement could be used wherever shear pins have been employed heretofore to releasably hold conventional slip members.

With such an arrangement, for example, a peripheral groove, similar to groove 71, would be provided around the outer tapered surface of the expander with an outwardly facing shoulder at the inner side and a beveled surface at the other or outer side of the recess. A mat-

ing recess provided in the inner tapered surface of the slip member would have a shoulder adjacent to the groove shoulder and facing outwardly toward the beveled surface.

A split-ring and stop band combination, similar to ring 68 and band 73, disposed in the groove and recess between the bevel and recess shoulder would prevent movement of one member relative to the other in one direction and restrain movement in the opposite direction until a force of a predetermined magnitude is applied sufficient to expand the ring and band over the beveled surface to free the slip member. It would be equally feasible, of course, to reverse the positions of the groove and recess, with the groove instead being in the inner tapered surface of the slip member.

Although a bridge plug is usually intended to be set in place permanently, it is sometimes necessary to remove it. Removal of a bridge plug in such cases is conventionally done by drilling or "milling" the plug with drilling bits. Accordingly, as is well-known in the art, the mandrel and other elements are made of such drillable metals as cast iron or magnesium.

The blind axial bore 14, previously described, extends a sufficient distance upwardly inside mandrel 11 to ensure that when the bridge plug is permanently set, bridge 19 is well above the upper slip member 37. Thus, it will be appreciated that as the bridge plug is being milled away, bridge 19 will be first cut away before the upper slip member is disturbed. This will accordingly allow any fluid pressure that may be below the bridge plug to bleed-off before the upper slip member is cut away to release the bridge plug. As is well-known in the art, if such a precaution were not taken and there was a substantial well bore pressure under the bridge plug, it would be possible that when the upper slip was released, the remaining portion of the plug could be forcibly propelled upwardly and possibly drive the drill bit and drill string out of the well bore.

It will be appreciated, therefore, that the expandible stop bands around the slips, the body lock and the upper stop ring in addition to preventing inadvertent setting of the device also eliminate the necessity for the various shear pin arrangements wherever they have been employed heretofore. Thus, as the setting tool is setting a bridge plug employing the principles of the present invention, the bridge plug elements will move positively and in a predetermined sequence to their respective positions without any sudden shocks being imparted to the bridge plug as is the case when a shear pin fails.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from this invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A well packer device comprising: a body member; a packing element on said body member; means including an expander member slidably mounted on said body member for expanding said packing element into sealing engagement with a well bore wall; means including a wall-engaging member slidably mounted on said expander member for anchoring said packer device to the well bore wall; and means releasably holding two of said members for preventing sliding of one of said two members relative to the other of said two members including a recess in said one member and an expandible member in said recess operatively engaged with said other member, said expandible member being releasable from said recess only in response to a force of a predetermined magnitude applied to one or the other of said two members.

2. A well packer device comprising: a body member; a packing element on said body member; means includ-

ing an expander member slidably mounted on said body member for expanding said packing element into sealing engagement with a well bore wall; means including a wall-engaging member slidably mounted on said expander member for anchoring said packer device to the wall of the well bore; and means releasably holding two of said members for preventing sliding of one of said two members relative to the other of said two members including an annular recess in said one member, said recess having a shoulder at one end and a cam surface at the other end thereof, and an expansible member in said recess operatively engaged with said shoulder and said other member for initially preventing sliding motion of said one member, said cam surface being operatively arranged to expand said expansible member out of said recess permitting sliding motion of said one member, said expansible member being releasable from said recess only in response to a force of a predetermined magnitude applied to one or the other of said two members.

3. A well packer device having a packer element mounted around a mandrel, upper and lower expanders slidably mounted on said mandrel and engageable with said packer element, upper and lower annular recesses in said mandrel adjacent said expanders, each of said recesses having a shoulder at one end and a cam surface at the other end thereof; and first and second expansible members respectively mounted in said upper and lower recesses, said first member being operatively engageable with said upper recess shoulder and said packer element, and said second member being operatively engageable with said lower recess shoulder and said lower expander, whereby said members prevent sliding motion of said packer element and said lower expander in one direction relative to said mandrel, said cam surfaces permitting sliding motion of said expansible members and expanders in an opposite direction relative to said mandrel.

4. The well packer device of claim 3 in which at least one of said expansible members is releasable from its associated recess only in response to a force of a predetermined magnitude applied to said expansible members.

5. In a packer having a packing element operatively mounted around a mandrel and adapted for expansion into sealing engagement with a well bore wall for packing off the annular space between said mandrel and the well bore wall in response to an axially directed force on said mandrel in conjunction with an oppositely directed force on said packing element; outwardly extendible slip members movably mounted around said mandrel and having outer wall-engaging surfaces and inner tapered surfaces; and a slip-expanding member movably mounted around said mandrel adjacent an end of said packing element and having an outer tapered surface complementarily shaped and coengaged with the tapered surfaces of said slip members, the combination with said packer of: detaining means responsive to an axially directed force of a predetermined magnitude on said mandrel for temporarily preventing operative travel of said mandrel relative to said slip-expanding member including an annular yieldable restraining member constructed of a ductile, stretchable material having a predetermined yield strength, said restraining member being contracted around said mandrel and operatively engageable between said mandrel and said slip-expanding member; and cam means on said mandrel adjacent said restraining member for expanding said restraining member outwardly of said mandrel whenever such a force of predetermined magnitude is applied to release said mandrel for free travel through said restraining member relative to said slip-expanding member.

6. In a packer having a packing element operatively mounted around a mandrel and adapted for expansion into sealing engagement with a well bore wall for packing off the annular space between said mandrel and the

well bore wall in response to an axially directed force on said mandrel in conjunction with an oppositely directed force on said packing element; outwardly extendible slip members movably mounted around said mandrel and having outer wall-engaging surfaces and inner tapered surfaces; and a slip-expanding member movably mounted around said mandrel adjacent an end of said packing element and having an outer tapered surface complementarily shaped and coengaged with the tapered surfaces of said slip members, the combination with said packer of: detaining means for temporarily preventing operative travel of said mandrel relative to said slip-expanding member including an annular expansible member contracted around said mandrel and operatively engageable between said mandrel and said slip-expanding member; means responsive to an axially directed force of a predetermined magnitude on said mandrel for releasing said expansible member from its contracted position around said mandrel including an annular yieldable restraining member contracted around said expansible member; and cam means on said mandrel adjacent said expansible member for expanding said expansible member against said restraining member whenever such a force of predetermined magnitude is applied to cause said restraining member to yield and release said mandrel for free travel through said expansible member relative to said slip-expanding member.

7. In a packer having a packing element operatively mounted around a mandrel and adapted for expansion into sealing engagement with a well bore wall for packing off the annular space between said mandrel and the well bore wall in response to an axially directed force on said mandrel; outwardly extendible slip members movably mounted around said mandrel and having outer wall-engaging surfaces and inner tapered surfaces; and slip-expanding members movably mounted around said mandrel adjacent opposite ends of said packing element and having outer tapered surfaces complementarily shaped and coengaged with the tapered surfaces of said slip members, said slip members being adapted for advancement over the outer tapered surface of said slip-expanding members to expand into anchoring engagement with the well bore wall in response to oppositely directed forces on said slip members in conjunction with an axially directed force on said mandrel, the combination with said packer of: restraining means responsive to a force of a first predetermined magnitude applied on said slip members for preventing relative advancement of said slip members over said slip-expanding members until such a force reaches such a magnitude including first annular yieldable restraining members contracted around each of said slip members for yieldably restraining outward extension of said slip members; detaining means responsive to an axially directed force of a second predetermined magnitude applied on said mandrel for temporarily preventing operative travel of said mandrel relative to one of said slip-expanding members including a second annular yieldable restraining member contracted around said mandrel and operatively engageable between said mandrel and said one slip-expanding member; and cam means on said mandrel adjacent said second restraining member for expanding said second restraining member outwardly of said mandrel whenever an axially directed force of such a second predetermined magnitude is applied to said mandrel to release said mandrel for free travel through said second restraining member relative to said one slip-expanding member.

8. The structure of claim 7 wherein said first restraining member is sized to withstand a force of greater magnitude than said second restraining member so that said second restraining member will yield first to release said mandrel for free travel to at least begin expanding said packing element into sealing engagement before said first restraining member yields to allow relative advancement of said slip members over said slip-expanding members

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for expanding said slip members into anchoring engagement.

9. The structure of claim 7 wherein said second restraining member is sized to withstand a force of greater magnitude than said first restraining member so that said first restraining member will yield first to allow relative advancement of said slip members over said slip-expanding members for expanding said slip members into anchoring engagement before said second restraining member yields to release said mandrel for free travel to expand said packing element into sealing engagement.

10. In a well tool having body means, expander means on said body means movable relative thereto responsive to longitudinally directed setting forces, slip means on said expander means movable relative thereto responsive to said setting forces, and elastomeric packing means movably mounted on body means and engageable with said expander means, the combination of stop means on said body means engageable with said expander means and said packing means, means coupling said stop means to said body means to prevent movement in one direction and permit movement in an opposite direction, and means for restraining movement of said stop means in said opposite direction until a force of predetermined magnitude is applied hereto.

11. In a well tool having an elastomeric packing sleeve mounted around a mandrel and expander means slidable on said body and engageable with an end of said packing sleeve, the combination of means functioning to stop movement of the packing sleeve relative to the body in one direction and functioning to releasably hold the expander means against movement relative to the body in a longitudinal direction opposite to said one direction, said means comprising groove means in said body adjacent said end of said packing means, said groove means providing a shoulder facing the end of said packing means and an inclined surface facing said shoulder, annular expandable means in said groove means engaging both the end of said packing means and said shoulder while performing said stopping function, and being shiftable over said inclined surface and out of said groove means after performing said releasable holding function, and means on said expander means for shifting said annular means over said inclined surface and out of said groove means.

12. A well packer comprising: a mandrel; a packing element on said mandrel; upper and lower anchor means including slips and expanders, respectively, above and below said packing element; upper and lower grooves in said mandrel adjacent the ends of said packing element, said grooves having shoulders on one side thereof and inclined surfaces on the other sides thereof; upper and lower expandable rings, respectively, in said upper and lower grooves, said upper ring engageable between said upper shoulder and the upper end of said packing element to stop upward movement of said packing element relative to said mandrel, said lower ring engageable between said lower shoulder and said lower expander to

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stop upward movement of said lower expander relative to said mandrel; and annular band means encircling and engaging said upper expandable ring to restrain downward movement of said upper ring over said upper inclined surface until a force of predetermined magnitude is applied hereto, said band means being constructed of a ductile, stretchable material having a predetermined yield strength.

13. In a well tool having body means, expander means on said body means movable relative thereto responsive to longitudinally directed setting forces, and slip means on said expander means movable relative thereto responsive to said setting forces, the improvement comprising, in combination, first restraining means for controlling relative movement between said slip and expander means, and second restraining means for controlling relative movement between said expander and body means, both of said restraining means being constructed of ductile, stretchable materials having predetermined yield strengths, one relative to the other, such that the sequence of relative movement between the slip and expander means and the expander and body means can be controlled.

14. The well tool recited in claim 13 wherein said second restraining means includes an annular groove in said body means adjacent said expander means, said groove having an inclined side wall surface; and band means initially positioned in said groove and engageable with said expander means, said band means being adapted, after restraining relative movement between said expander and body means, to be shifted over said inclined surface and out of said groove means.

15. The well tool recited in claim 13 wherein said first restraining means includes annular band means encircling and engaging said slip means.

16. The well tool recited in claim 15 wherein said second restraining means includes an annular groove in said body means adjacent said expander means, said groove having an inclined side wall surface; and band means initially positioned in said groove and engageable with said expander means and said band means being adapted, after restraining relative movement between said expander and body means, to be shifted over said inclined surface and out of said groove means.

References Cited by the Examiner

UNITED STATES PATENTS

50	1,188,489	6/1916	Rhea	-----	166—217	X
	2,623,593	12/1952	Pennington et al.	----	166—217	
	2,807,325	9/1957	Webb	-----	166—123	X
	3,082,824	3/1963	Taylor et al.	-----	166—135	X
	3,091,293	5/1963	Fry	-----	166—123	
55	3,163,225	12/1964	Perkins	-----	166—123	

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