Nov. 24, 1964 W. R. LEWIS ETAL 3,158,202

RETRIEVABLE BRIDGE PLUG

Filed April 18, 1963

3 Sheets-Sheet 1

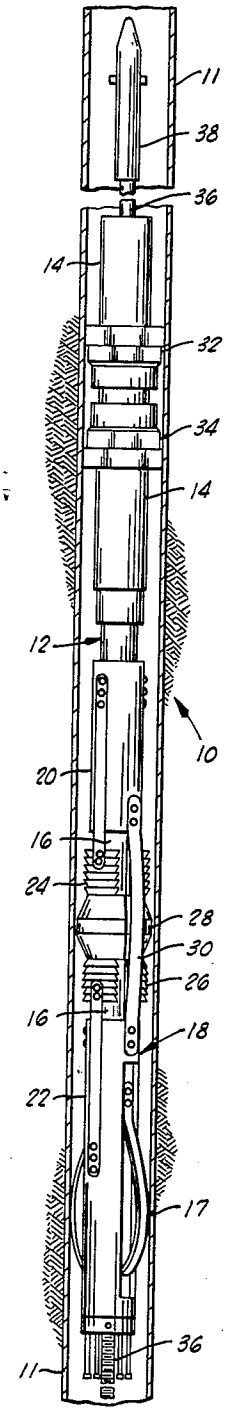


Fig. 1

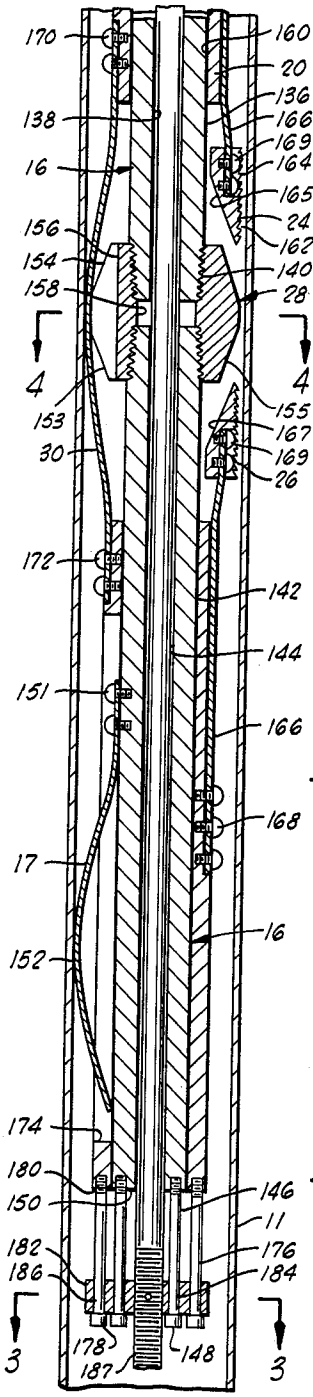


Fig. 2

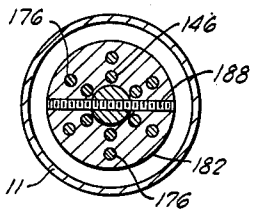


Fig. 3

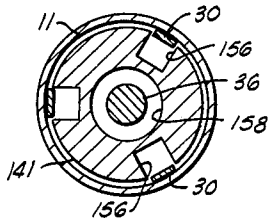


Fig. 4

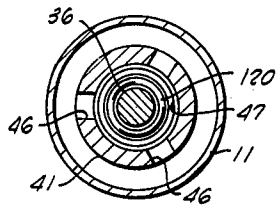


Fig. 6

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RETRIEVABLE BRIDGE PLUG

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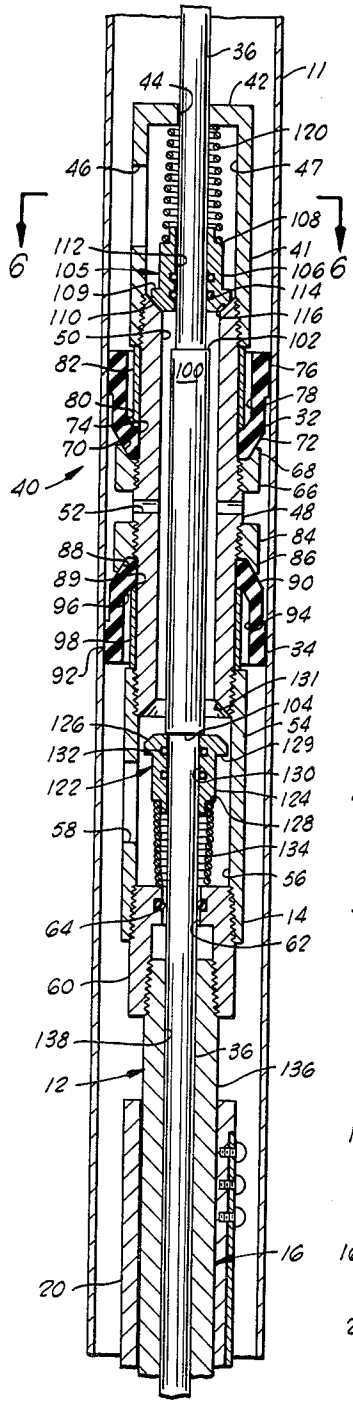


FIG. 5

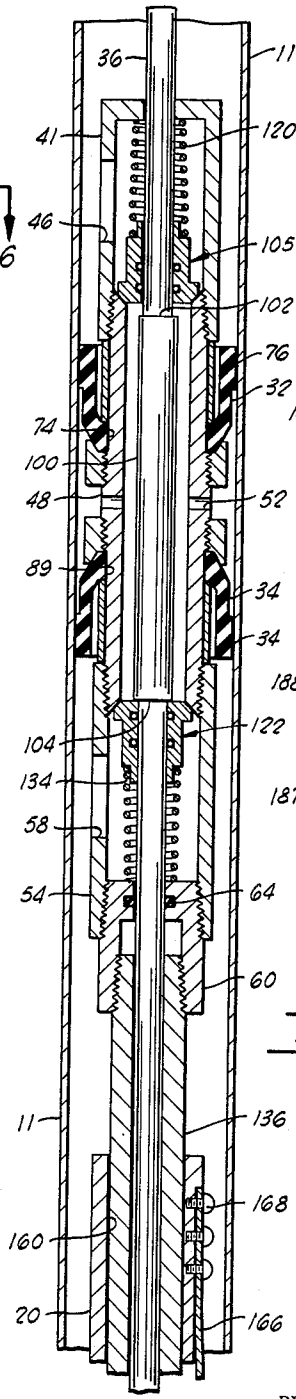


FIG. 7

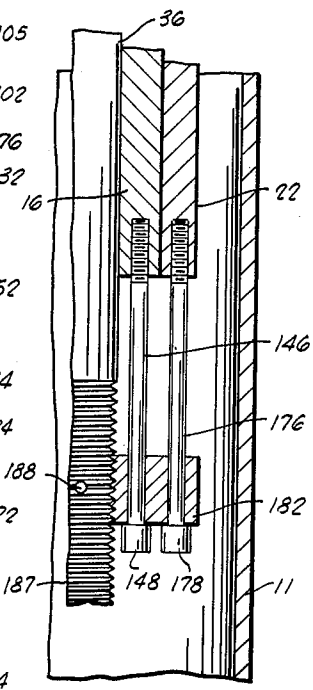


FIG. 8

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3 Sheets-Sheet 3

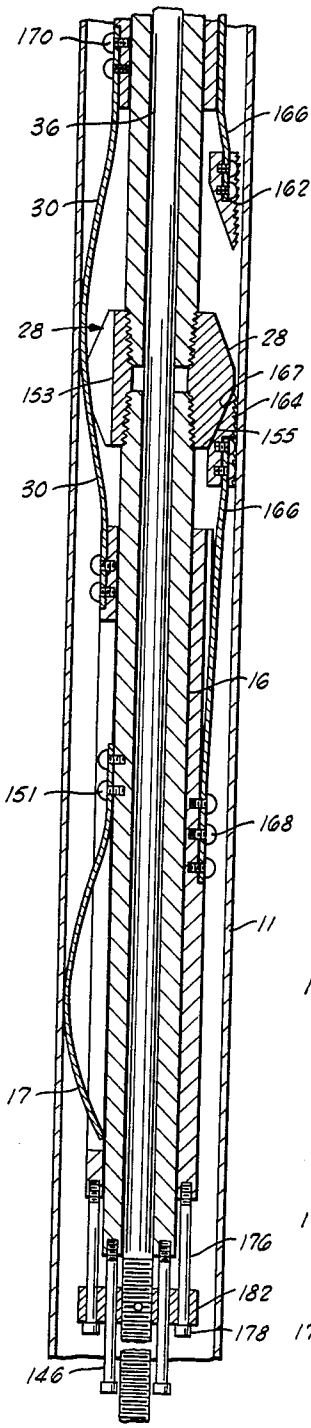


Fig. 9

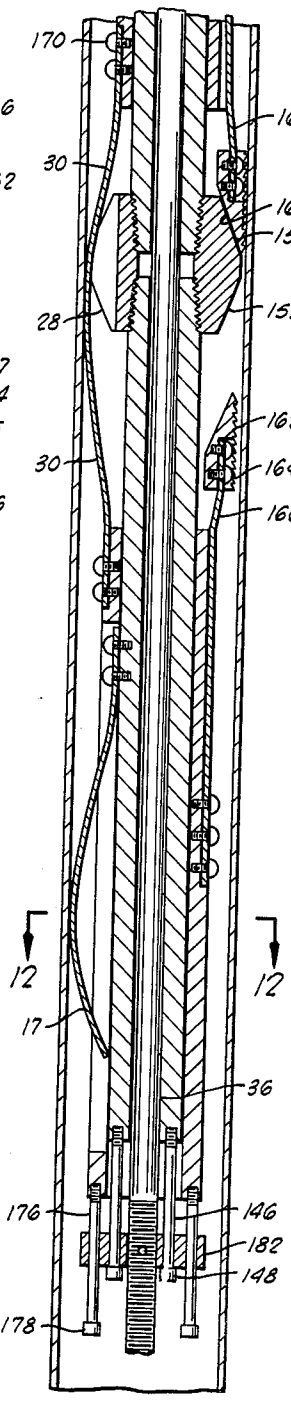


Fig. 10

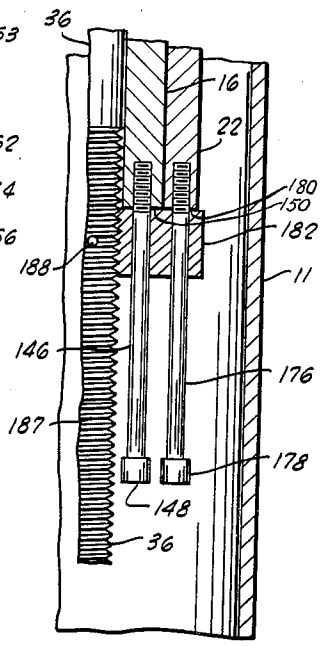


Fig. 11

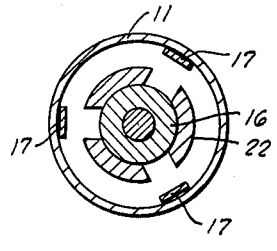


Fig. 12

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3,158,202

RETRIEVABLE BRIDGE PLUG

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Filed Apr. 18, 1963, Ser. No. 274,037
16 Claims. (Cl. 166—121)

This invention relates generally to subsurface well devices, and more particularly, but not by way of limitation, to a bridge plug adapted to be retrievably anchored in a packed-off condition in a well casing, or similar conduit, disposed in a well bore.

It has been known, heretofore, to provide well packers capable of being anchored in a packed-off condition against longitudinal movement in a well conduit. However, these well packers have been subject to a number of weaknesses which have limited their utility. Most of the previous well packers have provided a central longitudinal bore through which well fluid was directed when the packer was moved longitudinally within a well casing. Many times, the well fluid passing through this central bore carried pieces of rock bits, well casing, cement, sand, and other foreign objects or moving elements. These foreign objects tended to jam the mechanical operation of such a well packer so that it was impossible to retrieve it from the well casing. When this condition occurred, it became necessary for the well packer to be drilled out, an operation which required time and money as well as occasioning the loss of the packer itself.

Another weakness of previously obtainable well packers was their particular construction, which frequently resulted in structural failures. The structural design of these well packers and the resultant method of operation allowed the operating mechanism of the packer to fail, leaving the packer in an anchored position in the well casing and precluding longitudinal movement of the packer therein. Again, it was necessary to drill out the packer for access to the entire length of the well casing. More specifically, these particular packers used a control rod provided with an elongated transverse slot through which extended a member related to the operation of slip members. The removal of material from the control rod in providing this slot decreased the strength of the control rod and permitted it to fail during operation of the well packers. The present invention is believed to obviate the aforesaid weaknesses of the previously obtainable well packers. The general term "well packer" will also be considered to include a more specific type of well packer known as a bridge plug.

The present invention contemplates an improved bridge plug which is adapted to be retrievably positioned within a well casing and which substantially precludes the possibility of it being irretrievably anchored within the casing during longitudinal movement therein. In one of its broader aspects, the present invention may be defined as an elongated tubular body having upper and lower portions and carrying at its lower portion a plurality of drag members which frictionally engage the well casing. A sleeve means adapted for longitudinal movement with respect to the body is also carried by the lower portion of the body. The sleeve means is provided with upper and lower sets of slip members which may be urged radially outward into gripping engagement with the well casing. A double cone expander means is carried by the body and is adapted to actuate the aforesaid sets of slip members. A plurality of drag members are carried by the sleeve means and frictionally engage the well casing for longitudinally positioning the sleeve means therewithin.

Upper and lower packing cups are carried by the body for sealingly engaging the inner periphery of the well casing. The lower packing cup is responsive to a fluid pressure exerted in the well casing below the plug to move the body longitudinally upward with respect to the sleeve means thereby causing the double cone expander means to actuate the upper set of slip members. Similarly the upper packing cup is responsive to a fluid pressure exerted in the well casing above the plug to move the body longitudinally downward with respect to the sleeve means thereby causing the double cone expander means to actuate the lower set of slip members. It is apparent that when the slip members have been actuated to anchor the bridge plug within the well casing, the fluid pressure then urges the particular packing cup into tighter engagement with the well casing, thereby packing-off that fluid under pressure from the remaining portion of the well casing. A valve means is carried by the body and may be operated during longitudinal movement of the bridge plug within the well casing to direct well fluid only through the upper portion of the body thereby precluding jamming of the plug mechanism by foreign articles carried by the well fluid. At this time, foreign articles or objects are, to a great extent, directed downwardly into the well casing through the region between the outer portion of the bridge plug and the inner periphery of the casing. The construction of the bridge plug is further characterized by being simple and rugged thereby substantially precluding the possibility of the mechanism structurally failing while the plug is being longitudinally positioned within the well casing, which failure would require drilling out of the plug.

Accordingly, it is an object of the present invention to provide an improved retrievable bridge plug which may be anchored in a packed-off position in a well conduit against longitudinal movement in both longitudinal directions. The plug is set automatically within the well conduit by the removal of the means, such as a running string, used to longitudinally position the plug within the well conduit.

Another object of this invention is to provide an improved bridge plug which may be anchored in a well casing at any desired location merely by lowering the plug into the well conduit to the particular location. This improved plug eliminates the necessity of imposing any external forces, such as the dropping of a plurality of weighted balls onto the plug, to anchor it in the well casing against longitudinal movement in either direction.

And yet another object of this invention is to provide a retrievable bridge plug capable of being anchored to a well casing against longitudinal movement in either direction, anchoring of the plug and packing-off being affected automatically by fluid pressure exerted either above or below the plug in the well casing.

A further object of this invention is to provide a bridge plug capable of being retrievably anchored to a well casing against longitudinal movement in either direction. The plug may be retrieved from the well casing by raising a running-in string which may be connected to the plug.

A still further object of this invention is to provide a retrievable bridge plug capable of being anchored to a well casing against longitudinal movement in both directions, said plug embodying an improved arrangement for precluding actuation of the slip members carried by the plug during longitudinal movement of the plug within the casing.

Yet a still further object of this invention is to provide a novel retrievable bridge plug which materially reduces the possibility of the operating mechanism of the plug being jammed by foreign objects carried by the well fluid and being irretrievably anchored in the well casing.

Still another object of this invention is to provide a novel retrievable bridge plug that substantially reduces

the possibility of a structural failure of the plug when positioned within a well casing, which failure would cause the plug to be irretrievably anchored therewithin.

Yet still another object of this invention is to provide an improved bridge plug which is simple and rugged in construction, economical to build, and which has a long service life.

Other objects and advantages of the invention will be evident from the following detailed description, when read in conjunction with the accompanying drawings, which illustrate the invention.

In the drawings:

FIG. 1 is a side elevation of a retrievable bridge plug embodying this invention and being positioned in a well casing disposed in a well bore. The plug is shown as it appears when it is initially lowered into the well casing and before it is set to an anchored status.

FIG. 2 is an enlarged longitudinal section of a lower portion of the retrievable bridge plug, with the parts thereof being shown in the position they occupy when the bridge plug is run into the well casing.

FIG. 3 is a cross section taken along lines 3—3 in FIG. 2.

FIG. 4 is a cross section taken along lines 4—4 in FIG. 2.

FIG. 5 is a fragmentary longitudinal section, on an enlarged scale, of an upper portion of the retrievable bridge plug with the parts thereof being shown in the position they occupy when the plug is run into the well casing.

FIG. 6 is a cross section, on an enlarged scale, taken along the lines 6—6 in FIG. 5.

FIG. 7 is a fragmentary longitudinal section, on an enlarged scale, of an upper portion of the retrievable bridge plug illustrating the parts thereof when fluid pressure is exerted within the well casing either above or below the bridge plug.

FIG. 8 is a fragmentary longitudinal section, on an enlarged scale, of the lowermost portion of the retrievable bridge plug during a running-in operation.

FIG. 9 is a fragmentary longitudinal section, on an enlarged scale, of a lower portion of the novel retrievable bridge plug illustrating the parts thereof when a fluid pressure is exerted within the well casing above the plug.

FIG. 10 is a fragmentary longitudinal section illustrating the lower portion of the bridge plug when a fluid pressure is exerted within the well casing below the plug.

FIG. 11 is a fragmentary longitudinal section of the lowermost portion of the novel retrievable bridge plug, when the plug is being elevated within a well casing.

FIG. 12 is a cross section, on an enlarged scale, taken along the lines 12—12 in FIG. 10.

Referring to the drawings in detail, and particularly FIG. 1, reference character 10 generally designates one embodiment of a retrievable bridge plug constructed in accordance with this invention and longitudinally positioned in a well casing 11 disposed in a well bore. This retrievable bridge plug 10 comprises an elongated tubular body 12 having an upper portion 14 and a lower portion 16. The lower portion 16 carries a plurality of drag members 17 for positioning and centering the plug 10 within the well casing 11.

A sleeve means 18 comprising an upper sleeve 20 and a lower sleeve 22 is carried on the lower portion 16 of the body 12 and adapted for longitudinal movement with respect thereto. The upper sleeve 20 is provided with an upper set 24 of slip members which may be urged radially outward into gripping engagement with the inner periphery of the well casing 11. The lower sleeve 22 is similarly provided with a lower set 26 of slip members which also may be urged radially outward into gripping engagement with the inner periphery of the well casing 11 for anchoring the bridge plug 10 therewithin. A double cone expander means 28 is carried

by the lower portion 16 of the body 12 and is adapted to actuate either the upper set 24 or the lower set 26 of slip members into anchoring engagement with the well casing 11. A plurality of spring-like drag members 30 are carried by the sleeve means 18 for frictionally engaging the well casing 11 and longitudinally positioning the sleeve means 18 therewithin. An upper packing cup or sealing member 32 and a lower packing cup or sealing member 34 are carried by the upper portion 14 of the body 12 and are respectively responsive to fluid pressures exerted above and below the bridge plug 10 to move the body 12 longitudinally with respect to the sleeve means 18 thereby causing the double cone expander means 28 to actuate respectively either the upper set 24 of slip members or the lower set 26 of the slip members.

A central mandrel 36 is secured to a suitable means 38, such as a control head, for elevating or lowering the bridge plug 10 within the well casing 11 during the running-in or retrieving operation. The mandrel 36 is also used to control a valve means 40, shown in FIG. 5, carried within the upper portion 14 of the body 12. The valve means 40 permits fluid to flow through the upper portion 14 of the body 12 during a running-in or elevating operation, as will be hereinafter set forth more fully. The central mandrel 36 is also used to preclude the double cone expander means 28 actuating either the upper or lower set 24 or 26, of the slip members during longitudinal positioning of the bridge plug 10 within the casing 11.

Referring now to FIG. 5, the upper portion 14 of the body 12 includes an upper valve cage 41 having an upper closed end 42 which is provided with a central aperture 44 to accommodate the central mandrel 36. The medial portion of the valve cage 41 is provided with a plurality of circumferentially spaced elongated longitudinal slots or ports 46 which communicate with a central bore 47. The lower portion of the valve cage 41 is threadedly connected to a tubular member 48 which has a central bore 50 that communicates with the bore 47. The tubular member 48 is further provided with a plurality of circumferentially spaced ports 52 which communicate with the central bore 50.

A lower valve cage 54 having a central bore 56 that communicates with the bore 50 is threadedly connected to the tubular member 48. The lower valve cage 54 is further provided with a plurality of circumferentially spaced elongated longitudinal slots or ports 58 which communicate with the central bore 56. The lower end of the valve cage 54 is closed by a plug 60 which is threadedly connected to the lower portion of the valve cage 54. The plug 60 is provided with a central aperture 62 that communicates with the bore 56 and is further provided with a suitable sealing ring 64, such as an O-ring, which cooperates with the outer periphery of the mandrel 36 to furnish an efficient fluid seal.

The packing cup 32 is secured to the upper body portion 14 of the body 12 in a manner which will permit the upper packing cup 32 to be responsive to a fluid pressure exerted within the casing 11 above the bridge plug 10 to cause the body 12 to tend to move downwardly within the casing 11. Similarly, the lower packing cup 34 is secured to the upper portion 14 of the body 12 in a manner which will permit fluid pressure exerted within the casing 11 below the bridge plug 10 to tend to move the bridge plug 10 longitudinally upward within the casing 11. It is to be understood that the packing cups 32 and 34 are resilient or rubber-like and are composed of a suitable material which will resist the corrosive and abrasive effects of the well fluid and the well casing 11.

In the embodiment of the invention illustrated in the drawings, the structure used to secure the upper sealing cup to the body 14 includes a ring member 66 which is threadedly connected to the body element 48 at a medial portion immediately adjacent to and above the ports 52.

The ring member 66 is provided with an annular upwardly extending lip 68 which is formed so as to define an inwardly sloping shoulder 70. The packing cup 32 is provided with a similar sloping shoulder 72 which mates with the shoulder 70 of the ring member 66. The packing cup 32 is provided with a central aperture 74 so that it may be slidably disposed on the tubular member 48 with the shoulder 72 thereof abutting the shoulder 70 of the ring member 66. An outer surface 76 of the packing cup 32 contacts the inner periphery of the casing 11 to furnish a fluid seal therebetween. The packing cup 32 is further provided with an inner relieved portion 78 which opens at its upper end into the casing 11 and which is closed at its lower end by an inwardly sloping shoulder 80. A sleeve 82 is positioned on the outer periphery of the tubular member 48 adjacent to the packing cup 32. The upper valve cage 41 through its threaded connection to the tubular member 48 urges the sleeve 82 into contact with the shoulder 80 of the packing cup 32 thereby wedging the packing cup 32 against the ring member 66. An annular inner surface 83 of the packing cup 32 is urged tightly against the outer periphery of the tubular member 48 so that a sealing effect similar to that achieved by a conventional O-ring is affected.

Similarly, a ring member 84 having a downwardly extending lip 86 and an inwardly sloping shoulder 88 is threadedly connected to the tubular member 48 immediately adjacent to and below the ports 52. The packing cup 34 is provided with an annular inner surface 89 and with an inwardly sloping outer shoulder 90 which mates with the shoulder 88 of the ring member 84. The packing cup 34 is further provided with an outer surface 92 which cooperates with the inner periphery of the casing 11 to furnish an efficient fluid seal therebetween. The packing cup 34 is provided with an annular inner relieved portion 94 which is open at its lower end and closed at its upper end by an inwardly sloping shoulder 96. A suitable sleeve 98 is slidably positioned upon the outer periphery of the lower portion of the body element 48 so that its abuts the shoulder 96 of the packing cup 34. The lower valve cage 54 through its threaded connection to the tubular member 48 urges the sleeve 98 upward so that the packing cup 34 is wedged against the ring member 84 and the inner surface 89 is urged into sealing contact with the outer periphery of the tubular member 48.

A valve means 40 is carried within the upper portion 14 of the body 12 for directing well fluid through the bridge plug 10 while it is being moved longitudinally within the well casing 11. In the illustrated embodiment, the valve means 40 includes an enlarged portion 100 provided on the mandrel 36 so that an upwardly facing shoulder 102 and a downwardly facing shoulder 104 are formed on the upper and lower portions of the enlarged portion 100. The valve means 40 also includes an upper valve 105 comprising a valve member 106 having a pair of upper shoulders 108 and 109 and an inwardly inclined lower shoulder 110. The valve member 106 is provided with a central bore 112 through which the mandrel 36 extends. A suitable sealing means 114, such as a pair of spaced O-rings, is carried by the valve member 106 and cooperates with the outer periphery of the mandrel 36 to provide an efficient fluid seal therebetween. A valve seat for the valve member 106 is provided by an inwardly sloping shoulder 116 formed on the upper end of the tubular member 48 so that it may mate with the shoulder 110 of the valve member 106. The valve seat 116 cooperates with the similarly inclined shoulder 110 of the valve member 106 to provide an efficient fluid seal. The valve member 106 is urged downwardly against the valve seat 116 by a suitable spring 120 which cooperates with the closed upper end 42 of the valve cage 41 and the shoulder 108 of the valve member 106 to maintain the upper valve 105 in a normally closed condition. It is evident that the mandrel 36 may be raised to allow the upper portion 102 thereof to lift the valve member 106 off its seat 116 to allow fluid flow through the upper valve 105.

Similarly, the valve means 40 includes a lower valve 122. The lower valve 122 comprises a valve member 124 having an inwardly inclined upper shoulder 126 and a pair of lower shoulders 128 and 129 and being provided with a central bore 130 so that the valve member 124 may be slidably disposed on the mandrel 36. The lower end of the tubular member 48 is provided with a valve seat in the form of an inwardly sloping shoulder 131 which cooperates with the shoulder 126 to furnish an efficient fluid seal therebetween. The valve member 124 is provided with a pair of spaced suitable sealing rings 132, such as O-rings, which cooperate with the outer periphery of the mandrel 36 to provide an efficient fluid seal therebetween. A suitable spring 134 is disposed around the mandrel 36 and cooperates with the plug 60 and the shoulder 128 of the valve member 124 to maintain the lower valve 122 in a normally closed position. It is apparent that the lower shoulder 104 of the enlarged portion 100 of the mandrel 36 can lift the valve member 124 from its seat 131 to open the lower valve 122 and allow fluid flow therethrough.

The lower portion 16 of the body 12, as shown in FIG. 2, includes an elongated tubular member 136 provided with a central bore 138 and being threadedly connected to the plug 60. The double cone expander means 28 is threadedly connected to the lower end 140 of the tubular member 136. Another elongated tubular member 142 having a central bore 144 is threadedly connected to the double cone expander means 28. A plurality of downwardly extending circumferentially spaced bolts or inner limit pins 146 having enlarged ends 148 are threadedly connected to the downwardly facing lower end 150 of the tubular member 142.

A plurality of circumferentially spaced flat spring-like drag members 17 are secured to the tubular member 142 in a siutable manner such as by bolts 151. In the illustrated bridge plug 10, each drag member 17 is connected to the sleeve means 18 at an upper end and is formed with a free end having an outwardly extending arcuate portion 152 which frictionally engages the inner periphery of the casing 11. The drag members 17 assist in centering the bridge plug 10 within the casing 11 and assist in positioning the plug 10 in the casing 11 when fluid pressure is not exerted within the casing either above or below the plug 10.

The double cone expander means 28 comprises an expander body 153 formed with an upper and lower frustoconical configuration. The body 153 is provided with an upwardly facing inwardly inclined shoulder 154 and a downwardly facing inwardly inclined shoulder 155. The body 153 is further provided with a plurality of circumferentially spaced longitudinally extending relieved portions or guide slots 156, seen most clearly in FIG. 4, for receiving the drag members 30. The body 153 is provided with an axial bore 158 to permit the mandrel 36 to extend therethrough.

The sleeve means 18 includes the upper sleeve 20 which is provided with a central axial bore 160 and which is slidably disposed on the tubular member 136. The upper sleeve 20 carries the upper set 24 of slip members and the lower sleeve 22 carries the lower set 26 of slip members. The upper set 24 and lower set 26 of slip members comprise a plurality of circumferentially spaced slip shoes or slip members 162, each slip shoe 162 having an outwardly facing serrated gripping portion 164 which is adapted to be urged into gripping engagement with the inner periphery of the casing 11 thereby anchoring the bridge plug 10 therein. Each slip shoe 162 of the upper set 24 is provided with an inwardly inclined surface 165 which cooperates with the upper surface 154 of the expander body 153. Each slip shoe 162 of the lower set 26 is provided with an inwardly inclined surface 167 which cooperates with the lower surface 155 of the ex-

pander body 153. The slip shoes 162 of the upper set 24 and the lower set 26 are connected to the upper sleeve 20 and lower sleeve 22, respectively, through flat spring-like members 166 which are secured at one end to the sleeves 20 and 22 in a suitable manner, such as by bolts 168. The members 166 are secured to the slip shoes 162 at their other ends by a plurality of suitable bolts 169 or the like.

The lower sleeve 22 of the sleeve means 18 is connected to the upper sleeve 20 through a plurality of circumferentially spaced spring-like drag members 30. The upper portion of each drag member 30 is connected to the sleeve 20 in a suitable manner, such as by bolts 170. The lower portion of each drag member 30 is connected to the sleeve 22 in a suitable manner, such as by bolts 172. The lower sleeve 22 is provided with a plurality of circumferentially spaced longitudinal slots 174 whereby the drag members 17 carried by the tubular member 142 may extend therethrough and frictionally engage the inner periphery of the casing 11. A plurality of circumferentially spaced downwardly extending bolts or outer limit pins 176 having enlarged heads 178 are threadedly connected to a downwardly facing lower end 180 of the sleeve 22. An annular disc or plate 182 is provided with a plurality of circumferentially spaced inner apertures 184 and a plurality of circumferentially spaced outer apertures 186 which are arranged to permit the inner limit pins 146 and the outer limit pins 176 respectively to slidably extend therethrough. The plate 182 is threadedly connected to a threaded lower end 187 of the mandrel 36. A threaded pin 188 extends transversely through the plate 182 and the mandrel 36 thereby positioning the plate 182 on the mandrel 36 at a desired location.

Operation

When it is desired to lower the bridge plug 10 within the casing 11 to a desired location, a suitable running-in string (not shown) such as a conventional cable or tubing string is connected to the control head 38 in a suitable manner. Although the control head 38, illustrated in the drawings, is particularly adapted for connection with a conventional J-slot arrangement, other means for connection to a running-in string could be used in the practice of this invention. A downward force is then exerted on the control head 38 to cause the bridge plug 10 to move longitudinally downward within the casing 11. The pressure exerted upon the control head 38 causes the mandrel 36 to move downwardly within the body 12 until the plate 182 has reached the limit of its travel on the limit pins 146 and 176 and comes to rest against their respective enlarged portions 148 and 178. It is evident that regardless of the previous position of the body 12 or the sleeve means 18 with respect to the mandrel 36, the downward moving plate 182 carried by the mandrel 36 engages the enlarged portions 148 and 178 of the limit pins 146 and 176 and moves the body 12 and the sleeve means 18 into the position shown in FIG. 2. When the elements of the bridge plug 10 assume the position shown in FIG. 2, the double cone expander means 28 is placed in a neutral or non-actuating position. This neutral position precludes either the upper set 24 or the lower set 26 of slip members being actuated during the running-in operation and anchoring the bridge plug 10 at an undesired location.

The drag members 17 and 30 frictionally engage the inner periphery of the well casing 11 but allow the plug 10 to be moved freely downwardly within the casing 11. The downward movement of the mandrel 36 within the body 12 also causes the lower shoulder 104 of the enlarged portion 100 to engage the valve member 124 and move the shoulder 126 thereof away from the valve seat 131 of the tubular member 48 thereby opening the valve 122, as seen in FIG. 5. Well fluid which may be present in the casing 11 below the bridge plug is then allowed to flow, as the plug 10 is moved downwardly within the casing 11, upwardly through the upper portion 14 of the body 12. This fluid flow is accomplished by the well fluid flowing through the ports 58 in the lower valve cage 54, the open valve 122, the bore 50 of the tubular member 48, the upper valve 105 and thereafter flowing through the ports 46 into the portion of the casing 11 above the plug 10. It is apparent that as the bridge plug 10 is lowered into the casing 11 the pressure of the well fluid exerted within the bore 50 biases the valve member 106 upwardly against the pressure exerted downwardly by the spring 120.

Another path of travel for the well fluid is provided by ports 52 which allow fluid within the bore 50 to flow into the region between the packing cups 32 and 34 and thereafter flow upwardly past the surface 76 of the upper packing cup 32. Since the packing cup 32 extends upwardly the well fluid is allowed to flow freely upward. Although the packing cup 34 extends downwardly, it does not tend to preclude travel of the plug 10 within the casing 11 since well fluid below the plug 10 is allowed to flow freely through the valve means 40 and thereby substantially equalize the fluid pressures on either side of the plug 10. The sealing ring 64 provided for the plug 60 precludes the well fluid which is passing through the upper portion 14 of the body 12 from tending to flow downwardly through the bore 62 of the plug 60 into the bore 138 of the tubular member 136. Thus, it is evident that the portion of the bridge plug 10 which is exposed to the well fluid and the foreign objects carried thereby has been materially reduced. Any foreign objects present in the well fluid are carried by the well fluid past the packing cups 32 and 34 into the region of the casing 11 above the plug 10.

When the bridge plug 10 has been lowered within the casing to a desired position, the running-in string (not shown) is disengaged from the control head 38. The bridge plug 10 is automatically set within the casing 11 by the drag members 17 and 30 and the packing cup 32 and 34 which tend to hold the bridge plug 10 within the casing 11 at this location. Upon relieving the downward pressure on the mandrel 36 the spring 134 will shift the mandrel 36 upwardly to close the valve 122 and since no upwardly directed fluid pressure is then being exerted within the bore 50 against the valve member 106 the spring 120 will then close the upper valve 105. The arrangement of the parts just described is clearly shown in FIG. 7.

If a fluid pressure is exerted within the casing 11 above the plug 10, this pressurized fluid would exert a downward force on the upwardly extending packing cup 32 thereby moving the body 12 downwardly within the upper and lower sleeves 20 and 22 which are precluded from longitudinal movement within the casing 11 by the drag members 30. A downward movement of the body 12 allows the inner limit pins 146 to extend through the inner apertures 184 in the plate 182 and to move downwardly without restriction. A continued downward movement of the body 12 causes the lower inclined surface 155 of the expander body 153 to engage the upwardly facing surface 167 of the lower set 26 of the slip shoes 162 and to actuate them outwardly into a gripping engagement with the inner periphery of the casing 11, as shown in FIG. 9. The engagement of the casing by the slip shoes 162 securely anchors the bridge plug 10 within the casing 11.

The longitudinal guide slots 156 provided in the expander body 153 receive the drag members 30 and permit them to remain uneffected as the expander body 153 is moved longitudinally within the casing 11. The lower drag members 17 secured to the tubular member 142 move longitudinally downward within the casing 11 and pass downwardly along the longitudinal slots 174 provided in the lower sleeve 22. When the lower set 26 of slip members has been anchored within the casing 11 by the expander means 28, the body 12 ceases to move

relative to the sleeve means 18. The fluid pressure exerted within the region above the bridge plug 10 then, by flowing into the relieved portion 78 of the packing cup 32, tends to urge the outer surface 76 of the packing cup 32 into tighter contact with the inner periphery of the casing 11 thereby sealing or packing-off the fluid under pressure above the plug 10. Since the springs 120 and 134 maintain the upper valve 105 and the lower valve 122 in closed positions, the well fluid which flows through the ports 46 into the valve cage 41 is precluded from flowing through the bore 50 on into the region of the casing 11 below the bridge plug 10. A fluid pressure exerted on the outer shoulder 109 of the valve member 106 also urges the valve 105 more tightly closed. Thus, it is apparent that a fluid pressure exerted above the bridge plug 10 in the well casing 11 will automatically anchor the plug 10 within the casing 11 against longitudinal movement.

If a greater fluid pressure is now exerted on the bridge plug 10 from a region below its location in the well casing 11 than exists above the plug 10, this fluid under pressure will exert an upwardly directed force on the lower packing cup 34. This upwardly directed force will cause the body 12 to be moved longitudinally upward with respect to the sleeve means 18 as the frictional engagement of the drag members 30 with the inner periphery of the casing 11 is overcome by the upward force while the frictional engagement of the drag members 30 carried by the sleeve means 18 tends to preclude longitudinal movement of the sleeve means 18 within the casing 11.

As will be seen in FIG. 10, the drag members 30 pass through the longitudinal guide slots 156 provided in the expander body 153, so that the upwardly inclined surface 154 of the expander body 153 comes into contact with the inclined surfaces 165 of the upper set 24 of slip shoes 162. As the double cone expander means 28 is moved upwardly to actuate the upper set 24 of slip members, the serrated portions 164 of the slip shoes 162 are brought into gripping engagement with the inner periphery of the casing 11 and anchor the bridge plug 10 within the casing 11. The upward movement of the body 12 moves the tubular member 142 upwardly thereby causing the inner limit pins 146 carried thereby to slide upwardly within the apertures 184 provided in the plate 182 secured to the mandrel 36. The drag members 17 carried by the tubular member 142 will also move upwardly within the longitudinal slots 174 provided in the lower sleeve 22. The fluid pressure below the bridge plug 10 then exerts a pressure within the relieved portion 94 of the packing cup 34 so that the outer surface 92 thereof tightly engages the inner periphery of the casing 11 and efficiently packs-off the fluid under pressure in the region below the plug 10. A fluid pressure exerted on the shoulder 129 of the valve member 124 also urges the valve 122 more tightly closed. Thus, it is evident that a fluid pressure exerted in the well casing 11 below the bridge plug 10 will automatically anchor the plug 10 within the casing 11 against longitudinal movement therein.

When it is desired to elevate the plug 10 within the casing 11 for the purpose of either retrieving the plug or positioning it in another location the operation is quite simple. A suitable running-in string (not shown) is secured to the control head 38 in a suitable manner, as is well known in the art. When the running-in string is elevated to exert an upward force on the mandrel 36 the upper shoulder 102 thereof engages the valve member 106 to open the upper valve 105. Fluid which may be present in the region above the bridge plug 10 then flows through the ports 46, the open valve 105, the bore 50, and exerts a pressure upon the valve member 124 of the lower valve 122. When the pressure of the fluid within the bore 50 is sufficient to overcome the bias of the spring 134, the valve 122 is opened, thereby allowing fluid within the bore 50 to flow through the ports 56 in the lower valve cage 54 and into the region in the well casing below the bridge plug 10. The sealing ring 64 in the plug 60 precludes fluid which is passing through the bores 50 and 58 from leaking downwardly into the bore 138, thereby substantially precluding foreign objects which may be carried in well fluid from jamming the operation of the mandrel 36 within the body 12. It will be seen that pieces of rock bit, sand, casing, and other foreign objects which may be present in the well fluid in a region within the casing 11 above the bridge plug 10 may pass by the upper packing cup 32 since no fluid pressure is being exerted thereon to seal its outer surface 76 against the inner periphery of the well casing 11. The foreign objects which pass by the upper packing cup 32 will easily thereafter pass by the lower packing cup 34 and fall downwardly into the region below the bridge plug 10. Thus, the novel construction of the bridge plug 10 precludes the plug 10 being sanded up or jammed by foreign objects such as pieces of drill bit, pieces of casing, and the like which may be carried by a well fluid.

As the control mandrel 36 is moved upwardly within the body 12 of the bridge plug 10, the plate 182 carried thereby moves upwardly as to allow the inner limit pins 146 and the outer limit pins 176 to slide freely downward through the apertures 184 and 186 respectively. The plate 182 then engages the bottom surface 150 of the lower tubular member 142 and the bottom surface 180 of the lower sleeve 22 thereby maintaining the sleeve 22 and the member 142 in an aligned position. In this position, the surfaces 150 and 180 lie within the same horizontal plane, as shown clearly in FIG. 1. With the lower sleeve 182 and the inner tubular member 142 in an aligned position, the double cone expander means 28 will then be placed in a neutral or disengaged position. The neutral position of the double cone expander means 28 is as shown in FIG. 2 wherein the expander body 153 is precluded from actuating either the upper set 24 or the lower set 26 of slip members as the bridge plug is moved longitudinally within the well casing 11.

From the foregoing, it will be apparent that the present invention provides a novel retrievable bridge plug which may be anchored in a packed-off condition in a well conduit against movement in either longitudinal direction. This retrievable bridge plug is set automatically within a well conduit by being lowered into the conduit to a desired location by a suitable run-in string. The novel retrievable bridge plug automatically packs-off fluid pressure exerted within the well casing either above or below the bridge plug. A fluid pressure exerted within the casing above the plug automatically anchors the plug within the casing by setting a lower set of slip members and packs-off pressurized fluid. Similarly, fluid pressure exerted within the well casing below the bridge plug automatically anchors the plug by setting an upper set of slip members and packs-off the fluid under pressure.

It is also apparent, that the novel retrievable bridge plug embodys an improved arrangement for precluding actuation of the slip members carried by the plug during longitudinal movement of the plug within the casing. When the plug is being longitudinally positioned within the well casing it is connected to a suitable running-in string. The running-in string operates a mandrel that places a double cone expander means for actuating the slip members in a neutral position thereby precluding the bridge plug being anchored within the well casing. Furtheremore, since the mandrel of the bridge plug comprises a solid rod with an enlarged portion formed thereon, the possibility of the mandrel breaking during operation and causing the plug to be irretrievably anchored within the well casing has been materially reduced. Also, it is apparent that the present invention provides a novel retrievable bridge plug which primarily directs foreign objects carried by a well fluid by the outer portion thereof and at most through only the upper portion of the body so

as to preclude the bridge plug from being sanded up or foreign objects jamming the mechanism thereof so that the bridge plug is irretrievably anchored within the well casing. Finally, it will be apparent that the present invention provides a novel retrievable bridge plug which is simple and rugged in construction, which may be economically manufactured, and which has a long service life.

Changes may be made in the combination and arrangement of parts or elements as heretofore set forth in the specification and shown in the drawings, it being understood that changes may be made in the precise embodiment disclosed without departing from the spirit and scope of the invention as defined in the following claims.

We claim:

1. A bridge plug adapted to be retrievably positioned within a well casing, comprising:

a body adapted for longitudinal movement within a well casing;

sleeve means slidably disposed on the body;

drag means carried by the sleeve means and adapted to slidably position the sleeve means within the casing;

upper and lower slip members carried by the sleeve means and adapted to be actuated into gripping engagement with the well casing for anchoring the bridge plug within the well casing;

a double cone expander means carried by the body between and adapted to actuate said slip members;

sealing means carried by the body above the sleeve means and slip members and adapted to cooperate with the well casing for sealing off fluid pressure both above and below the plug, said sealing means being responsive to fluid pressure exerted thereon to longitudinally slide the body relative to the sleeve means so that the expander means actuates said slip members into gripping engagement with the casing; and

valve means carried by the body for directing fluid through the body when the plug is longitudinally moved within the casing.

2. A bridge plug adapted to be retrievably positioned within a well casing by means of a running in string, comprising:

a tubular body having upper and lower portions and adapted to be positioned within a well casing;

a sleeve means slidably disposed on the lower portion of said body;

upper and lower slip members carried by the sleeve means and adapted to be actuated into gripping engagement with the well casing;

means for actuating the slip members into engagement with said casing, said means including a double cone expander member located on said tubular body between said upper and lower slip means;

sealing means carried by the upper portion of the body, said sealing means being responsive to fluid pressure exerted within the casing and below the plug to actuate the upper slip members and being responsive to fluid pressure exerted within the casing and above the plug to actuate the lower slip members;

valve means carried by the body and adapted to direct fluid flow through the upper portion of the body when the plug is moved longitudinally within the casing; and

means carried by the body for cooperation with the sleeve means to preclude actuation of the slip members during raising and lowering of the plug within the casing and to permit actuation of said slip members without rotation of the running in string.

3. A bridge plug adapted to be retrievably positioned within a well casing, comprising:

an elongated tubular body having upper and lower portions;

spaced upper and lower connected outer sleeves slidably positioned on the lower portion of the body;

a plurality of drag members carried by the sleeves for frictionally engaging the well casing;

a plurality of slip members carried by each sleeve;

expander means carried by the lower portion of the body between said sleeves for actuating the slip members;

sealing means carried by the upper portion of the body, said means being responsive to a fluid pressure exerted within the casing to cause the body to move relative to the outer sleeves whereby said expander means actuates slip members carried by one of said outer sleeves and anchors the bridge plug within the well casing;

valve means for directing fluid flow through the upper portion of the body when the bridge plug is longitudinally moved within the casing; and

means for precluding the actuation of the slip members during vertical positioning of the plug within the well casing.

4. A bridge plug adapted to be retrievably positioned within a well casing, comprising:

an elongated tubular body having upper and lower portions and adapted for longitudinal movement within a well casing;

sleeve means adapted for longitudinal movement with respect to said body;

drag members carried by the sleeve means for frictionally engaging the well casing;

upper and lower slip members carried by the sleeve means;

an expander means carried by said body between said upper and lower slip members and adapted to actuate the slip members into gripping engagement with the well casing for anchoring the bridge plug within the well casing;

upper and lower sealing means carried by the body above the upper slip members for sealingly engaging the well casing, said lower sealing means being responsive to a fluid pressure exerted within the casing and below the plug to move the body longitudinally with respect to the sleeve means thereby causing the expander means to actuate the upper slip members, said upper sealing means being responsive to a fluid pressure exerted within the casing and above the bridge plug to move the body longitudinally with respect to the sleeve means thereby causing the expander means to actuate the lower slip members; and

valve means carried by the body for directing fluid through the upper portion of said body when the plug is moved longitudinally within the well casing.

5. A bridge plug as defined in claim 4 wherein the expander means comprises:

an expander body carried by the lower portion of the body and formed with an upper and a lower frustoconical configuration so that upwardly facing and downwardly facing shoulders are provided, the upwardly facing shoulder cooperating with the upper set of slip members for actuating it into gripping engagement with the well casing, the downwardly facing shoulder cooperating with the lower set of slip members for actuating it into gripping engagement with the well casing;

said expander body also being provided with a plurality of circumferentially spaced longitudinal guide slots which receive the drag members carried by the sleeve means and thereby preclude the upwardly or downwardly facing shoulders of the expander body distorting the drag members when the body is moved longitudinally with respect to the sleeve means.

6. A bridge plug adapted to be retrievably positioned within a well casing, comprising:

a tubular body having upper and lower portions;

a plurality of drag members carried by the body for frictionally engaging the well casing;
upper and lower connected sleeves slidably positioned on said body;
a plurality of drag members carried by the sleeves for frictionally engaging the well casing;
upper and lower slip members carried by the upper and lower sleeves respectively;
expander means carried by the body between said upper and lower slip members and adapted to actuate the slip members into gripping engagement with the casing for anchoring the bridge plug within the casing;
upwardly and downwardly extending sealing members carried by the body above the slip members, each sealing member being responsive to a fluid pressure to slide the body relative to said sleeves whereby slip members are actuated by the expander means, said sealing members, when the slip members have been actuated, then being responsive to the fluid pressure to pack-off the fluid under pressure;
valve means carried by the upper portion of the body and operable to direct fluid therethrough when the plug is moved longitudinally within the casing; and
means to preclude actuation of the slip members by the expander means when the plug is moved longitudinally within the well casing.

7. A bridge plug as defined in claim 6 wherein the drag members carried by the lower portion of the body comprise:
a plurality of circumferentially spaced flat spring-like members, each of which has at least one end secured to the lower portion of the body and which has a medial arcuate portion that extends through a longitudinal slot provided in the lower sleeve for frictionally engaging the well casing.

8. A bridge plug adapted to be retrievably positioned within a well casing, comprising:
an elongated tubular body having upper and lower portions;
an outer sleeve means slidably positioned on said body;
a plurality of upper and lower slip members carried by the outer sleeve means;
friction means carried by the sleeve means for engaging the casing;
a double cone expander means carried by the body between the upper and lower slip members and adapted to cooperate with said slip members for urging them into gripping engagement with the inner periphery of the casing;
upwardly and downwardly extending packing cups carried by said body above said slip members for sealingly engaging the casing, said downwardly extending cup being responsive to a fluid pressure exerted within the well casing and below the plug to slide the body longitudinally within the outer sleeve means, thereby bringing the expander means into contact with the upper slip members for urging them into gripping engagement with the inner periphery of the well casing, said upwardly extending cup being responsive to a fluid pressure exerted within the well casing and above the plug to slide said body longitudinally within the outer sleeve means and bring the expander means into contact with the lower slip members, thereby urging them into gripping engagement with the inner periphery of the well casing; and
valve means carried by said body and operable to permit fluid flow through the upper portion of the body when the plug is moved longitudinally within said well casing.

9. A bridge plug adapted to be retrievably positioned within a well casing, comprising:
an elongated body having a central bore and being longitudinally movable within a well casing;
friction means carried by the body for engaging the casing;
upper and lower outer sleeves slidably positioned on said body;
drag means connecting said sleeves in spaced longitudinal relationship and frictionally engaging the well casing;
upper and lower sets of slip members carried by said upper and lower sleeves respectively;
expander means carried by the body intermediately of said sleeves and adapted to actuate either set of slip members into gripping engagement with the well casing;
upwardly and downwardly extending packing cups carried by the body above said upper and lower outer sleeves, each of said respective packing cups being responsive to a fluid pressure exerted thereon to slide the body relative to said outer sleeves whereby the expander means actuates a set of slip members into gripping engagement with the casing and anchors the bridge plug within the well casing, said packing cups also being responsive to a fluid pressure to pack-off a fluid under pressure;
a mandrel slidably positioned within said body;
valve means carried by the body and actuated by said mandrel to direct fluid through the body when the bridge plug is moved longitudinally within the casing; and
means cooperating with the mandrel to preclude actuation of either set of slip members by the expander means when the plug is moved longitudinally within the well casing.

10. A bridge plug as defined in claim 9 wherein the valve means comprises:
a tubular member included in the upper portion of said body and provided with a plurality of ports at a medial portion thereof;
an upper valve cage provided with ports and secured to the upper end of said tubular member;
a lower valve cage provided with ports and secured to the lower end of said tubular member;
an upper valve seat in the upper portion of the tubular member and a lower valve seat in the lower portion of the tubular member;
a normally closed, spring loaded valve member carried in the upper valve cage and a spring loaded normally closed valve member carried in the lower valve cage; and
said mandrel slidably extending longitudinally through said valve cages and tubular member and having an enlarged portion between the upper and lower valve cages and cooperating with said spring loaded, normally closed valves upon longitudinal movement of the mandrel to open one of said valve members to permit fluid to flow through the opened valve member and through the ports provided in the tubular member.

11. A retrievable bridge plug, comprising:
a centrally bored body having upper and lower portions;
friction means carried by the body for engaging a well casing;
upper and lower outer sleeves slidably disposed on said body;
an upper set and a lower set of slip members carried by the upper and lower sleeves respectively;
expander means carried by the body intermediately of said sleeves and adapted to actuate the slip members into gripping engagement with the well casing thereby anchoring the bridge plug within the casing;
drag means connected to the sleeves and being adapted to frictionally engage the well casing;
upwardly and downwardly extending sealing members carried by the upper portion of the body above said slip members, said upwardly extending sealing member being responsive to a downwardly directed force exerted by a fluid under pressure within the casing above the plug to slide the body relative to said

sleeves whereby the expander means actuates the lower set of slip members into gripping engagement with the casing, said downwardly extending sealing member being responsive to an upwardly directed force exerted by a fluid under pressure within the casing below the plug to slide the body relative to the sleeves whereby the expander means actuates the upper set of slip members into gripping engagement with the casing, said sealing members also being responsive to a continued fluid pressure to pack-off the fluid under pressure from the other portion of the well casing;

valve means carried by the body and operable to direct fluid through the upper portion of the body when the plug is moved longitudinally within the casing; and

means to preclude the expander means actuating either set of slip members when the apparatus is moved longitudinally within the well casing.

12. A bridge plug as defined in claim 11 wherein each set of slip members comprises:

a plurality of circumferentially spaced slip shoes which are provided with an outer portion adapted for gripping engagement with a well casing and which are connected to each of said sleeves through flat, spring-like members, each of the slip shoes also being provided with an inner shoulder which is adapted to cooperate with the expander means so that the slip shoe may be actuated into gripping engagement with the well casing and the bridge plug may be anchored therewithin.

13. A bridge plug adapted to be retrievably positioned within a well casing, comprising:

an elongated tubular body having upper and lower portions and being adapted for longitudinal movement within a well casing;

a plurality of circumferentially spaced drag members carried by the lower portion of the body and adapted to frictionally engage the well casing;

a sleeve means including an upper sleeve and a lower sleeve slidably positioned on the lower portion of the body;

an upper set of slip members carried by the upper sleeve and a lower set of slip members carried by the lower sleeve, said upper and lower sets of slip members adapted to be actuated into gripping engagement with the well casing;

an expander means located on said body between said upper set and lower set of slip members and adapted to alternately actuate the upper and lower sets of slip members;

a plurality of circumferentially spaced drag members carried by the sleeve means and adapted to frictionally engage the well casing;

upwardly and downwardly extending packing cups carried by the upper portion of the body and adapted to sealingly engage the well casing, the upper packing cup being responsive to a fluid pressure exerted within the well casing and above the bridge plug to slide the body longitudinally within the sleeve means so that the expander means actuates the lower set of slip members into gripping engagement with the well casing, said lower packing cup being responsive to a fluid pressure exerted within the well casing and below the bridge plug to slide the body longitudinally within the sleeve means so that the expander means actuates the upper set of slip members into gripping engagement with the well casing, each of said packing cups being further responsive to continued fluid pressure to pack-off that pressure from the other portion of the well casing;

valve means carried by the upper portion of the body and adapted to permit fluid to flow through the upper portion of the body when the plug is moved longitudinally within the well casing, whereby fluid pressures on either end of the plug may be substantially equalized;

a mandrel slidably disposed within the body and adapted to operate the valve means; and

means cooperating with said mandrel to preclude actuation of the sets of slip members when the plug is moved longitudinally within the well casing.

14. A bridge plug as defined in claim 13 wherein the means to preclude actuation of the sets of slip members comprises:

a plate carried at the lower end of the mandrel and spaced from the lower ends of the sleeve means and the body;

a plurality of downwardly extending, circumferentially spaced limit pins carried by the lower portion of the body;

a plurality of downwardly extending, circumferentially spaced limit pins carried by the sleeve means;

said plate being provided with a plurality of apertures through which the limit pins slidably extend;

stop means on the limit pins to limit the distance the plate is spaced from said lower ends of the body and sleeve means;

the plate cooperating with the limit pins to bring the body and sleeve means into a desired alignment during longitudinal movement of the bridge plug within the well casing so that the expander means is precluded from actuating either set of slip members during said movement.

15. A bridge plug adapted to be retrievably positioned within a well casing, comprising:

an elongated tubular body having upper and lower portions and adapted for longitudinal movement within a well casing;

a sleeve means including an upper sleeve and a lower sleeve which are slidably positioned on the lower portion of the body;

a plurality of circumferentially spaced drag members connecting the upper and lower sleeves in a spaced relationship and adapted to frictionally engage the well casing;

an upper set of slip members carried by the upper sleeve and a lower set of slip members carried by the lower sleeve, said upper and lower sets of slip members adapted to be actuated into gripping engagement with the well casing for anchoring of the bridge plug within the well casing;

an expander means carried by the body intermediately of the upper and lower sleeves and adapted to alternately actuate the upper and lower sets of slip members;

upwardly and downwardly extending packing cups carried by the upper portion of the body and adapted to sealingly engage the well casing, the upper packing cup being responsive to a fluid pressure exerted within the well casing and above the bridge plug to slide the body longitudinally within the sleeve means so that the expander means actuates the lower set of slip members into gripping engagement with the well casing and being responsive to continued fluid pressure to pack-off that pressure from the portion of the well casing below the bridge plug, said lower packing cup being responsive to a fluid pressure exerted within the well casing and below the bridge plug to slide the body longitudinally within the sleeve means so that the expander means actuates the upper set of slip members into gripping engagement with the well casing and being responsive to continued fluid pressure to pack-off that pressure from the portion of the well casing above the bridge plug;

valve means carried by the upper portion of the body and adapted to permit fluid to flow therethrough when the plug is moved longitudinally within the well casing so that fluid pressures on either end of the plug may be substantially equalized and foreign objects carried by the well fluid may easily pass around the plug during longitudinal movement thereof;

a mandrel slidably disposed within the body and adapted to operate the valve means;

means operated by the mandrel for bringing the sleeve means and the body into a desired alignment during longitudinal movement of the plug within the well casing so that the expander means is precluded from actuating the sets of slip members during said movement.

16. A bridge plug as defined in claim 15 wherein the means to preclude actuation of the sets of slip members comprises:

a plate carried at the lower end of the mandrel;

a plurality of downwardly extending limit pins carried by the lower portion of the body;

a plurality of downwardly extending limit pins carried by the sleeve means;

said plate being provided with a plurality of apertures through which the limit pins extend;

the plate cooperating with the limit pins to bring the body and sleeve means into a desired alignment during longitudinal movement of the plug within the well casing so that the expander means is precluded from actuating either the upper set or lower set of slip members.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,158,202 November 24, 1964

William R. Lewis et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 75, for "portion" read -- shoulder --; column 10, line 32, for "FIG. 1" read -- FIG. 11 --.

Signed and sealed this 20th day of April 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents