

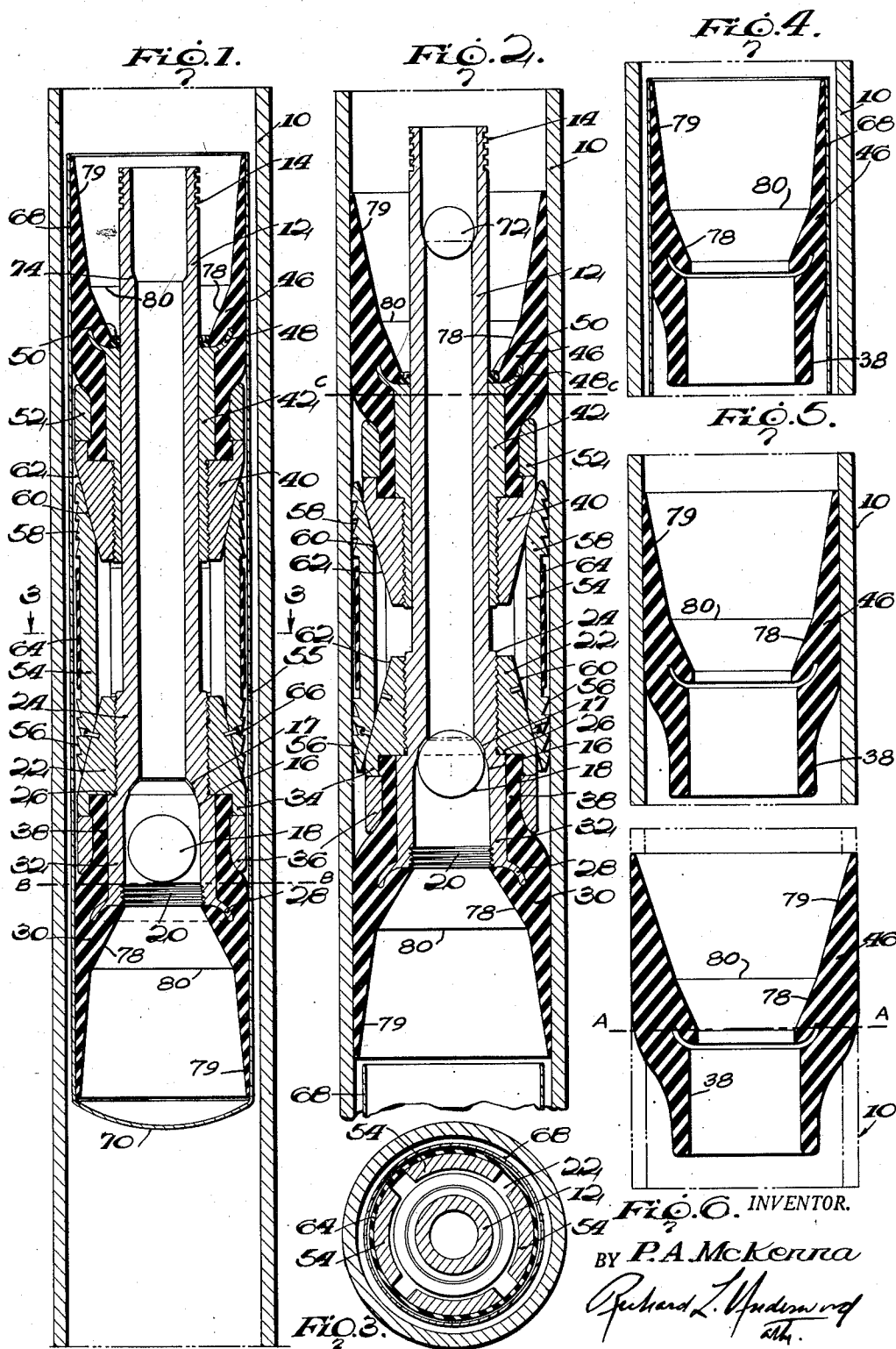
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CEMENT RETAINER AND BRIDGE PLUG

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CEMENT RETAINER AND BRIDGE PLUG

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This invention relates to cement retainers and bridge plugs used primarily in oil and gas wells to block off or cement selected strata temporarily and in some instances permanently.

An object of the invention is to facilitate the operation of packing off the selected strata at depths where the pressure may be exceedingly high. In the drilling operations being carried on today depths of from two to three miles are not uncommon. Such depths are frequently necessary in exploratory work before any sign of oil-bearing strata is developed and the pressure in the well at such depths is considerable. My improved arrangement insures that an effective seal may be maintained under the pressures developed at these depths and consequently permits an effective cementing or bridging job.

Another object of the invention is to simplify the construction of a cement packer without in any way detracting from the effectiveness of its operation in performing its intended function, thereby reducing the cost of production which is a considerable factor inasmuch as such retainers may be used only once and a number of them may be necessary during the completion of a single well.

Still a further object of the invention is to so construct and arrange the constituent elements of the mechanism that there is no possibility of jamming any of the parts while the retainer is being lowered and set in the well. To this end I provide a tubular sleeve surrounding the entire retainer during the operation of lowering it into the well, thereby precluding any possibility of the slips which ultimately grip the wall of the well casing expanding before the desired level is reached and interfering with the lowering operation. Not only does the sleeve or tube perform the important function just mentioned, but it is so arranged in conjunction with the elements of the retainer or packer per se as to bring about an important cooperative function in obtaining the exceptionally effective seal which constitutes one of the primary objects of the invention.

In the drawings, wherein like numerals refer to like parts throughout the figures:

Fig. 1 is a longitudinal sectional view of my improved retainer;

Fig. 2 is a similar view after the packing elements and slips have been set;

Fig. 3 is a section through 3-3 of Fig. 1;

Fig. 4 illustrates the form assumed by the cups when restrained by the enclosing boot;

Fig. 5 illustrates the form assumed by the cup when the restraint of the boot is released, and

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Fig. 6 illustrates the principle to which in large measure the effective seal may be attributed.

Referring now to Fig. 1, the numeral 10 indicates a well casing into which the retainer assembly is lowered until it reaches the desired depth. The retainer assembly comprises a tubular mandrel 12 exteriorly threaded with a coarse left-hand thread at its upper end, as indicated at 14. The threaded upper end is adapted for securement to the lower end of a string of pipe with which the retainer assembly is lowered down the casing to the desired level. The lower end of the mandrel 12 is belled outwardly as indicated at 16 and a seat 17 is provided at the base of the enlarged portion for a buoyant ball 18 which is prevented from falling through the lower end of the tube by an apertured closure 20 which is threaded into the lower end of the mandrel to form a cage within which the ball is free to float.

A lower expanding cone 22 is threaded over a shouldered portion 24 of the mandrel and the threaded portion terminates at a cone shoulder 26 which engages a second shoulder on the mandrel lying substantially in the transverse plane of the ball seat 17. The wall of the mandrel 12 at its lower end is flared to form a shoulder 28 extending downwardly and outwardly from the lower end of the mandrel.

About this flange 28 a resilient molded sealing cup 30 is seated so that the portion of the cup on the inside of flange 28 seats against the lower edge of the wall 32 which constitutes the lower extremity of the mandrel and forms the side wall of the cage within which the ball floats. The cup includes a cylindrical neck portion 38 which lies above the flange 28 and circumferentially engages wall 32 throughout its length. The upper end of neck 38 seats against shoulder 26 of expanding cone 22 and lies between the wall 32 of the cage and a peripheral flange 34 depending from the lower margin of the expanding cone 22, and providing an annular pocket for the upper or free end of the neck.

A metallic ring 36 encircles and holds the neck 38 of the sealing cup under substantial compression against the outside of cage wall 32, the ring 36 being of the same outside diameter as that of flange 34 of cone 22 at its lower extremity and abutting against the under face of flange 34.

An upper expanding cone 40 is threadedly engaged with the lower end of a sleeve member 42 which is slidable along the mandrel wall. A second resilient molded sealing cup 46 is seated about a flared flange 48 of sleeve 42 which corresponds to flange 28 and is assembled to sleeve

42 in the manner described in conjunction with lower sealing cup 30. An annular gasket 50 provides a seal between the sealing cup 43 and the wall of mandrel 12. The upper sealing cup 46 is held in position against sleeve 42 by ring 52 in the manner described with reference to the lower sealing cup.

Segmental slips 54 having lower gripping surfaces 56 and upper gripping surfaces 58 are provided with inclined camming faces 60 which are held in engagement with the inclined faces 62 of the expanding cones by means of an elastic ring 64 encircling the central portion of the slip segments. The lower gripping surfaces 56 are held in positive engagement with expanding cone 22 by means of shear pins 66.

Here an important phase of the invention should be pointed out. The sealing cups 30 and 46 are preferably made of synthetic rubber and molded. The cup material may be bonded or unbonded to the metallic supporting flanges 28 and 48, but it has been found that unbonded neoprene rubber gives eminently satisfactory results.

Exclusive of the neck 38 previously described, each cup 30 comprises a base 78 just outwardly of the neck 38 and a lip 79 outwardly of the base 78 and merging therewith on a transverse plane 80. As is apparent, each base 78 is thicker than its associated lip 79. In the form illustrated, the inner periphery of each base 78 tapers outwardly relatively sharply as compared with the taper of the inner surface of each lip 79, whereby the plane 80 is defined by the merger of the inner surfaces of the lip and base of each cup. Obviously, the merger of the lip and base of each cup can be otherwise defined within the scope of the invention as claimed.

As illustrated graphically in Fig. 6, the outside diameter of each of the cups 30 from the free edge of its lip 79 inwardly to a point on its base 78 defined by the transverse plane A—A of Figure 6 which is located substantially in the plane of the outer edge of a flange 28 or 48 is a constant diameter which, when unrestrained, as in Figure 6, is substantially greater than the inside diameter of the casing 10. However, as best seen in Figure 1, when the cups 30 are stretched and compressed for insertion into the boot 68, each is elongated so that the inner terminus of the area of constant diameter extends from the free edge of each lip 79 to a point on the base 78 defined by the transverse plane B—B, Figure 1, which is located between the outer edge of one of the rings 36 or 52 and the root of one of the flanges 28 or 48 but somewhat nearer the associated ring. Likewise, as seen in Figure 2, the inner terminus of the area of constant diameter moves axially outwardly a short distance to the plane of the line C—C, Figure 2, when the boot 68 is removed and the cups expand into engagement with the casing 10. The line or plane C—C is located on the base 78 substantially midway between the outer edge of a ring 36 or 52 and the root of the adjacent flange 28 or 48. Moreover, it is important to note that the major portion of the work in obtaining and maintaining the improved seal is carried on not by the lips 79 of the cups but by the bases 78 thereof. The thickness of the resilient cup material in this circumferential area is greater than the thickness requisite for what may be termed the outer free ends or lips of the cups which lie beyond said area. In the form illustrated the cups are tapered radially outwardly on the inside from the

plane of the shoulders 28 and 48. The outer free ends serve to preclude any possibility of the cup walls folding back or buckling under severe pressures.

It is also important that the resiliency characteristic of the material of which the sealing cups are formed be such that it may be stressed without loss of resiliency to an extent where its outside diameter is less than the inside diameter of the casing. An example may be given, but not by way of limitation, to illustrate the over-size diameter of the sealing cup material, when unrestrained. In a casing having an inside diameter of 4.892 inches the outside diameter of the cups from the region of the flanges 28 and 48 throughout their length, when unrestrained, may be approximately 5.3125 inches and the material should be compressible without loss of its resilient characteristics to an outside diameter of approximately 4.4375 inches. Such an arrangement has been found eminently successful.

A sleeve or boot 68 receives the entire retainer assembly as thus described, the inside diameter of the boot 68 being such as to clear the gripping surfaces of the slips when the latter are in the inoperative position and compress the sealing cups 30 and 46 in the manner heretofore explained. The outside diameter of the boot 68 is, as shown, substantially less than the inside diameter of the casing 10. The boot 68 is open at the top but closed at the bottom as indicated at 70. In positioning the retainer assembly in the boot, the resilient sealing cups, because of their form, substance and relative proportions as heretofore described in reference to the inside wall of the casing, are stretched during the relative sliding movement of the boot and the rest of the assembly. This stretching or longitudinal tensioning is accompanied by a substantial compression of the material. It is believed that the effective seal provided by the cups, and particularly by the circumferential areas adjacent the flanges 28, 48, is largely attributable to the outward radial pressure set up by reaction of the resilient and elastic material when partially released from the combination of tension and compression stresses which had been set up in the material during the assembling of the boot and retainer assembly.

In operation the retainer assembly and boot are lowered into the casing at the end of a string of pipe secured thereto at the upper threaded portion 14 to the desired position. During the lowering operation valves or jars in the pipe string above the retainer are opened and the well fluid enters the retainer from above to equalize the pressure inside and outside the boot, thereby preventing collapse. During the lowering operation the ball 18 floats in its cage. Openings or ports 55 in the wall of the boot adjacent the slips serve to equalize the pressure inside the boot between the cups.

When the retainer reaches the desired level in the well, the pumps at ground level are started and fluid under pressure passes down the pipe string to blow off the boot. The ball 18 cannot blow down with the boot because it is housed in a cage and after the boot has been displaced the ball floats up to seat at the upper end of its cage as soon as the pumps at ground level are cut off. This prevents the well fluid from entering the retainer through the tubular mandrel 12.

When the boot is blown off, the upper and lower sealing cups, released from restraint, expand radially outwardly at once to form a seal-

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ing contact with the well casing. By virtue of the manner in which the sealing cups are associated with the mandrel and the force with which their outer walls grip the inside wall of the casing on release of the compressive and tensile strain due to the boot, an exceptionally strong seal is provided.

The pumps having been shut off after the boot was blown and the sealing cups having set, the pipe string by which the retainer was lowered into the well is pulled up slightly, during which operation the upper cup 46 is held against any possible upward slipping movement by reason of the pressure of the well fluid above it. During this pull-up the upper ends of the slips 15 move over the upper expanding cone to force the upper gripping surface out against the restraining pressure of the elastic ring 64 to engage the wall of the casing. Substantially simultaneously with this movement the shear pins 20 66 are broken and the upward movement of lower expanding cone 22 against the slips forces the lower gripping surfaces 56 outwardly into engagement with the casing wall. This operation is possible because of the fact that the tubular mandrel 12 and the lower expanding cone 22 threaded thereto, with its associated lower sealing cup, is free to slide upwardly with reference to the slips, upper cone and sealing cup assembly.

Subsequent downthrust of the pipe string by which the retainer was lowered assures the set of the upper gripping surfaces 58, the pull-up having been positively stopped when the lower gripping surfaces of the slips engaged the wall of the casing.

After the cementing operation a bridging ball 72 may be dropped down the pipe string to seat upon shoulder 74 adjacent the upper end of the tubular mandrel 12 to seal the retainer from above. The pipe string by which the retainer was lowered is then backed off the tubular mandrel 12. All the metal parts of the assembly are of drillable material.

As aforesaid, the pressures the plug must withstand are tremendous. However, the structure of each of the cups 30 and 46 is such as to withstand much more pressure than can previously known cups. In the first place, as the cups each have a normal outside diameter throughout substantially its entire length which is greater than the inside diameter of the casing 10, each cup is always under compression and is not fully expanded even after the boot 68 has been removed and each cup is engaged with casing 10. This fact enables each cup to resist bursting pressures better than can a cup whose normal diameter is less than that of the casing throughout its length except for the region of the cup lip.

Then, too, the cups of the invention are strengthened in the danger areas by being provided with walls of increased thickness in the regions of the flanges 28 and 48. Also, the flanges 28 and 48 provide internal reinforcements for the cups in the areas where the cups are most vulnerable to bursting pressures.

Finally, the rings 52 and 36 cooperate with the flanges 48 and 28, respectively to prevent the cups 30 and 46 from being stripped from the bases 42 and 32 when the cups are stretched and compressed sufficiently to permit the boot 68 to be applied to the plug. This is an important feature as considerable stress must be imposed on the cups at this time and known bonds between the cup necks and the metal parts

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of the mandrel consistently failed until the cooperative structure of the flanges 28 and 48 with the rings 36 and 52 was achieved. However, this cooperative arrangement of parts has been found to operate effectively even with no other bond between the cups and the mandrel.

What I claim is:

1. In a cement retainer and bridge plug for sealing off the casing of a well at a desired depth, the combination with a central tubular run-in mandrel, of at least one downwardly directed resilient sealing cup fixedly engaged with said mandrel, said cup comprising a relatively thick base and a relatively thinner lip depending therefrom, said lip and at least an adjacent portion of said base providing an elongated cylindrical cup wall having an unrestrained outside diameter throughout its length which is greater than the inside diameter of the casing, a downwardly removable sleeve of lesser diameter than said casing surrounding said cup and holding the same under compression to permit the insertion of said sleeve and cup into said casing, said entire cup wall upon removal of said sleeve being adapted to expand by its own resiliency sufficiently to engage the casing throughout the entire length of said cup wall, and said cup expanding progressively from said base to said lip as said sleeve is removed, whereby said base engages said casing at least slightly before said lip.

2. In a cement retainer and bridge plug for sealing off the casing of a well at a desired depth, the combination with a central tubular run-in mandrel, of at least a lower downwardly directed resilient sealing cup fixedly engaged with said mandrel adjacent the lower end thereof, said cup comprising a relatively thick base and a relatively thinner lip depending therefrom, said lip and at least an adjacent portion of said base providing an elongated cylindrical cup wall having an unrestrained outside diameter throughout its length which is greater than the inside diameter of said casing, removable means normally compressing said cup to a diameter less than the inside diameter of said casing to permit the insertion of said cup and mandrel into said casing, said entire cup wall upon removal of said removable means expanding by its own resiliency into sealing engagement with said casing, and said removable means being removable so that said cup wall expands progressively from said base to said lip, whereby said base engages said casing at least slightly before said lip.

3. In a cement retainer and bridge plug for sealing off the casing of a well at a desired depth, the combination with a central tubular run-in mandrel having upper and lower ends, of upwardly and downwardly directed resilient cups fixedly engaged with said mandrel in the region of said upper and lower ends respectively, each cup comprising a relatively thick inwardly disposed base and a relatively thinner lip extending axially outwardly therefrom, the lip and at least an adjacent portion of the base of each cup together providing an elongated cylindrical cup wall having an unrestrained outside diameter throughout its length which is greater than the inside diameter of said casing, a downwardly removable sleeve of lesser diameter than said casing surrounding both of said cups and holding the same under compression to permit the insertion of said mandrel and cups into said casing, said cup walls upon removal of said sleeve expanding by their own resiliency into sealing engagement with said casing throughout the entire

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lengths of said cup walls, and said downwardly directed cup expanding progressively from said base to said lip as said sleeve is removed, whereby its base engages said casing at least slightly before its lip.

4. In a cement retainer and bridge plug for sealing off the casing of a well at a desired depth, the combination with a central tubular run-in mandrel, of deformable and resilient means surrounding said mandrel and fixed thereto, said sealing means having an upper and lower end, said sealing means having an elongated cylindrical outer surface engageable throughout its length with said casing to seal the latter, said sealing means when unrestrained having an outside diameter throughout the length of said cylindrical outer surface which is substantially greater than the inside diameter of said casing, removable means compressing said sealing means to an outside diameter less than the inside diameter of said casing to permit the insertion of said mandrel and sealing means into said casing, and said removable means being so removable that said sealing means expands progressively from said upper to said lower end, whereby said upper end engages said casing at least slightly before said lower end.

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5. The structure of claim 4, wherein said sealing means is fixed to said mandrel adjacent the lower end thereof, a second and similar resilient and deformable sealing means surrounding said mandrel and fixed thereto adjacent the upper end thereof, said second sealing means being operative in the same manner as said first named sealing means, and said removable means comprising a single, downwardly removable sleeve surrounding both of said sealing means.

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