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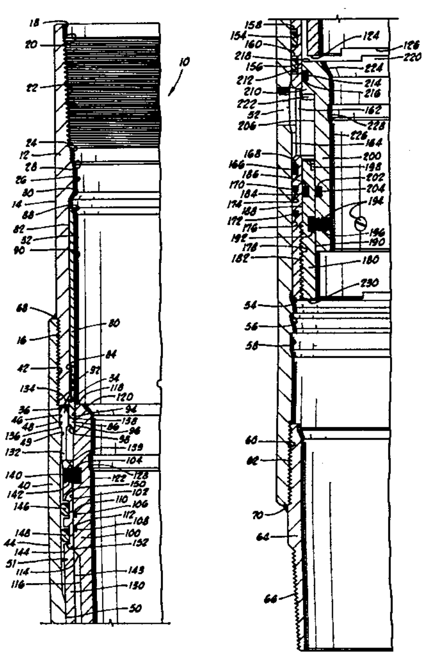
(54) Cement collar and method of use.

(57) A cementing collar for inclusion in a well casing to permit primary multiple stage cementing comprises a tubular housing (12, 40, 64), a cementing port (52) and sleeve means (200) inside the housing and slidable in response to pressure changes to open and close the port.



EP 0 166 568 A2

CEMENT COLLAR AND METHOD OF USE

The present invention relates to a cementing collar for use in the cementing of wells, in particular oil and gas wells.

Cementing a casing or liner in a well bore protects possible oil and/or gas-producing zones surrounding the casing from contamination by subterranean brine sources, as well as corrosion of the casing or liner from brine or other corrosive fluids and electrolysis. In addition, cementing eliminates contamination of fresh water-containing strata by brine or petroleum fluids which could otherwise travel in the well bore annulus. Further benefits of cementing include the prevention of blowouts and fires caused by high pressure gas zones penetrated by the well bore, external physical support of the casing in the well bore, and the plugging of "lost circulation" zones into which oil and gas might otherwise flow.

A cementing operation designed to achieve any of the above-described results is generally termed primary cementing; secondary cementing involves cementing processes used on a well during its productive life, such as remedial cementing and repair of previously cemented areas. The present invention is primarily directed to primary cementing.

In the early days of oil and gas exploration and production, wells were generally very shallow and cementing was accomplished by pumping the cement slurry down the interior of the casing to the bottom thereof and back up the exterior of the casing in the well bore annulus. However, as wells became progressively deeper, it became more difficult to cement an entire well bore annulus from the bottom of the casing. As a result, so called multiple stage cementing was developed to permit cementing of the well bore annulus in several steps.

Multiple stage cementing is effected by first placing tubular cementing "collars" in the casing at predetermined locations as the casing joints are made up and lowered into the well bore. These cementing collars include cementing ports through the walls thereof, which ports may be opened and closed by sliding valve sleeve means.

Cementing collars of this type usually have two sleeves, both of which are usually shearpinned initially in an upper position, closing the cementing ports in the tool. To open the cementing ports a plug, dart or ball is pumped or dropped down the casing and seated on the lower sleeve. The fluid pressure is then increased in the casing until sufficient force is developed on the plug and sleeve to shear the shear pins and move the lower sleeve to the position uncovering the cementing ports. Cement is then flowed down the casing and out of the open ports into the annulus. When the predetermined desired amount of cement has been flowed into the annulus, another plug, dart or ball is placed in the casing behind the cement and flowed down the casing to seat on the upper sleeve. The pressure is increased on the second plug until the shear pins holding it are severed and the upper sleeve is moved down to close the cementing ports.

When a multiple stage cementing operation is then conducted in a well having such cementing collars therein, the first "stage" of cement is placed in the manner described above, e.g. cement slurry is pumped down the casing to the bottom thereof and back up the well bore annulus to the desired level or predetermined level, which may be the level of the first cementing collar. Pumping of the cement slurry is then stopped, and re-entry of the slurry into the casing is prevented by a check valve means at or near the bottom of the casing, generally referred to as a float shoe or float collar. The valve sleeve means in the lowermost cementing collar is then shifted as heretofore noted by a plug, dart or ball pumped or dropped down the casing from the rig floor. Slurry is then pumped through the opened cementing ports in the collar to the level of the next higher collar, then the valve sleeve means is shifted closed by a second plug, dart or ball. The process is then repeated at the next higher collars until the desired length of casing is cemented. Cementing collars which operate as described above are disclosed in U.S. patents nos. 3,768,556, 3,811,500 and 4,246,968.

An alternative cementing collar design is disclosed in U.S. patent no. 3,768,562. The collar disclosed therein has a single valve sleeve which is manipulated with respect to the cementing ports by opening and closing tools incorporated in a tubing string lowered inside the casing, and cement slurry is placed adjacent the opened ports by pumping through the center of the tubing string to an isolation packer adjacent the collar, the isolation packer containing the cement between facing packer cups. When the cementing is finished at one collar, moving the string to the next higher collar causes the closing tool on the string to engage the sleeve, recovering the ports.

While the prior art cementing tools are widely used, all such tools require the use of mechanical means in the casing to open. In the instance of the plug, dart or ball operated tools, when the well operator wishes to pump a plug down to engage a float shoe or collar at the bottom of the casing to shut off the float collar or shoe prior to pressure testing the casing, the plug, dart or ball subsequently employed to open the lowermost cementing collar must be of the free-fall type, as one cannot pump fluid behind the object to drive it down the casing after the float collar or shoe is shut off. While in substantially vertical wells this presents little problem, in highly deviated wells, such as many offshore wells, the well bore angle may deviate 50 degrees or more from the vertical and the plug, dart or ball quite simply takes a great deal of time to fall. In cases of extreme casing deviation, it may not fall all the way and the operator may have to push it down to the collar with drill pipe, a costly and time consuming operation. Another disadvantage of using a free-fall object to open a collar is the inability to wipe, or remove, the thin film of drilling mud on the inside of the casing before passage of the cement slurry and the plug which is pumped behind the slurry to close the tool. Consequently, the last cement to exit the collar to the annulus is highly contaminated with the mud wiped off the casing interior, resulting in a poor cement job adjacent the collar.

A further disadvantage of using free-fall objects results when the operator wishes to circulate through the lowermost cementing collar while the first stage cement sets, and ascertain the level of the top of the first stage of cement which has been pumped through the float shoe or float collar. In order to accomplish this, the plug, dart or ball must be fished out of the casing after it is used to open the cementing collar sleeve, in order to run a temperature probe down the casing interior below the cementing collar to locate the cement level in the annulus.

While a cementing system of the type described in the aforesaid U.S. patent no. 3,768,562 eliminates the use of plugs, darts or balls, it is also difficult to use in highly deviated holes as the weight of the tubing string tends to prevent the opening and closing tools from engaging the collar sleeve, and the isolation packer cups from sealing effectively. Moreover, running a tubing string takes time and money, and does not effect the wiping of mud from the casing interior.

We have now devised a cementing collar which includes a pressure-actuated opening sleeve responsive to an increase in pressure inside the casing, thus eliminating the need for an opening plug, dart or ball, or mechanical manipulation via a tubing string. The present invention thus permits running of a wiper-plug below the cement slurry to clear the casing of mud, and also permits easy temperature surveying of the first stage of cement to ascertain its top.

According to the present invention, there is provided a cementing collar comprising: substantially tubular housing means; cementing port means through the wall of said housing means; and opening sleeve means inside said housing means covering said port means; and pressure responsive sleeve shifting means associated with said opening sleeve means.

The cementing collars and method of cementing of the present invention will be more fully understood by one of ordinary skill in the art by a reading of the following detailed description of one preferred embodiment and operation thereof, given by way of illustration only, take in conjunction with the accompanying drawings, wherein:

FIGS. 1A and 1B comprise half-section vertical elevations of the embodiment of tool of the present invention in its initial, closed mode as run into the well bore.

FIGS. 2A and 2B comprise a view similar to FIGS. 1A and 1B, but with the cementing collar in an open mode.

FIGS. 3A and 3B show the cementing collar of the present invention in a final closed mode as it would appear after cementing has been conducted therethrough.

FIG. 4 is a full section schematic of a casing string incorporating the collar of the present invention showing a wiper plug preceding the cement slurry with the collar in an open mode.

FIG. 5 is a full section enlarged schematic showing the collar of the present invention as it is closed by a plug following the cement slurry pumped through the collar ports.

Referring to FIGS. 1A and 1B, cementing collar 10 of the present invention comprises tubular upper body 12 with cylindrical exterior 14 having external threads 16 on its lower end. The interior of upper body 12 includes entry bore wall 18, followed by radial annular step 20 leading to internal threads 22 by which collar 10 is made up with a casing joint thereabove (not shown). Below threads 22, surface 24 leads to annular shoulder 26, flanked by oblique edges 28 and 30. Below shoulder 26, cylindrical inner wall 32 leads to beveled lower edge

34, terminating at the radially flat bottom edge 36 of upper body 12.

Case 40 is secured by threads 42 to upper body 12, and possesses a substantially uniform cylindrical exterior 44. Below threads 42, collet wall 46 leads to oblique annular shoulder 48, extending radially inward to shallow annular step 49, below which is shallow annular recess 51 in cylindrical wall 50. Wall 50 is pierced by a plurality of circumferentially spaced cementing ports 52, below which a plurality of lock ring notches 54, 56 and 58 are cut. At the bottom of wall 50, internal threads 60 engage external threads 62 of lower body 64, which has a second set of external threads 66 on its lower exterior for connection to a casing joint (not shown). Upper body 12 is welded to case 40 at 68, and case 40 is in turn welded to lower body 64 at 70, to form a unitary assembly.

On the interior of collar 10, thin tubular protective sleeve 80 is slidably disposed within inner wall 32 of upper body 12. Protective sleeve 80 has an upper exterior wall 82, terminating in shallow annular groove 84 near its lower end. Below groove 84, wall 86 thickens and extends radially outward a slight distance beyond wall 82, terminating at its lower end in oblique annular edge 98. The interior of protective sleeve 80 has a beveled entry wall 88, followed by a smooth cylindrical interior wall 90, which is pierced by relief ports 92 opening into groove 84. At the bottom of sleeve 80, internal threads 94 engage external threads 96 of releasing sleeve 100.

Releasing sleeve 100 is generally tubular in shape, but is relatively thick-walled in comparison to protective sleeve 80. Releasing sleeve 100 includes upper exterior wall 102 into which a plurality of apertures 104 are bored. Below apertures 104, grooves 106 and 108 hold O-rings 110 and 112. At the bottom of exterior wall 102, beveled annular edge 114 leads inwardly to lower exterior wall 116 of lesser diameter. The interior of releasing sleeve 100 has a radially flat upper edge 118, the interior of which abuts frustoconical wall 120 extending into cylindrical interior wall 122, leading to the bottom 124 of releasing sleeve 100. A plurality of notches 126 are cut in the bottom 124 of sleeve 100. Plug latch groove 128 is disposed in interior wall 122.

Closing sleeve 130 is disposed between releasing sleeve 100 and case 40. Closing sleeve 130 includes a plurality of circumferentially spaced, longitudinally upward extending collet fingers 132 having lugs 134 at their upper end. Lugs 134 have edges 136 extending outward over annular shoulder 48 in case 40, and longitudinally oriented inner faces 138 against which bears the exterior of wall 86 of protective sleeve 80. Upward facing oblique annular edge 139 is disposed at the radially inner bottom of collet fingers 132. Shear screws 140 extend through threaded apertures 142 in closing sleeve 130 into apertures 104 in releasing sleeve 100. A seal is effected between releasing sleeve 100 and closing sleeve 130 by O-rings 106 and 108 bearing against interior wall 143 of closing sleeve 130. The exterior wall 144 of closing sleeve 130 is of slightly lesser diameter than collet fingers 132. A set of annular seals 146 and 148 are disposed in annular grooves 150 and 152 in wall 144, and are in an uncompressed state as they protrude into shallow annular recess 51 in case 40. A second set of annular seals 154 and 156 are disposed in annular grooves 158 and 160 in exterior wall 144, and sealingly bear against wall 50 of case 40. A plurality of circumferentially spaced valve ports 162 extend through the wall of closing sleeve 130 and open onto annular groove 164 in exterior wall 144 thereof. O-ring 166 in annular groove 168 sealing bears against wall 50 of case 40 below valve ports 162. Wedge lock rings 170 and 172 are disposed in tapered recesses 174 and 176 in closing sleeve 130 below O-ring 166, and are maintained in a radially inwardly compressed state by wall 50.

Opening seat retainer 180 is disposed below valve ports 162 within the lower portion of closing sleeve 130, threads 182 thereof engaging threads 178 of sleeve 130. O-ring 184, disposed in groove 186 in exterior wall 188 of retainer 180 bears against interior wall 143, effecting a seal between closing sleeve 130 and opening seat retainer 180.

Interior wall 190 of retainer 180 is pierced by apertures 192, into which a plurality of shear screws 194 extend through threaded apertures 196 in the wall of opening sleeve 200, which is disposed within retainer 180. O-ring 202 in groove 204 in exterior wall 206 of opening sleeve 200 bears against interior wall 190 of retainer 180, effecting a seal between opening sleeve 200 and seat retainer 180. Annular recess 198 extends around the interior of seat retainer 180 at the top of wall 190.

At the top of opening sleeve 200, flange 210 extends radially outward over seat retainer 180, and the outer face 212 of flange 210 contains annular groove 214 therein, wherein O-ring 216 is disposed, bearing against interior wall 143 of closing sleeve 130. The top of flange 210 comprises a radially flat surface 218, above which a plurality of upstanding circumferentially extending studs 220 extend in alignment with notches 126 in releasing sleeve 100. At the bottom of flange 210, a plurality of lugs 222 extends downwardly therefrom. On the interior of opening sleeve 200, oblique entry wall 224 leads to cylindrical bore 226, within which an annular plug groove 228 is disposed. At the bottom of opening sleeve 200 is radially flat annular surface 230.

Referring now to FIGS. 1-5 of the drawings, the operation of the cementing collar of the present invention will be described in detail. When a well is to be cemented in several stages, a collar or collars 10 of the present invention are incorporated in the casing as casing joints are made up and run into the well bore. Collar 10 is in its initial, closed mode as shown in FIGS. 1A and 1B as it is run into the well bore.

As shown in FIG. 4, when running the casing 302 into well bore 300 is completed, the first stage of cementing is begun, with cement slurry being pumped down the casing bore 304 to a float shoe 306 at the bottom of the casing, and out into annulus 308 between the casing 302 and the wall 310 of the well bore 300. Pumping of the slurry is continued until the cement level in the annulus reaches a desired level 312, which may be adjacent the lowermost cementing collar 10 of the present invention. As noted previously in the background of the invention, the well operator may then wish to pressure test the casing 302 prior to initiating the second stage of cementing. In this case, shut-off plug 313 is pumped to float shoe 306 to shut off thereon and prevent increased casing pressure from opening the check valve in float shoe 306. The casing may then be pressured up to the desired level.

While pressure is being applied for the test, it can if desired be further increased so as to shift opening sleeve 200 downward, opening the casing bore 304 to the annulus 308 through valve ports 162 and cementing ports 52. (See FIGS. 2A and 2B, and FIG. 4). The aforesaid shifting is effected by the longitudinal pressure differential across opening sleeve 200, when the force generated by casing pressure acting on the larger area provided by the top surface 218 of flange 210 exceeds the force generated by the same pressure acting upon bottom surface 230, by the amount of force required to sever shear screws 194 securing opening sleeve 200 to opening seat retainer 180. By varying the number and metallurgical composition of shear screws 194, opening sleeve 200 in different collars 10 in the same casing may be caused to shear at different pressures, an opening sleeve 200 in a lower collar 10 being shifted at a lower pressure than the opening sleeve 200 in a higher collar 10 next above.

As shown in FIG. 4, the operator can circulate through the opened collar 10 while the first stage of cement is setting, and run a temperature probe through and below the unobstructed bore of collar 10 and casing bore 304.

Upon commencing the second stage of cementing, a wiper plug 314 may be run ahead of the second stage cement slurry 316 in order to wipe the casing interior of drilling mud, which as noted previously, contaminates the cement and impairs the performance. When wiper plug 314 reaches collar 10, it moves therethrough to a position just below ports 162 and 52, as shown in FIG. 5, pushing most of the drilling mud through ports 162 and 52 and out into the annulus 308. The second stage cement slurry then exits collar 10 and fills the annulus above collar 10 to the next higher collar 10, if any, or to any other desired level.

At the top of the second stage cement slurry column, closing plug 318 is released by the well operator, and is pumped down casing 302 to contact releasing sleeve 100, shouldering on wall 120 thereof. The pressure above closing plug 318 will cause severing of shear screws 140 securing releasing sleeve 100 to closing sleeve 130, which permits downward movement of releasing sleeve 100 until downward facing edge 98 of wall 86 contacts upward facing edge 139 on closing sleeve 130. This movement removes the outward bias against the inner faces 138 of collet lugs 134 by wall 86 of protective sleeve 80. As a result, continued application of pressure above closing plug 318 will cause lugs 134 on collet fingers 132 to move radially inwardly, whereupon closing sleeve 130 moves downwardly with releasing sleeve 100, protective sleeve 80, opening sleeve 200 and opening seat retainer 180 to the position shown in FIGS. 3A, 3B and 5, wherein sets of seals 146 and 148 and seals 154 and 156, respectively, on closing sleeve 130 are positioned above and below cementing ports 52 in case 40, shutting off annulus 308 from casing bore 304. Closing sleeve 130 is locked in the position shown in FIGS. 3A, 3B and 5 by the expansion of wedge lock rings 170 and 172 into two of notches 54, 56 and 58.

Of course, if when casing pressure is initially applied to shift opening sleeve 200, sleeve 200 is jammed or otherwise will not shift, for example due to the use of incorrect shear screws of the wrong number thereof, a conventional free-fall opening plug may be dropped as an emergency measure and pressure applied across the entire cross-sectional area thereof, so as to shift sleeve 200 to its open mode.

Thus it is apparent that a novel and unobvious cementing collar and method of cementing has been invented. The present invention permits the opening of cementing collar ports without mechanical means, and regardless of the degree of well bore deviation. Moreover, the collar of the present invention permits the use of a wiper plug prior to the second stage of cement, and facilitates the placement of instrumentation used to locate cement level in the annulus.

Of course, many additions, deletions and modifications may be made to the preferred embodiment of the invention as described herein without departing from the spirit and scope of the invention as claimed. For example, and not by way of limitation, the shear screws employed in the preferred embodiment might be deleted and expandable locking rings employed to retain components together until a specified level of force is employed; the closing sleeve and the opening seat retainer might be fashioned as a single piece; shear means rather than collet fingers might be used to secure the closing sleeve to the case of the collar; the outer housing of the collar might be machined as one piece; and others.

CLAIMS:

1. A cementing collar comprising: substantially tubular housing means (12,40,64); cementing port means (52) through the wall (50) of said housing means; and opening sleeve means (200) inside said housing means covering said port means; and pressure responsive sleeve shifting means (218) associated with said opening sleeve means.

2. A collar according to claim 1, wherein said sleeve shifting means is adapted to shift said opening sleeve means in response to a pressure increase inside said housing means.

3. A collar according to claim 2, wherein said sleeve shifting means comprises flange means disposed at one end of said opening sleeve means.

4. A collar according to claim 3, wherein said flange means is disposed at the top of said opening sleeve means.

5. A collar according to any of claims 1 to 4, further including opening seat retainer means (180) disposed between said housing means and said opening sleeve means, said opening sleeve means being slidable with respect to said opening seat retainer means, and shearably secured thereto.

6. A collar according to claim 5, further including closing sleeve means (130) disposed between said opening seat retainer means, to which it is secured, and said housing means, said closing sleeve means having valve port means (162) therethrough aligned with said cementing port means.

7. A collar according to claim 6, further including releasing sleeve means (100) slidably disposed within and shearably secured to said closing sleeve means above said opening sleeve means.

8. A collar according to claim 7, further including collet means (132) associated with said closing sleeve means and adapted to prevent longitudinal shifting thereof with respect to said housing means by said releasing sleeve means while said releasing sleeve means is secured to said closing sleeve means.

9. A collar according to claim 8, wherein said releasing sleeve means further includes tubular protective sleeve means (80) at the top thereof and extending upward therefrom.

10. A collar according to claim 8 or 9, further including sleeve locking means (170,172) associated with said housing means and said closing sleeve means and adapted to lock said closing sleeve means in a position wherein said valve port means are misaligned with said cementing port means.

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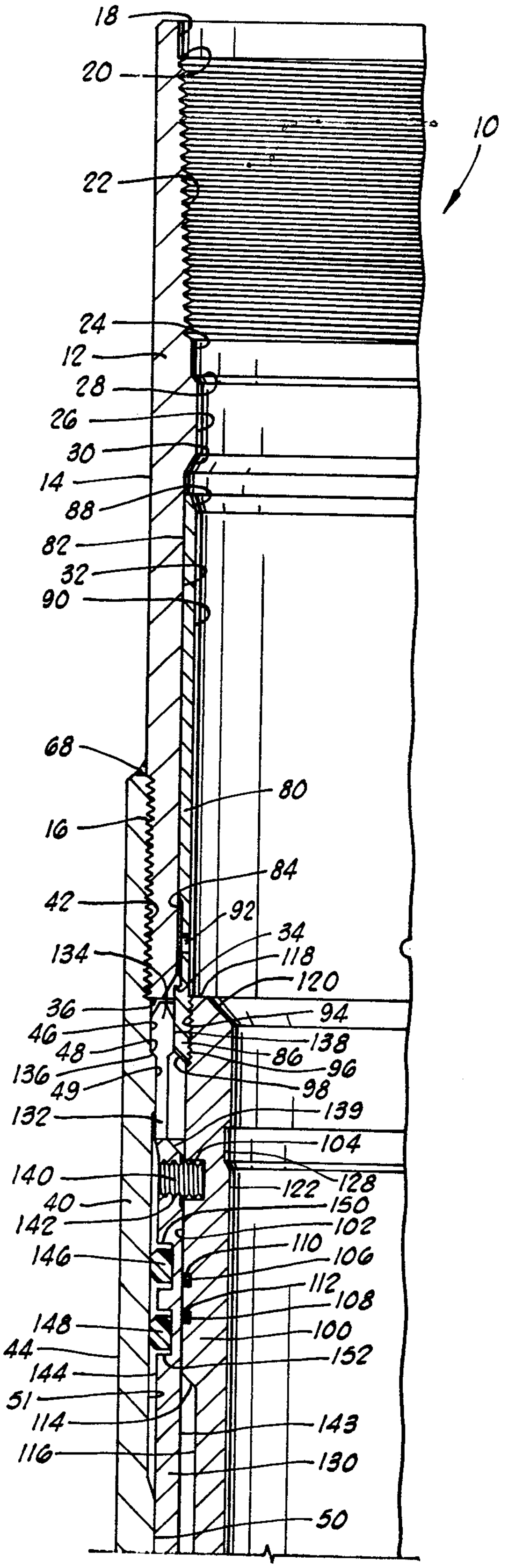

FIG. 1A

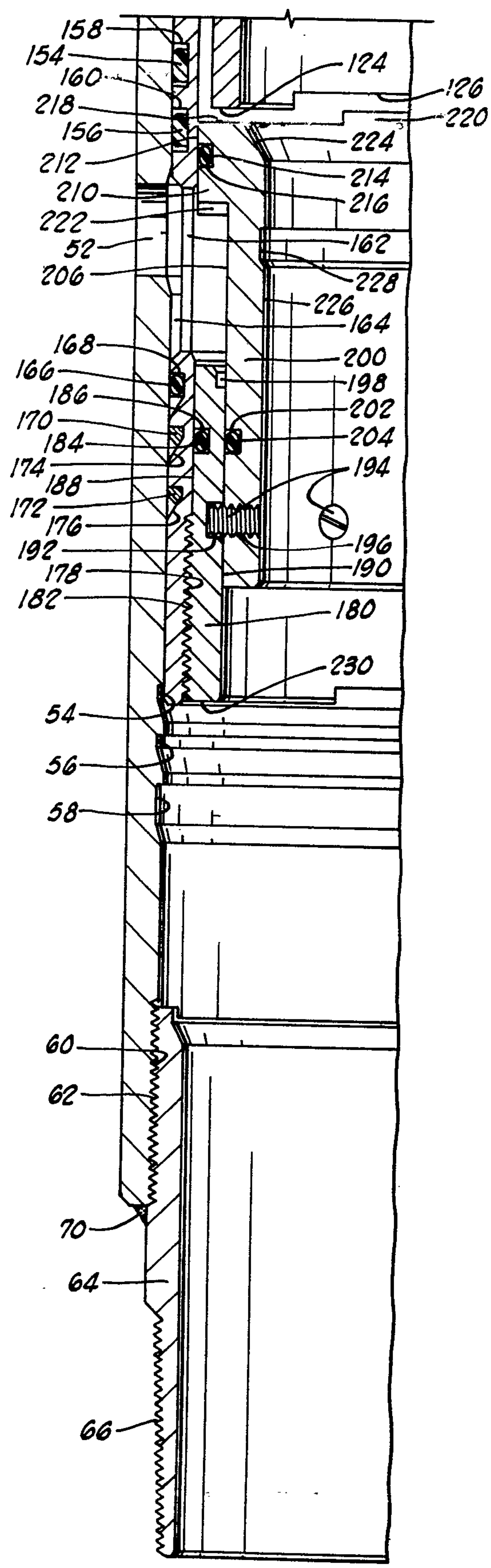

FIG. 1B

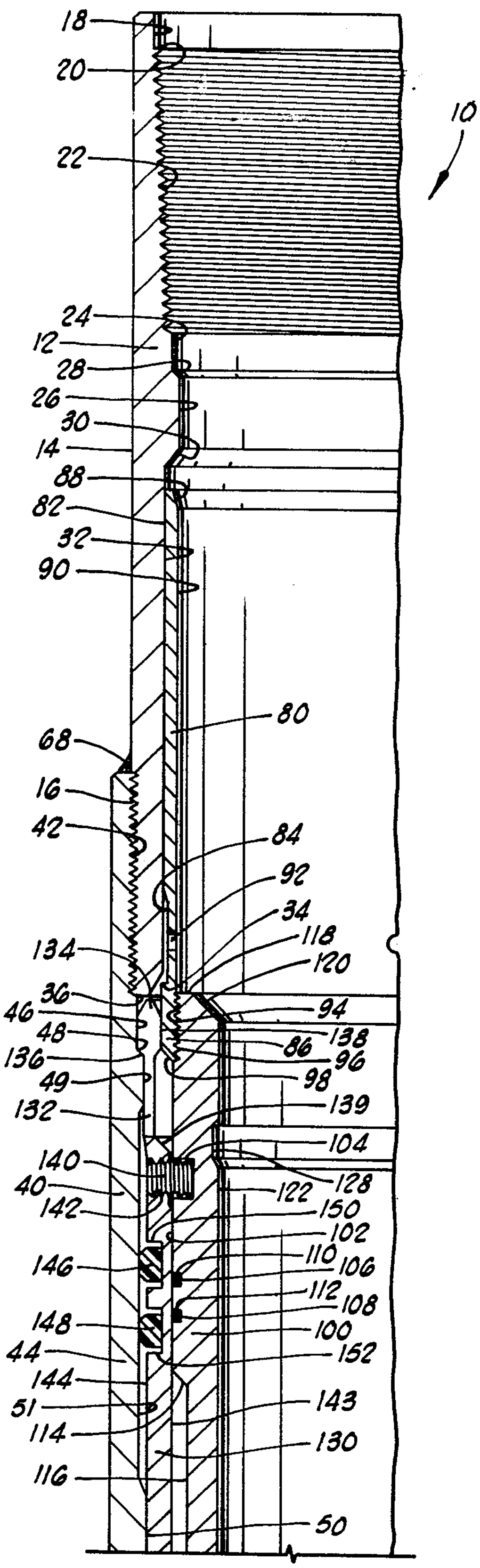
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FIG. 2A

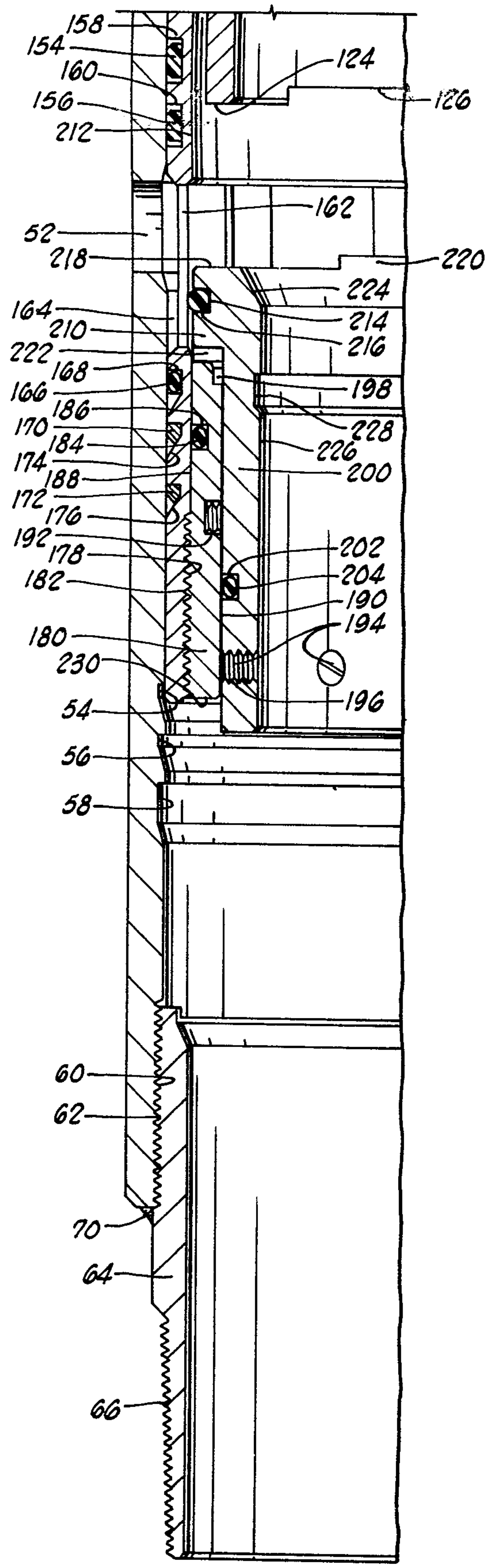
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FIG. 2B

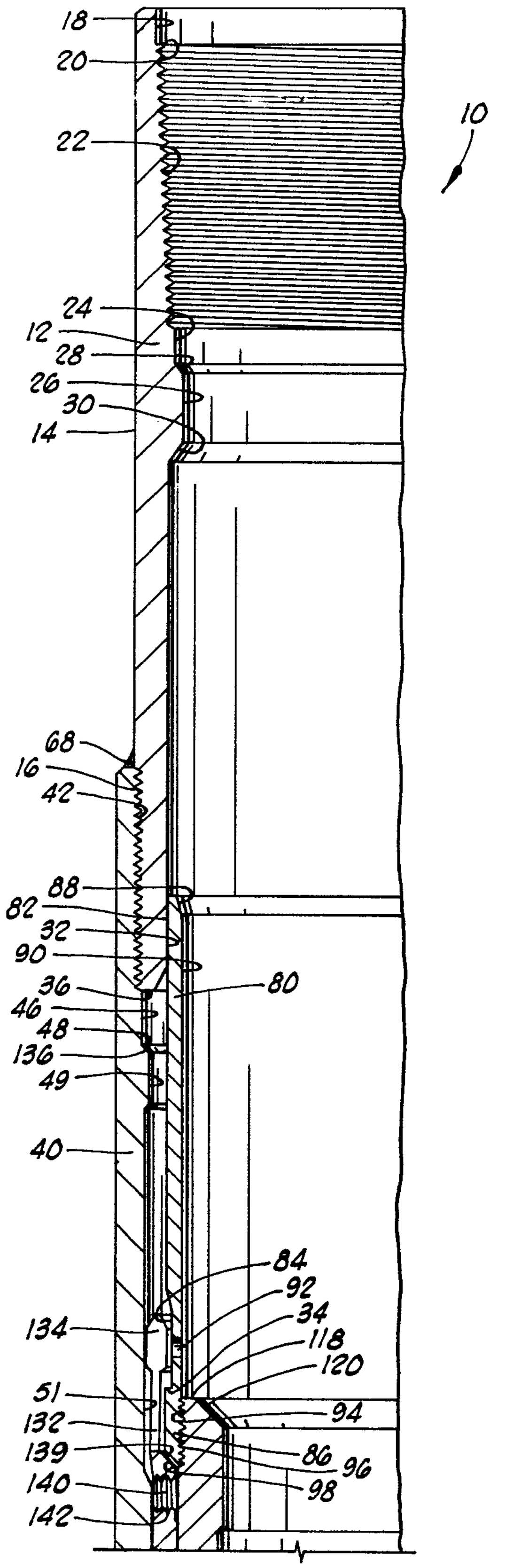

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FIG. 3A

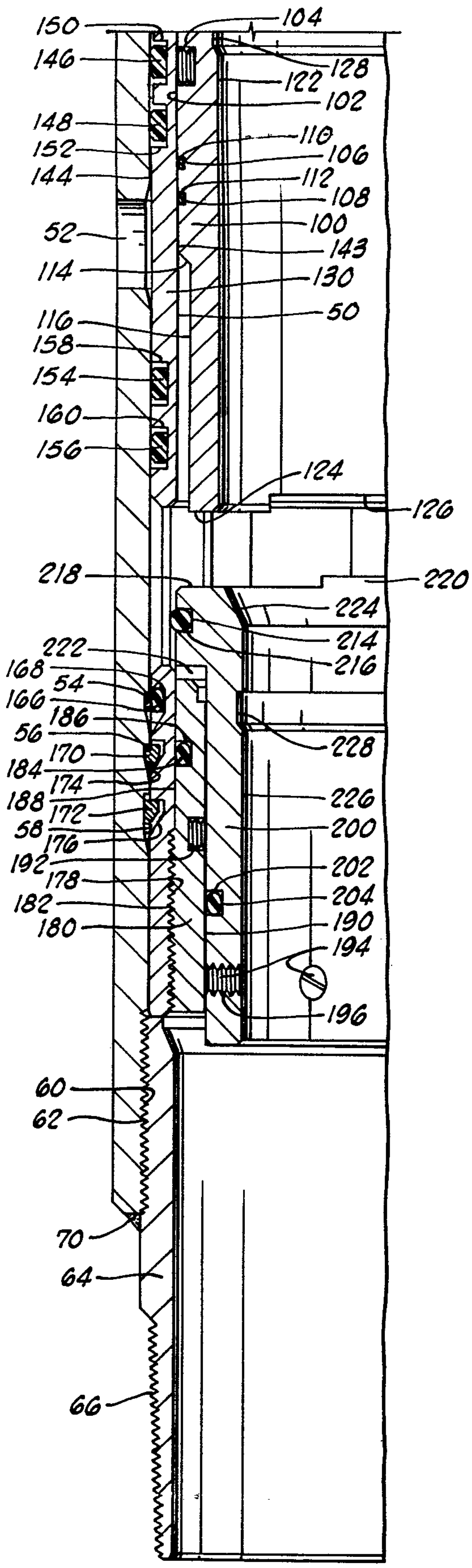

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FIG. 3B

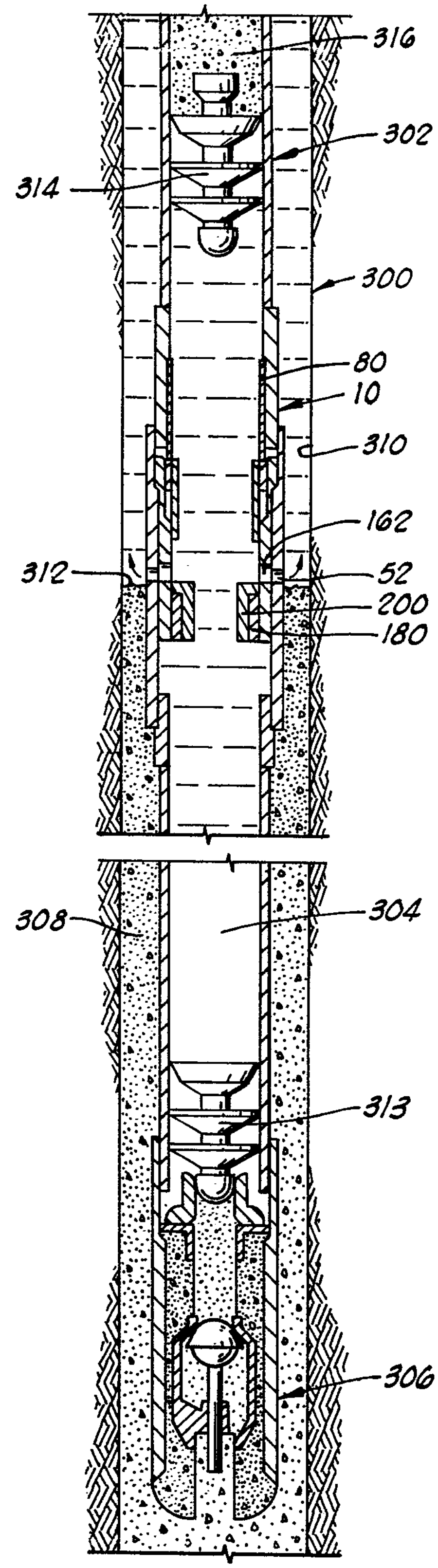
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FIG. 4

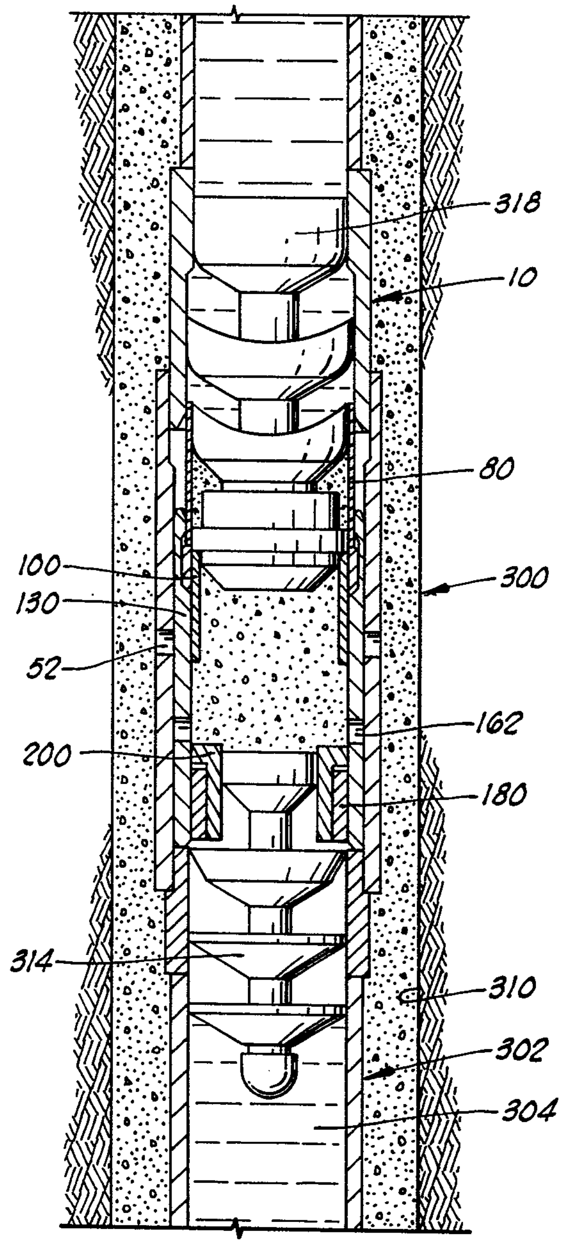
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FIG. 5