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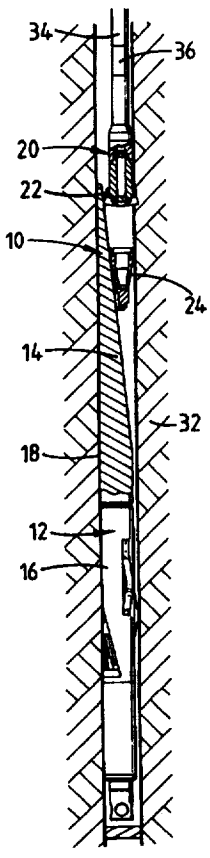
(54) Title: APPARATUS AND METHOD FOR MILLING A HOLE IN CASING

(57) Abstract

A milling apparatus which comprises a mill, and a starter bar which depends from said mill, characterised in that said starter bar is detachably connected to said mill.



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Apparatus and Method for Milling a Hole in Casing

This invention relates to an apparatus and a method for milling a hole in casing.

During the construction of oil and gas wells a hole is drilled in the ground. A string of casing is then lowered down the hole and the space between the casing and the hole filled with cement.

In modern drilling practice it is often desirable to be able to drill one or more additional holes which extend from the casing. In order to achieve this a tapered device known as a whipstock is lowered down the casing and secured in position at the desired level. Whilst it is being lowered down the casing the whipstock is usually supported by a starting mill which is supported by a string of tubulars or coil tubing. Typically, the whipstock is connected to the starting mill by a starter bar which depends from the starting mill, tapers downwardly, and is connected to the top of the whipstock by a shear bolt which is secured to a lug on the whipstock.

After the whipstock has been set in position the starting mill is raised or pressed downwardly to shear the shear bolt. The starting mill is then rotated and moved downwardly. As the starting mill is lowered the starter bar slides over the lug and urges the starter mill against the casing to cut/grind a window therein.

Although this arrangement works admirably the length of the window is limited by engagement of the bottom of the starter bar with the whipstock.

In order to overcome this problem one aspect of the present invention provides an apparatus which comprises a mill, and a starter bar which depends from said mill, characterised in that said starter bar is detachably connected to said mill.

Further features are set out in Claims 2 to 15.

* * *

Another problem is inhibiting the starter mill damaging the whipstock whilst forming the initial window in the casing.

In order to address this problem another aspect of the present invention provides a milling apparatus which comprises a mill for milling a tubular member, a whipstock for directing the mill towards the tubular member, and a pivoted link between the mill and the whipstock, the pivoted link being arranged to, in use, direct the mill towards the tubular member and subsequently to be removed.

Further features of the invention are set out in Claims 17 et seq.

The starter bar may be solid or hollow. It can be made of plastic, fibreglass, cement, composite, wood, metal (for example brass, aluminium, zinc, steel or an alloy thereof), or any other suitable material.

For a better understanding of the present invention reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig. 1 is a side view, partly in cross-section, of a first embodiment of a milling apparatus according to the present invention at a first stage of operation;

Figs. 2 shows the milling apparatus of Fig. 1 at a second stage of operation;

Fig. 3 shows the milling apparatus of Fig. 1 at a third stage of operation;

Fig. 4 is a view similar to Figure 2 showing a second embodiment of a milling apparatus according to the present invention in a second stage of operation;

Fig. 5 is a section, to an enlarged scale, through part of a milling apparatus similar to that shown in Fig. 1;

Fig. 6 is a side view, partly in cross-section of a third embodiment of a milling apparatus according to the present invention at a first stage of operation;

Fig. 7 shows the milling apparatus of Fig. 6 at a second stage of operation;

Fig. 8a is a side view in cross-section of a fourth embodiment of a milling apparatus according to the present invention;

Fig. 8b is an end view of the milling apparatus of Fig. 8a;

Fig. 9 is a side view, partly in cross-section, of a fifth embodiment of a milling apparatus according to the present invention;

Fig. 10a is a side view, partly in cross-section, of a sixth embodiment of a milling apparatus according to the present invention;

Fig 10b is a partial perspective view of the milling apparatus of Fig. 10a;

Figs. 11 - 14 are side views in cross-section of

four further milling systems according to the present invention;

Fig. 15 is a side view in cross-section of a concave of a whipstock according to the present invention;

Fig. 16 is a side view in cross-section of another milling system according to the present invention;

Fig. 17a is a side view in cross-section of another milling system according to the present invention;

Fig. 17b is a temporally subsequent view to that of Fig. 17a;

Fig. 17c is a temporally subsequent view to that of Fig. 17b;

Fig. 18a - 18h show details of another milling system according to the present invention;

Figs. 19a and 19b show the milling system including the parts shown in Figs. 18a - 18h and show steps in the operation of the system;

Fig. 20 is an enlarged view of part of the tool show in Fig. 19a;

Fig. 21 is an enlarged view of a part of the tool shown in Fig. 19b;

Fig. 22 is an enlarged view of a portion of the tool of Fig. 19a;

Fig. 23 is a side view of the tool as shown in Fig. 22;

Fig. 24 is a side view of the whipstock concave member of the tool of Fig. 19a;

Fig. 25 is a side view of apparatus according to the present invention;

Fig. 26a is a side view of apparatus used in a method according to the present invention; and

Fig. 26b is a side view of apparatus used in a method according to the present invention.

Fig. 1 shows a milling apparatus according to the present invention which is generally identified by

reference numeral 10.

The milling apparatus 10 comprises a whipstock 12 with a concave 14 and an anchor 16. The milling apparatus 10, which is connected to a tubular string or coiled tubing 34 and rotatable by a downhole motor 36 or by a rotary (not shown), has a mill 22 and a starter bar 24 releasably attached at the top to the mill 22 and at the bottom with a shear bolt 26 to a lug 17 of the whipstock 12. The whipstock 12 (which term includes diverters) may be any known type for a bit or mill. The milling system 10 is in a tubular string 18 (e.g. casing) in a wellbore 30 extending through a formation 32 from the earth's surface to a point underground.

As shown in Fig. 2, the shear bolt 26 has been sheared by increasing weight on the milling system 20, the starter bar 24 has been released and has fallen down wedging itself between the concave and the casing, and the mill 22 has milled through the lug and through the casing to initiate a casing window slightly above and adjacent the top of the concave 14. The starter bar 24 may be detached by any suitable means, hydraulic fluid pressure through the coiled tubing 34 being used in this case. However, it is also envisaged that the starter bar 24 could be released by dropping a suitably heavy ball bearing down the coiled tubing 34.

As shown in Fig. 3 the milling system 20 has progressed downwardly milling out a portion of a window 38 and it has also commenced to mill the starter bar 24. The concave 14 has biased the mill 22 toward the casing to facilitate milling of the window 38. The mill 22 will now proceed to mill further to complete the window 38.

Fig. 4 presents an alternative way to dispose of the starter bar 24. With an appropriate explosive charge, a releasable mechanism releasably securing the

starter bar to the concave is exploded, thereby releasing the starter bar and disintegrating it. In one aspect a single explosive device is used. In another aspect one device releases the starter bar from the concave and another explosive charge disintegrates the starter bar resulting in relatively small pieces 39 or a structurally weakened body to facilitate milling thereof.

The milling system 10 (as is true of any system disclosed herein) can employ any known and suitable cutter, reamer, bit, mill or combination thereof. The anchor 16 can be any known anchor, setting tool, packer, etc. The mill or mills may have any number of known blades, knives, or cutting elements with any known matrix milling material and/or cutting inserts in any known array or pattern, with or without chipbreakers, over some or all of the blade or element surface. Instead of a mill or mills, a drill bit and drilling system may be used.

Fig. 5 shows a milling system 40 (like the milling system 10, Fig. 1 and useful in the methods illustrated in Figs. 1 - 4) which has a mill 42 on a string 43 with a hollow starter bar 44. The starter bar 44 has an inner space 46. A top end 48 is secured to the mill 42 by pins 50 (e.g. stainless steel pins straddling tops of the fingers and extending into half-recesses in the fingers and half recesses in the mill body). The starter bar has a body 52 and a lower taper portion 54, the taper portion meeting at an end 56 from which projects a stub 58 through which extends a shear bolt 60 that pins the stub 58 to a lug 62 of a concave 64 of a whipstock 66. The whipstock 66 is in a tubular (e.g. casing) in a string of tubulars in a wellbore (not shown). For stability a shoulder 68 abuts a surface 69 of the mill 42. An explosive charge may be placed on the hollow

starter bar and detonated by a firing head in or above the mill to disintegrate the starter bar following its release from the mill.

Figs. 6 and 7 disclose a milling system 80 with a mill 82 on a string 84 having a starter bar 86 with its top releasably attached to the mill 82 and with its bottom releasably attached to a concave 88 of a whipstock 89. The starter bar 86 can be attached to the concave 88 with a shear pin or shear bolt or by welding or using an adhesive. The starter bar can be separated from the concave by applying weight on shear pin(s), shear bolt(s), or on a welded area, or by using an explosive charge to sever the concave-pilot-member connection.

The starter bar 86 has a taper surface 85 fashioned and configured to move down along the concave 88 thereby inhibiting movement of the mill against the concave and facilitating direction of the mill against casing 81 which is to have a window 87 milled therethrough. As shown, the starter bar 86 is a cylinder with an upper end secured to the mill 82 in a fashion similar to that of the starter bar 44 in Fig. 5. Alternatively, the starter bar 86 can have fins like those of the nose cone 44.

When the starter bar 86 reaches the position shown in Fig. 7, it is released from the mill 82, explosively severed from the mill 82, and/or explosively destroyed or explosively weakened so the mill 82 can continue downward milling of the window 87. In one aspect the portion of the window 87 milled as shown in Fig. 7 is between about 10 to about 30 inches (25 to 76cm); but this distance is adjustable depending on the length of the pilot member 86.

Figs. 8a and 8b show a milling system 100 according to the present invention which is disposable in a tubu-

lar 101 (e.g. casing) of a tubular string 102 in a wellbore 103 in a formation 104 extending from the earth's surface to a location beneath it. The milling system 100 has milling apparatus 110 associated with a concave 105 of a whipstock 106. The whipstock may be any known suitable whipstock or diverter, as may be the concave. A starter bar 111 has an end 112 shear-pinned with a pin 113 to a lug 114 which is secured to or formed integrally of the concave 105. The lug 114 has a projection 115 with a threaded hole 116 for receiving and threadedly mating with a threaded projection 117 of the starter bar 111. A brace 118 extends between two arms 119 of the starter bar 111 and an upper piece 120 is secured to the milling apparatus 110 with a bolt 121 which extends into a body 122 of the milling apparatus 110. Upon shearing of the pin 113, the tapered arms 119 move on a corresponding tapered surface 123 of the lug 114 and keep the milling apparatus 110 spaced apart from the concave 105 facilitating engagement of the casing 101 by the cutting portion of the milling apparatus 110. The threaded projection 117 eventually enters and is threaded into the hole 116 at which point the starter bar is released from the milling apparatus 110 due to its further rotation and downward movement as it mills the casing 101. The milling apparatus 110 then mills away the lug 114 and the starter bar 111.

Fig. 9 shows a milling system 130 according to the present invention which is disposable in a tubular (e.g. casing) (not shown, like the system of Fig. 8a). The milling system 130 has a mill 132 associated with a concave 133 of a whipstock 134. The whipstock may be any known suitable whipstock or diverter, as may be the concave. A starter bar 135 has a hole 142 therethrough through which extends a shear bolt 138. The shear bolt 138 releasably pins the starter bar 135 to a top portion

139 of a lug 140. The lug 140 is secured to the concave 133. Two braces 136 of the starter bar 135 are secured with bolts 137 to the mill 132. In one aspect the starter bar is made of mild steel. The mill 132 is freed for milling by shearing the shear bolt 138. Then the tapered brace surface of a brace 136 moves down on the tapered surface of the lug 140, spacing apart the mill 132 from the concave 133 as milling of the tubular commences. In one aspect the starter bar 135 is a solid cone releasable by circulating fluid under pressure down through the mill 132 with sufficient force to shear the bolts 137.

Figs. 10a and 10b show a milling system 150 with a mill 152 releasably secured to a lug 155 on a concave 153 of a whipstock 154 set in a tubular (not shown, as in Fig. 8a). The mill 152 has a body 156 with a channel 157 in which is movably disposed a central member 158 which is urged upwardly by a spring 159. A shear pin 160 initially prevents the central member 158 from moving up in the mill 152. A shear bolt 161 releasably holds the central member 158 to the lug 155 and a shear bolt 162 releasably holds the lug 155 to the concave 153. Upon shearing of the shear bolt 162, the lug 155 is free to move downwardly at an angle within a sleeve 163 secured to the concave 153. As the lug 155 moves down, the mill is rotated about the central member 158 without severing the shear bolt 161 to initiate milling of the tubular in which the system is positioned. Once the lug 155 reaches the limit of its downward travel in the sleeve 163, the shear bolt 161 is sheared to permit further downward movement of the mill 152. At this point the shear pin 160 is sheared permitting the central member 158 to retract back into the mill 152 due to the force of the spring 159. As the central member 158 moves up, spring loaded detents 164 move into recesses

165 to hold the central member 158. A lower end 166 of the central member 158 is dressed with milling material and/or inserts to assist in milling of the opening through the tubular. Alternatively the lug 155 can have a projection into a recess in the concave, the recess holding the projection and the projection moving down in the recess once the shear bolt 162 is sheared. In another aspect projections on the lug 155 ride in or on rails on the concave.

Fig. 11 shows a milling system 170 similar to that of Figs. 8a and 9 with a mill 172 and a concave 173; but a starter bar 174 is not directly secured to a lug. Instead a hinge 176 is pivotably connected to the concave 173 and pivotably connected to a bar 177 which is secured to the starter bar 174 but rotatable relative thereto. The hinge 176 will space the mill 172 apart from the concave as the mill 172 begins to mill an opening in a tubular (not shown) in which the system 170 is disposed until the hinge 176 reaches a downward travel limit. At this point the mill 172 will mill away the hinge 176 and continue to mill an opening, window, etc. in the tubular.

Fig. 12 shows a milling system 190 according to the present invention which has a mill 192 whose body 193 is initially freely movable in a sleeve 194. A hinge 195 is pivotably connected to the sleeve 194 and to an upper extension 196 of a concave 197 of a whipstock 198. Initially a shear pin 199 releasably holds the mill 192 to the concave 197. A shear pin 191 holds the hinge 195 to the sleeve 194. A spring 171 on the hinge 195 urges it back into a recess 175 when the shear pin 191 is sheared. Upon shearing of the shear pin 199, the mill is freed to move out and down to commence milling an opening in a tubular 179 (like the tubular of Fig. 8a). The concave 197 directs the mill 192 to the tubular 179.

Upon reaching the downward travel limit of the hinge 195, the shear pin 191 is sheared, the hinge 195 moves into the recess 175, and the mill 192 is freed for further milling of the tubular 179. The hinge 195 serves to initially space apart the mill 192 and the concave 197.

A milling system 200 shown in Fig. 13 is like the system 170 (Fig. 11) but a hinge 206 is pivotably connected directly to a mill 202 at one end and at the other to a concave 203. A central milling member 207 projects downwardly from the mill 202 and has fluid circulation channels 208 and 209 in fluid communication with a central fluid channel 201 of the mill 202. The mill 202 has typical fluid circulation channels 205. Any mill described or shown herein can have well-known fluid circulation channels to facilitate debris and cuttings movement and removal. A shear pin 204 is used to initially releasably hold the hinge 206 to the mill 202.

Fig. 14 shows a system 210 with a mill 212 having a starter bar 216 projecting downwardly and shear-pinned with a pin 222 to a concave 217 of a whipstock 218. This system is for milling a tubular (not shown) like the tubulars of the previously described systems. Circulating fluid flows through a string (not shown) to which the mill 212 is connected into a channel 211 of the mill 212, to wash ports 213 and through a channel 223 to a channel 215 of the starter bar 216 and then to wash ports 221 of the starter bar 216. Shear pins 214 releasably hold the starter bar 216 to the mill 212. A nose end 225 of the starter bar 216 is sized and configured to move down (upon shearing of the shear pin 222) a tapered surface 226 of a recess 227 in the concave 217 and then to be received in a correspondingly-shaped recess 228 in the concave 217. As the nose end 225 of

the starter bar 216 moves, it spaces apart the mill 212 and concave 217 as the mill 212 begins to mill the tubular in which the system 210 is located. When the nose end 225 enters the recess 228, the shear pins 214 shear, freeing the mill 212 for milling the opening in the tubular and for milling the starter bar 216.

Fig. 15 shows a whipstock 240 with a concave 242 and an armored portion 244 of the concave 242 armored with armor material. In a particular embodiment in which the whipstock 240 is used in a tubular 246 (in a wellbore such as previously described wellbores) to mill a window 247 with a mill 248 (such as, e.g., mills previously described herein), the armor material is harder than the material of which the tubular 246 is made. Any previously described lug, concave, or part thereof, or nose may be armored with the armored material. Suitable armor material includes CONFORMA CLAD (TM), ARNCO 200 (TM) and TECNOGINIA (TM). Such material is welded on, baked on, plasma flame-sprayed on or explosively bonded on.

Fig. 16 shows a mill 260 according to the present invention with a nose 262 dressed with milling material 264 and an upper portion 266 dressed with milling material 268. A shear pin 270 releasably connects the mill 260 to an armor starter bar 272 which is itself releasably connected to a concave 274 of a whipstock by a shear pin 275. The mill 260 is useful to mill a tubular (as any tubular previously described herein). A recessed portion 276 of the mill 260 is configured, shaped, positioned and disposed to receive a finger 271 of the starter bar 272 when the mill 260 is removed from the wellbore in which it is being used to remove the member 272 upon shearing of the shear pin 275.

Figs. 17a - 17c show a milling system 280 according to the present invention for milling a window 281 in a

casing 282 in a wellbore 283. The milling system 280 is connected to a tubular string or coiled tubing 284 which extends to the surface and a mill 285 is rotated by a downhole motor (not shown) or by a rotary (not shown). The system 280 includes a tubular body 286 to which the mill 285 is secured and a sleeve 287 disposed around and fixed to the tubular body 286. Initially the mill 285 (see Fig. 17a) is releasably attached to a lug 288 of a concave 296 of a whipstock 297 set in the casing 282 (lug made, in one aspect, of wear resistant material), and the bottom of the mill 285 and sides of the mill 285 dressed with matrix milling material and presenting a rough surface to the casing 282. Preferably the sleeve 287 is dressed with milling matrix material and has a rough surface for smoothing edges of the opening made by the mill 285. The nose 289 of the mill 285 has a taper which corresponds to a taper 290 of the lug 288. As shown in Fig. 17b, the mill 285 has moved down on the lug 288 and initiated an opening through the casing 282. As shown in Fig. 17c, the mill 285 has begun milling the window 281 and has milled off the lug 288. The sleeve 287 may be rotatably mounted around the body 286.

When any system used herein results in a mill milling through the casing and then milling into formation outside the casing, an initial part of a lateral wellbore may be formed by the mill. This part, in certain embodiments, may extend for several feet, e.g. up to about two, ten, fifty, or a hundred feet. Alternatively a mill may be used which will advance a hundred yards or more into the formation.

Referring now to Figs. 18a - 18h and 19a and 19b, a tool 310 according to the present invention has a whipstock 320 according to the present invention with a pilot block 324 welded near a top 326 thereof. The whipstock has a concave face 322. The pilot block 324

has bolt holes 328.

The tool 310 has a starting bar 360 which has a body 362 which is secured to the whipstock 320 by bolts 369 through holes 363 extending into holes 328 in the pilot block 324. A groove 364 encircles the body 362. A stop bar 329 (see Fig. 21) extends through a stop pin hole 366.

The tool 310 has the milling apparatus 330 which includes at least one and preferably two or more mills so that a milling operation for producing a sidetracking window in casing can be accomplished in a dual or single tool trip into a cased wellbore. As shown in Figs. 18a and 19a, the milling apparatus 330 includes a starting mill 340 connected to and below a hollow finishing mill 350. Interior threads 348 of the starting mill 340 engage exterior threads 358 of the finishing mill 350.

The starting mill 340 has a central channel 344 therethrough and a cutting end with carbide cutters 342. A core catcher 314 is disposed within the starting mill 340 and rests on a shoulder 347 to receive and hold debris such as an initial casing sliver, etc. The core catcher 314 is a typical two-piece core catcher.

The finishing mill 350 has a plurality of milling blades 352 and a central channel 354 therethrough. A retainer 312 is disposed within the channel 354 and rests on a shoulder 357 of the mill 350. The retainer 312, as shown in Fig. 18g, preferably is a spring with a plurality of fingers 355 which are disposed so that the fingers 355 protrude into the groove 364 of the starting bar 360, preventing the starting bar 360 from moving downwardly from the position shown in Fig. 21.

To accommodate a substantial portion of the starting bar 360 when its length exceeds that of the combined lengths of the mill(s), a pup joint may be used such as the pup joint 380. External threads 386 on the lower

end of the pup joint 380 engage upper internal threads 356 of the finishing mill 350. Upper internal threads 388 of the pup joint engage a part of a drill string (not shown) e.g. a crossover sub with a mud motor above it. A central channel 384 extends through the pup joint and is sized and configured to receive a portion of the starting bar 360.

Figs. 19a and 19b illustrate steps in the use of a tool 310 according to this invention. As shown in Fig. 19a, the milling apparatus 330 has a top portion 365 of the starting bar 360 within the starting mill 340 and the starting bar 360 is secured to the whipstock 320. As shown in Fig. 19b the starting mill 340 and apparatus above it have pushed down on the bar 329, breaking it, and permitting the milling apparatus 330 to receive a substantial portion of the starting bar 360. The starting mill 340 has moved to contact the pilot block 324 and mill off the bar 329.

Milling now commences and the starting mill 340 mills through the pilot block 324. As the starting mill moves down the concave face of the concave member 320, the concave member 320 is moved sideways in the casing (to the left in Figs. 19a and 19b) and a window is begun in the casing's interior wall. As shown in Fig. 21 the fingers 355 have entered the groove 364, preventing the starting bar 360 from falling out of the apparatus or from being pumped out by circulating well fluid. The starting bar 360 has an indented end 371 to facilitate entry of a core into the mill.

To move cutting and debris out of the wellbore a circulation fluid is, preferably, circulated downhole through the drill pipe, outside of and past the starting bar between the starting bar's exterior and the mills' interiors, past the core catcher, past a splined bearing 391, past the starting mill between its exterior and the

casing's interior and back up to the surface.

As the milling apparatus mills down against the concave member, the finishing mill 350 smooths the transition from the casing edge to the wellbore to complete the milling operation. Then the milling apparatus is removed from the wellbore with the starting bar 360, casing sliver, debris, and core held within the interior of the mills.

As shown in Figs. 26a and 26b, in a two-trip milling operation according to the present invention, a tool 420 including a whipstock concave member 422 and a starting mill 425 secured thereto with a sheer stud 426 is run into a cased wellbore in which some type of anchoring-orientation device, e.g. a keyed packer (not shown), has been installed. Upon emplacement and orientation of the tool 420, the shear stud 426 is sheared by pushing down on the tool and milling is commenced producing an initial window or pocket in the casing. The tool 420 is removed leaving the whipstock concave member 422 in place and then a milling system (like the system shown in Fig. 19b) is run into the hole to continue milling at the location of the initial window or pocket. This milling system includes the items above the starting bar 360 in Fig. 19a, but not the starting bar 360; and the milling system, as shown in Fig. 26b, is used as previously described but without the starting bar. This two-trip operation results in a finished window through the casing.

In the following claims the term "milling apparatus" includes a "drilling apparatus" and the term "mill" includes "drill".

CLAIMS

1. A milling apparatus which comprises a mill, and a starter bar which depends from said mill, characterised in that said starter bar is detachably connected to said mill.

2. A milling apparatus as claimed in Claim 1, wherein said starter bar is detachable from said mill by the application of weight.

3. A milling apparatus as claimed in Claim 1, wherein said starter bar is detachable from said mill by the application of fluid pressure.

4. A milling apparatus as claimed in Claim 3, including a connector between said starter bar and said mill, said connector being releasable by fluid pressure.

5. A milling apparatus as claimed in Claim 1, which includes an explosive charge and wherein said starter bar is detachable from the mill, in use, by detonation of said explosive charge.

6. A milling apparatus as claimed in Claim 5, including a connector between said starter bar and said mill, and wherein an explosive charge (which may be the same as or separate from that of Claim 5) is provided for removing the connector between said starter bar and said mill.

7. A milling apparatus as claimed in any preceding claim, including a connector between the starter bar and the mill, said connector being releasable by means that, in use, inhibits rotation of the starter bar.

8. A milling apparatus as claimed in Claim 7, including a formation on the starter bar which is engageable with a formation on a whipstock on downward movement of the starter bar relative thereto.

9. A milling apparatus as claimed in any preceding claim, wherein the starter bar is provided with a follower for following the profile of a whipstock during

downward travel of the starter bar.

10. A milling apparatus as claimed in Claim 10, wherein the follower is arranged to operated during a first portion of downward travel of the mill, at the end of which the starter bar is arranged to detach.

11. A milling apparatus as claimed in any preceding claim including a whipstock, wherein the whipstock comprises support means for supporting the whipstock at a predetermined position in a tubular, and a guide member carried by the support means.

12. A milling apparatus as claimed in any preceding claim, further comprising a downhole motor for rotating the mill.

13. A milling apparatus, comprising a mill for milling a tubular member, a starter bar depending from the mill, and a whipstock for directing the mill towards the tubular member, wherein the starter bar is formed in two portions which are releasably connected together, one portion being carried by a guide member and the other portion being retractable into the mill.

14. A milling apparatus as claimed in Claim 13, wherein said one portion is supported for limited downward movement on said guide member.

15. A milling apparatus as claimed in Claim 14, including a connection between the first and second portions of the starter bar arranged to be released on movement of the mill beyond the limited downward movement of said one portion.

16. A milling apparatus, comprising a mill for milling a tubular member, a whipstock for directing the mill towards the tubular member, and a pivoted link between the mill and the whipstock, the pivoted link being arranged to, in use, direct the mill towards the tubular member and subsequently to be removed.

17. A milling apparatus, comprising a mill for milling

a tubular member, a whipstock for directing the mill towards the tubular member, means releasably connecting the mill to the whipstock and armoured material covering at least a portion of the surface of the whipstock.

18. A milling apparatus as claimed in Claim 17, wherein armoured material is removably connected to the whipstock and the mill and the whipstock have interengaging formations arranged to remove the whipstock on upward travel of the mill past the whipstock.

19. A milling apparatus, comprising a mill for milling a tubular member, a whipstock for directing the mill towards the tubular member, means releasably connecting the mill to the whipstock and a guide on the whipstock arranged to direct the mill towards the tubular member and to be milled away on subsequent downward travel of the mill.

20. A milling apparatus comprising

a mill for milling a tubular member, and

a starter bar releasably connected to the mill and releasably connectable to a whipstock that directs the milling means towards the tubular member.

21. A starter bar for a milling apparatus, the starter bar comprising a body member,

the body member having a mid portion, a top portion and a lower nose portion, and

the top portion releasably securable to the milling apparatus and the lower nose portion releasably securable to a concave of a whipstock.

22. A whipstock comprising

a body member,

the body member having an upwardly extending concave portion with a concave surface, and

at least a portion of the concave surface covered with armor material, said portion contactable by a milling apparatus during a milling procedure.

FIG.1

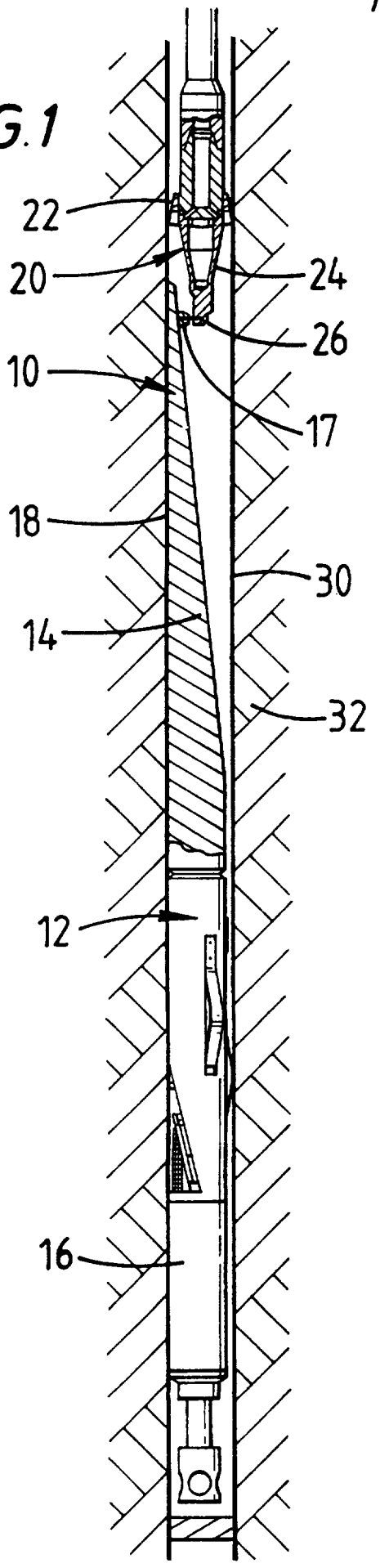


FIG.2

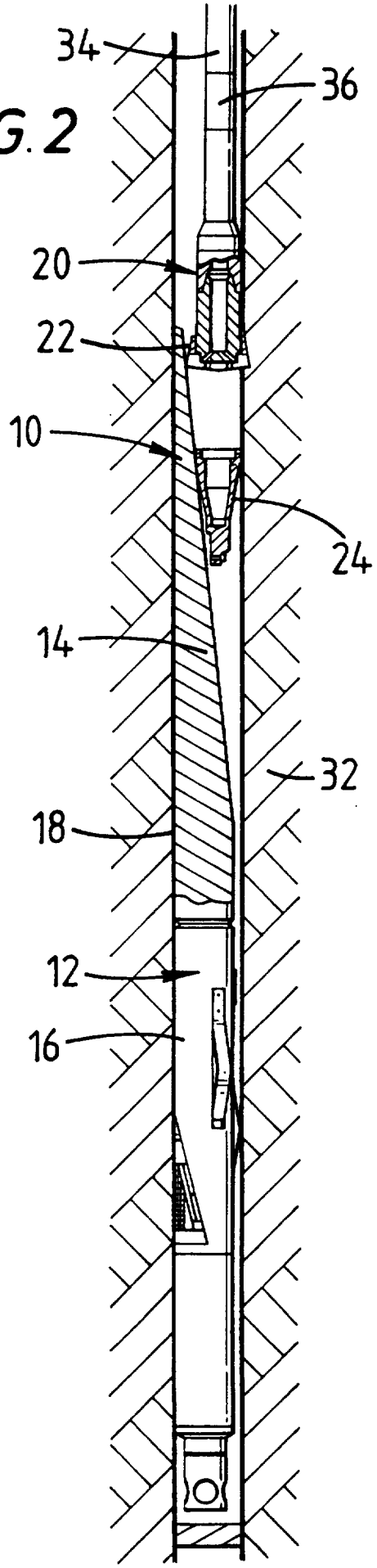


FIG. 3

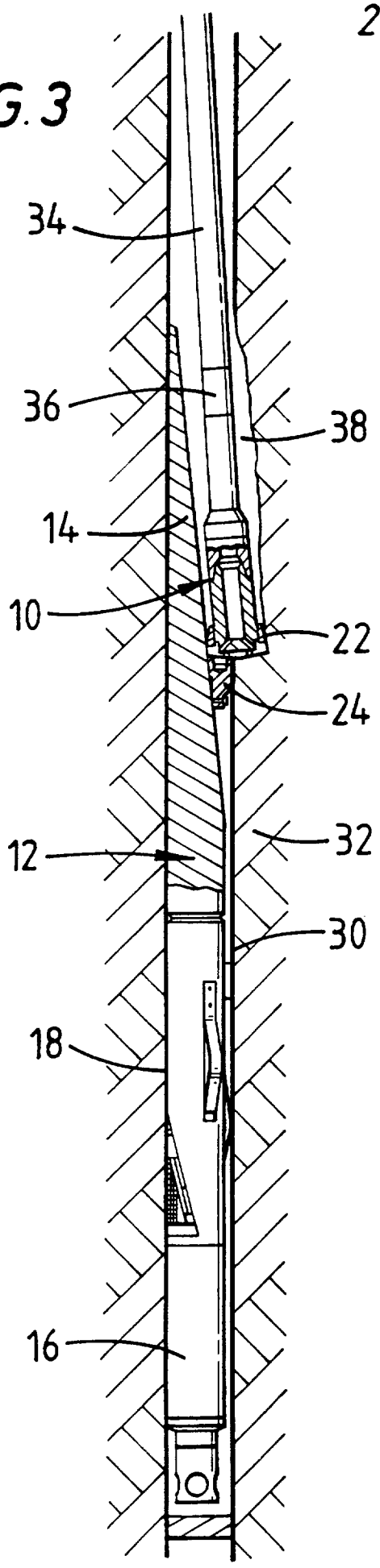


FIG. 4

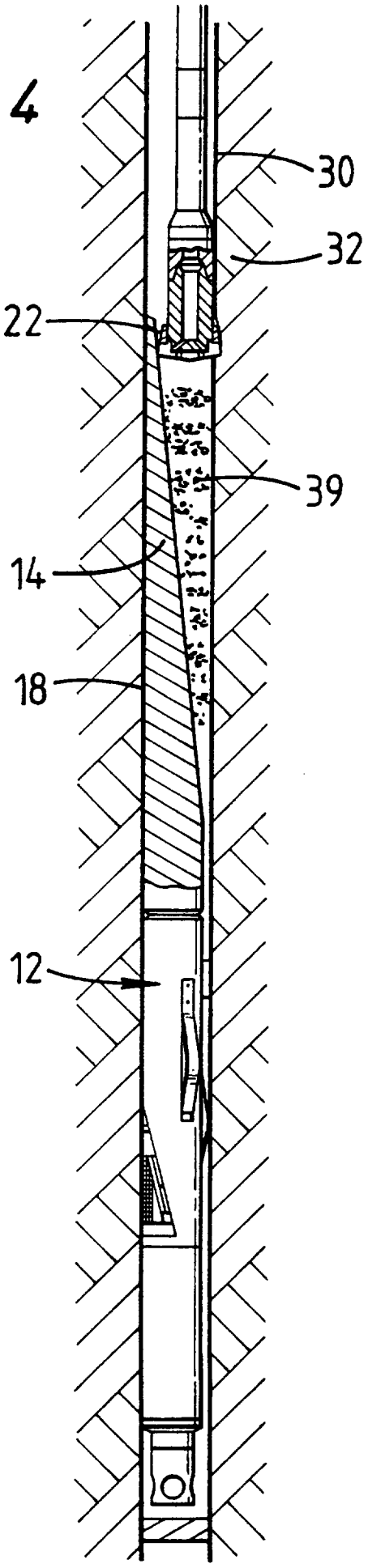


FIG. 5

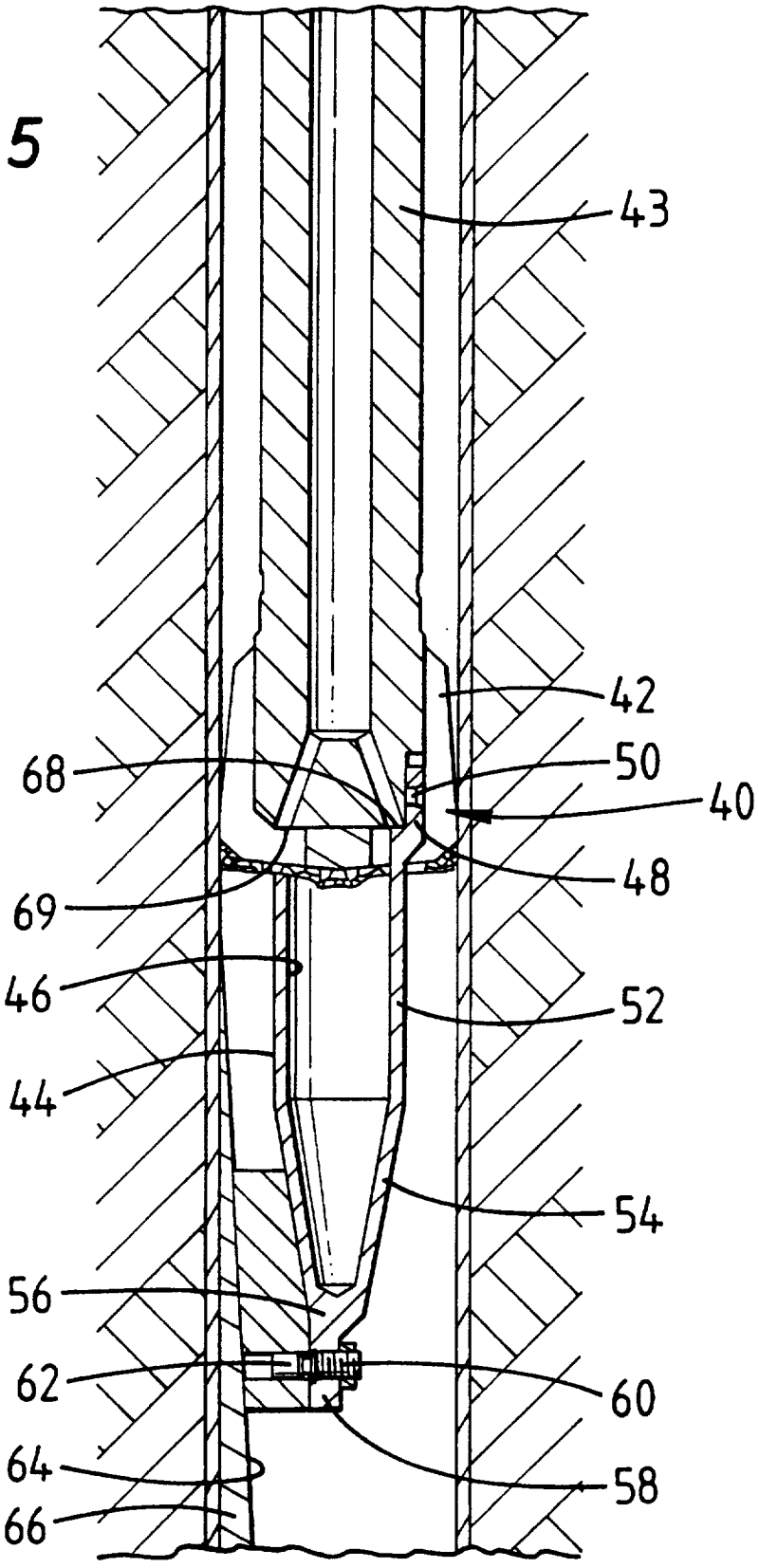


FIG.6

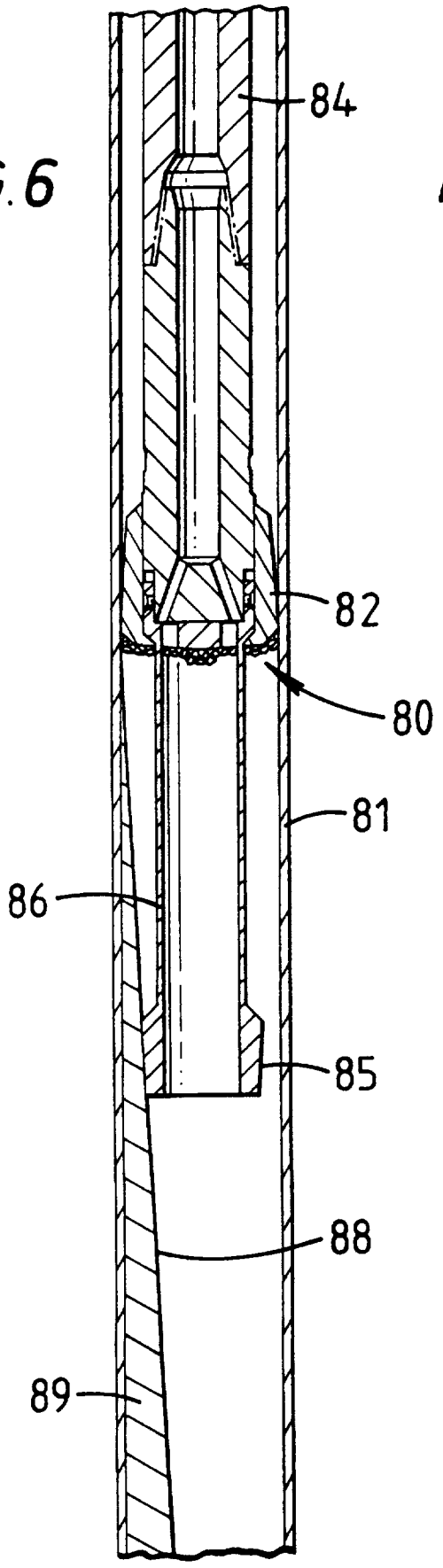


FIG.7

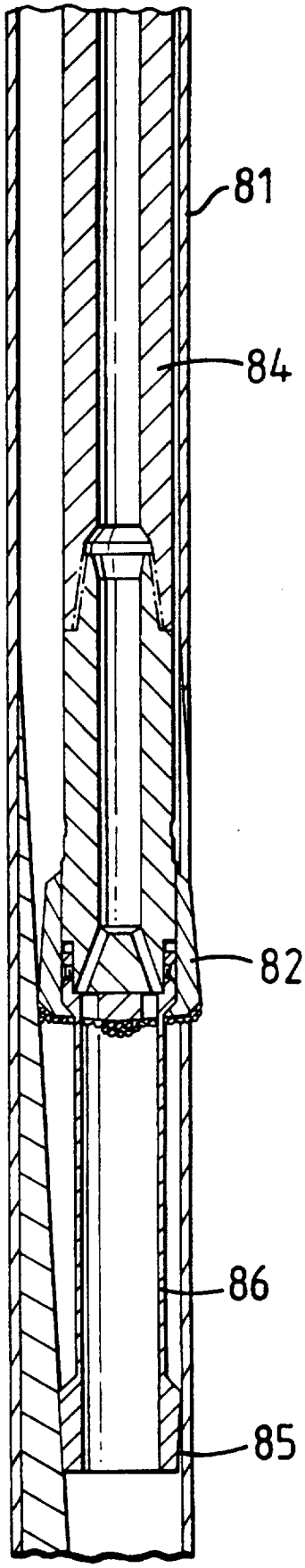


FIG.8a

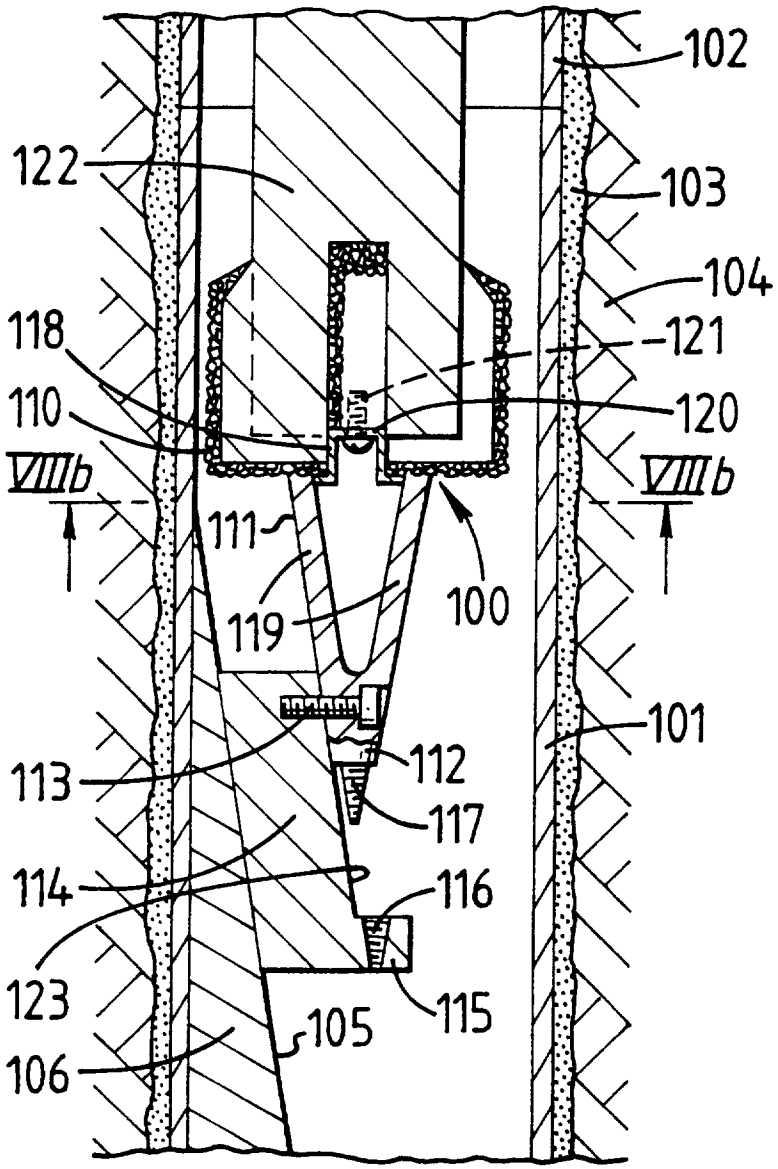


FIG.8b

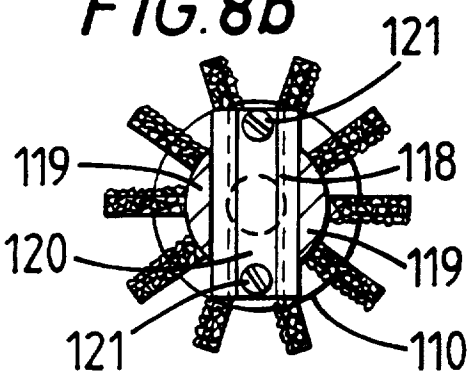


FIG.9

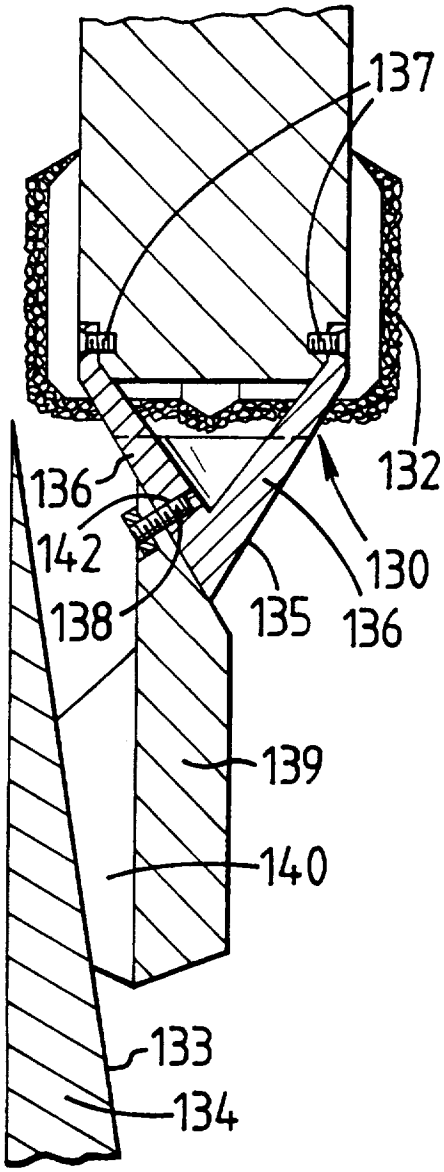


FIG. 10a

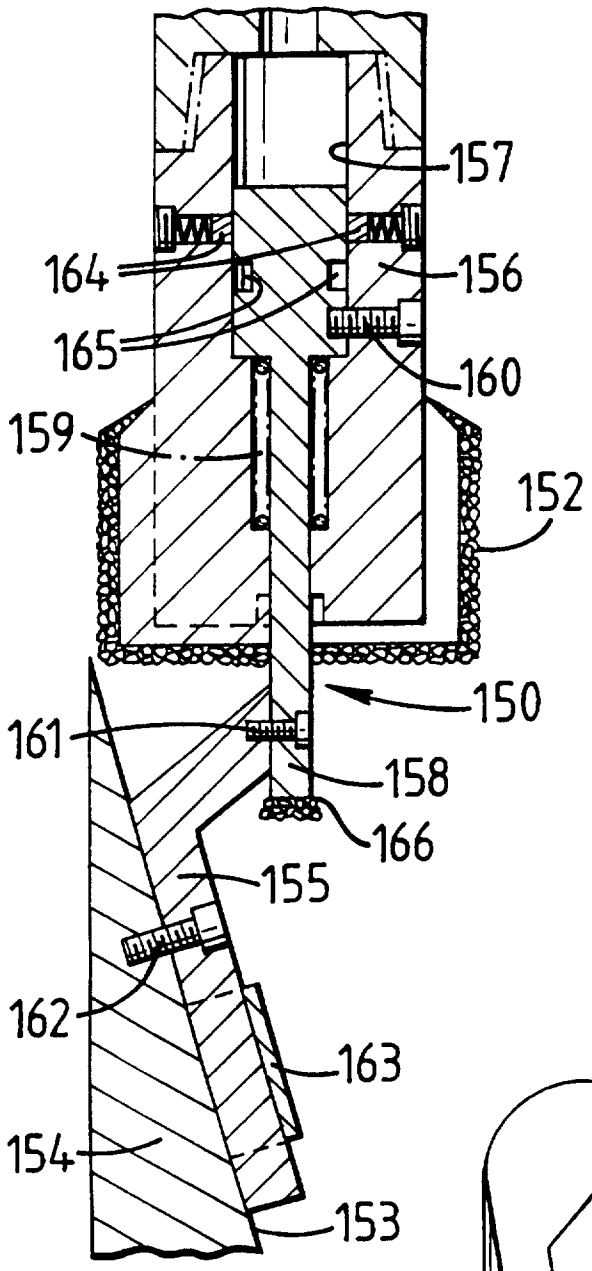
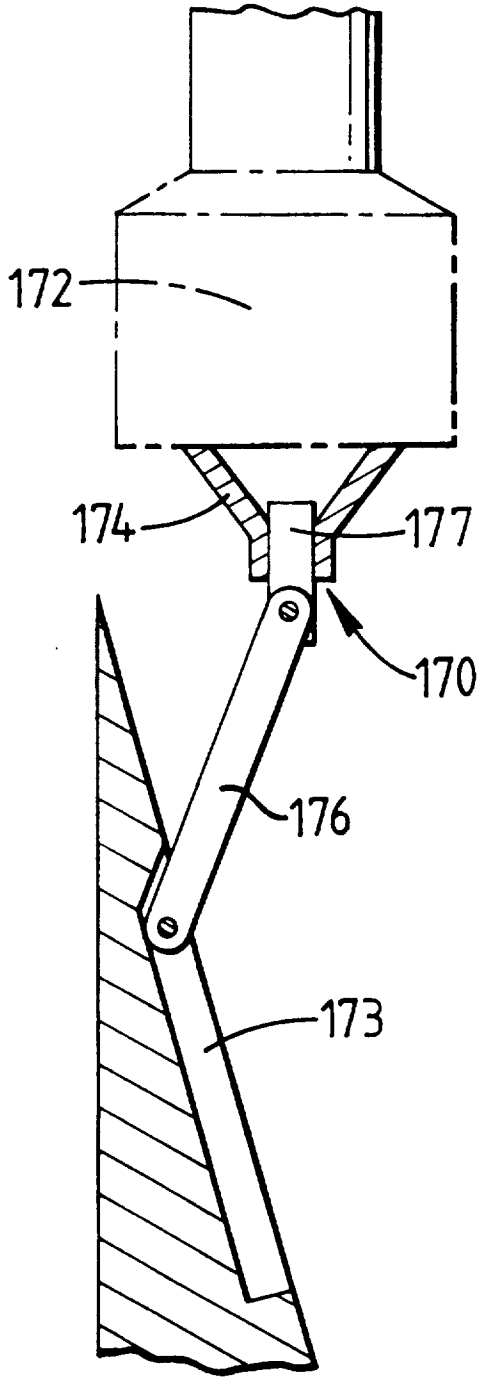


FIG. 11



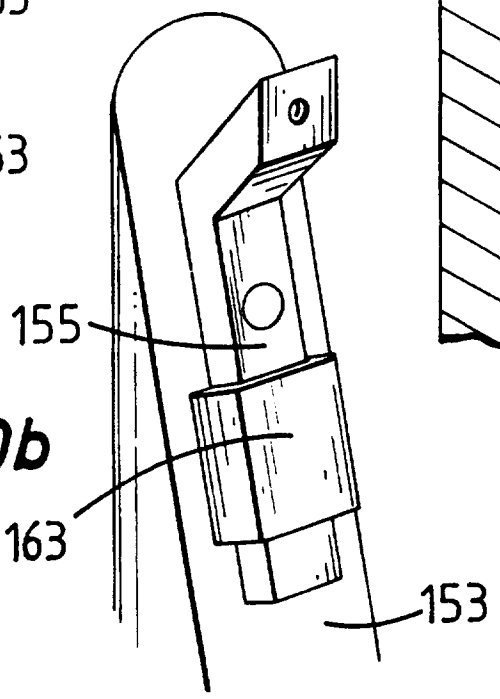


FIG. 10b

FIG. 12

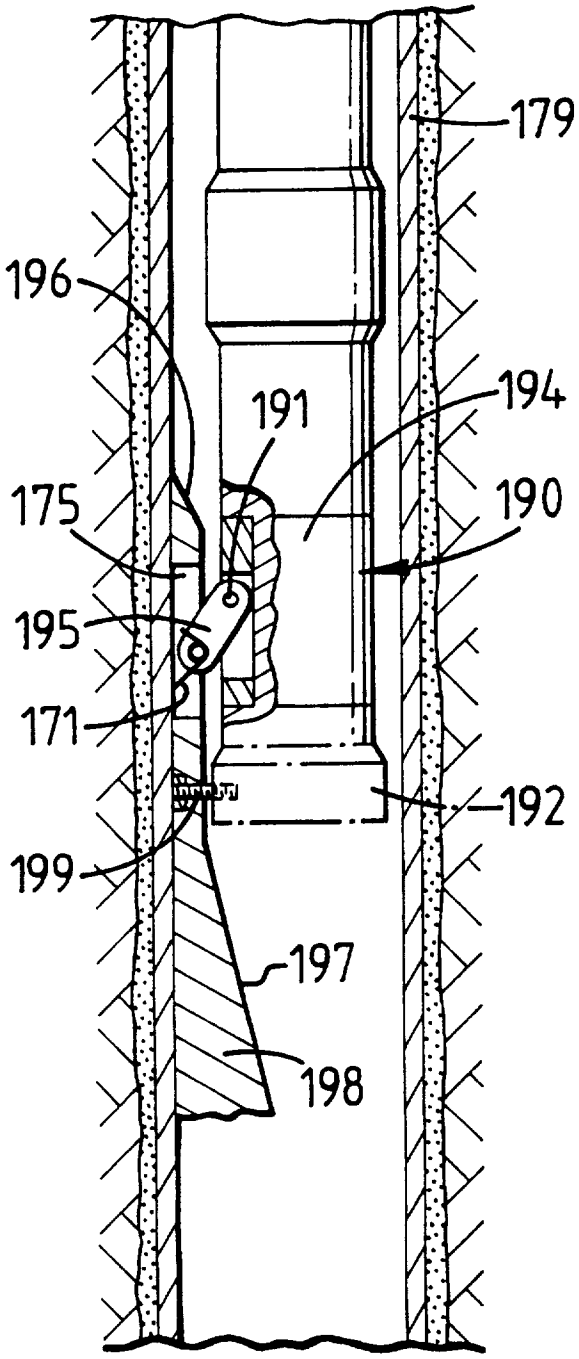

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FIG. 13

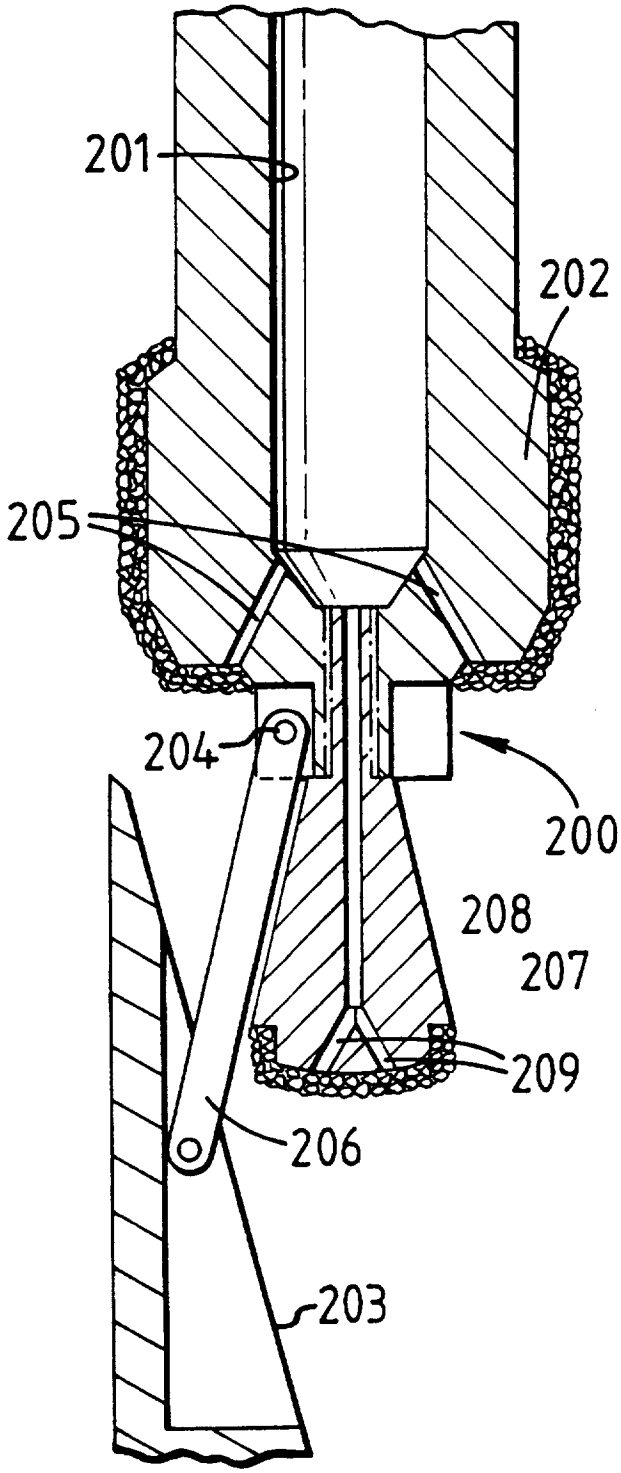
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FIG. 14

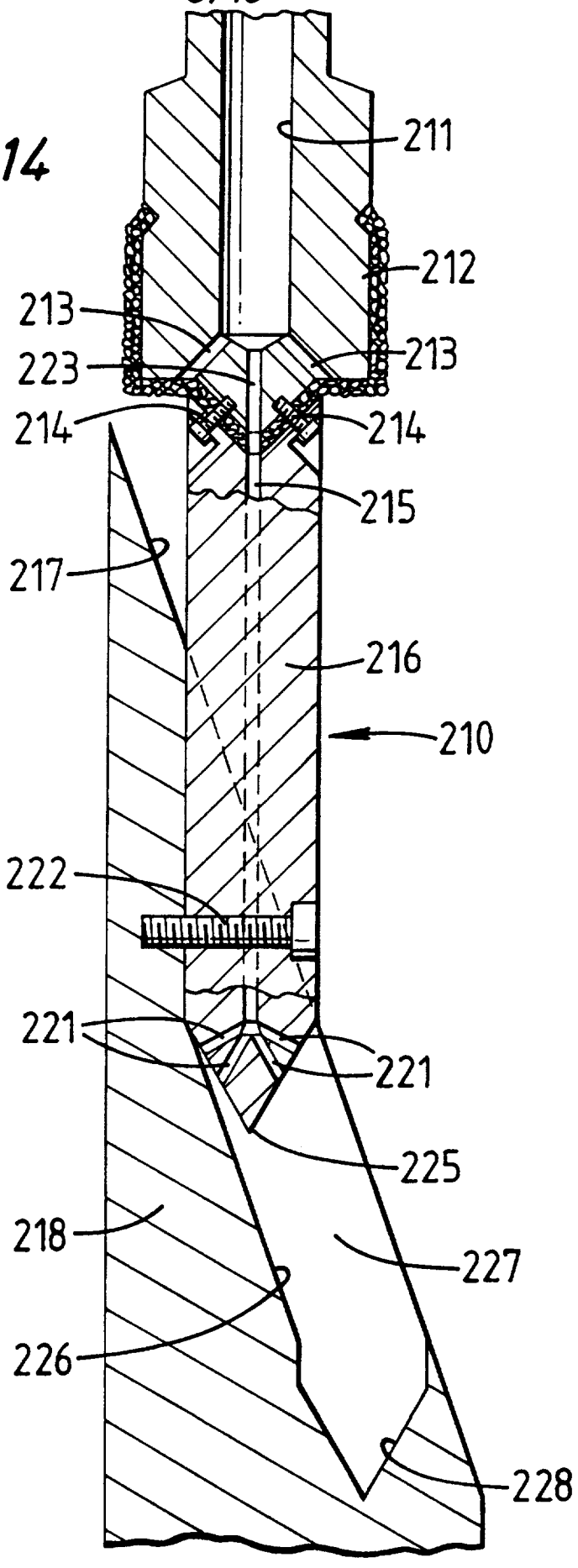
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FIG. 15

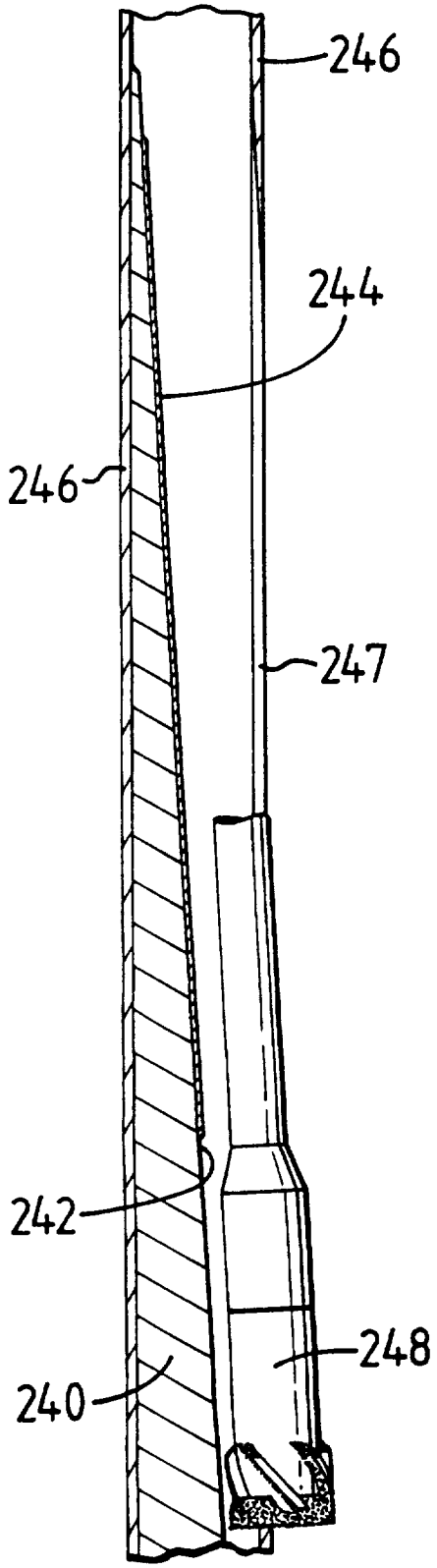
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FIG. 16

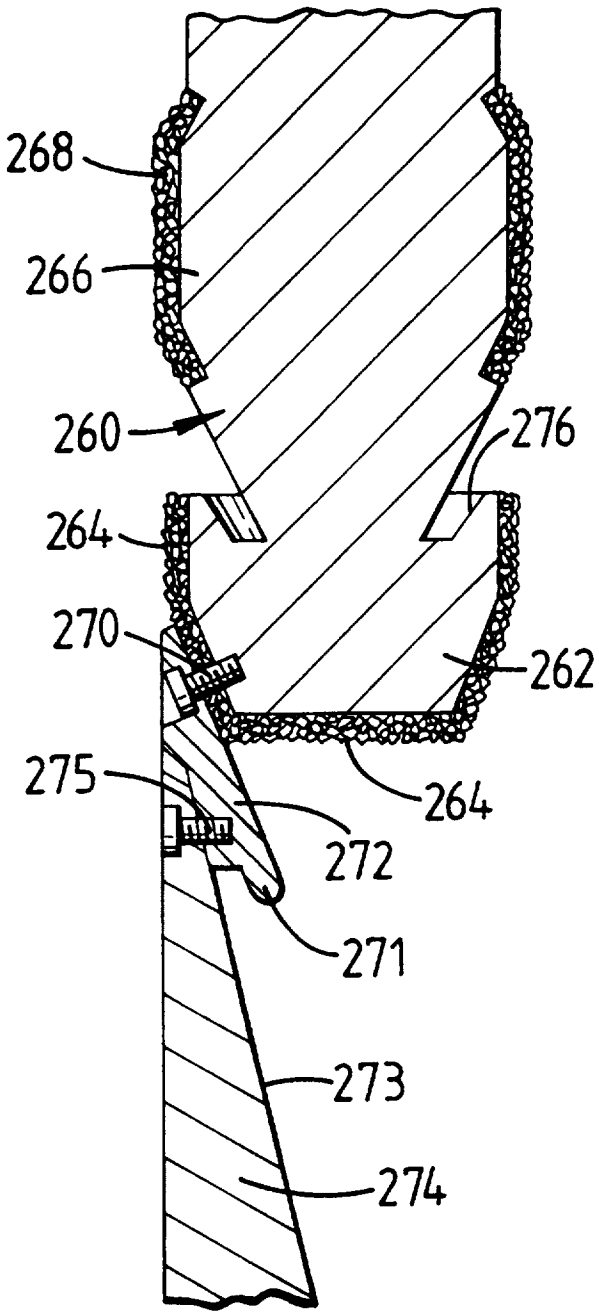
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FIG. 17a

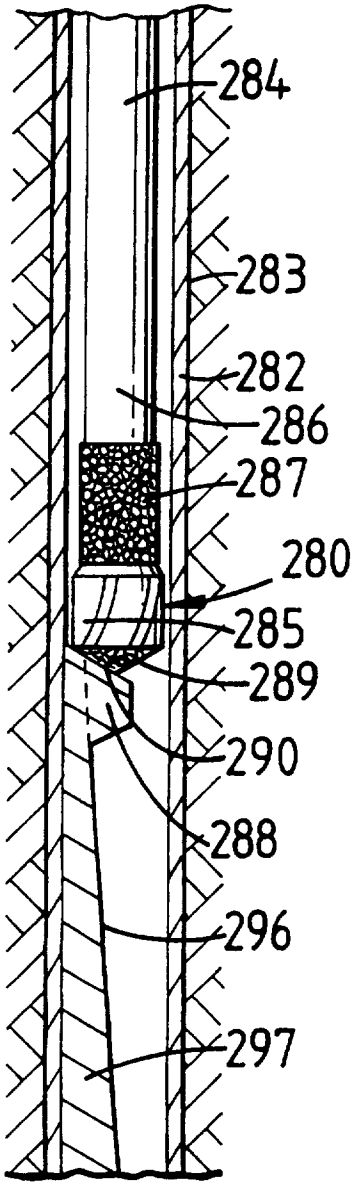


FIG. 17b

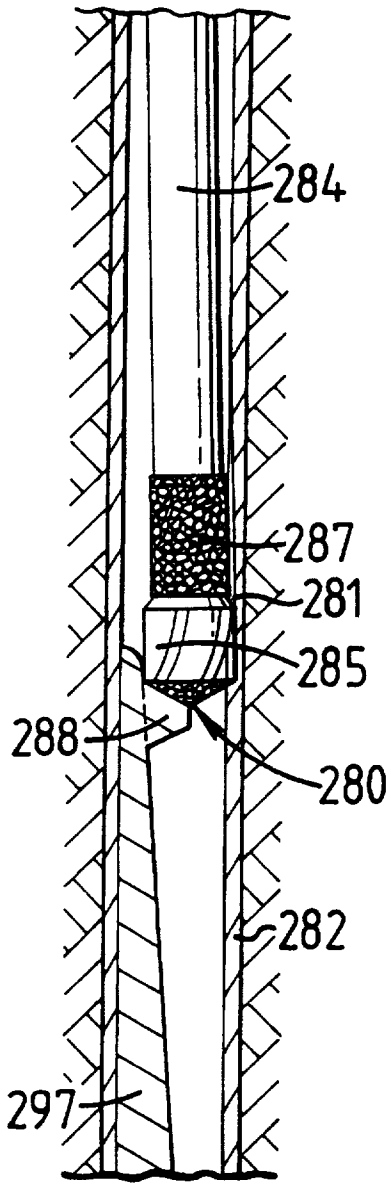
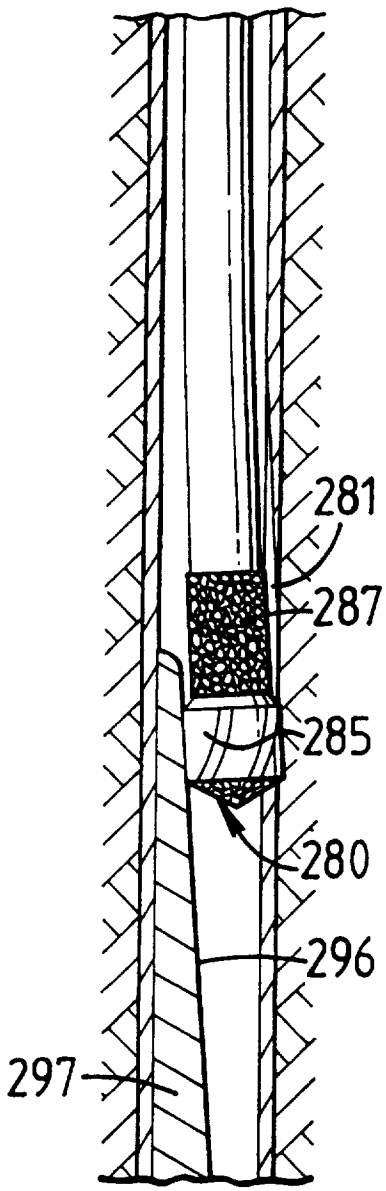


FIG. 17c



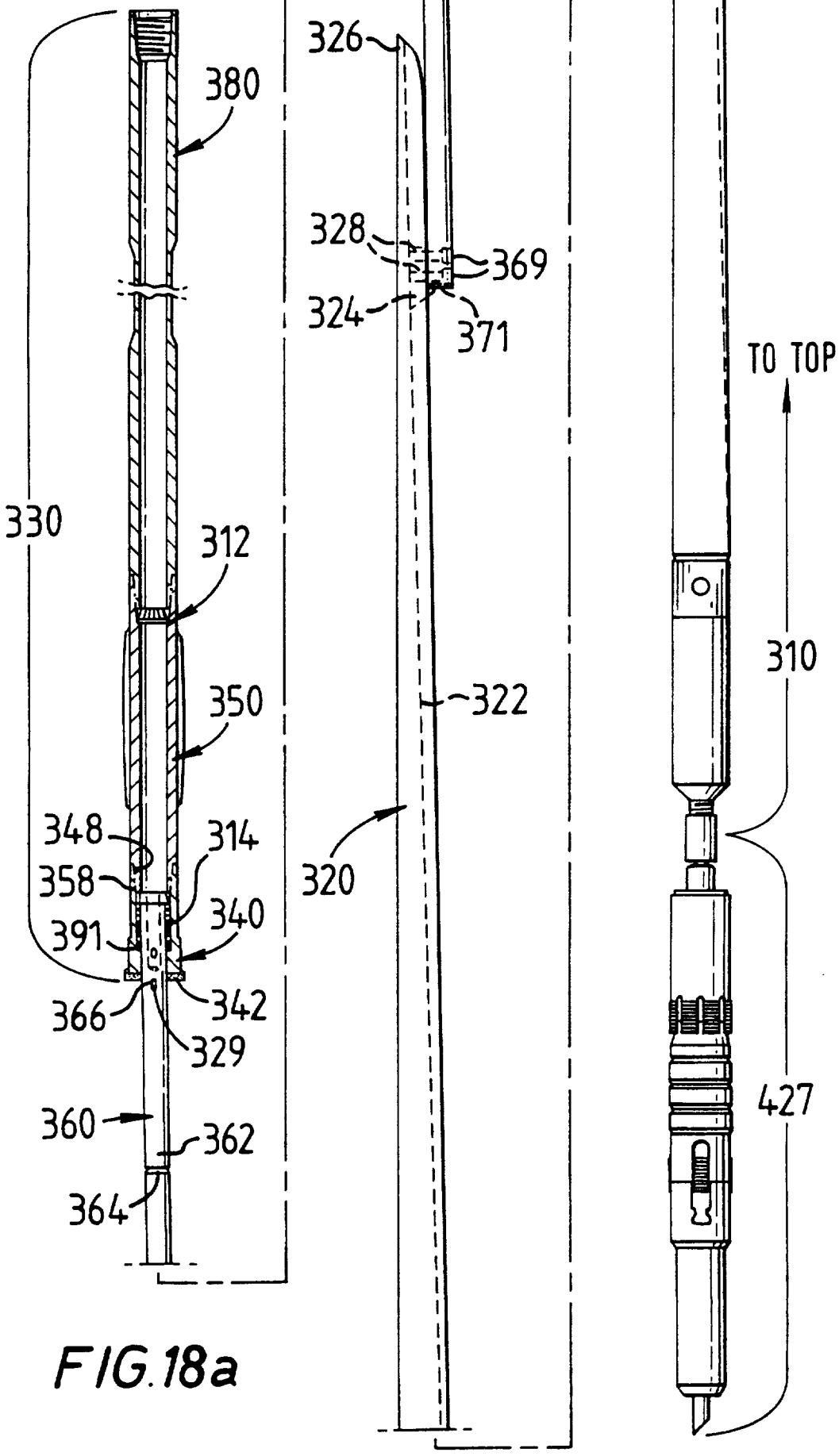

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FIG. 18a

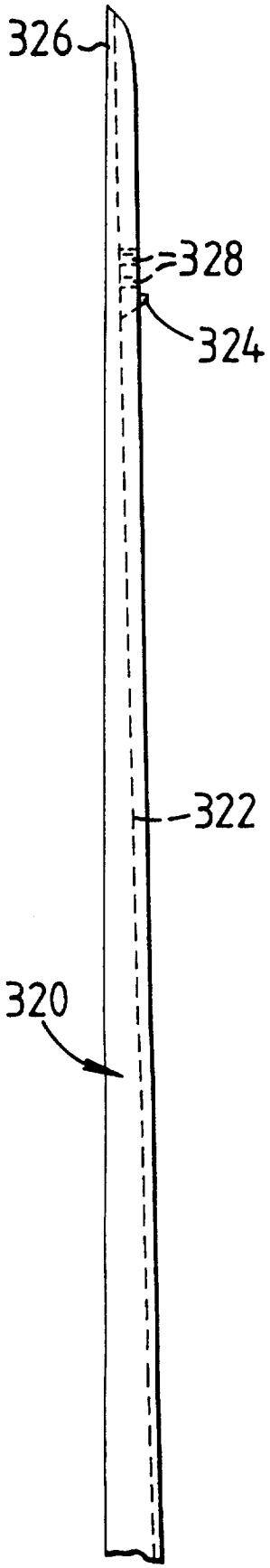


FIG. 18b

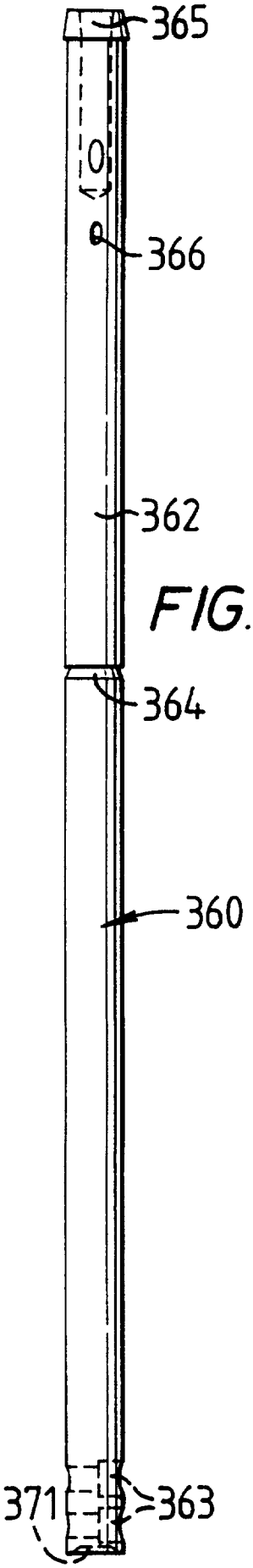


FIG. 18c

FIG. 18g

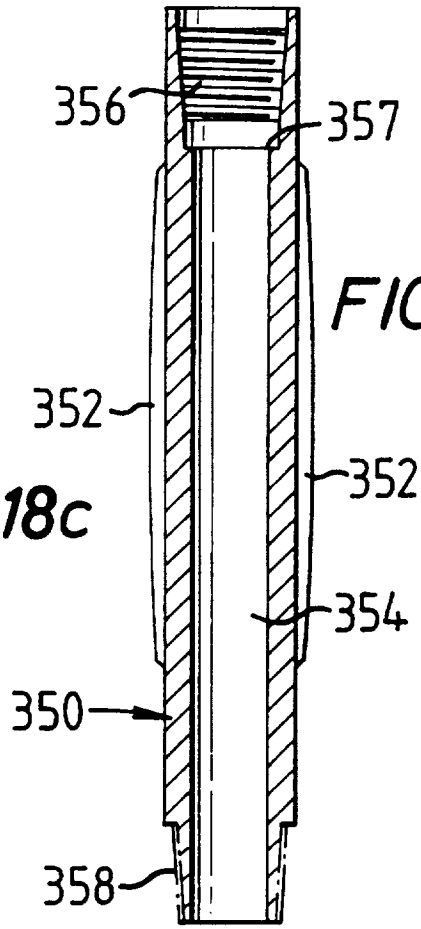


FIG. 18f

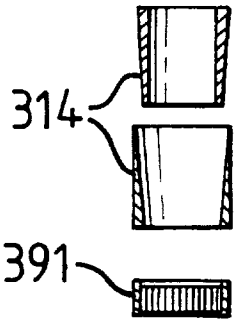


FIG. 18e

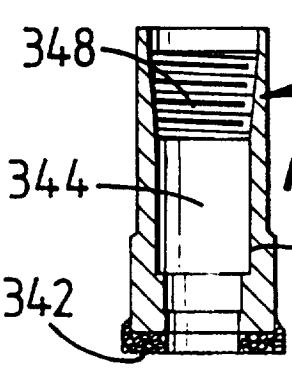


FIG. 18d

FIG. 18h

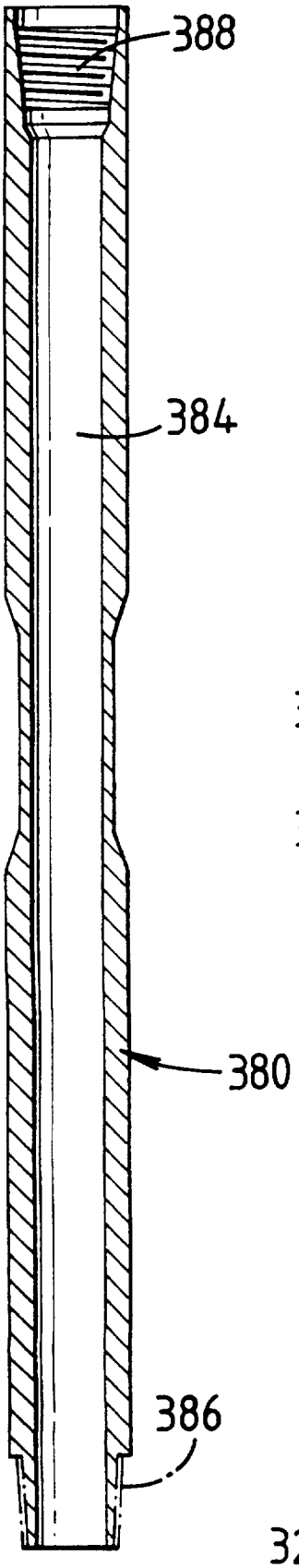


FIG. 19a

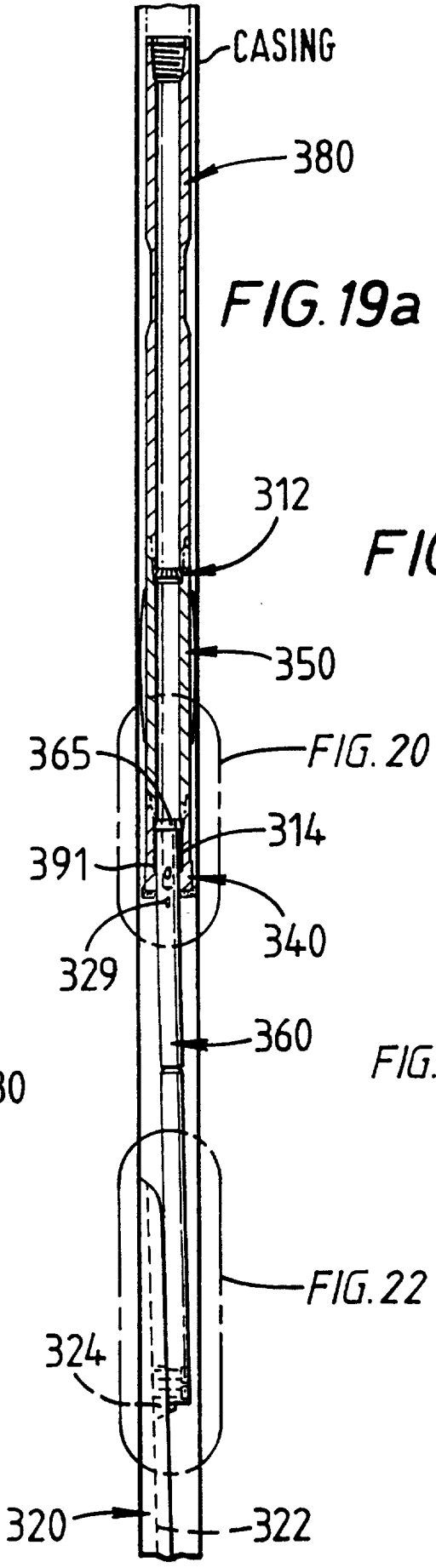


FIG. 19b

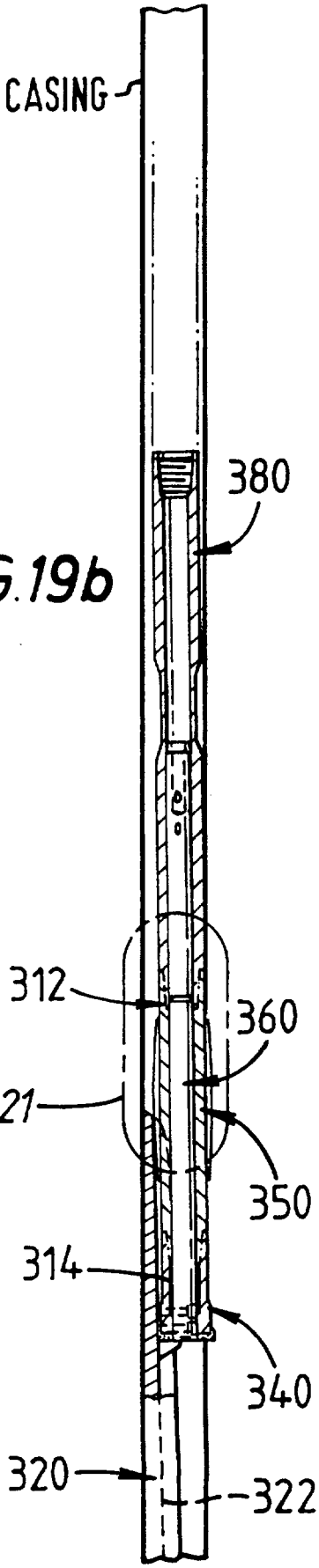


FIG. 20

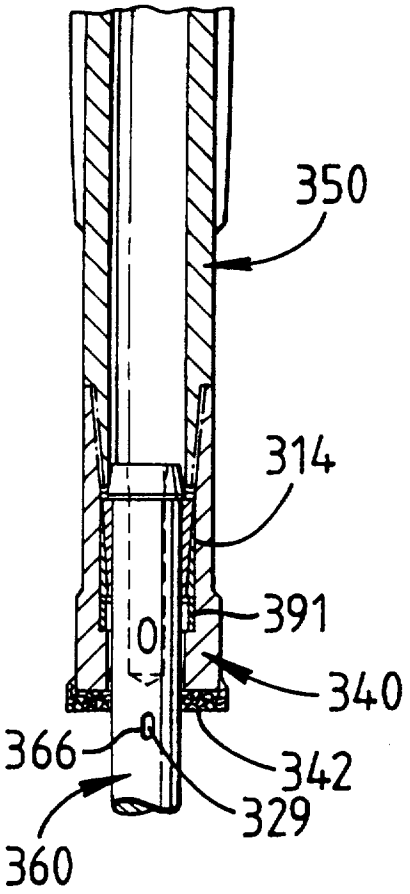
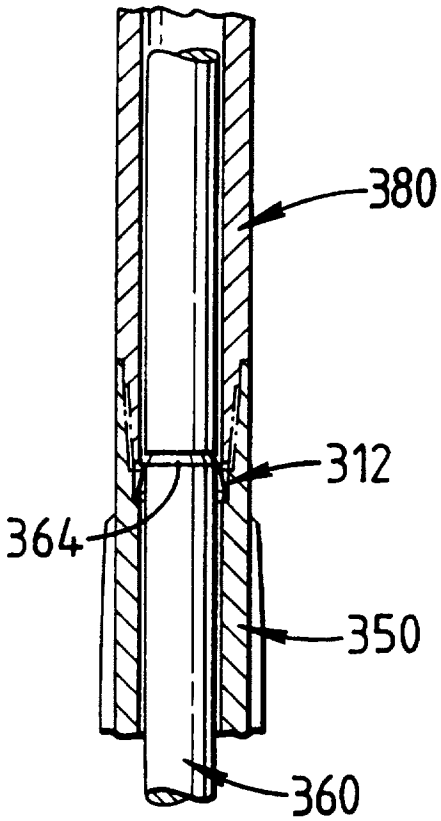


FIG. 21



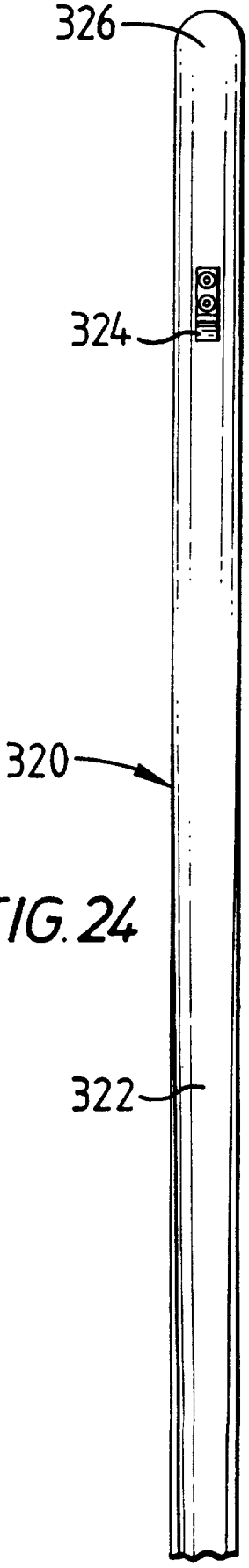


FIG. 22

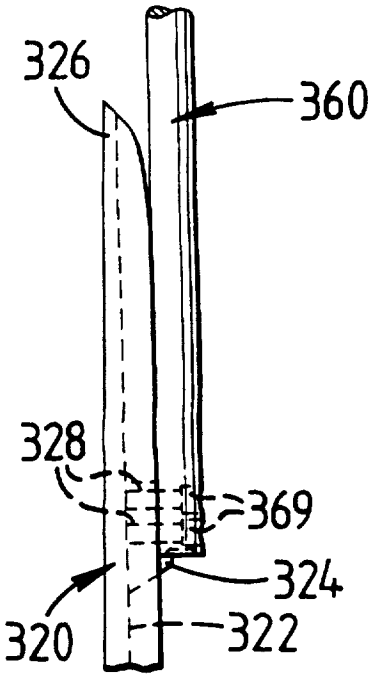


FIG. 23

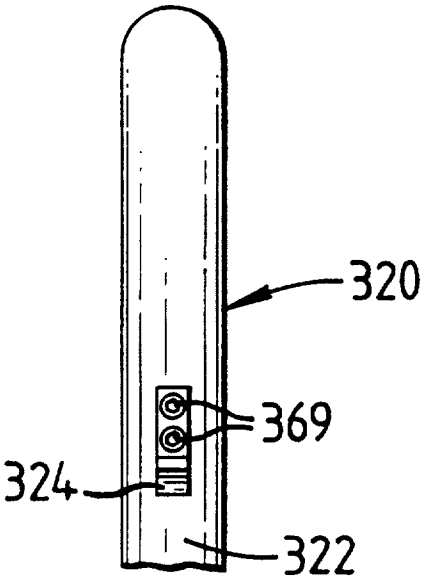


FIG. 24

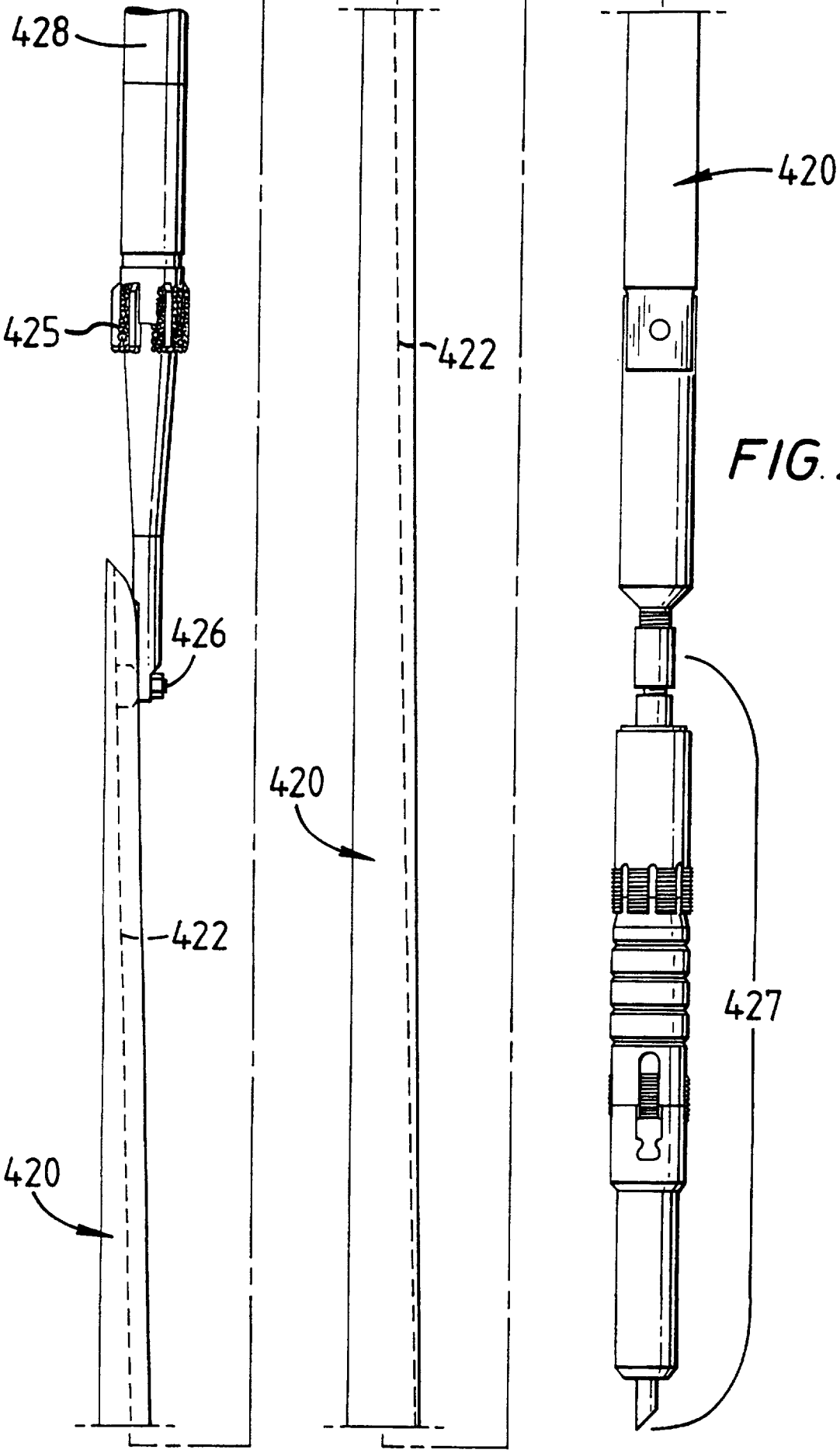


FIG. 25

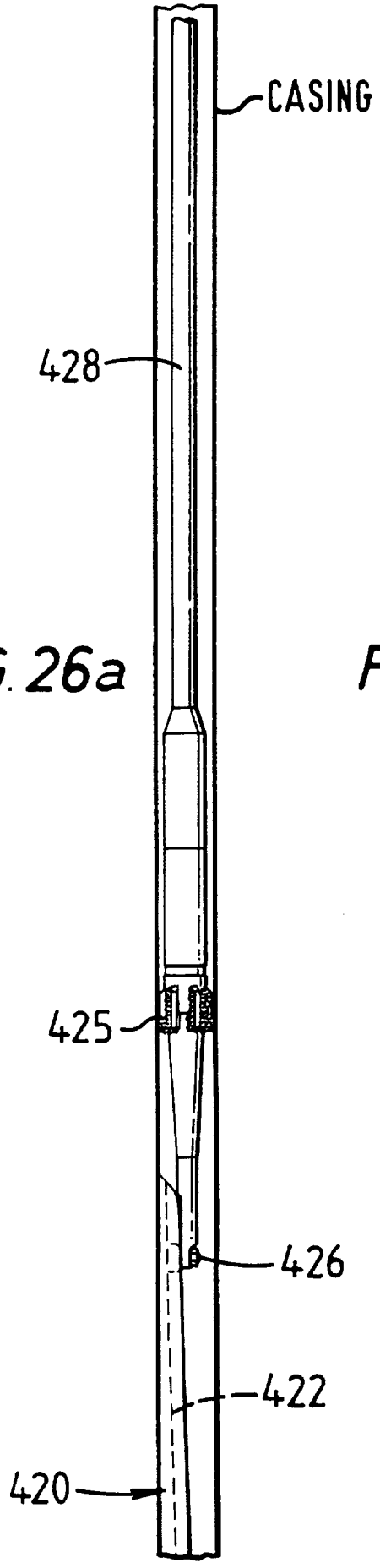


FIG. 26a

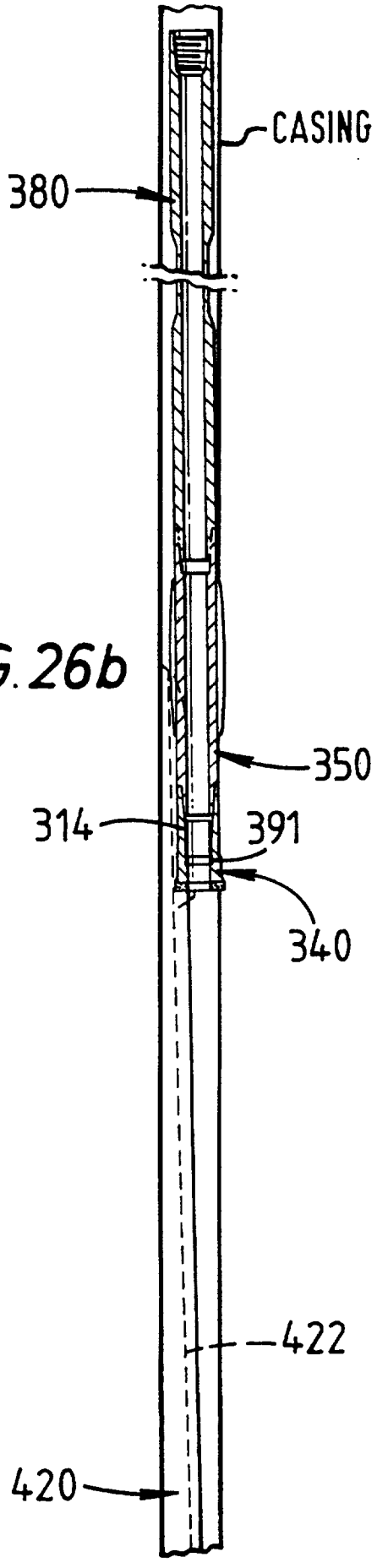


FIG. 26b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 97/02054

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: E21B 29/06, E21B 7/08
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2299106 A (TIW CORPORATION), 25 Sept 1996 (25.09.96) --	1-22
A	US 5193620 A (B.O. BRADDICK), 16 March 1993 (16.03.93) --	1-22
A	US 4397355 A (R.T. MCLAMORE), 9 August 1983 (09.08.83) --	1-22
A	US 3908759 A (W.S. CAGLE ET AL), 30 Sept 1975 (30.09.75) -- --------	1-22

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 October 1997	25. 11. 97
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Authorized officer Christer Bäcknert

INTERNATIONAL SEARCH REPORT

International application No.
PCT/GB 97/02054

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see extra sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

Invention No. 1; according to Claims 1-12, a milling apparatus comprising a mill and a starter bar wherein the starter bar is detachably connected to the mill. Optionally, the starter bar is also connected to a whipstock.

Invention No. 2; according to Claims 13-18 and 20-21, a milling apparatus incorporating a mill, a starter bar and a whipstock wherein the starter bar is formed in two portions, one of which is being carried by a guide member and the other being retractable into the mill.

Invention No. 3; according to Claim 19, a milling apparatus incorporating a mill and a whipstock for directing the mill towards a tubular member in the hole, the whipstock including a guide arranged to be milled away by the mill on its downward travel.

Invention No. 4; according to Claim 22, a whipstock having its upwardly extending concave surface covered with armour material.

The four inventions have some technical features in common but the technical relationship between the inventions can not be said to be such as is mentioned in PCT Rule 13.2. Thus, unity of invention is lacking.

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/10/97

International application No.
PCT/GB 97/02054

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2299106 A	25/09/96	CA 2164773 A	25/09/96
		GB 9524769 D	00/00/00
		US 5551509 A	03/09/96
		US 5647436 A	15/07/97
US 5193620 A	16/03/93	AU 2157592 A	02/03/93
		CA 2071183 A,C	06/02/93
		GB 2258479 A,B	10/02/93
		MX 9102538 A	01/02/93
		WO 9303252 A	18/02/93
US 4397355 A	09/08/83	NONE	
US 3908759 A	30/09/75	NONE	