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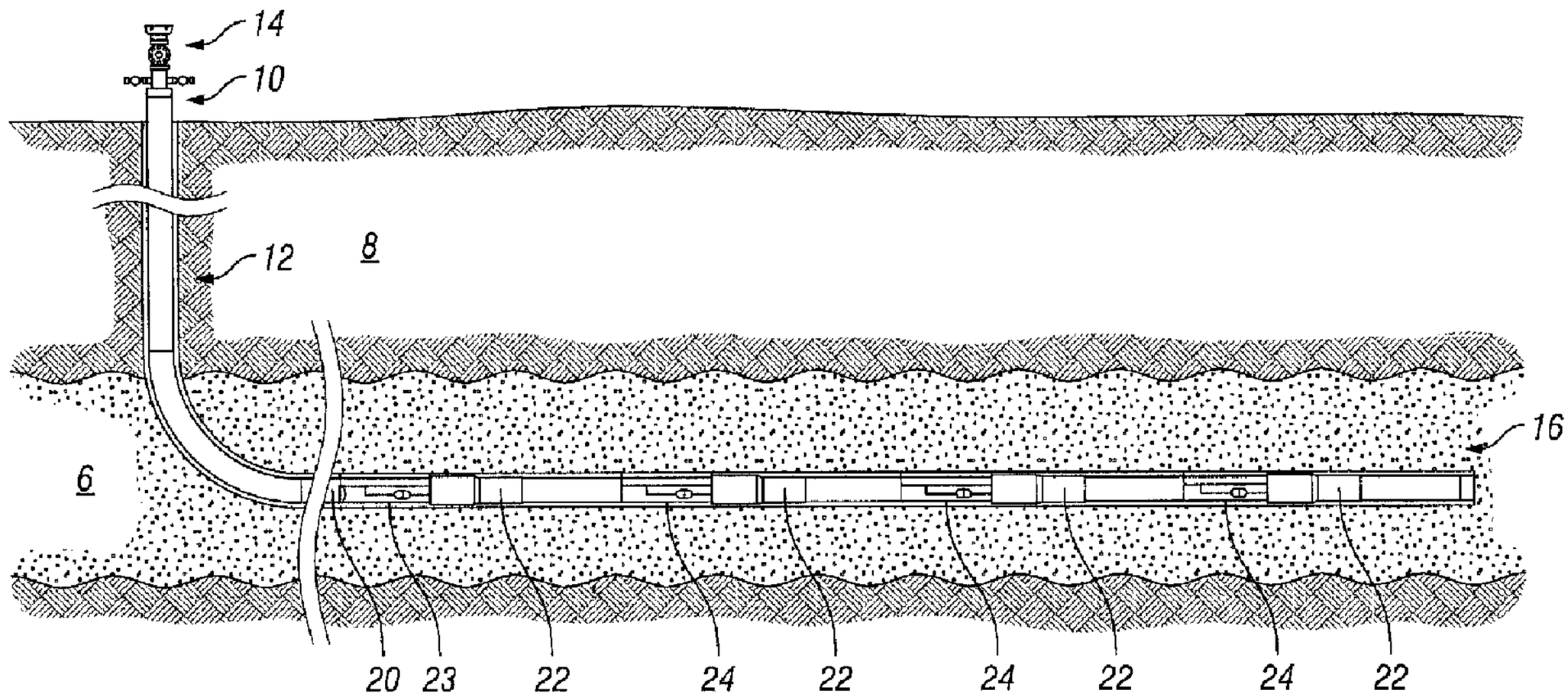
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(54) **Titre : PROCEDE ET APPAREIL DE COMPLETION DE PUITS**
(54) **Title: METHOD AND APPARATUS FOR WELL COMPLETION**



(57) **Abrégé/Abstract:**
Disclosed is a method and apparatus for performing a well completion. The apparatus comprises a tool string slidably locatable within the well and a shifting tool slidably locatable within the sleeve at an end of a tool string the shifting tool having a central bore therethrough and keys operable to be extended from an outer surface of the shifting tool when the central bore is supplied with the fluid above a predetermined pressure, the keys being engagable upon the sleeve so as to permit the shifting tool to move the sleeve longitudinally within the tubular body. The apparatus further comprises a motor located at a distal end of the tool string having a mill operably rotated thereby and means for selectably actuating one of the shifting tool or motor. The method comprises locating the tool string into the well and providing a fluid flow rate through the tool string to the first fluid flow range to actuate the shifting tool. The method further comprises increasing the fluid flow rate above the first fluid flow range to deactivate the shifting tool and increasing the fluid flow rate above the first fluid flow range and a predetermined fluid flow rate to activate the motor.

IS14.9708-CA-NP

ABSTRACT

Disclosed is a method and apparatus for performing a well completion. The apparatus comprises a tool string slidably locatable within the well and a shifting tool slidably locatable within the sleeve at an end of a tool string the shifting tool having a central bore therethrough and keys operable to be extended from an outer surface of the shifting tool when the central bore is supplied with the fluid above a predetermined pressure, the keys being engagable upon the sleeve so as to permit the shifting tool to move the sleeve longitudinally within the tubular body. The apparatus further comprises a motor located at a distal end of the tool string having a mill operably rotated thereby and means for selectably actuating one of the shifting tool or motor. The method comprises locating the tool string into the well and providing a fluid flow rate through the tool string to the first fluid flow range to actuate the shifting tool. The method further comprises increasing the fluid flow rate above the first fluid flow range to deactivate the shifting tool and increasing the fluid flow rate above the first fluid flow range and a predetermined fluid flow rate to activate the motor.

IS14.9708-CA-NP

METHOD AND APPARATUS FOR WELL COMPLETION

BACKGROUND:

1 Field

[0001] The present disclosure relates to well completion in general and in particular to a method and apparatus for operating a high pressure shifting tool within a well.

2 Description of Related Art

[0002] Hydrocarbon fluids such as oil and natural gas are obtained from a subterranean geologic formation, referred to as a reservoir, by drilling a well that penetrates the hydrocarbon-bearing formation. Once a wellbore is drilled, various forms of well completion components may be installed in order to control and enhance the efficiency of producing the various fluids from the reservoir.

[0003] Fracturing is used to increase permeability of subterranean formations. A fracturing fluid is injected into the wellbore passing through the subterranean formation. A propping agent (proppant) is injected into the fracture to prevent fracture closing and, thereby, to provide improved extraction of extractive fluids, such as oil, gas or water.

[0004] One difficulty that may be encountered in some fracturing operations is that there me debris located within the wellbore which impedes the movement of the equipment necessary for the fracturing operation. In such situations it may be conventionally necessary to remove the fracturing equipment from the hole and introduce a drill thereinto to clear the debris whereafter the fracturing operations may continue.

[0005] Improvements in completing these unconventional formations would be welcome by the industry.

SUMMARY:

[0006] In embodiments the disclosure pertains to methods for completing a well comprising completing at least a zone of a first well using a pin-point fracturing technique without using a sealing element.

[0007] In embodiments, the disclosure relates to methods for completing a well comprising cleaning out the wellbore and then fracturing the well without having the tool coming out of the well.

[0008] In embodiments, the disclosure aims at completions tools combining cleaning tool and fracturing tool on a same toolstring.

[0009] According to a further embodiment, there is disclosed an apparatus for performing a well completion comprising a tool string slidably locatable within the well and a shifting tool slidably locatable within the sleeve at an end of a tool string the shifting tool having a central bore therethrough and keys operable to be extended from an outer surface of the shifting tool when the central bore is supplied with the fluid above a predetermined pressure, the keys being engagable upon the sleeve so as to permit the shifting tool to move the sleeve longitudinally within the tubular body. The apparatus further comprises a motor located at a distal end of the tool string having a mill operably rotated thereby and means for selectably actuating one of the shifting tool or motor.

[0010] The means for selectably actuating one of the shifting tool or motor may be operable to actuate the shifting tool between a first fluid flow range through the tool string. The means for selectably actuating one of the shifting tool or motor may be operable to actuate the shifting tool above a predetermined fluid flow rate. The predetermined fluid flow rate may be higher than the first fluid flow range.

[0011] According to a further embodiment, there is disclosed a method for performing a well completion comprising locating a tool string into a well having a shifting tool and a motor operably rotating a mill at distal end thereof and providing a fluid flow rate through the tool string to a first fluid flow range to

actuate the motor. The method further comprises increasing the fluid flow rate above the first fluid flow range to deactivate the motor and increasing the fluid flow rate above the first fluid flow range and a predetermined fluid flow rate to activate the shifting tool.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0012] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying drawings illustrate only the various implementations described herein and are not meant to limit the scope of various technologies described herein. The drawings show and describe various embodiments of the current disclosure.

[0013] Figure1 is a cross-sectional view of a wellbore having a plurality of flow control valves according to a first embodiment of the present disclosure located therealong.

[0014] Figure 2 is a cross sectional view of a control valves of for use in the system of Figure 1.

[0015] Figure 3 is a longitudinal cross-sectional view of the control valve of Figure 2 as taken along the line 3-3.

[0016] Figure 4 is a detailed cross-sectional view of the extendable ports of the valve of Figure 2 in a first or retracted position.

[0017] Figure 5 is a detailed cross-sectional view of the extendable ports of the valve of Figure 2 in a second or extended position with the sleeve valve in an open position.

[0018] Figure 6 is a cross sectional view of the valve of Figure 2 as taken along the line 3-3 showing a shifting tool located therein.

[0019] Figure 7 is an axial cross-sectional view of the shifting tool of Figure 6 as taken along the line 7-7.

[0020] Figure 8 a lengthwise cross sectional view of the shifting tool of Figure 6 taken along the line 8-8 in Figure 7 with a control valve

located therein according to one embodiment with the sleeve engaging members located at a first or retracted position.

[0021] Figure 9 is a cross sectional view of the shifting tool of Figure 6 taken along the line 8-8 with a control valve located therein according to one embodiment with the sleeve engaging members located at a second or extended position

[0022] Figure 10 is a perspective view of a shifting tool according to a further embodiment.

[0023] Figure 11 exemplifies a possible bottom hole assembly envisaged by the present disclosure.

DETAILED DESCRIPTION:

[0024] At the outset, it should be noted that in the development of any such actual embodiment, numerous implementation—specific decisions must be made to achieve the developer's specific goals, such as compliance with system related and business related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure. In addition, the composition used/disclosed herein can also comprise some components other than those cited. In the summary and this detailed description, each numerical value should be read once as modified by the term "about" (unless already expressly so modified), and then read again as not so modified unless otherwise indicated in context. Also, in the summary and this detailed description, it should be understood that a concentration range listed or described as being useful, suitable, or the like, is intended that any and every concentration within the range, including the end points, is to be considered as having been stated. For example, “a range of from 1 to 10” is to be read as indicating each and every possible number along the continuum between about 1 and about 10. Thus, even if specific data points within the range, or even no data points within the range, are explicitly identified or refer to only a few specific,

it is to be understood that inventors appreciate and understand that any and all data points within the range are to be considered to have been specified, and that inventors possessed knowledge of the entire range and all points within the range.

[0025] The statements made herein merely provide information related to the present disclosure and may not constitute prior art, and may describe some embodiments illustrating the disclosure.

[0026] In the specification and appended claims: the terms "connect", "connection", "connected", "in connection with", and "connecting" are used to mean "in direct connection with" or "in connection with via one or more elements"; and the term "set" is used to mean "one element" or "more than one element". Further, the terms "couple", "coupling", "coupled", "coupled together", and "coupled with" are used to mean "directly coupled together" or "coupled together via one or more elements". As used herein, the terms "up" and "down", "upper" and "lower", "upwardly" and downwardly", "upstream" and "downstream"; "above" and "below"; and other like terms indicating relative positions above or below a given point or element are used in this description to more clearly describe some embodiments of the disclosure.

[0027] The disclosure pertains to methods of treating an underground formation penetrated by either vertical wells or wells having a substantially horizontal section. Horizontal well in the present context may be interpreted as including a substantially horizontal portion, which may be cased or completed open hole, wherein the fracture is transversely or longitudinally oriented and thus generally vertical or sloped with respect to horizontal. The following disclosure will be described using horizontal well but the methodology is equally applicable to vertical wells.

[0028] The industry has privileged, when it comes to hydraulic fracturing, what is known as being "plug-and-perf" technique. Horizontal wells may extend

hundreds of meters away from the vertical section of the wellbore. Most of the horizontal section of the well passes through the producing formation and are completed in stages. The wellbore begins to deviate from vertical at the kickoff point, the beginning of the horizontal section is the heel and the farthest extremity of the well is the toe. Engineers perform the first perforating operation at the toe, followed by a fracturing treatment. Engineers then place a plug in the well that hydraulically isolates the newly fractured rock from the rest of the well. A section adjacent to the plug undergoes perforation, followed by another fracturing treatment. This sequence is repeated many times until the horizontal section is stimulated from the toe back to the heel. Finally, a milling operation removes the plugs from the well and production commences.

[0029] The common practice in the art is to perforate 4-6 clusters, and push a slickwater laden fluid at or above fracture pressure to create fractures; it is estimated that 30 to 60% of these perforations do not produce due to for example screen out, geological constraint, etc., and thus for every 100 perforations in a wellbore, commonly only 30 to 70 of the conventional perforations are useful for production.

[0030] To respond to that, some operations now involve what is known as pin-point fracturing, which may be defined as the operation of pumping a fluid above the fracturing pressure of the formation to be treated through a single entry. The entry may be a perforation, a valve, a sleeve, or a sliding sleeve. Generally, sliding sleeves in the closed position are fitted to the production liner. The production liner is placed in a hydrocarbon formation. An object is introduced into the wellbore from surface, and the object is transported to the target zone by the flow field or mechanically, for example using a wireline or a coiled tubing. When at the target location, the object is caught by the sliding sleeve and shifts the sleeve to the open position, alternatively the object is catching the sleeve and opens it. A sealing device, such as a packer or cups, is positioned below the sleeve to be treated in order to isolate the lower portion of the wellbore. The sealing device is set, fluid is pumped into the fracture and then

the sealing device is unset and moved below the next zone (or sleeve) to be treated. Representative examples of sleeve-based systems are disclosed in US 7,387,165, US 7,322,417, US 7,377,321, US 2007/0107908, US 2007/0044958, US 2010/0209288, US 7,387,165, US2009/0084553, US 7,108,067, US 7,431,091, US 7,543,634, US 7,134,505, US 7,021,384, US 7,353,878, US 7,267,172, US 7,681,645, US 7,066,265, US 7,168,494, US 7,353,879, US 7,093,664, and US 7,210,533, which are hereby incorporated herein by reference. A fracturing treatment is then circulated down the wellbore to the formation adjacent the open sleeve.

[0031] Operations involving sliding sleeve imply to have a casing or liner that having pre-fitted or preinstalled sleeves when the well is cased thereby prior to cementing the well. Operators then typically need to clean the well in order to start the hydraulic stimulation; this is known in the industry as a clean out run which involves cleaning potential debris that may remain in the wellbore and usually takes hours before the fracturing tools can be lowered down the well. The present disclosure aims at optimizing such clean out by enabling to combine both the clean out run with the trip to lower the hydraulic stimulation tools.

[0032] Embodiments herein relate to methods of completing an underground formation using multi-stage pin-point fracturing for treating a well without using any sealing element.

[0033] In embodiments, a cased-hole is provided with a production tubing (or casing) fitted with sliding reclosable sleeves (as in Figure 1) at the desired location and quantity. After the completion (desired amount of sleeves and casing) is installed into the well, the well would be set up for fracture/stimulation operations. Using, for example, a coil tubing or stick pipe an actuation device would be conveyed into the well.

[0034] The actuation device, indifferently mentioned here as shifting tool, may be a tool that is equipped with a sleeve engaging member selectably

extendable from the shifting tool in parallel to a central axis of the shifting tool and engagable upon the sleeve wherein the shifting tool is moveable so as to cause the sleeve to selectably cover and uncover the apertures. A suitable combination sliding sleeve and shifting tool may be found in US2012/0125627 incorporated herein by reference in its entirety.

[0035] Referring to FIG. 1, a wellbore 10 is drilled into the ground 8 to a production zone 6 by known methods. The production zone 6 may contain a horizontally extending hydrocarbon bearing rock formation or may span a plurality of hydrocarbon bearing rock formations such that the wellbore 10 has a path designed to cross or intersect each formation. As illustrated in FIG. 1, the wellbore includes a vertical section 12 having a valve assembly or Christmas tree 14 at a top end thereof and a bottom or production section 16 which may be horizontal or angularly oriented relative to the horizontal located within the production zone 6. After the wellbore 10 is drilled the production tubing 20 is of the hydrocarbon well is formed of a plurality of alternating liner or casing 22 sections and in line valve bodies 24 surrounded by a layer of cement 23 between the casing and the wellbore. The valve bodies 24 are adapted to control fluid flow from the surrounding formation proximate to that valve body and may be located at predetermined locations to correspond to a desired production zone within the wellbore. In operation, between 8 and 100 valve bodies may be utilized within a wellbore although it will be appreciated that other quantities may be useful as well.

[0036] Turning now to FIG. 2, a perspective view of one valve body 24 is illustrated. The valve body 24 comprises a substantially elongate cylindrical outer casing 26 extending between first and second ends 28 and 30, respectively and having a central passage 32 therethrough. The first end 28 of the valve body is connected to adjacent liner or casing section 22 with an internal threading in the first end 28. The second end 30 of the valve body is connected to an adjacent casing section with external threading around the second end 30. The valve body 24 further includes a central portion 34 having a plurality of raised sections 36

extending axially therealong with passages 37 therebetween. As illustrated in the accompanying figures, the valve body 24 has three raised sections although it will be appreciated that a different number may also be utilized.

[0037] Each raised section 36 includes a radially movable body or port body 38 therein having an aperture 40 extending therethrough. The aperture 40 extends from the exterior to the interior of the valve body and is adapted to provide a fluid passage between the interior of the bottom section 16 and the wellbore 10 as will be further described below. The aperture 40 may be filled with a sealing body (not shown) when installed within a bottom section 16. The sealing body serves to assist in sealing the aperture until the formation is to be fractured and therefore will have sufficient strength to remain within the aperture until that time and will also be sufficiently frangible so as to be fractured and removed from the aperture during the fracing process. Additionally, the port bodies 38 are radially extendable from the valve body so as to engage an outer surface thereof against the wellbore 10 so as to center the valve body 24 and thereby the production section within the wellbore.

[0038] Turning now to FIG. 3, a cross sectional view of the valve body 24 is illustrated. The central passage 32 of the valve body includes a central portion 42 corresponding to the location of the port bodies 38. The central portion is substantially cylindrical and contains a sliding sleeve 44 therein. The central portion 42 is defined between first or entrance and second or exit raised portions or annular shoulders, 46 and 48, respectively. The sliding sleeve 44 is longitudinally displaceable within the central portion 42 to either be adjacent to the first or second shoulder 46 or 48. At a location adjacent to the second shoulder, the sliding sleeve 44 sealably covers the apertures 40 so as to isolate the interior from the exterior of the bottom section 16 from each other, whereas when the sliding sleeve 44 is adjacent to the first shoulder 46, the sliding sleeve 44

[0039] The central portion 42 includes a first annular groove 50 a therein

proximate to the first shoulder 46. The sliding sleeve 44 includes a radially disposed snap ring 52 therein corresponding to the groove 50 a so as to engage therewith and retain the sliding sleeve 44 proximate to the first shoulder 46 which is an open position for the valve body 24. The central portion 42 also includes a second annular groove 50 b therein proximate to the aperture 40 having a similar profile to the first annular groove 50 a. The snap ring 52 of the sleeve is receivable in either the first or second annular groove 50 a or 50 b such that the sleeve is held in either an open position as illustrated in FIG. 5 or a closed position as illustrated in FIG. 4. The sliding sleeve 44 also includes annular wiper seals 54 which will be described more fully below proximate to either end thereof to maintain a fluid tight seal between the sliding sleeve and the interior of the central portion 42.

[0040] The port bodies 38 are slidably received within the valve body 24 so as to be radially extendable therefrom. As illustrated in FIG. 3, the port bodies are located in their retracted position such that an exterior surface 60 of the port bodies is aligned with an exterior surface 62 of the raised sections 36. Each raised section may also include limit plates 64 located to each side of the port bodies 38 which overlap a portion of and retain pistons within the cylinders as are more fully described below.

[0041] Each raised section 36 includes at least one void region or cylinder 66 disposed radially therein. Each cylinder 66 includes a piston 68 therein which is operably connected to a corresponding port body 38 forming an actuator for selectably moving the port bodies 38. Turning now to FIGS. 4 and 5, detailed views of one port body 38 are illustrated at a retracted and extended position, respectively. Each port body 38 may have an opposed pair of pistons 68 associated therewith arranged to opposed longitudinal sides of the valve body 24. It will be appreciated that other quantities of pistons 68 may also be utilized for each port body 38 as well. The pistons 68 are connected to the valve body by a top plate 70 having an exterior surface 72. The exterior surface 72 is positioned to correspond to the exterior surface 62 of the raised sections 36 so as to present

a substantially continuous surface therewith when the port bodies 38 are in their retracted positions. The exterior surface 72 also includes angled end portions 74 so as to provide a ramp or inclined surface at each end of the port body 38 when the port bodies 38 are in an extended position. This will assist in enabling the valve body to be longitudinally displaced within a wellbore 10 with the vertical section 12 under thermal expansion of the production string and thereby to minimize any shear stresses on the port body 38.

[0042] The pistons 68 are radially moveable within the cylinders relative to a central axis of the valve body so as to be radially extendable therefrom. In the extended position illustrated in FIG. 5, the exterior surface 72 of the port bodies are adapted to be in contact with the wellbore 10 so as to extend the port body 38 and thereby enable the wellbore 10 to be placed in fluidic communication with the central portion 42 of the valve body 24. The pistons 68 may have a travel distance between their retracted positions and their extended positions of between 0.10 and 0.50 inches although it will be appreciated that other distances may also be possible. In the extended position, it will be possible to frac that location without having to also fracture the concrete which will be located between the valve body 24 and the wellbore wall thereby reducing the required frac pressure. Additionally, more than one port body 38 may be utilized and radially arranged around the valve body so as to centre the valve body within the wellbore when the port bodies are extended therefrom.

[0043] The pistons 68 may include seals 76 therearound so as to seal the piston within the cylinders 66. Additionally, the port body 38 may include a port sleeve 78 extending radially inward through a corresponding port bore 81 within the valve body. A seal 80 may be located between the port sleeve 78 and the port bore 81 so as to provide a fluid tight seal therebetween. A snap ring 82 may be provided within the port bore 81 adapted to bear radially inwardly upon the port sleeve 78. In the extended position, the snap ring 82 compresses radially inwardly to provide a shoulder upon which the port sleeve 78 may rest so as to prevent retraction of the port body 38 as illustrated in FIG. 5. The pistons 68 may

be displaceable within the cylinders 66 by the introduction of a pressurized fluid into a bottom portion thereof. It will also be appreciated that other sleeve valves may be utilized which do not include extendable pistons as illustrated herein as are commonly known in the art.

[0044] With reference to FIG. 3, the entrance bore 94 intersect the central passage 32 of the valve body 24. As illustrated each entrance bore 94 may be covered by a knock-out plug 102 so as to seal the entrance bore until removed. In operation, as concrete is pumped down the bottom section 16, it will be followed by a plug so as to provide an end to the volume of concrete. The plug is pressurized by a pumping fluid (such as water, by way of non-limiting example) so as to force the concrete down the production string and thereafter to be extruded into the annulus between the horizontal section and the wellbore. The knock-out plugs 102 are designed so as to be removed or knocked-out of the entrance bore by the concrete plug passing thereby. In such a way, once the concrete has passed the valve body 24, the concrete plug removes the knock-out plugs 102 so as to pressurize the entrance bore 94 and fluid bore 90 and thereafter to extend the pistons 68 from the valve body 24 once the pressurizing fluid has reached a sufficient pressure.

[0045] Turning now to FIG. 6, a shifting tool 200 is illustrated within the central passage 32 of the valve body 24. The shifting tool 200 is adapted to engage the sliding sleeve 44 and shift it between a closed position as illustrated in FIG. 4 and an open position in which the apertures 40 are uncovered by the sliding sleeve 44 so as to permit fluid flow between and interior and an exterior of the valve body 24 as illustrated in FIG. 5. The shifting tool 200 comprises a substantially cylindrical elongate tubular body 202 extending between first and second ends 204 and 206, respectively. The shifting tool 200 includes a central bore 210 therethrough (shown in FIGS. 7 through 9) to receive an actuator or to permit the passage of fluids and other tools therethrough. The shifting tool 200 includes at least one sleeve engaging member 208 radially extendable from the tubular body 202 so as to be selectably engageable with the sliding sleeve 44 of

the valve body 24. As illustrated in the accompanying figures, three sleeve engaging members 208 are illustrated although it will be appreciated that other quantities may be useful as well.

[0046] The sleeve engaging members 208 comprise elongate members extending substantially parallel to a central axis 209 of the shifting tool between first and second ends 212 and 214, respectively. The first and second ends 212 and 214 include first and second catches 216 and 218, respectively for surrounding the sliding sleeve and engaging a corresponding first or second end 43 or 45, respectively of the sliding sleeve 44 depending upon which direction the shifting tool 200 is displaced within the valve body 24. As illustrated in FIGS. 8 and 9, the first and second catches 216 and 218 of the sleeve engaging member 208 each include and inclined surface 220 and 222, respectively facing in opposed directions from each other. The inclined surfaces 220 and 222 are adapted to engage upon either the first or second annular shoulder 46 or 48 of the valve body as the shifting tool 200 is pulled or pushed there into. The first or second annular shoulders 46 or 48 press the first or second inclined surface 220 or 222 radially inwardly so as to press the sleeve engaging members 208 inwardly and thereby to disengage the sleeve engaging members 208 from the sliding sleeve 44 when the sliding sleeve 44 has been shifted to a desired position proximate to one of the annular shoulders. In an optional embodiment, one or both of the catches 216 or 218 may have an extended length as illustrated in FIG. 10 such that the sleeve engaging members are disengaged from the sliding sleeve at a position spaced apart from one of the first or second annular shoulders 46 or 48 and thereby adapted to position the sliding sleeve at a third or central position within the valve body 24.

[0047] Turning to FIG. 7, the sleeve engaging members are maintained parallel to the tubular body 202 of the shifting tool 200 by a parallel shaft 230. Each parallel shaft 230 is linked to a sleeve engaging member 208 by a pair of spaced apart linking arms 232. The parallel shaft 230 is rotatably supported within the shifting tool tubular body 202 by bearings or the like. The linking arms

232 are fixedly attached to the parallel shaft 230 at a proximate end and are received within a blind bore 234 of the sleeve engaging members 208. As illustrated in FIG. 6, the linking arms 232 are longitudinally spaced apart from each other along the parallel shaft 230 and the sleeve engaging member 208 so as to be proximate to the first and second ends 212 and 214 of the sleeve engaging member 208.

[0048] Turning now to FIG. 8, the tubular body 202 of the shifting tool includes a shifting bore 226 therein at a location corresponding to each sleeve engaging member. The shifting bore 226 extends from a cavity receiving the sleeve engaging member to the central bore 210 of the shifting tool 200. Each sleeve engaging member 208 includes a piston 224 extending radially therefrom which is received within the shifting bore 226. In operation, a fluid pressure applied to the central bore 210 of the shifting tool will be applied to the piston 224 so as to extend the piston within the shifting bore 226 and thereby to extend the sleeve engaging members 208 from a first or retracted position within the shifting tool tubular body 202 as illustrated in FIG. 8 to a second or extended position for engagement on the sliding sleeve 44 as discussed above as illustrated in FIG. 9. The parallel shafts also include helical springs (not shown) thereon to bias the sleeve engaging members to the retracted position.

[0049] The first end 204 of the shifting tool 200 includes an internal threading 236 therein for connection to the external threading of the end of a production string or pipe (not shown). The second end 206 of the shifting tool 200 includes external threading 238 for connection to internal threading of a downstream productions string or further tools, such as by way of non-limiting example a control valve as will be discussed below. An end cap 240 may be located over the external threading 238 when such a downstream connection is not utilized.

[0050] With reference to FIGS. 8 and 9, a first control valve 300 according to a first embodiment located within a shifting tool 200 for use in wells having low

hydrocarbon production flow rates. The low flow control valve 300 comprises a valve housing 302 having a valve passage 304 therethrough and seals 344 therearound for sealing the valve housing 302 within the shifting tool 200. The low flow control valve 300 includes a central housing extension 306 extending axially within the valve passage 304 and a spring housing portion 320 downstream of the central portion 310. The central housing extension 306 includes an end cap 308 separating an entrance end of the valve passage from a central portion 310 of the valve passage and an inlet bore 322 permitting a fluid to enter the central portion 310 from the valve passage 304.

[0051] The central portion 310 of the valve passage contains a valve piston rod 312 slidably located therein. The valve piston rod 312 includes leading and trailing pistons, 314 and 316, respectively thereon in sealed sliding contact with the central portion 310 of the valve passage. The leading piston 314 forms a first chamber 313 with the end cap 308 having an inlet port 315 extending through the leading piston 314. The valve piston rod 312 also includes a leading extension 318 having an end surface 321 extending from an upstream end thereof and extending through the end cap 308. The valve piston rod 312 is slidable within the central portion 310 between a closed position as illustrated in FIG. 8 and an open position as illustrated in FIG. 9. In the closed position, the second or trailing piston 316 is sealable against the end of the central portion 310 to close or seal the end of the central passage and thereby prevent the flow of a fluid through the control valve. In the open position as illustrated in FIG. 9, the trailing piston 316 is disengagable from the end of the central portion 310 so as to provide a path of flow, generally indicated at 319, therethrough from the central passage to the spring housing.

[0052] A spring 324 is located within the spring housing 320 and extends from the valve piston rod 312 to an orifice plate 326 at a downstream end of the spring housing 320. The spring 324 biases the valve piston rod 312 towards the closed position as illustrated in FIG. 8. Shims or the like may be provided between the spring 324 and the orifice plate 326 so as to adjust the force exerted

by the spring upon the valve piston rod 312. In other embodiments, the orifice plate may be axially moveable within the valve body by threading or the like to adjust the force exerted by the spring. In operation, fluid pumped down the production string to the valve passage 304 passes through the inlet bore and into the central portion 310. The pressure of the fluid within the central portion 310 is balanced upon the opposed faces of leading and trailing pistons 314 and 316 such that the net pressure exerted upon the valve piston rod 312 is provided by the pressure exerted on the end surface 321 of the leading extension 318 and on the leading piston 314 from within the first chamber 313. The resulting force exerted upon the end surface 321 is resisted by the biasing force provided by the spring 324 as described above.

[0053] Additionally, the orifice plate 326 includes an orifice 328 therethrough selected to provide a pressure differential thereacross under a desired fluid flow rate. In this way, when the fluid is flowing through the central portion 310 and the spring housing 320, the spring housing 320 will have a pressure developed therein due to the orifice plate. This pressure developed within the spring housing 320 will be transmitted through apertures 330 within the spring housing to a sealed region 332 around the spring housing proximate to the shifting bore 226 of the shifting tool 200. This pressure serves to extend the pistons 224 within the shifting bores 226 and thereby to extend the sleeve engaging members 208 from the shifting tool. The pressure developed within the spring housing 320 also resists the opening of the valve piston rod 312 such that in order for the valve to open and remain open, the pressure applied to the entrance of the valve passage 304 is required to overcome both the biasing force of the spring 324 and the pressure created within the spring housing 320 by the orifice 328.

[0054] The valve 300 may be closed by reducing the pressure of the supplied fluid to below the pressure required to overcome the spring 324 and the pressured created by the orifice 328 such that the spring is permitted to close the valve 300 by returning the valve piston rod 312 to the closed position as illustrate

in 11 as well as permitting the springs on the parallel shaft 230 to retract the sleeve engaging members 208 as the pressure within the spring housing 320 is reduced. Seals 336 as further described below may also be utilized to seal the contact between the spring housing 320 and the interior of the central bore 210 of the shifting tool 200.

[0055] A shear sleeve 340 may be secured to the outer surface of the valve housing 302 by shear screws 342 or the like. The sheer sleeve 340 is sized and selected to be retained between a pipe threaded into the internal threading 236 of the shifting tool 200 and the remainder of the shifting tool body. In such a way, should the valve be required to be retrieved, a spherical object 334, such as a steel ball, such as are commonly known in the art may be dropped down the production string so as to obstruct the valve passage 304 of the valve 300. Obstructing the flow of a fluid through the valve passage 304 will cause a pressure to develop above the valve so as to shear the shear screws 342 and force the valve through the shifting tool. The strength of the sheer screws 342 may be selected so as to prevent their being sheered during normal operation of the valve 300 such as for pressures of between 1000 and 3000 psi inlet fluid pressure. The valve illustrated in FIGS. 8 and 9 is adapted for use in a low hydrocarbon flow rate well. In such well types, the flow of fluids such as hydrocarbons or other fluids is low enough that the fluid pumped down the well to pressurize the central portion 310 is sufficient to overcome the flow of the fluids up the well so as to pass through the orifice 328. It will be appreciated that for wells of higher well pressure or flow rates, such a valve will be limited in its application.

[0056] In embodiments, the method for completing a well involves an apparatus for selectably opening a valve body in a well casing having a central passage and a plurality of apertures therethrough. The apparatus comprises a sleeve slidably located within the central passage of the valve body adapted to selectably cover or uncover the apertures and a shifting tool slidably locatable within the sleeve. The apparatus further comprises at least one sleeve engaging

member selectably extendable from the shifting tool in parallel to a central axis of the shifting tool and engagable upon the sleeve wherein the shifting tool is moveable so as to cause the sleeve to selectably cover and uncover the apertures.

[0057] The sleeve may be axially displaceable within the central passage. The sleeve may be displacable between a first position covering the apertures and a second position uncovering the apertures. The sleeve may seal the apertures in the first position.

[0058] The shifting tool may be securable to the end of a production casing nested within the well casing. The shifting tool may include a central bore therethrough. The central bore may include a plurality of shifting bores extending therefrom, each shifting bore having a piston therein operably connected to a sleeve engaging member for extending the sleeve engaging member when the central bore is supplied with a pressurized fluid.

[0059] The sleeve engaging members may comprise elongate members extending between first and second ends. The sleeve engaging members may extend parallel to an axis of the central bore. The first and second ends of the sleeve engaging members may include first and second catches for engaging corresponding first and second ends of the sleeve. The first and second catches may be spaced apart by a distance sufficient or receive the sleeve therebetween.

[0060] The first and second ends of the elongate members may include corresponding first and second inclined surfaces. The central passage may include a raised portion proximate to the first position of the sleeve so as to be engaged by the first inclined surface as the sleeve is moved into the first position and thereby to disengage the catches from the sleeve. The central passage may include a raised portion proximate to the second position of the sleeve so as to be engaged by the second inclined surface as the sleeve is moved into second first position and thereby to disengage the catches from the sleeve.

[0061] Each sleeve engaging member may include a shaft extending therealong and at least two linking arms extending from the shaft to the sleeve engaging member so as to maintain the sleeve engaging member parallel thereto. The linking arms may be received within sockets within the sleeve engaging member.

[0062] According to further embodiments, there is disclosed an apparatus for shifting a sleeve of a sleeve valve, the sleeve valve comprising a valve body with at least one aperture extending therethrough and an axially displaceable sleeve adapted to selectably cover or uncover the apertures. The apparatus comprises a shifting tool slidably locatable within the sleeve and at least one sleeve engaging member selectably extendable from the shifting tool in parallel a central axis of the shifting tool and engagable upon the sleeve.

[0063] According to further embodiments, there is disclosed a method for selectably opening a valve body in a well casing having a central passage and a plurality of apertures therethrough. The method comprises providing a sleeve slidably located within the central passage of the valve body adapted to selectably cover or uncover the apertures. The sleeve is located in one of a first or second position. The method further comprises positioning an shifting tool slidably locatable within the sleeve, extending the at least one sleeve engaging member selectably extendable from the shifting tool in parallel to a central axis of the shifting tool into engagement upon the sleeve, and axially moving the shifting tool and the sleeve to another of the first or second positions.

[0064] The method may further comprise disengaging the at least one sleeve engaging member from the sleeve at the other of the first or second positions.

[0065] According to further embodiments, there is disclosed a method for actuating a sleeve valve, the sleeve valve comprising a valve body with at least one aperture extending therethrough and an axially displaceable sleeve adapted

to selectably cover or uncover the apertures. The method comprises locating a shifting tool within the sleeve, extending at least one sleeve engaging member from the shifting tool until engaged upon the sleeve, axially moving the shifting tool and sleeve and retracting the sleeve engaging member until disengaged from the sleeve.

[0066] According to further embodiments, there is disclosed a method for applying a fluid actuation pressure to a portion of an actuator, the method comprising sealably locating a valve body within the interior of the actuator, the valve body having an interior cavity therein and applying a fluid pressure to an upstream end of the valve body. The method further comprises slidably displacing a piston within the interior cavity after the fluid pressure reaches a desired pressure so as to open a fluid path through the valve body and passing the fluid through ports in an exterior of the valve body to provide the supply pressure to the actuator.

[0067] According to further embodiments, there is disclosed an apparatus for applying a fluid actuation pressure to a portion of an actuator comprising a valve body sealably locatable within the interior of the actuator, having an interior cavity. The valve body has a cylinder portion and a spring housing portion. The spring housing portion has a plurality of ports therethrough at a location corresponding to the actuator. The apparatus further includes an entrance end for applying a fluid pressure to an upstream end of the valve body and a rod slidably locatable within the cylinder portion. The entrance end is in fluidic communication with the cylinder portion. The rod has a piston sealed within the interior of the cylinder portion, the rod and piston displaceable to an actuating position wherein the piston is displaced out of the cylinder portion so as to place the entrance end in fluidic communication with the spring housing portion. The apparatus further comprises a compression spring engaged against a downstream portion of the rod and piston so as to bias the rod and piston into a closed position within the cylinder portion and an outlet orifice at a downstream end of the spring portion so as to release fluid from the spring housing at a

desired rate.

[0068] According to further embodiments, there is disclosed a method for applying a fluid actuation pressure to a portion of an actuator. The method comprises sealably securing a valve body to a distal end of the actuator and pumping a pressurized fluid through the valve body and actuator so as to provide an actuation pressure to the actuator.

[0069] According to further embodiments, there is disclosed a method for opening a passage through a terminal end of a production string. The method comprises providing a valve body at a distal end of the production string, providing an actuation pressure to actuation fluid within the so as to open a flap at a distal end thereof. The flap being operably connected to an annular piston longitudinally displaceable within the valve body and being biased with a spring so as to bias the flap to a closed position.

[0070] According to further embodiments, there is disclosed an apparatus for selectably sealing and pressurizing a production string. The apparatus comprises a valve body connectable to a distal end of a production string, the valve body having an interior cavity in fluidic communication with the production string and an annulus between the valve body and the well casing and a flapper valve rotatably located at a distal end of the interior cavity at a distal end of the valve body. The apparatus further comprises a spring biased piston longitudinally displaceable within the valve body, the piston operatively connected to the flapper valve so as to bias the flapper valve to a closed position and be openable when a fluid is pumped through the interior cavity.

[0071] In embodiments the string is supplemented with a cleaning equipment, thus enabling to prepare the wellbore for stimulation and to begin operation directly after cleaning. In the art, this type of operation would have imposed for example a coiled tubing lowering a first toolstring comprising a mill and motor, or other cleanout bottom hole assembly such as cleanout nozzle or

Junk Basket, to assure well cleaning conditions prior to replacing the with toolstring with a further toolstring comprising the completion equipment such as a shifting-tool to manipulate specific sleeves in the wellbore; once well is ready, the shifting tool would be run in the hole next.

[0072] The current disclosure describes a bottom hole assembly enabling such efficiency by combining a mill equipment with a motor and a shifting tool for actuating the sleeves installed in the casing. An exemplary embodiment illustrated in Figure 11 where the bottom hole assembly 500 (also sometimes referred to as tool string) comprise a connector or joint 502 to connect the assembly to the conveyance mean which may be for example a coiled tubing. Then optionally some centralizers 504 may be present. The bottom hole assembly 500 may also include an optional mechanical disconnect mean 506 and/or a hydraulic disconnect mean 508 as are commonly known and an optional circulation sub 510 followed by the shifting 200 equipment useful for selectively activating the sleeves in later operations as set out above. An orifice sub 512 may also present then the downhole motor 514 to empower the mill 516 which will effectively destroy or drill potential remaining debris. The circulation sub 510 may be optional, however, it offer at least another potential circulation path for the fluid which may be useful for example when the primary flow path becomes blocked or obstructed; in such situation the circulation sub may be opened for example by either flow or pressure to re-establish full circulation. In embodiments, the circulation sub may also be used when a nitrogen lift, to help the well flow following the fracturing treatment, is needed. The circulation sub may be actuated to prevent pumping the nitrogen through the motor thus extending the life of the motor.

[0073] In embodiments, the motor is conveyed by coiled tubing or joint pipe. The mill is driven by the motor which is actuated depending on the pump rate used examples of suitable flow rate may be from 60 galUS/min to 119 galUS/min. The motor is actuated by flow rate, which creates relative rotation between the rotor rolling in the inner wall of the stator. This eccentric motion is

translated to rotation by way of a flexshaft in the transmission section of the motor. This in turn powers the bit or mill below the motor. The flow rate required to actuate the motor is a function of the number of stages in the motor power section (combination of rotor and stator), the lobe configuration of the motor power section and the clearance between the rotor and inner wall of the stator (referred to as 'fit'). The operator can choose to actuate the motor in order to rotate the mill while lowering down the tool or the mill might be rotated at any specific location where a sleeve should then be opened or the operator may lower down the whole bottom hole assembly until encountering a restriction. In the latter case, the operator would then actuate the motor in order to clean the restriction and then further continue the hydraulic fracturing by opening the targeted sleeve.

[0074] In embodiments, the shifting tool may be actuated at flow rate superior to the flow rates suitable to actuate the motor. In embodiments the shifting tool may be actuated at flow rates above 120 gal US/min, or above 130 gal US/min, or between 130 gal US/min and 160 gal US/min. These values may be modified according to the well operating conditions. This may be achieved with a circulation device, such as an annular circulation device, a multi-cycle circulation device, a tubing pressure circulation device, an inline universal valve, a ported sub or a burst disc (collectively referred to as a "circulation device"). The circulation device may be located between the shifting tool and motor (513 in Fig 11). During the cleanout operation, flow will be directed through the motor, actuating the motor without extending the shifting tool keys. When the flow rate is elevated above a predetermined value, the increased differential pressure will activate the circulation device, which will divert flow away from the motor, to the wellbore annulus. The rate can then be increased beyond the range of the motor and allow full extension of the shifting tool keys for sleeve manipulation. The circulating device may or may not be resettable, depending on device used and objectives. If device is resettable, flow to the motor may be restored upon reduction of pump rate. If device is not resettable, flow path will continue to the

annulus, however shifting tool keys can be retracted with slight reduction in flow rate.

[0075] Fracturing operations could then start at any location in the well; for example from toe-to-heel, or from heel-to-toe or at any preferred location by opening the sleeve corresponding to the chosen zone to be fracture; then, the fluid pressure would be increased until reaching the fracturing pressure of the formation. The created fracture may then be propped with the fracturing fluid and when the operator decides to move to another zone, the activation device will then be used to reclose the opened sleeve, thus isolating the treated zone. This will be repeated until the amount of targeted zone has been treated; at any time if a restriction is encountered, the mill might be used.

[0076] Accordingly, each zone may be fractured independently and then isolated after the fracture is complete. The reclosing sleeve enables to fracture and isolate each specific zone without using any isolation (or sealing) elements such as packer, isolation plug, or cups. Combined with a cleaning equipment (motor and mill); this would make the pin-point fracturing technique much more efficient and reliable than the current techniques involving setting and unsetting a packer for each zone or even having to run a cleaning stage before initiating any fracturing operations. While taking into account that in many of past fracturing operations, the use of sealing elements such as packer have been the source of problems, the currently disclosed methods alleviate questions about reliability of sealing element and one of the many further advantages is that it would also not require having a toe valve or opening to run in equipment. The sleeve is reclosed after fracture/stimulation to provide pressure integrity back to the casing string. This opens up the opportunity to fracture/stimulate the wellbore in any fashion. Then, by removing the sealing element, there will no longer needs to be a washing step for cleaning the sealing elements thus reducing fluid consumption, suppressing overflush which will contribute to better fracturing jobs.

[0077] In embodiment, the actuation device is mounted on a coiled tubing

element. The coiled tubing may remain in the wellbore during the fracture/stimulation. Once all the zones are fractured / stimulated the coil tubing may be lowered to the toe of the well. During this time, the clean out of the well can be performed without having to change any part of the Bottom Hole Assembly (BHA) to ensure all debris and sand are washed from the wellbore.

[0078] Once the cleanout is completed, the actuation device is put in opening position and the coil tubing is pulled out of the well. The upward motion would open all the sleeves coming out of the well leaving the well clean and ready for production.

[0079] While the present disclosure has been disclosed with respect to a limited number of embodiments, those skilled in the art, having the benefit of this disclosure, will appreciate numerous modifications and variations there from. It is intended that the appended claims cover such modifications and variations as fall within the true spirit and scope of the disclosure.

CLAIMS

What is claimed is:

1. An apparatus for performing a well completion comprising:

a tool string slidably locatable within said well;

shifting tool slidably locatable within said sleeve at an end of a tool string said shifting tool having a central bore therethrough and keys operable to be extended from an outer surface of said shifting tool when said central bore is supplied with said fluid above a predetermined pressure, said keys being engagable upon said sleeve so as to permit said shifting tool to move said sleeve longitudinally within said tubular body;

a motor located at a distal end of said tool string having a mill operably rotated thereby; and

means for selectably actuating one of said shifting tool or motor.

2. The apparatus of claim 1 wherein said means for selectably actuating one of said shifting tool or motor is operable to actuate said motor between a first fluid flow range through said tool string.

3. The apparatus of claim 2 wherein said means for selectably actuating one of said shifting tool or motor is operable to actuate said shifting tool above a predetermined fluid flow rate.

4. The apparatus of claim 3 wherein said predetermined fluid flow rate is higher than said first fluid flow range.

5. The apparatus of claim 1 wherein the first fluid flow range is from from 60 galUS/min to 119 galUS/min.

6. The apparatus of claim 2 wherein the predermined fluid flow rate is between 120 gal US/min and 160 gal US/min.

7. The apparatus of claim 1 wherein a circulation device is located between the shifting tool and motor.

8. The apparatus of claim 7 wherein the circulating device is resettable.

9. A method for performing a well completion comprising:

locating a tool string into a well having a shifting tool and a motor operably rotating a mill at distal end thereof;

providing a fluid flow rate through said tool string to a first fluid flow range to actuate said motor;

increasing said fluid flow rate above said first fluid flow range to deactivate said motor; and

increasing said fluid flow rate above said first fluid flow range and a predetermined fluid flow rate to activate said shifting tool.

10. The method of claim 9 wherein the first fluid flow range is from from 60 galUS/min to 119 galUS/min.

11. The method of claim 9 wherein the predermined fluid flow rate is between 120 gal US/min and 160 gal US/min.

12. A method for hydraulically fracturing a well comprising:

locating a tool string, mounted with sliding sleeves, into a well having a shifting tool and a motor operably rotating a mill at distal end thereof;

providing a fluid flow rate through said tool string to a first fluid flow range to actuate said motor;

increasing said fluid flow rate above said first fluid flow range to deactivate said motor;

increasing said fluid flow rate above said first fluid flow range and a predetermined fluid flow rate to activate said shifting tool;

opening a sliding sleeve using the shifting tool; and

pumping a fluid above the fracturing pressure of the formation.

13. The method of claim 12 wherein the hydraulic fracturing is a pin-point fracturing.

14. The method of claim 12 wherein the fluid contains proppant.

15. The method of claim 12 wherein the first fluid flow range is from from 60 galUS/min to 119 galUS/min.

16. The method of claim 12 wherein the predermined fluid flow rate is between 120 gal US/min and 160 gal US/min.

17. The method of claim 12 further comprising closing the sleeve after the formation has been hydraulically fractured.

18. The method of claim 17 further comprising hydraulically fracturing at least a further zone.

19. The method of claim 12 wherein no sealing element is present on the tool string during the hydraulic fracturing operations.

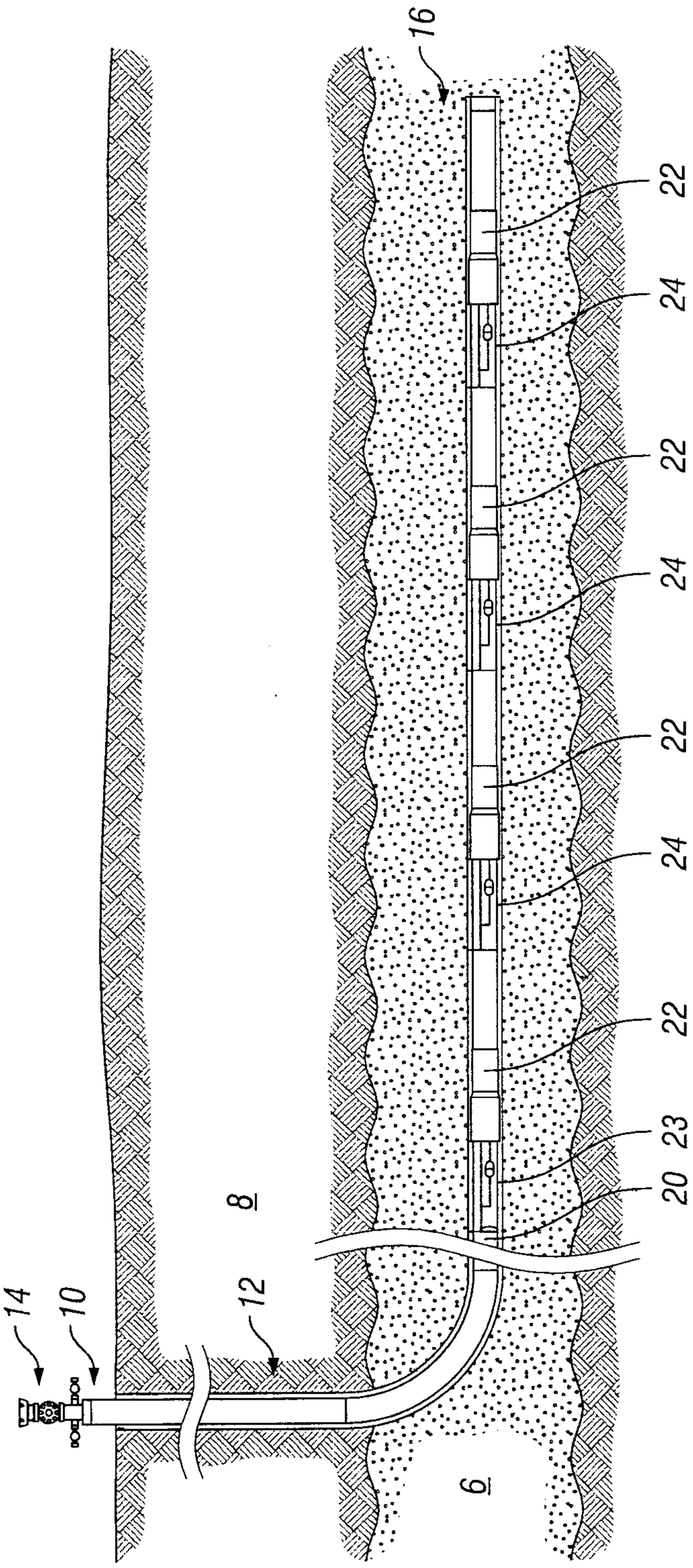


FIG. 1

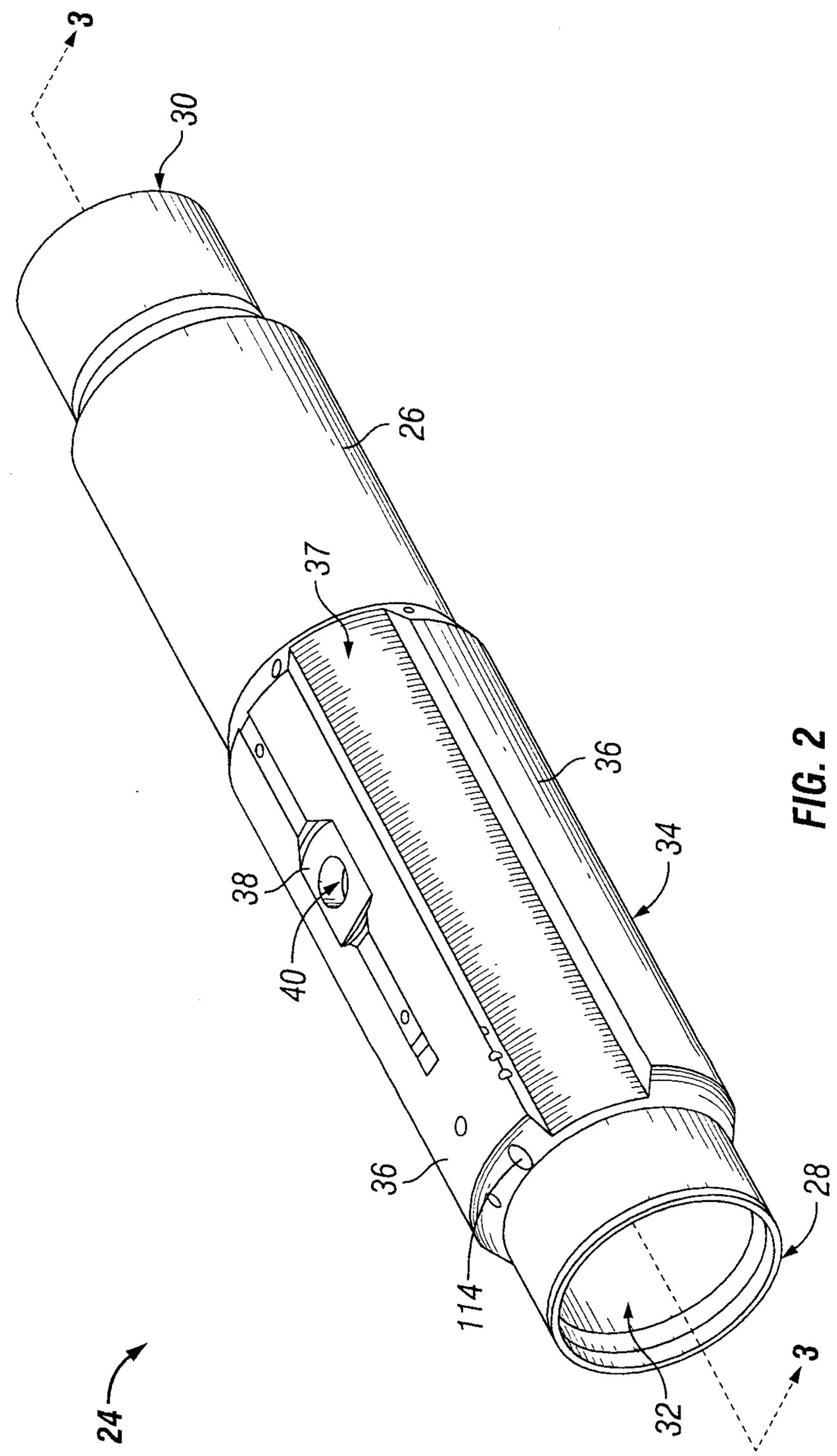


FIG. 2

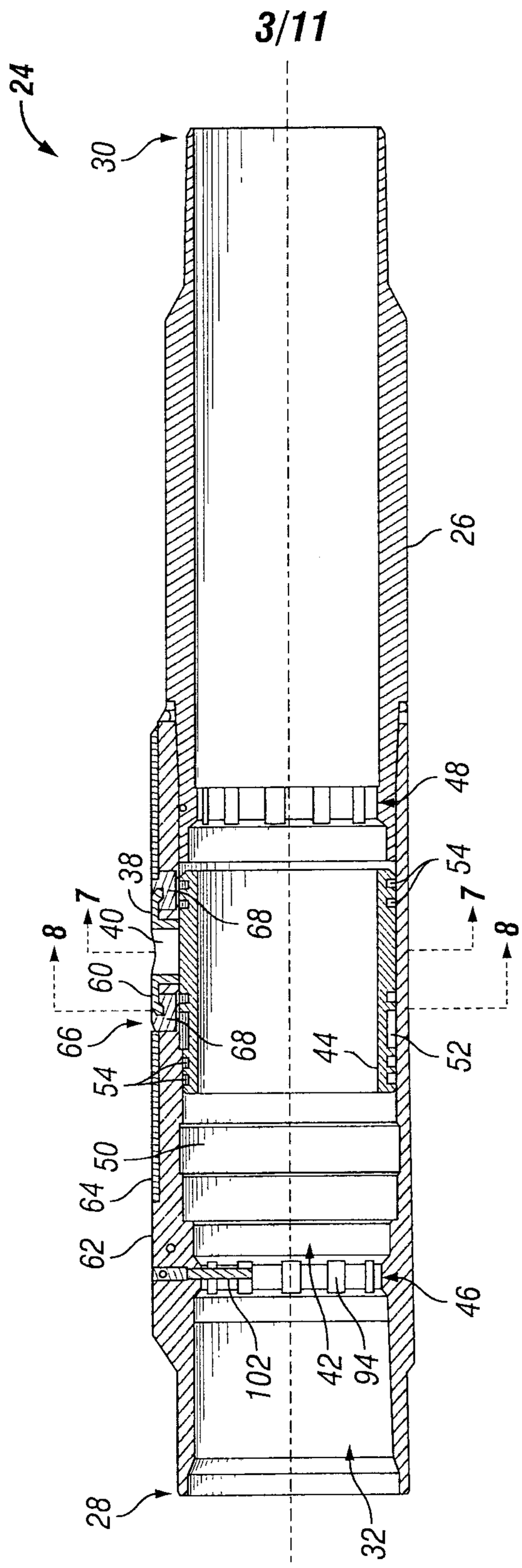


FIG. 3

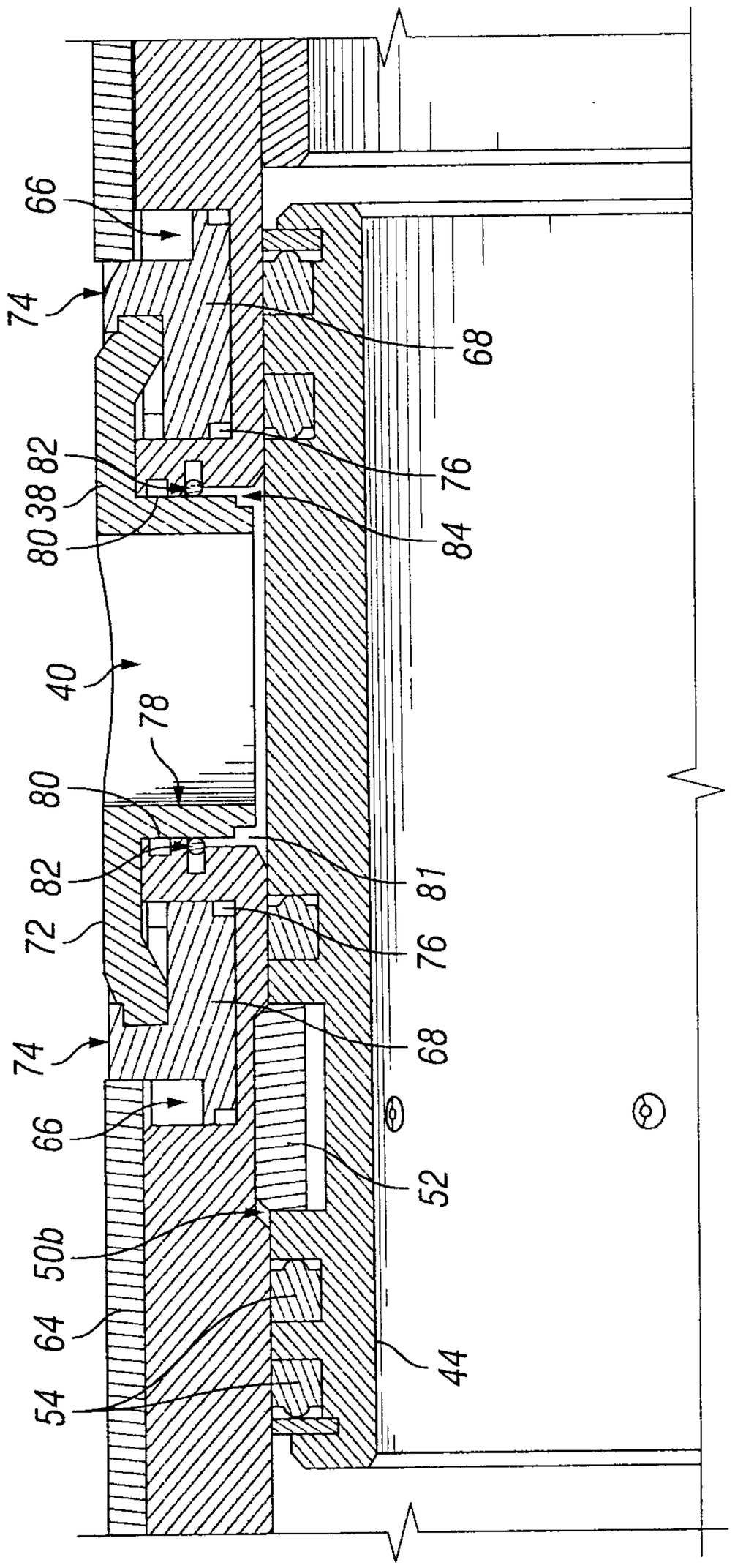


FIG. 4

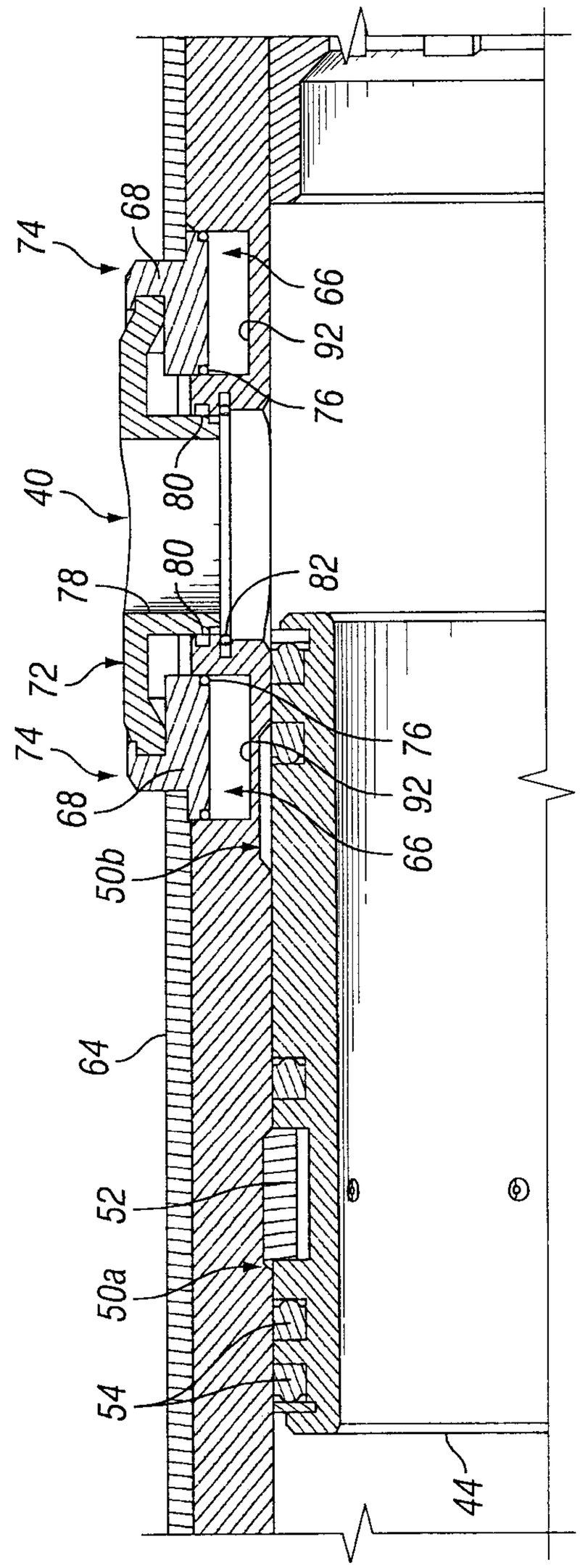


FIG. 5

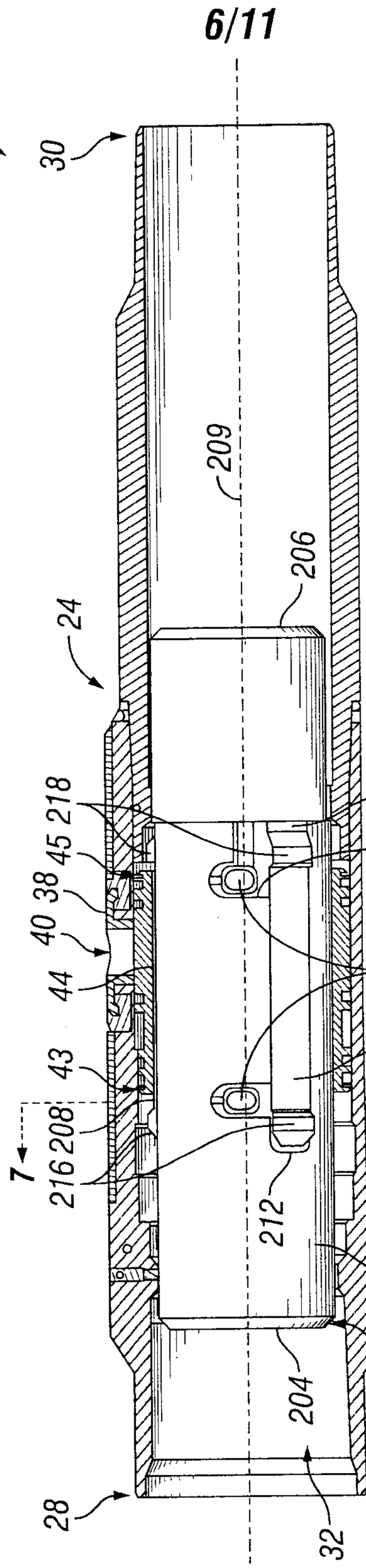

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FIG. 6

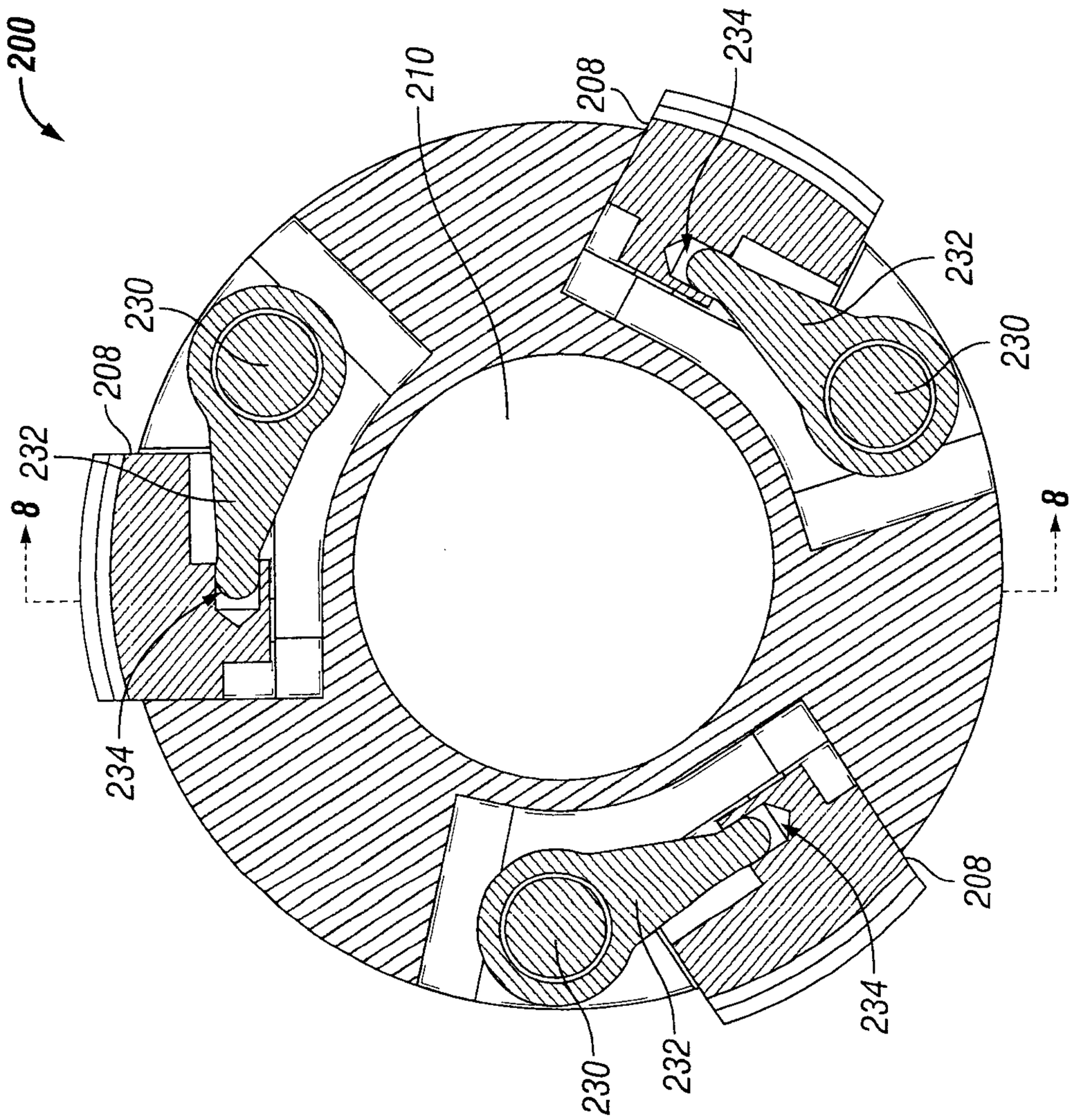


FIG. 7

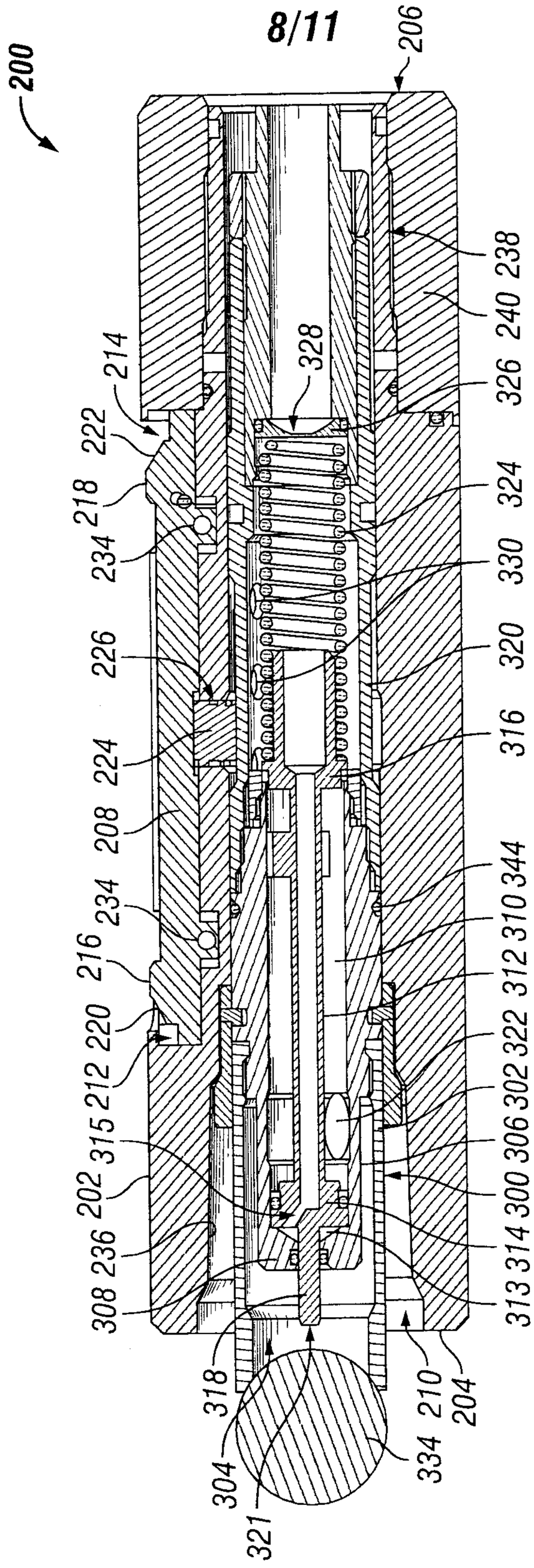

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FIG. 8

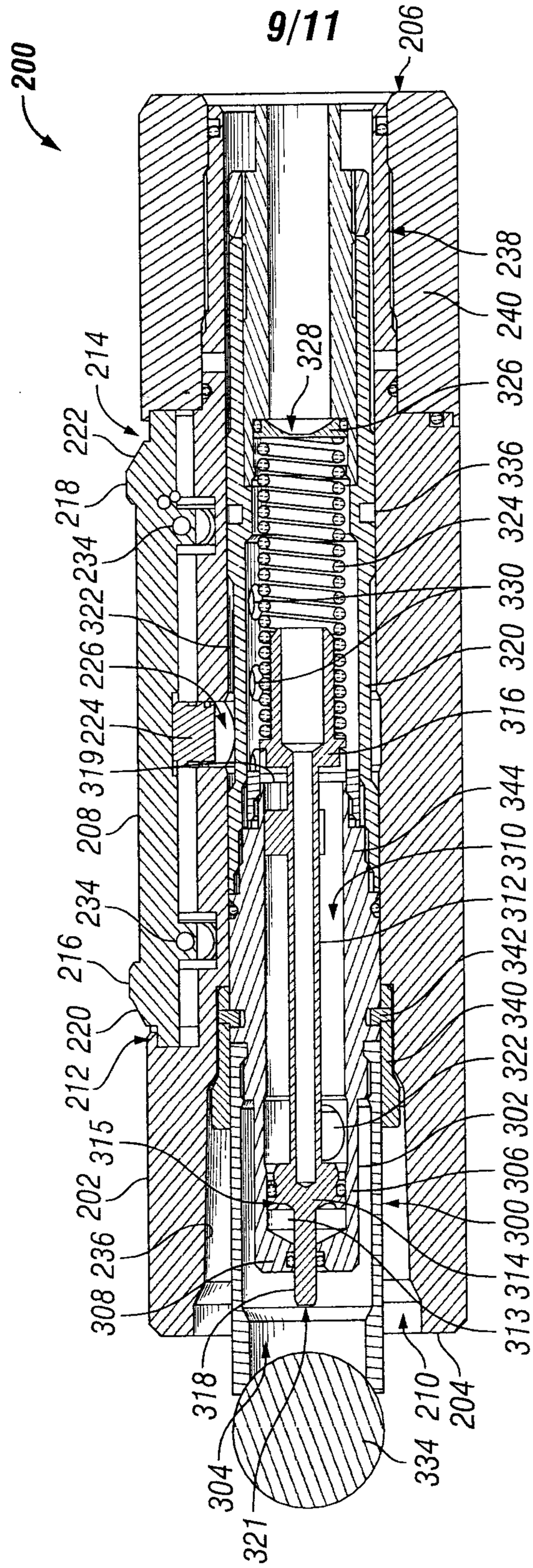

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FIG. 9

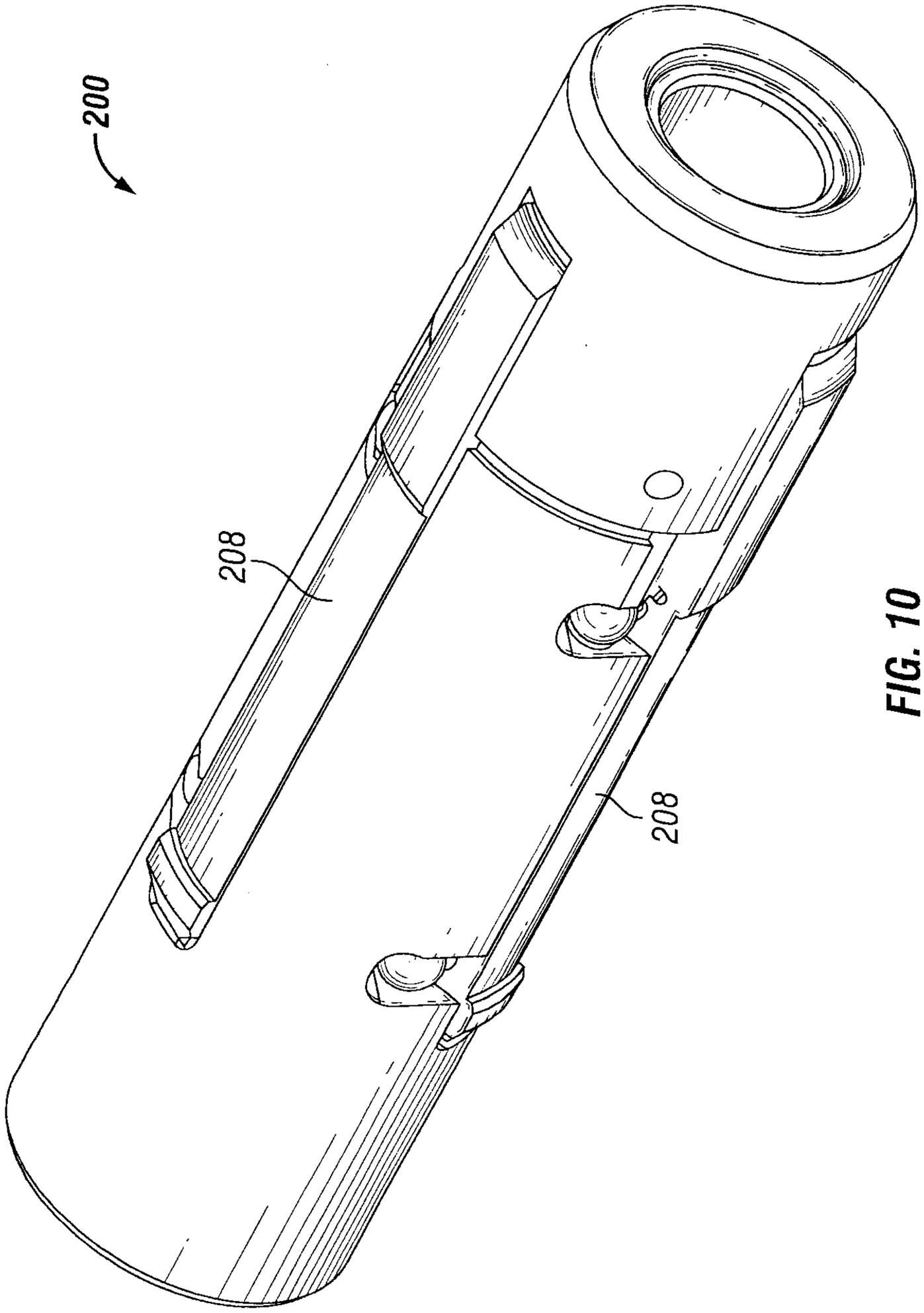


FIG. 10

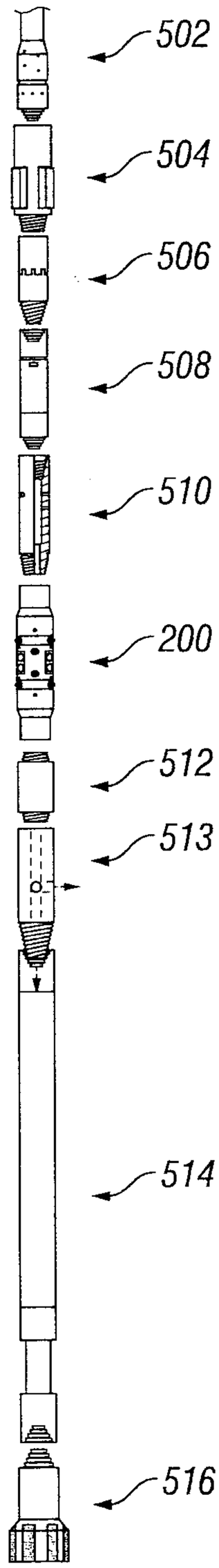
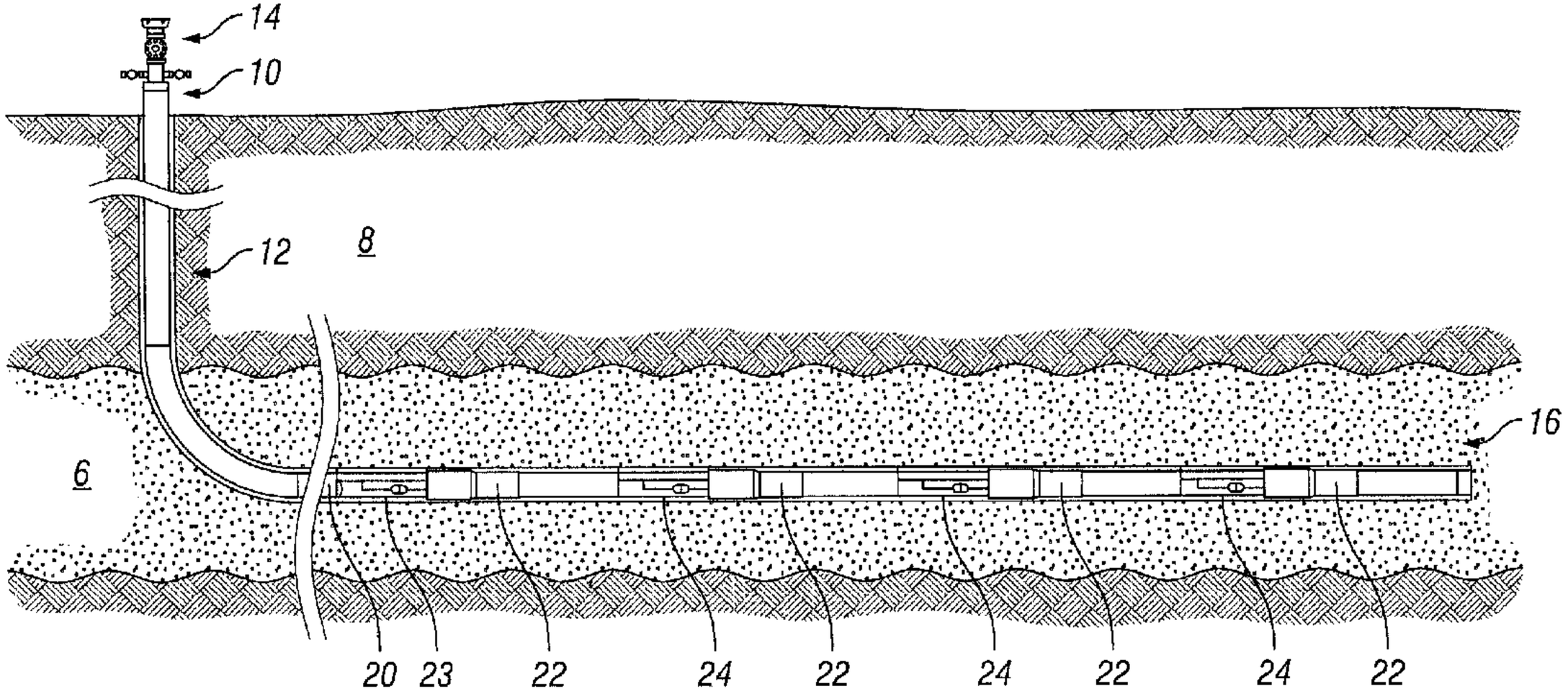


FIG. 11


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