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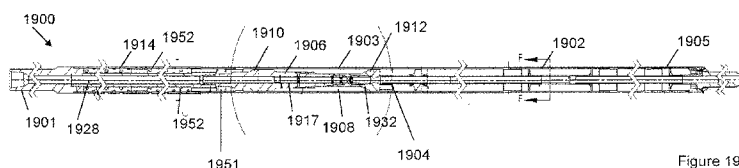


Figure 19B

(57) **Abstract:** A method includes running a downhole tool into a wellbore, operating the downhole tool in a suction mode and removing debris from the wellbore, and operating the downhole tool in a circulation mode. A tool includes a body sub, a debris sub coupled to the body sub, a suction sub disposed in the debris sub, an annular jet pump sub disposed in the body sub and in fluid communication with the suction sub, and a seal sub disposed in the annular jet pump sub and configured to move from a first position to a second position. The tool operates in a first mode when the seal sub is in the first position and in a second mode when the seal sub is in the second position.



## PACKER PLUG RETRIEVAL TOOL AND RELATED METHODS

### BACKGROUND

#### Background Art

- [0001] A wellbore may be drilled in the earth for various purposes, such as hydrocarbon, geothermal energy, or water extraction. After a wellbore is drilled, the wellbore is typically lined with casing. The casing preserves the shape of the wellbore as well as provides a sealed conduit for produced fluids to be transported to the surface.
- [0002] A tool known as a packer may be used to seal off a specific cross-section or region of the wellbore to fluidly isolate a first region of the wellbore from a second region of the wellbore. As an example, the packer may be used to seal the first region and direct flow of the produced fluid to a tubing string attached to the packer. In this arrangement, there is an annular space created between the tubing string attached to the packer and the cased wellbore. As such, well fluid in the annulus may contain solids in solution which, in time, precipitate out and settle or are deposited on top of the packer. If it is desired to remove the packer from the wellbore, difficulties arise because of the solids or debris that has settled on the packer resulting in retrieval of the packer being difficult.
- [0003] In certain configurations, the packer may include a mechanism by which a retrieval tool grabs the packer from above and removes it from the wellbore. Otherwise, if the packer is stuck in the wellbore and cannot be removed by manipulation of the tubing string, it is common practice to cut off the tubing string attached to the packer at a location just above the packer and utilize a string of fishing pipe with a fishing overshot to attach to the cut off tubing string and remove the packer. Either way, build-up of debris and solids above the packer makes retrieval of the packer difficult and impractical because a retrieval tool is unable to grab the packer or the cut tubing string.

## BRIEF DESCRIPTION OF DRAWINGS

- [0004] Figures 1A and 1B are views of a graph displaying the basic principles of jet pump operation in accordance with embodiments disclosed herein.
- [0005] Figure 2A shows a side view of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0006] Figure 2B shows a cross sectional view of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0007] Figure 3 shows a cross sectional view of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0008] Figure 4 shows a cross sectional view of a ported sub of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0009] Figure 5 shows a cross sectional view of a debris sub of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0010] Figure 6 shows a cross sectional view of a bottom sub of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0011] Figure 7 shows a cross sectional view of a bottom sub of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0012] Figure 8 shows a side view of a screen of a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0013] Figure 9A shows a cross sectional view of a downhole debris removal tool having an extension piece in accordance with embodiments disclosed herein.
- [0014] Figure 9B shows a detailed cross sectional view of a downhole debris removal tool having an extension piece in accordance with embodiments disclosed herein.
- [0015] Figure 10 shows a perspective view of an isolation valve in accordance with embodiments disclosed herein.
- [0016] Figure 11A shows a perspective view of an isolation valve in an open configuration in accordance with embodiments disclosed herein.

- [0017] Figure 11B shows a perspective view of an isolation valve in a closed configuration in accordance with embodiments disclosed herein.
- [0018] Figure 12 shows a perspective view of an isolation valve in accordance with embodiments disclosed herein.
- [0019] Figure 13A shows a perspective view of an isolation valve in an open configuration in accordance with embodiments disclosed herein.
- [0020] Figure 13B shows a perspective view of an isolation valve in a closed configuration in accordance with embodiments disclosed herein.
- [0021] Figure 14A shows a cross sectional view of an isolation valve in an open configuration in accordance with embodiments disclosed herein.
- [0022] Figure 14B shows a cross sectional view of an isolation valve in a closed configuration in accordance with embodiments disclosed herein.
- [0023] Figure 15 shows a cross sectional view of a downhole debris removal tool having a magnet disposed therein in accordance with embodiments disclosed herein.
- [0024] Figure 16 shows a cross sectional view of a downhole debris removal tool having a debris pin disposed therein in accordance with embodiments disclosed herein.
- [0025] Figure 17A shows a cross sectional view of a downhole debris removal tool having a drain pin in an open configuration in accordance with embodiments disclosed herein.
- [0026] Figure 17B shows a cross sectional view of a downhole debris removal tool having a drain pin in a closed configuration in accordance with embodiments disclosed herein.
- [0027] Figure 18A shows a side view of an annular jet pump sub for a downhole debris removal tool in accordance with embodiments disclosed herein.
- [0028] Figure 18B shows a cross sectional view of an annular jet pump sub for a downhole debris removal tool in accordance with embodiments disclosed herein.

- [0029] Figure 19A is a side view of a downhole retrieval tool in accordance with embodiments disclosed herein.
- [0030] Figure 19B is a cross sectional view of the downhole retrieval tool of Figure 19A.
- [0031] Figure 20 is a cross sectional view of a filter sub of a downhole retrieval tool in accordance with embodiments disclosed herein.
- [0032] Figure 21 is cross sectional view of a flow diverter sub of a downhole retrieval tool in accordance with embodiments disclosed herein.
- [0033] Figure 22A is a side view of a seal sub of a downhole retrieval tool in accordance with embodiments disclosed herein.
- [0034] Figure 22B is a cross sectional view of the seal sub of Figure 22A.
- [0035] Figure 23 is a cross sectional view of a jet pump sub, a seal sub, and a diverter sub of a downhole retrieval tool in accordance with embodiments disclosed herein.
- [0036] Figure 24A is a cross sectional view of a downhole retrieval tool in a suction mode in accordance with embodiments disclosed herein.
- [0037] Figure 24B is a cross sectional view of the downhole retrieval tool of Figure 24A when the seal sub is in a second position in accordance with embodiments disclosed herein.
- [0038] Figure 24C is a cross sectional view of the downhole retrieval tool of Figure 24B in a circulation mode in accordance with embodiments disclosed herein.

## DETAILED DESCRIPTION

- [0039] Generally, embodiments of the present disclosure relate to a downhole tool for removing debris from a wellbore. More specifically, embodiments disclosed herein relate to a downhole debris removal tool that includes an annular jet pump. Further, certain embodiments disclosed herein relate to a downhole tool for debris removal with maximum efficiency at a low pump rates.
- [0040] A downhole debris removal tool, in accordance with embodiments disclosed herein, includes a jet pump device. Generally, a jet pump is a fluid device used to

move a volume of fluid. The volume of fluid is moved by means of a suction tube, a high pressure jet, a mixing tube, and a diffuser. The high pressure jet injects fluid into the mixing tube, displacing the fluid that was originally static in the mixing tube. This displacement of fluid due to the high pressure jet imparting momentum to the fluid causes suction at the end of the suction tube. The high pressure jet and the entrained fluid mix in the mixing tube and exit through the diffuser.

**[0041]** Basic principles of jet pump operation may generally be explained by Equation 1 below, with reference to Figures 1A and 1B.

$$\text{Jet Pump Efficiency} = (H_D - H_S / H_J - H_D)(Q_S / Q_J) \quad (1)$$

where  $H_D$  is discharge head,  $H_S$  is suction head,  $H_J$  is jet head,  $Q_S$  is suction volume flow, and  $Q_J$  is driving volume flow. In accordance with certain embodiments of the present disclosure, for maximum jet pump efficiency, an inlet of the annular jet pump is smooth and convergent, while the diffuser is divergent. Additionally, the ratio of the inner diameter,  $d$ , of the jet to the inner diameter,  $D$ , of the mixing tube ranges from 0.14 to 0.9. Further, the jet standoff distance or driving nozzle distance,  $\ell$ , ranges from 0.8 to 2.0 inches. The mixing tube length,  $L_m$ , is approximately 7 times the inner diameter of the mixing tube,  $D$ .

**[0042]** Embodiments of the present disclosure provide a downhole debris removal tool for removing debris from a completed wellbore with a low rig pump rate. An operator may circulate fluid conventionally down a drill string at a low flow rate when desirable, *e.g.*, in wellbores with open perforations or where a pressure sensitive formation isolation valve (FIV) is used. The downhole debris removal tool, in accordance with embodiments disclosed herein, lifts (through a vacuum effect) a column of fluid from the bottom of the tool at a velocity high enough to capture heavy debris, such as perforating debris or milling debris, with a low rig pump rate. In certain embodiments, the downhole debris removal tool may have sufficient capacity to store the collected debris in-situ, thereby providing easy removal and disposal of the debris when the tool is returned to the surface.

**[0043]** Referring generally to Figures 2-7, multiple views of a downhole debris removal tool 200, in accordance with embodiments of the present disclosure, are shown. Specifically, Figure 2A shows a side view of the downhole debris removal

tool 200, Figure 2B shows a cross sectional view of the downhole debris removal tool 200, Figure 3 shows a cross sectional view of fluid flow through the downhole debris removal tool 200, Figure 4 shows a cross sectional view of a ported sub 203 of the downhole debris removal tool 200, Figure 5 shows a cross sectional view of a debris sub 202 of the downhole debris removal tool 202, and Figures 6 and 7 show cross sectional views of a bottom sub 207 of the downhole debris removal tool 200.

**[0044]** Referring now to Figures 2A and 2B, a side view and a cross sectional view of a downhole debris removal tool 200, in accordance with embodiments of the present disclosure, are shown. The downhole debris removal tool 200 includes a top sub 201, a ported sub 203, a debris sub 202, a bottom sub 205, and a debris removal cap 207. The top sub 201 may connect to a drill string and include a central bore 243 configured to provide a flow of fluid through the downhole debris removal tool 200. In certain embodiments, the debris sub 202 may be made up of more than one tubing section coupled together. For example, an extension piece, or additional tubing, may be added to the debris sub 202 to provide additional collection and storage space for debris. A section of washpipe (not shown) may be provided below the downhole debris removal tool 200.

**[0045]** The ported sub 203 is disposed below the top sub 201 and houses a mixing tube 208, a diffuser 210, and an annular jet pump sub 206. The ported sub 203 is a generally cylindrical component and includes a plurality of ports configured to align with the diffuser 210 proximate the upper end of the ported sub 203, thereby allowing fluids to exit the downhole debris removal tool 200. The ported sub 203 may be connected to the top sub 201 by any mechanism known in the art, for example, a threaded connection and/or welding.

**[0046]** As shown in more detail in Figure 4, the annular jet pump sub 206 is a component disposed within the ported sub 203. The annular jet pump sub 206 includes a bore 228 in fluid connection with the central bore of the top sub 201. At least one small opening or jet 209 fluidly connects the bore 228 of the annular jet pump sub 206 to the mixing tube 208. The jets 209 provide a flow of fluid from the drill string into the mixing tube 208 to displace initially static fluid in the mixing tube

208. The fluid then flows upward in the mixing tube 208 and exits the ported sub 203 through the diffuser 210, as indicated by the solid black lines.

[0047] Referring to Figures 2A, 2B, 4, and 5, a lower end 230 of the annular jet pump sub 206 is disposed proximate an exit end of a screen 214 disposed in the debris sub 202, forming an inlet 226 into the mixing tube 208. Fluid suctioned up through the debris sub 202 enters the mixing tube 208 through the inlet 226 and exits the mixing tube 208 through one or more diffusers 210. An annular jet cup 232 is disposed over the lower end 230 of the annular jet pump sub 206 and configured to at least partially cover jets 209 to provide a ring nozzle. The at least one jet 209 size may be changed by varying the gap between the annular jet cup 232 and the annular jet pump sub 206, thereby providing for flexible operation of the downhole debris removal tool 200. The gap may be varied by moving the annular jet cup 232 in an uphole or downhole direction along the annular jet pump sub 206. In one embodiment, the annular jet cup 232 may be threadedly coupled to the annular jet pump sub 206, thereby allowing the annular jet cup 232 to be threaded into a position that provides a desired gap between annular jet cup 232 and the annular jet pump sub 206.

[0048] A spacer ring 224 may be disposed around the lower end 230 of the annular jet pump sub 206 and proximate a shoulder 234 formed on an outer surface of the lower end 230. The spacer ring 224 is assembled to the annular jet pump sub 206 and the annular jet cup 232 is disposed over the lower end 230 and the spacer ring 224. Thus, the spacer ring 224 limits the movement of the annular jet cup 232. One or more spacer rings 224 with varying thickness may be used to selectively choose the location of the assembled annular jet cup 232, and provide a pre-selected gap between the annular jet cup 232 and the annular jet pump sub 206. That is, the thickness of the spacer ring 224 may be selected so as to provide a desired  $d/D$  ratio. Varying the gap between the annular jet cup 232 and the annular jet pump sub 206 also provides for adjustment of the distance of the at least one jet 209 from the mixing tube 208 entrance. Thus, the jet standoff distance ( $\ell$ ), shown in Figure 1A, of the tool 200 may be increased, thereby promoting jet pump efficiency.

[0049] Referring back to Figures 2A and 2B, the debris sub 202 is coupled to a lower end of the ported sub 203 and houses a suction tube 204, a flow diverter 212, and the

screen 214. The debris sub 202 may be connected to the ported sub 203, in which the debris sub 202 may collect and separate debris from a fluid stream as the fluid is vacuumed or suctioned up through the downhole debris recovery tool 200. Referring also to Figure 5, the suction tube 204 may receive a stream of fluid and debris from the wellbore and direct the stream through the flow diverter 212. In one embodiment, the flow diverter 212 may be a spiral flow diverter, in which the spiral flow diverter may impart rotation to the fluid/debris stream as the fluid/debris stream enters a debris chamber from the suction tube 204. The rotation imparted to the fluid may assist in separating the fluid stream from the debris. The debris separated from the fluid stream drops down and is contained within the debris sub 202.

**[0050]** A debris removal cap 207 may be coupled to a lower end of the debris sub 202 and may be removed from the downhole debris recovery tool 200 at the surface to remove debris collected within the downhole debris recovery 200 (see Figures 6 and 7). The downhole debris recovery tool 200 may be configured to collect a specified anticipated debris volume. The length of the debris sub 202 may be selected based on the anticipated debris volume in the wellbore.

**[0051]** In one embodiment, the screen 214 may be a cylindrical component 810 with one or more perforations 812 formed therein, as shown in Figure 8. In alternate embodiments, the screening device 214 may be formed from a wire mesh cloth, as shown in Figure 5. One of ordinary skill in the art will appreciate that any screen or screening device known in the art may be used without departing from the scope of the present disclosure. In certain embodiments, the screen 214 may be a low differential pressure screen.

**[0052]** Further, a packing element 240 and an element seal ring 242 may be disposed around a pin end of the screen 214, such as to prevent fluid from bypassing the screen 214. The fluid stream flowing through the diverter 212 enters the screen 214. Debris larger than the perforations or mesh size of the screen cloth remains on the surface of the screen or fall and remain within the debris sub 202. The filtered stream of fluid is then further suctioned up into the ported sub 203.

**[0053]** Figure 3 shows a general overview of the operation of the downhole debris removal tool 200. Solid arrow lines indicate driving flow, while dashed arrow lines

indicate suction flow of the tool. As shown, fluid is pumped down through the central bore of the top sub 201 and into the bore 228 of the annular jet pump sub 206. The fluid may be pumped at a low flow rate, such as having the fluid flowing into the bore 228 of the annular jet pump sub 206 pumped at a rate of less than 10 BPM. In some embodiments, the annular jet pump sub 206 may pump at a rate of approximately 7 BPM. The fluid may then exit the annular jet pump sub 206 through a high pressure jet 209 into the mixing tube 208. Injection of the fluid into the mixing tube 208 displaces the originally static fluid in the mixing tube 208, thereby causing suction at the suction tube 204. The high pressure jet fluid and the entrained fluid mix in the mixing tube 208 and exit through the diffuser 210. The fluid exiting the diffuser 210 and vacuum effect at the suction tube 204 may dislodge and remove debris from the wellbore.

**[0054]** In certain embodiments, at least one extension piece may be added to the downhole debris removal tool 200 to increase the capacity of the debris sub 202 such that more debris may be stored/collected therein. For example, Figures 9A and 9B show one embodiment having one or more extension pieces 900 disposed between two sections of debris sub 202. The extension piece 900 may have an inner tube 904 configured to align with the suction tube 204. Additionally, in select embodiments, the inner tube 904 of the expansion piece 900 may be coupled to a flow diverter 212, and/or inner tubes 904 of additional expansion pieces 900. The extension piece 900 may also have an outer housing 902 configured to couple to at least one debris sub 202, and/or outer housing 902 of additional expansion pieces. One of ordinary skill in the art will appreciate that multiple extension pieces may be added to the downhole debris recovery tool, and that components may be coupled by any means known in the art.

**[0055]** At least one isolation valve 906 may be integrated into the at least one extension piece 900, as shown in Figure 9. Alternatively, one of ordinary skill in the art will appreciate that the extension piece 900 and the isolation valve 906 may be independent components, or in another embodiment, the isolation valve 906 may be integrated into a debris sub 202. In select embodiments, more than one isolation valve may be used such that multiple chambers may be created within the debris removal tool with multiple isolation valves.

**[0056]** Referring generally to Figures 10, 11A, and 11B, multiple views of an isolation valve 1000 in accordance with embodiments of the present disclosure, are shown. Specifically, Figure 10 shows a perspective view of the isolation valve 1000, Figure 11A shows a perspective view of the isolation valve 1000 in an open configuration, and Figure 11B shows a perspective view of the isolation valve 1000 in a closed configuration.

**[0057]** Referring to Figure 10, an isolation valve 1000 in accordance with embodiments disclosed herein is shown. The isolation valve 1000 may include a housing 1002, upper and lower portions of an inner tube, referred to herein as velocity tube 1004, an annular space 1026 disposed between the housing 1002 and the velocity tube 1004, a gate 1006, a cutout 1014, and a central axis 1020. The velocity tube 1004 and the housing 1002 may have inner and outer diameters substantially the same as the inner and outer diameters of suction tube 204 and debris sub 202, respectively, of Figures 2A and 2B. The isolation valve 1000 may also include a cutout 1014 disposed through the velocity tube 1004 and the housing 1002, which accommodates a gate 1006. The gate 1006 may rotate about a cutout axis 1016. The cutout axis 1016 may be substantially perpendicular to the central axis 1020 of the isolation valve 1000. The gate 1006 may further include a seal 1008, such as an o-ring, a circlip 1010, a head 1022, such as a hex socket head, a gate hole 1018, and a gate hole axis 1024. The gate hole 1018 may have a diameter substantially equal to the inner diameter of the upper and lower portions of velocity tube 1004.

**[0058]** Figures 11A and 11B show open and closed configurations, respectively, of the isolation valve 1000 shown in Figure 10. As shown in Figure 11A, the isolation valve 1000 is open when the gate hole axis 1024 is axially aligned with central axis 1020, thus allowing flow through both the velocity tube 1004 and the annular space 1026. Figure 11B shows a closed isolation valve 1000 having the gate hole axis 1024 disposed perpendicular to the central axis 1020. In the closed configuration, flow through the velocity tube 1004 and the annular space 1026 is restricted. In the embodiment shown in Figures 10, 11A, and 11B, the head 1022 may be engaged, such as with a corresponding tool (not shown), to rotate and change the position of the gate 1006 relative to the velocity tube 1004 and annular space 1026. Other head geometries, such as square or star socket heads, may also be used. Furthermore, one

of ordinary skill in the art will appreciate that other mechanical or hydraulic means for controlling the gate may be used without departing from the scope of the present disclosure. For example, a shearing pin may be used to control the actuation of isolation valve 1000 in accordance with embodiments disclosed herein.

**[0059]** Referring generally to Figures 12, 13A, 13B, 14A, and 14B, multiple views of another isolation valve 1200 in accordance with embodiments of the present disclosure, are shown. Specifically, Figure 12 shows a perspective view of the isolation valve 1200, Figure 13A shows a perspective view of the isolation valve 1200 in an open configuration, Figure 13B shows a perspective view of the isolation valve 1200 in a closed configuration, Figure 14A shows a cross sectional view of the isolation valve 1200 in an open configuration, and Figure 14B shows a cross sectional view of the isolation valve 1200 in a closed configuration.

**[0060]** In accordance with the embodiments disclosed herein, the isolation valve 1200 may allow uninterrupted flow through a velocity tube 1204 and selectively allow flow through an annular space 1226. The isolation valve 1200 may include a housing 1202, a velocity tube 1204, an annular space 1226 disposed between housing 1202 and velocity tube 1204, a central axis 1220, a gate 1206, and rotatable brackets 1208. The gate 1206 may further include a hole 1214 through which velocity tube 1204 is disposed, and at least one curved surface 1210 that may enable movement of the gate 1206 relative to the velocity tube 1204. Rotatable brackets 1208 may be used to couple the gate 1206 and bracket holes 1216 disposed in the housing 1202. Additionally, a head 1222 may be disposed on at least one of the rotatable brackets 1208. Alternatively, other head geometries, such as square or star socket heads, may be used. The rotatable brackets 1208, together with the gate 1206, may be rotated about a gate axis 1224 relative to the velocity tube 1204.

**[0061]** The gate 1206 may be positioned such that flow through the annular space 1226 is allowed (Figure 13A). In certain embodiments, the at least one curved surface 1210 of the opened gate 1206 may contact an outer surface of the velocity tube 1204. Referring to Figures 13B and 14B, the gate 1206 of isolation valve 1200 may be positioned such that flow through the annular space 1226 is restricted. In the

embodiment shown in Figures 13A, 13B, 14A, and 14B, flow through the velocity tube 1204 of isolation valve 1200 is allowed, regardless of the position of gate 1206.

**[0062]** During operation, the isolation valve may remain open so that the suction action of the tool is maintained. It may be advantageous to close isolation valve when the downhole debris removal tool is pulled from the well so that an extension piece may be installed. While the isolation valve is in the closed position, components may be added, removed, and/or replaced therebelow without fluid and debris that may have accumulated above the isolation valve spilling out into the wellbore or onto the deck. Additionally, after the debris removal tool is removed from the well, components therebelow may be removed and the isolation valve may be opened so that accumulated debris may be removed from the tool.

**[0063]** Referring back to Figure 3, suction at the suction tube 204 provided by the annular jet pump sub 206 may draw fluid and debris into the downhole debris removal tool 200, and through one or more isolation valves. After passing through the isolation valve, the flow diverter 212 diverts the fluid/debris mix from the suction tube 204 downward, as shown in more detail in Figure 5. The flow diverter 212 may provide rotation to the fluid stream as it is diverted downwards. The rotation provided to the fluid stream may help separate the debris from the fluid stream due to the centrifugal effect and the greater density of the debris. Thus, the flow diverter 212 may separate larger pieces of debris from the fluid. The debris separated from the fluid streams drop downwards within the debris sub 202, while the fluid stream that exits the diverter may travel through the screen 214. The screen 214 may be used to remove additional debris entrained in the fluid stream.

**[0064]** Referring now to Figure 15, in select embodiments, one or more magnets 1502 may be disposed on or near an end of the screen 214. The magnets 1502 may magnetically attract metallic debris suspended in the fluid and may prevent the metallic debris from clogging the screen 214. As shown, in one or more embodiments, the magnets 1502 may be ring-shaped and disposed around an outer surface of a shaft 1506. Further, in one or more embodiments, the magnets may be rare earth magnets, such as samarium-cobalt or neodymium-iron-boron (NIB) magnets. However, one of ordinary skill in the art will appreciate that magnets of

other shapes, sizes, and materials may additionally or alternatively be used without departing from the scope of the present application. Furthermore, as shown in Figure 15, a magnet cover 1504 may be disposed around the magnets 1502 such that the fluid may not directly contact the magnets 1502. The cover 1504 may protect the magnets 1502 from being damaged by debris.

[0065] Referring back to Figure 3, after passing through the screen 214, the fluid flows past the annular jet pump sub 206 into the mixing tube 208. The fluid is then returned to the casing annulus (not shown) through the diffuser 210. In one or more embodiments disclosed herein, as shown in Figures 2-7, the fluid entering the mixing tube 208 from the suction tube 204 may not significantly change direction until after the fluid enters the diffuser 210 and is diverted into the casing annulus.

[0066] After completion of the debris recovery job, the drill string may be pulled from the wellbore and the downhole debris recovery tool 200 may be returned to the surface. As shown in Figures 6 and 7, a retaining screw 220 may be removed from the debris removal cap 207 to allow the debris removal cap 207 to be removed from the downhole debris recovery tool 200, thereby allowing the debris to be easily removed (indicated by dashed arrows) from the debris sub 202.

[0067] Referring now to Figure 16, 17A, and 17B, multiple views of a downhole debris removal tool having a drain pin 1902 disposed therein in accordance with embodiments disclosed herein are shown. Specifically, Figure 16 shows a cross sectional view of the downhole debris removal tool having the drain pin 1902 disposed therein, Figure 17A shows a cross sectional view of a downhole debris removal tool having the drain pin 1902 in an open configuration, and Figure 17B shows a cross sectional view of a downhole debris removal tool having the drain pin 1902 in a closed configuration.

[0068] In certain embodiments, the drain pin 1902 may be disposed in bottom sub 205 and may be opened before removing debris removal cap 207 such that fluid may be emptied from the bottom sub 205 and/or the debris sub 202. For example, referring to Figures 16, 17A, and 17B, the drain pin 1602 may be opened to allow fluid from at least one cavity 1604, disposed in bottom sub 205, to flow out through

suction tube 204. In certain embodiments, a head 1606 may be disposed on the drain pin 1602.

**[0069]** Figures 17A and 17B show cross-sectional views of a debris removal tool having the drain pin 1602. Figure 17A shows the drain pin 1602 in the open position, allowing fluid communication between the cavity 1604 and the suction tube 204. In certain embodiments, the space created by the opened drain pin 1602 may be sized to prevent debris from escaping with the fluid. Figure 17B shows drain pin 1602 in the closed position preventing fluid in cavity 1604 from entering suction tube 204. In one or more embodiments, one may open the drain pin 1602 prior to removing debris removal cap 207 such that fluid may be released from the tool before debris removal, thereby preventing the fluid from spilling out onto, for example, the rig floor.

**[0070]** Referring now to Figures 18A and 18B, multiple views of an alternative embodiment of an annular jet pump sub 1806 for a downhole debris removal tool 1800 in accordance with embodiments disclosed herein are shown. Specifically, Figure 18A shows a side view of the annular jet pump sub 1806 for the downhole debris removal tool 1800, and Figure 18B shows a cross sectional view of the annular jet pump sub 1806 for the downhole debris removal tool 1800.

**[0071]** As shown, the annular jet pump sub 1806 may be disposed within a ported sub 1803 which provides a mixing zone or mixing tube 1808, and may include an annular jet pump 1860. As shown, the annular jet pump sub 1806 may include at least two stages 1813, 1815. The annular jet pump sub 1806 includes a bore 1828 in fluid connection with the central bore of a top sub 1801. As shown, the first stage 1813 may include at least one small opening or jet 1809 disposed near a lower end of the annular jet pump sub 1806, and the second stage 1815 may include at least one small opening or jet 1811 disposed axially above the first stage 1813. The jets 1809, 1811 fluidly connect the bore 1828 of the annular jet pump sub 1806 to the mixing tube 1808.

**[0072]** In one or more embodiments, the stages 1813, 1815 of the annular jet pump sub 1806 may increase the efficiency of a pumping tool. In particular, a two staged annular jet pump may reduce the pumping flow rate of the tool and double the overall efficiency of the downhole debris removal tool. For example, in the embodiment

shown in Figures 18A and 18B, a flow of fluid may exit the annular jet pump sub 1806 through jets 1809 of first stage 1813 into mixing tube 1808. Injection of the fluid into the mixing tube 1808 displaces the originally static fluid in the mixing tube 1808, thereby causing suction at a suction tube (204 in Figure 3) disposed below the annular jet pump sub 1806. Additionally, a flow of fluid may exit the annular jet pump sub 1806 through jets 1811 of second stage 1815 into mixing tube 1808. The flow of fluid exiting the annular jet pump sub 1806 through second stage 1815 may accelerate fluid flow in the mixing tube 1808. The fluid may then flow upward in the mixing tube 1808 and exit the ported sub through the diffuser 1810. As such, the suction provided by the first stage 1813 and the acceleration of fluid provided by the second stage 1815 of the annular jet pump sub 1806 may allow a small volume of fluid to pull a larger volume of fluid with a lower pressure, such as compared to a one-stage annular jet pump.

**[0073]** Referring to Figures 5, 18A, and 18B collectively, a lower end 1830 of the annular jet pump sub 1806 may be disposed proximate an exit end of a screen 214 disposed in the debris sub 202, forming an inlet (not shown) into the mixing tube 1808. Fluid suctioned up through the debris sub 202 may enter the mixing tube 1808 through the inlet and may exit the mixing tube 1808 through one or more diffusers 1810. An annular jet cup 1823 may be disposed over the lower end 1830 of the annular jet pump sub 1806 to at least partially cover jets 1809 of the first stage 1813 to provide a ring nozzle. Further, a second annular jet cup 1825 may be disposed around the annular jet pump sub 1806 proximate the second stage 1815 to at least partially cover jets 1811 to provide a ring nozzle.

**[0074]** One of ordinary skill in the art will appreciate that based on the specific needs of a given application, the annular jet pump sub 1806 may include an annular jet cup 1823 for only the first stage 1813, an annular jet cup 1825 for only the second stage 1815, or an annular jet cup 1823, 1825 for both the first and second stages 1813, 1815. The size of the jets 1809, 1811 may be changed by varying the gap between the annular jet cup 1823, 1825 and the annular jet pump sub 1806, thereby providing for flexible operation of the downhole debris removal tool 1800. Further, the gap may be varied by moving the annular jet cup 1823, 1825 in an uphole or downhole direction along the annular jet pump sub 1806. In one embodiment, the annular jet cup 1823,

1825 may be threadedly coupled to the annular jet pump sub 1806, thereby allowing the annular jet cup 1823, 1825 to be threaded into a position that provides a desired gap between the annular jet cup 1823, 1825 and the annular jet pump sub 1806.

[0075] Further, similar to as discussed above, a spacer ring may be disposed around the lower end 1830 of the annular jet pump sub 1806 and proximate a shoulder formed on an outer surface of the lower end 1830. The spacer ring may limit the movement of the annular jet cup 1823, 1825. One or more spacer rings with varying thickness may be used to selectively choose the location of the assembled annular jet cup 1823, 1825, and provide a pre-selected gap between the annular jet cup 1823, 1825 and the annular jet pump sub 1806. That is, the thickness of the spacer ring may be selected so as to provide a desired d/D ratio. Varying the gap between the annular jet cup 1823, 1825 and the annular jet pump sub 1806 may also provide for adjustment of the distance of the at least one jet 1809, 1811 from the mixing tube 1808 entrance. Thus, the jet standoff distance ( $\ell$ ) of the tool 1800 may be increased, thereby promoting jet pump efficiency.

[0076] Embodiments of the present disclosure may provide for an apparatus and a method that may remove precipitated solids within a wellbore. For example, in one or more embodiments, a tool in accordance with the present disclosure may be disposed downhole within a wellbore, such as to remove and/or clear solids that have collected above a packer. As such, this may allow for and/or enhance the removal of the packer from within the wellbore.

[0077] In one aspect, embodiments disclosed herein relate to a method of operating a downhole retrieval tool in a wellbore. The method includes lowering the downhole retrieval tool into the wellbore, with the downhole retrieval tool including an annular jet pump sub, a seal sub disposed in the annular jet pump sub, a ball seat disposed in the seal sub, and a suction tube. The method further includes flowing a fluid through a bore of the annular jet pump sub, jetting the fluid from the annular jet pump sub into a mixing tube or mixing zone, displacing an initially static fluid in the mixing zone through the diffuser element, thereby causing a suction in the suction tube, suctioning a wellbore fluid into the downhole retrieval tool, actuating the downhole retrieval tool

to switch from a suctioning mode to a circulating mode, and circulating the wellbore fluid.

**[0078]** In another aspect, embodiments disclosed herein relate to a downhole retrieval tool. The tool includes a main body sub, a debris sub coupled to the main body sub, a suction tube disposed in the debris sub, an annular jet pump sub disposed in the main body sub and in fluid communication with the suction tube, and a seal sub disposed in the annular jet pump sub adapted to move from a first position to a second position. The downhole retrieval tool operates in a first mode when the seal sub is in the first position, and in a second mode when the seal sub is in the second position.

**[0079]** In yet another aspect, embodiments disclosed herein relate to a downhole retrieval tool. The tool includes a main body sub, a debris sub coupled to the main body sub, a suction tube disposed in the debris sub, an annular jet pump sub disposed in the main body sub and in fluid communication with the suction tube, the annular jet pump sub including a first annular jet for creating a vacuum and a second annular jet for accelerating a fluid, and a seal sub disposed in the annular jet pump sub adapted to move from a first position to a second position. The downhole retrieval tool operates in a first mode when the seal sub is in the first position, and in a second mode when the seal sub is in the second position.

**[0080]** As discussed above, a downhole retrieval tool may operate in a suction mode or a circulation mode and may switch between the modes while downhole. In the circulation mode, the jet pump sub is no longer used to create a vacuum to move a volume of liquid. Fluid provided down through the drill string flows through the downhole retrieval tool and exits at a bottom end thereof. The exiting fluid then circulates wellbore fluids and may be used to actuate another downhole tool. In one embodiment, the downhole retrieval tool may be used to retrieve another pre-disposed (*i.e.*, already set or positioned) downhole apparatus, such as, for example, a packer. In such an embodiment, the downhole retrieval tool may be coupled to another downhole apparatus to assist in removing the downhole apparatus from the wellbore.

**[0081]** In order to couple the downhole retrieval tool with the downhole apparatus, debris that has settled out on the upper end of the downhole apparatus may be removed using the suction mode of the downhole retrieval tool. As discussed in detail

above, a volume of fluid may be moved by the downhole retrieval tool. For example, the jet pump sub may be used to create suction to draw in a volume of fluid and downhole debris, thereby capturing the downhole debris in the debris sub. Once the debris has been removed from the downhole apparatus, the downhole retrieval tool may be operated in circulation mode to allow the downhole retrieval tool to couple to the downhole apparatus.

**[0082]** Referring to Figures 19A and 19B, a side view and a cross sectional view, respectively, of a downhole retrieval tool according to embodiments of the present disclosure are shown. The downhole retrieval tool 1900 may include a top sub 1901, a body sub 1903, a debris sub 1902, and a bottom sub 1905. The body sub 1903 may be an elongated, generally cylindrical body disposed below and coupled to the top sub 1901 by any means known in the art, such as, for example, threaded connection, welding, etc. An annular jet pump sub 1906 and a diffuser 1910 are disposed within the body sub 1903.

**[0083]** The top sub 1901 may be a tubular configured to couple with a drill string (not shown). The top sub 1901 includes a central flowbore 1928 in fluid communication with the annular jet pump sub 1906 to provide a flow of pressurized fluid to the downhole retrieval tool 1900. As the tool 1900 is lowered into the wellbore, it may operate in the suction mode to clear and capture debris from the wellbore. In this mode, a plurality of ports 1951 of the body sub 1903 proximate the upper end of the jet pump sub 1906 are configured to align with diffuser 1910.

**[0084]** The body sub 1903 may also house any number of other internal components and features, including, for example as a mixing tube 1908, a seal sub 1917, and a flow diverter 1912. The mixing tube 1908 or mixing zone may be an annular space disposed within the body sub 1903, and may be proximate to the flow diverter 1912 and the jet pump sub 1906. During suction, the mixing tube 1908 receives fluid from the annular jet pump sub 1906 and the debris sub 1902.

**[0085]** Referring briefly to Figure 20, a close-up, cross-sectional view of a filter sub 1914 coupled with the body sub 1903 according to embodiments of the present disclosure is shown. The filter sub 1914 includes a body having a plurality of openings 1952 therethrough. The filter sub 1914 is configured to separate and

retain debris, while expelling fluids received from the mixing tube (1908, Figure 19B) outwardly into the wellbore. In the suction mode, fluid received in the mixing tube (1908, Figure 19B) flows past the diffuser 1910, through the plurality of openings 1951, and into the filter sub 1914. In general, downhole retrieval tool 1900 removes debris from a fluid in suction mode as a discussed above with respect to Figures 2-18. During the suction mode, the annular jet pump sub 1906 jets a fluid to create a vacuum, such that wellbore fluid and debris may be suctioned into suction tube 1904. The debris sub 1902 collects any suctioned debris as the downhole retrieval tool 1900 is run into the wellbore and operated in suction mode.

**[0086]** Referring to Figure 21, a cross-sectional view of a flow diverter sub 1932 having a flow diverter 1912 according to embodiments of the present disclosure is shown. As illustrated, the suction tube 1904 may have an upper end disposed below the flow diverter 1912. The flow diverter 1912 is configured to divert fluid and debris downwardly into the debris sub (1902, Figure 19B). Thus, in the suction mode, fluid flows through the flow diverter 1912 and upwardly into the mixing tube (1908, Figure 19B). The flow diverter sub 1932 may be sealingly engaged with the annular pump sub (1906, Figure 19B), and may be configured so that the seal sub 1917 may slidably move into an end of the flow diverter sub 1932.

**[0087]** At least a portion 1976 of an internal bore of the flow diverter sub 1932 may have a diameter larger than a diameter of the internal bore proximate the end of the flow diverter sub 1932, indicated at 1919. The larger diameter bore in the portion 1976 of the internal bore may be configured to form flow paths (63, Figure 24C) when the seal sub 1917 is positioned therethrough. When it is desired to switch from the suction mode to a circulation mode, a drop ball (not shown) placed into the drill string may be directed downwardly through the central flowbore (1928, Figure 19B), and into the ported sub (1903 Figure 19B). After pressure builds against the ball seated in a ball seat (not shown) to a predetermined pressure, the seal sub 1917 may move from a first position to a second position (not shown) to seal off the mixing tube (1908, Figure 19B) to any jetted fluids flowing from the jet pump sub 1906, thereby stopping suction.

**[0088]** Referring to Figures 22A and 22B, a side view and a cross sectional view, respectively, of a seal sub 1917 according to embodiments of the present disclosure are shown. The seal sub 1917 includes a body having a bore through at least a portion thereof. As shown, the seal sub 1917 may have a first bore and a second bore. The first and second bores may be coaxial, but may not be connected. The first bore may be configured to receive a ball seat (not shown). The second bore may be configured to receive or sealingly engage with a portion of the flow diverter sub (1932, Figure 21). The first and second bores may have the same or different width / diameter.

**[0089]** Referring to Figures 22A, 22B, and 23, the seal sub 1917 may have various grooves 81 for seating a plurality of sealing elements, which may be of any type known in the art, such as standard O-rings. In one embodiment, the sealing elements may be used to provide sealing engagement between the seal sub 1917 and other surfaces within the downhole retrieval tool 1900. The seal sub 1917 may also have one or more retainer holes 72 configured to receive a retainer 44. The seal sub 1917 may also have a plurality of apertures 82 disposed therearound. In one example, there may be a plurality of apertures 82 disposed around a circumference of an upper portion of the seal sub 1917, and/or disposed around a circumference of a lower portion of the seal sub. One of ordinary skill in the art will appreciate that the seal sub 1917 may include any number of sets of apertures along the length thereof. In one embodiment, the apertures 82 may align with the position of the annular jet pump sub 1906 so that the bore of the jet pump sub 1906 is in fluid communication with the mixing tube 1908 during the suction mode. In another embodiment, the apertures 82 may align with the portion of the bore having a larger diameter (1976, Figure 21) to form flow paths (63, Figure 24C) for fluid to flow through during the circulation mode.

**[0090]** The seal sub 1917 may be slidably disposed within the bore of the jet pump sub 1906. A retainer 44 may secure the seal sub 1917 within the jet pump sub 1906 and may be configured to disengage or break once a pre-determined force is exceeded. One of ordinary skill in the art will appreciate that various mechanical or hydraulic retainers may be used without departing from the scope of the present disclosure. For example, a shear pin may be used to retain the seal sub 1917 within the jet pump sub 1906. To achieve the pre-determined force or pressure, a ball seat 11

may be coupled to an upper end of the seal sub 1917 or disposed within the bore of the seal sub 1917. When a ball or other obstruction device is run into the hole and seated in the ball seat 11, fluid pressure may be built up above the seat until the predetermined pressure is reached, at which time the retainer is disengaged, *e.g.*, the shear pins are sheared.

**[0091]** There may be at least one small opening or first jet 7 in the jet pump sub 1906 that may align with apertures 82 of the seal sub 1917 to fluidly connect the bore of the annular jet pump sub 1906 to the mixing tube 1908. The jet 7 is configured to provide a high pressure flow of fluid from the drill string (not shown) into the mixing tube 1908. Thus, the jetted flow of fluid may displace fluid in the mixing tube 1908. Accordingly, in the suction mode, the resultant movant force of the jetted fluid may be sufficient to create a vacuum so that wellbore fluids and debris may be suctioned into the bottom sub 1902.

**[0092]** As illustrated, the annular jet pump sub 1906 may have a second annular jet 9 disposed above the first annular jet 7, which may operate similar to the first annular jet 7. Accordingly, during suction mode the fluid pumped down into the downhole retrieval tool 1900 may exit the annular jet pump sub 1906 from both jets (or sets of jets) 7, 9 and into the mixing tube 1908. Fluid exiting the second annular jet 9 may provide a movant force used for accelerating the flow of the fluids in the mixing tube 1908. The annular jets 7 and 9 may be configured to provide a first jet pump stage and a second jet pump stage, therein forming a two-stage pump within the downhole retrieval tool 1900.

**[0093]** The downhole retrieval tool 1900 may further include annular jet cups 33 and 35 disposed around a portion of the annular jet pump sub 1906 and configured to at least partially cover jets 7 and 9, respectively, to provide an adjustable gap. In one embodiment, annular jet cup 33 may be integral with the diverter sub 32. Either of the jets 7 and 9 size may be changed by varying gaps 91 and 93 by adjusting their respective annular jet cups 33 and 35, thereby providing for flexible operation of the downhole retrieval tool 1900. The gaps 91 and 93 may be varied by moving either of the annular jet cups 33 or 35 in an uphole or downhole direction along the annular jet pump sub 1906. The annular jet cups 33 and 35 may be threadedly coupled to the

annular jet pump sub 1906, thereby allowing the annular jet cups 33 and 35 to be threaded into a position that provides a desired gap between annular jet cups 33, 35 and the annular jet pump sub 1906.

**[0094]** Referring now to Figures 24A-24C, cross sectional views of downhole retrieval tool 1900 in multiple configurations according to embodiments of the present disclosure are shown. Figures 24A and 24B show the seal sub 1917 is movable between a first position (Figure 24A) and a second position (Figure 24B). As shown, the downhole retrieval tool 1900 operates in the suction mode when the seal sub 1917 is in the first position and operates in the circulation mode after the seal sub 1917 has moved to the second position.

**[0095]** In operation, as the downhole retrieval tool 1900 is deployed into the wellbore it may operate in the suction mode. As indicated by the arrows 401, a fluid is pumped downwardly through the work string (not shown) and into the bore of the jet pump sub 1906. The pressure of the fluid may be sufficient enough so that a portion of the fluid may exit both the first annular jet 7 and the second annular jet 9 into mixing tube 1908, as indicated by arrows 402 and 403, respectively. Initially, the fluid leaving the jets 7 and 9 will have the effect of displacing any static fluid that resides in the mixing tube 1908. The displacement of the static fluid in the mixing tube 1908 results in a vacuum or suction effect on at least a portion of fluid and debris in the upper end of the suction tube 1904. Thus, as indicated by the arrows 404 and 406, the fluid/debris mixture may be suctioned up through the suction tube 1904, and into the diverter sub 1932. In one embodiment, the diverter sub 1932 may be configured to divert at least a portion of the fluid/debris mix into the mixing tube 1908. Fluid flow from the second annular jet 9 may be used for accelerating the flow of the fluids in the mixing tube 1908. Arrows 403 illustrate fluid exiting the second annular jet 9 and mixing with the wellbore fluid/debris mixture in the mixing tube 1908, indicated by arrow 408.

**[0096]** As indicated by arrows 406, fluid suctioned through the upper end of the suction tube 1904 passes through the flow diverter 1912, and into the mixing tube 1908. The jetted fluid and the suctioned fluid mix together in the mixing tube 1908, as illustrated by arrows 408, and continue upwardly through the diffuser 1910, *e.g.*

past a plurality of diffuser blades, as shown by arrows 409. The momentum of the mixture of fluids carries the mixture into the filter sub (1914, Figure 19A). In one embodiment, the filter sub 1914 may be configured to separate and retain debris, while fluid is expelled outwardly into the wellbore.

**[0097]** As described, the downhole debris removal tool 1900, in the suction mode, may dislodge, remove, and/or capture debris from the wellbore (not shown). As indicated by arrows 407, the diverter 1912 may divert a portion of the fluid/debris mix from the suction tube 1904 downwardly into the debris sub 1902. For example, the flow diverter 1912 may be configured to separate larger pieces of debris from the fluid, and the separated debris may drop downward into the debris sub 1902.

**[0098]** The downhole retrieval tool 1900 may operate in the suction mode for as long as may be necessary or desired. For example, the downhole retrieval tool 1900 may be operated in the suction mode for an amount of time sufficient to remove a volume of debris that may be collected or precipitated on a separate pre-positioned downhole tool so that the pre-positioned tool may be cleanly coupled to and retrieved by tool 1900. The debris may be removed or suctioned from the neck of a packer plug (not shown) so that the tool 1900 may couple to the packer for removal of the packer.

**[0099]** As will now be described, when it is desired, the downhole retrieval tool 1900 may be transitioned to the circulation mode. In circulation mode, the downhole retrieval tool 1900 may be used to actuate another downhole tool, couple to another downhole tool, and/or retrieve another downhole tool. For example, an operator may determine that the downhole retrieval tool 1900 has reached a depth in a wellbore at which a downhole tool such as, for example, a packer plug, is presently located. To prepare the packer for retrieval by the downhole retrieval tool 1900, the downhole retrieval tool 1900 may be operated in suction mode to remove debris that may have collected on the packer plug (or other downhole tool). Once the operator has determined that suctioning of debris may be discontinued, or if a monitored pressure indicates that indicates the filter sub (not shown) may have become plugged or filled with debris (*e.g.*, an increase in pressure is observed), the operator may then switch the downhole retrieval tool 1900 from the suction mode to the circulation mode.

**[00100]** Before beginning circulation, the downhole retrieval tool 1900 is changed from a first configuration (Figure 24A) to a second configuration (Figure 24B). A drop ball or similar apparatus is inserted into the work string (not shown), through the central bore (1928, Figure 19B), and into the annular jet pump sub 1906 and seal sub 1917. A ball seat 11 disposed on an upper end of the seal sub 1917 is configured to receive the drop ball. After insertion into the work string, the ball is directed toward the ball seat 11 by the flow of fluid in the direction of arrows 401. The ball may then be seated within the ball seat 11, thus causing a blockage of flow into the annular jet pump 1906. The pressure will increase above the ball seat until it exceeds the pre-determined set-point of the retainer 44.

**[00101]** In operation, a pressure increase creates a force sufficient to disengage or break the retainer 44 so that the seal sub 1917 may move to the second position (Figure 24B). While described as a retainer, one of ordinary skill in the art will appreciate that other mechanical or hydraulic means for retaining the ball seat 11 may be used without departing from the scope of the present disclosure. Once the pre-determined force is exceeded and retainer 44 is disengaged, the fluid pressure exerted on the ball causes the seal sub 1917 to translate downward into the second configuration. In moving to the second position, the seal sub 1917 moves downwardly until it comes into contact with a shoulder of the suction tube 1904.

**[00102]** As illustrated by Figure 24B, once the seal sub 1917 has moved to the second position, the annular jets 7 and 9, as well as the diverter 1912, are blocked by the seal sub 1917 so that bore is no longer in fluid communication with the mixing tube 1908, thereby stopping the suction mode. In this configuration, arrows 410 illustrate fluid from the surface is now blocked from entering into the seal sub 1917.

**[00103]** Pressure may be further increased above the ball until a second predetermined force for the ball seat 11 is exceeded. When the second pre-determined force is exceeded, the ball seat disengages or breaks, such that the ball may then move past the ball seat 11 and into a secondary ball seat or ball receiver 62 disposed within the seal sub 1917. One of ordinary skill will appreciate that ball seat may be formed by any kind of seating apparatus or retainer known in the art. For example, the ball seat

may include a set of dogs or collared fingers that displace at a predetermined force so that the ball may pass therethrough.

**[00104]** As illustrated by Figure 24C, once the ball is moved to the ball receiver 62 proximate the lower end of the seal sub 1917, fluid flows through the seal sub 1917, as indicated by arrows 412. The portion 1976 of the internal bore of the flow diverter sub 1932 with an enlarged diameter is now aligned with the apertures 1982 of the seal sub 1917 to form flow passages 63. As indicated by arrows 413, fluid may now circumnavigate the dropped ball that is seated in the ball receiver 62 of the seal sub 1917 by flowing through the apertures 1982, down through the passages 63, back into the seal sub 1917 through the apertures 1983, and exit out the downhole retrieval tool 1900 via the suction tube 1904. Thus, a flow path is re-established between the body sub 1903 and the bottom sub (not shown), such that the downhole retrieval tool 1900 may now operate in the circulation mode. As mentioned previously, the circulation mode allows the downhole retrieval tool 1900 to couple to a prepositioned downhole tool. Once the prepositioned downhole tool has been cleared of debris using the suction mode, the downhole retrieval tool 1900 may cleanly couple to the prepositioned tool so that prepositioned tool may be retrieved and removed from the wellbore. The circulation of fluid may be used to actuate one or more locking mechanisms disposed on the downhole retrieval tool 1900 or on the prepositioned downhole tool. An observed pressure increase while in the circulation mode may indicate that the coupling between the retrieval tool 1900 and the prepositioned tool has occurred.

**[00105]** Thus, embodiments disclosed herein may provide a method for switching between a suction mode and a circulation mode of a downhole tool. The method may include running a downhole tool into a wellbore, operating the downhole tool in a suction mode and removing debris from the wellbore; and operating the downhole tool in a circulation mode. Switching operation of the downhole tool from the suction mode to the circulation mode may include changing a flow path of fluid through the downhole tool, as discussed above. The flow path of fluid through the downhole tool may be changed by actuating a seal sub disposed within the downhole tool to move the seal sub from a first position to a second position, as discussed above. The method may further include coupling the downhole tool to a

prepositioned downhole tool, and retrieving the downhole tool and the prepositioned downhole tool together from the wellbore. The coupling of the downhole tool and the prepositioned downhole tool may include actuating a locking mechanism with a circulation fluid from the downhole retrieval tool.

**[00106]** Although only a few example embodiments have been described in detail above those skilled in the art will readily appreciate that many modifications are possible in the example embodiments without materially departing from this invention. Accordingly, all such modifications are intended to be included within the scope of this disclosure as defined in the following claims. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents, but also equivalent structures. Thus, although a nail and a screw may not be structural equivalents in that a nail employs a cylindrical surface to secure wooden parts together, whereas a screw employs a helical surface, in the environment of fastening wooden parts, a nail and a screw may be equivalent structures. It is the express intention of the applicant not to invoke 35 U.S.C. § 112, paragraph 6 for any limitations of any of the claims herein, except for those in which the claim expressly uses the words ‘means for’ together with an associated function.

## CLAIMS

What is claimed is:

1. A method comprising:  
lowering a downhole retrieval tool into the wellbore,  
flowing a fluid through a bore of the downhole retrieval tool;  
jetting the fluid from the downhole retrieval tool into a mixing zone;  
displacing fluid in the mixing zone through a diffuser, thereby causing a suction in a  
suction tube of the downhole retrieval tool;  
suctioning a wellbore fluid into the downhole retrieval tool; and  
actuating the downhole retrieval tool to switch from a suctioning mode to a  
circulating mode.
2. The method of claim 1, further comprising:  
locating a prepositioned downhole tool;  
sealing the mixing zone from the bore of the downhole retrieval tool so the wellbore  
fluid is no longer suctioned into the downhole debris retrieval tool; and  
connecting a coupler disposed on the downhole retrieval tool to the prepositioned  
downhole tool.
3. The method of claim 1, wherein the connecting the coupler comprises actuating the  
coupler with a circulating fluid.
4. The method of claim 1, wherein the actuating the downhole retrieval tool comprises  
disengaging a retainer coupled between a jet pump sub and a seal sub disposed therein.
5. The method of claim 4, wherein the retainer comprises a shear pin, and wherein the  
disengaging comprises shearing the shear pin.
6. The method of claim 1, further comprising flowing the fluid jetted from the downhole  
retrieval tool, the wellbore fluid, or mixtures thereof through a filter sub.
7. The method of claim 2, wherein the prepositioned downhole tool is a packer plug.

8. The method of claim 1, further comprising capturing an amount of debris separated from the wellbore fluid into a debris sub in the suctioning mode.
9. A tool comprising:
  - a body sub;
  - a debris sub coupled to the body sub;
  - a suction tube disposed in the debris sub;
  - an annular jet pump sub disposed in the body sub and in fluid communication with the suction tube; and
  - a seal sub disposed in the annular jet pump sub and configured to move from a first position to a second position,wherein the tool operates in a first mode when the seal sub is in the first position, and in a second mode when the seal sub is in the second position.
10. The tool of claim 9, wherein the annular jet pump sub comprises:
  - a first annular jet for creating a vacuum.
11. The tool of claim 10, wherein the seal sub comprises at least one aperture configured to align with the first annular jet in the first position.
12. The tool of claim 11, wherein the at least one aperture of the seal sub is configured to be misaligned with the first annular jet in the second position.
13. The tool of claim 9, further comprising:
  - a ball seat coupled to the seal sub.
14. The tool of claim 13, further comprising:
  - a retainer device configured to maintain the seal sub in the first position until a predetermined pressure is applied to the ball seat.
15. The downhole retrieval tool of claim 9, wherein the first mode comprises a suction flow in the suction tube, and the second mode comprises a circulation flow through the suction tube.

16. A method comprising:
  - running a downhole tool into a wellbore;
  - operating the downhole tool in a suction mode and removing debris from the wellbore; and
  - operating the downhole tool in a circulation mode.
17. The method of claim 16, further comprising switching operation of the downhole tool from the suction mode to the circulation mode by changing a flow path of fluid through the downhole tool.
18. The method of claim 17, wherein the changing the flow path of fluid through the downhole retrieval tool comprises actuating a seal sub disposed within the downhole tool to move the seal sub from a first position to a second position.
19. The method of claim 16, further comprising:
  - coupling the downhole tool to the prepositioned downhole tool; and
  - retrieving the downhole tool and the prepositioned downhole tool together from the wellbore.
20. The method of claim 19, wherein the coupling comprises actuating a locking mechanism with a circulation fluid from the downhole tool.

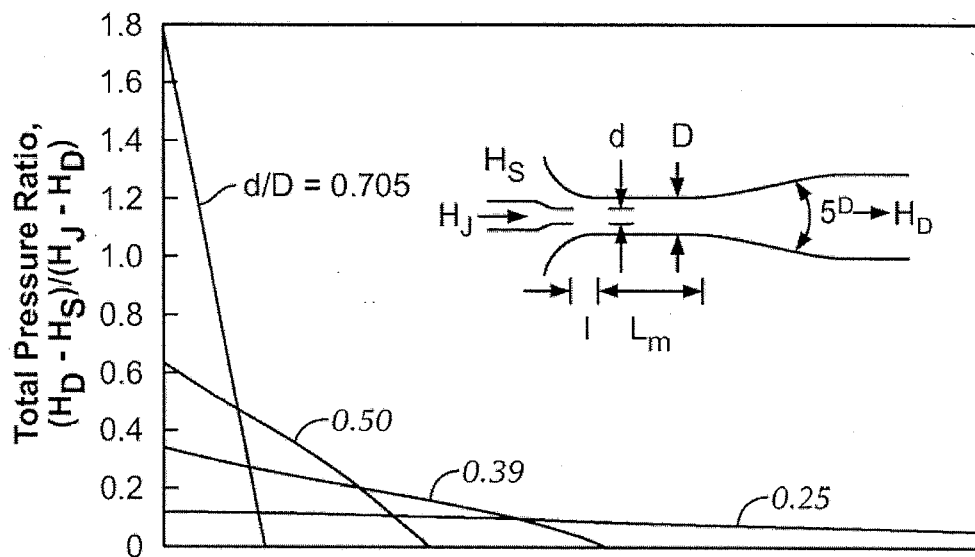


FIG. 1A

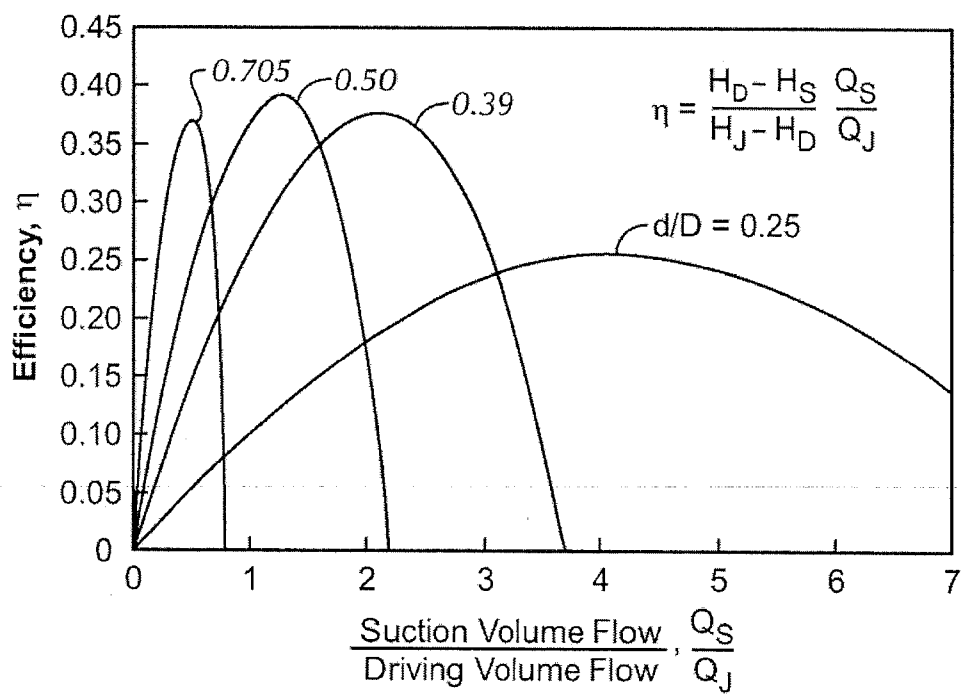


FIG. 1B

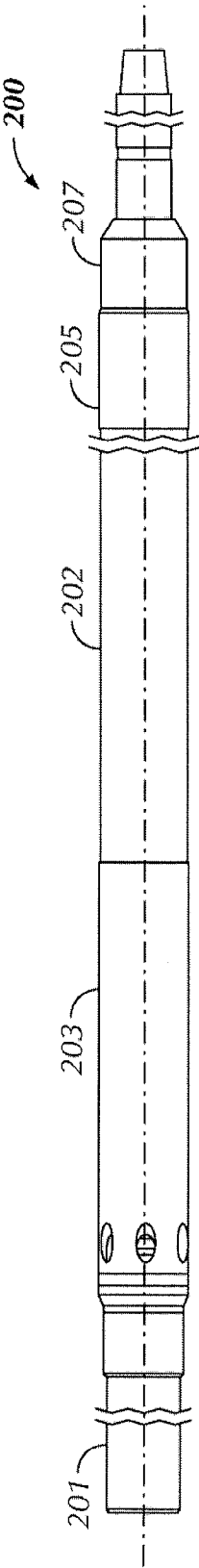


FIG. 2A

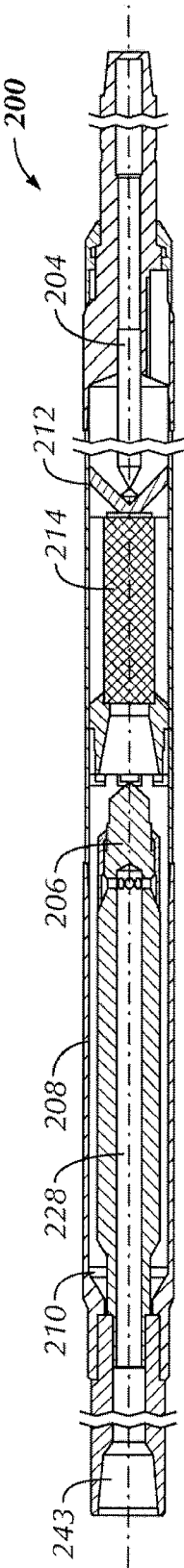


FIG. 2B

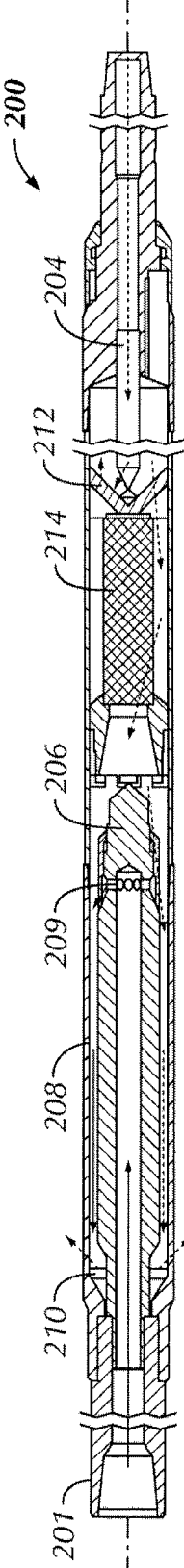


FIG. 3

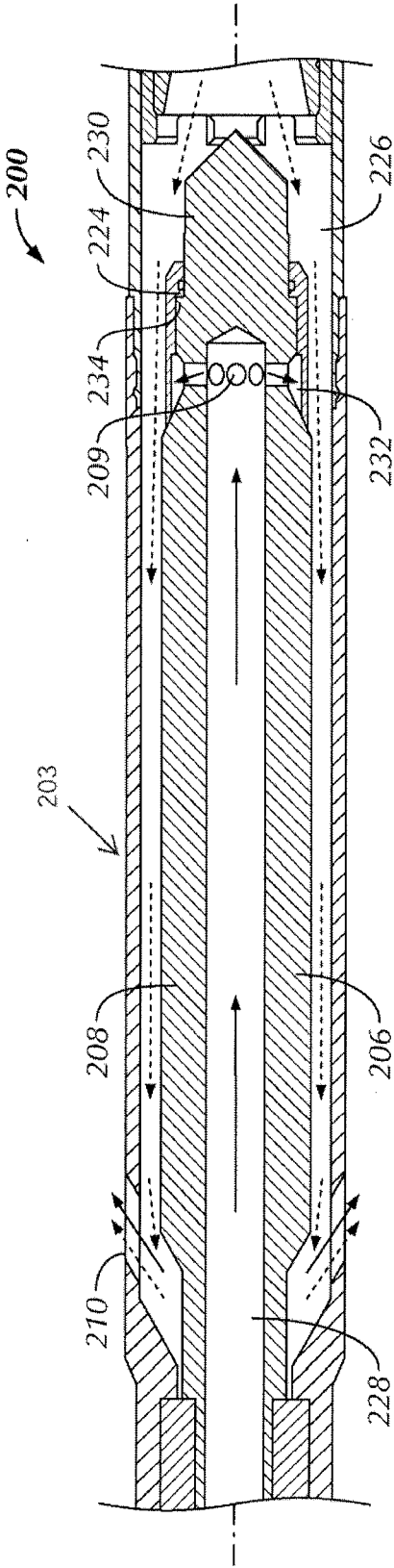


FIG. 4

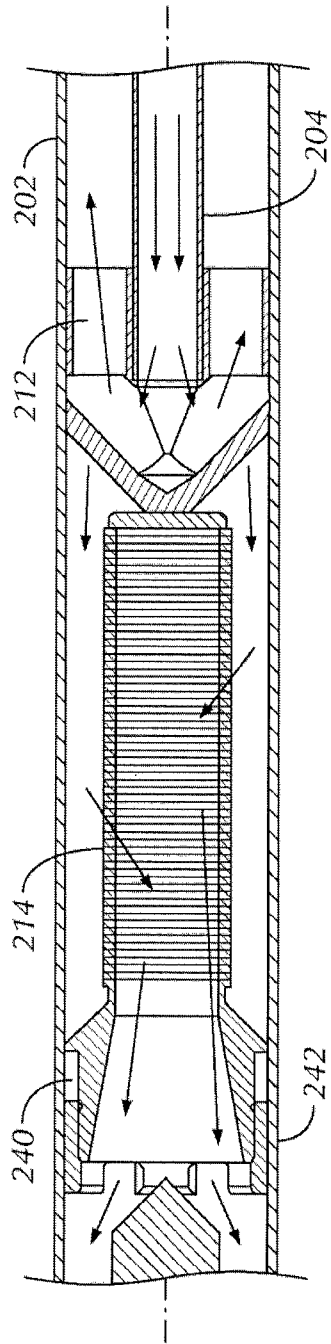


FIG. 5

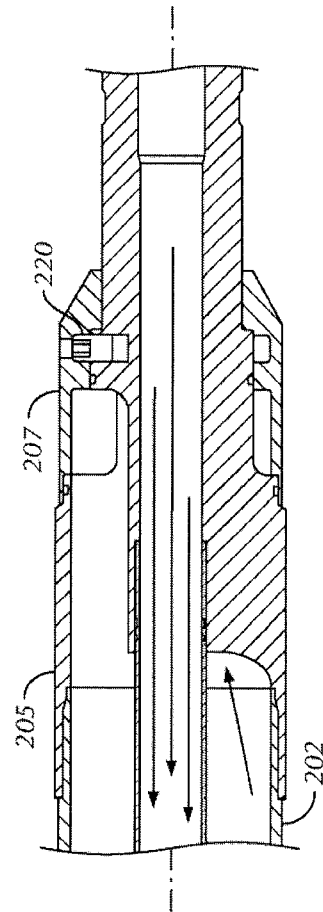


FIG. 6

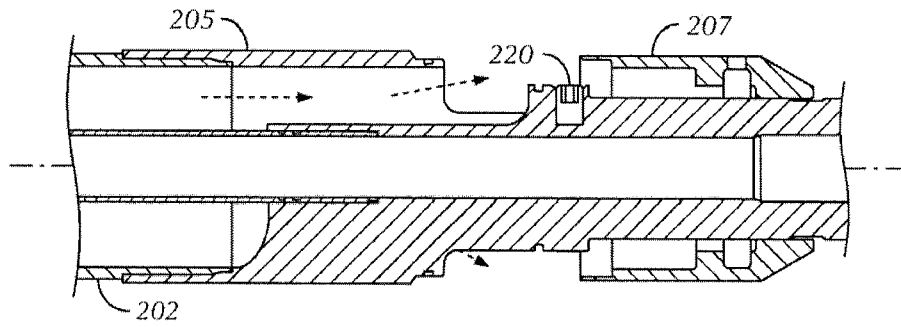


FIG. 7

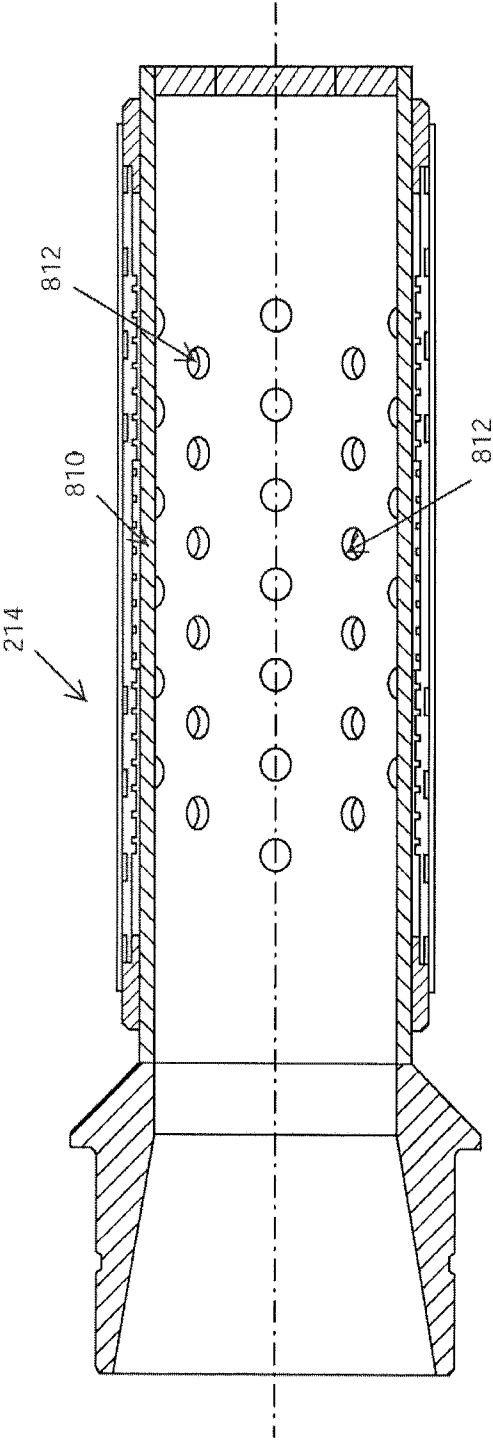


FIG. 8

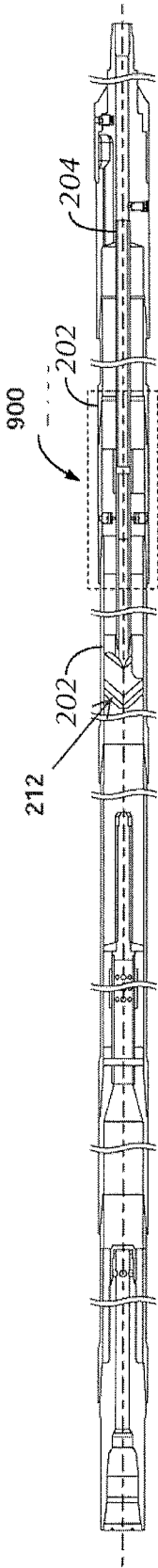


FIG. 9A

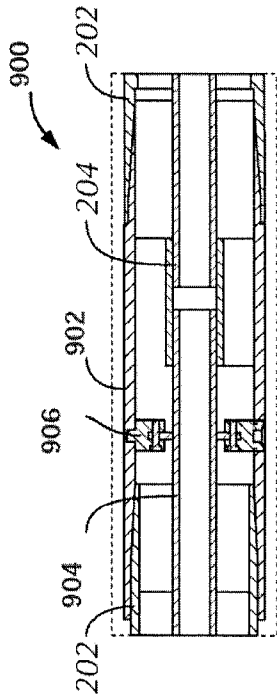


FIG. 9B

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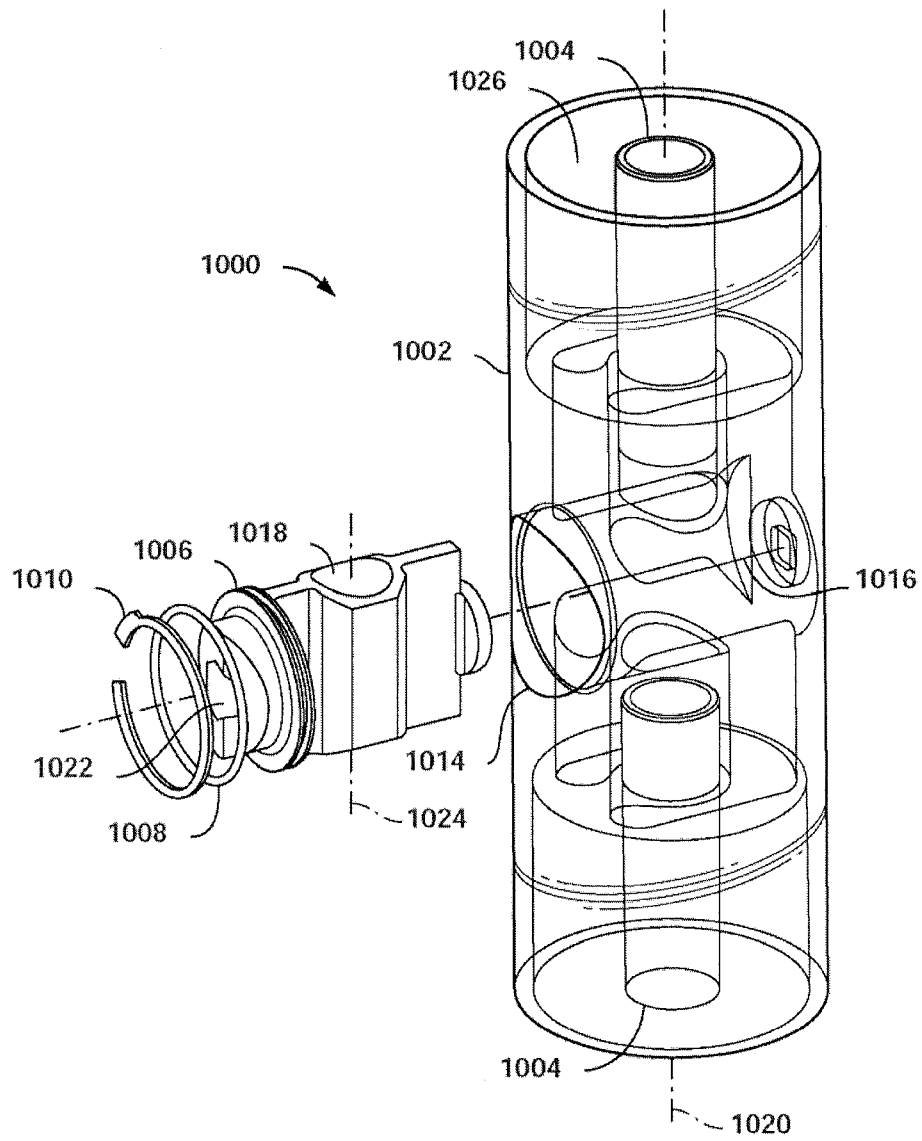


FIG. 10

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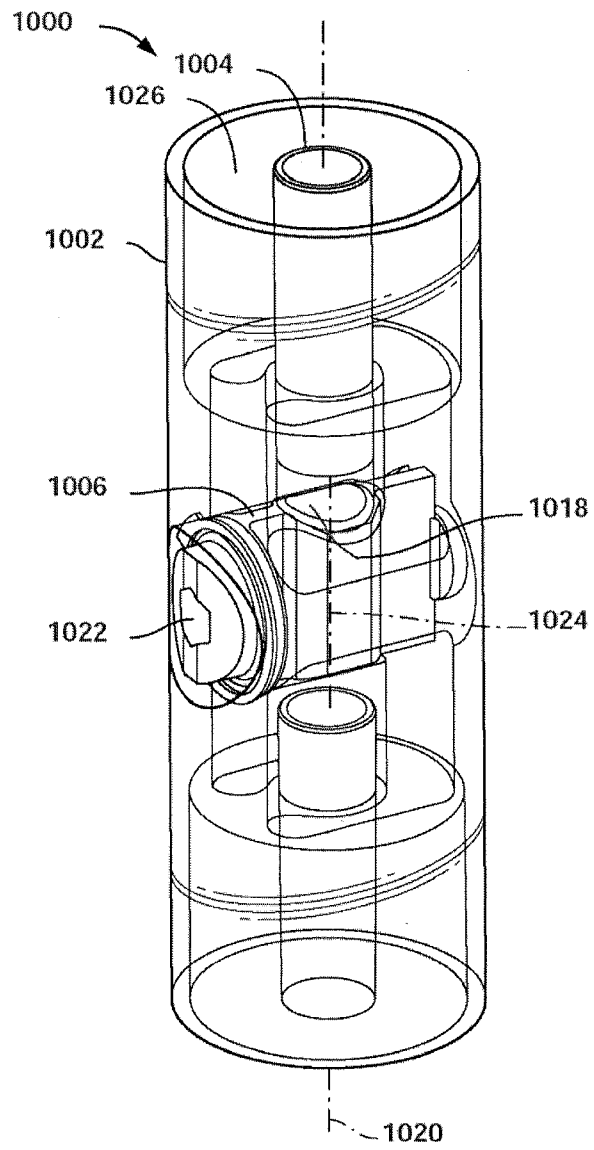


FIG. 11A

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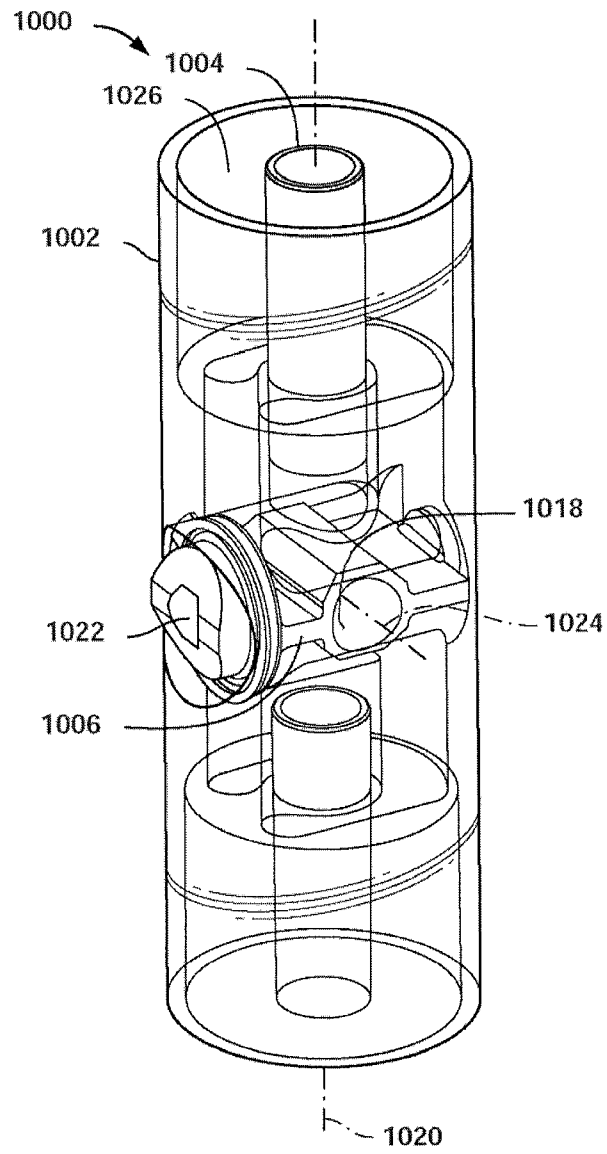


FIG. 11B

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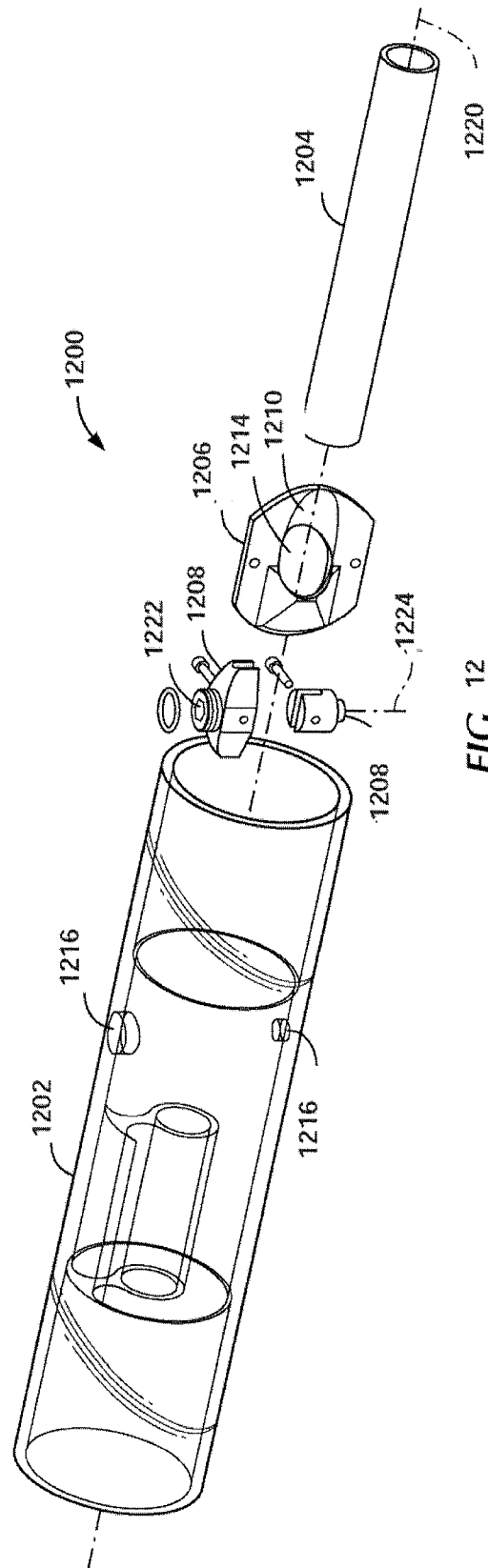


FIG. 12

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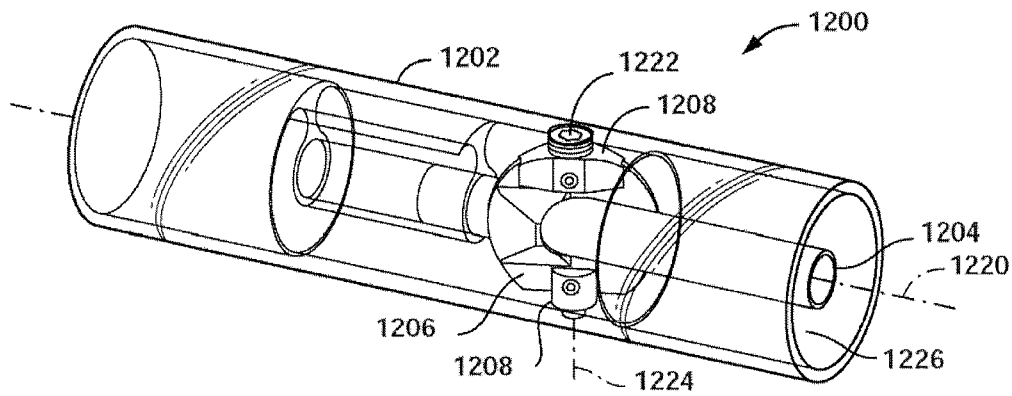


FIG. 13A

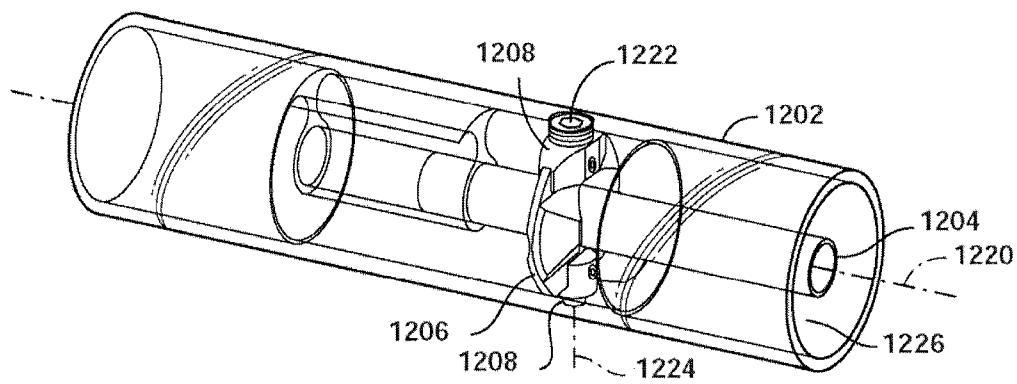


FIG. 13B

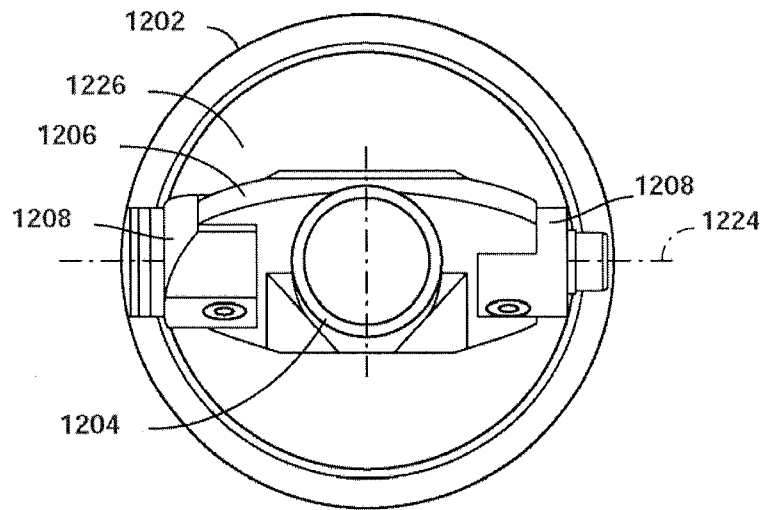


FIG. 14A

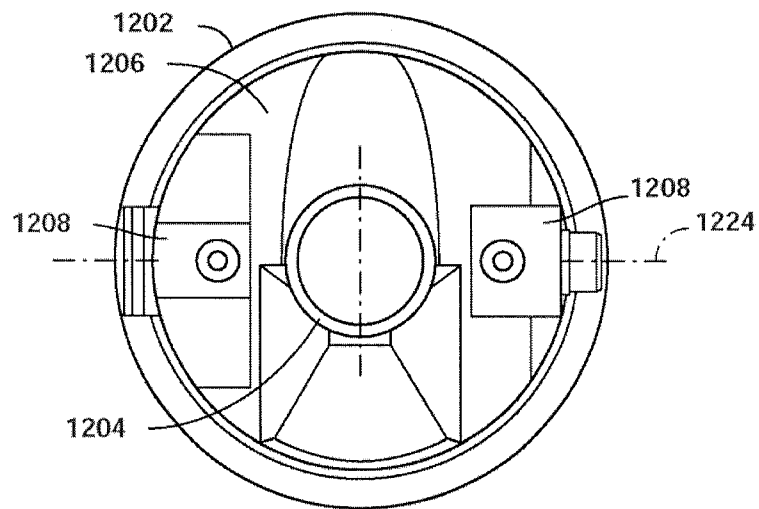
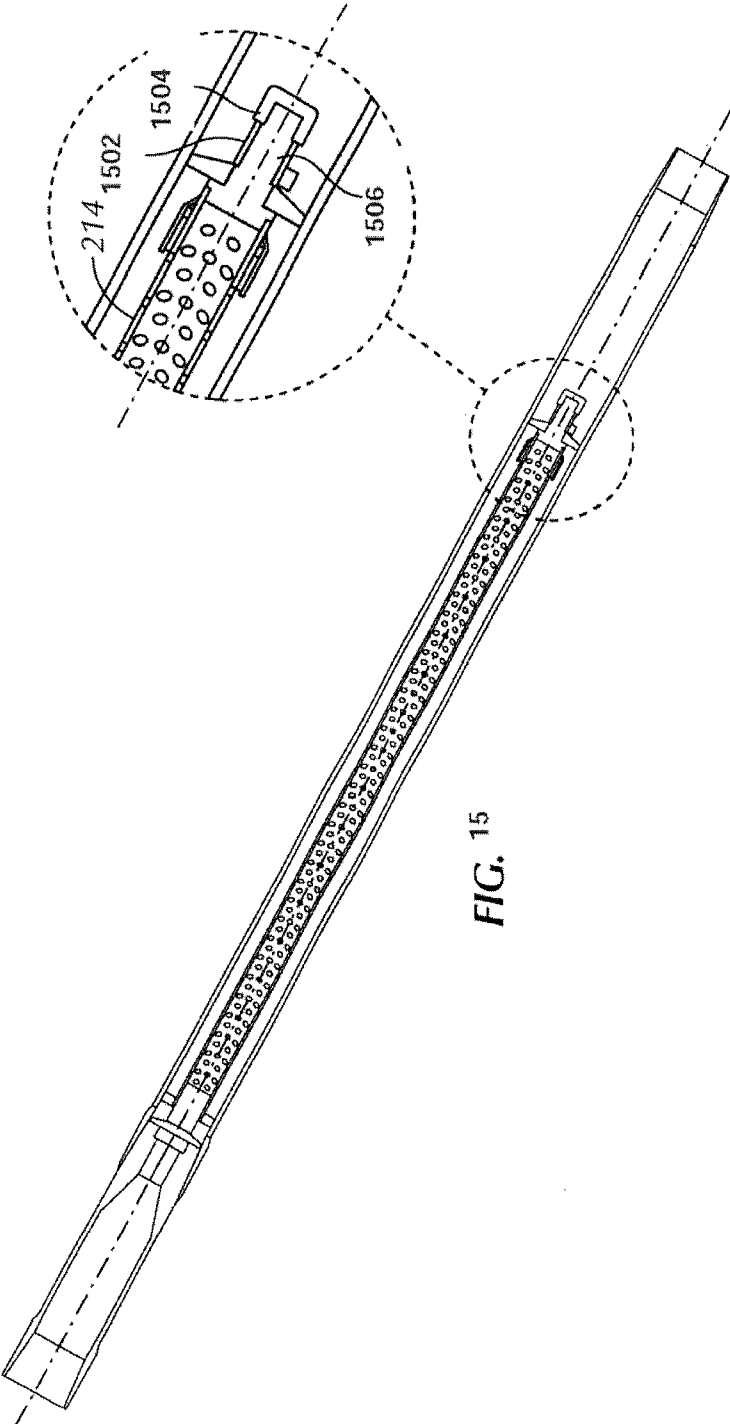


FIG. 14B



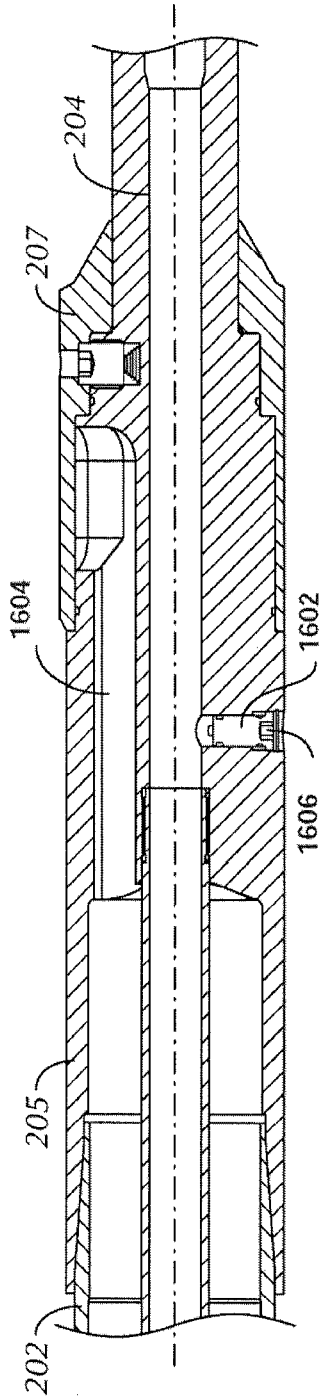


FIG. 16

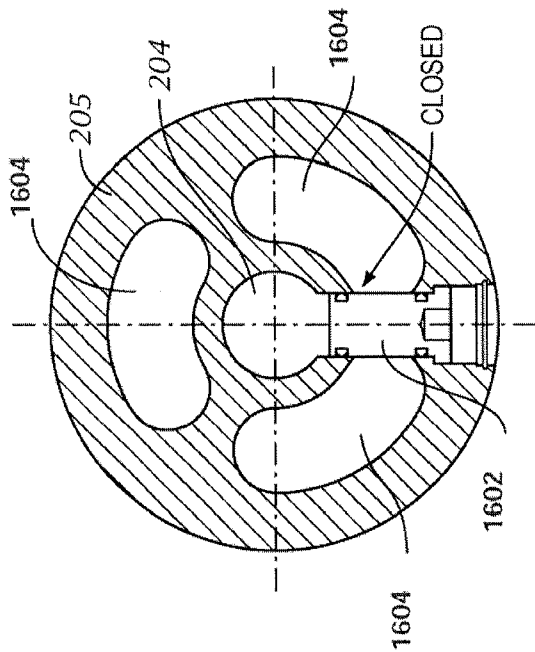


FIG. 17A

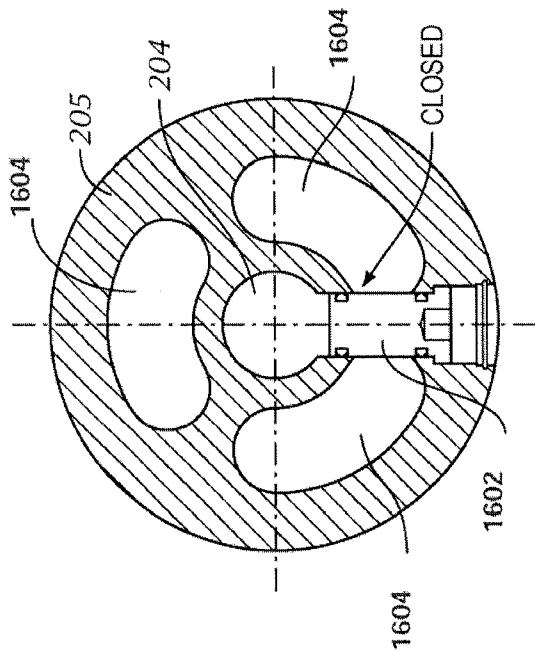


FIG. 17B

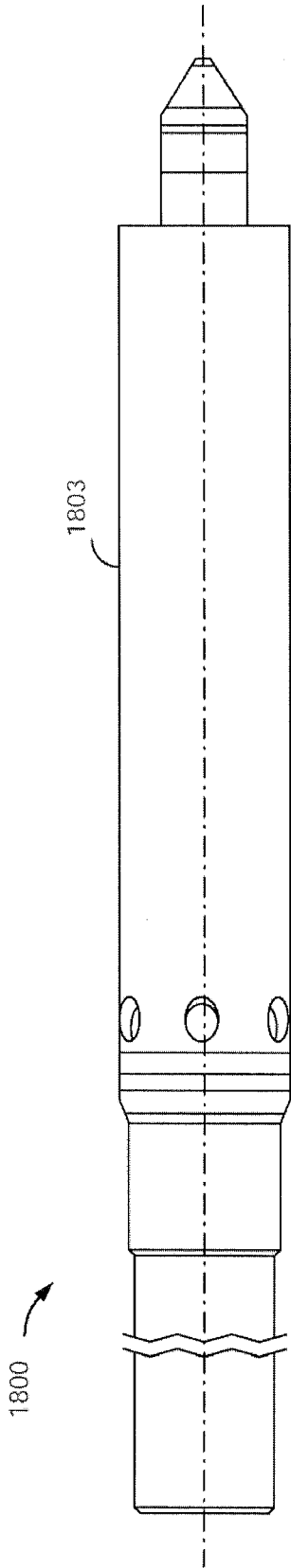


FIG. 18A

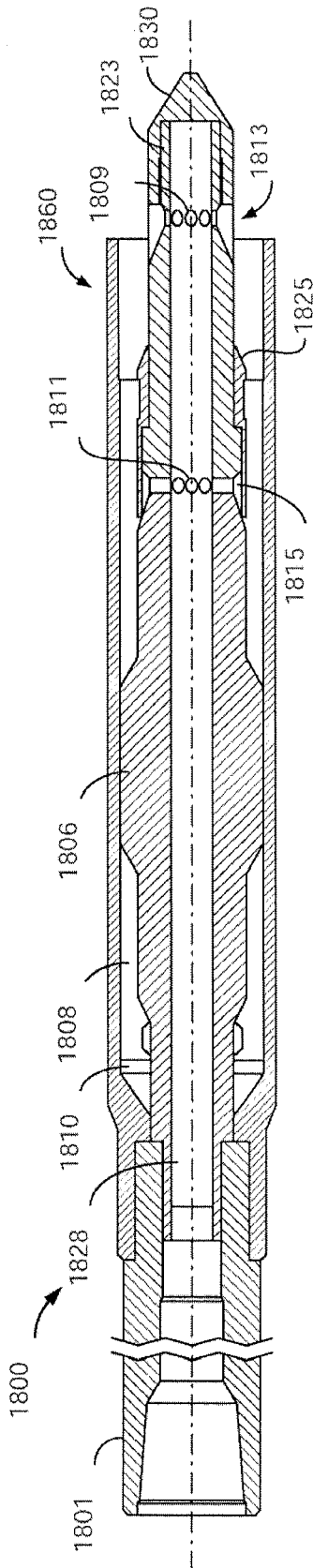


FIG. 18B

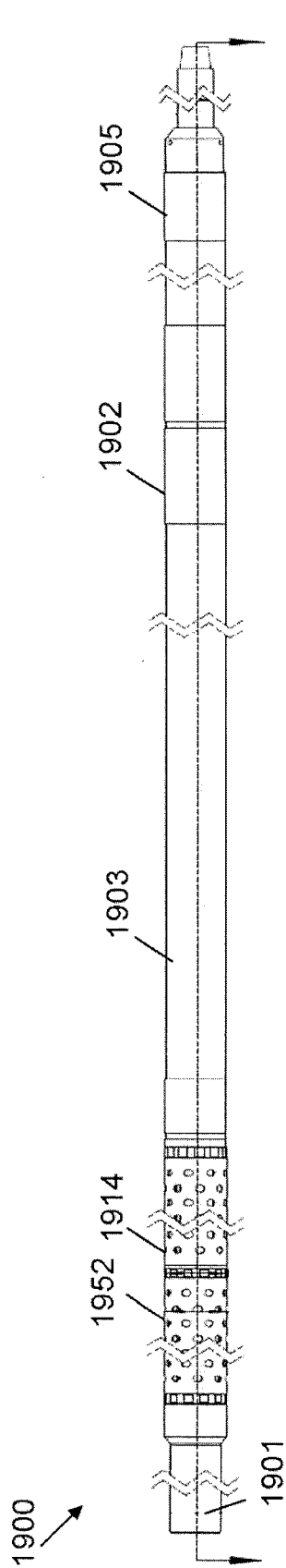


Figure 19A

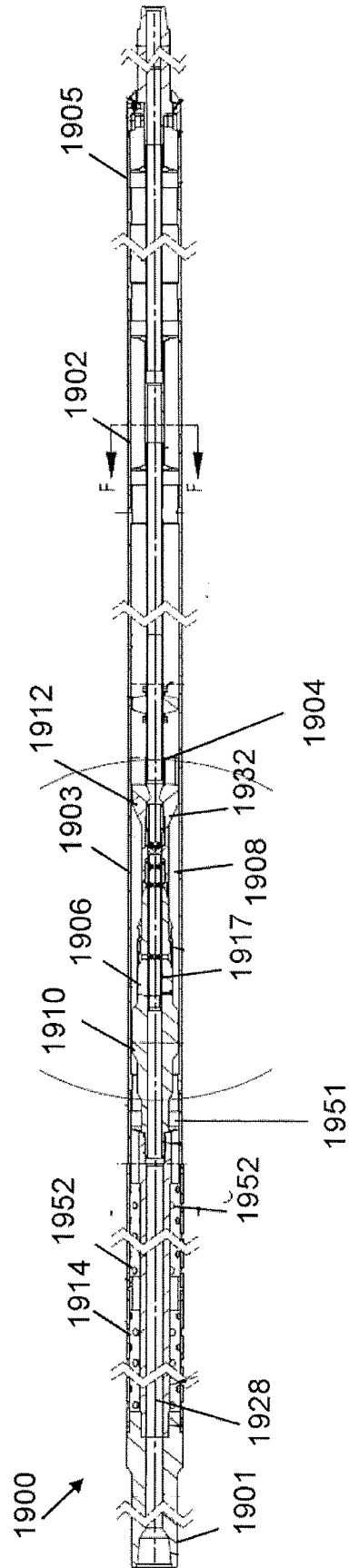


Figure 19B

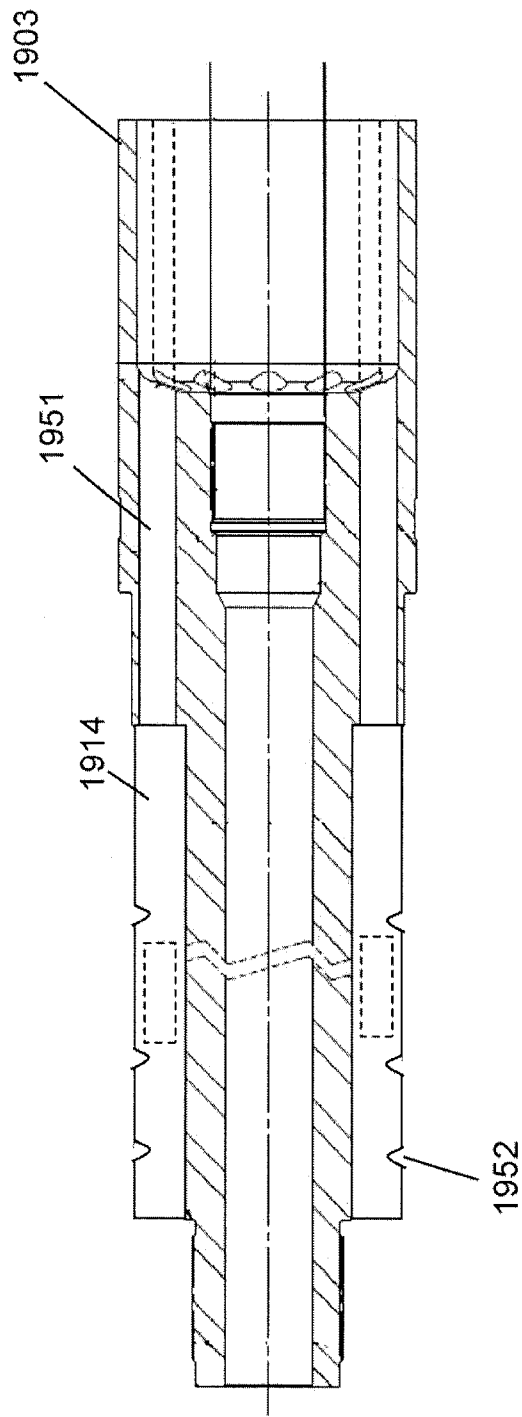


Figure 20

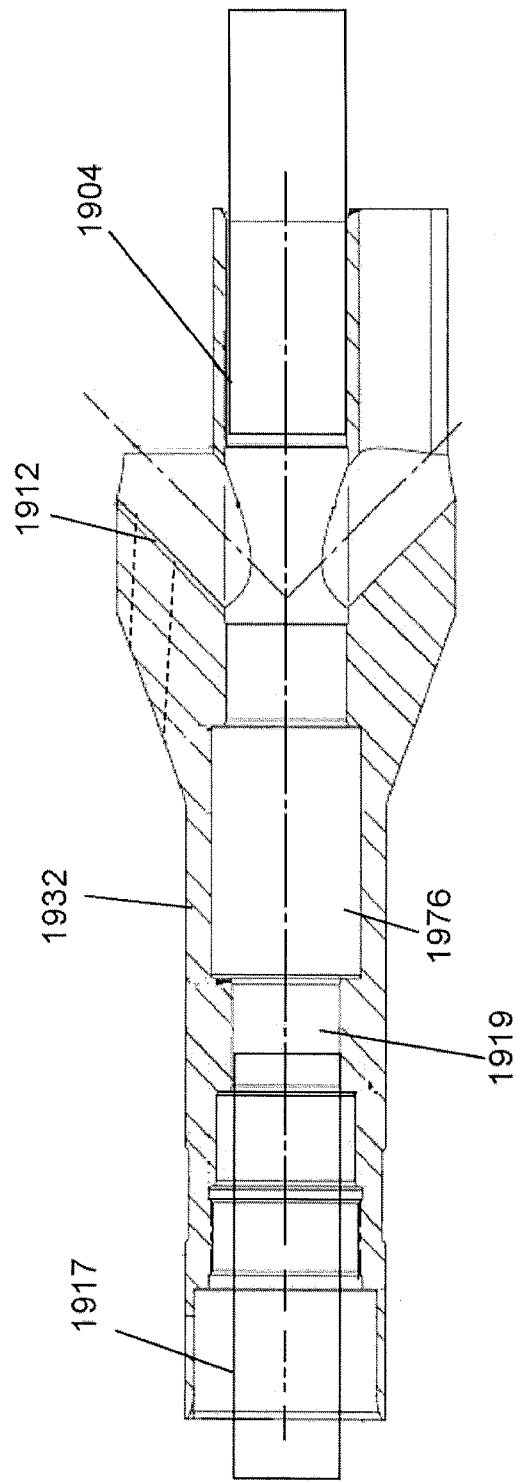


Figure 21

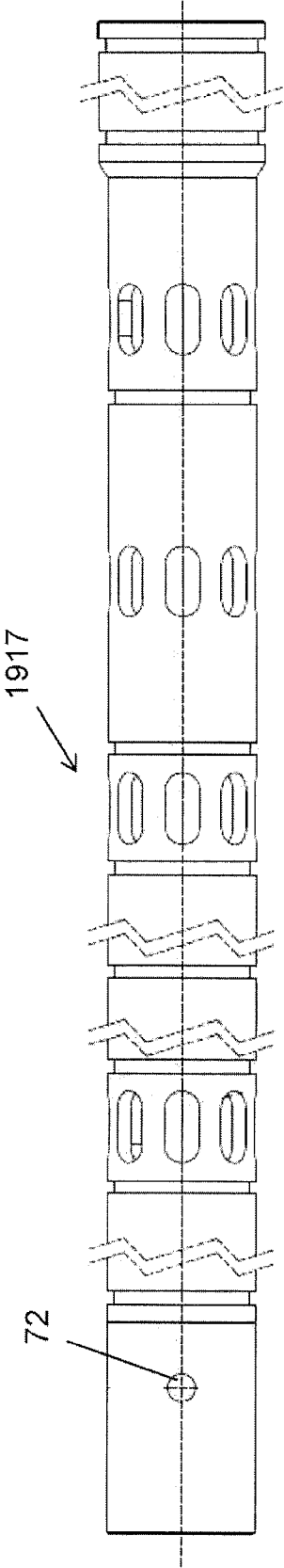


Figure 22A

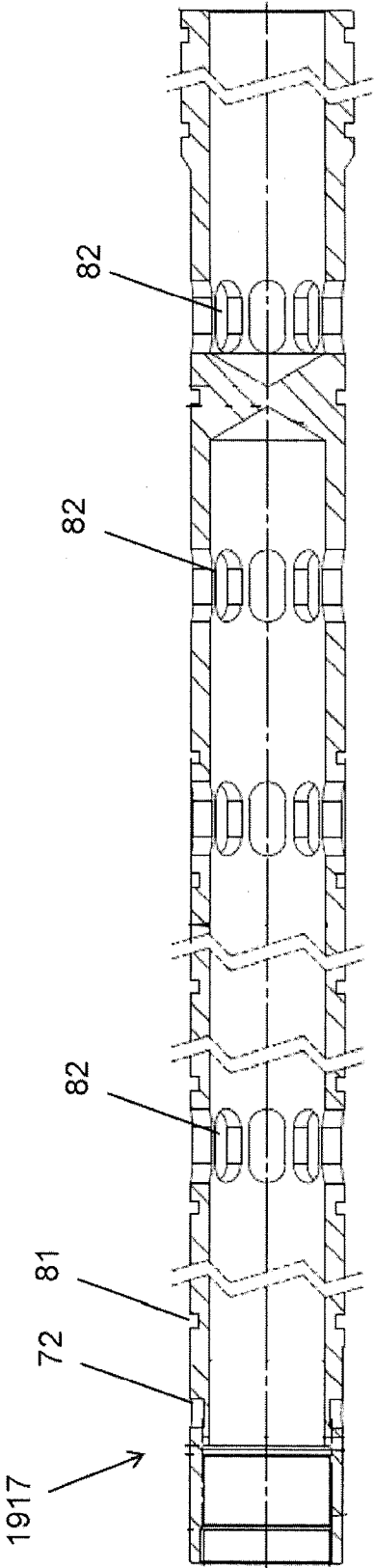


Figure 22B

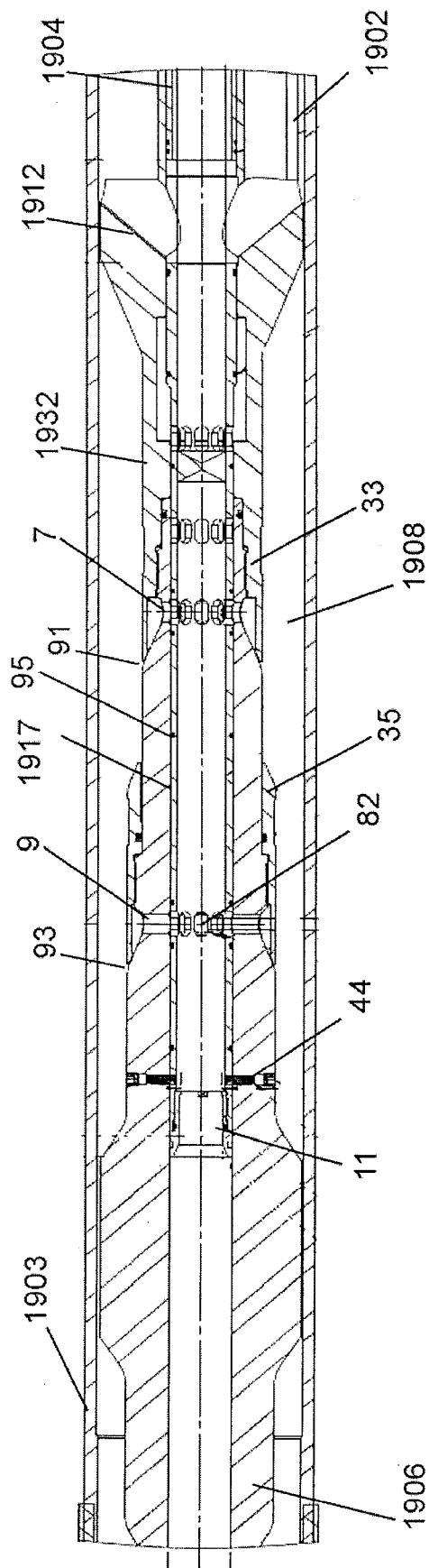


Figure 23

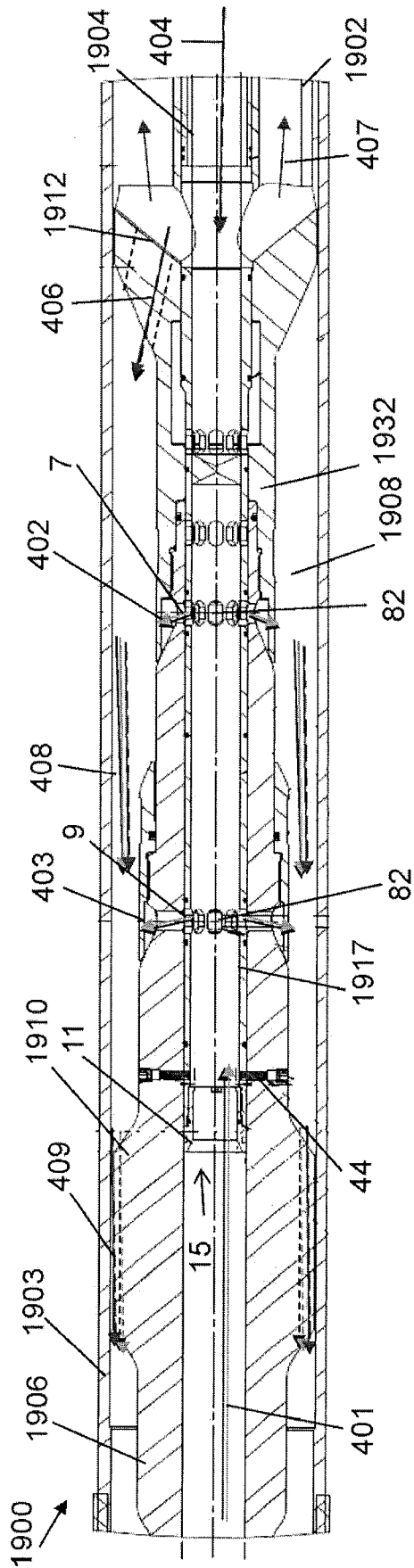


Figure 24A

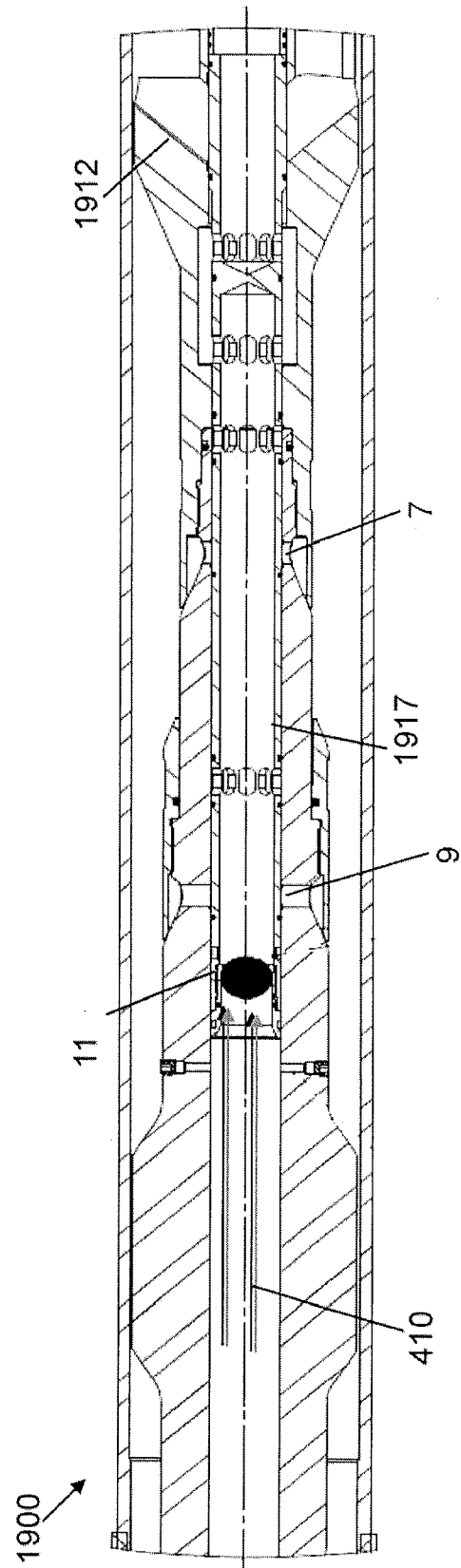


Figure 24B

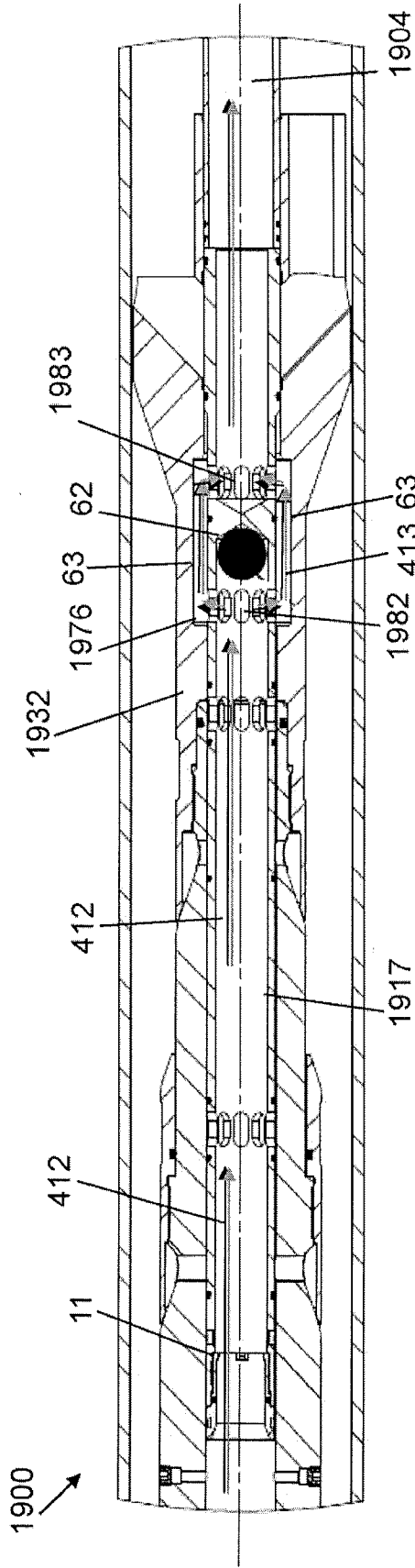


Figure 24C

## INTERNATIONAL SEARCH REPORT

International application No.  
**PCT/US2013/060849****A. CLASSIFICATION OF SUBJECT MATTER****E21B 33/122(2006.01)i, E21B 33/124(2006.01)i**

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)

E21B 33/122; E21B 7/12; E21B 31/00; E21B 33/12; E21B 23/12; E21B 23/00; E21B 31/08; E21B 33/124

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) &amp; Keywords: downhole retrieval tool, suction, debris, fluid, mixing zone, and diffuser

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                    | Relevant to claim No.      |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| X         | US 2004-0177951 A1 (HOFFMAN, COREY E. et al.) 16 September 2004<br>See paragraphs [0046]-[0047], [0049]-[0051] and figures 2-3, 8-10. | 1-3, 6-8, 16-17<br>, 19-20 |
| Y         |                                                                                                                                       | 4-5, 9-10, 13-15, 18       |
| A         |                                                                                                                                       | 11-12                      |
| Y         | US 6681860 B1 (YOKLEY, JOHN M. et al.) 27 January 2004<br>See column 5, lines 55-64 and figures 4-6.                                  | 4-5, 9-10, 13-15, 18       |
| A         | US 2010-0270018 A1 (HOWLETT, PAUL) 28 October 2010<br>See paragraphs [0036]-[0040], [0045]-[0049] and figures 1-5.                    | 1-20                       |
| A         | US 2011-0036564 A1 (WILLIAMSON, SCOTT) 17 February 2011<br>See paragraphs [0043]-[0045], [0059]-[0061] and figure 3B.                 | 1-20                       |
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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

19 December 2013 (19.12.2013)

Date of mailing of the international search report

**20 December 2013 (20.12.2013)**

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2013/060849**

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/US2013/060849**

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