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(54) **DOWNHOLE MULTI-ACTION JETTING TOOL**

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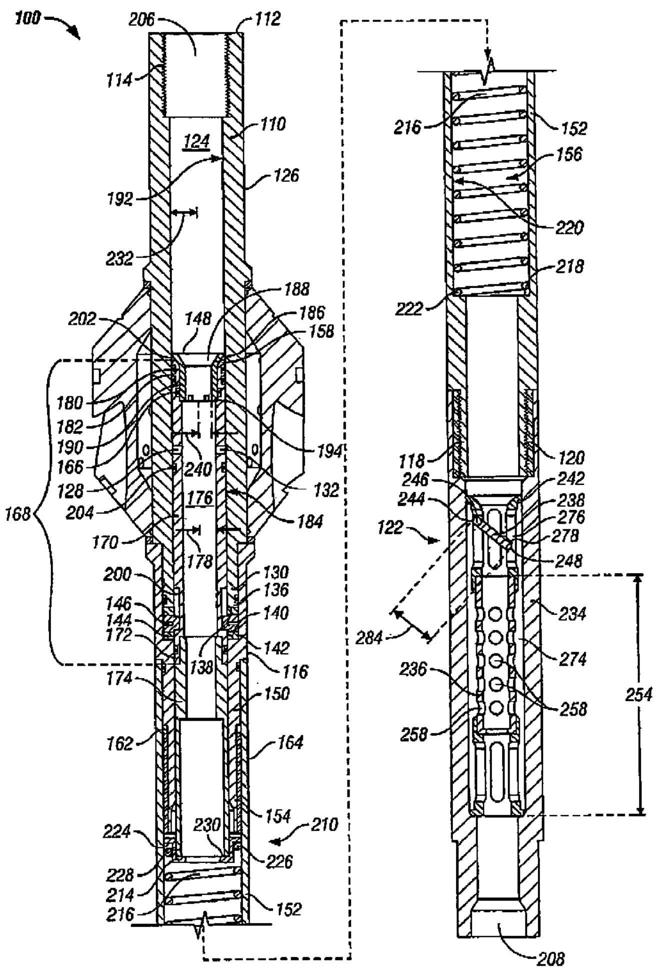
(57) **ABSTRACT**

An apparatus for cleaning a wellbore casing includes an outer housing having an axial through passage between an inlet and a first outlet wherein the inlet and the first outlet are adapted for connection in a work string, the outer housing having a second outlet extending in a direction generally transversely of the through passage, an index mandrel slidably located within the outer housing and having an axial bore extending therethrough, the index mandrel being movable relative to the outer housing between a first position in which the second outlet is closed and a second position in which the second outlet is open, a ball seat located on an upper end of the index mandrel, a spring located within the outer housing and biasing the index mandrel toward the first position, a ball retainable on the ball seat to prevent flow from the inlet to the first outlet, and wherein application of a first pressure on the ball forces the index mandrel against the spring into the second position and reduction of said first pressure permits return of the index mandrel to the second position.



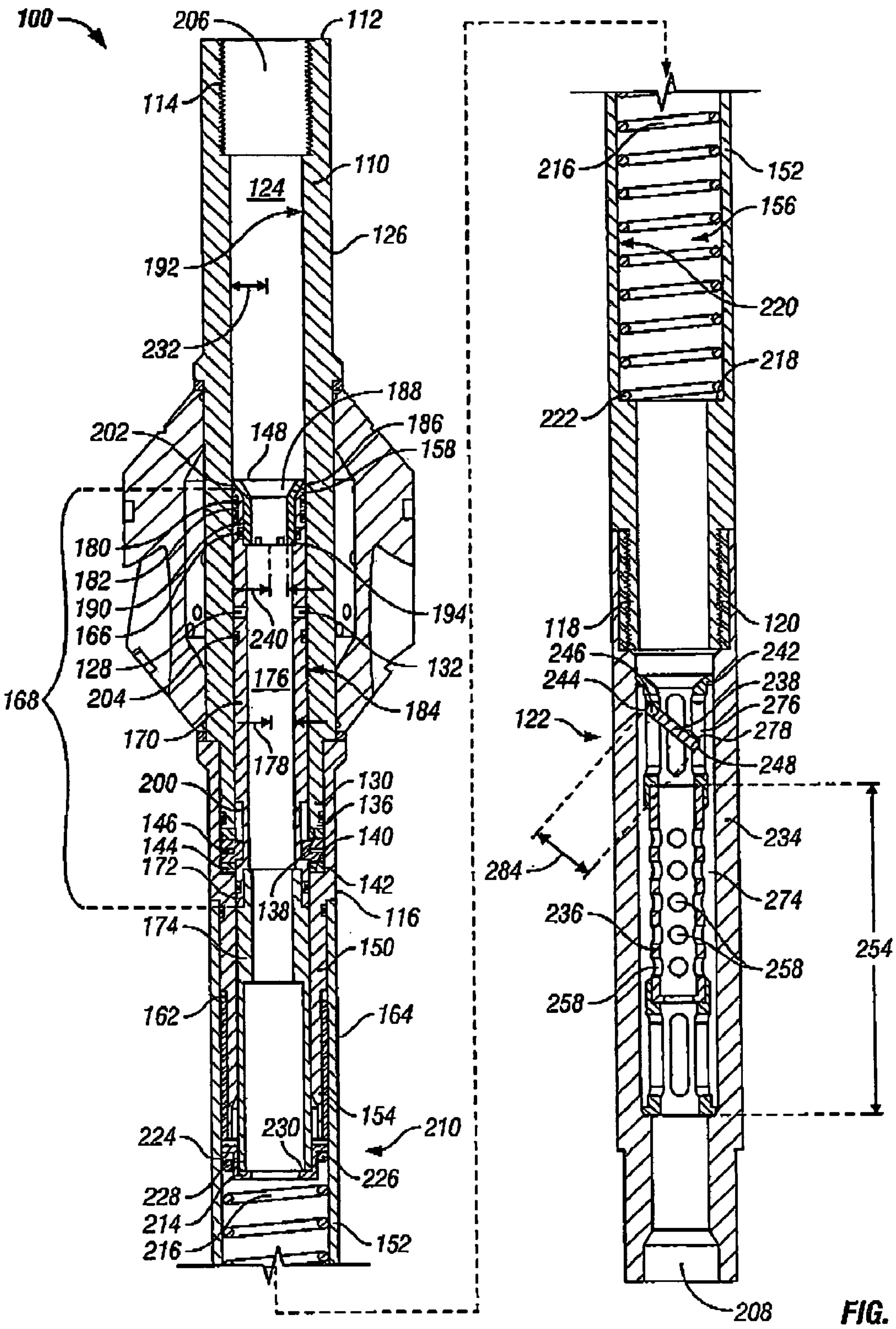

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FIG. 1

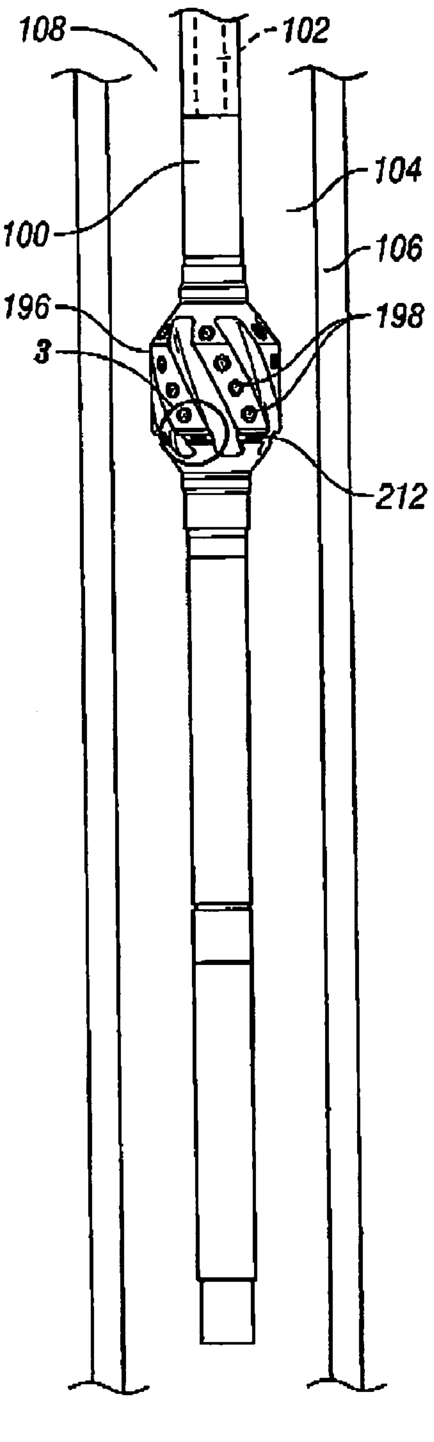


FIG. 2

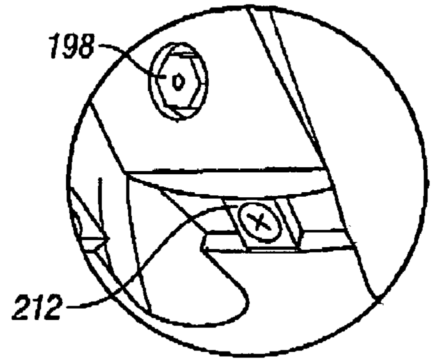
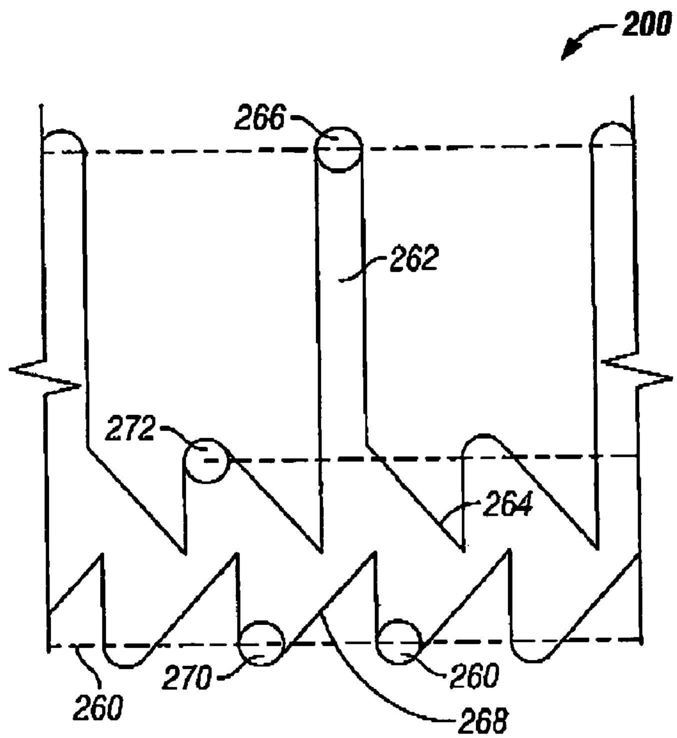


FIG. 3



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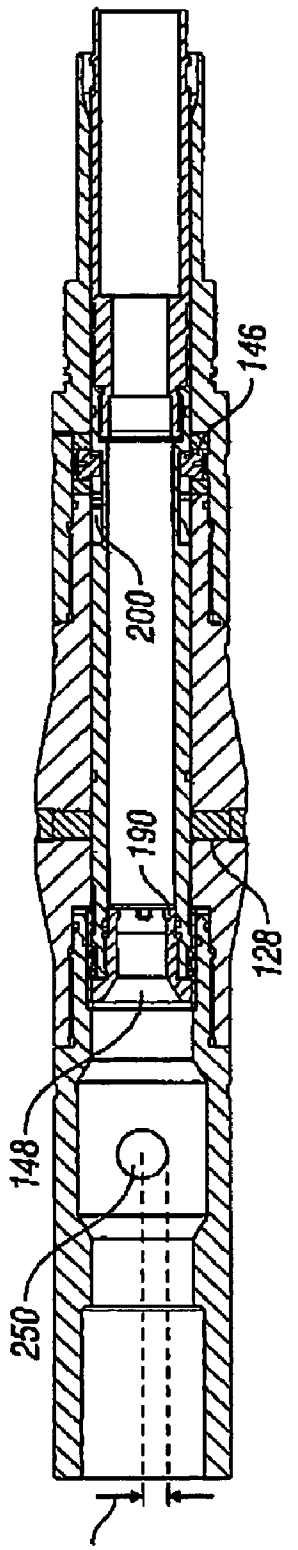

FIG. 5

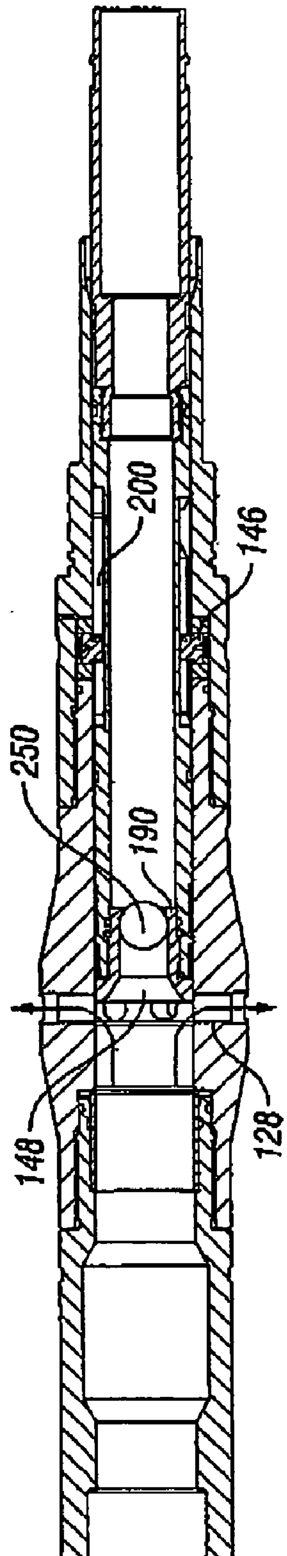

FIG. 6

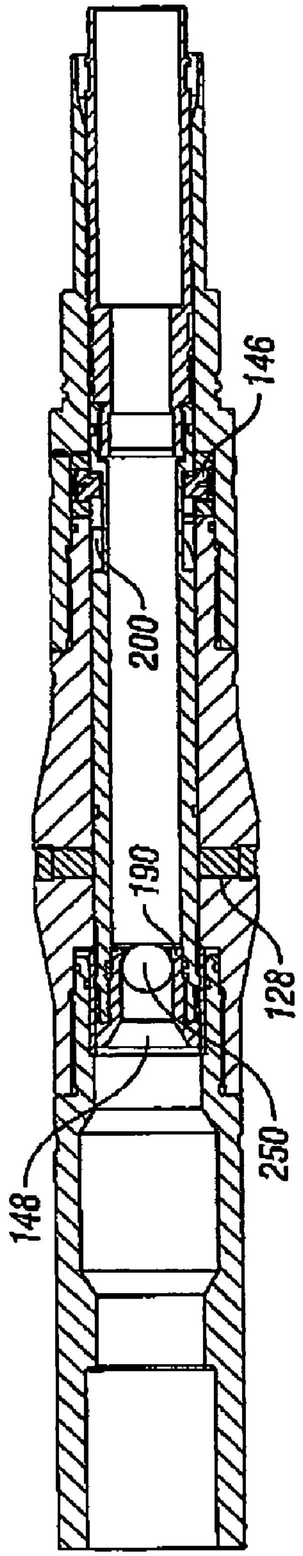

FIG. 7

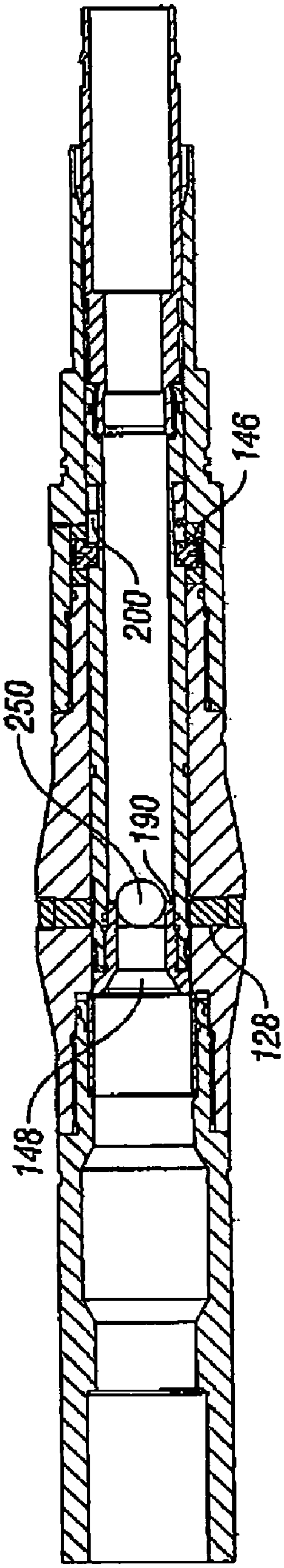

FIG. 8

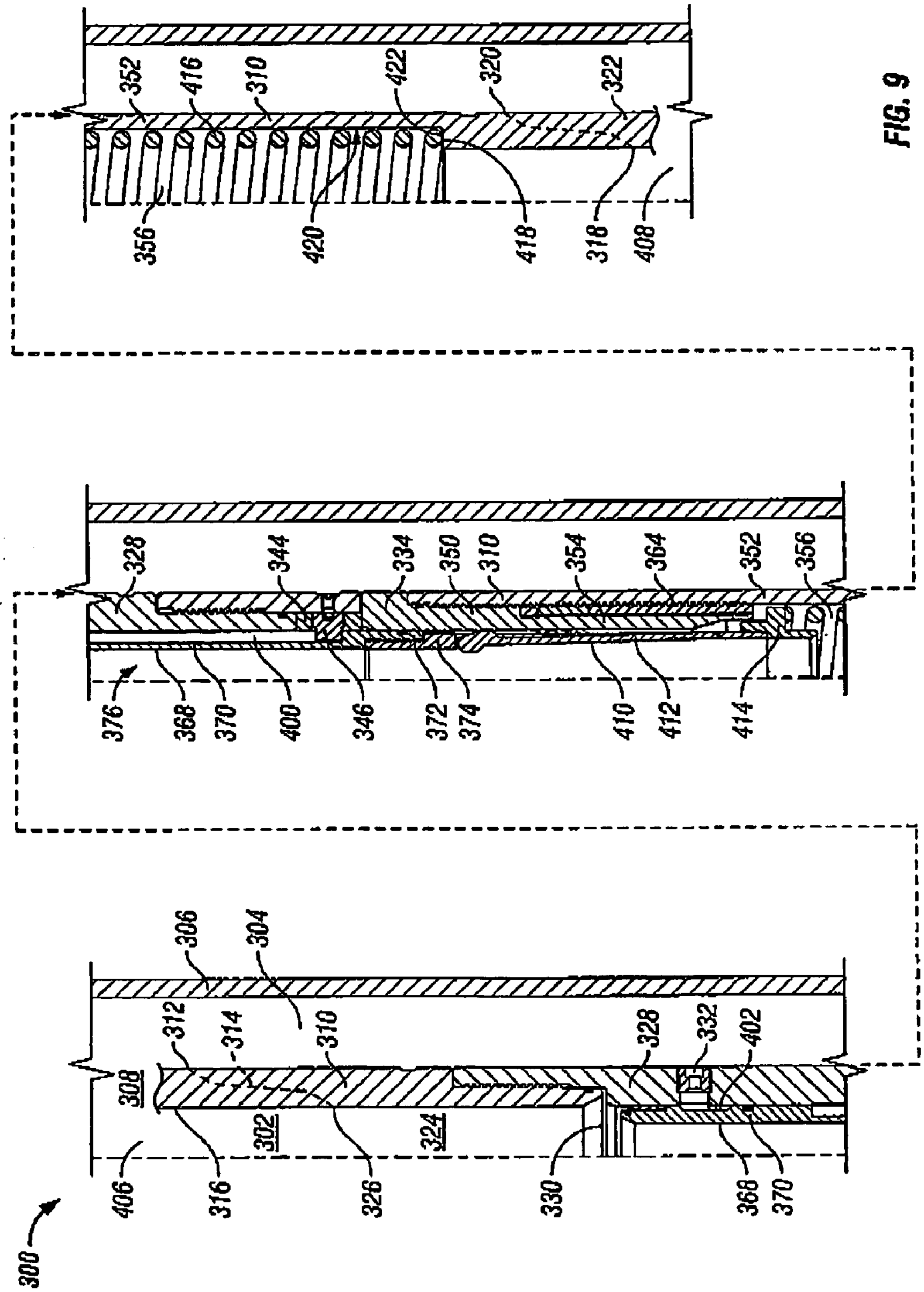
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FIG. 9

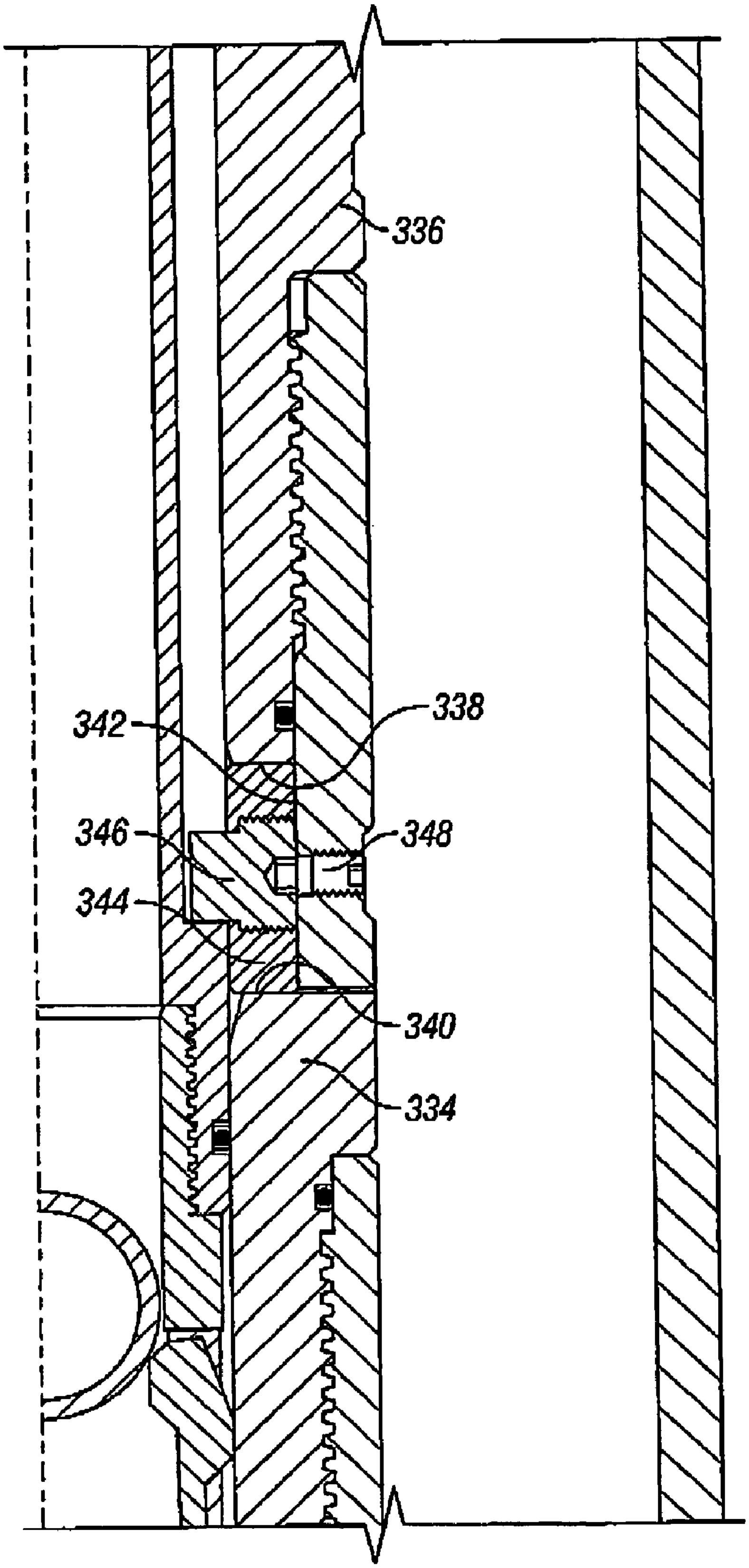

FIG. 10a

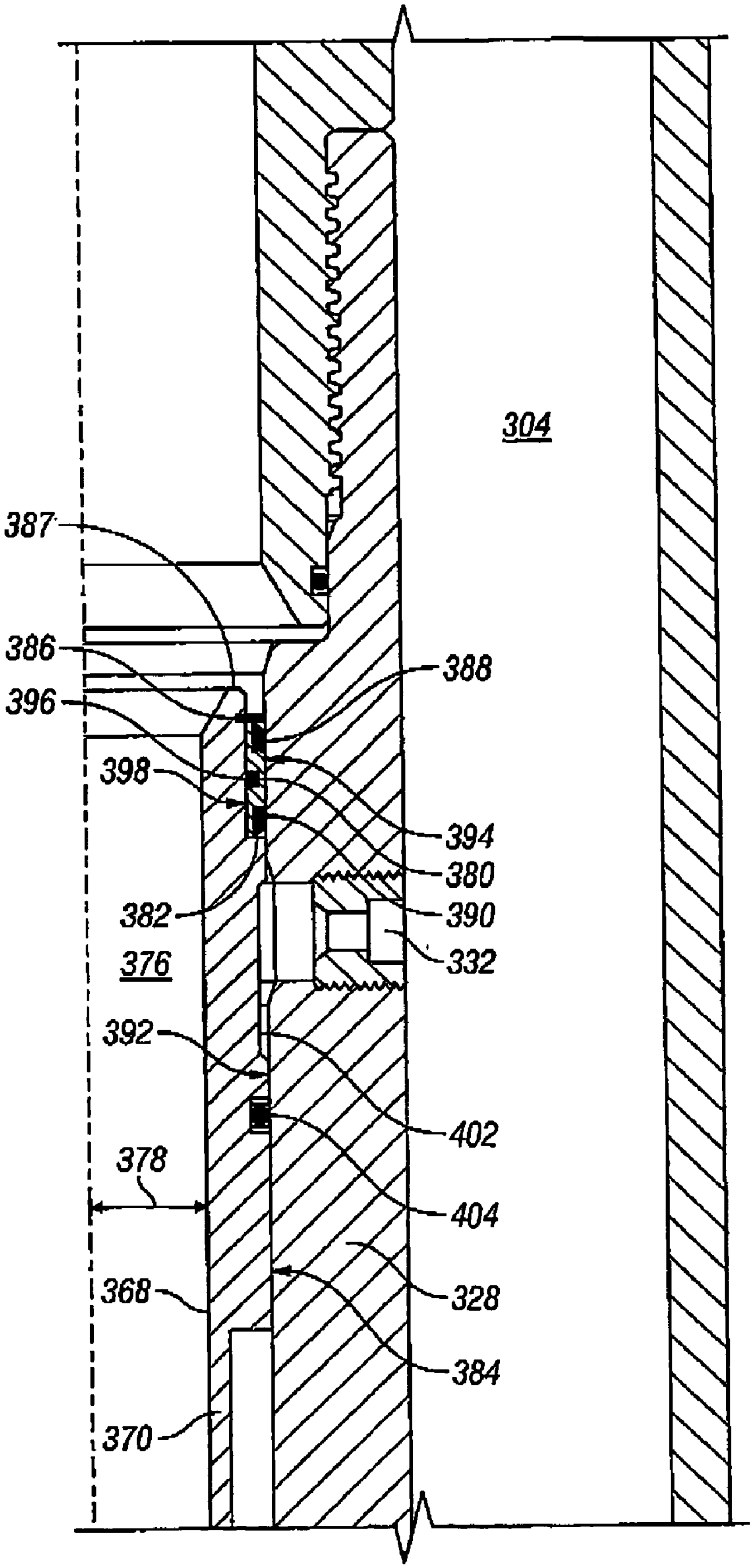

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FIG. 10b

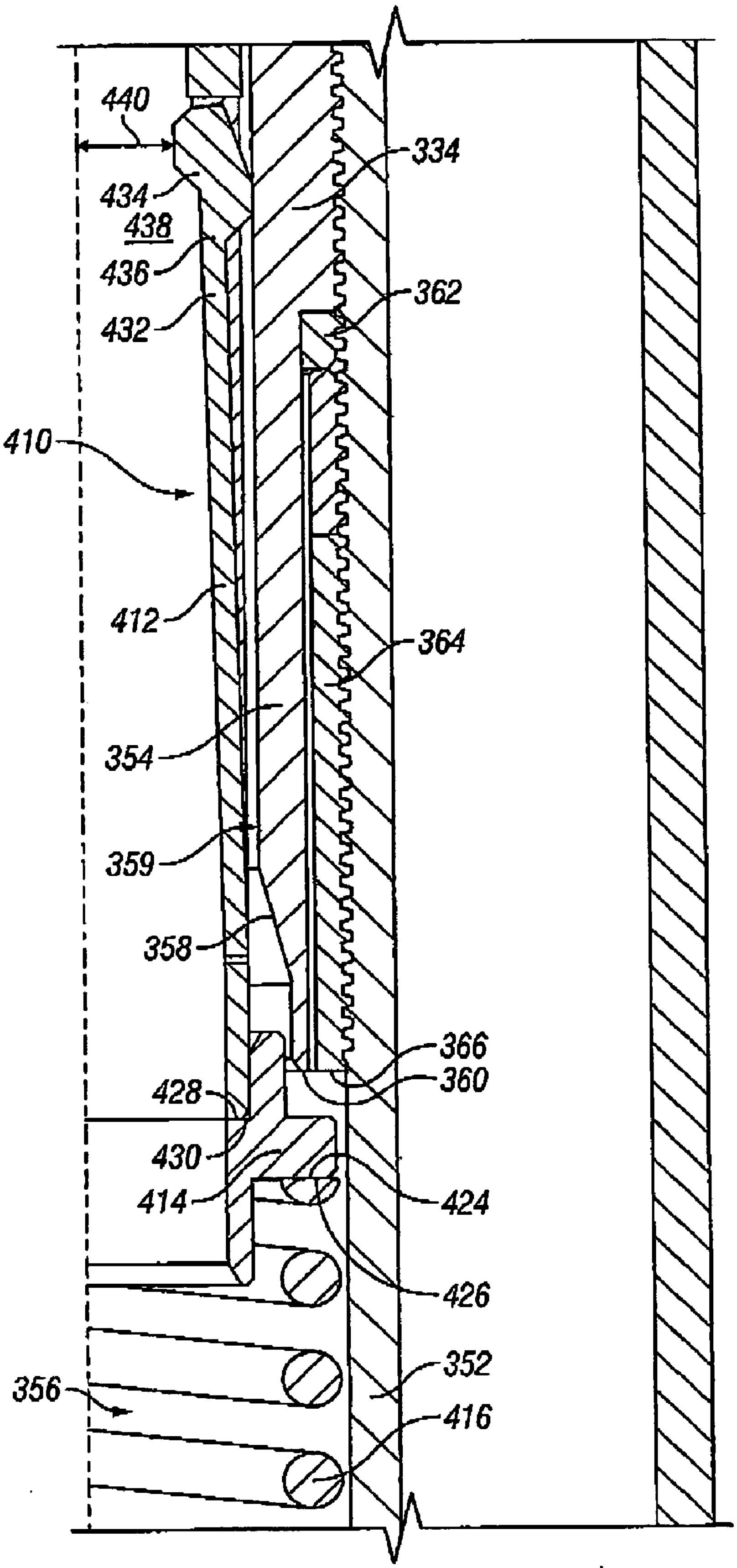
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FIG. 10c

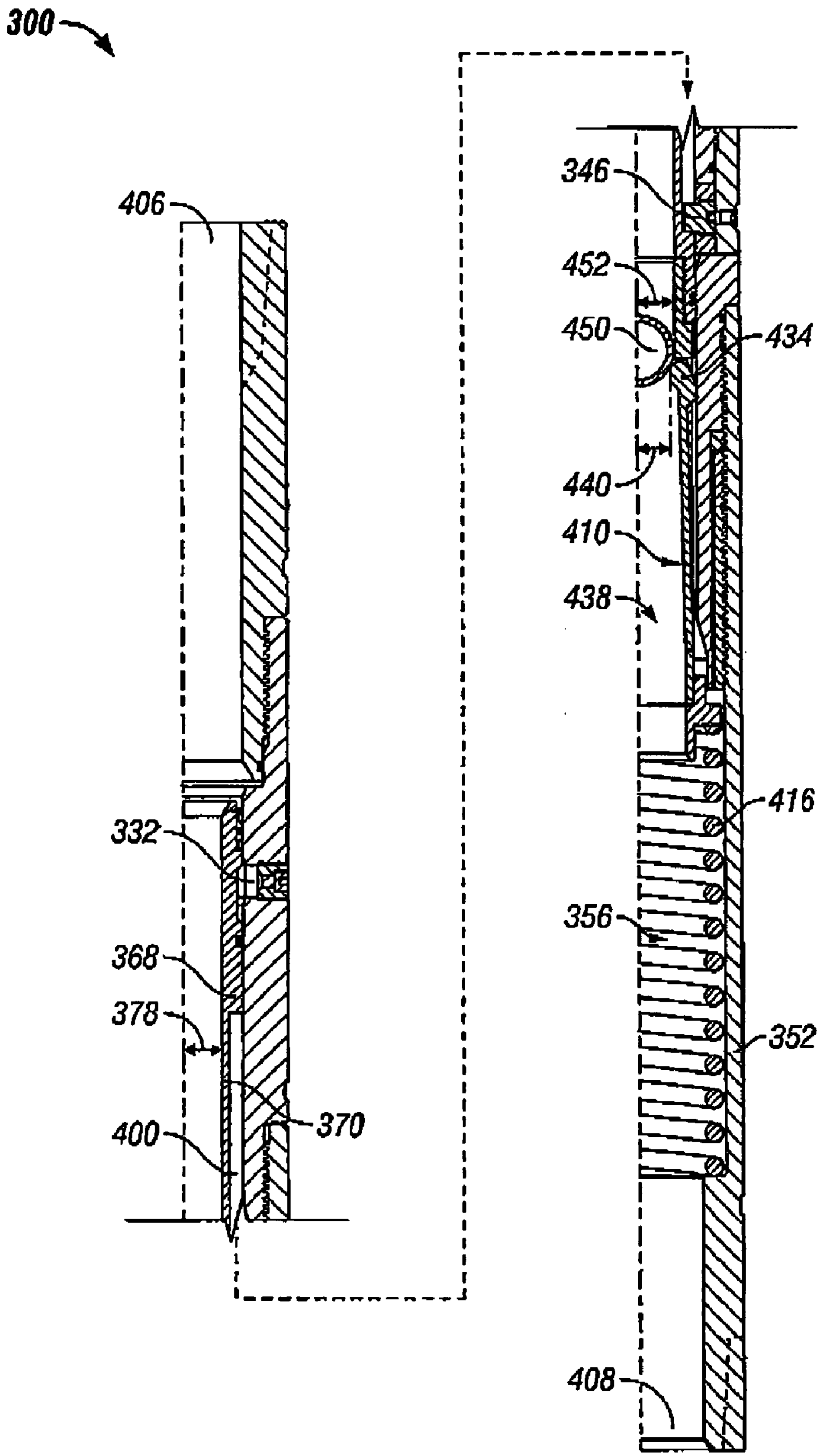
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FIG. 11

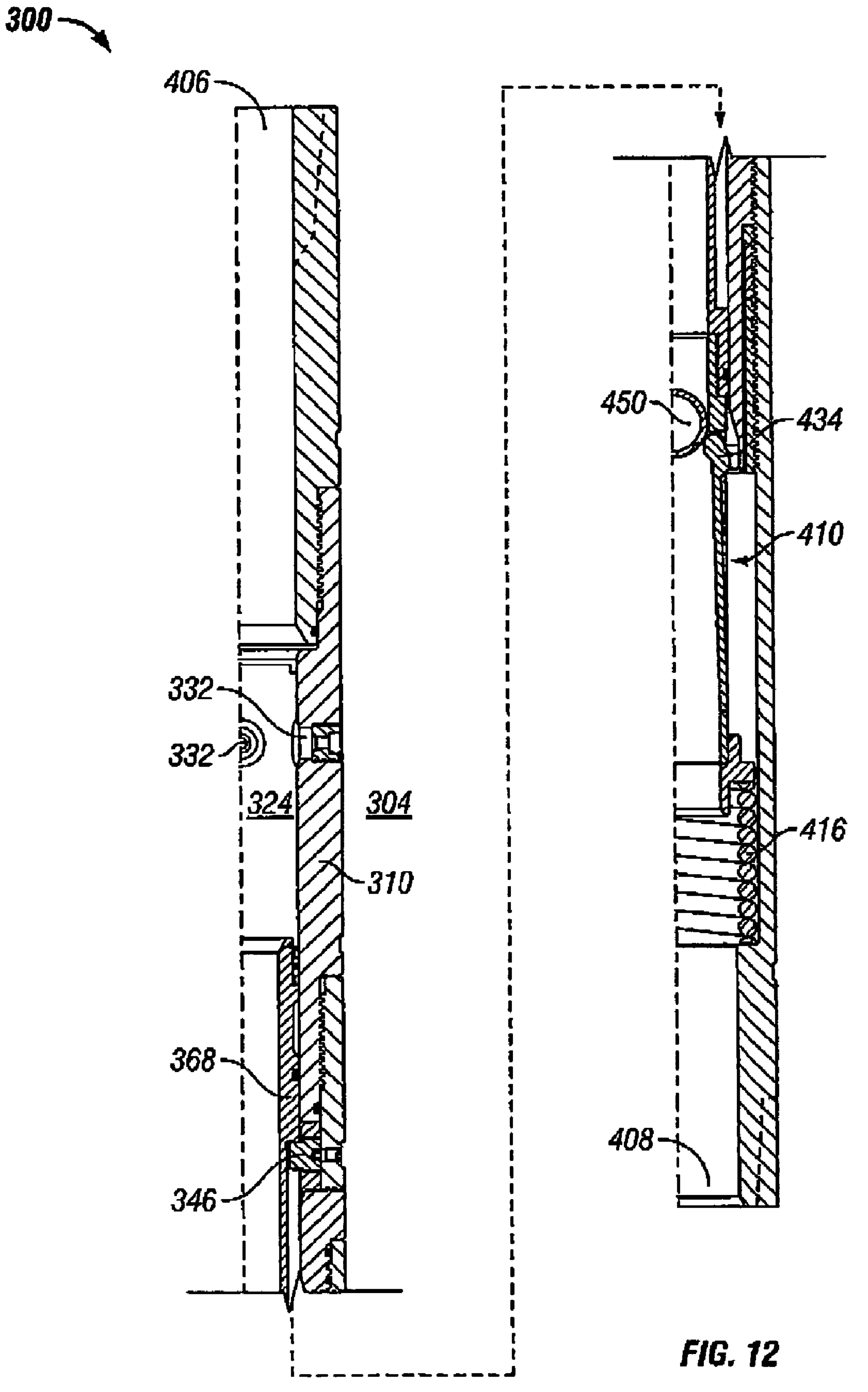

FIG. 12

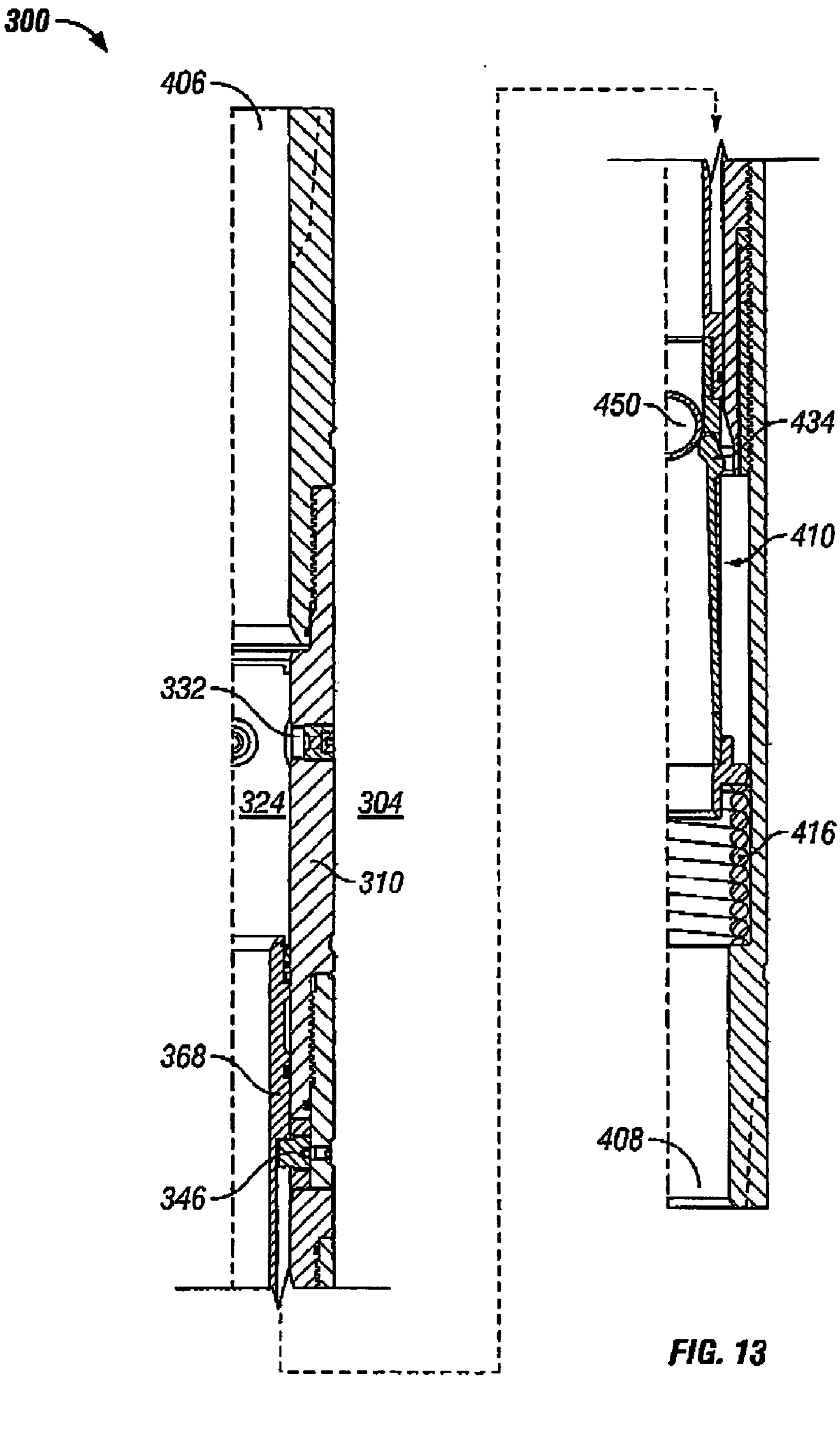

FIG. 13

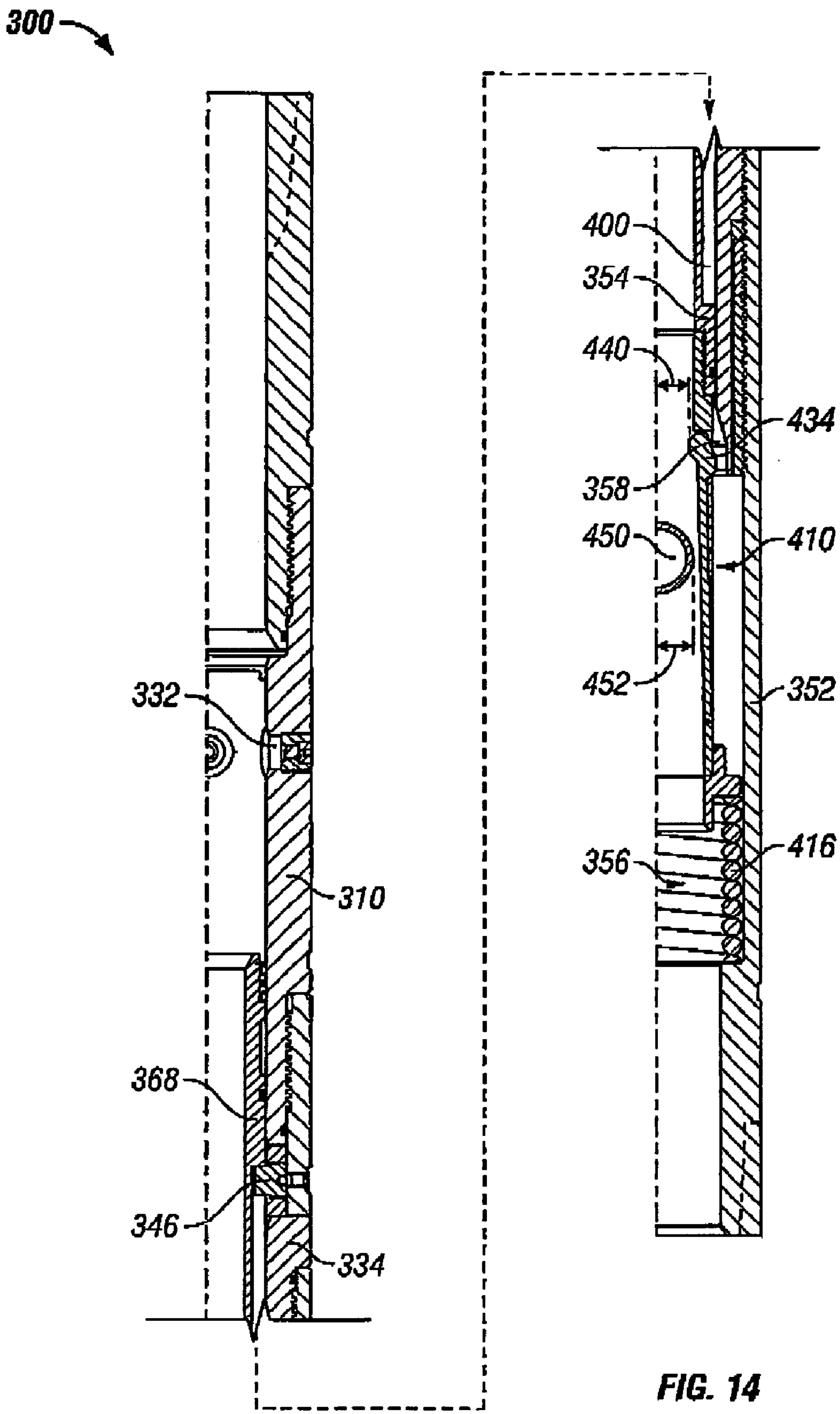
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FIG. 14

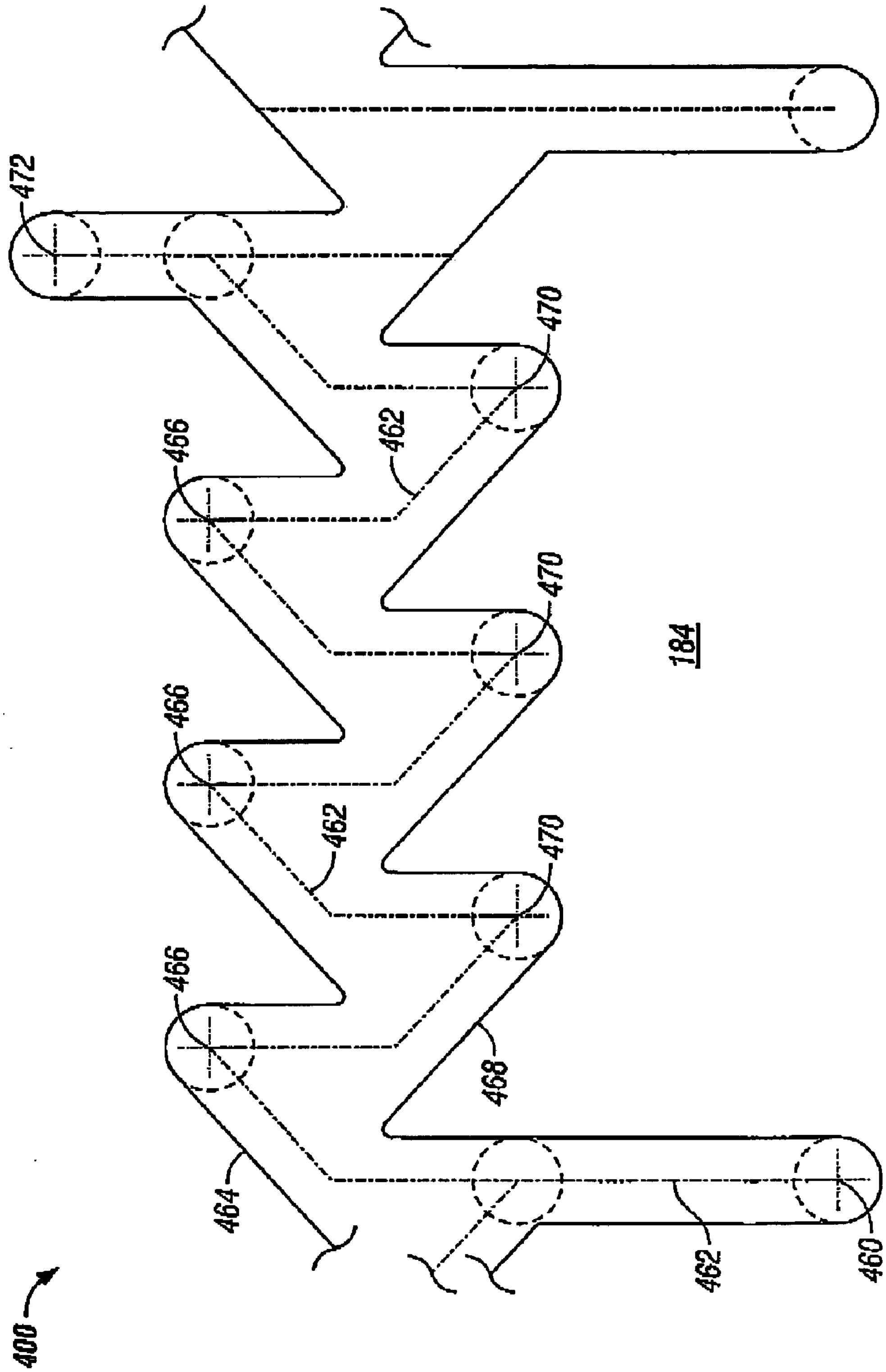

FIG. 15

DOWNHOLE MULTI-ACTION JETTING TOOL

[0001] This application claims priority to Provisional Patent Application 60/695,828 filed on Jun. 30, 2005 and entitled, "Downhole Bypass Valve" the contents of which are incorporated herein by reference for all purposes. New matter has been added.

BACKGROUND OF INVENTION

[0002] A wellbore may be drilled in the earth for various purposes, such as hydrocarbon extraction, geothermal energy, or water. After a wellbore is drilled, the wellore is typically lined with casing. The casing preserves the shape of the wellore as well as provides a sealed conduit for fluid to be transported to the surface.

[0003] In general, it is desirable to maintain a clean wellore to prevent possible complications that may occur from debris in the wellore. For example, accumulation of debris can prevent free movement of tools through the wellore during operations, as well as possibly interfere with production of hydrocarbons or damage tools. Potential debris includes cuttings produced from the drilling of the wellore, metallic debris from the various tools and components used in operations, and corrosion of the casing. Much of this debris may be removed by increasing the annular fluid velocity to bring larger particles to the surface of the wellbore.

[0004] However, over time, the casing or liner within the wellbore becomes covered with hard deposits. These deposits must be periodically removed or they can build up to levels of thickness and hardness where they can adversely affect efficient operation of the oil well.

[0005] Many tools operate continuously through a wellbore, for example scrapers and brushes. While it is useful to have such continuous use tools, it is often beneficial to have tools that are selectively operable when the tool has reached a preferred location in the wellbore.

[0006] Cleaning involves spraying or jetting the inner wall of the casing with cleaning fluid at very high pressure to break up and dislodge the deposited material. A cleaning device having side jetting nozzles is lowered into the wellbore casing on the end of a drill string. Once a section of the wellbore casing has been jet cleaned, the cleaning device is withdrawn from the wellbore casing and removed from the end of the string. The drill string is then returned to the wellbore casing and cleaning fluid is run through the casing to a point below the section of the wellbore casing that was jet cleaned. The cleaning fluid circulates upward through the annulus between the wellbore casing and the drill string, carrying material dislodged during the jetting operation to the top of the wellbore casing. This operation of jetting and flushing is repeated as necessary to clean the wellbore casing of deposited material. Many cleaning and jetting tools use multiple balls to actuate and de-actuate the tool. It would be an improvement to have a cleaning tool that can be actuated and de-actuated without the need to use multiple balls.

SUMMARY

[0007] In one aspect, the disclosed invention relates to an apparatus for cleaning a wellbore casing including an outer housing having an axial through passage between an inlet and a first outlet wherein the inlet and the first outlet are adapted for connection in a work string, the outer housing having a second outlet extending in a direction generally transversely of the through passage, an index mandrel slidably located within the outer housing and having an axial bore extending therethrough, the index mandrel being movable relative to the outer housing between a first position in which the second outlet is closed and a second position in which the second outlet is open, a ball seat located on an upper end of the index mandrel, a spring located within the outer housing and biasing the index mandrel toward the first position, a ball retainable on the ball seat to prevent flow from the inlet to the first outlet, and wherein application of a first pressure on the ball forces the index mandrel against the spring into the second position and reduction of said first pressure permits return of the index mandrel to the second position.

[0008] In another disclosed embodiment of the invention, a method of cleaning an inner surface of a casing in a wellbore includes lowering a jetting tool on a work string into the wellbore to a desired location, wherein the jetting tool has an outer housing with an axial through passage between an inlet and a first outlet, the outer housing also having a second outlet substantially transverse to the axial through passage, and an index housing slidingly retained within the outer housing in a first position such that the second outlet is closed, the index housing having a ball seat on an upper end and being biased toward the first position, dropping a ball into the axial through passage to rest on the ball seat, thereby preventing fluid flow between the inlet and the first outlet of the axial through passage, causing fluid pressure to force the index housing to a second position wherein the second outlet is open, circulating fluid from the axial through passage and the second outlet at a fluid pressure sufficient to clean the casing, decreasing the fluid pressure to return the index housing to the first position, increasing the fluid pressure to move the index housing to a third position wherein the second outlet is closed, and wherein the increased fluid pressure is sufficient to shear the ball from the ball seat, thereby reducing the fluid pressure on the index housing causing it to return to the first position.

[0009] In another embodiment of the disclosed invention, a method of opening and closing an outlet through a side of a cylindrical outer housing of a jetting tool in a wellbore includes biasing the index housing to an upward position within the outer housing in which the index housing is blocking the fluid outlet through the side of the outer housing, dropping a ball to seal against a ball seat located at the upper end of the index housing and block fluid flow through the jetting tool, forcing the index housing to a lower position inside the outer housing as a result of increased pressure behind the ball, wherein the fluid outlet through the side of the outer housing is open, reducing the fluid pressure on the ball to permit the biasing of the index housing towards the upward position, wherein the fluid outlet through the side of the outer housing is closed, and increasing the fluid pressure on the ball to a pressure sufficient to shear the ball through the ball seat, thereby permitting the index housing to return to the upward position.

[0010] Other aspects and advantages of the claimed subject matter will be apparent from the following description and the appended claims.

DESCRIPTION OF THE DRAWINGS

[0011] FIG. **1** is a cross-sectional view of an embodiment of a well cleaning tool.

[0012] FIG. **2** is a front view of an embodiment of a well cleaning tool.

[0013] FIG. **3** is a detail cross sectional view of an embodiment of a well cleaning tool.

[0014] FIG. **4** is a layout of an embodiment of an indexing groove.

[0015] FIG. **5** is a schematic of a well cleaning tool in a first, run-in-hole, position.

[0016] FIG. **6** is a schematic of a well cleaning tool in a second, jetting, position.

[0017] FIG. **7** is a schematic of a well cleaning tool in a third, intermediate, position.

[0018] FIG. **8** is a schematic of a well cleaning tool in a fourth, ball shear, position.

[0019] FIG. **9** is a partial cross sectional view of the downhole bypass valve in a first run in position.

[0020] FIG. **10***a* is a partial cross sectional view of the indexing pin and surrounding components.

[0021] FIG. **10***b* is a partial cross sectional view of a port and a bonded seal member.

[0022] FIG. **10***c* is a partial cross sectional view of a collet assembly.

[0023] FIG. **11** is a partial cross sectional view of the downhole bypass valve in the first position with the ball actuator.

[0024] FIG. **12** is a partial cross sectional view of the downhole bypass valve in a second position.

[0025] FIG. **13** is a partial cross sectional view of the downhole bypass valve in a third position.

[0026] FIG. **14** is a partial cross sectional view of the downhole bypass valve in a fourth position.

[0027] FIG. **15** is a layout of the indexing groove.

DETAILED DESCRIPTION

[0028] Referring to FIGS. **1** and **2**, a downhole jetting tool **100** that may be used to selectively divert fluid that is flowing down the drill string bore **102** to the annulus **104** between the drill string and the casing **106** of a wellbore **108**. The jetting tool **100** includes an outer housing **110** and a spring-loaded index mandrel **168** defining a tubular assembly having an inlet **206** and a first outlet **208**.

[0029] The outer housing **110** defines an axial through passage **124** within which the index housing **168** is located. The outer housing **110** has a top sub **126** provided at a top end **112**, wherein the top sub **126** includes a threaded box **114** to couple to an upper drill string component (not shown). The top sub **126** has one or more radially extending ports **132** extending from the axial through passage **124** to the annulus **104**, collectively defining a second outlet **128**. The top sub **126** is coupled to a swivel housing **116** for the index housing **168** at a lower end **130**. The coupling of the swivel housing **134** and the top sub **126** provides an upper shoulder **138** at the lower end **136** of the top sub **126**. A lower shoulder **140**, formed in the swivel housing **116**, is spaced apart from the upper shoulder **136** to form an inner recess **142** within which a swivel ring **144** is retained. The swivel ring **144** includes at least one indexing pin **146** extending radially into the axial through passage **124** defined by the outer housing **110**. While the swivel ring **144** is axially retained by the upper and lower shoulders **138**, **140**, the swivel ring **144** is not rotationally retained to the outer housing **110**. Thus, the swivel ring **144** may rotate within the confines of the upper and lower shoulders **138**, **140**. Along a middle portion **150** of the swivel housing **116**, a spring housing **152** is coupled thereto. A lower portion **154** of the swivel housing **116** protrudes axially within a through bore **156** defined by the spring housing **152**. The lower portion **154** of the swivel housing **116** is spaced apart from the corresponding portion of the spring housing **152** such that a small gap **162** is created. Within this small gap **162**, a spring sleeve **162** is coupled to the spring housing **152**. As will be explained below, the spring sleeve **164** is included primarily to aid in the assembly and disassembly of the jetting tool **100**. The spring housing **152** is provided with external threads **120** at lower end **118** to coupled to a ball catcher **122** or another lower drill string component (not shown).

[0030] As previously stated, the index housing **168** is located within the outer housing **110**. The index housing **168** includes an indexing mandrel **170** coupled at a lower end **172** to a collet blank **174** to define a mandrel through passage **176**. The through passage **176** has a mandrel bore radius **178**. The indexing mandrel **170** has a ball seat **148** sealingly coupled at a top end **158**. An o-ring **166** may be included to seal the interface between the ball seat **148** and the index mandrel **170**. Other sealing means known in the art may be used. The ball seat **148** includes a lower shoulder **186**, which rests against top end **158**. A frustroconical section **188** at the top of the ball seat **148** provides a guide to direct a ball **250** (the ball **250** and related features are shown in FIGS. **5-8**) through the center of the through passage. A landing section **190** projects generally inward at the bottom **194** of the ball seat **148**. The landing section **190** projects inward a sufficient distance and angle to seat the ball **250** as will be described. The radius **240** of the landing section **190** is thus smaller than the ball radius **252**. A seal member **180** is located above a shoulder formation **182** in the outer surface **184** of the indexing mandrel **170** and below the lower shoulder **186** of the ball seat **148**. Below the shoulder formation **182**, a recess **202** is formed in the outer surface **184** of the indexing mandrel **170**. An o-ring **204** or other sealing member seals the interface between the outer surface **184** of the indexing mandrel **170** and the inner surface **192** of the top sub **126** below the recess **202**.

[0031] An indexing groove **200** is formed into the outer surface **184** of the indexing mandrel **170** between the o-ring **204** and a lower end **172** of the indexing mandrel **170**. The indexing pin **146**, coupled to the outer housing **110**, is positioned within the indexing groove **200**. The function of the indexing groove **200** and the indexing pin **146** is described in greater detail below.

[0032] A spring assembly **210** includes the collet blank **174**, a spring follower **214** and a spring **216**. As was previously described, the collet blank **174** couples to the index mandrel **170**. The spring **216** is located within the through passage **156** defined by the spring housing **152**. A shoulder formation **218** in the inner surface **220** of the spring housing **152** near the lower end **118** provides support to a lower end **222** of the spring **216**. The spring follower **214** has a lower shoulder **224** that is seated atop an upper end **226** of the spring **216**. The collet blank **174** has a lower end **228** that is seated atop an inner shoulder **230** of the spring follower **214** such that the lower end **228** of the collet blank **174** is within the spring follower **214**.

[**0033**] The ball **250** will be used to actuate the jetting tool **100**. The ball **250** will be dropped from the top of the work string and allowed to float downward through the fluid in the axial through passage **124** until it reaches the ball seat **148**. Thus, the ball **250** is formed from a material having a specific gravity greater than fluid though which it will be dropped. Further, the ball **250** must be made from a material that will not be degraded by the chemical composition of the fluid in axial though passage **102**. Also, when the jetting tool **100** no longer needs to be cycled, the ball **250** can be sheared through the ball seat **148** by increasing the fluid pressure through the axial through passage **102**. Thus, the ball **250** is also formed from a material that will deform under a predetermined minimum pressure. For example, in one embodiment, the ball is made from a thermoplastic polyester based on polyethylene terephthalate, such as ERTALYTE (™).

[**0034**] When the jetting tool **100** is assembled, the spring **216** is lowered into the spring housing **152** and the spring follower **214** is placed atop the spring **216**. The swivel housing **116** couples to the spring housing **152**. However, the length of the spring **216** when loaded only with the spring follower **214** would extend beyond the lower end **160** of the lower portion **154** of the swivel housing **134** when the swivel housing **116** is coupled to the spring housing **152**. Instead of loading the spring **216** with the swivel housing **116** while coupling to the spring housing **152**, the spring sleeve **164** is coupled to the spring housing **152** to preload the spring **216**, through the spring follower **214**, against a lower shoulder **166**. The smaller size of the spring sleeve **164** makes it easier to couple to the spring housing **152** while simultaneously preloading the spring **216**. The larger swivel housing **134** may then be simply coupled to the spring housing **152**. When disassembling the jetting tool **100**, the spring sleeve **164** retains the spring **162** and spring follower **214** within the spring housing **152** while the swivel housing **116** is removed.

[**0035**] In one embodiment a jetting housing **196** is provided around the bypass valve **100**. The jetting housing **196** displaces annular space when the bypass valve **100** is to be used in a bore, such as that of a riser, having a sufficiently large inner diameter that annular fluid velocity would be lost if the jetting tool **100** were used without the jetting housing **196**. By reducing the annular area, fluid velocity through the second outlet **132** into the annulus **104** may be maintained at a rate that is effective for removing debris or circulating fluid. Jetting housings **196** having different outer diameters may be available and the choice of size is typically based upon the diameter of the casing to be cleaned. Referring to FIGS. **2** and **3**, the jetting housing **196** includes a plurality of jetting ports **198**. When the second outlet **128** is open, the jetting ports **198** focus a stream of fluid toward the casing **106** of the wellbore **108** in a direction substantially perpendicular to the axial through passage **124**. As the fluid exits the jetting ports **198**, the direction of the stream of fluid will be affected by fluid circulation in the annulus **104** fluid pressure in the annulus **104**, as well as the geometry of the jetting port exits. While the fluid is directed toward the casing **106**, it will be appreciated by a person of skill in the art that the fluid direction will not be precisely pointed at a point on the casing, but rather a general area of the casing **106**. In one embodiment, the jetting housing **196** includes a plurality of tangent jetting ports **212**, as can be seen in FIG. **3**. Tangent jetting ports **212** direct fluid flow in a direction substantially tangent to the flow of fluid out of the jetting ports **198**. As with the jetting ports **198**, fluid flow out of the tangent jetting ports **212** is affected by a variety of factors including fluid circulation in the annulus **104** fluid pressure in the annulus **104**, as well as the geometry of the tangent jetting port exits. In one embodiment, the jetting housing **196** is rotationally retained on the outer housing **110**. In one embodiment, tangent jetting ports **212** rotate the jetting housing **196** about the outer housing **110**.

[**0036**] When lowered downhole on the drill string, the jetting tool **100** is in a first position, as depicted in FIGS. **1** and **5**. In this position, the recess **202** of the indexing mandrel **170** is positioned inside the second outlet **128**. As depicted in FIG. **1**, the seal ring **180** is located above the second outlet **128** while the o-ring **204** is positioned below the second outlet **128** to prevent fluid communication between the through passage **176** and the annulus **104**. Returning to FIGS. **1** and **5**, fluid may continue to flow through the through passage **176** defined by the index housing **168** and the through passage **156** defined by the spring housing **152**.

[**0037**] Referring to FIG. **6**, when it is desired to actuate the jetting tool **100**, a ball **250** is dropped through the drill string and circulated until it reaches the jetting tool **100**. The ball **250** has a ball radius **252**, which is less than the outer housing radius **232** and greater than the landing section radius **240**, thus permitting the ball **250** to continue to circulate through the jetting tool **100** until it comes to rest atop the landing section **190**. The ball **250** prevents further fluid flow through the bore **238**, **156** of the index housing **168**, spring **216**, and spring housing **152**. As the fluid pressure is increased, the ball seat **148** and index housing **168** are pushed downward against the upward force of the spring **216**. The indexing groove **200** on the indexing mandrel **170** interfaces with the indexing pin **146** to direct the position of the indexing mandrel **170** within the outer housing **110**.

[**0038**] The indexing groove path **262** is depicted in FIG. **4**. When the jetting tool **100** is in the first position, the indexing pin **146** is located in a first groove location **260**. Referring to FIG. **6**, after the ball **250** is seated on the ball seat **148**, fluid pressure is increased until the ball seat **148** and indexing mandrel **170** are driven downward against the force of the spring **216**. As the indexing mandrel **170** moves downward within the outer housing **110**, the indexing pin **146** follows the indexing groove path **262** until it has reached a first groove wall **264**. Upon contacting the first groove wall **264**, the indexing pin **146** continues a path parallel to the first groove wall **264** until it has shouldered against second groove location **266**. The outer housing **110** is rotationally fixed by the drill string. The swivel ring **144** is rotated within the outer housing **110** as the indexing pin **146** follows the indexing groove path **262**. When the indexing pin **146** is shouldered against the second groove location **266**, the jetting tool **100** is in a corresponding second position, shown in FIG. **6**.

[**0039**] In the second position, the ball **250** remains seated atop the landing section **190** of the ball seat **148**. The indexing mandrel **170** and ball seat **148** have moved a sufficient distance downward to open the second outlet **128**, providing fluid communication from the through passage **124** to the annulus **104**. So long as the fluid flow remains sufficient to provide pressure to the ball **250** and the index housing **168** to overcome the upward force of the spring **216**, the jetting tool **100** will remain in the second position.

[**0040**] Referring to FIGS. **6** and **7**, when the flow drops to below a predetermined flow rate corresponding to a predetermined fluid pressure, the spring **216** will push the index housing **168** upward. The indexing pin **146** continues to follow the indexing groove path **262** and contacts a second groove wall **268**. The indexing pin **146** follows the incline of the second groove wall **268** to position the indexing mandrel **170** within the outer housing **110**. The indexing mandrel **170** continues to move upward until the indexing pin **146** shoulders against a third groove location **270**. When the indexing pin **146** is in the third groove location **270**, the jetting tool **100** is in a corresponding third position, shown in FIG. **7**.

[**0041**] In the third position, the ball **250** remains seated atop the landing section **190** of the ball seat **148**. The second outlet **128** is closed, resulting in no fluid communication from the through passage **124** to the annulus **104** and no flow through the through passage **124** to the first outlet **208**.

[**0042**] The fluid pressure may be increased to cycle the indexing mandrel **170** to a fourth position, in which the indexing pin **146** is shouldered against a fourth groove location **272** longitudinally located along the indexing mandrel **170** between the second groove location **266** and the third groove location **270**. So long as the fluid pressure does not exceed a predetermined pressure sufficient to deform the ball **250**, decreasing the fluid pressure again will return the indexing mandrel **168** to the third position, wherein the indexing pin **146** is shouldered against another third groove location **270**. Increasing pressure when the ball **250** is in the third position for the second time will return the indexing mandrel **170** to a second position in which the second outlet **128** is open. This cycle may be continued until the indexing pin **146** has traversed the indexing groove path **262** any number of times.

[**0043**] When the jetting operation is completed, the jetting tool **100** is cycled by increasing and decreasing fluid pressure on the ball **250** until the indexing pin **146** is again in the fourth groove location **272**. The pressure may then be increased to a predetermined pressure sufficient to shear the ball **250** through the bottom **194** of the ball seat **148**, as shown in FIG. **8**. The ball **250** is then forced downward through the through passage **238** of the index housing **168** and the through passage **156** of the spring housing **152**. The ball **250** is caught in a downstream ball catcher **122**. When the ball **250** is released from the ball seat **148**, the fluid pressure counteracting the spring force is relieved and the spring **216** pushes the index housing **168** and the ball seat **148** upward. The indexing groove **200** and pin **146** interact to reposition the indexing mandrel **170** in the first position in which the second outlet **128** is closed and from which the entire process may be performed again.

[**0044**] Referring to FIG. **1**, the ball catcher **122** includes a ball catcher sub **234** within which a ball catcher tube **236** is retained. A trap finger **238** is provided near the top end **242** of the ball catcher tube **236**. The top end **242** of the ball catcher tube **236** may be provided with slots **276**. The trap finger **238** is pivotally retained to the ball catcher tube **236** near the top end **242** along a pivot edge **244**. A torsion spring **246** biases the trap finger **238** toward a "closed" position. As shown in FIG. **1**, a free edge **248** is rotatable within the ball catcher sub **234**. The trap finger **238** has a length **254** such that the trap finger **238** free edge **248** can travel through slot **276** and is caught on an edge of the slot **276** before opening in an upward position. A stopper **178** may be included near the free edge **248** to aid in catching the slot edge before over-traveling. When the ball **250** is discharged from the ball seat **148**, the ball **250** pushes the free edge **248** downward and enters the ball tube **236**. Once the ball **250** has cleared the trap finger **238**, the torsion spring **246** moves the trap finger **238** back to the closed position.

[**0045**] The ball catcher tube **236** has an outer diameter less than the inner diameter of the ball catcher sub **234**, defining a ball catcher annulus **274**. The ball catcher tube **236** is also provided with a number of holes **258** though the wall of the tube **236** providing fluid communication from the though passage of the ball catcher tube **236** to the ball catcher annulus **274**. If reverse circulation is desired, the holes **258** and ball catcher annulus **274** allow fluid flow around any balls **250** retained in the ball catcher tube **236** and to the tools above the ball catcher **122**. Any balls **150** in the ball catcher tube **236** that are forced upward by the reverse circulation are retained by the trap finger **238**. Any force on the trap finger **238** by retained balls **250** will reinforce the force of the torsion spring **246** in pushing the free edge **248** against the slot edge of the ball catcher tube **236**, thereby preventing the loss of balls **250** from the ball catcher **122**. The ball catcher tube **236** may be sized to accommodate any number of balls **250**. For example, in one embodiment, the ball catcher tube **126** holds six balls **250**.

[**0046**] The jetting tool **100** can be used to clean the inner surface of a casing and/or a blowout preventor (BOP). To perform a cleaning operation, the jetting tool **100** is assembled on a work string and lowered into the wellbore **108** to a location to be cleaned. The index housing **168** is in a first position relative to the outer housing **110**, as shown in FIG. **5**, and the second outlet **128** through the outer housing **110** is closed off by the index housing **168**. The ball **250** is dropped into the axial through passage **102** of the work string and is circulated through the work string until the it reaches the ball seat **148** of the jetting tool **100**. When the ball **150** reaches the ball seat **128**, it is directed to a landing section **190** where it prevents fluid from flowing through the index housing **168** and spring housing **152** as well as the lower work string tools (not shown). Fluid continues to be pumped at a predetermined rate into the through passage **102** of the work string, thereby applying pressure to the ball **250**. This pressure works against the upward force of the spring **216**. As the pressure on the ball **250** increases, the index housing **168** is lowered relative to the outer housing **110** until the index housing **168** reaches a second position, shown in FIG. **6**. When the index housing **168** is in the second position, the second outlet **128** through the outer housing **110** is open. The fluid that is being pumped into the axial through passage is then directed through the second outlet **128** and the jetting ports **198** at a pressure sufficient to clean the casing and/or BOP. The jetting tool **100** may be rotated by rotating the work string to direct fluid flow from the jetting ports **198** at a circumferential area of the casing or BOP. The jetting tool **100** may be raised and/or lowered by raising and/or lowering the work string to direct flow from the jetting ports **198** at a longitudinal area of the casing or BOP. As previously discussed, the jetting housing **196** may be rotationally retained on the outer housing **110** and tangential jetting ports **212** utilized to rotate the jetting housing **196** to clean a circumferential area of the casing and/or BOP.

[0047] When a location of the casing and/or BOP has been cleaned, fluid pressure through the axial through passage **124** may be reduced. As the pressure is reduced to a pressure insufficient to overcome the spring force, the spring **216** pushes the index housing **168** upward relative to the outer housing **110** to a third position, shown in FIG. **7**. The second outlet **128** through the outer housing **110** is closed when the index housing **168** is in the third position.

[0048] The pressure may be increased again to a predetermined pressure that is sufficient to overcome the spring force but that is insufficient to deform the ball **250**. This drives the index housing **168** to a fourth position. From the fourth position, the fluid pressure may be decreased again so that the spring **216** forces the index housing **168** into another first position. Increasing the pressure from this third position will force the index housing **168** into another second position in which the second outlet **128** is again open and additional cleaning activities may be performed. If such additional cleaning activities are not desired, from the fourth position, the fluid pressure may be increased by an additional amount sufficient to shear the ball **250** from the ball seat **148**. When the ball **250** has been sheared from the ball seat **148**, the spring **216** will force the index housing **168** into another first position and the jetting tool may be re-actuated by dropping another ball **250**. The sheared ball **250** is circulated through the remainder of the jetting tool **100** and is caught by the ball catcher **122**. As previously discussed, if recirculation of the fluid is desired, the ball catcher **122** will retain any sheared balls **250** previously caught in the ball catcher **122**.

[0049] Referring to FIG. **9**, in another embodiment, a downhole bypass valve **300** is used to selectively divert fluid that is flowing down the drill string bore **302** to the annulus **304** between the drill string and the casing **306** of a wellbore **308**. The bypass valve **300** includes an outer housing **310**, a spring-loaded mandrel **368**, and a cantilever-type ball seat collet assembly **410** defining a tubular assembly having an inlet **406** and a first outlet **408**.

[0050] The outer housing **310** defines an outer housing through bore **324** within which the spring-loaded mandrel **368** and the collet assembly **410** are located. The outer housing **310** has a top sub **326** provided at a top end **312**, wherein the top sub **326** includes a threaded box **314** to couple to an upper drill string component **316**. The top sub **326** is coupled to a ported seal housing **328** at a lower end **330**. The ported seal housing **328** has one or more radially extending ports **332** extending from the outer housing through bore **324** to the annulus **304**, defining a second outlet. A swivel housing **334** is coupled to a lower end **336** of the ported seal housing **328**. As shown more clearly in FIG. **10***a*, the coupling of the swivel housing **334** and the ported seal housing **328** provides an upper shoulder **338** at the lower end **336** of the ported seal housing **328**. A lower shoulder **340**, formed in the swivel housing **334**, is spaced apart from the upper shoulder **336** to form an inner recess **342** within which a swivel ring **344** is retained. The swivel ring **344** includes at least one indexing pin **346** extending radially into the through bore **324** defined by the outer housing **310**. While the swivel ring **344** is axially retained by the upper and lower shoulders **338**, **340**, the swivel ring **344** is not rotationally retained to the outer housing **310**. Thus, the swivel ring **344** may rotate within the confines of the upper and lower shoulders **338**, **340**. Returning to FIG. **9**, along a middle portion **350** of the swivel housing **334**, a spring housing **352** is coupled thereto. As shown more clearly in FIG. **10***c*, a lower portion **354** of the swivel housing **334** protrudes axially within a through bore **356** defined by the spring housing **352** and has a recess formation **358** in an inner surface **359** at its lower end **360**. The lower portion **354** of the swivel housing **334** is spaced apart from the corresponding portion of the spring housing **352** such that a small gap **362** is created. Within this small gap **362**, a spring sleeve **362** is coupled to the spring housing **352**. As will be explained below, the spring sleeve **364** is included primarily to aid in the assembly and disassembly of the bypass valve **300**. Returning again to FIG. **9**, the spring housing **352** is provided with external threads **320** at lower end **318** to couple to a lower drill string component **322**.

[0051] As previously stated, the spring-loaded mandrel **368** is located within the outer housing **310**. The spring-loaded mandrel **368** includes an indexing mandrel **370** coupled at a lower end **372** to a shoulder sub **374** to define a mandrel through bore **376**. As shown in FIG. **10***b*, the through bore **376** has a mandrel bore radius **378**. A bonded seal member **380** is located above a shoulder formation **382** in the outer surface **384** of the indexing mandrel **370**. A retaining ring **386** may be secured to the indexing mandrel **370** such that it is spaced apart from the shoulder formation **382** to maintain the bonded seal member **380** in a position near the upper end **387** of the indexing mandrel **370**. The bonded seal member **380** includes a pair of resilient outer seals **388**, **390**, which seal the interface between the inner surface **392** of the ported seal housing **328** and the outer surface **394** of the bonded seal member **380**. An o-ring **396** seals the interface between an inner surface **398** of the bonded seal member **380** and the outer surface **384** of the indexing mandrel **370**. Below the shoulder formation **382**, a recess **402** is formed in the outer surface **384** of the indexing mandrel **370**. An o-ring **404** seals the interface between the outer surface **384** of the indexing mandrel **370** and the inner surface **392** of the ported seal housing **328** below the recess **402**. Returning to FIG. **9**, an indexing groove **400** is formed into the outer surface **384** of the indexing mandrel **370** between the o-ring **404** and a lower end **372** of the indexing mandrel **370**. The indexing pin **346**, coupled to the outer housing **310**, is positioned within the indexing groove **400**. The function of the indexing groove **400** and the indexing pin **346** is described in greater detail below.

[0052] The ball seat collet assembly **410** includes a collet member **412**, a spring follower **414** and a spring **416**. As will be described, the collet assembly **410** has limited axial mobility within the through bore **324** of the outer housing **310**. The spring **416** is located within the through bore **356** defined by the spring housing **352**. A shoulder formation **418** in the inner surface **420** of the spring housing **352** near the lower end **318** provides support to a lower end **422** of the spring **416**. As can be seen more clearly in FIG. **10***c*, the spring follower **414** has a lower shoulder **424** that is seated atop an upper end **426** of the spring **416**. The collet member **412** has a lower end **428** that is seated atop an upper shoulder **430** of the spring follower **414**. From the collet member lower end **428**, several cantilevered collet arms **432** extend upward. A collet head **434** is located at an upper end **436** of each collet arm **432**. In the position shown in FIG. **9**, each collet head **434** is biased outward by the corresponding cantilevered collet arm **432** to contact the inner surface **359** of the lower portion **354** of the swivel housing **334**. The collet heads **434** form a collet through bore **438** having a collet inner radius **440**.

[**0053**] When the bypass valve **300** is assembled, the spring **416** is lowered into the spring housing **352** and the spring follower **414** is placed atop the spring **416**. The swivel housing **334** couples to the spring housing **352**. However, the length of the spring **416** when loaded only with the spring follower **414** would extend beyond the lower end **360** of the lower portion **354** of the swivel housing **334** when the swivel housing **334** is coupled to the spring housing **352**. Instead of loading the spring **416** with the swivel housing **334** while coupling to the spring housing **352**, the spring sleeve **364** is coupled to the spring housing **352** to preload the spring **416**, through the spring follower **414**, against a lower shoulder **366**. The smaller size of the spring sleeve **364** makes it easier to couple to the spring housing **352** while simultaneously preloading the spring **416**. The larger swivel housing **334** may then be simply coupled to the spring housing **352**. When disassembling the bypass valve **300**, the spring sleeve **364** retains the spring **362** and spring follower **414** within the spring housing **352** while the swivel housing **334** is removed.

[**0054**] In an alternative embodiment a jetting housing (not shown) may be provided around the bypass valve **300**. The jetting housing displaces annular space when the bypass valve **300** is to be used in a bore, such as that of a riser, having a sufficiently large inner diameter that annular fluid velocity would be lost if the bypass valve **300** were used alone. By reducing the annular area, fluid velocity through the ports **332** into the annulus **304** may be maintained at a rate that is effective for removing debris or circulating fluid.

[**0055**] When lowered downhole on the drill string, the bypass valve **300** is in a first position, as depicted in FIG. **9**. In this position, the recess **402** of the indexing mandrel **370** is positioned inside the ports **332**. As depicted in FIG. **10***c*, the outer seals **388**, **390** of the bonded seal ring **380** are located above the ports **332** while the o-ring **404** is positioned below the ports **332** to prevent fluid communication between the through bore **376** and the annulus **304**. Returning to FIG. **9**, fluid may continue to flow through the through bore **376** defined by the spring loaded mandrel **368** and the through bore **356** defined by the spring housing **352**. In the first position, the collet inner radius **440** is slightly smaller than the mandrel radius **378** (shown in FIGS. **10***c* and **10***b*, respectfully).

[**0056**] Referring to FIG. **11**, when it is desired to actuate the bypass valve **300**, a ball **450** is dropped through the drill string and circulated until it reaches the bypass valve **300**. The ball **450** has a ball radius **452**, which is less than the mandrel bore radius **378** and greater than the collet inner radius **440**, thus permitting the ball **450** to continue to circulate through the bypass valve **300** until it comes to rest atop the collet heads **434** of the collet assembly **410**. The ball **450** prevents further fluid flow through the bore **438**, **456** of the collet assembly **410**, spring **416**, and spring housing **352**. As the fluid pressure is increased, the collet assembly **410** is pushed downward against the upward force of the spring **416**. The increased fluid pressure within the axial through bore **376** and the lower pressure outside of the mandrel **368** causes the spring loaded mandrel **368** to move downward as well. The indexing groove **400** on the indexing mandrel **370** interfaces with the indexing pin **346** to direct the position of the spring loaded mandrel **368** within the outer housing **310**.

[**0057**] The indexing groove path **462** is depicted in FIG. **15**. When the bypass valve **300** is in the first position, the indexing pin **346** is located in a first groove location **460**. Referring to FIGS. **12** and **15**, after the ball **450** is seated on the collet heads **434**, fluid pressure is increased until the collet assembly **410** is driven downward against the force of the spring **416**. The spring loaded mandrel **368** is also pushed downward by the increased fluid pressure within the axial bore **376**. As the spring loaded mandrel **368** moves downward within the outer housing **310**, the indexing pin **346** follows the indexing groove path **462** until it has reached a first groove wall **464**. Upon contacting the first groove wall **464**, the indexing pin **346** continues a path parallel to the first groove wall **464** until it has shouldered against second groove location **466**. The outer housing **310** is rotationally fixed by the drill string. The spring loaded mandrel **368** is rotated within the outer housing **310** as the indexing pin **346** follows the indexing groove path **462**. When the indexing pin **346** is shouldered against the second groove location **466**, the bypass valve **300** is in a corresponding second position, shown in FIG. **12**.

[**0058**] In the second position, the ball **450** remains seated atop the collet heads **434**. The spring loaded mandrel **368** has moved a sufficient distance downward to open the ports **332**, providing fluid communication from the through bore **324** to the annulus **304**. So long as the fluid flow remains sufficient to provide pressure to the ball **450** and the collet assembly **410** to overcome the upward force of the spring **416**, the bypass valve **300** will remain in the second position.

[**0059**] Referring to FIGS. **13** and **15**, when the flow drops to below a predetermined flow rate corresponding to a predetermined fluid pressure, the spring **416** will push the collet assembly **410** upward. The collet assembly **410** in turn pushes the spring loaded mandrel **368** upward. The indexing pin **346** continues to follow the indexing groove path **462** and contacts a second groove wall **468**. The indexing pin **346** follows the incline of the second groove wall **468** to rotate the spring loaded mandrel **368** within the outer housing **310** as it continues to move upward until the indexing pin **346** shoulders against a third groove location **470**. When the indexing pin **346** is in the third groove location **470**, the bypass valve **300** is in a corresponding third position, shown in FIG. **13**.

[**0060**] In the third position, the ball **450** remains seated atop the collet heads **434**. The ports **332** remain open, providing fluid communication from the through bore **324** to the annulus **304**. In this position, the fluid can be reverse circulated at any desired rate. Circulation can be maintained up to a predetermined rate at which the fluid pressure would overcome the spring force once again. In the third position, multiple batches of various fluids can be circulated, depending upon the viscosity and density of the fluids, so long as the predetermined rate is not exceeded.

[0061] The fluid pressure may be increased to cycle the spring loaded mandrel **368** to the second position, in which the indexing pin **346** is shouldered against another second groove location **466**. Decreasing the fluid pressure again will return the spring loaded mandrel **368** to the third position, wherein the indexing pin **346** is shouldered against another third groove location **470**. This cycle may be continued until the indexing pin **346** has traversed the indexing groove path **462** to shoulder against a final third groove location **470**, corresponding to the third position.

[0062] Referring to FIGS. **14** and **15**, to close the bypass valve **300**, the fluid pressure may be increased when the indexing pin **346** is shouldered against the final third groove location **470**. As previously described, as the fluid pressure is increased, the collet assembly **410** and mandrel **368** are driven downward against the force of the spring **416**. This time, however, the indexing pin **346** is directed along the indexing groove path **462** until it shoulders against a final groove location **472**. The final groove location **472** corresponds to a fourth position of the spring loaded mandrel **368** that is farther downhole, relative to the outer housing **310**, than in the first, second, or third positions. In the fourth position, the collet assembly **410** is driven downward against the force of the spring **416** until the collet heads **434** are received into corresponding recess formations **358** in the lower portion **354** of the swivel housing **334**. Once the collet heads **434** spring outward into the recess formations **358**, the collet inner radius **440** is enlarged such that it is larger than the ball radius **452**. The ball **450** is then forced downward through the bore **438** of the collet assembly **310** and the bore **356** of the spring housing **352**. The ball **450** will be caught in a downstream ball catcher (not shown). When the ball **450** is released from the collet heads **434**, the fluid pressure counteracting the spring force is relieved and the spring **416** pushes the collet assembly **410** upward. The collet assembly **410** in turn pushes the spring loaded mandrel **368** upward. The indexing groove **400** and pin **346** interact to reposition the spring-loaded mandrel **368** in the first position in which the ports **332** are closed and from which the entire process may be performed again.

[0063] While the claimed subject matter has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the claimed subject matter as disclosed herein. Accordingly, the scope of the claimed subject matter should be limited only by the attached claims.

What is claimed is:

1. An apparatus for cleaning a wellbore casing comprising:

an outer housing having an axial through passage between an inlet and a first outlet wherein the inlet and the first outlet are adapted for connection in a work string, the outer housing having a second outlet extending in a direction generally transversely of the through passage;

an index mandrel slidably located within the outer housing and having an axial bore extending therethrough, the index mandrel being movable relative to the outer housing between a first position in which the second outlet is closed and a second position in which the second outlet is open;

a ball seat located on an upper end of the index mandrel;

a spring located within the outer housing and biasing the index mandrel toward the first position;

a ball retainable on the ball seat to prevent flow from the inlet to the first outlet; and

wherein application of a first pressure on the ball forces the index mandrel against the spring into the second position and reduction of said first pressure permits return of the index mandrel to the second position.

2. The apparatus of claim 1, further comprising:

an indexing pin retained on an inner surface of the outer housing;

wherein the index mandrel has an indexing groove in an outer surface; and

wherein the indexing pin cooperates with the indexing groove to position the index mandrel in the first position and the second position.

3. The apparatus of claim 2, wherein the index mandrel has a third position, between the first position and the second position, in which the second outlet is closed.

4. The apparatus of claim 1, further comprising:

a jet housing around the outer housing, the jet housing including a plurality of nozzles in fluid communication with the second outlet and positioned to direct fluid received from the second outlet in a direction substantially perpendicular to the axial through passage.

5. The apparatus of claim 4, wherein the jet housing further comprises:

a plurality of nozzles in fluid communication with the second outlet and positioned to direct fluid received from the second outlet in a direction substantially tangent to the jet housing.

6. The apparatus of claim 5, wherein the jet housing is rotatable about the outer housing.

7. The apparatus of claim 1, wherein the ball is deformable to be pushed through the ball seat and discharged through the first outlet.

8. The apparatus of claim 1, further comprising:

a ball catcher sub positioned below the outer housing, the ball catcher sub comprising:

a ball catcher housing having a ball catcher axial through passage between a ball catcher inlet and a ball catcher outlet wherein the ball catcher inlet and the ball catcher outlet are adapted for connection in a work string;

a trap finger pivotally retained within the ball catcher housing, wherein the trap finger is pivotable to receive the ball when discharged from the first outlet;

a ball catcher tube retained within the ball housing and having a length and an inner diameter sufficient to hold a plurality of balls; and wherein an annulus is formed between the ball catcher tube and the ball catcher housing sufficient for fluid to be communicated through the ball catcher sub.

9. The apparatus of claim 8, wherein the trap finger pivots downward to receive the ball within the ball catcher tube and cannot pivot upwards, thereby preventing the ball from escaping the ball catcher tube when fluid is reverse circulated through the axial through passage.

10. The apparatus of claim 8, wherein the ball catcher tube has a plurality of holes therein to communicate fluid from the ball catcher tube to the annulus.

11. A method of cleaning an inner surface of a casing in a wellbore comprising:

lowering a jetting tool on a work string into the wellbore to a desired location, wherein the jetting tool has an outer housing with an axial through passage between an inlet and a first outlet, the outer housing also having a second outlet substantially transverse to the axial through passage, and an index housing slidingly retained within the outer housing in a first position such that the second outlet is closed, the index housing having a ball seat on an upper end and being biased toward the first position;

dropping a ball into the axial through passage to rest on the ball seat, thereby preventing fluid flow between the inlet and the first outlet of the axial through passage, causing fluid pressure to force the index housing to a second position wherein the second outlet is open;

circulating fluid from the axial through passage and the second outlet at a fluid pressure sufficient to clean the casing;

decreasing the fluid pressure to return the index housing to the first position;

increasing the fluid pressure to move the index housing to a third position wherein the second outlet is closed; and

wherein the increased fluid pressure is sufficient to shear the ball from the ball seat, thereby reducing the fluid pressure on the index housing causing it to return to the first position.

12. The method of claim 11, further comprising:

rotating the jetting tool while circulating the fluid to direct the circulating fluid circumferentially around the inner surface of the casing.

13. The method of claim 12, further comprising:

raising and lowering the jetting tool in the wellbore while circulating the fluid to clean a longitudinal area of the inner surface of the casing.

14. The method of claim 13, further comprising:

positioning the jetting tool within the blowout preventor; and

circulating the fluid from the axial through passage and the second outlet at a fluid pressure sufficient to clean the blowout preventor.

15. The method of claim 11, further comprising:

catching the ball in a ball catcher located below the index housing.

16. The method of claim 15, further comprising:

reverse circulating the fluid through the axial through passage; and

retaining the ball in the ball catcher with a trap finger during reverse circulation.

17. A method of opening and closing an outlet through a side of a cylindrical outer housing of a jetting tool in a wellbore, the method comprising:

biasing the index housing to an upward position within the outer housing in which the index housing is blocking the fluid outlet through the side of the outer housing;

dropping a ball to seal against a ball seat located at the upper end of the index housing and block fluid flow through the jetting tool;

forcing the index housing to a lower position inside the outer housing as a result of increased pressure behind the ball, wherein the fluid outlet through the side of the outer housing is open;

reducing the fluid pressure on the ball to permit the biasing of the index housing towards the upward position, wherein the fluid outlet through the side of the outer housing is closed; and

increasing the fluid pressure on the ball to a pressure sufficient to shear the ball through the ball seat, thereby permitting the index housing to return to the upward position.

18. The method of claim 17, wherein the fluid pressure is increased and decreased a quantity of times to open and close the fluid outlet through the side of the outer housing before increasing the fluid pressure sufficient to shear the ball.

19. The method of claim 18, further comprising:

dropping a second ball after shearing the first ball to seal against the ball seat and block fluid flow through the jetting tool;

repeating the forcing, repeating, and increasing steps.

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