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George et al.

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(54) **DOWNHOLE EXTENDING PORTS**

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E21B 34/14 (2006.01)
E21B 43/26 (2006.01)
E21B 34/00 (2006.01)

(52) **U.S. Cl.**
CPC ***E21B 34/14*** (2013.01); ***E21B 43/26*** (2013.01); *E21B 2034/007* (2013.01)

(58) **Field of Classification Search**
CPC E21B 41/0078
USPC 166/373, 374, 377, 177.5, 22, 223, 317, 166/334.1
See application file for complete search history.

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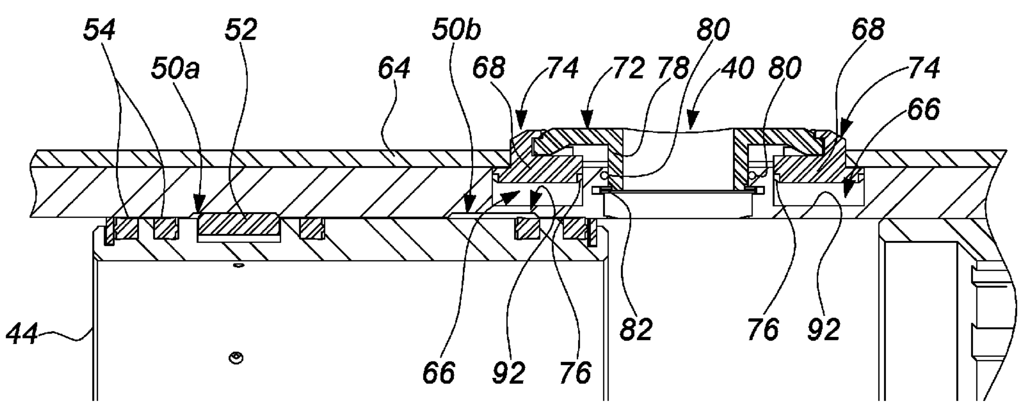
(57) **ABSTRACT**

A method and apparatus for centering and engaging a casing against a wellbore. The apparatus comprises a valve body locatable in-line with the casing the valve body having an outer casing extending between first and second ends and a central passage therethrough, and at least one radially movable body extending therethrough. Each radially movable body has an aperture therethrough so as to permit an exterior of the valve body and the central passage to be in fluidic communication with each other. The apparatus further comprises a cylinder and a piston therein operable connected to the radially movable body in selective fluidic communication with the central passage. The method comprises locating the valve body in line with a wellbore casing, pressurizing the casing with a pressurizing fluid and transmitting the pressurizing fluid the cylinder so as to displace a piston located therein and extend the radially movable body.

14 Claims, 17 Drawing Sheets



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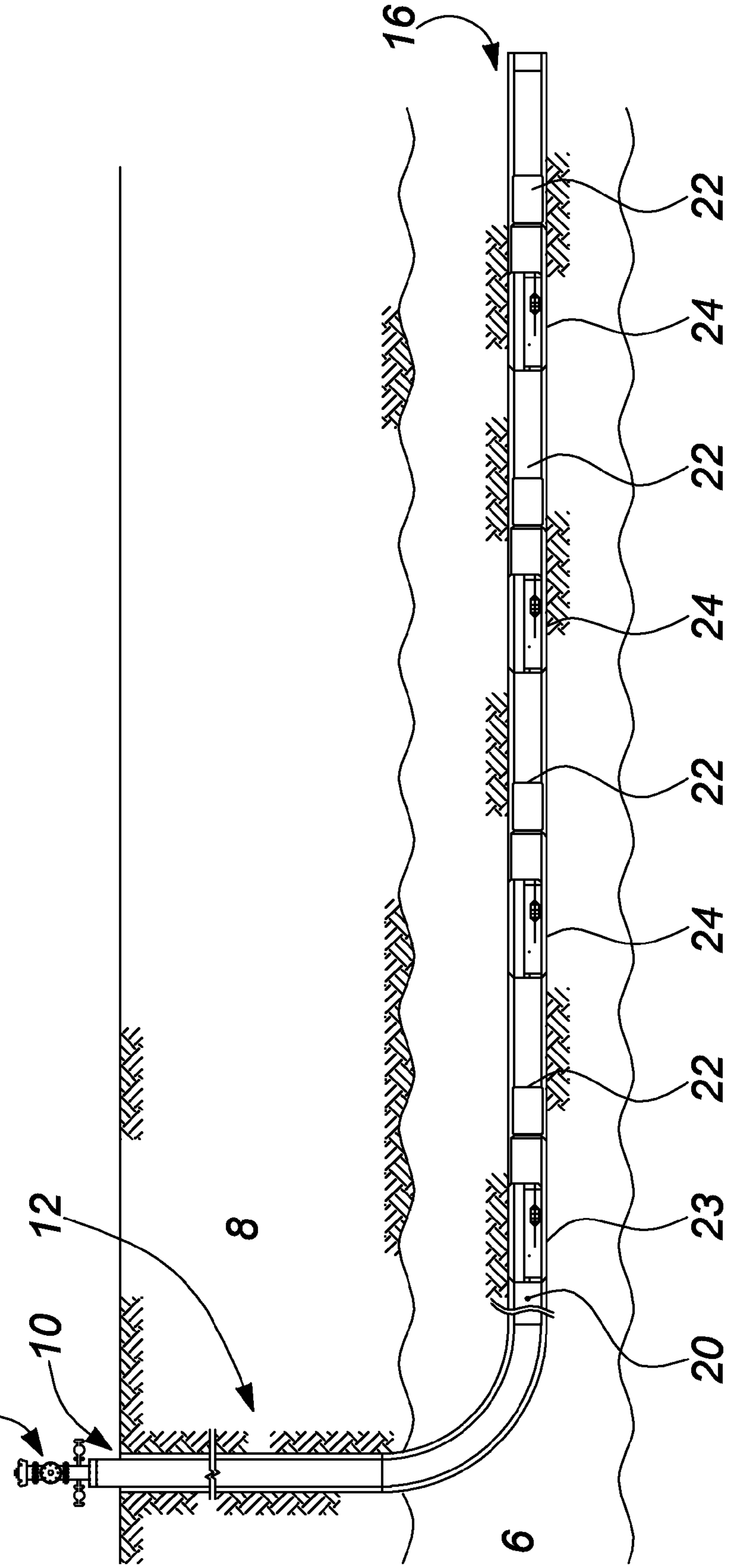

FIG. 1

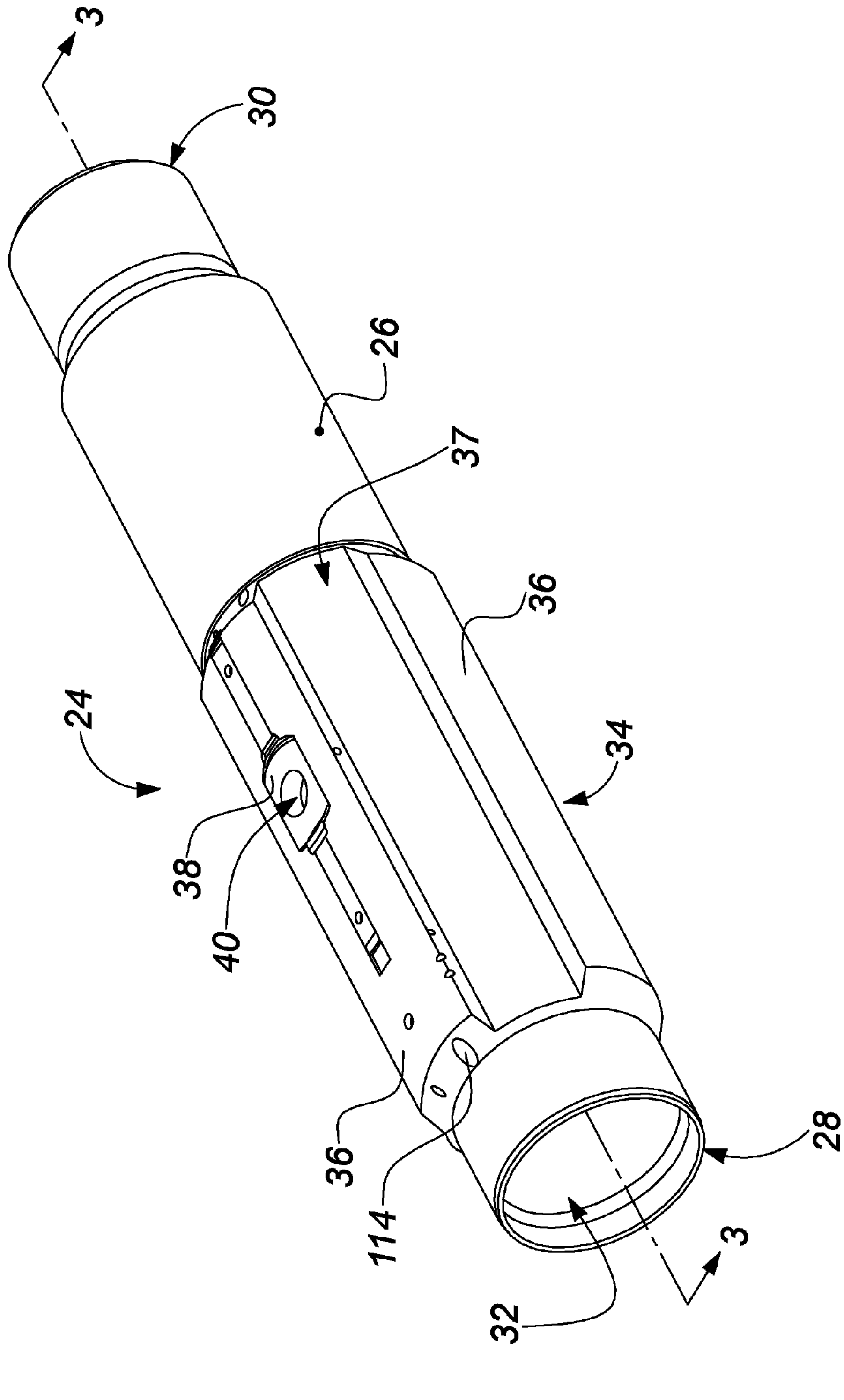

FIG. 2

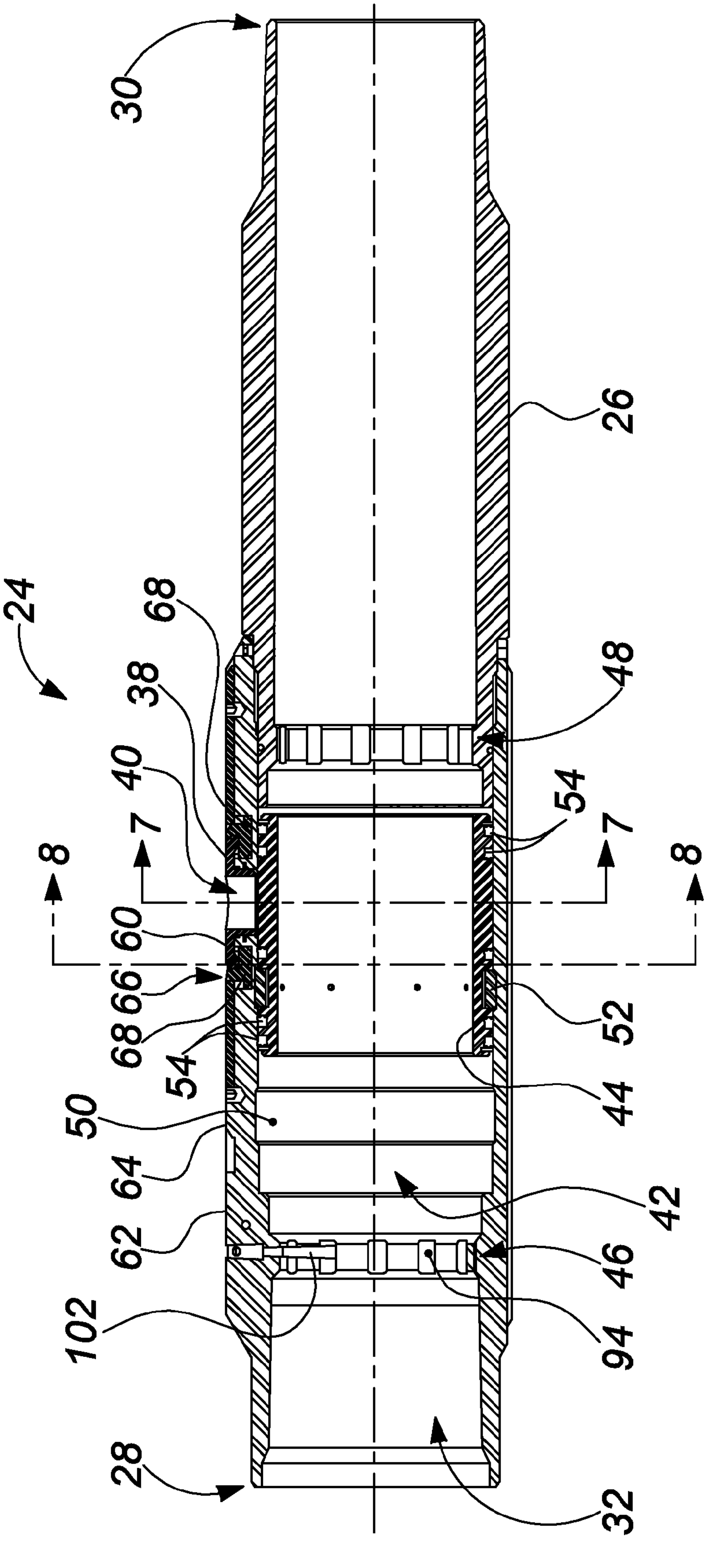
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FIG. 3

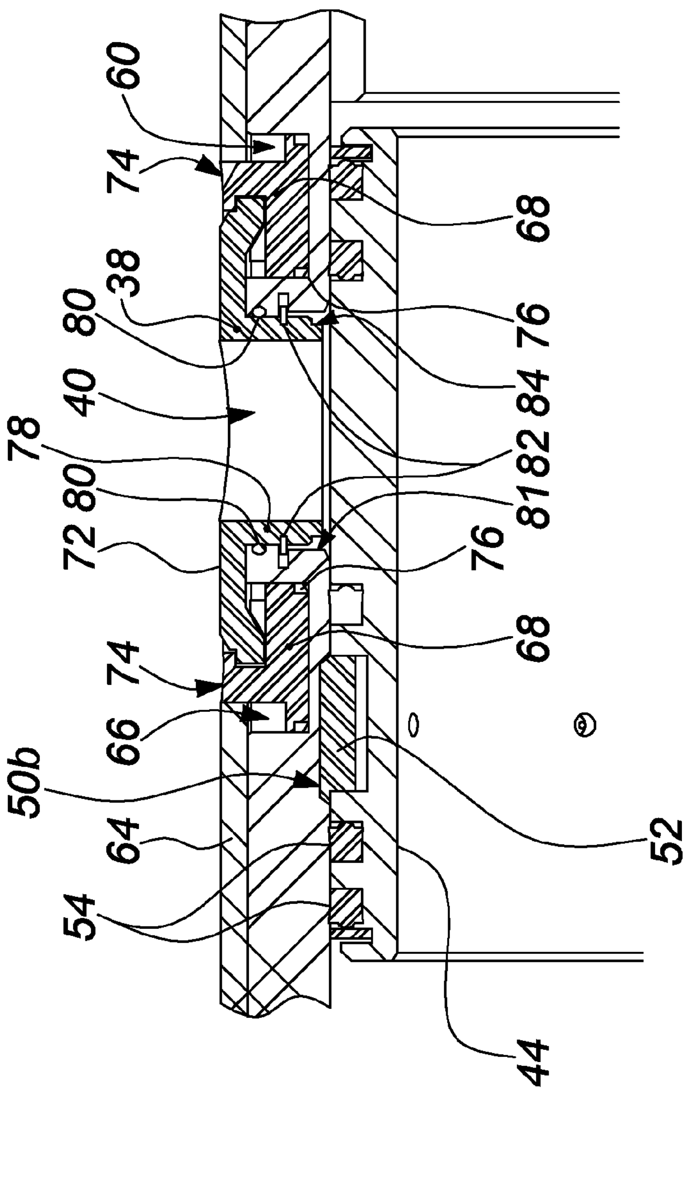

FIG. 4

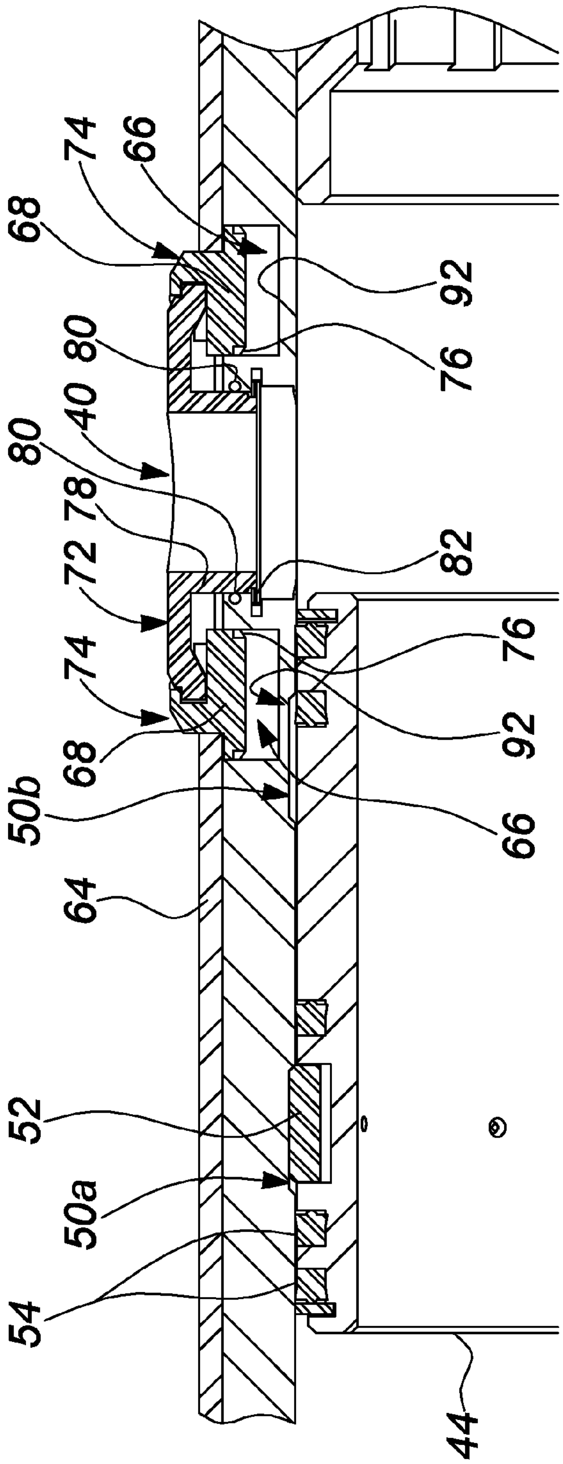

FIG. 5

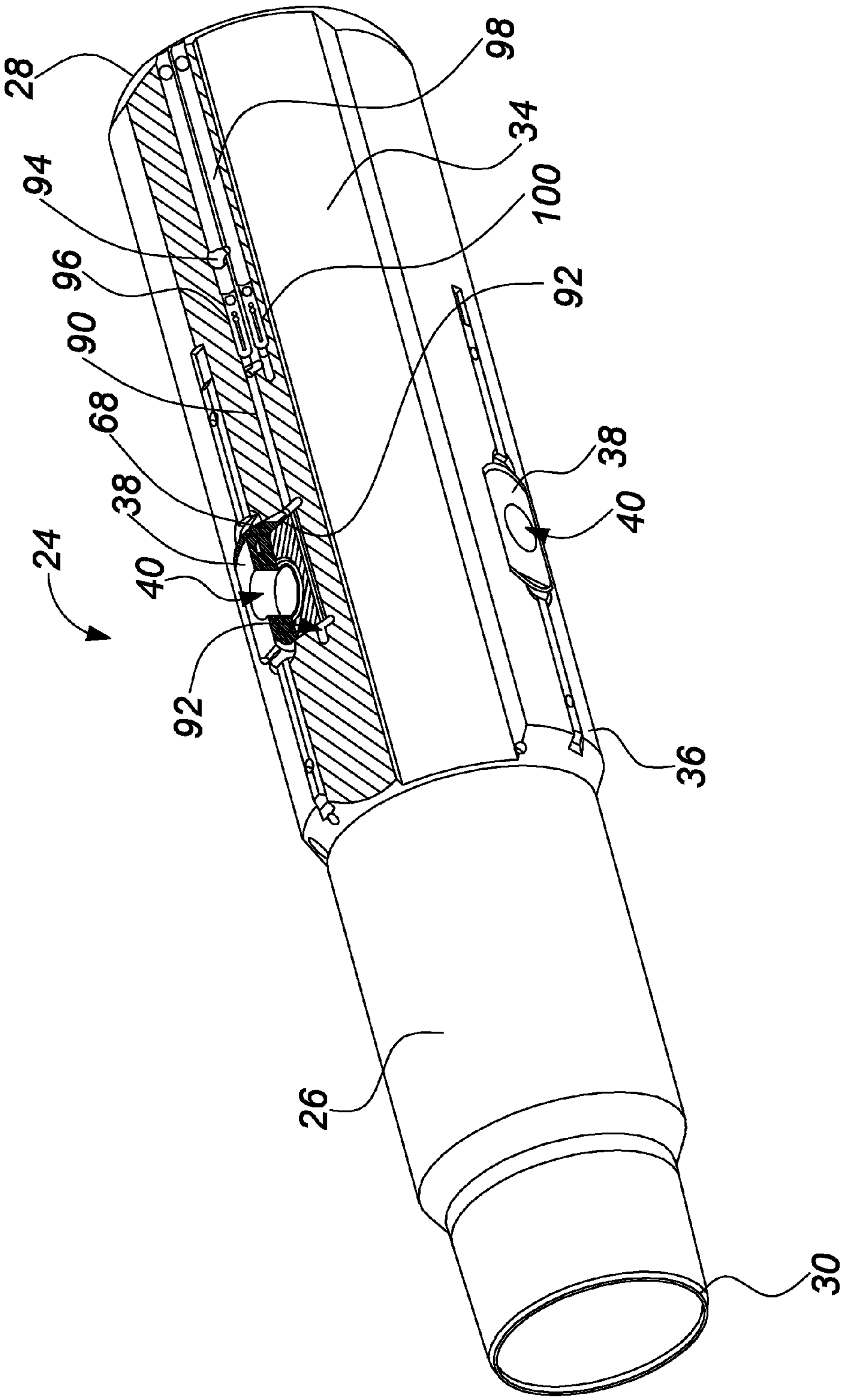

FIG. 6

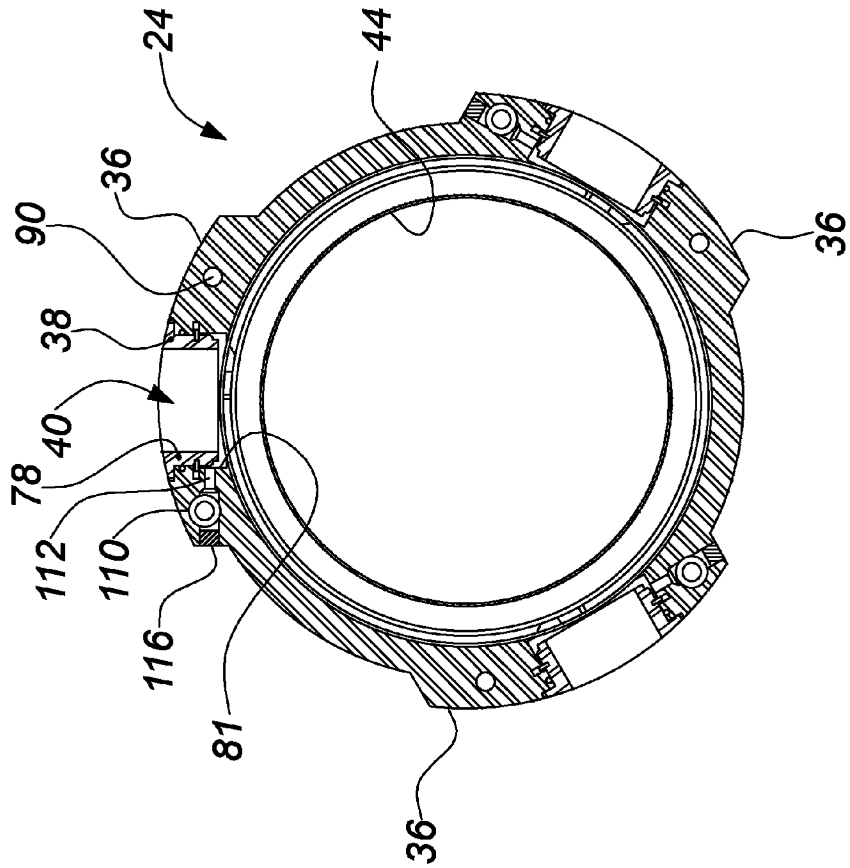

FIG. 7

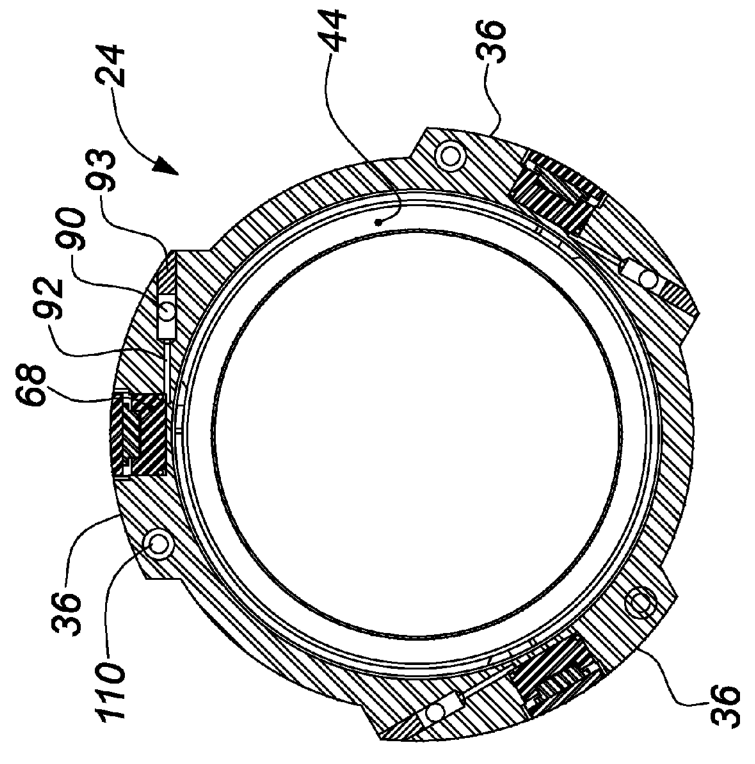

FIG. 8

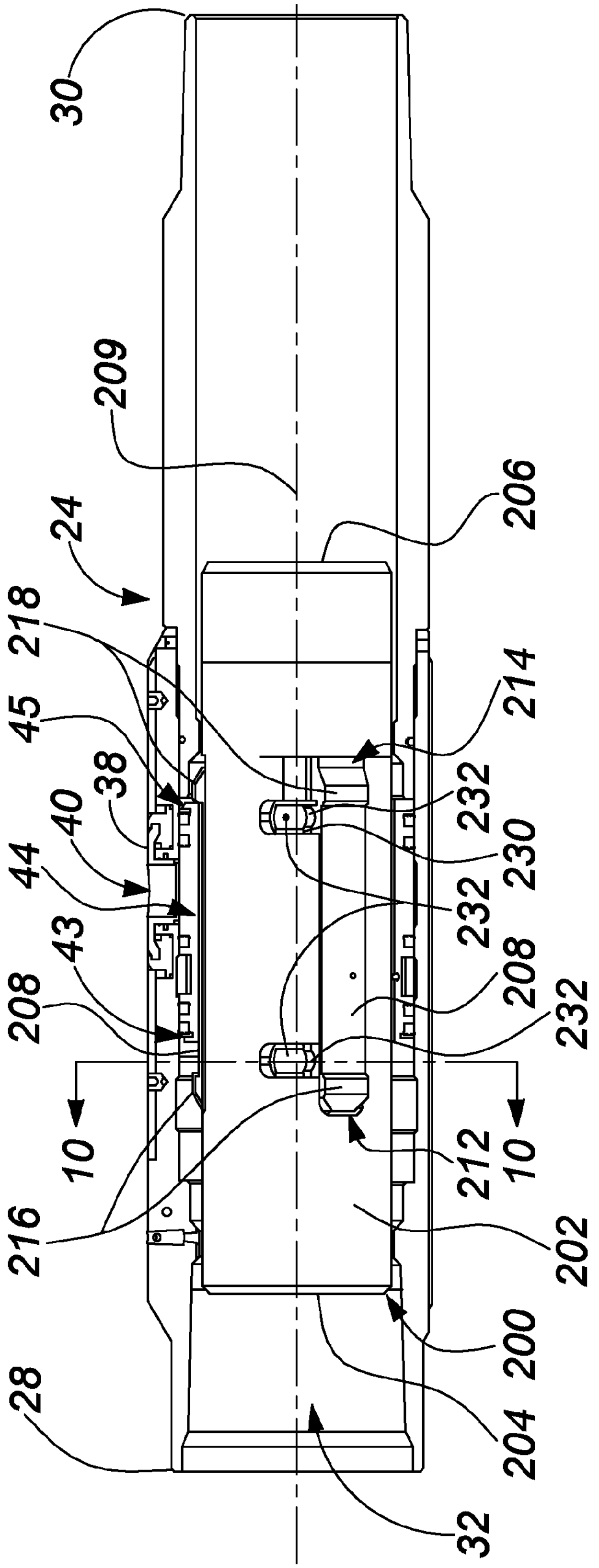
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FIG. 9

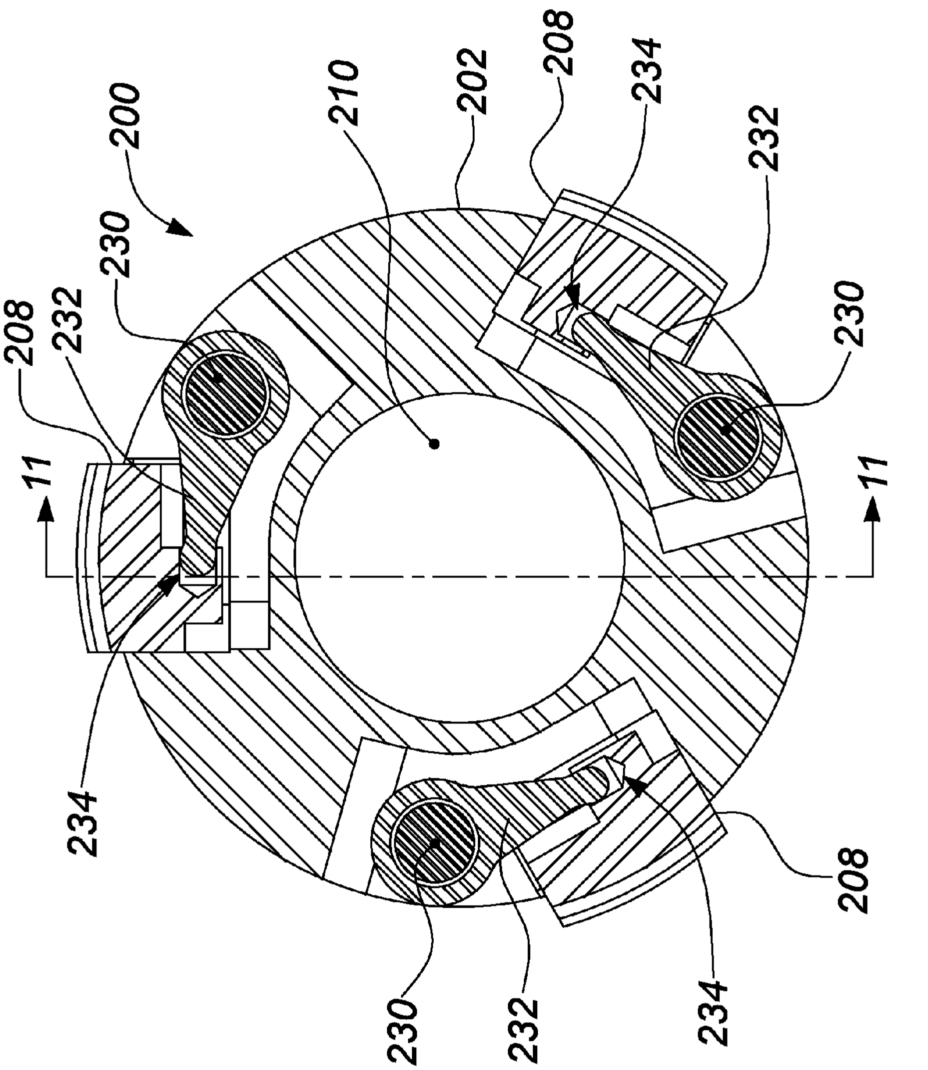

FIG. 10

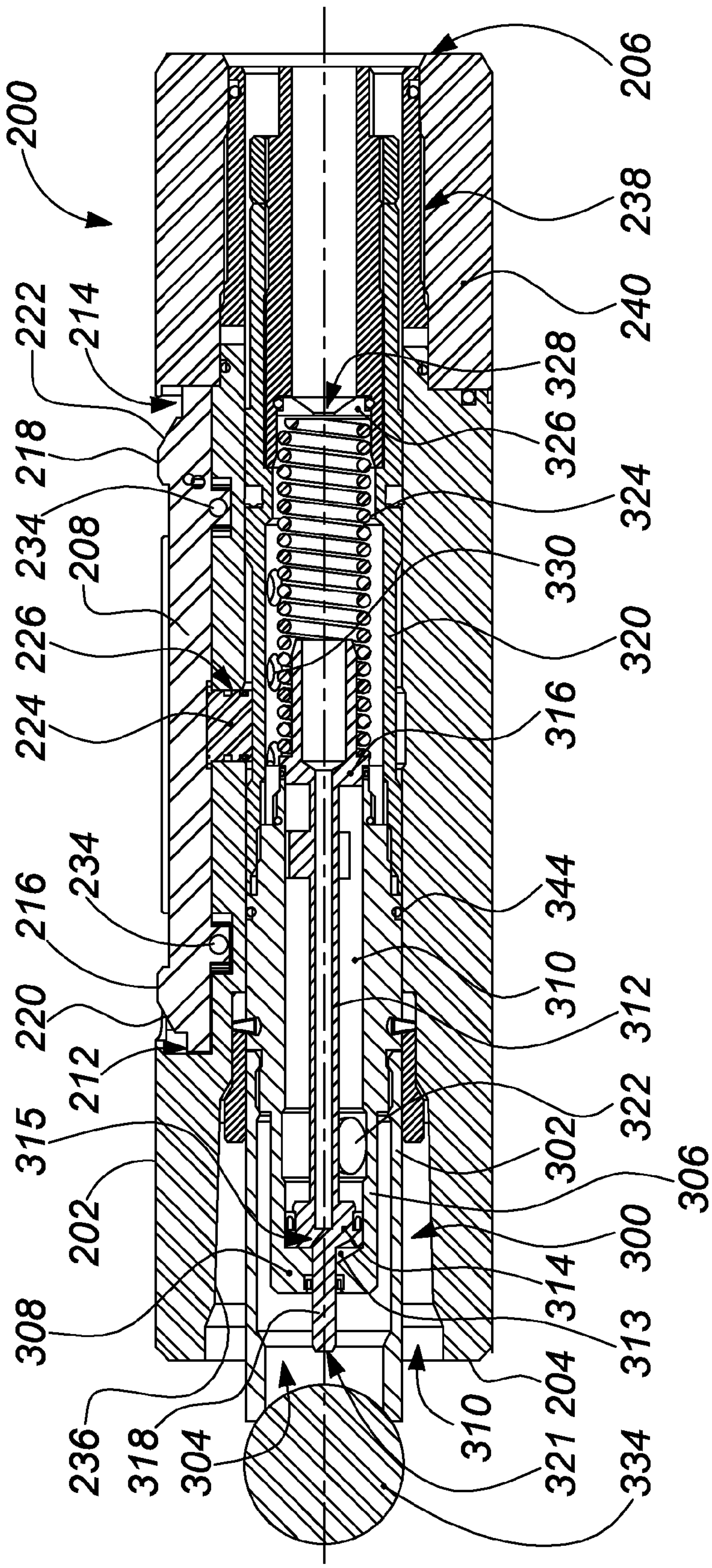
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FIG. 11

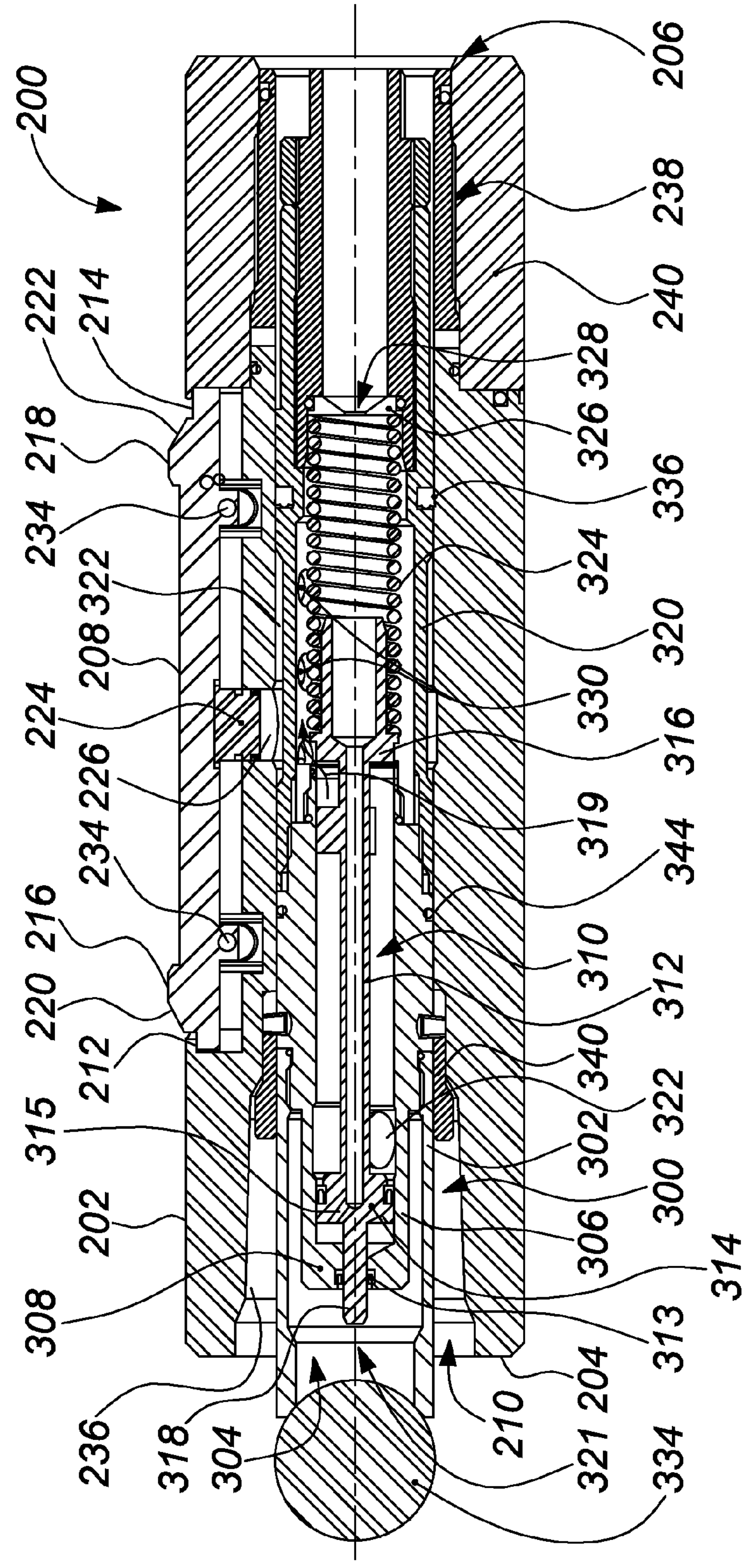
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FIG. 12

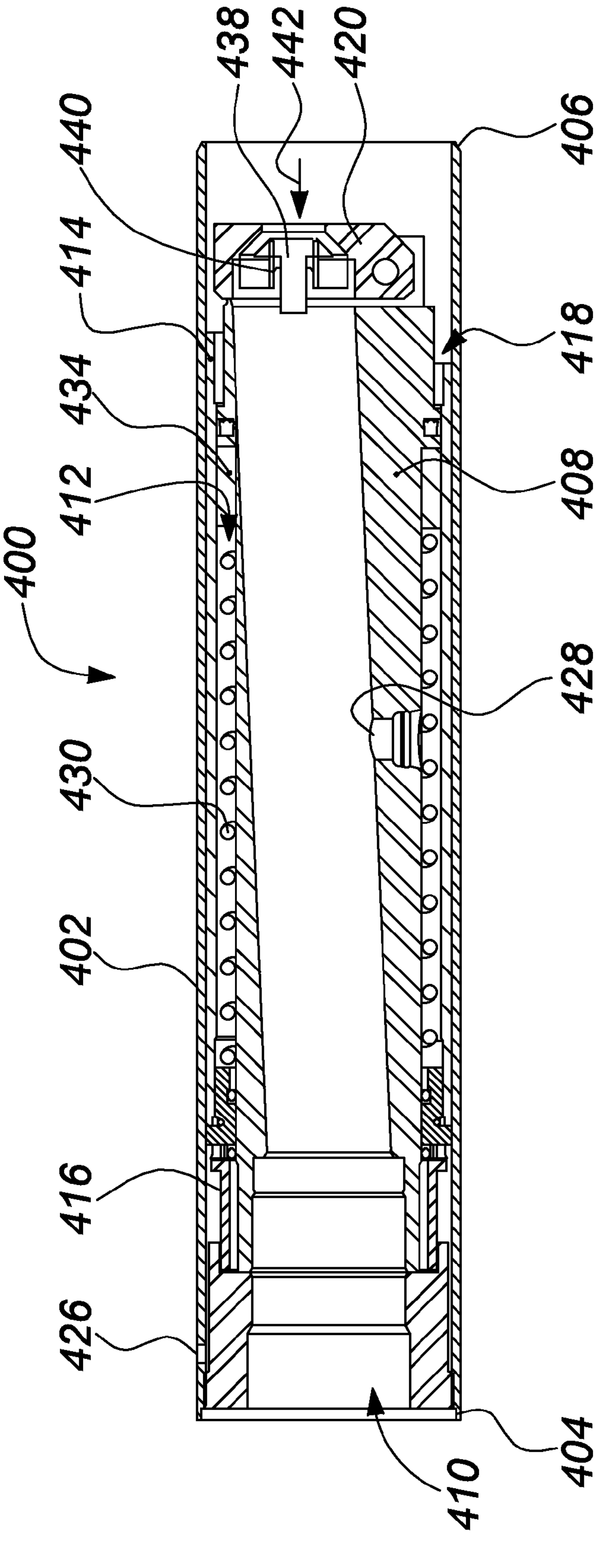
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FIG. 13

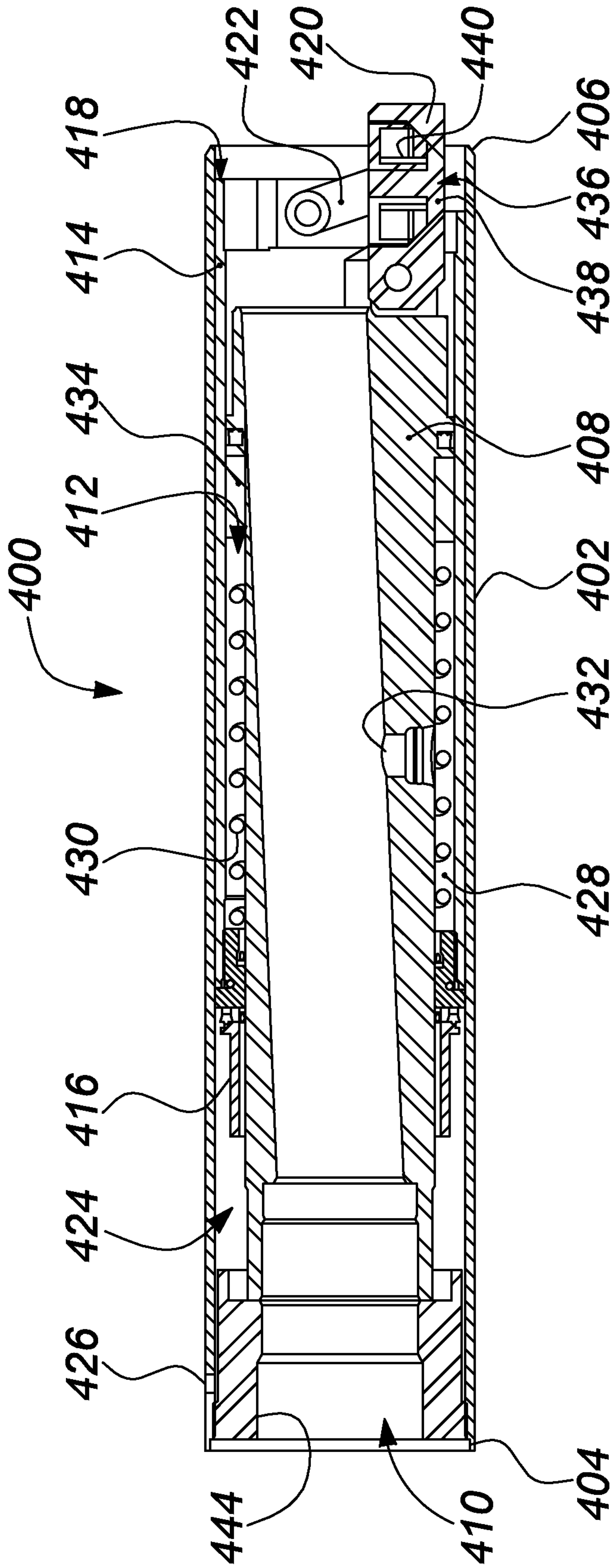
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FIG. 14

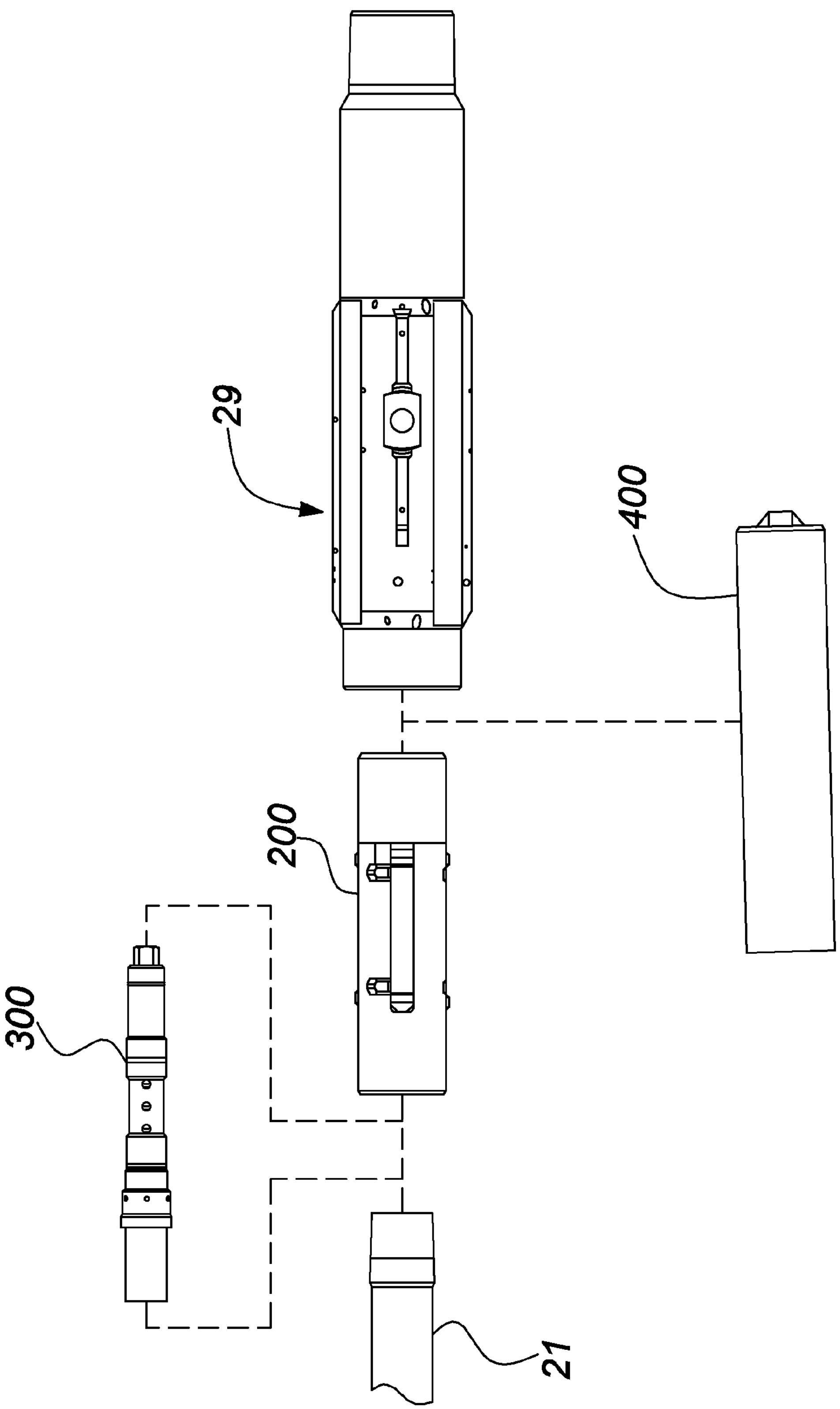

FIG. 15

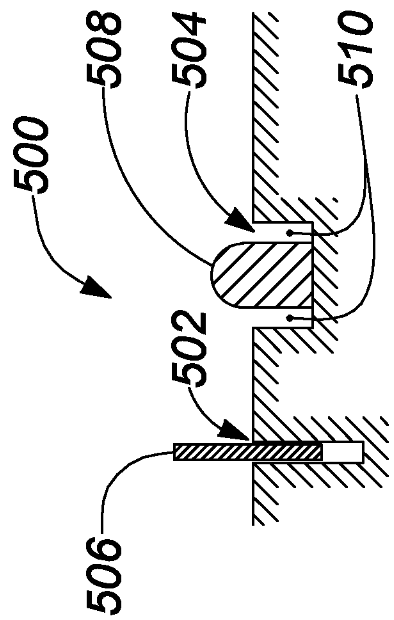

FIG. 16

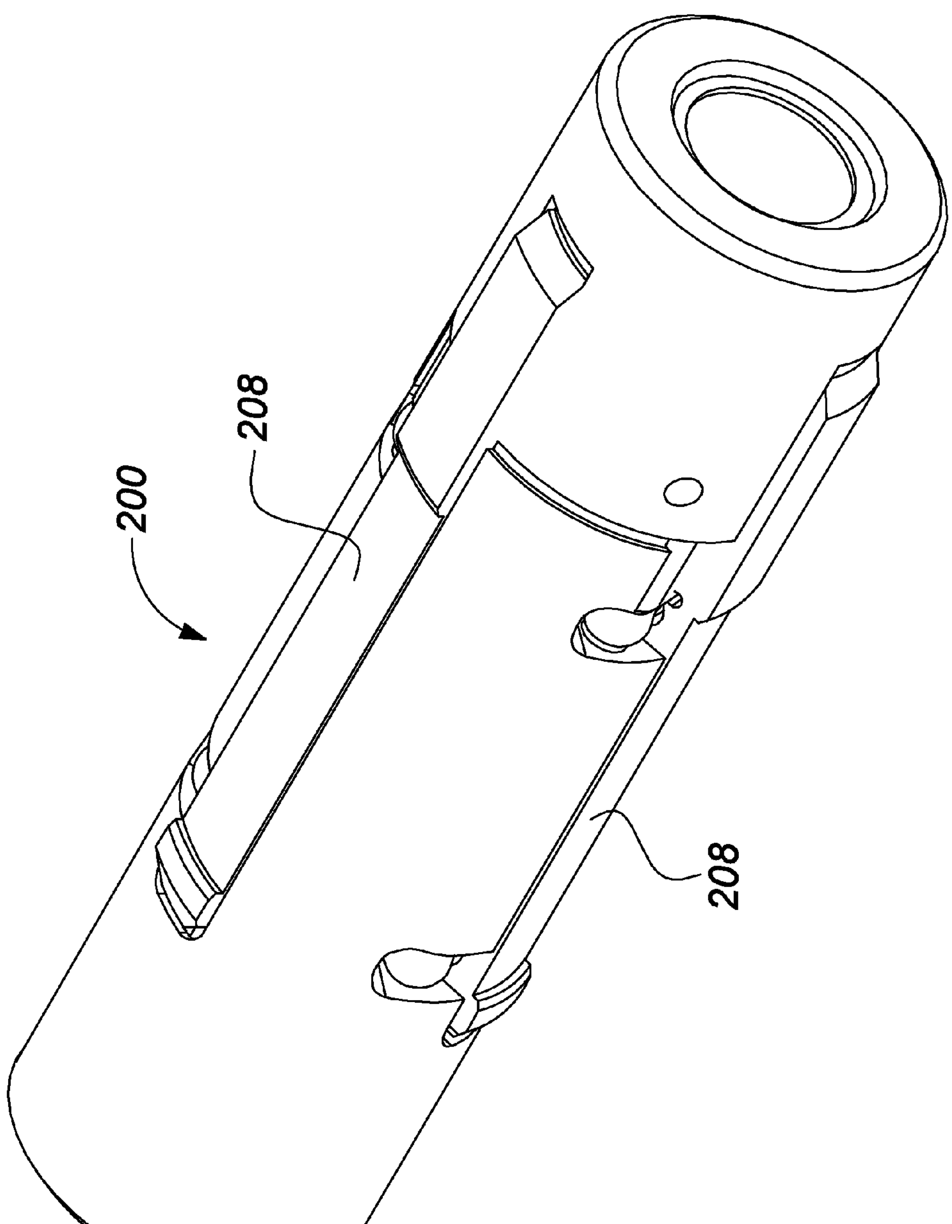

FIG. 17

DOWNHOLE EXTENDING PORTS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from U.S. Provisional Patent Application No. 61/344,812 filed Oct. 15, 2010 entitled Downhole Control Valve System.

BACKGROUND OF THE INVENTION

1. Field of Invention

The present invention relates to hydrocarbon well control in general and in particular methods and apparatuses for selectably opening and closing zones within a hydrocarbon well during completion, hydraulic fracturing or production.

2. Description of Related Art

In hydrocarbon production, it has become common to utilize directional or horizontal drilling to reach petroleum containing rocks, or formations, that are either at a horizontal distance from the drilling location. Horizontal drilling is also commonly utilized to extend the wellbore along a horizontal or inclined formation or to span across multiple formations with a single wellbore. With horizontal drilling the well casing is prone to resting upon the bottom of the wellbore requiring the use of spacers so as to centre the casing within the wellbore.

In horizontal hydrocarbon wells, it is frequently desirable to select which zone of the wellbore is to be opened for production or to stimulate one or more zones of the well to increase production of that zone from time to time. One current method of stimulating a portion of the well is through the use of hydraulic fracturing or fracing. One difficulty with conventional fracing systems, it that is necessary to isolate the zone to be stimulated on both the upper and lower ends thereof so as to limit the stimulation to the desired zone. Such isolation has typically been accomplished with sealing elements known as production packers located to either side of the zone to be isolated.

One of the prior problems with current fracing methods is that most hydrocarbon wells are constructed with a well casing located within the wellbore which is cemented in place by pumping cement down the casing to the bottom of the well so as to fill the annulus between the casing and the wellbore from the bottom up. Such concrete provides an additional barrier between the center of the well casing and wellbore which is to be fraced. In conventional methods, in order to thereafter frac a zone which has been constructed in such a manner, it is necessary to form a conduit from the interior of the casing to the wellbore wall by fracturing the cement as well as the formation. Needing to fracture the concrete as well as the formation increases the pressure required for the fracing process thereby increasing the equipment requirements as well as the resulting cost and time requirements.

Previous attempts to resolve some of the above difficulties has been to provide valves inline within the casing so as to selectably provide access to the desired zones of the well. Such valves may be sliding valves having actuators such as are described in US Patent Application Publication No. 2006/0207763 to Hofman published Sep. 21, 2006. With the use of such sliding valves however, it is still necessary to fracture, dissolve or otherwise perforate the concrete surrounding the casing to access the formation.

SUMMARY OF THE INVENTION

According to a first embodiment of the present invention there is disclosed an apparatus for centering and engaging a

casing against a wellbore. The apparatus comprises a valve body locatable in-line with a wellbore casing, at least one cylinder associated with the valve body and a central passage extending between an interior of the casing so as to transmit a pressure within the valve body to the at least one cylinder. The apparatus further includes a piston slidably locatable within the at least one cylinder operable to be displaced by the pressure and at least one port body slidably locatable within the valve body, the port body having an aperture therethrough and being connected to the piston so as to extend the port body from the valve body into contact with the wellbore as the piston is displaced.

According to a further embodiment of the present invention there is disclosed an apparatus for centering and engaging a casing against a wellbore. The apparatus comprises a valve body locatable in-line with the casing, the valve body having an outer casing extending between first and second ends and having a central passage therethrough and at least one radially movable body extending through the outer casing. Each radially movable body has an aperture therethrough so as to permit an exterior of the valve body and the central passage to be in fluidic communication with each other. The apparatus further comprises an actuator for radially moving the radially movable body.

The actuator may comprises at least one cylinder associated with the at least one radially moveable body, each cylinder having a piston therein operable connected to the radially movable body. The cylinder may be in selective fluidic communication with the central passage such that a pressurized fluid in the central passage selectably displaces the piston within the cylinder so as to extend the radially movable body.

The apparatus may further comprise a fluid bore extending between an interior of the casing and the at least one cylinder. The fluid bore may include a selectably removable plug. The selectably removable plug may selectably seal an inlet of the fluid bore within the central passage. The plug may be frangibly connected to the inlet of the fluid bore.

The fluid bore may include a lower limit pressure relief check valve for preventing actuation of the pistons in the cylinders until a fluid in the central passage reaches a predetermined pressure. The fluid bore may include an upper limit pressure relief valve for preventing the pressure in the cylinder from exceeding a predetermined pressure. The upper limit relieve valve may vent to an exterior of the valve body.

The apparatus may further comprise a pair of cylinders and associated pistons located to opposed sides of the radially movable body. The radially movable body may be movable between first and second positions, the first position being retracted into the valve body, the second position extending radially from the valve body. The radially movable body may include an exterior surface, the exterior surface being substantially aligned with an exterior of the valve body in the first position. The radially movable body may extend from the valve body by a distance sufficient for the exterior surface to engage the wellbore in the second position.

The apparatus may further comprise a valve member for selectably covering the aperture so as to isolate the central passage from an exterior of the valve body. The valve member may comprise an axially slidably sleeve located within the central passage.

According to a further embodiment of the present invention there is disclosed a method of centering and engaging a valve body against a wellbore. The method comprises locating a valve body in line with a wellbore casing, the valve body having an outer casing extending between first and second ends and a central passage therethrough, pressurizing the casing with a pressurizing fluid and transmitting the pressurizing fluid to at least one cylinder within the valve body with the pressurizing fluid so as to displace a piston located therein and extend at least one radially movable body operably connected to the piston. The radially movable body extends through the valve body and has an aperture therethrough so as to permit an exterior of the valve body and the central passage to be in fluidic communication with each other.

According to a further embodiment of the present invention there is disclosed a method of centering and engaging a valve body against a wellbore comprising providing a valve body in line with a wellbore casing and pumping a volume of concrete down the casing to fill the annulus around the casing with a wellbore plug following the concrete. The method further comprise pressurizing the casing with a pressurizing fluid, pressurizing at least one piston with the pressurizing fluid so as to displace a piston located therein and extending at least one body having an aperture therethrough operably connected to the piston from the casing into contact with the wellbore.

Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

In drawings which illustrate embodiments of the invention wherein similar characters of reference denote corresponding parts in each view,

FIG. **1** is a cross-sectional view of a wellbore having a plurality of flow control valves according to a first embodiment of the present invention located therealong.

FIG. **2** is a perspective view of one of the control valves of FIG. **1**.

FIG. **3** is a longitudinal cross-sectional view of the control valve of FIG. **2** as taken along the line **3-3**.

FIG. **4** is a detailed cross-sectional view of the extendable ports of the valve of FIG. **2** in a first or retracted position.

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

FIG. **6** is a partial cross-sectional view of one raised portion of the valve body of FIG. **2** illustrating a fluid control system for extending the

FIG. **7** is an axial cross-sectional view of the control valve of FIG. **2** as taken along line **7-7**.

FIG. **8** is an axial cross-sectional view of the control valve of FIG. **2** as taken along line **8-8**.

FIG. **9** is a cross sectional view of the valve of FIG. **2** as taken along the line **3-3** showing a shifting tool located therein.

FIG. **10** is an axial cross-sectional view of the shifting tool of FIG. **9** as taken along the line **10-10**.

FIG. **11** a lengthwise cross sectional view of the shifting tool of FIG. **9** taken along the line **11-11** in FIG. **10** with a control valve located therein according to one embodiment with the shifting keys located at a first or retracted position.

FIG. **12** is a cross sectional view of the shifting tool of FIG. **9** taken along the line **11-11** with a control valve located therein according to one embodiment with the shifting keys located at a second or extended position

FIG. **13** is a cross sectional view of a control valve according to a further embodiment for actuating the shifting keys at a closed position.

FIG. **14** is a cross sectional view of a control valve according to a further embodiment for actuating the shifting keys at an open position.

FIG. **15** is a schematic view of a system for controlling fluid flow through a wellbore.

FIG. **16** is a cross sectional view of a seal for use between tool parts in a wellbore.

FIG. **17** is a perspective view of a shifting tool according to a further embodiment.

DETAILED DESCRIPTION

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

Turning now to FIG. **2**, a perspective view of one valve body **24** is illustrated. The valve body **24** comprises a substantially elongate cylindrical outer casing **26** extending between first and second ends **28** and **30**, respectively and having a central passage **32** therethrough. The first end **28** of the valve body is connected to adjacent liner or casing section **22** with an internal threading in the first end **28**. The second end **30** of the valve body is connected to an adjacent casing section with external threading around the second end **30**. The valve body **24** further includes a central portion **34** having a plurality of raised sections **36** extending axially therealong with passages **37** therebetween. As illustrated in the accompanying figures, the valve body **24** has three raised sections although it will be appreciated that a different number may also be utilized.

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

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

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

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

Each raised section **36** includes at least one void region or cylinder **66** disposed radially therein. Each cylinder **66** includes a piston **68** therein which is operably connected to a corresponding port body **38** forming an actuator for selectably moving the port bodies **38**. Turning now to FIGS. **4** and **5**, detailed views of one port body **38** are illustrated at a retracted and extended position, respectively. Each port body **38** may have an opposed pair of pistons **68** associated therewith arranged to opposed longitudinal sides of the valve body **24**. It will be appreciated that other quantities of pistons **68** may also be utilized for each port body **38** as well. The pistons **68** are connected to the valve body by a top plate **70** having an exterior surface **72**. The exterior surface **72** is positioned to correspond to the exterior surface **62** of the raised sections **36** so as to present a substantially continuous surface therewith when the port bodies **38** are in their retracted positions. The exterior surface **72** also includes angled end portions **74** so as to provide a ramp or inclined surface at each end of the port body **38** when the port bodies **38** are in an extended position. This will assist in enabling the valve body to be longitudinally displaced within a wellbore **10** with the vertical section **12** under thermal expansion of the production string and thereby to minimize any shear stresses on the port body **38**.

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

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

The pistons **68** may be displaceable within the cylinders **66** by the introduction of a pressurized fluid into a bottom portion thereof. As illustrated in FIG. **6**, a fluid control system is illustrated for providing a pressurized fluid to the bottom portion of the cylinder **66** from the interior of the valve body **24**. In this way a fluid pumped down the center of the bottom section **16** may be utilized to extend the port bodies **38**. The fluid control system comprises a fluid bore **90** extending longitudinally within the raised section **36** between an entrance bore **94** and a pair of spaced apart piston connection bores **92**. The piston connection bores **92** intersect the bottom portion of the cylinders **66** while the entrance bore extends to the central passage **32** of the valve body **24**. The fluid bore **90** may include a relief check valve **96** located therein so as to only pressurize the cylinders **66** when a fluid of a sufficient pressure has been pumped down the production string. In operation, a user may select a check valve **96** of the desired actuation pressure which may be between 500 and 2000 pounds per square inch (psi) with a pressure of between 1000 and 1200 being particularly useful. Other pressures may also be selected which are sufficient to centralize the valve body **24** within the wellbore. This pressure may be referred to as an extension pressure. The fluid control system also includes a relieve bore **98** extending from the fluid bore **90** to an exterior of the valve body **24**. As illustrated in FIG. **8**, the piston connection bores **92** may be formed by boring into the raised section **36** so as to intersect both the fluid bore **90** and the cylinder **66** and thereafter filing the exterior portion of the piston connection bores with a piston connection plug **93** or the like.

The relief bore **98** includes a relief check valve **100** therein and is adapted to relieve the pressure within the fluid control system and to ensure that the pressure therein as well as within the bottom portion of the cylinders **66** does not reach a pressure which may cause damage to apparatus. In particular, as the extension pressure will be typically selected to be below the pressure required to fracture the formation, or the frac pressure, it will be necessary to ensure that such a higher frac pressure does not rupture the cylinder when it is applied to the interior of the bottom section **16**. Frac pressures are known to often be 10,000 psi or higher and therefore the relief check valve **100** may be selected to have a opening pressure of between 5,000 and 8,000 psi.

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

With reference to FIGS. **7** and **8**, axial cross-sectional view of the valve body **24** is illustrated through the center of the aperture **40** and port body **38** and through the center of the pistons **68**, respectively. Each raised section **36** includes a balancing bore **110** extending therealong substantially parallel to the central axis of the valve body **24**. The balancing bore **110** extending between and entrance end **114** (shown on FIG. **2**) and a connection bore **112** extending to the port bore **81**. The balancing bore **110** may include a piston therein and be pre-filled with a fluid such as oil, by way of non-limiting example. In operation, the balancing bore **110** balances the pressure within the bore port **81** as the port body **38** is extended from the valve body **24**. In particular, as the port body **38** is extended from the valve body, a negative pressure will be created within the space between the closed sliding sleeve **44** and the sealing body (not shown) located within the aperture **40** as this space is increased in volume. The balancing bore **110** reduces this negative pressure by providing an additional fluid contained therein to be drawn into the port bore **81** to fill this volume and balance the pressure therein with the pressures to the exterior of the valve body **24**. As illustrated in FIG. **7**, the connection bore **112** may be formed by boring into the raised section **36** so as to intersect both the balancing bore **110** and the port bore **81** and thereafter filing the exterior portion of the connection bore with a plug **116** or the like.

Turning now to FIG. **9**, a shifting tool **200** is illustrated within the central passage **32** of the valve body **24**. The shifting tool **200** is adapted to engage the sliding sleeve **44** and shift it between a closed position as illustrated in FIG. **9** and an open position in which the apertures **40** are uncovered by the sliding sleeve **44** so as to permit fluid flow between and interior and an exterior of the valve body **24** as illustrated in FIG. **5**. The shifting tool **200** comprises a substantially cylindrical elongate tubular body **202** extending between first and second ends **204** and **206**, respectively. The shifting tool **200** includes a central bore **210** therethrough (shown in FIGS. **10** through **12**) to receive an actuator or to permit the passage of fluids and other tools therethrough. The shifting tool **200** includes at least one sleeve engaging member **208** radially extendable from the tubular body **202** so as to be selectably engageable with the sliding sleeve **44** of the valve body **24**. As illustrated in the accompanying figures, three sleeve engaging members **208** are illustrated although it will be appreciated that other quantities may be useful as well.

The sleeve engaging members **208** comprise elongate members extending substantially parallel to a central axis **209** of the shifting tool between first and second ends **212** and **214**, respectively. The first and second ends **212** and **214** include first and second catches **216** and **218**, respectively for surrounding the sliding sleeve and engaging a corresponding first or second end **43** or **45**, respectively of the sliding sleeve **44** depending upon which direction the shifting tool **200** is displaced within the valve body **24**. As illustrated in FIGS. **11** and **12**, the first and second catches **216** and **218** of the sleeve engaging member **208** each include and inclined surface **220** and **222**, respectively facing in opposed directions from each other. The inclined surfaces **220** and **222** are adapted to engage upon either the first or second annular shoulder **46** or **48** of the valve body as the shifting tool **200** is pulled or pushed there into. The first or second annular shoulders **46** or **48** press the first or second inclined surface **220** or **222** radially inwardly so as to press the sleeve engaging members **208** inwardly and thereby to disengage the sleeve engaging members **208** from the sliding sleeve **44** when the sliding sleeve **44** has been shifted to a desired position proximate to one of the annular shoulders. In an optional embodiment, one or both of the catches **216** or **218** may have an extended length as illustrated in FIG. **17** such that the sleeve engaging members are disengaged from the sliding sleeve at a position spaced apart from one of the first or second annular shoulders **46** or **48** and thereby adapted to position the sliding sleeve at a third or central position within the valve body **24**.

Turning to FIG. **10**, the sleeve engaging members are maintained parallel to the tubular body **202** of the shifting tool **200** by a parallel shaft **230**. Each parallel shaft **230** is linked to a sleeve engaging member **208** by a pair of spaced apart linking arms **232**. The parallel shaft **230** is rotatably supported within the shifting tool tubular body **202** by bearings or the like. The linking arms **232** are fixedly attached to the parallel shaft **230** at a proximate end and are received within a blind bore **234** of the sleeve engaging members **208**. As illustrated in FIG. **9**, the linking arms **232** are longitudinally spaced apart from each other along the parallel shaft **230** and the sleeve engaging member **208** so as to be proximate to the first and second ends **212** and **214** of the sleeve engaging member **208**.

Turning now to FIG. **11**, the tubular body **202** of the shifting tool includes a shifting bore **226** therein at a location corresponding to each sleeve engaging member. The shifting bore **226** extends from a cavity receiving the sleeve engaging member to the central bore **210** of the shifting tool **200**. Each sleeve engaging member **208** includes a piston **224** extending radially therefrom which is received within the shifting bore **226**. In operation, a fluid pressure applied to the central bore **210** of the shifting tool will be applied to the piston **224** so as to extend the piston within the shifting bore **226** and thereby to extend the sleeve engaging members **208** from a first or retracted position within the shifting tool tubular body **202** as illustrated in FIG. **11** to a second or extended position for engagement on the sliding sleeve **44** as discussed above as illustrated in FIG. **12**. The parallel shafts also include helical springs (not shown) thereon to bias the sleeve engaging members to the retracted position.

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

With reference to FIGS. **11** and **12**, a first control valve **300** according to a first embodiment located within a shifting tool **200** for use in wells having low hydrocarbon production flow rates. The low flow control valve **300** comprises a valve housing **302** having a valve passage **304** therethrough and seals **344** therearound for sealing the valve housing **302** within the shifting tool **200**. The low flow control valve **300** includes a central housing extension **306** extending axially within the valve passage **304** and a spring housing portion **320** downstream of the central portion **310**. The central housing extension **306** includes an end cap **308** separating an entrance end of the valve passage from a central portion **310** of the valve passage and an inlet bore **322** permitting a fluid to enter the central portion **310** from the valve passage **304**.

The central portion **310** of the valve passage contains a valve piston rod **312** slidably located therein. The valve piston rod **312** includes leading and trailing pistons, **314** and **316**, respectively thereon in sealed sliding contact with the central portion **310** of the valve passage. The leading piston **314** forms a first chamber **313** with the end cap **308** having an inlet port **315** extending through the leading piston **314**. The valve piston rod **312** also includes a leading extension **318** having an end surface **321** extending from an upstream end thereof and extending through the end cap **308**. The valve piston rod **312** is slidable within the central portion **310** between a closed position as illustrated in FIG. **11** and an open position as illustrated in FIG. **12**. In the closed position, the second or trailing piston **316** is sealable against the end of the central portion **310** to close or seal the end of the central passage and thereby prevent the flow of a fluid through the control valve. In the open position as illustrated in FIG. **12**, the trailing piston **316** is disengagable from the end of the central portion **310** so as to provide a path of flow, generally indicated at **319**, therethrough from the central passage to the spring housing.

A spring **324** is located within the spring housing **320** and extends from the valve piston rod **312** to an orifice plate **326** at a downstream end of the spring housing **320**. The spring **324** biases the valve piston rod **312** towards the closed position as illustrated in FIG. **11**. Shims or the like may be provided between the spring **324** and the orifice plate **326** so as to adjust the force exerted by the spring upon the valve piston rod **312**. In other embodiments, the orifice plate may be axially moveable within the valve body by threading or the like to adjust the force exerted by the spring. In operation, fluid pumped down the production string to the valve passage **304** passes through the inlet bore and into the central portion **310**. The pressure of the fluid within the central portion **310** is balanced upon the opposed faces of leading and trailing pistons **314** and **316** such that the net pressure exerted upon the valve piston rod **312** is provided by the pressure exerted on the end surface **321** of the leading extension **318** and on the leading piston **314** from within the first chamber **313**. The resulting force exerted upon the end surface **321** is resisted by the biasing force provided by the spring **324** as described above.

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

The valve **300** may be closed by reducing the pressure of the supplied fluid to below the pressure required to overcome the spring **324** and the pressured created by the orifice **328** such that the spring is permitted to close the valve **300** by returning the valve piston rod **312** to the closed position as illustrate in **11** as well as permitting the springs on the parallel shaft **230** to retract the sleeve engaging members **208** as the pressure within the spring housing **320** is reduced. Seals **336** as further described below may also be utilized to seal the contact between the spring housing **320** and the interior of the central bore **210** of the shifting tool **200**.

A shear sleeve **340** may be secured to the outer surface of the valve housing **302** by shear screws **342** or the like. The sheer sleeve **340** is sized and selected to be retained between a pipe threaded into the internal threading **236** of the shifting tool **200** and the remainder of the shifting tool body. In such a way, should the valve be required to be retrieved, a spherical object **334**, such as a steel ball, such as are commonly known in the art may be dropped down the production string so as to obstruct the valve passage **304** of the valve **300**. Obstructing the flow of a fluid through the valve passage **304** will cause a pressure to develop above the valve so as to shear the shear screws **342** and force the valve through the shifting tool. The strength of the sheer screws **342** may be selected so as to prevent their being sheered during normal operation of the valve **300** such as for pressures of between 1000 and 3000 psi inlet fluid pressure. The valve illustrated in FIGS. **11** and **12** is adapted for use in a low hydrocarbon flow rate well. In such well types, the flow of fluids such as hydrocarbons or other fluids is low enough that the fluid pumped down the well to pressurize the central portion **310** is sufficient to overcome the flow of the fluids up the well so as to pass through the orifice **328**. It will be appreciated that for wells of higher well pressure or flow rates, such a valve will be limited in its application.

Turning now to FIGS. **13** and **14**, a second control valve **400** according to a further embodiment located for use in wells having high hydrocarbon production flow rates is illustrated. The high flow control valve **400** comprises an outer tubular body **402** extending between first and second ends **404** and **406**, respectively. An inner tubular body **408** is located within the outer tubular body **402** having a central passage **410** therethrough and forming an annular cavity **412** with the outer tubular body. A flap **420** is pivotally connected to a distal end of the inner tubular body **408**. The flap **420** selectably closes and seals the central passage **410** as the flap **420** is rotated into a first or closed position as illustrated in FIG. **13**. The flap **420** may also be rotated to a second or open position as illustrated in FIG. **14** so as to permit fluids and tools to be passed through second control valve **400**.

An elongate longitudinally displacable sleeve **414** is received within the annular cavity **412**. The sleeve **414** includes an annular piston **416** at a first end and a free second end **418**. The second end **418** is connected to the flap **420** by a linkage **422** such that when flap **420** is rotated to the open position as illustrated in FIG. **14**, the sleeve will be extended towards the second end **406** of the control valve **400**. Similarly, when the flap **420** is rotated to the closed position as illustrated in FIG. **13**, the sleeve **414** is retracted towards the first end **404**.

The annular piston **416** is located within a first end **424** of the annular cavity **412** proximate to the first end **404** of the valve **400**. The first end **424** is in fluidic communication with an annulus around the exterior of the outer tubular body **402** and also the distal end of the control valve **400** through a bore hole **426**. The annular sleeve **414** is approximately hydrostatically balanced due to the same pressurized fluid from the wellbore being present at the second end **418** of the sleeve as well as upon the annular piston **416** within the first end **424**. Biasing the annular piston **416** towards the first end of the control valve **400** is a spring **430** contained within a spring cavity **428** between the annular sleeve **414** and the outer tubular body **402**. Additionally a spring cavity **428** may include an internal bore **432** from the central passage **410** so as to port or introduce a fluid into the spring cavity **428** and thereby prevent any fluid contained therein from acting as a further biasing spring. The force exerted upon the annular piston **416** may be adjusted by providing one or more shims **434** at an opposite end of the spring from the annular piston **416**.

In a free resting state, the spring **430** biases the piston towards the first end **404** of the control valve and thereby maintains the flap **420** in the closed position. The flap **420** may be opened by pumping a fluid down the production string so as to introduce a pressurized fluid into the central passage thereof. The pressurized fluid forces the flap **420** open as illustrated in FIG. **14** when the flow and pressure of the pressurized fluid is sufficient to overcome the force of the spring **430**.

The flap **420** may optionally include a check valve **436** therein comprising a plug **438** compressed into the flap **420** by a spring **440** or the like. When a closed flap **420** experiences a pressure from the bottom of the well greater than the set point of the check valve, the well pressure will displace the plug **438** against the spring **440** in a direction generally indicated at **442** in FIG. **13**. This will then open the check valve and permit fluid to flow past the check valve in direction **442**. The central passage **410** of the valve also includes internal threading **444** adapted to be threadably secured to the external threading **238** of a shifting tool as described above. In such a connection, it will be appreciated that the end cap **240** of the sleeve engaging member must be removed to permit access to the external threading **238**.

In operation, the control valve **400** actuates the sleeve engaging members of the shifting tool by providing a pressurized fluid to the common passage through the shifting tool **200** and the valve **400**. When the central passage is pressurized to a sufficient pressure by a fluid pumped down the production string, the fluid from the central passage forces the flap **420** open. Thereafter, the fluid will need to be pumped down the production string at a sufficiently high volume so as to maintain the pressure within the production string at a pressure sufficient to act upon the pistons **224** so as to extend the sleeve engaging members **208**.

Turning now to FIG. **15**, a schematic view of a system according to the present invention is illustrated. The system may include one or more valve bodies **24** located within a bottom section **16** as described above. In operation, a user may extend a shifting tool **200** down the bottom section to shift the sliding sleeve **44** at the end of a production casing **21**. The shifting tool **200** may be actuated by either the first valve **300** which is located within the shifting tool **200** or by the second valve **400** which is located to a distal end of the shifting tool.

With reference to FIG. **16**, one or more of the seals for use with the above system may comprise first and second spaced apart grooves **502** and **504**, respectively. The first groove is sized to receive a wiper **506**, such as a radially compressible ring having a gap therein as are commonly known in the art. As illustrated, the wiper **506** may have an uncompressed radius greater than the radius of the first groove **502** so as to provide a radial space into which the wiper may be compressed. The second groove is sized to receive a vulcanized rubber seal **508** therein such that a gap, generally indicated at **510** is left between the seal **508** and the sides of the second groove **504**. The top of the seal **508** may be domed such that as the seal encounters an opposed surface (not shown) the seal is pressed down into the second groove to fill the gaps **510**. The gaps **510** may have a distance of between 0.010 and 0.50 inches although it will be appreciated that other gap distances may be used as well. When the seal encounters a space in the opposed surfaces, such as for example at a port or the like the seal is permitted to expand to it's uncompressed shape to limit the volume of fluid which may be permitted to pass into the port.

While specific embodiments of the invention have been described and illustrated, such embodiments should be considered illustrative of the invention only and not as limiting the invention as construed in accordance with the accompanying claims.

What is claimed is:

1. An apparatus for centering a casing within a wellbore, the apparatus comprising:

a valve body locatable in-line with the casing, said valve body having an outer casing extending between first and second ends and a central passage therethrough,

at least one radially movable body extending through said outer casing, each radially movable body having an aperture therethrough so as to permit an exterior of the valve body and said central passage to be in fluidic communication with each other; and

a pair of cylinders located on opposed sides of said radially movable body and associated with said at least one radially moveable body in fluidic communication with said central passage, each cylinder having an associated piston therein operably connected to said radially movable body for radially moving said radially movable body, said pistons being located to opposed sides of said radially movable body,

wherein each of said cylinders is in selective fluidic communication with said central passage such that a pressurized fluid in said central passage selectably displaces said pistons within said cylinders so as to extend said radially movable body.

2. The apparatus of claim **1** further comprising a fluid bore extending between an interior of the casing and said cylinders.

3. The apparatus of claim **2** wherein said fluid bore further includes a selectably removable plug.

4. The apparatus of claim **3** wherein said selectably removable plug selectably seals an inlet of said fluid bore within said central passage.

5. The apparatus of claim **4** wherein said plug is frangibly connected to said inlet of said fluid bore.

6. The apparatus of claim **2** wherein said fluid bore includes a lower limit pressure relief check valve for preventing actuation of said pistons in said cylinders until a fluid in said central passage reaches a predetermined pressure.

7. The apparatus of claim **2** wherein said fluid bore includes an upper limit pressure relief valve for preventing the pressure in said cylinders from exceeding a predetermined pressure.

8. The apparatus of claim **7** wherein said upper limit relief valve vents to an exterior of said valve body.

9. The apparatus of claim **1** wherein said radially movable body is movable between first and second positions, said first position being retracted into said valve body, said second position extending radially from said valve body.

10. The apparatus of claim **9** wherein said radially movable body includes an exterior surface, said exterior surface being substantially aligned with an exterior of said valve body in said first position.

11. The apparatus of claim **10** wherein said radially movable body extends from said valve body by a distance sufficient for said exterior surface to engage the wellbore in said second position.

12. The apparatus of claim **1** further comprising a valve member for selectably covering said aperture so as to isolate said central passage from an exterior of said valve body.

13. The apparatus of claim **12** wherein said valve member comprises an axially slidable sleeve located within said central passage.

14. A method of centering a valve body within a wellbore comprising:

locating a valve body in line with a wellbore, said valve body having an outer casing extending between first and second ends and a central passage therethrough;

providing at least one radially movable body extending through said outer casing, each radially movable body having an aperture therethrough so as to permit an exterior of the valve body and said central passage to be in fluidic communication with each other;

pressurizing said easing central passage with a pressurizing fluid; and

transmitting said pressurizing fluid to a pair of cylinders located to opposed sides of said radially movable body within said valve body so as to displace a respective piston located within each of the cylinders and extend at least one radially movable body operably connected to said pistons.

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