US010385990B2

# (12) United States Patent
**Zähe**

(10) **Patent No.: US 10,385,990 B2**
(45) **Date of Patent: Aug. 20, 2019**

(54) **PRESSURE-BALANCED PULL-TYPE MANUAL ACTUATION MECHANISM FOR A VALVE**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 127 days.

(21) Appl. No.: **15/797,177**

(22) Filed: **Oct. 30, 2017**

(65) **Prior Publication Data**

US 2019/0128443 A1 May 2, 2019

(51) **Int. Cl.**

| | |
|---|---|
| ***F16K 39/02*** | (2006.01) |
| ***F16K 35/02*** | (2006.01) |
| ***F16K 1/30*** | (2006.01) |
| ***F16K 31/06*** | (2006.01) |
| ***F16K 31/60*** | (2006.01) |
| ***F16K 1/12*** | (2006.01) |

(52) **U.S. Cl.**

CPC .............. ***F16K 35/027*** (2013.01); ***F16K 1/12*** (2013.01); ***F16K 1/30*** (2013.01); ***F16K 31/0693*** (2013.01); ***F16K 31/60*** (2013.01); ***F16K 39/022*** (2013.01)

(58) **Field of Classification Search**

CPC ............................... F16K 31/60; F16K 39/022
USPC ............................................ 251/282, 129.03
See application file for complete search history.

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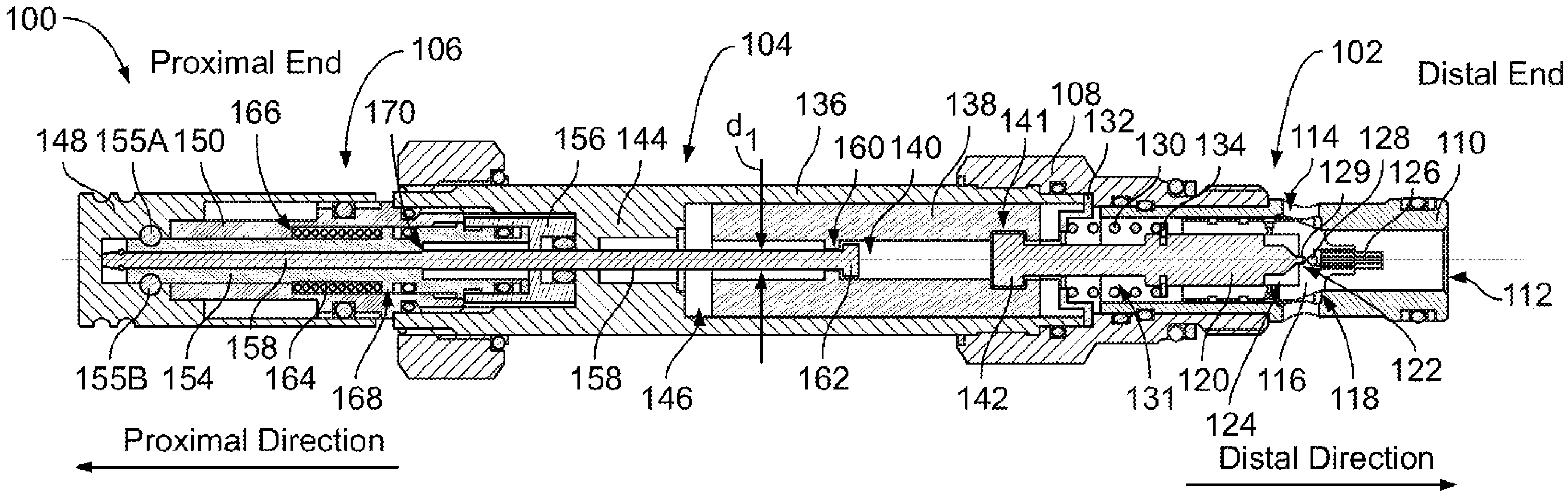
(57) **ABSTRACT**

An example manual actuation mechanism includes (i) a piston having: (a) a first flanged portion with a first annular surface area, (b) a second flanged portion with a second annular surface area, (c) a longitudinal cavity bounded by an interior peripheral surface of the piston, and (d) a shoulder on the interior peripheral surface of the piston; and (ii) a pin disposed in the longitudinal cavity of the piston, where the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the pin in a given axial direction is transferred to the piston, and where a difference between the second annular surface area of the second flanged portion and the first annular surface of the first flanged portion is substantially equal to a cross-sectional area of the pin.

**20 Claims, 5 Drawing Sheets**



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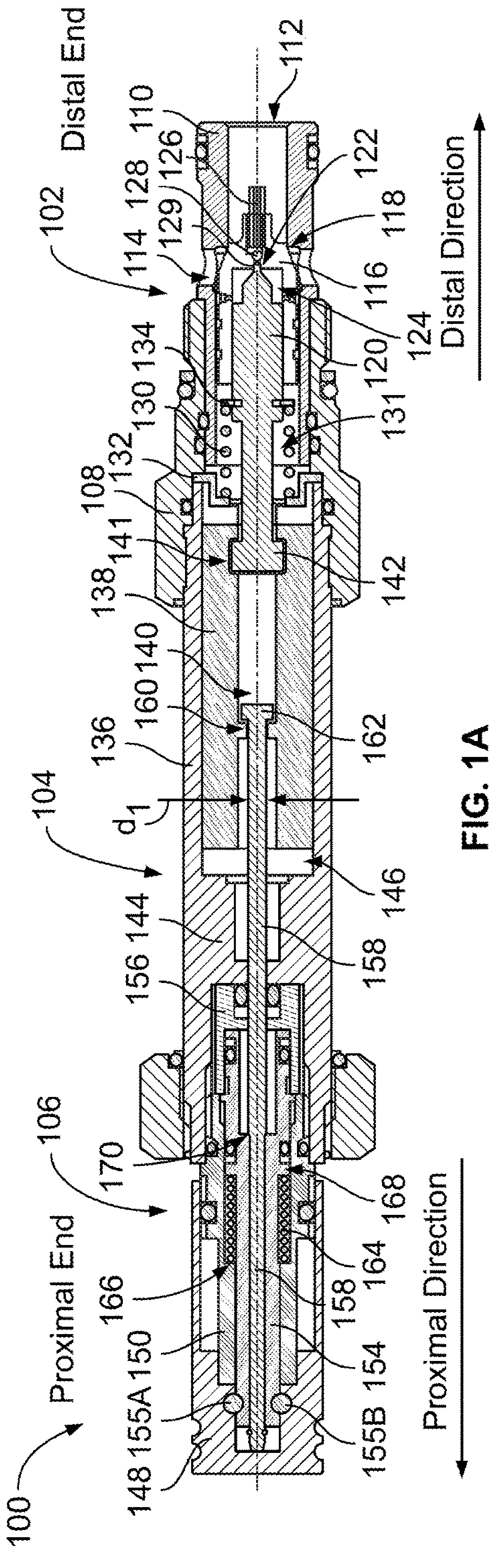
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102
104
106
Distal End
Proximal End
Distal Direction
Proximal Direction
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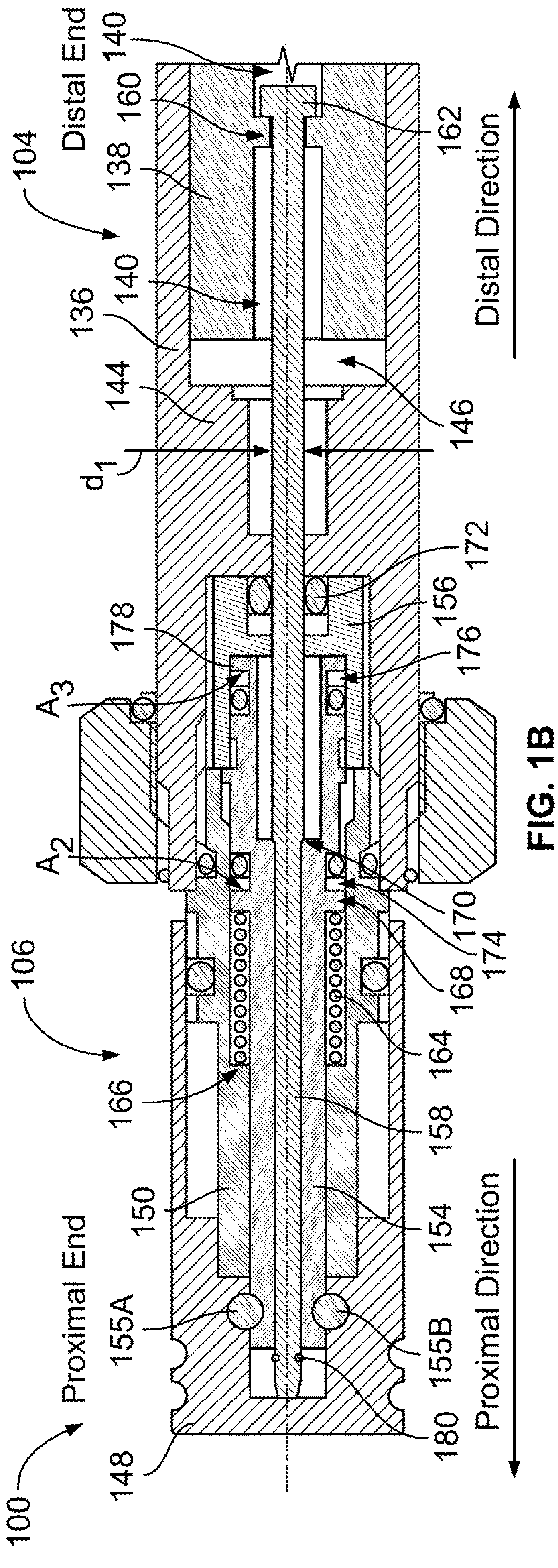
FIG. 1A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d1
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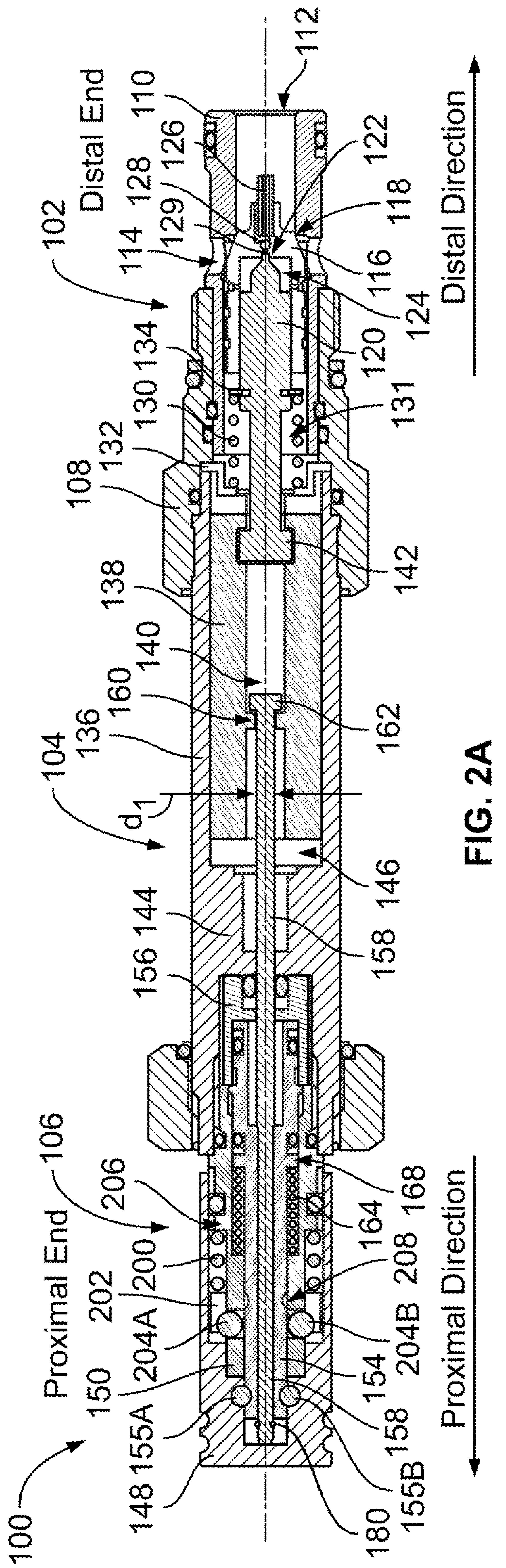
FIG. 1B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146
144
156
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Proximal End
206
200
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204A
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208
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155B
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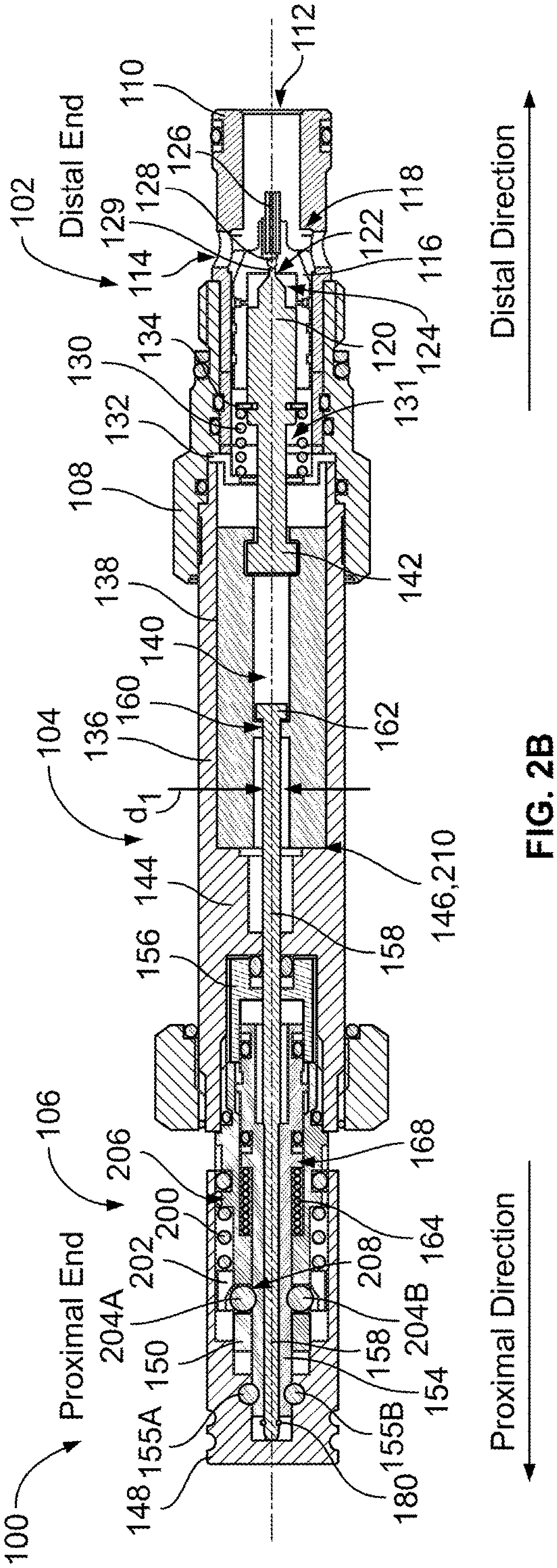
Proximal Direction

FIG. 2A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d1
146,210
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Proximal End
206
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168
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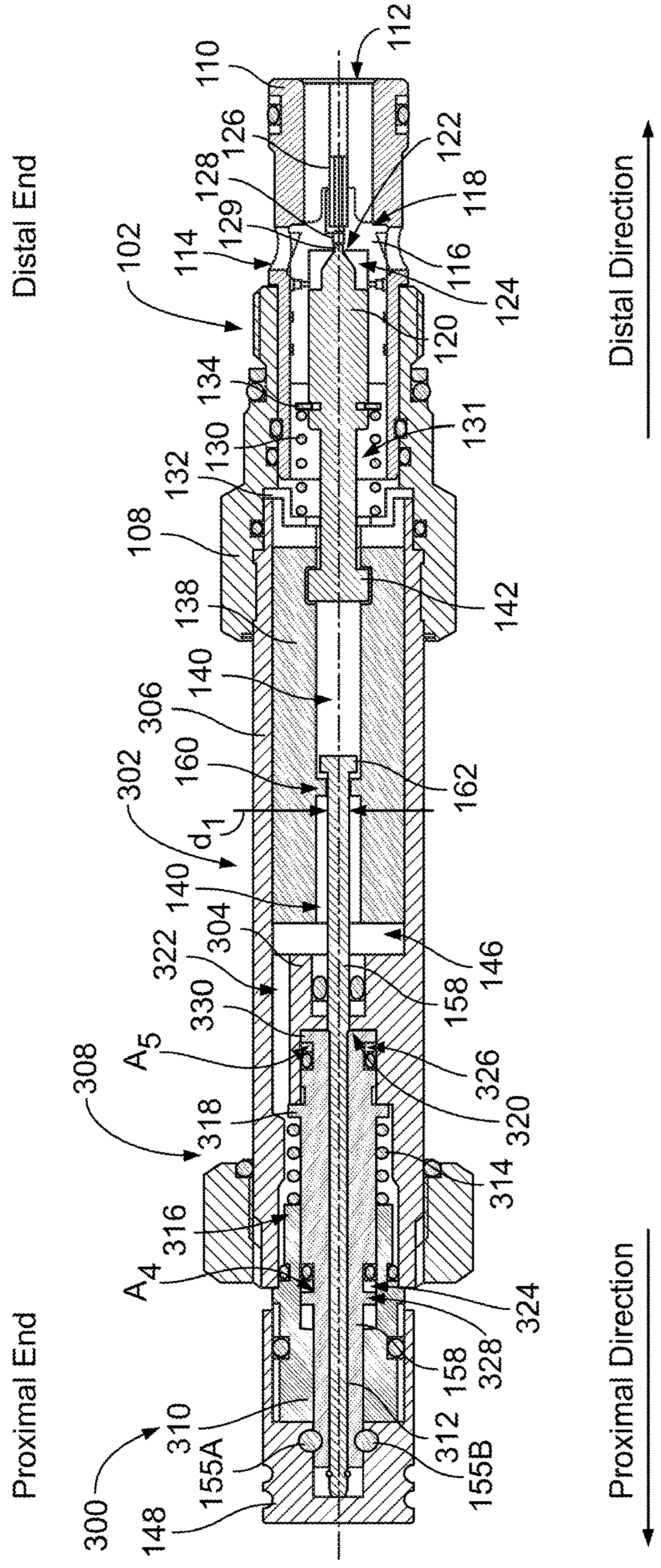
Proximal Direction

FIG. 2B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306
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162
302
$d_1$
140
304
146
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158
330
$A_5$
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$A_4$
324
328
158
310
312
155A
155B
300
148

FIG. 3

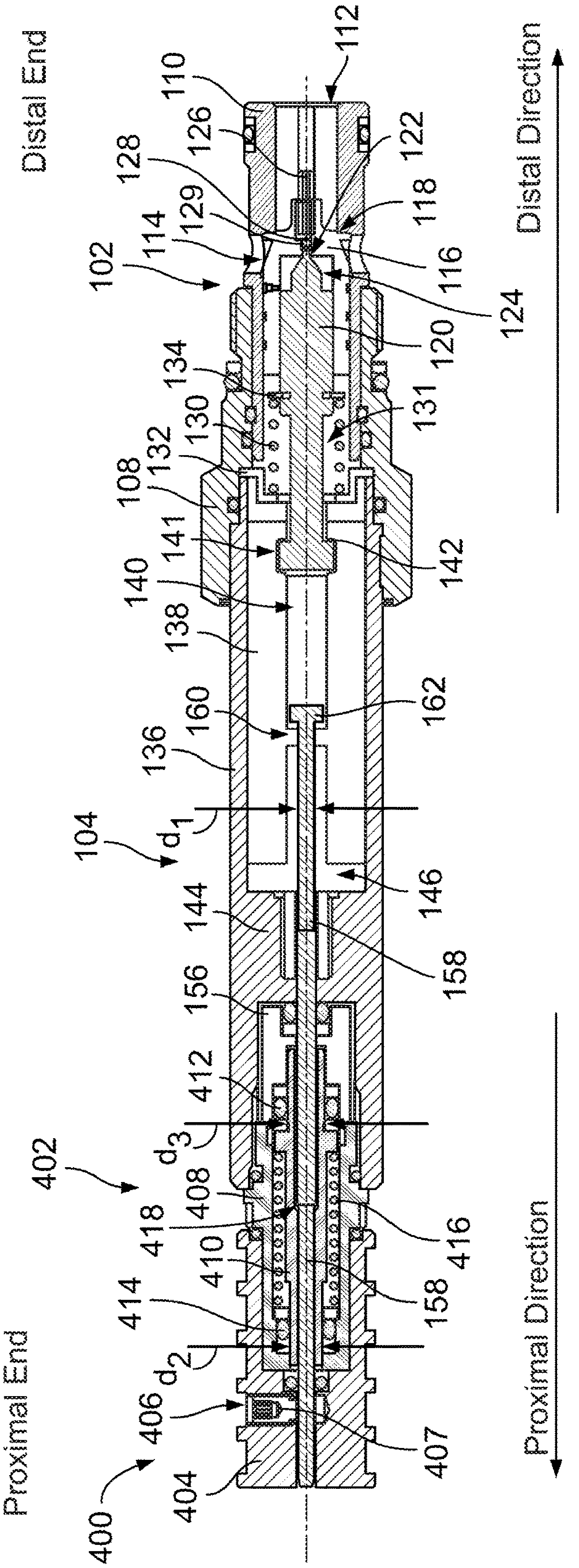
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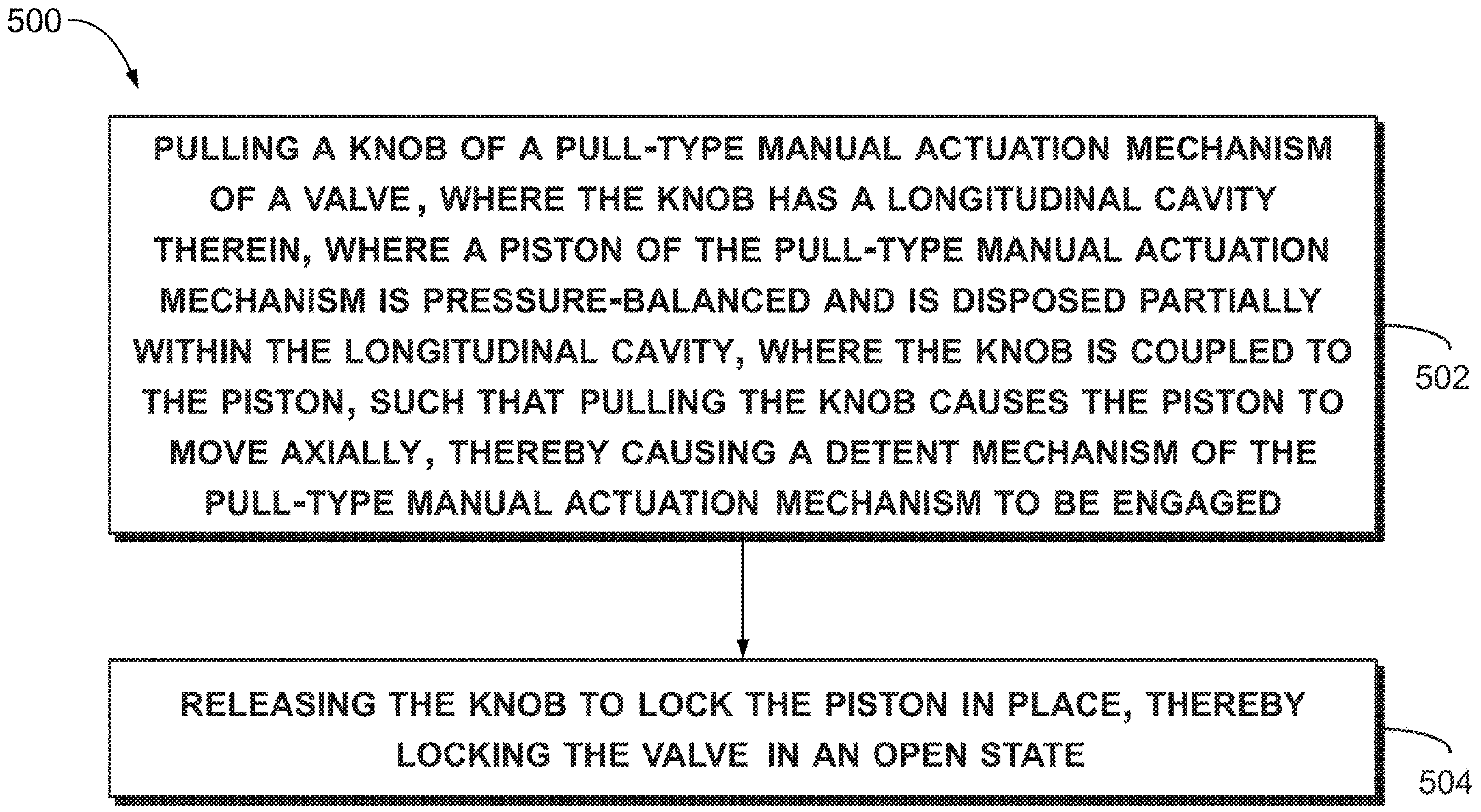
FIG. 4



PULLING A KNOB OF A PULL-TYPE MANUAL ACTUATION MECHANISM OF A VALVE, WHERE THE KNOB HAS A LONGITUDINAL CAVITY THEREIN, WHERE A PISTON OF THE PULL-TYPE MANUAL ACTUATION MECHANISM IS PRESSURE-BALANCED AND IS DISPOSED PARTIALLY WITHIN THE LONGITUDINAL CAVITY, WHERE THE KNOB IS COUPLED TO THE PISTON, SUCH THAT PULLING THE KNOB CAUSES THE PISTON TO MOVE AXIALLY, THEREBY CAUSING A DETENT MECHANISM OF THE PULL-TYPE MANUAL ACTUATION MECHANISM TO BE ENGAGED

RELEASING THE KNOB TO LOCK THE PISTON IN PLACE, THEREBY LOCKING THE VALVE IN AN OPEN STATE

FIG. 5

# PRESSURE-BALANCED PULL-TYPE MANUAL ACTUATION MECHANISM FOR A VALVE

## BACKGROUND

A hydraulic valve directs the flow of a liquid medium, usually oil, through a hydraulic system. The direction of the oil flow is determined by the position of a spool or a poppet. An example valve may have a movable element inside a housing or sleeve. For instance, the valve may include a poppet that is movable by an actuation mechanism (e.g., electric, hydraulic, pneumatic, or manual). The poppet may be seated on a valve seat formed inside the housing. Once the valve is actuated, the poppet moves off the seat to allow flow around the poppet from a first port to a second port.

In examples, if the valve is a manually-actuated valve, then to actuate the valve, an operator may apply a large force to a knob or a similar element to overcome a large spring force applied by a spring having a high spring rate and cause the poppet to be unseated. If the valve is electrically-actuated, e.g., via a solenoid, in some cases, the solenoid fails and it may be desirable to have a manual override feature to allow the valve to be manually activated to place a machine in a safe condition. Using the manual override feature would also involve applying the large force that overcomes the aforementioned large spring force.

Further, in some examples, it may be desirable to include a detent mechanism in the valve such that when the valve is actuated, e.g., manually, the operator moves a lever or a knob until the detent mechanism is engaged. Once the detent mechanism is engaged, the operator can release the lever or knob, while the movable element remains locked in place. In the case of a large spring force, the detent mechanism is configured to be able to oppose the large spring force, and as such the detent mechanism may be complicated and costly.

Therefore, it may be desirable to have a valve that has a manual actuation mechanism that enables using a soft spring having a small spring rate such that the manual actuation force is reduced, and the complexity and cost of an associated detent mechanism is also reduced.

## SUMMARY

The present disclosure describes implementations that relate to pressure-balanced pull-type manual actuation mechanism for a valve. In a first example implementation, the present disclosure describes a pull-type manual actuation mechanism for a valve. The pull-type manual actuation mechanism includes: (i) a piston having: (a) a first flanged portion with a first annular surface area, (b) a second flanged portion with a second annular surface area, where the first flanged portion and the second flanged portion project from an exterior peripheral surface of the piston, (c) a longitudinal cavity bounded by an interior peripheral surface of the piston, and (d) a shoulder on the interior peripheral surface of the piston; and (ii) a pin disposed in the longitudinal cavity of the piston, where the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the pin in a given axial direction is transferred to the piston, and where a difference between the second annular surface area of the second flanged portion and the first annular surface of the first flanged portion is substantially equal to a cross-sectional area of the pin.

In a second example implementation, the present disclosure describes another pull-type manual actuation mechanism for a valve. The pull-type manual actuation mechanism includes: (i) a knob having a first longitudinal cavity therein; (ii) a sleeve disposed in the first longitudinal cavity coaxial with the knob, where the sleeve has a second longitudinal cavity therein; (iii) a piston disposed in the second longitudinal cavity coaxial with the sleeve, where the knob is coupled to the piston such that as the knob is pulled in a given axial direction, the piston moves in the given axial direction along with the knob, where the piston has: (a) a first flanged portion having a first annular surface area, (b) a second flanged portion having a second annular surface area, where the first flanged portion and the second flanged portion project from an exterior peripheral surface of the piston, (c) a third longitudinal cavity bounded by an interior peripheral surface of the piston, and (d) a shoulder on the interior peripheral surface of the piston; and (iv) a pin disposed and axially movable in the third longitudinal cavity of the piston, where an end of the pin is configured to be subjected to pressurized fluid from an inlet of the valve, where the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the end of the pin via the pressurized fluid in the given axial direction is transferred to the piston, and where a difference between the second annular surface area of the second flanged portion and the first annular surface of the first flanged portion is substantially equal to a cross-sectional area of the pin.

In a third example implementation, the present disclosure describes a valve. The valve includes: (i) a main valve section; and (ii) a pull-type manual actuation mechanism. The main valve section includes a housing; a sleeve disposed in the housing, where the sleeve defines a first port and a second port; and a movable element configured to move axially within the sleeve. The pull-type manual actuation mechanism includes: (i) a knob having a first longitudinal cavity therein; (ii) a piston disposed partially within the first longitudinal cavity, where the knob is coupled to the piston, where the piston has: (a) a first flanged portion having a first annular surface area, (b) a second flanged portion having a second annular surface area, where the first flanged portion and the second flanged portion project from an exterior peripheral surface of the piston, and (c) a second longitudinal cavity bounded by an interior peripheral surface of the piston, and (d) a shoulder on the interior peripheral surface of the piston; and (iii) a pin disposed in the second longitudinal cavity of the piston, where the pin is coupled to the movable element of the main valve section, where the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the pin in a given axial direction via pressurized fluid received at the second port acting on a cross-sectional area of the pin is transferred to the piston. A difference between the second annular surface area of the second flanged portion and the first annular surface area of the first flanged portion is substantially equal to the cross-sectional area of the pin, such that when pressurized fluid is communicated to the first annular surface area and the second annular surface area, the piston is pressure-balanced. When the knob is pulled in the given axial direction, the piston moves in the given axial direction along with the knob, allowing the pin and the movable element coupled thereto to move in the given axial direction, thereby allowing fluid to flow from the second port to the first port.

The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the

illustrative aspects, implementations, and features described above, further aspects, implementations, and features will become apparent by reference to the figures and the following detailed description.

## BRIEF DESCRIPTION OF THE FIGURES

FIG. **1**A illustrates a cross section of an example valve in a closed position, in accordance with an example implementation.

FIG. **1**B illustrates a zoomed-in view of a portion of the valve shown in FIG. **1**A, in accordance with an example implementation

FIG. **2**A illustrates the valve of FIG. **1**A including a detent mechanism while the valve is in a closed state and the detent mechanism is disengaged, in accordance with an example implementation.

FIG. **2**B illustrates the valve of FIG. **2**A locked in an open state with the detent mechanism in an engaged state, in accordance with another example implementation.

FIG. **3** illustrates a cross-sectional view of a valve, in accordance with an example implementation.

FIG. **4** illustrates a cross-sectional view of another valve, in accordance with an example implementation.

FIG. **5** illustrates a flowchart of an example method of operating a valve, in accordance with an example implementation.

## DETAILED DESCRIPTION

In examples, a normally-closed valve may have a poppet that is seated on a seat formed as a protrusion from an interior peripheral surface of a cage, sleeve, valve body, or housing. When the valve is actuated, the poppet is unseated and moves within the valve body to form a gap between an exterior peripheral surface of the poppet and the seat, thereby allowing fluid to flow from an inlet through the gap to an outlet. The valve may be a proportional valve where an axial position of the poppet affects the amount the flow rate across the valve for a given pressure drop between the inlet and the outlet.

In examples, the poppet may be unseated using an electric force applied by a solenoid or by direct manual actuation. If the poppet is unseated via a solenoid, it may be desirable to have a manual-override feature to allow manual actuation of the valve in the case of a solenoid failure. An example manual actuation of the valve may have a movable element, such as a pin, that is subjected to inlet pressure of the valve, which could be as high as 6000 psi. The inlet pressure thus applies a large force on the pin. For instance, for a pin having a diameter of 0.078 inches, the force may be 28.65 lbs. To maintain the pin within a particular chamber of the valve and preclude it from moving when subjected to pressure spikes at the inlet of the valve, a spring with a large spring rate is disposed in the manual actuation mechanism to oppose the large force applied to the pin. For instance, the spring may be configured to apply a force of about 30 to 35 lbs or more to oppose the force applied to the pin. Whether the valve is manually actuated or includes a manual override feature, to actuate the valve, an operator may apply a large force against the large spring force and against friction of seals and other springs within the valve. Such large force that the operator applies may be difficult to achieve and may lead to operator fatigue.

Further, in some valve configurations, the pressure at the inlet is communicated to the manual actuation mechanism and the operator may apply a force that opposes both the spring force and the inlet pressure applied on a component within the manual actuation mechanism. As the poppet is unseated, the pressure at the inlet collapses as fluid flows from the inlet to the outlet. Thus, the force that the operator has been applying to overcome an initial large inlet pressure and the spring may cause the poppet to suddenly move a large axial distance, thus allowing a large flow rate across the valve. This configuration renders the valve operating as an on-off valve, not a proportional valve as may be desired. Such sudden increase in flow rate may cause an actuator (e.g., a cylinder or motor) controlled by the valve to move faster than expected, which may be undesirable.

Thus, it may be desirable to configure the valve such that the manual actuation mechanism is pressure-balanced regardless of the pressure level at the inlet. This way, a soft spring may be used rather than a stiff spring having a large spring rate. Also, a pressure-balanced configuration is insensitive to the pressure level at the inlet, and thus the operator can operate the valve proportionally as the change in pressure level at the inlet does not affect the amount of force that the operator applies to move the poppet.

FIG. **1**A illustrates a cross section of an example valve **100** in a closed position, in accordance with an example implementation. The valve **100** may include a main valve section **102**, a pull-type solenoid actuator mechanism **104**, and a pull-type manual actuation mechanism **106**.

The main valve section **102** includes a housing **108** that defines a longitudinal cylindrical cavity therein. The longitudinal cylindrical cavity of the housing **108** is configured to receive at a distal or first end thereof a cage or sleeve **110** coaxial with the housing **108**. The sleeve **110** defines a first port **112** and a second port **114**. The first port **112** is defined at a nose of the sleeve **110**, whereas the second port **114** may be defined as holes disposed in a radial array about an exterior surface of the sleeve **110**. The valve **100** is configured to control flow of fluid between the second port **114** and the first port **112**.

The sleeve **110** defines a respective longitudinal cylindrical cavity therein, and a first poppet **116** is disposed in the cavity defined within the sleeve **110**, where the first poppet **116** is coaxial with the housing **108** and the sleeve **110**. The first poppet **116** could also be referred to as a main or primary poppet.

In the closed position shown in FIG. **1**A, the first poppet **116** is seated on a seat **118** defined by an interior peripheral surface of the sleeve **110**. The first poppet **116** has a respective tapered circumferential surface that contacts the seat **118** when the first poppet **116** is seated.

The first poppet **116** defines a respective longitudinal cylindrical cavity therein. A second poppet **120** is disposed in the cavity defined within the first poppet **116**, and the second poppet **120** is coaxial with the housing **108**, the sleeve **110**, and the first poppet **116**. The second poppet **120** may also be referred to as a dart or secondary poppet.

In the closed position shown in FIG. **1**A, the second poppet **120** is seated on a seat **122** defined by an interior peripheral surface of the first poppet **116**. The second poppet **120** has a respective tapered circumferential surface that contacts the seat **122** when the second poppet **120** is seated. Further, a chamber **124** is defined within the first poppet **116** between an exterior peripheral surface of the second poppet **120** and the interior peripheral surface of the first poppet **116**.

The valve **100** further includes a roll pin **126** coupled to a ball **128** (e.g., a metal sphere) that operates as a check valve. The roll pin **126** and the ball **128** are disposed within the first poppet **116** at a nose section or a distal end thereof.

The ball **128** blocks a longitudinal passage or longitudinal channel **129** defined in the distal end of the first poppet **116**, and thus the ball **128** blocks fluid flow from the first port **112** through the nose section of the first poppet **116** and the longitudinal channel **129** to the chamber **124** when the second poppet **120** is unseated. However, when the second poppet **120** is unseated, fluid flows from the chamber **124** though the longitudinal channel **129**, pushing the ball **128** and the roll pin **126**, to flow to the first port **112**.

The valve **100** further includes a spring **130** disposed in a chamber **131** defined within the sleeve **110** and the housing **108**. The spring **130** is disposed around an exterior peripheral surface of the second poppet **120** between a spring support member **132** fixedly disposed in the longitudinal cavity of the housing **108** and a washer or retaining ring **134** disposed in a groove defined in the exterior surface of the second poppet **120**. The spring **130** applies a force on the retaining ring **134**, and thus on the second poppet **120**, in a closing distal direction (e.g., to the right in FIG. **1**A). As a result of the force applied by the spring **130** on the second poppet **120**, the second poppet **120** remains seated at the seat **122**.

The second poppet **120** is configured to move axially in the cavity defined within the first poppet **116** when the valve **100** is actuated by any type of actuation mechanisms. As depicted in FIG. **1**A, the valve **100** includes the pull-type solenoid actuator mechanism **104** configured to move the second poppet **120**; however, other actuation mechanisms could be used.

In examples, the pull-type solenoid actuator mechanism **104** may include a solenoid tube **136** disposed within and received at a proximal or second end of the housing **108**, such that the solenoid tube **136** is coaxial with the housing **108**. A solenoid coil (not shown) may be disposed about an exterior surface of the solenoid tube **136**.

The solenoid tube **136** is configured to house a plunger or armature **138**. The armature **138** defines therein a longitudinal channel **140**. The armature **138** also defines an annular internal groove **141** on an interior peripheral surface of the armature **138**, where the annular internal groove **141** is formed as a recessed portion from the longitudinal channel **140** and is configured to receive an enlarged proximal end **142** of the second poppet **120**. With this configuration, the second poppet **120** is coupled to the armature **138**, and thus, axial motion of the armature **138** causes the second poppet **120** to move axially as well.

Further, the solenoid tube **136** defines a pole piece **144** formed as a protrusion from an interior peripheral surface of the solenoid tube **136**. The pole piece **144** is separated from the armature **138** by an airgap **146**. The pole piece **144** may be composed of material of high magnetic permeability.

When an electric current is provided through the windings of the solenoid coil, a magnetic field is generated. The pole piece **144** directs the magnetic field through the airgap **146** toward the armature **138**, which is movable and is attracted toward the pole piece **144**. In other words, when an electric current is applied to the solenoid coil, the generated magnetic field forms a north and south pole in the pole piece **144** and the armature **138**, and therefore the pole piece **144** and the armature **138** are attracted to each other. Because the pole piece **144** is fixed as part of the solenoid tube **136** and the armature **138** is movable, the armature **138** traverses the airgap **146** toward the pole piece **144**.

As the armature **138** moves toward the pole piece **144**, the second poppet **120** also moves axially against a force of the spring **130** and is thus unseated off the seat **122**. As a result, fluid in the chamber **124** is allowed to flow through the longitudinal channel **129**, thereby pushing the ball **128** and the roll pin **126**, and then flowing to the first port **112**. The first port **112** may be fluidly coupled to a low pressure reservoir or tank. Thus, the pressure level in the chamber **124** is reduced as the fluid is vented from the chamber **124** through the first port **112** to the tank.

The second port **114** may be fluidly coupled to a source of pressurized fluid (e.g., a pump or accumulator). The pressurized fluid received at the second port **114** applies a force on a tapered exterior peripheral surface of a nose or distal end of the first poppet **116**. Because of the difference in pressure level between the fluid received at the second port **114** and the fluid in the chamber **124**, the first poppet **116** is moved axially in a proximal direction (e.g., to the left in FIG. **1**A) and is unseated off the seat **118**. Thus, a gap or flow area is formed between the exterior surface of the first poppet **116** and the interior peripheral surface of the sleeve **110**, thus allowing fluid to flow from the second port **114** around the first poppet **116** through the flow area to the first port **112**.

In some cases, the pull-type solenoid actuator mechanism **104** might fail, might become inoperable, or might not operate as expected. In these cases, sending an electric signal to the windings of the solenoid coil might not cause the first poppet **116** to be unseated. As a safety feature, it may be desirable for the valve **100** to include the pull-type manual actuation mechanism **106** that allows an operator to manually override the pull-type solenoid actuator mechanism **104**. Specifically, the pull-type manual actuation mechanism **106** may allow the operator to manually pull the armature **138** toward the pole piece **144** to unseat the second poppet **120**, which causes the first poppet **116** to be unseated, thus allowing flow from the second port **114** to the first port **112** as described above. In some examples, the valve **100** might not include the pull-type solenoid actuator mechanism **104**, and the pull-type manual actuation mechanism **106** operates as the actuation mechanism for the valve **100**.

The pull-type manual actuation mechanism **106** includes a knob **148** that defines a respective longitudinal cylindrical cavity therein. A sleeve **150** is fixedly disposed partially in the cavity defined within the knob **148** and partially in a cavity defined within a proximal end of the solenoid tube **136**. The sleeve **150** is coaxial with the knob **148** and the solenoid tube **136**.

Further, the sleeve **150** defines a respective longitudinal cylindrical cavity therein and houses a piston **154** that is axially movable within the longitudinal cylindrical cavity of the sleeve **150**. The piston **154** may include one or more grooves on an exterior peripheral surface thereof that correspond to respective one or more grooves in the interior peripheral surface of the knob **148**, such that roll pins **155**A and **155**B are disposed partially in the grooves of the piston **154** and partially in the grooves of the knob **148**. With this configuration, the knob **148** is coupled to the piston **154**, such that moving the knob **148** axially causes the piston **154** to move axially therewith.

A spacer **156**, which may be ring-shaped, is disposed within the cavity defined at the proximal end of the solenoid tube **136**. The spacer **156** interfaces with the sleeve **150** and is configured to house a portion of the piston **154** in a cavity defined within the spacer **156**.

The piston **154** also defines therein a respective longitudinal cylindrical cavity that houses a pin **158**. The pin **158** extends longitudinally between the knob **148** and the armature **138** such that the pin **158** is disposed partially within the knob **148**, partially within the piston **154** and the sleeve **150**, partially within the spacer **156**, partially within the solenoid tube **136**, and partially within the armature **138**.

The armature **138** includes a protrusion **160** emanating from the interior peripheral surface of the armature **138** into the longitudinal channel **140** to define a restriction therein through which the pin **158** is disposed. The pin **158** has an enlarged distal end **162** disposed in a recessed area of the interior peripheral surface of the armature **138** formed as a result of the protrusion **160**. With this configuration, if the pin **158** is moved axially in a proximal direction (e.g., to the left in FIG. 1A), the enlarged end **162** of the pin **158** engages the protrusion **160** of the armature **138**, thus causing the armature **138** to move axially along with the pin **158**. As described above, axial motion of the armature **138** causes the second poppet **120** to move axially therewith due to the engagement of the enlarged proximal end **142** of the second poppet **120** with the armature **138**. As such, the pin **158** is indirectly coupled to the second poppet **120** via the armature **138**.

The pull-type manual actuation mechanism **106** further includes a spring **164** disposed about an exterior peripheral surface of the piston **154** within the cavity defined by the sleeve **150**. The spring **164** is supported between a shoulder **166** defined by the interior peripheral surface of the sleeve **150** and a flanged portion **168** defined as a rim, collar, or rib projecting from the exterior peripheral surface of the piston **154**.

The sleeve **150** is fixed, whereas the piston **154** is axially movable therein. Thus, the spring **164** applies a force on the piston **154** that maintains the piston **154** biased in a distal direction, e.g., to the right in FIG. **1**A.

Further, the piston **154** defines a shoulder **170** (e.g., a stepped surface with a reduction in internal diameter of the piston **154**) against which the pin **158** rests. Specifically, the pin **158** may define a shoulder (a stepped surface) with an enlarged diameter that rests against the shoulder **170**, such that forces applied to the pin **158** in the proximal direction (e.g., to the left in FIG. **1**) are transferred to the piston **154** via the shoulder **170**.

In operation, pressurized fluid may be received at the second port **114** as described above. The pressurized fluid is communicated through unsealed space between the interior peripheral surface of the sleeve **110** and the exterior peripheral surface of the first poppet **116** to the chamber **131** within which the spring **130** is disposed. The pressurized fluid is then communicated around the second poppet **120** and through unsealed space between the interior peripheral surface of the armature **138** and the exterior peripheral surface of the second poppet **120** to the longitudinal channel **140**.

The pressurized fluid in the longitudinal channel **140** applies a force on the pin **158** in a proximal direction, e.g., to the left in FIG. **1**. This force may be estimated as the pressure level of the pressurized fluid in the longitudinal channel **140** multiplied by cross-sectional area "$A_1$" of the pin **158** that is equal to $\pi d_1^2/4$ where "$d_1$" is the diameter of the pin **158** as labelled in FIG. **1**A. The area "$A_1$" is the difference between an area of an end face of the enlarged end **162** of the pin **158** and an annular area on the other side of the enlarged end **162**, which interfaces with the protrusion **160**. Thus, assuming that the pressure level of the pressurized fluid "P," then the force applied to the pin **158** is $=PA_1$. This force acts in a first (proximal) axial direction, e.g., to the left in FIG. **1**A, and the force is transferred to the piston **154** via the shoulder **170**.

FIG. **1**B illustrates a zoomed-in view of a portion of the valve **100**, in accordance with an example implementation. The pressurized fluid in the longitudinal channel **140** is further communicated around the pin **158** to the cavity at the proximal end of the solenoid tube **136**, which houses the spacer **156**. The pressurized fluid may then push an O-ring **172** axially in the proximal direction (e.g., to the left in FIG. **1**B) in a cavity or axial space defined between an interior peripheral surface of the spacer **156** and the exterior peripheral surface of the pin **158**.

The pressurized fluid is then communicated around the spacer **156** through an unsealed space between the exterior surface of the spacer **156** and the interior surface of the solenoid tube **136** to the exterior peripheral surface of the piston **154** as indicated by the thick arrows depicted in FIG. **1**B. The pressurized fluid is thus communicated to a first groove **174** and a second groove **176** defined in the exterior peripheral surface of the piston **154**. The first groove **174** is bounded by the flanged portion **168** and the second groove **176** is bounded by a flanged portion **178** defined at a distal end of the piston **154**.

The pressurized fluid thus applies a force on an annular surface area "$A_2$" of the flanged portion **168** in the first (proximal) axial direction, and applies a force on an annular surface area "$A_3$" of the flanged portion **178** in a second (distal) axial direction opposite the first (proximal) axial direction. Therefore, the resultant force acting on the piston **154** can be estimated by the following equation:

$$F=PA_1+PA_2-PA_3=P(A_1+A_2-A_3) \tag{1}$$

The valve **100** is configured such that the area difference $A_3-A_2$ is substantially equal to the area $A_1$. The term "substantially" is used, for example, to indicate that the area difference $A_3-A_2$ is equal to the area $A_1$ or within a threshold area or percentage area (e.g., ±1-3%) from the area $A_1$. As a result, $(A_1+A_2-A_3)$ is substantially equal to zero, and thus the force "F" defined by equation (1) is substantially equal to zero (e.g., within a threshold force value, such as 1 lbs, from zero lbs).

With this configuration, the piston **154** is pressure-balanced as the pressurized fluid communicated from the second port **114** exerts opposing forces on the piston **154** on surface areas that are selected such that the resultant force exerted on the piston **154** is substantially equal to zero. As a result, the spring **164** could be configured as a soft spring having a small spring rate that is sufficient to bias the piston **154** and the pin **158** in the distal direction (e.g., to the right in FIG. **1**B) to maintain the second poppet **120** seated and the valve **100** closed. For example, the spring **164** may exert a small force in a range between 2 lbs and 4 lbs. As an example for illustration, the spring **164** may have a spring rate of about 20 lbs/inch, and thus if the spring **164** is compressed by 0.15 inches, then the spring **164** applies a force of 3 lbs on the piston **154**.

As an example for illustration, assuming that the diameter "$d_1$" is 0.08 inches, then the cross-sectional area "$A_1$" can be determined to be about 0.005 square inches. Assuming that the pressure level "P" is about 5000 psi, then the force applied on the pin **158** in the first (proximal) direction can be determined to be about 25 lbs. If the piston **154** is not pressure-balanced, then the spring **164** would be designed to be a stiff spring to oppose such high force. For instance, the spring **164** would be configured to exert a force of about 30 lbs. However, with the configuration described above where the area difference $A_3-A_2$ is substantially equal to $A_1$, the piston **154** is pressure-balanced, and the spring **164** could be configured as a soft spring with a small spring rate, and the spring **164** applies a small force (e.g., 2-4 lbs) to maintain the valve **100** closed.

The pressure-balanced configuration enabling the spring **164** to be a soft spring, enhances operation of the pull-type manual actuation mechanism **106**. When an operator pulls the knob **148** to manually actuate the valve **100**, the operator overcomes the force of the spring **164** to move the piston **154** in the proximal direction in addition to other resisting force resulting from seal friction for example and the spring **130**. If the spring **164** has a high spring rate causing a large force (e.g., 30 lbs), then the operator applies a large force (e.g., 36 lbs) to be able to overcome the spring **164** and move the piston **154**. However, if the spring **164** is a soft spring with a small spring rate causing a small force (e.g., 4 lbs), then the operator applies a corresponding small force (e.g., 12-18 lbs) to be able to overcome the spring **164**, friction forces, and the spring **130**, and move the piston **154**. This way, operator fatigue may be avoided as the effort exerted in operating the pull-type manual actuation mechanism **106** is reduced.

Further, with the pressure-balanced configuration, operation of the pull-type manual actuation mechanism **106** is insensitive to variation of the pressure level "P" at the second port **114**. The pressure level "P" may change during operation of the valve **100**. For instance, as soon as the first poppet **116** is moved off the seat **118**, the pressure level "P" at the second port **114** may collapse (e.g., may be reduced at a high rate of pressure reduction). However, regardless of the pressure level "P," the pressurized fluid is communicated to the pull-type manual actuation mechanism **106** and applies forces on the areas $A_1$, $A_2$, and $A_3$ as described above, and the piston **154** is maintained in a pressure-balanced state. Thus, regardless of the variation of the pressure level "P," the operator overcomes a fixed spring force of the spring **164**, friction forces, and the force of the spring **130**.

This way, consistent operation of the pull-type manual actuation mechanism **106** is achieved. In other words, for a given pulling force level that the operator applies on the knob **148**, the piston **154** moves proximally a corresponding axial distance that is consistent regardless of the pressure level "P." Thus, proportional control of the valve **100** via manual actuation is enabled.

As the piston **154** moves axially in the proximal direction (e.g., to the left in FIGS. **1A-1B**) when the operator pulls the knob **148**, the pressurized fluid in the longitudinal channel **140** applies a force on the pin **158** (e.g., on the enlarged end **162**) that causes the pin **158** to also move axially in the proximal direction. In some cases, the pressure level "P" in the longitudinal channel **140** might be low and might not be sufficient to apply a force on the pin **158** to move it in the proximal direction. As such, a wire **180** (e.g., a protrusion) is disposed about the exterior peripheral surface of the pin **158** toward the proximal end thereof that enables the piston **154** to move the pin **158** when the pressure level "P" is low. Particularly, the interior peripheral surface of the piston **154** engages with the wire **180** as the piston **154** move in the proximal direction, and thus the piston **154** drags the pin **158** along in the proximal direction.

As the pin **158** move axially in the proximal direction, the pin **158** applies a force on the armature **138** via the protrusion **160**, thus causing the armature **138** to also move axially in the proximal direction. Referring back to FIG. **1A**, as the armature **138** moves axially in the proximal direction, the armature **138** causes the second poppet **120** to also move axially in the same direction as a result of the enlarged proximal end **142** being coupled to the armature **138**. The second poppet **120** thus moves off the seat **122**, which causes the first poppet **116** to move off the seat **118** to follow the second poppet **120** as described above. As a result, the valve **100** is activated manually by pulling the knob **148**.

In some examples, the operator pulls the knob **148** and holds the knob **148** in a pulled position to maintain the valve **100** in an activated state; however, if the operator releases the knob **148**, the valve **100** returns to an unactivated (closed) state. In other examples, a detent mechanism may be added to the valve **100** to enable the operator to release the knob **148**, yet lock the valve **100** in an open or activated state.

FIG. **2A** illustrates the valve **100** including a detent mechanism while the valve **100** is in a closed state and the detent mechanism is disengaged, in accordance with an example implementation. The detent mechanism may include, for example, a spring **200**, a spacer **202**, and a plurality of balls (e.g., metal spheres), such as balls **204**A, **204**B. The balls of the detent mechanism may be disposed in respective holes formed in the sleeve **150**, and the balls may be disposed in a radial array about the sleeve **150**. FIG. **2A** depicts the two balls **204**A, **204**B; however, in other example implementations, more or fewer balls could be used. For instance, four balls may be disposed in a radial array about the sleeve **150**.

The spring **200** is constrained between (i) a flanged portion **206** formed as a rim, collar, or rib projecting from the exterior peripheral surface of the sleeve **150**, and (ii) the spacer **202**. The sleeve **150** is fixed or immovable, while the spacer **202** is slidably disposed about the exterior peripheral surface of the sleeve **150**. The spacer **202** is ring-shaped and is configured to interface with and contact the balls **204**A-**204**B. The spring **200** applies a force on the spacer **202** in the proximal direction, and thus the spacer **202** in turn applies a force on the balls **204**A-**204**B in the proximal direction as well.

Further, the piston **154** defines a groove **208** on the exterior peripheral surface of the piston **154**, and the groove **208** operates as a detent. In other example implementations, rather than the groove **208**, the exterior peripheral surface of the piston **154** may include holes corresponding to the balls of the detent mechanism. In operation, as the operator pulls the knob **148** in the proximal direction, and accordingly pulls the piston **154** via the roll pins **155**A, **155**B, the groove **208** becomes aligned with the balls (e.g., the balls **204**A, **204**B). Under spring pressure from the spring **200** pushing the spacer **202** in the proximal direction, the spacer **202** pushes the balls causing the balls to move partially in, and engage with, the groove **208**.

FIG. **2B** illustrates the valve **100** locked in an open state with the detent mechanism in an engaged state, in accordance with an example implementation. As described above, when the operator pulls the knob **148**, the piston **154** is also pulled via the roll pins **155**A, **155**B. As the piston **154** moves axially, the balls **204**A, **204**B engage with the groove **208** due to action of the spring **200** on the spacer **202**, and action of the spacer **202** on the balls **204**A, **204**B.

The pin **158** follows the piston **154** as a result of the pressurized fluid in the longitudinal channel **140** applying a force on the pin **158** and/or due to engagement between the piston **154** and the pin **158** via the wire **180**. As described above, axial motion of the pin **158** causes the armature **138** to move axially, thus causing the second poppet **120** to move off the seat **122**. The first poppet **116** follows the second poppet **120** moving off the seat **118** as shown in FIG. **2B**, and the valve **100** is open where fluid is allowed to flow from the second port **114** to the first port **112**.

If the operator releases the knob **148**, the piston **154** does not return back (e.g., does not move in the distal direction) because the spring **200** maintains pressure on the spacer **202**, which maintains respective pressure on the balls **204**A, **204**B, thus holding the piston **154** in position. With this configuration, the piston **154** is locked in place even when the knob **148** is released, and the valve **100** is thus locked in the open state.

As depicted in FIG. **2**B, while the valve **100** is in the open state and the detent mechanism is engaged, the airgap **146** shrinks to a small gap **210**. For instance, the small gap could be about 0.01 inches; however, other values are possible. Configuring the valve **100** to have the gap **210** when the detent mechanism is engaged, precludes the armature **138** from ending its stroke, i.e., contacting the pole piece **144**, prior to the balls **204**A, **204**B snapping into place within the groove **208** to lock the piston **154**. In other words, having the gap **210** ensures that the detent mechanism is engaged prior to the armature **138** reaching the end of its stroke.

To unlock the detent mechanism, additional force may be applied to the knob **148** in the distal direction (to the right in FIG. 2B) to push the balls **204**A, **204**B out of the groove **208**, thus allowing the piston **154** to move in the distal direction.

The pressure-balanced configuration of the pull-type manual actuation mechanism **106** simplifies the detent mechanism described above. Particularly, the pressure-balanced configuration of the pull-type manual actuation mechanism **106** enables the valve **100** to operate with a soft spring, i.e., the spring **164**. Thus, the detent mechanism holds the piston **154** locked against the small force caused by the spring **164**. As such, the spring **200** may also be a soft spring, and no additional components or operations are used to hold the balls **204**A, **204**B in the detent (e.g., in the groove **208**).

Without the piston **154** being pressure-balanced, the spring **164** would have been a stiff spring applying a large force on the piston **154** in the closing direction. In this case, the spring **200** would have been a stiff spring and additional components and operations may be implemented to ensure that the balls **204**A, **204**B remain engaged with the groove **208** when the knob **148** is released. Thus, the pressure-balanced configuration of the pull-type manual actuation mechanism **106** may reduce the cost and complexity of the valve **100**.

The configurations and components shown in FIGS. **1**A-**1**B and **2**A-**2**B are examples for illustration, and different configurations and components could be used. For example, different types of springs could be used. The knob **148** may be replaced by any type of collar coupled to a lever for manual actuation. Also, the detent mechanism shown in FIGS. **2**A-**2**B may be used in some configurations and applications, and might not be used in others. In other examples, several components may be integrated into a single component rather than having separate components to simplify the valve **100**. As a specific example, the spacer **156** may be integrated with the solenoid tube **136** into a single component as described next.

FIG. **3** illustrates a cross-sectional view of a valve **300**, in accordance with an example implementation. Similar components between the valve **100** and the valve **300** are designated with the same reference numbers. As shown, the main valve section **102** is the same between the valve **100** and the valve **300**. The valve **300** includes a pull-type solenoid actuator mechanism **302** that is similar to the pull-type solenoid actuator mechanism **104**, except that the spacer **156** is integrated with the pole piece **144** to form a pole piece **304**, which is a portion of a solenoid tube **306** shown in FIG. **3**.

The valve **300** includes a pull-type manual actuation mechanism **308** having the knob **148** that defines a longitudinal cylindrical cavity therein. A sleeve **310** is fixedly disposed partially in the cavity defined within the knob **148** and partially in a cavity defined within a proximal end of the solenoid tube **306**. The sleeve **310** is coaxial with the knob **148** and the solenoid tube **306**.

Further, the sleeve **310** defines a respective longitudinal cylindrical cavity therein and houses a piston **312** that is axially movable within the longitudinal cylindrical cavity of the sleeve **310**. The piston **312** may include grooves on an exterior peripheral surface thereof that correspond to respective grooves in the interior peripheral surface of the knob **148**, such that the roll pins **155**A and **155**B are disposed partially in the grooves of the piston **312** and partially in the grooves of the knob **148**. With this configuration, the knob **148** is coupled to the piston **312**, such that moving the knob **148** axially, e.g., to the left in FIG. **3**, causes the piston **312** to move axially therewith.

The piston **312** also defines therein a respective longitudinal cylindrical cavity that houses the pin **158**. The pull-type manual actuation mechanism **308** further includes a spring **314** disposed about an exterior peripheral surface of the piston **312** within the cavity defined by the solenoid tube **306**. The spring **314** is supported between a distal end **316** of the sleeve **310** and a flanged portion **318** defined as a rim, collar, or rib projecting from the exterior peripheral surface of the piston **312**.

The sleeve **310** is fixed, whereas the piston **312** is axially movable therein. Thus, the spring **314** applies a force on the piston **312** that maintains the piston **312** biased in the distal direction.

Further, the piston **312** defines a shoulder **320** against which the pin **158** rests. Specifically, the pin **158** may define an area with an enlarged diameter that rests against the shoulder **320**, such that forces applied to the pin **158** in the proximal direction are transferred to the piston **312** via the shoulder **320**.

In operation, as described above with respect to the valve **100**, the pressurized fluid received at the second port **114** through unsealed spaces to the longitudinal channel **140**. The pressurized fluid in the longitudinal channel **140** applies a force on the pin **158** in the proximal direction, where the force is equal to $PA_1$. This force acts in the first (proximal) axial direction, and is transferred to the piston **312** via the shoulder **320**.

The solenoid tube **306** further includes a hole **322** (e.g., a drilled hole) that is configured to receive the pressurized fluid from the longitudinal channel **140** and communicate the pressurized fluid through an unsealed space between the interior peripheral surface of the pole piece **304** and the exterior peripheral surface of the piston **312** to a first groove **324** and a second groove **326** defined in the exterior peripheral surface of the piston **312**. The first groove **324** is bounded by a flanged portion **328** and the second groove **326** is bounded by a flanged portion **330** defined at a distal end of the piston **312**.

The pressurized fluid thus applies a force on an annular surface area "$A_4$" of the flanged portion **328** in the first (proximal) axial direction, and applies a force on an annular surface area "$A_5$" of the flanged portion **330** in the second (distal) axial direction opposite the first (proximal) axial direction. Therefore, the resultant force acting on the piston **312** can be estimated by the following equation

$$F=PA_1+PA_4-PA_5P(A_1+A_4-A_5) \tag{2}$$

In an example, A4 could be equal to A2, and A5 may be equal to A3. However, in another example, A4 might not be equal to A2, and A5 might not be equal to A3. In either example, the area difference $A_5-A_4$ is substantially equal to the area $A_1$. The term "substantially" is used herein to indicate that the area difference $A_5-A_4$ is equal to the area $A_1$ or within a threshold area or percentage area (e.g., ±1-3%) from the area $A_1$. As a result, $A_1+A_4-A_5$) is substantially equal to zero, and thus the force "F" defined by equation (2) is substantially equal to zero (e.g., within a threshold force value, such as 1 lbs, from zero lbs).

As such, the piston **312** is similar to the piston **154** in that the piston **312** is pressure-balanced as the pressurized fluid exerts opposing forces on the piston **312** on surface areas that are selected such that the resultant force exerted on the piston **312** is substantially equal to zero. With this configuration, the spring **314** could be a soft spring having a small spring rate that is sufficient to bias the piston **312** and the pin **158** in the distal direction to maintain the second poppet **120** seated and the valve **100** closed. For example, the spring **314** may exert a small force in a range between 2 lbs and 4 lbs.

As such, the valve **300** represents a variation in the configuration of the components relative to the valve **100**. With the configuration shown in FIG. **3**, the valve **300** is shorter than the valve **100** as the valve **300** does not include an elongated chamber that houses the detent mechanism shown in FIGS. **2A-2B**. However, in other examples, the detent mechanism could also be added to the valve **300**.

Further, the valve **300** does not include the spacer **156**; rather, the pole piece **304** and the solenoid tube **306** are different from the pole piece **144** and the solenoid tube **136**, respectively, such that the spacer **156** is integrated in the solenoid tube **306**. The solenoid tube **306**, however, includes the hole **322**, which operates as a channel or passage to communicate fluid to the surfaces areas $A_4$ and $A_5$ as described above.

FIG. **4** illustrates a cross-sectional view of another valve **400**, in accordance with an example implementation. Similar components between the valve **100**, **300**, and the valve **400** are designated with the same reference numbers. As shown, the main valve section **102** and the pull-type solenoid actuation mechanism **104** are substantially similar between the valve **100** and the valve **400**.

The valve **400** includes a pull-type manual actuation mechanism **402** having a knob **404** that defines a longitudinal cylindrical cavity therein. The knob **404** has a threaded blind hole **406** configured to receive a set screw **407** that then engages and grabs the pin **158**. With this configuration, as the knob **404** is pulled axially in the proximal direction (e.g., to the left in FIG. **4**), the pin **158** also moves axially along with the knob **404**. This configuration is an alternative to the configuration described above including the roll pins **155**A, **155**B and the wire **180**. Other configurations are also possible.

A sleeve **408** is fixedly disposed partially in the cavity defined within the knob **404** and partially in a cavity defined within a proximal end of the solenoid tube **136**. The sleeve **408** is coaxial with the knob **404** and the solenoid tube **136**.

Further, the sleeve **408** defines a respective longitudinal cylindrical cavity therein and houses a piston **410** that is axially movable within the longitudinal cylindrical cavity of the sleeve **408**. The piston **410** has a different configuration compared to the pistons **154**, **312**; however, similar to the pistons **154**, **312**, the piston **410** is also pressure-balanced.

Particularly, similar to the valve **100** and as similarly described above with respect to FIGS. **1A-1B**, pressurized fluid received at the second port **114** is communicated as described above through unsealed spaces to chambers or spaces formed between the spacer **156** and the piston **410** and between the sleeve **408** and the piston **410**. The pressurized fluid then acts on a cross sectional area characterized by diameter "$d_2$" in the proximal direction and acts on a cross sectional area characterized by diameter "$d_3$" in the distal direction. The difference between the cross sectional area characterized by the diameter "$d_3$" and the cross sectional area characterized by the diameter "$d_2$" is substantially equal to the cross sectional area of the pin **158** characterized by the diameter "$d_1$" on which the pressurized fluid in the longitudinal channel **140** acts in the proximal direction. As a result, the piston **410** is pressure-balanced.

A first seal **412** is disposed about the piston **410**, and specifically about a section of the piston **410** having the diameter "$d_3$," whereas a second seal **414** is disposed about the piston **410**, and specifically about a section of the piston **410** having the diameter "$d_2$." The seals **412**, **414** are disposed about sections of the piston **410** having diameters that could be less than respective diameters about which corresponding seals of the valve **100**, **300** are disposed. As such, the piston **410** may be subjected to less friction forces from the seals **412**, **414** as the piston **410** move axially because the seals **412**, **414** may cause friction about a smaller circumferential area compared to the seals in the valves **100**, **300**.

The valve **400** further includes a spring **416** disposed in a chamber formed between the interior peripheral surface of the sleeve **408** and the exterior peripheral surface of the piston **410**. The spring **416** corresponds to the spring **164** of the valve **100** and the spring **314** of the valve **300**. However, the springs **164**, **314** are disposed in respective chambers that are subjected to the atmosphere or the environment around their respective valves **100**, **300**. On the other hand, the chamber housing the spring **416** is isolated from the atmosphere or the environment of the valve **400** by way of the seal **414**. The chamber that houses the spring **416** may be filled with hydraulic oil during operation of the valve **400**. With this configuration, the probability of corrosion of the spring **416** may be reduced.

The piston **410** defines therein a respective longitudinal cylindrical cavity that houses the pin **158**. The piston **410** further defines a shoulder **418** (similar to the shoulders **170**, **320**) against which the pin **158** rests. Specifically, the pin **158** may define an area with an enlarged diameter that rests against the shoulder **418**, such that forces applied to the pin **158** in the proximal direction are transferred to the piston **410** via the shoulder **418**.

Further, as the knob **404** is pulled in the proximal direction, the pin **158** is pulled therewith as described above, and the pin **158** interacts with the piston **410** via the shoulder **418** to cause the piston **410** to move axially with the knob **404** and the pin **158** against the force of the spring **416**. Due to the pressure-balanced configuration of the piston **410**, the spring **416** may have a smaller spring rate and may be configured to apply a smaller force (e.g., 6 lbs) on the piston **410** in the distal direction compared to a non-pressure-balanced configuration.

FIG. **4** illustrates the valve **400** without a detent mechanism. However, in other example implementations, a detent mechanism could be added to the valve **400**.

The configuration of the valves **300**, **400** thus represents example variations from the valve **100**, and other configurations are also possible. Regardless of the details of construction of the pull-type solenoid actuator mechanisms **104**, **302** and the pull-type manual actuation mechanisms **106**, **308**, and **402**, the knob **148** or **404** is coupled to a pressure-balanced piston (e.g., the piston **154**, **312**, **410**). The pressure-balanced piston configuration enhances operation of the pull-type manual actuation mechanism **106**, **308**, **402**, reduces complexity of the detent mechanism if the valve includes such a detent mechanism, and achieves consistent operation of the valve regardless of the inlet pressure level at the second port **114**.

Further, the valves **100**, **300**, and **400** are shown as poppet valves; however, the pull-type manual actuation mechanisms **106**, **308**, **402** having respective pressure-balanced pistons could also be implemented for other valve configurations. For instance, the pull-type manual actuation mechanisms **106**, **308**, **402** described herein could be coupled to a spool of a spool valve to enhance manual actuation of the spool, reduce complexity of the spool valve, and achieve consistent operation regardless of an inlet pressure level. As such, the description above with respect to the pull-type manual actuation mechanisms can be applied to any valve with axially or longitudinally movable element(s), whether the movable element(s) are poppets or spools.

Further, the valves **100**, **300**, **400** are represented as electrically actuated valves having the pull-type solenoid actuator mechanisms **104**, **302**, with the pull-type manual actuation mechanisms **106**, **308**, **402** being used as manual override mechanisms that are used when the pull-type solenoid actuator mechanism **104**, **302** fails. However, in other example implementations, the pull-type manual actuation mechanisms **106**, **308**, **402** could be the primary actuation mechanisms. For instance, the pull-type manual actuation mechanisms **106**, **308**, **402** could be directly coupled to the second poppet **120**, without having the pull-type solenoid actuator mechanisms **104**, **302** disposed between the main valve section **102** and the pull-type manual actuation mechanisms **106**, **308**, **402**. As such the pull-type manual actuation mechanisms **106**, **308**, **402** could be the primary actuation mechanism, and the pressure-balanced configurations of the pull-type manual actuation mechanisms **106**, **308**, **402** enhance operation of a manually actuated valve, reduce its complexity, and achieve consistent performance.

FIG. **5** illustrates a flowchart of an example method of operating a valve, in accordance with an example implementation. Method **500** shown in FIG. **5** presents an example of a method that could be used with any of the valves (e.g., the valves **100**, **300**, **400**) described above and shown in FIGS. **1A-4**, for example. The method **500** may include one or more operations, functions, or actions as illustrated by one or more of blocks **502-504**. Although the blocks are illustrated in a sequential order, these blocks may also be performed in parallel, and/or in a different order than those described herein. Also, the various blocks may be combined into fewer blocks, divided into additional blocks, and/or removed based upon the desired implementation. It should be understood that for this and other processes and methods disclosed herein, flowcharts show functionality and operation of one possible implementation of present examples. Alternative implementations are included within the scope of the examples of the present disclosure in which functions may be executed out of order from that shown or discussed, including substantially concurrent or in reverse order, depending on the functionality involved, as would be understood by those reasonably skilled in the art.

At block **502**, the method **500** includes pulling the knob **148**, **404** of the pull-type manual actuation mechanism **106**, **308**, **402** of the valve **100**, **300**, **400** where the knob **148**, **404** has a longitudinal cavity therein, where the piston **154**, **312**, **410** of the pull-type manual actuation mechanism **106**, **308**, **402** is pressure-balanced and is disposed partially within the longitudinal cavity, where the knob **148**, **404** is coupled to the piston **154**, **312**, **410** directly or indirectly via the pin **158** such that pulling the knob **148**, **404** causes the piston **154**, **312**, **410** to move axially, thereby causing a detent mechanism of the pull-type manual actuation mechanism **106**, **308**, **402** to be engaged. As described above, in an example, the valve may be a manually-actuated and may have the pull-type manual actuation mechanism **106**, **308**, **402**. In other examples, the valve may be actuated by a solenoid or may be pneumatically or hydraulically actuated. In these examples, the valve may include the pull-type manual actuation mechanism **106**, **308**, **402** for manual override if a primary actuation mechanism does not operate properly. The pull-type manual actuation mechanism **106**, **308**, **402** are configured such that the pistons **154**, **312**, **410** are pressure-balanced as described above.

The pull-type manual actuation mechanism **106**, **308**, **402** may include the detent mechanism described above with respect to FIGS. **2A-2B**. As such, pulling the knob **148**, **404** may cause the groove **208** disposed on the external peripheral surface the piston **154**, **312**, **410** to be aligned with the balls **204A**, **204B**. The spring **200** may push the spacer **202**, which pushes the balls **204A**, **204B** into the groove **208**, and the detent mechanism is thus engaged.

As mentioned above, pulling the knob **148**, **404** causes the pin **158** to move therewith. The pin **158** causes the armature **138** to move axially, thus causing the movable elements (e.g., the first and second poppets **116**, **120**) of the valve **100**, **300**, **400** to move, thereby opening the valve **100**, **300**, **400** and allowing fluid to flow from the second port **114** to the first port **112**.

At block **504**, the method **500** includes releasing the knob **148**, **404** to lock the piston **154**, **312**, **410** in place, thereby locking the valve **100**, **300**, **400** in an open state. The detent mechanism precludes the piston **154**, **312**, **410** from returning return back (e.g., moving in the distal direction) because the spring **200** maintains pressure on the spacer **202**, which maintains respective pressure on the balls **204A**, **204B**, thus holding the piston **154**, **312**, **410** in position. With this configuration, the piston **154**, **312**, **410** is locked in place even when the knob **148**,**404** is released, and the valve **100**, **300**, **400** is thus locked in the open state.

The detailed description above describes various features and operations of the disclosed systems with reference to the accompanying figures. The illustrative implementations described herein are not meant to be limiting. Certain aspects of the disclosed systems can be arranged and combined in a wide variety of different configurations, all of which are contemplated herein.

Further, unless context suggests otherwise, the features illustrated in each of the figures may be used in combination with one another. Thus, the figures should be generally viewed as component aspects of one or more overall implementations, with the understanding that not all illustrated features are necessary for each implementation.

Additionally, any enumeration of elements, blocks, or steps in this specification or the claims is for purposes of clarity. Thus, such enumeration should not be interpreted to require or imply that these elements, blocks, or steps adhere to a particular arrangement or are carried out in a particular order.

Further, devices or systems may be used or configured to perform functions presented in the figures. In some instances, components of the devices and/or systems may be configured to perform the functions such that the components are actually configured and structured (with hardware and/or software) to enable such performance. In other examples, components of the devices and/or systems may be arranged to be adapted to, capable of, or suited for performing the functions, such as when operated in a specific manner.

By the term "substantially" it is meant that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations, including for example, tolerances, measurement error, measurement accuracy limitations and other factors known to skill in the art, may occur in amounts that do not preclude the effect the characteristic was intended to provide

The arrangements described herein are for purposes of example only. As such, those skilled in the art will appreciate that other arrangements and other elements (e.g., machines, interfaces, operations, orders, and groupings of operations, etc.) can be used instead, and some elements may be omitted altogether according to the desired results. Further, many of the elements that are described are functional entities that may be implemented as discrete or distributed components or in conjunction with other components, in any suitable combination and location.

While various aspects and implementations have been disclosed herein, other aspects and implementations will be apparent to those skilled in the art. The various aspects and implementations disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope being indicated by the following claims, along with the full scope of equivalents to which such claims are entitled. Also, the terminology used herein is for the purpose of describing particular implementations only, and is not intended to be limiting.

What is claimed is:

**1**. A pull-type manual actuation mechanism for a valve, the pull-type manual actuation mechanism comprising:

a piston having: (i) a first flanged portion with a first annular surface area, (ii) a second flanged portion with a second annular surface area, wherein the first flanged portion and the second flanged portion project from an exterior peripheral surface of the piston, (iii) a longitudinal cavity bounded by an interior peripheral surface of the piston, and (iv) a shoulder on the interior peripheral surface of the piston; and

a pin disposed in the longitudinal cavity of the piston, wherein the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the pin in a given axial direction is transferred to the piston, and wherein a difference between the second annular surface area of the second flanged portion and the first annular surface of the first flanged portion is substantially equal to a cross-sectional area of the pin.

**2**. The pull-type manual actuation mechanism of claim **1**, wherein the longitudinal cavity is a first longitudinal cavity, and wherein the pull-type manual actuation mechanism further comprises:

a knob having a second longitudinal cavity therein, wherein the piston is disposed in the second longitudinal cavity of the knob, and wherein the knob is coupled to the piston such that as the knob is pulled in the given axial direction, the piston moves in the given axial direction along with the knob.

**3**. The pull-type manual actuation mechanism of claim **2**, wherein the knob defines a groove on an interior peripheral surface of the knob, wherein the piston defines a groove on the exterior peripheral surface of the piston, and wherein the pull-type manual actuation mechanism further comprises:

a roll pin disposed partially in the groove of the knob and partially in the groove of the piston to couple the piston to the knob.

**4**. The pull-type manual actuation mechanism of claim **2**, further comprising:

a sleeve disposed in the second longitudinal cavity coaxial with the knob, wherein the sleeve has a third longitudinal cavity therein, wherein the piston is disposed, and is axially movable, within the third longitudinal cavity of the sleeve.

**5**. The pull-type manual actuation mechanism of claim **4**, wherein the given axial direction is a first axial direction, and wherein the pull-type manual actuation mechanism further comprises:

a spring disposed about the exterior peripheral surface of the piston such that the spring applies a spring force on the piston in a second axial direction opposite the first axial direction.

**6**. The pull-type manual actuation mechanism of claim **5**, wherein the spring is disposed between the first flanged portion and a respective shoulder defined on an interior peripheral surface of the sleeve.

**7**. The pull-type manual actuation mechanism of claim **4**, further comprising a detent mechanism, wherein the detent mechanism comprises:

a plurality of balls disposed in a radial array about the sleeve;

a spacer that is ring-shaped and interfacing with the plurality of balls; and

a spring disposed about an exterior peripheral surface of the sleeve between: (i) a respective shoulder projecting from the exterior peripheral surface of the sleeve, and (ii) the spacer, wherein the piston includes a groove defined on the exterior peripheral surface of the piston, such that as the piston moves in the given axial direction, the spring pushes the spacer in the given axial direction, and the spacer pushes the plurality of balls causing the plurality of balls to move partially in the groove so as to lock the piston in place relative to the sleeve.

**8**. A pull-type manual actuation mechanism for a valve, the pull-type manual actuation mechanism comprising:

a knob having a first longitudinal cavity therein;

a sleeve disposed in the first longitudinal cavity coaxial with the knob, wherein the sleeve has a second longitudinal cavity therein;

a piston disposed in the second longitudinal cavity coaxial with the sleeve, wherein the knob is coupled to the piston such that as the knob is pulled in a given axial direction, the piston moves in the given axial direction along with the knob, wherein the piston has: (i) a first flanged portion having a first annular surface area, (ii) a second flanged portion having a second annular surface area, wherein the first flanged portion and the second flanged portion project from an exterior peripheral surface of the piston, (iii) a third longitudinal cavity bounded by an interior peripheral surface of the piston, and (iv) a shoulder on the interior peripheral surface of the piston; and

a pin disposed and axially movable in the third longitudinal cavity of the piston, wherein an end of the pin is configured to be subjected to pressurized fluid from an inlet of the valve, wherein the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the end of the pin via the pressurized fluid in the given axial direction is transferred to the piston, and wherein a difference between the second annular surface area of the second flanged portion and the first annular surface of the first flanged portion is substantially equal to a cross-sectional area of the pin.

**9**. The pull-type manual actuation mechanism of claim **8**, wherein the knob defines a groove on an interior peripheral surface of the knob, wherein the piston defines a groove on the exterior peripheral surface of the piston, and wherein the pull-type manual actuation mechanism further comprises:

a roll pin disposed partially in the groove of the knob and partially in the groove of the piston to couple the piston to the knob.

**10**. The pull-type manual actuation mechanism of claim **8**, wherein the given axial direction is a first axial direction, and wherein the pull-type manual actuation mechanism further comprises:

a spring disposed about the exterior peripheral surface of the piston such that the spring applies a spring force on the piston in a second axial direction opposite the first axial direction.

**11**. The pull-type manual actuation mechanism of claim **10**, wherein the spring is disposed between (i) a third flanged portion projecting from the exterior peripheral surface of the piston, and (ii) an end of the sleeve.

**12**. The pull-type manual actuation mechanism of claim **8**, further comprising a detent mechanism, wherein the detent mechanism comprises:

a plurality of balls disposed in a radial array about the sleeve;

a spacer that is ring-shaped and interfacing with the plurality of balls;

a spring disposed about an exterior peripheral surface of the sleeve between: (i) a respective shoulder projecting from the exterior peripheral surface of the sleeve, and (ii) the spacer, wherein the piston includes a groove defined on the exterior peripheral surface of the piston, such that as the piston moves in the given axial direction, the spring pushes the spacer in the given axial direction, and the spacer pushes the plurality of balls causing the plurality of balls to move partially in the groove so as to lock the piston in place relative to the sleeve.

**13**. A valve comprising:

a main valve section comprising: (i) a housing, (ii) a sleeve disposed in the housing, wherein the sleeve defines a first port and a second port, and (iii) a movable element configured to move axially within the sleeve; and

a pull-type manual actuation mechanism comprising:

a knob having a first longitudinal cavity therein;

a piston disposed partially within the first longitudinal cavity, wherein the knob is coupled to the piston, wherein the piston has: (i) a first flanged portion having a first annular surface area, (ii) a second flanged portion having a second annular surface area, wherein the first flanged portion and the second flanged portion project from an exterior peripheral surface of the piston, and (iii) a second longitudinal cavity bounded by an interior peripheral surface of the piston, and (iv) a shoulder on the interior peripheral surface of the piston, and

a pin disposed in the second longitudinal cavity of the piston, wherein the pin is coupled to the movable element of the main valve section, wherein the pin has an area with an enlarged diameter configured to interface with and rest against the shoulder of the piston, such that a force applied on the pin in a given axial direction via pressurized fluid received at the second port acting on a cross-sectional area of the pin is transferred to the piston, and wherein a difference between the second annular surface area of the second flanged portion and the first annular surface area of the first flanged portion is substantially equal to the cross-sectional area of the pin, such that when pressurized fluid is communicated to the first annular surface area and the second annular surface area, the piston is pressure-balanced, and wherein when the knob is pulled in the given axial direction, the piston moves in the given axial direction along with the knob, allowing the pin and the movable element coupled thereto to move in the given axial direction, thereby allowing fluid to flow from the second port to the first port.

**14**. The valve of claim **13**, further comprising:

a pull-type solenoid actuator mechanism comprising:

a solenoid tube disposed partially within the housing of the main valve section; and

an armature disposed within the solenoid tube, wherein the armature is coupled to the movable element and the pin, such that axial motion of the pin in the given axial direction causes the armature to move axially along with the pin, thereby causing the movable element to move axially in the given axial direction.

**15**. The valve of claim **14**, further comprising:

a spacer that is ring-shaped and disposed within the solenoid tube, wherein the piston is disposed partially within and interfaces with the spacer, such that pressurized fluid is allowed to traverse unsealed spaces between the spacer and the solenoid tube and between the piston and the spacer so as to be communicated to the first annular surface area and the second annular surface area.

**16**. The valve of claim **13**, wherein the sleeve is a first sleeve, wherein the pull-type manual actuation mechanism further comprises:

a second sleeve disposed in the first longitudinal cavity coaxial with the knob, wherein the second sleeve has a third longitudinal cavity therein, wherein the piston is disposed, and is axially movable, in the third longitudinal cavity of the second sleeve.

**17**. The valve of claim **16**, wherein the pull-type manual actuation mechanism further comprises a detent mechanism, wherein the detent mechanism comprises:

a plurality of balls disposed in a radial array about the second sleeve;

a spacer that is ring-shaped, slidably disposed about the second sleeve, and interfacing with the plurality of balls;

a spring disposed about an exterior peripheral surface of the second sleeve between: (i) a shoulder projecting from the exterior peripheral surface of the second sleeve, and (ii) the spacer, wherein the piston includes a groove defined on the exterior peripheral surface of the piston, such that as the piston moves in the given axial direction, the spring pushes the spacer in the given axial direction, and the spacer pushes the plurality of balls causing the plurality of balls to move partially in the groove so as to lock the piston in place relative to the second sleeve.

**18**. The valve of claim **16**, wherein the given axial direction is a first axial direction, and wherein the pull-type manual actuation mechanism further comprises:

a spring disposed about the exterior peripheral surface of the piston such that the spring applies a spring force on the piston in a second axial direction opposite the first axial direction, wherein the spring is disposed between the first flanged portion and a respective shoulder defined on an interior peripheral surface of the second sleeve.

**19**. The valve of claim **13**, wherein the knob defines a groove on an interior peripheral surface of the knob, wherein the piston defines a groove on the exterior peripheral surface of the piston, and wherein the pull-type manual actuation mechanism further comprises a roll pin disposed partially in the groove of the knob and partially in the groove of the piston to couple the piston to the knob.

**20**. The valve of claim **13**, wherein the movable element is a first movable element, wherein the main valve section further comprises:

a second movable element configured to be seated on a first seat defined on an interior peripheral surface of the sleeve, wherein when the second movable element is seated on the first seat, the second movable element blocks the second port, wherein the first movable element is disposed within the second movable element, wherein the first movable element is configured to be seated on a second seat defined on an interior peripheral surface of the second movable element, and wherein when the first movable element moves axially off the second seat, the second moveable element follows the first movable element and moves off the first seat, thereby allowing fluid to flow from the second port to the first port.

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