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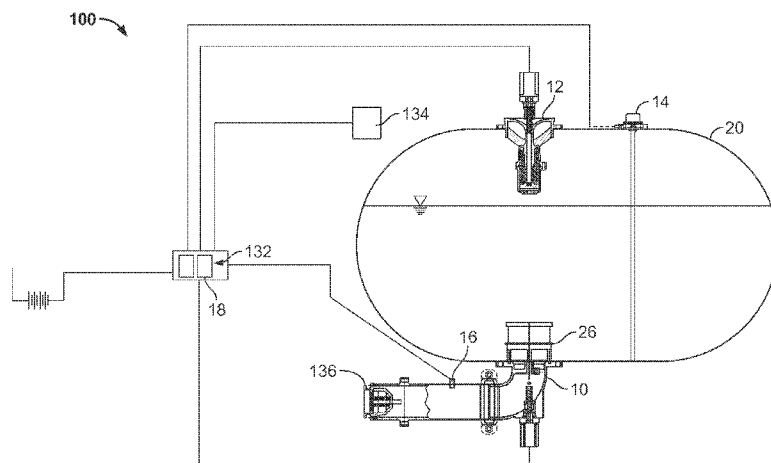


FIG. 1

(57) Abstract: According to the embodiments described herein, a bottom loading valve can include a drive member, a valve body, and a piston. The drive member can be operably coupled to a motor. The valve body can define a fluid passageway and one or more lateral openings. The drive member can be positioned within the fluid passageway. The one or more lateral openings can be offset laterally from the drive member. The piston can be engaged with the drive member. The piston can move throughout an open position and a closed position, as the drive member communicates force from the motor. When the piston is in the closed position, the piston can fully obstruct the one or more lateral openings from the fluid passageway.



**BOTTOM LOADING VALVES, TANK MANAGEMENT
SYSTEMS INCORPORATING THE SAME, AND METHODS FOR
MANAGING TANKS**

5 The present disclosure relates to a bottom loading valve and tank management system for use on-loading and off-loading fuel on commercial trucking vehicles. Specifically, the disclosure relates to a bottom loading valve and a tank management system that may be electrically operated in order to efficiently add and remove fuel from fuel tanks.

10 Many fuel tank refueling and defueling systems for large or commercial scale trucks require an air source to operate a bottom loading valve and tank vent valve simultaneously during fueling operations. These valves combine to prevent collapse or rupture of the tank as well as provide the ability to monitor fueling rates and pressures. Many of these systems require primary and secondary air sources with
15 associated tubing and brackets. These systems can be complicated to install and maintain and can fail in cold weather conditions because the pumps that actuate the valves may have difficulty starting in extreme conditions (below 10°F). It would be beneficial to simplify the installation of these systems and improve reliability in cold weather conditions.

20 According to the embodiments described herein, an electrically operated tank management system can include a bottom loading valve and vent valve for use in fueling and refueling a tank that are electrically actuated. The bottom loading valve can include a valve body, a motor, a cylinder, and a piston; the piston is configured to be moved from a closed position to an open position by rotating a lead screw drive
25 attached to both the piston and the motor.

 In one embodiment, a bottom loading valve can include a drive member, a valve body, and a piston. The drive member can be operably coupled to a motor. The valve body can define a fluid passageway and one or more lateral openings. The drive member can be positioned within the fluid passageway. The one or more lateral

openings can be offset laterally from the drive member. The piston can be engaged with the drive member. The piston can move throughout an open position and a closed position, as the drive member communicates force from the motor. When the piston is in the closed position, the piston can fully obstruct the one or more lateral
5 openings from the fluid passageway.

In another embodiment, a tank management system can include a tank surrounding an interior, a vent valve, and a bottom loading valve. The vent valve can be coupled to the tank. The vent valve can actuate throughout a venting position and a non-venting position. The vent valve can communicate a vent position signal
10 indicative of actuation of the vent valve. The bottom loading valve can be coupled to the tank. The bottom loading valve can include a valve body and a motor. The valve body can define a fluid passageway and one or more lateral opening. The motor can move a piston throughout an open position and a closed position. When the piston is in the closed position, the piston can fully obstruct the one or more lateral openings
15 from the fluid passageway.

In a further embodiment, a method for operating a bottom loading valve or a tank management system can include rotating a drive member within a fluid passageway and around an axis of rotation. In response to rotation of the drive member, a piston engaged with the drive member can be translated throughout an
20 open position and a closed position. The piston can be confined within a valve body that defines one or more lateral openings. The one or more lateral openings can be offset laterally from the axis of rotation. When the piston is in the closed position, the piston can fully obstruct the one or more lateral openings from the fluid passageway. According to any of the bottom loading valves, systems or methods described herein,
25 the drive member can be in fixed and rotatable engagement with the valve body. The drive member can rotate around an axis of rotation. Alternatively or additionally, the drive member can be in threaded engagement with the piston.

According to any of the bottom loading valves, systems or methods described herein, a position detector can be mounted to the motor. The position detector can
30 include a disk that is attached to the drive member and an optical reflective sensor

located proximate the disk. Alternatively or additionally, the disk can be indexed with a plurality of through holes.

According to any of the bottom loading valves, systems or methods described herein, the drive member can include a pinion operably coupled to the motor and a rack engaged with the piston. The motor can rotate the pinion to translate the rack and the piston.

According to any of the bottom loading valves, systems or methods described herein, the valve body can include a cylindrical portion. The one or more lateral openings can be formed in the cylindrical portion of the valve body. Alternatively or additionally, the valve body can include an exterior flange coupled to a fluid port, and an interior flange coupled to the cylindrical portion. The exterior flange and the interior flange can be configured to cooperate to clamp a tank.

According to any of the bottom loading valves, systems or methods described herein, the piston can include a hub configured to receive force from the motor, and a sealing member that forms a substantially cylindrically shaped outer rim that is concentric to the hub. The sealing member of the piston can fully obstruct the one or more lateral openings from the fluid passageway, when the piston is in the closed position. Alternatively or additionally, the piston can include low drag spokes that couple the hub and the sealing member. Alternatively or additionally, the low drag spokes can be tapered as the low drag spokes extend away from a first end of the piston towards a second end of the piston.

According to any of the bottom loading valves, systems or methods described herein, the bottom loading valve can include a spring for biasing the bottom loading valve to the closed position.

According to any of the bottom loading valves, systems or methods described herein, the controller can be communicatively coupled to the vent valve and the bottom loading valve. The controller can execute machine readable instructions to cause the vent valve to actuate to the venting position. The vent position signal can be received by the controller. The controller can determine that the vent valve is in the venting position from the vent position signal. The controller can cause the piston of the bottom loading valve to move to the open position after the vent valve is

determined as being in the venting position. Alternatively or additionally, the controller can execute the machine readable instructions to cause the piston of the bottom loading valve to move to the closed position. The controller can cause the vent valve to actuate from the venting position to the non-venting position a
5 predetermined amount of time after the piston of the bottom loading valve is moved to the closed position. Alternatively or additionally, a fuel level sensor can be communicatively coupled to the controller. The controller can execute machine readable instructions to receive a fuel level signal from the fuel level sensor that is indicative of an amount of fuel contained by the tank. The controller can determine
10 that the tank has additional capacity. The piston of the bottom loading valve can be moved to the open position after the additional capacity is determined. Alternatively or additionally, a pressure sensor can be disposed upstream of the bottom loading valve and communicatively coupled to the controller. The controller can execute machine readable instructions to receive a pressure signal from the pressure sensor
15 indicative of an upstream pressure. The controller can determine that a pressure check is satisfied when the upstream pressure meets a minimum threshold pressure. The controller can move the piston of the bottom loading valve to the open position after the pressure check is satisfied. Alternatively or additionally, the controller can execute machine readable instructions to cause the piston of the bottom loading valve
20 to move to the closed position. The controller can cause the vent valve to actuate from the venting position to the non-venting position a predetermined amount of time after the piston of the bottom loading valve is moved to the closed position.

According to any of the bottom loading valves, systems or methods described herein, a controller can be communicatively coupled to the vent valve and the bottom
25 loading valve. The controller can execute machine readable instructions to cause the vent valve to actuate from the non-venting position to the venting position. The controller can cause the piston of the bottom loading valve to move from the closed position to the open position contemporaneously to actuation of the vent valve.

In the accompanying drawings, structures are illustrated that, together with the
30 detailed description provided below, describe exemplary embodiments of the claimed invention. Like elements are identified with the same reference numerals. It should

be understood that elements shown as a single component may be replaced with multiple components, and elements shown as multiple components may be replaced with a single component. The drawings are not to scale and the proportion of certain elements may be exaggerated for the purpose of illustration.

5 **Figure 1** is a schematic representation of a tank management system;

Figure 2 is a perspective view of a bottom loading valve for use in the tank management system;

Figure 3 is a cross-sectional view of the bottom loading valve of Figure 2;

10 **Figure 4** is a perspective view of a piston for use in the bottom loading valve of Figure 2;

Figure 5 is a perspective view of an position detector for use in the bottom loading valve of Figure 2;

Figure 6 is another embodiment of a bottom loading valve for use in the tank management system;

15 **Figure 7** is another embodiment of a bottom loading valve for use in the tank management system; and

Figure 8 is another embodiment of a bottom loading valve for use in the tank management system.

20 The embodiments described herein generally relate to a bottom loading valve that can be utilized to regulate the on-loading and offloading of fuel. The bottom loading valve can define a fluid passageway for the flow of fluid and can comprise a piston that can be actuated throughout an open and a closed position. Further embodiments relate to a tank management system that can comprise the bottom loading valve and a vent valve that can function cooperatively with the bottom loading valve during operation of a tank that stores fluids such as, for example, a fuel tank. Various embodiments of the tank management system, the bottom loading valve and their operation is described in more detail herein.

25 Referring now to **Figure 1**, an embodiment of the tank management system **100** is schematically depicted. The system **100** can comprise a bottom loading valve **10** that can be actuated throughout an open and a closed position to regulate the flow of a fluid. For the purpose defining and describing the present disclosure, it is noted

that the term "fluid" as used herein can mean a substance, such as a liquid or a gas, that is capable of flowing and that changes its shape when acted upon by a force tending to change its shape.

Referring collectively to **Figures 2 and 3**, the bottom loading valve **10** can
5 comprise a valve body **22** that defines a fluid passageway **120** for delivering fluid
(e.g., fuel) through the bottom loading valve **10**. Specifically, the fluid passageway
120 can be bounded by a fluid facing surface **122** formed within the valve body **22**.
The valve body **22** can comprise a cylindrical portion **26** that defines a fluid
regulating port for the passage of fluid into the bottom loading valve **10**, out of the
10 bottom loading valve **10**, or both. In some embodiments, one or more lateral
openings **124** can be formed through the cylindrical portion **26** of the valve body **22**
for the passage of fluid.

The bottom loading valve **10** can comprise a motor **38** for actuating the bottom
loading valve **10** throughout a closed position (**Figure 2**) and an open position
15 (**Figure 3**). The motor **38** can be any servo-mechanism suitable for providing motive
force such as, for example, an electric motor, a stepper motor, or the like. In some
embodiments, the motor **38** can be operably coupled to drive member **40** that is
configured to communicate force from the motor **38** to other components of the
bottom loading valve **10**. For example, the drive member **40** can comprise a drive
20 shaft or rod that is engaged with the motor **38** and configured to communicate
rotational motion of the motor **28**. Specifically, the drive member **40** can be engaged
with the motor **38** at a first end and extend to a second end. The drive member **40**
can comprise a threaded portion **42** located proximate to the second end of the drive
member **40**. In one embodiment, the threaded portion **42** of the drive member **40** can
25 comprise a high efficiency lead screw.

Referring collectively to **Figures 3 and 4**, bottom loading valve **10** can
comprise a piston **44** configured to move within the bottom loading valve **10** to
regulate the flow of fluid throughout the bottom loading valve **10**. The piston **44** can
comprise a hub **50** that is configured to receive force from the motor **38**. In some
30 embodiments, the piston **44** can comprise a sealing member **126** that extends between
a first end **45** and a second end **47** of the piston **44**. The hub **50** can be coupled to the

sealing member **126** via low drag spokes **128**. In the depicted embodiment, the sealing member **44** can form a substantially cylindrically shaped outer rim that is concentric to the hub **50**. The low drag spokes **128** can span from the hub **50** to the sealing member **44**. Accordingly, the low drag spokes **128**, the hub **50**, and the
5 sealing member **44** can cooperate to define a plurality of pressure balancing orifices. The pressure balancing orifices can allow fluid to flow between the low drag spokes **128**, the hub **50**, and the sealing member **44**.

In some embodiments, the low drag spokes **128** can be shaped to reduce the drag of the piston **44**. For example, the low drag spokes **128** can be shaped to reduce
10 the amount of friction between the piston **44** and a fluid located in the fluid passageway **120** as the piston **44** moves towards the closed position (**Figure 2**). Specifically, the low drag spokes **128** can be tapered as the low drag spokes **128** extend away from the first end **45** of the piston **44** towards the second end **47** of the piston **44**. That is, the cross-sectional area of the low drag spokes **128** can be reduced
15 as the low drag spokes **128** extend away from the first end **45** of the piston **44** towards the second end **47** of the piston **44**.

Referring now to **Figure 5**, the bottom loading valve **10** can comprise a position detector **56** configured to detect motion of the motor **58** and transform the motion into a data signal. Accordingly, the position detector **56** can be any device
20 capable of providing a signal indicative of the motion of the motor **58** such as, for example, an encoder or the like. In some embodiments, the position detector **56** can comprise an optical reflective sensor **58** configured to detect motion of a circular disk **60**. Specifically, the optical reflective sensor **58** can be located proximate to the circular disk **60** such as, for example, offset by about one millimeter. Accordingly,
25 the optical reflective sensor **58** can be responsive to the circular disk **60**. The circular disk **60** can be provided with indexed features having a known relationship to motion of the circular disk **60**. For example, the circular disk **60** can comprise through holes **62**. It is noted that the term "sensor," as used herein, can mean a device that measures a physical quantity and encodes the measurement into a signal, which is correlated to
30 the measured value of the physical quantity.

In some embodiments, the position detector **56** can be located proximate to the motor **38**. Specifically, the optical reflective sensor **58** can be mounted to the top of the motor **38**, e.g., facing upward along the drive member **40**. The circular disk **60** can be attached to the drive member **40**. Accordingly, the disk **60** can be configured to rotate in response to rotation of the motor **38**. The rotation can cause the through holes **62** to rotate above the over the sensor **58**. Thus, the optical reflective sensor **58** can provide position signals that are indicative of the rotational motion of the drive member **40** (e.g., speed, position, or the like). The position signals can be extrapolated or decoded to determine the position of the piston **44**. It is noted that the position detector **56** described herein can accommodate a large range of rotation speeds, which can increase the range of opening times of the bottom loading valve **10**.

Referring again to **Figures 2 and 3**, the piston **44** of the bottom loading valve **10** can be configured to translate within the valve body **22** to selectively obstruct the one or more lateral openings **122**. In some embodiments, the piston **44** can be arranged to interact with the fluid passageway **120** within the valve body **22**. Specifically, the cylindrical portion **26** of the valve body **22** can be configured to constrain motion of the piston **44**. Accordingly, the fluid facing surface **122** of the cylindrical portion **26** of the valve body **22** can comprise one or more features that guide the translation of the piston **44**.

As is noted above, force from the motor **38** can be communicated to the piston **44** via the drive member **40**. In some embodiments, the piston **44** can be configured to translate in response to rotation of the drive member **40**. For example, in the depicted embodiment, the drive member **40** can be aligned along and rotate with respect to an axis of rotation **130**. In response, the piston **44** can translate axially, i.e., along the axis of rotation **130**, to selectively obstruct the one or more lateral openings **124**. Additionally, it is noted that the term “lateral,” as used herein can mean a direction that is substantially orthogonal to the axis of rotation **130**. Accordingly, the one or more lateral openings can be located in a position that is offset laterally from the axis of rotation **130**.

According to the embodiments described herein, the drive member **40** can be in fixed and rotatable engagement with the valve body **22**. It is noted that the term

“fixed and rotatable engagement” can mean that a component interacts with another component such that the component is substantially free to rotate with respect to a substantially fixed axis. For example, in the depicted embodiment, the drive member **40** can extend through the fluid passageway **120** along the axis of rotation **130**. The drive member **40** can span the fluid passageway **120** from the motor **38** to a valve cap **28**, which can axially limit the extent of the cylindrical portion **26** of the valve body **22**. The drive member **40** can be in fixed and rotatable engagement with the valve cap **28**. For example, the drive member **40** can be in fixed and rotatable engagement with the valve cap **28** by disposing an upper end of drive member **40** within an opening **48** formed in the inner surface of the valve cap **28**. __Alternatively or additionally, the drive member **40** can be in fixed and rotatable engagement with a motor housing **24** of the valve body **22**, which can be configured to retain the motor **38** in alignment with the axis of rotation **130**.

The piston **44** can be in threaded engagement with the threaded portion **42** of the drive member **40**. Accordingly, the piston **44** can be axially offset from the motor **38**. In some embodiments, the hub **50** can be in substantially fixed engagement with a threaded member **46** such as, for example, a lead screw nut, or the like. Optionally, the threaded member **46** can be formed integrally with the hub **50** of the piston **44**. Accordingly, rotation of the drive member **44** can be transformed into translation of the piston **44**.

Referring still to **Figures 2 and 3**, the bottom loading valve **10** can comprise an anti-rotation member **52** configured to mitigate rotational motion of the piston **44** as the motor is communicating force to the piston **44**. The anti-rotation member **52** can be coupled to the valve body **22** and held substantially fixed. The anti-rotation member **52** can constrain the rotation of the piston **44**. In one embodiment, the anti-rotation member **52** can comprise an outer surface with a substantially square cross-section configured for contacting the piston **44**. For example, the anti-rotation member **52** can be positioned within a pressure balancing orifice of the piston **44** such that the low drag spokes **128** and the anti-rotation member **52** interact to mitigate rotation. Specifically, the anti-rotation member **52** can extend into the fluid

passageway **120** from the valve cap **28** and into the contact with a low drag spoke **128**.

The bottom loading valve **10** can comprise a spring **54** for biasing the bottom loading valve **10** to the closed position (**Figure 2**). Accordingly, the spring **54** can be configured to automatically close the bottom loading valve **10** should the motor **38** lose power or cease operation. In some embodiments, the spring **54** can be placed into contact with the valve cap **28** and disposed within the piston **44**. For example, the spring **54** can be constrained within the piston **44** by the sealing member **126** and the low drag spokes **128**. Accordingly, as the spring **54** is compressed against the valve cap **28** by the low drag spokes **128**, the spring **54** can increasingly exert downward pressure against the piston **44**.

Referring now to **Figure 6**, according to the embodiments described herein, a bottom loading valve **600** can comprise a drive member formed from a rack **64** and pinion **66**. Specifically, the pinion **66** can be operably coupled to the motor **38** and the rack **64**, such that rotational motion applied to the pinion **66** translates the rack **64**. The rack **64** can be coupled to the piston **44**. Accordingly, translation of the rack **64** can cause a corresponding translation of the piston **44**. Thus, the sealing member **126** of the piston **44** can selectively obstruct the one or more lateral openings **124** of the valve body **22**.

Referring now to **Figures 7 and 8**, a bottom loading valve **700** can comprise a motor **38** that is offset from the axis of rotation **130**. In some embodiments, the bottom loading valve **700** can comprise a timing belt **68** and pulley system. Specifically, the motor **38** can be operably coupled to a pulley **70** such that the pulley **70** can be rotated by actuation of the motor **38**. A pulley **72** can be aligned with the axis of rotation **130** and configured to communicate force to the piston **44** such as, for example, via the drive member **40** (**Figure 3**). The timing belt **68** can be operably coupled to the pulley **70** and the pulley **72** and span the distance between the pulley **70** and the pulley **72**. Accordingly, the timing belt **68** can communicate force supplied by the motor **38** to the pulley **72** via rotation of the pulley **70**.

Referring again to **Figures 2 and 3**, the motor **38** can be electronically activated to cause the motor **38** to selectively rotate the drive member **40** with respect

to the axis of rotation **130** in a closing direction or an opening direction. Accordingly, the piston **44** can be actuated to selectively obstruct the one or more lateral openings **124**. Specifically, the piston **44** can be actuated to the closed position (**Figure 2**), such that the piston **44** fully obstructs the one or more lateral openings **124** from the fluid passageway **120**. It is noted that the phrase “fully obstruct,” as used herein, can mean that an opening is substantially sealed to prevent fluid flow. Thus, when in the closed position, the piston **44** can substantially prevent fluidic communication via the one or more lateral openings **124**. In the depicted embodiment, the sealing member **126** of the piston **44** can separate the fluid passageway **120** from the one or more lateral openings **124**. Additionally, the sealing member **126** can span the one or more lateral openings **126** from the interior of the valve body **22**. Accordingly, in some embodiments, the sealing member **126** can be larger than the one or more lateral openings **124** with respect to the axial direction.

As shown in **Figure 3**, when the piston **44** is moved to an open position such that the one or more lateral openings **124** are partially obstructed or completely unobstructed, fluid can be communicated via the one or more lateral openings **124**. Specifically, starting from the closed position (**Figure 2**), the motor **38** can selectively rotate the drive member **40** with respect to the axis of rotation **130** in the opening direction. As the drive member **40** rotates in the opening direction, the piston **44** can be translated by the threaded engagement formed with the drive member **40**. The anti-rotation member **52** can mitigate rotation of the piston **44** to improve the efficiency of the translation. Translation of the piston **44** can cause the sealing member **126** to reveal the one or more lateral openings **124** to the fluid passageway **120**. Accordingly, rotation of the drive member **40** in the opening direction can transition the one or more lateral openings **124** from being completely obstructed by the sealing member **126** to being partially obstructed or completely unobstructed. Additionally, it is noted that the one or more lateral openings **124** can be transitioned from being completely unobstructed by the sealing members **126** to being partially obstructed or completely obstructed by rotating the drive member **40** in the closing direction, which can cause the piston **44** to translate in the opposite direction in a manner as described above with respect to opening.

As is noted above, the spring **54** can be compressed as the piston **44** translates to open the bottom loading valve **10**. Accordingly, should power to the motor **38** be discontinued, the energy stored in the spring **54** can cause the piston **44** to move back to the closed position. As the piston **44** translates, the drive member **40** can rotate in the closing direction due to the force exerted upon the piston **44** by the spring **54**. Thus, the bottom loading valve **10** can be automatically closed in the event of power loss. Additionally, it is noted that the pressure balancing orifices of the piston **44** can allow fluid to flow through the piston **44** to achieve an immediate pressure balance on both sides of the piston **44**. Accordingly, resistance of the fluid to translation of the piston **44** can be reduced. Moreover, the shape of the low drag spokes **128** can be configured to reduce friction between the piston **44** and fluid in the fluid passageway **120** as the piston **44** translates to close the bottom loading valve **10**. As a result, the amount of spring force needed to close the bottom loading valve **10** can be reduced and the response time of the piston **44** during automatic closure can be improved. Alternatively or additionally, the bottom loading valve **10** may also have a failsafe mechanism that closes the bottom loading valve **10** to prevent flow of fluid if a nozzle is not connected to the bottom loading valve **10**. Accordingly, in embodiments wherein the bottom loading valve **10** is utilized with a fuel tank, unintended dumping of fuel can be prevented.

Referring again to **Figure 1**, the system **100** can comprise a vent valve **12** for regulating the pressure contained within a tank **20**, which can be any pressure vessel suitable for the storage of fluids. The vent valve **12** can be configured to be actuated throughout a venting position and a non-venting position. When in the venting position, the vent valve **12** can be opened to communicate fluid such as, for example, the gas phase of substances stored in the tank **20**. When in the non-venting position, the vent valve **12** can be closed to mitigate the communication of fluid. In some embodiments, the vent valve **12** can be electrically actuated. Accordingly, the vent valve **12** can comprise a servo-mechanism suitable for actuation throughout the venting position and the non-venting position such as, for example, electrically driven motors, solenoids, or the like. Moreover, the vent valve **12** can be configured to communicate a vent position signal indicative of actuation of the vent valve. For

example, the vent valve **12** can comprise positional sensors configured to detect the position of the vent valve **12** such as, but not limited to, two position switches, proximity sensor, or the like.

The system **100** can comprise a fuel level sensor **14** for detecting and communicating an amount of fuel contained within the tank **20**. The fuel level sensor **14** can comprise a robust gauging system configured to detect a standard “fill” level and a “high fill” level. The fuel level sensor **14** can communicate a fuel level signal indicative of an amount of fuel contained by the tank **20**. In some embodiments, the fuel level sensor **14** can be configured to be mounted to the top of the tank **20**. The fuel level sensor **14** can comprise a portion configured to rest at the bottom of the tank **20** and measure the head pressure of the fluid in the tank **20**, which can be utilized to determine a volume contained by the tank **20**.

The system **100** can comprise a pressure sensor **16** for detecting and communicating an amount of pressure contained within a vessel. Specifically, the pressure sensor **16** can detect an amount of force and communicate a pressure signal indicative of the detected amount of force. It is noted that the term "signal" can mean a waveform (e.g., electrical, optical, magnetic, or electromagnetic), such as DC, AC, sinusoidal-wave, triangular-wave, square-wave, and the like, capable of traveling through a medium.

The system **100** can comprise a controller **18** configured to direct the operations of the various system components. The controller **18** can comprise one or more processors that execute machine readable instructions and a memory for storing machine readable instructions. The one or more processors can be communicatively coupled to the memory. The one or more processors can comprise an integrated circuit, a microchip, a computer, or any other computing device capable of executing machine readable instructions. The memory can be RAM, ROM, a flash memory, a hard drive, or any device capable of storing machine readable instructions. Additionally, the controller **18** can comprise one or more input device **132** for receiving tactile input from an operator such as, for example, a button, knob, touch screen, or the like. The one or more input device **132** can be communicatively

coupled to the one or more processors such that the received tactile input can be transformed into signals indicative of a desired command.

In the embodiments described herein, the one or more processors and the memory may be integral with the controller **18**. However, it is noted that the controller **18**, the one or more processors, and the memory may be discrete components communicatively coupled with one another without departing from the scope of the present disclosure. Thus, embodiments of the present disclosure may comprise logic or an algorithm written in any programming language of any generation (e.g., 1GL, 2GL, 3GL, 4GL, or 5GL) such as, e.g., machine language that may be directly executed by the processor, or assembly language, object-oriented programming (OOP), scripting languages, microcode, etc., that may be compiled or assembled into machine readable instructions and stored on a machine readable medium. Alternatively, the logic or algorithm may be written in a hardware description language (HDL), such as implemented via either a field-programmable gate array (FPGA) configuration or an application-specific integrated circuit (ASIC), or their equivalents.

Referring collectively to **Figures 1 - 3**, the system **100** can be configured to manage fuel contained within the tank **20**. The bottom loading valve **10** can be mounted to the bottom of the tank **20** and configured to control the ingress and egress of fluid with respect to the bottom of the tank **20**. In some embodiments, a fluid port **30** of the bottom loading valve **10** can be in fluidic communication with a nozzle adapter **136**, which is configured to be coupled to a fuel nozzle. The cylindrical portion **26** of the bottom loading valve **10** can be disposed within the tank **20**, such that the one or more lateral openings **126** of the bottom loading valve **10** are exposed to the interior of the tank **20**. In some embodiments, the cylindrical portion **26** of the bottom loading valve **10** can be provided as a separate component. Specifically, the valve body **22** can comprise an exterior flange **32** and an interior flange **34**. The exterior flange **32** can be coupled to the fluid port **30** and the interior flange **34** can be coupled to the cylindrical portion **26**. The exterior flange **32** of the valve body **22** can be mounted to an outside surface of the tank **20** and the interior flange **34** of the cylindrical portion **26** can be mounted to an inside surface of the tank **20**.

Accordingly, a wall of the tank **20** can be clamped between the exterior flange **32** and the interior flange **34**. Thus, the bottom loading valve **10** can be partially disposed within the tank **20** and partially disposed outside the tank **20** such that the fluid passageway **120** extends from the fluid port **30** through the cylindrical portion **26**.

5 In order to relieve pressure within the tank **20** when fueling or defueling, the vent valve **12** can be disposed at the top of the tank **20**. In some embodiments, each of the bottom loading valve **10** and the vent valve **12** can be communicatively coupled to the controller **18**. As used herein, the phrase “communicatively coupled” can mean that components are capable of exchanging data signals with one another such as, for
10 example, electrical signals via conductive medium, electromagnetic signals via air, optical signals via optical waveguides, or the like. Accordingly, operation of the tank **20** and the vent valve **12** can be directed by the controller **18**. Alternatively or additionally, the system **100** may also include a mechanical linkage between the bottom loading valve **10** and the vent valve **12**.

15 As is noted herein, the system **100** may be used to on-load, off-load, or recirculate fuel within the tank **20**. In accordance with the embodiments described herein, the controller **18** can execute machine readable instructions to automatically implement methods to perform on-loading, off-loading, recirculating, or combinations thereof.

20 According to the embodiments described herein, on-loading can be performed to add fuel to the tank **20**. The system **100** can be configured to perform a pressure check that determines the pressure upstream of the bottom loading valve **10** with the pressure sensor **16**. Accordingly, the pressure sensor **16** can be communicatively coupled to the controller **18**, and can be disposed between the fluid port **30** of the
25 bottom loading valve **10** and the nozzle adapter **136**. The pressure sensor **16** can communicate the pressure signal to the controller **18**. The controller **18** can determine that the pressure check is satisfied when the pressure signal corresponds to a pressure that meets a minimum threshold of pressure (*e.g.* about 10 PSI). Accordingly, the controller **18** can determine, from the pressure check, that fuel pressure is provided in
30 the system **100**.

Referring still to **Figures 1 - 3**, the system **100** can be configured to perform a fuel level check that determines an amount of fuel located within the tank **20** using the fuel level sensor **14**. Accordingly, the fuel level sensor **14** can communicate the fuel level signal to the controller **18**. The controller **18** can determine that the fuel level
5 check is satisfied when the fuel level signal corresponds to an amount of fuel that is less than the full capacity of the tank **20**. Accordingly, the controller **18** can determine, from the fuel level check, that the tank **20** is not already full, i.e., that the tank **20** has available capacity to store additional fuel.

The system **100** can be configured to transition the vent valve **12** from the
10 non-venting position to the venting position prior to adding fuel to the tank **20**. In some embodiments, the vent valve **12** can be transitioned from the non-venting position to the venting position after the pressure check, the fuel level check, or both are satisfied. To vent the tank **20**, the controller **18** can send a control signal to the vent valve **12**. In response to the control signal the vent valve **12** can transition to the
15 venting position, i.e., a vent can be opened. The controller **18** can monitor the vent position signal to determine the response of the vent valve to the control signal.

In some embodiments, the controller **18** can be configured to maintain the bottom loading valve **10** in the closed position as a default. The bottom loading valve **10** can be maintained in the closed position until the controller **18** determines that the
20 system **100** is prepared for on-loading. Specifically, the controller **18** can determine that the system **100** is prepared for on-loading when the pressure check and the fuel level check are satisfied. Alternatively or additionally, the controller **18** can verify that the vent valve **12** is in the venting position. Upon determining that the system **100** is prepared for on-loading, the controller **18** can communicate an actuation signal
25 to the bottom loading valve **10**. The actuation signal can be encoded to indicate motor parameters such as, for example, torque, speed, or the like. The bottom loading valve **10** can receive the actuation signal. In response to the actuation signal, the motor **38** of the bottom loading valve **10** can be activated to actuate the piston **44** to the open position. Specifically, the sealing member **126** can be translated away from the one or
30 more lateral openings **124** to allow fuel to travel through the bottom loading valve **10** and into the tank **20**. Once bottom loading valve **10** is fully open, which can be

measured by the position detector **56**, the controller **18** can cause the motor **38** to decelerate the motion of the piston **44** and hold the piston **44** in the open position (i.e., the hold phase).

During fueling, the controller **18** can monitor the system **100** to assure that the operations are being performed appropriately. For example, the controller **18** can perform periodic fault monitoring checks with a predetermined frequency. In some embodiments, the controller **18** can monitor signals to or from the bottom loading valve **10**, the vent valve **12**, the fuel level sensor **14**, the pressure sensor **16**, or any combination thereof. For example, during actuation or the hold phase of the bottom loading valve **10**, the controller **18** can monitor the current supplied to the motor **38** in order to detect stall or fault conditions. If the controller **18** detects stall or fault conditions, the controller **18** can deactivate the motor **38** to mitigate damage, or to prevent excessive heat buildup. Additionally, it is noted that, the controller **18** can be communicatively coupled to components via conductive wires. In some embodiments, the control signals may be isolated from other signals in order to mitigate cross talk or noise. For example, additional ground lines can be utilized to isolate the analog signals of the motor **38** and control signals.

Upon the completion of the on-loading process, the bottom loading valve **10** can be closed. In some embodiments, the controller **18** can determine that the on-loading process is complete by monitoring the fuel level sensor **14**. Specifically, the controller **18** can determine from the fuel level signal of the fuel level sensor **14** that the tank **20** is at capacity or some other desired level. Alternatively or additionally, input can be received via the one or more input device **132** to stop the on-loading process. For example, the operation can be manually stopped by the operator actuating the one or more input device **132**. Upon the controller **18** determining that the on-loading process is complete, the controller **18** can provide control signals that cause the bottom loading valve **10** to close. For example, the bottom loading valve **10** can be closed by reducing the current supplied to the motor **38** and allowing the spring force of the spring **54** to back drive the bottom loading valve **10** to the closed position. Alternatively or additionally, the bottom loading valve **10** can be closed by rotating the drive member **40** in the closing direction with the motor **38**. Upon the

controller **18** determining that the on-loading process is complete, the controller **18** can also provide control signals that cause the vent valve **12** to transition from the venting position to the non-venting position for a predetermined amount of time after the bottom loading valve **10** is closed.

5 According to the embodiments described herein, off-loading can be performed to remove fuel from the tank **20**. In some embodiments, the system **100** can be configured to prevent unintended removal of fuel from the system **100**. Specifically, nozzle adapter **136** can be configured to remain closed until a fuel nozzle engages with the nozzle adapter **136**.

10 The controller **18** can be configured to perform a nozzle cycle check. During the nozzle cycle check, the controller **18** can generate control signals that cause the bottom loading valve **10** to open and the vent valve **12** to move the venting position contemporaneously, while the nozzle adapter **136** is closed. The controller **18** can generate control signals that cause the bottom loading valve **10** to close and the vent
15 valve **12** to move to the non-venting position using a powered operation. Optionally, during the nozzle cycle check, the controller **18** can generate control signals that cause the bottom loading valve **10** to open and the vent valve **12** to move the venting position. The fail safe operation of the bottom loading valve **10** can be tested by simulating an unpowered condition and determining if the bottom loading valve **10**
20 closes without power. Similarly, fail safe operation of the vent valve **12** can be tested by simulating an unpowered condition and determining if the vent valve **12** closes without power. Should operation of the bottom loading valve **10** and the vent valve **12** perform as expected, the nozzle cycle check can be determined by the controller **18** as being completed successfully.

25 In some embodiments, the off-loading operation can be started by the controller **18**. Input can be received via the one or more input device **132** to start the off-loading process. For example, the operation can be manually started by the operator actuating the one or more input device **132**. In some embodiments, upon starting the off-loading process, the controller **18** can first perform the nozzle cycle
30 check. In some embodiments, the input received via the one or more input device **132** to start the off-loading process can replace the pressure sensor **16**, i.e., the controller

18 can ignore the pressure signal during the off-loading process. The controller **18** can end the off-loading process if the nozzle cycle check is determined by the controller **18** as being completed unsuccessfully.

Referring again to **Figure 1**, the system **100** can comprise an interlock **132**
5 configured to detect whether the fuel nozzle is removed from a holder or engaged with the system **100**. The interlock **132** can be communicatively coupled to the controller **18**. Accordingly, the interlock **132** can provide an interlock signal indicative of the positioning of the fuel nozzle. The controller **18** can determine from the interlock signal that the fuel nozzle is disengaged from the system **100** (e.g., the
10 nozzle adapter **136**). The controller **18** can end the off-loading process if the fuel nozzle is determined as being disengaged from the system **100**.

Referring collectively to **Figures 1 - 3**, the controller **18** can further execute the off-loading process by causing the bottom loading valve **10** to open and the vent valve **12** to move to the venting position, as described herein. Additionally, the
15 controller **18** can perform periodic fault monitoring checks during the off-loading process.

Once the controller **18** has determined that a desired amount of fuel has been removed from the tank **20**, the controller **18** can cause the bottom loading valve **10** to close, as described herein. In some embodiments, the controller **18** can determine that
20 the desired amount of fuel has been removed by monitoring the fuel level signal of the fuel level sensor **14**. Alternatively or additionally, input can be received via the one or more input device **132** to stop the off-loading process.

According to the embodiments described herein, recirculation can be performed to recirculate the fuel of the tank **20**. The recirculation operation can be
25 started by the controller **18**. Input can be received via the one or more input device **132** to start the recirculation process. For example, the operation can be manually started by the operator actuating the one or more input device **132**. In some embodiments, upon starting the recirculation process, the controller **18** can first perform the nozzle cycle check. In some embodiments, the input received via the one
30 or more input device **132** to start the recirculation process can replace the pressure

sensor **16**, i.e., the controller **18** can ignore the pressure signal during the recirculation process.

The controller **18** can end the recirculation process if the nozzle cycle check is determined by the controller **18** as being completed unsuccessfully. Alternatively or
5 additionally, the controller **18** can end the recirculation process if the fuel nozzle is determined as being disengaged from the system **100**.

During the recirculation process, the controller **18** can monitor the fuel level signal of the fuel level sensor **14** to ensure the tank **20** is not exceeding capacity. For example, the controller **18** can check the “high fill” level on the fuel level sensor **14** to
10 ensure the tank **20** is not exceeding capacity. The controller **18** can ignore the “fill” level of the fuel level sensor **14**. The controller **18** can end the recirculation process if the fuel level signal indicates that the tank **20** is exceeding capacity. The controller **18** can further execute the recirculation process by causing the bottom loading valve **10** to open and the vent valve **12** to move to the venting position, as described herein.
15 Additionally, the controller **18** can perform periodic fault monitoring checks during the recirculation process.

Once the controller **18** has determined that the recirculation process is complete, the controller **18** can cause the bottom loading valve **10** to close, as described herein. For example, input can be received via the one or more input device
20 **132** to stop the recirculation process.

It should now be understood that the bottom loading valves described herein can be utilized to perform on-loading, off-loading or recirculation operations. The bottom loading valves can be electrically operated and configured to perform operations according to a controller . Accordingly, the bottom loading valves
25 described herein can be incorporated into systems and perform methods without the use of a secondary air source, and associated tubing and brackets, that traditionally would have been used to operate a bottom loading valve and tank vent valve. As a result, embodiments of the present disclosure can be relatively simple to install and maintain compared to systems with secondary air sources. Moreover, the
30 embodiments described herein can operate in colder conditions and with improved reliability compared to systems with secondary air sources.

To the extent that the term “includes” or “including” is used in the specification or the claims, it is intended to be inclusive in a manner similar to the term “comprising” as that term is interpreted when employed as a transitional word in a claim. Furthermore, to the extent that the term “or” is employed (e.g., A or B) it is
5 intended to mean “A or B or both.” When the applicants intend to indicate “only A or B but not both” then the term “only A or B but not both” will be employed. Thus, use of the term “or” herein is the inclusive, and not the exclusive use. See, Bryan A. Garner, A Dictionary of Modern Legal Usage 624 (2d. Ed. 1995). Also, to the extent that the terms “in” or “into” are used in the specification or the claims, it is intended
10 to additionally mean “on” or “onto.” Additionally, to the extent that the terms “on” or “onto” are used in the specification or the claims, it is intended to additionally mean “in,” “into,” or “near.” Furthermore, to the extent the term “connect” is used in the specification or claims, it is intended to mean not only “directly connected to,” but also “indirectly connected to” such as connected through another component or
15 components.

It is noted that the terms "substantially" and "about" may be utilized herein to represent the inherent degree of uncertainty that may be attributed to any quantitative comparison, value, measurement, or other representation. These terms are also utilized herein to represent the degree by which a quantitative representation may vary
20 from a stated reference without resulting in a change in the basic function of the subject matter at issue. Accordingly, a quantitative representation preceded by the term “about” should be understood to include the exact quantity in addition to a functionally equivalent range surrounding the exact quantity.

While the present disclosure has been illustrated by the description of
25 embodiments thereof, and while the embodiments have been described in considerable detail, it is not the intention of the applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the disclosure, in its broader aspects, is not limited to the specific details, the representative apparatus
30 and method, and illustrative examples shown and described. Accordingly, departures

may be made from such details without departing from the spirit or scope of the applicant's general inventive concept.

CLAIMS

1. A bottom loading valve comprising:
a drive member operably coupled to a motor;
5 a valve body that defines a fluid passageway and one or more lateral openings, wherein the drive member is positioned within the fluid passageway, and wherein the one or more lateral openings is offset laterally from the drive member; and
a piston engaged with the drive member, wherein the piston moves throughout an open position and a closed position as the drive member communicates force from
10 the motor, and wherein, when the piston is in the closed position, the piston fully obstructs the one or more lateral openings from the fluid passageway.
2. The bottom loading valve of claim 1, wherein the drive member is in fixed and rotatable engagement with the valve body and rotates around an axis of rotation.
15
3. The bottom loading valve of claim 2, wherein the drive member is in threaded engagement with the piston.
4. The bottom loading valve of claim 1, comprising a position detector mounted
20 to the motor, wherein the position detector comprises a disk that is attached to the drive member and an optical reflective sensor located proximate the disk.
5. The bottom loading valve of claim 4, wherein the disk is indexed with a plurality of through holes.
25
6. The bottom loading valve of claim 1, wherein the drive member comprises a pinion operably coupled to the motor and a rack engaged with the piston, wherein the motor rotates the pinion to translate the rack and the piston.
- 30 7. The bottom loading valve of claim 1, wherein:

the valve body comprises a cylindrical portion; and
the one or more lateral openings are formed in the cylindrical portion of the valve body.

5 8. The bottom loading valve of claim 7, wherein:
the valve body comprises an exterior flange coupled to a fluid port, and an interior flange coupled to the cylindrical portion; and
the exterior flange and the interior flange are configured to cooperate to clamp
a tank.

10

9. The bottom loading valve of claim 1, wherein:
the piston comprises a hub configured to receive force from the motor, and a sealing member that forms a substantially cylindrically shaped outer rim that is concentric to the hub; and

15 the sealing member of the piston fully obstructs the one or more lateral openings from the fluid passageway, when the piston is in the closed position.

10. The bottom loading valve of claim 9, wherein the piston comprises low drag spokes that couple the hub and the sealing member.

20

11. The bottom loading valve of claim 10, wherein the low drag spokes are tapered as the low drag spokes extend away from a first end of the piston towards a second end of the piston.

25 12. The bottom loading valve of claim 1, wherein the bottom loading valve comprises a spring for biasing the bottom loading valve to the closed position.

13. A tank management system comprising:
a tank surrounding an interior;

a vent valve coupled to the tank that actuates throughout a venting position and a non-venting position, wherein the vent valve communicates a vent position signal indicative of actuation of the vent valve; and

5 a bottom loading valve coupled to the tank, the bottom loading valve comprising a valve body that defines a fluid passageway and one or more lateral openings and a motor that moves a piston throughout an open position and a closed position, wherein, when the piston is in the closed position, the piston fully obstructs the one or more lateral openings from the fluid passageway.

10 14. The tank management system of claim 13 further comprising a controller communicatively coupled to the vent valve and the bottom loading valve, wherein the controller executes machine readable instructions to:

cause the vent valve to actuate to the venting position;

receive the vent position signal;

15 determine that the vent valve is in the venting position from the vent position signal; and

cause the piston of the bottom loading valve to move to the open position after the vent valve is determined as being in the venting position.

20 15. The tank management system of claim 14, wherein the controller executes the machine readable instructions to:

cause the piston of the bottom loading valve to move to the closed position;

and

25 cause the vent valve to actuate from the venting position to the non-venting position, a predetermined amount of time after the piston of the bottom loading valve is moved to the closed position.

16. The tank management system of claim 14, further comprising a fuel level sensor communicatively coupled to the controller, wherein the controller executes the
30 machine readable instructions to:

receive a fuel level signal from the fuel level sensor that is indicative of an amount of fuel contained by the tank; and

determine that the tank has additional capacity, wherein the piston of the bottom loading valve is moved to the open position after the additional capacity is determined.

17. The tank management system of claim 14, further comprising a pressure sensor disposed upstream of the bottom loading valve and communicatively coupled to the controller, wherein the controller executes the machine readable instructions to:

10 receive a pressure signal from the pressure sensor indicative of an upstream pressure; and

determine that a pressure check is satisfied when the upstream pressure meets a minimum threshold pressure, wherein the piston of the bottom loading valve is moved to the open position after the pressure check is satisfied.

15

18. The tank management system of claim 14, wherein the controller executes the machine readable instructions to:

cause the piston of the bottom loading valve to move to the closed position; and

20 cause the vent valve to actuate from the venting position to the non-venting position a predetermined amount of time after the piston of the bottom loading valve is moved to the closed position.

19. The tank management system of claim 13 further comprising a controller communicatively coupled to the vent valve and the bottom loading valve, wherein the controller executes machine readable instructions to:

25 cause the vent valve to actuate from the non-venting position to the venting position; and

30 cause the piston of the bottom loading valve to move from the closed position to the open position contemporaneously to actuation of the vent valve.

20. A method for operating a tank management system comprising:
rotating a drive member within a fluid passageway and around an axis of
rotation;

5 translating, in response to rotation of the drive member, a piston engaged with
the drive member throughout an open position and a closed position; and

confining the piston within a valve body that defines one or more lateral
openings, wherein the one or more lateral openings is offset laterally from the axis of
rotation, and wherein, when the piston is in the closed position, the piston fully
obstructs the one or more lateral openings from the fluid passageway.

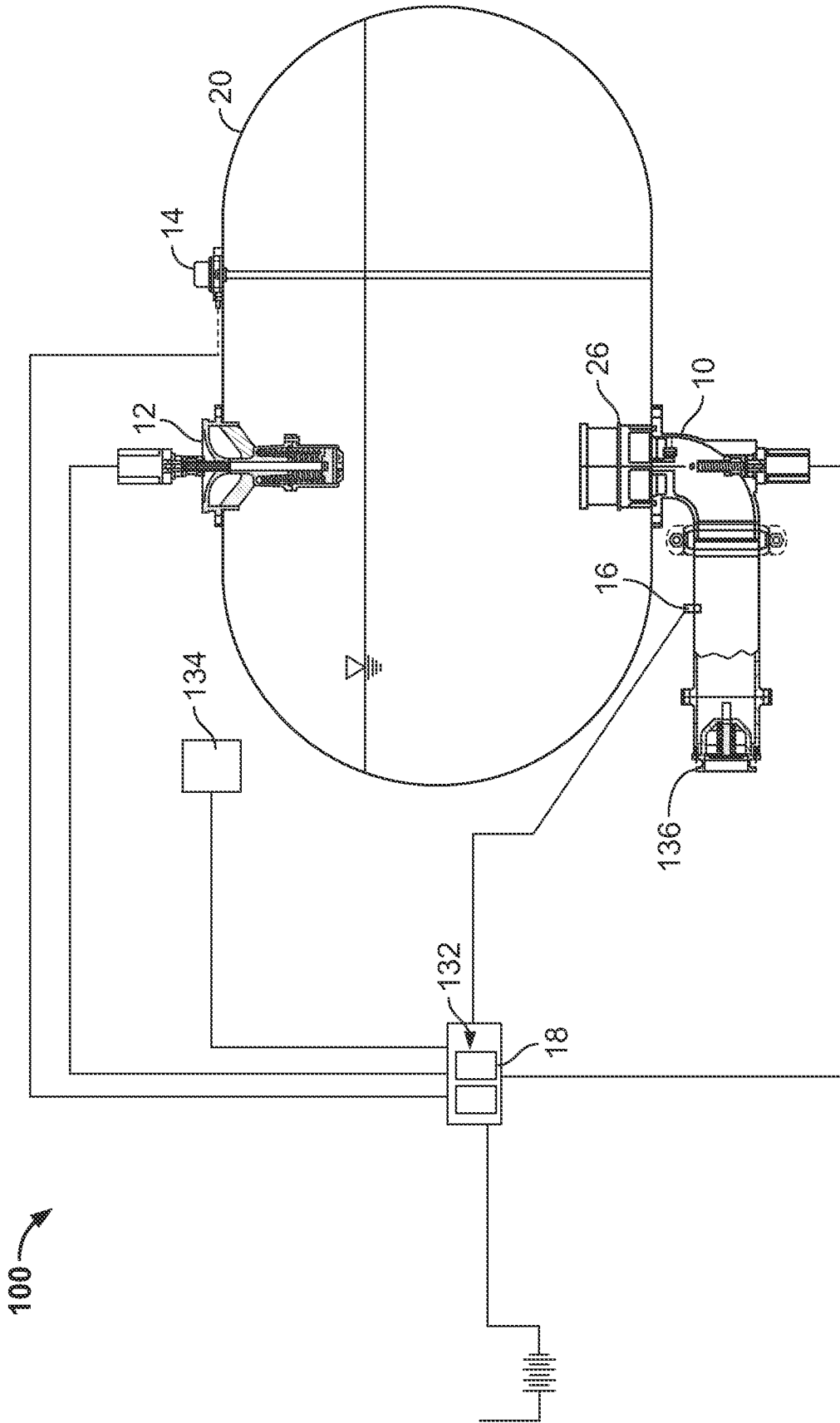


FIG. 1

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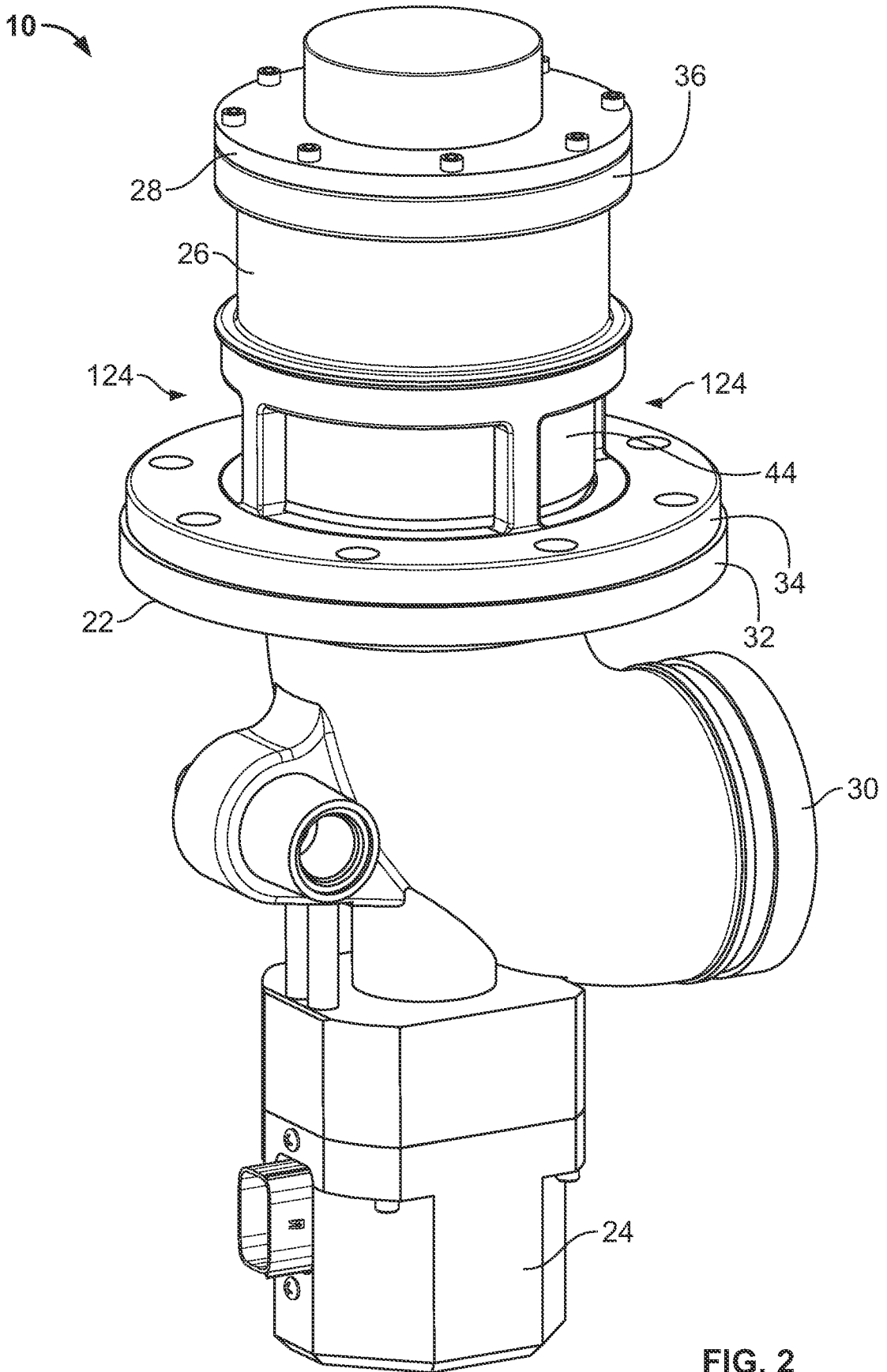


FIG. 2

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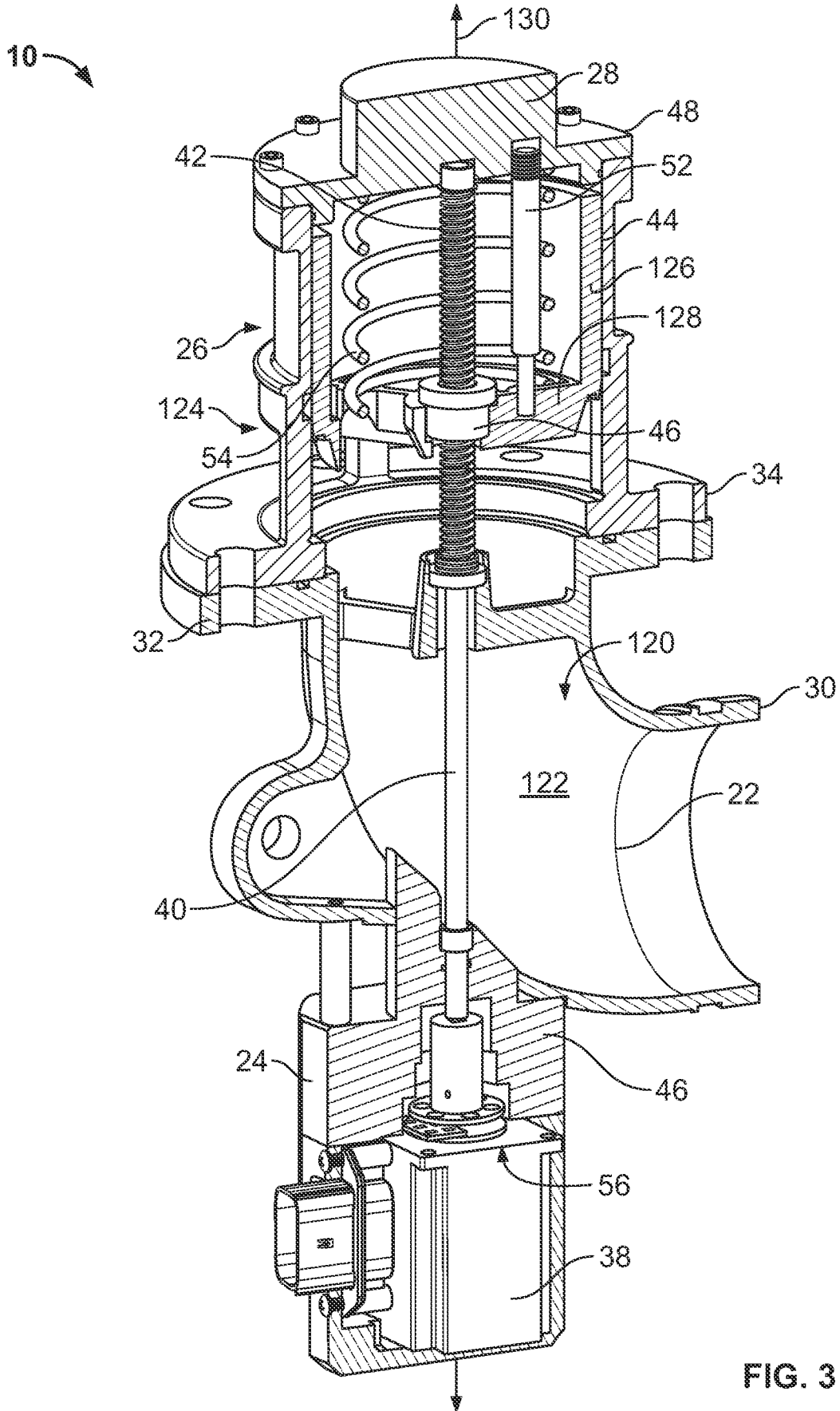


FIG. 3

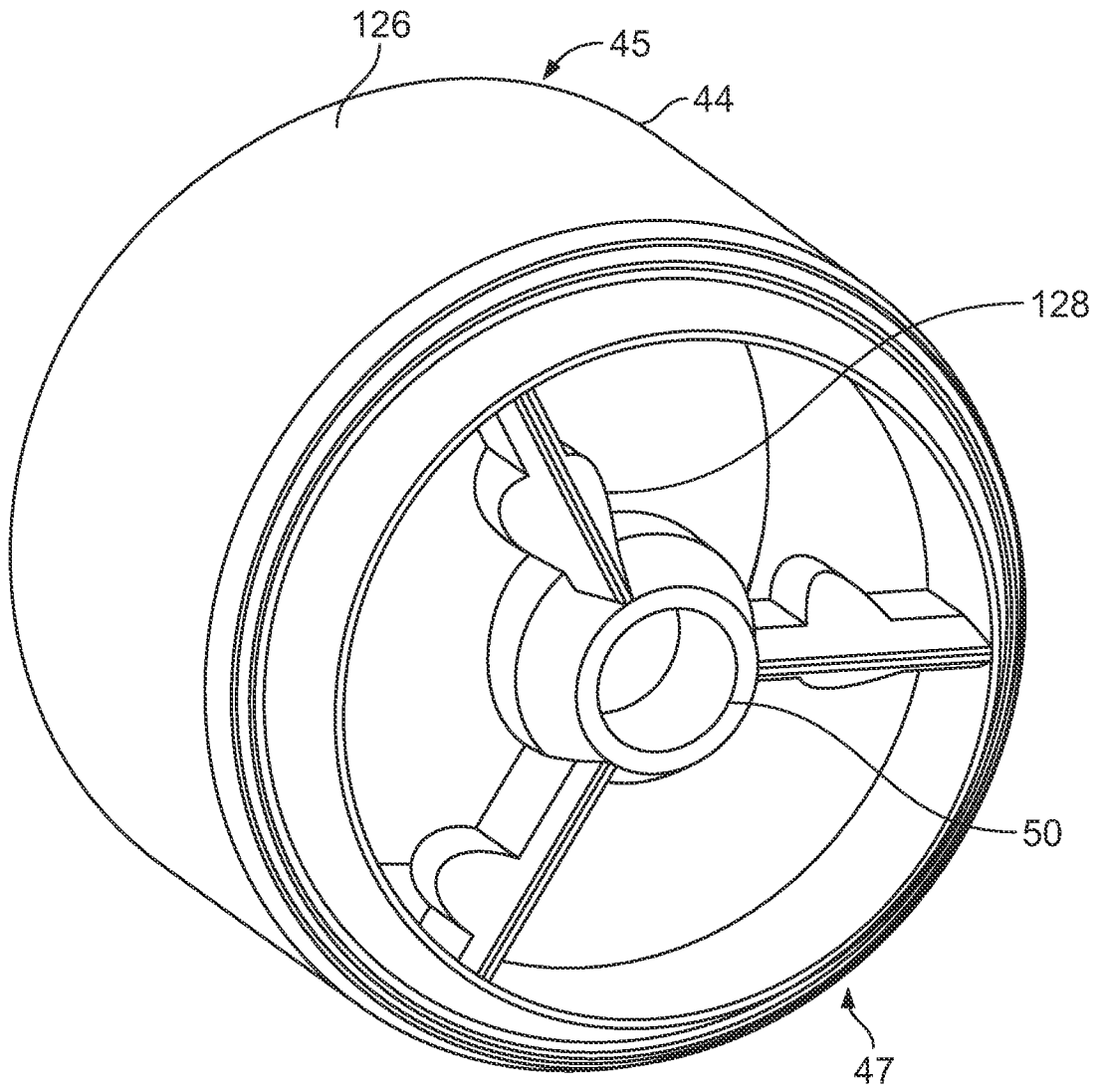


FIG. 4

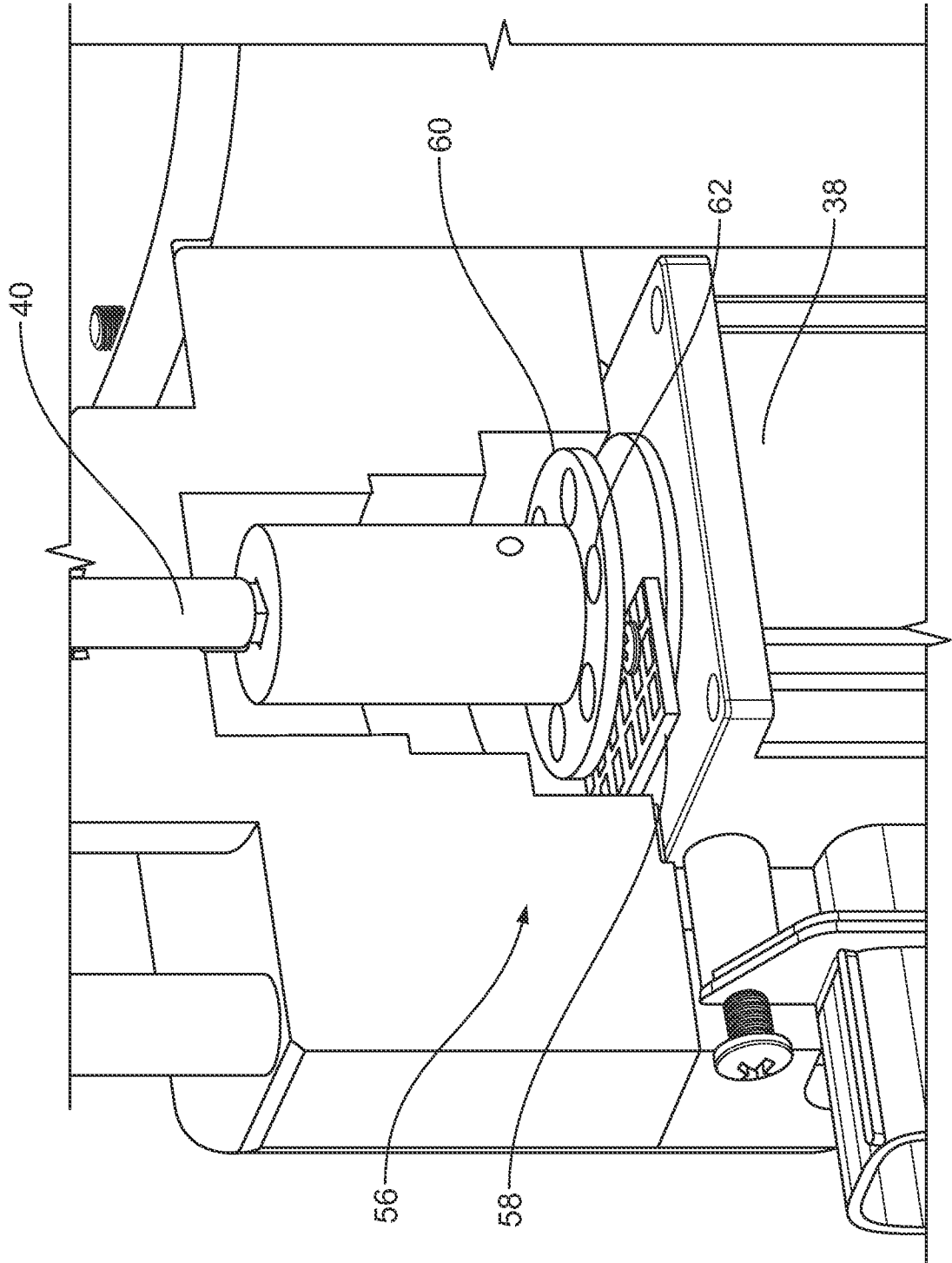


FIG. 5

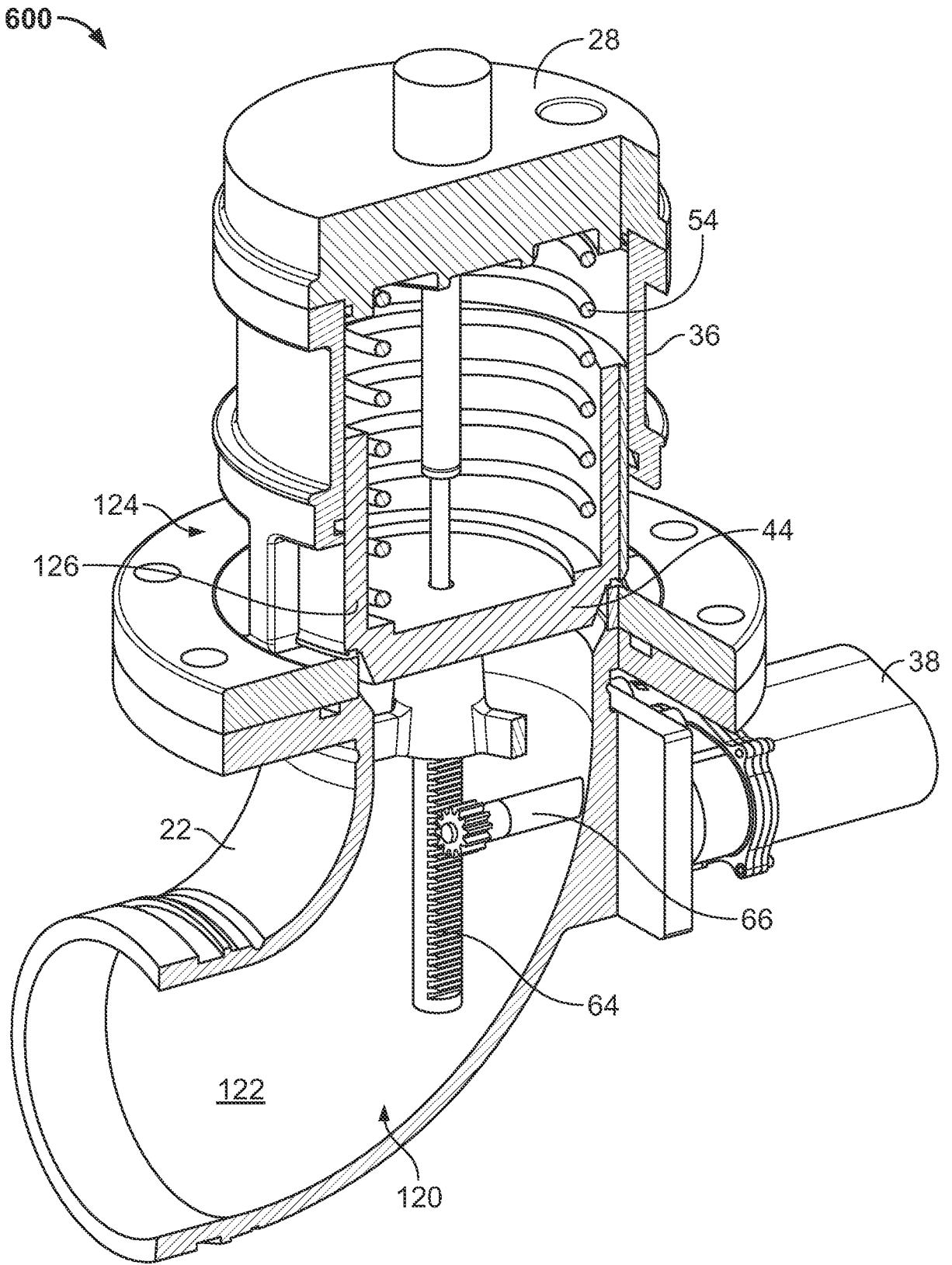


FIG. 6

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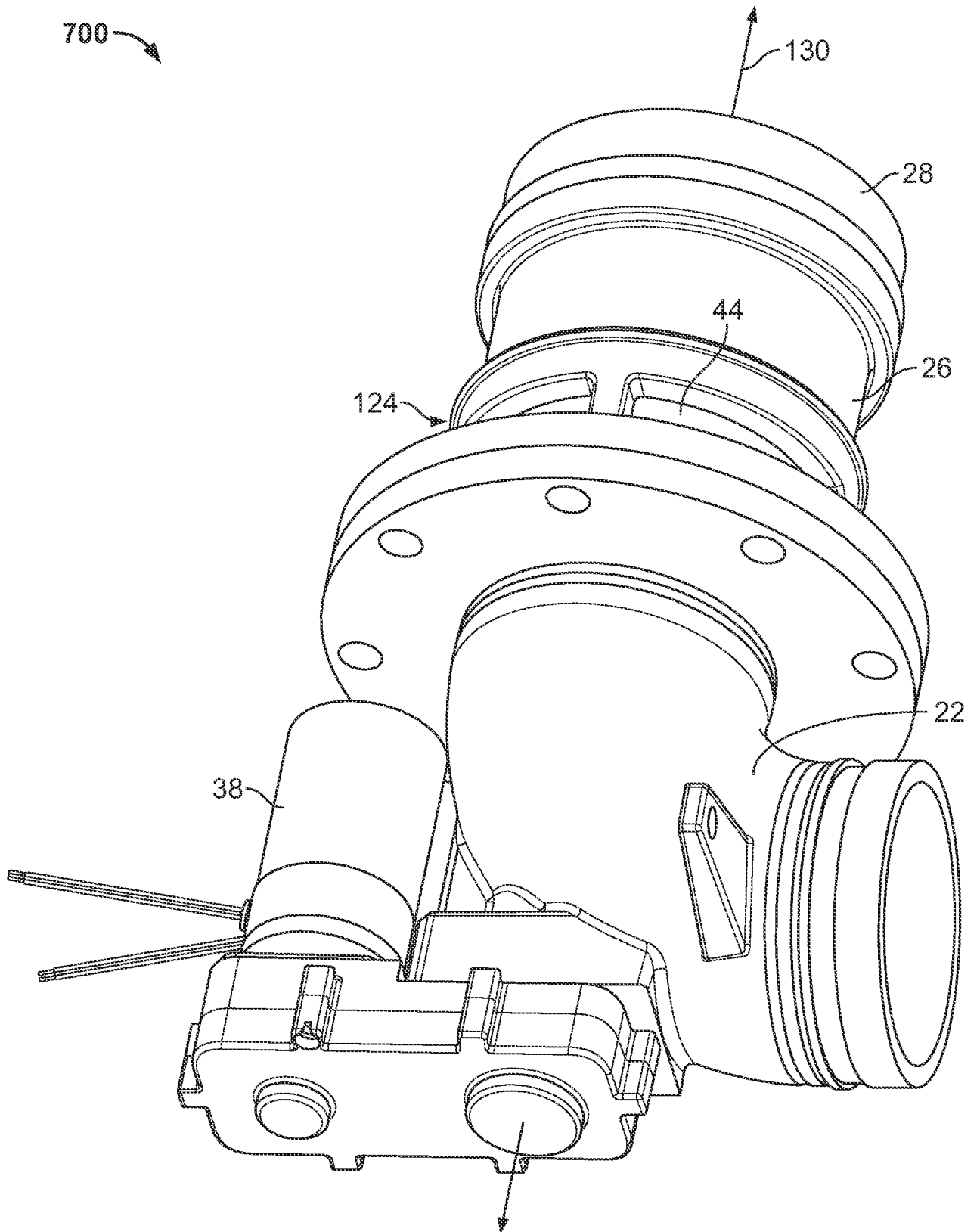


FIG. 7

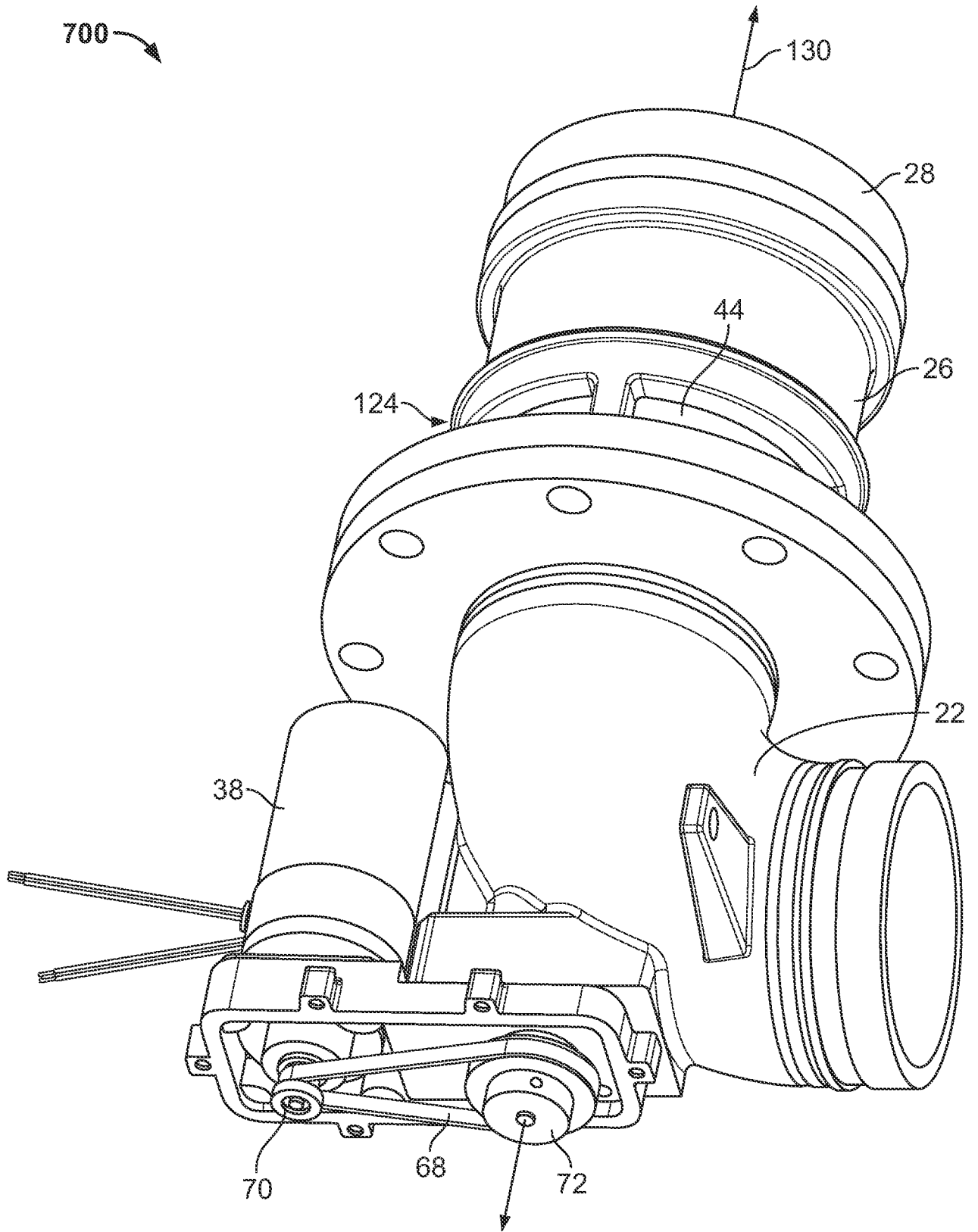


FIG. 8