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**Uhler**

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(54) **POSITIONABLE OUTLET FOR A WATER MONITOR**

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**F16L 27/12** (2006.01)  
**F16L 27/08** (2006.01)

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

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(58) **Field of Classification Search**

CPC .. **A62C 31/00**; **F16L 27/0816**; **F16L 27/0828**; **F16L 27/12**

See application file for complete search history.

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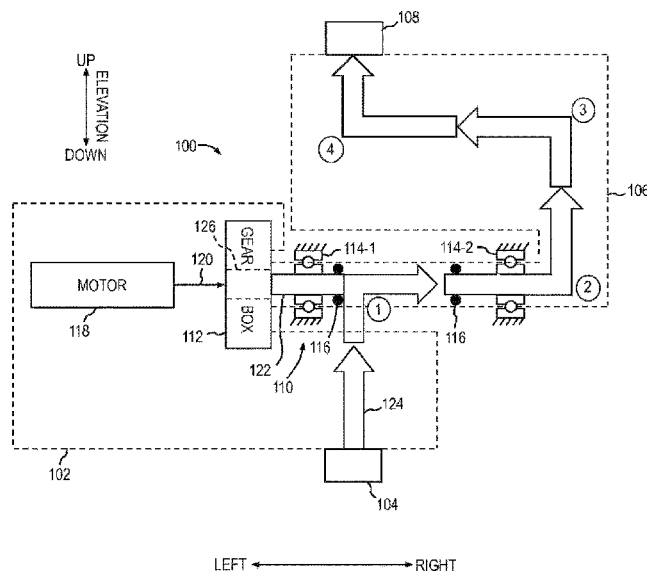
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(57) **ABSTRACT**

One or more techniques and/or systems are disclosed for a water monitor with a stationary fluid inlet. A movable portion has a first piece rotatably coupled to the stationary portion and a second piece rotatably coupled to the first piece. The second piece has an inlet portion that extends through a second end of the first piece. The second piece couples with a power transmission disposed on a first side of the first piece, and couples with the first piece at a second side of the first piece. In this way, the power transmission can remain outside a path of fluid flow, and may be able to apply rotational force to the second piece to alter an elevation of the fluid outlet in the second piece.

**19 Claims, 15 Drawing Sheets**



**Related U.S. Application Data**

- continuation of application No. 13/921,696, filed on Jun. 19, 2013, now Pat. No. 8,678,022.
- (60) Provisional application No. 61/663,526, filed on Jun. 22, 2012.
- (52) **U.S. Cl.**  
 CPC ..... *F16L 27/0849* (2013.01); *F16L 27/12* (2013.01); *Y10T 137/0402* (2015.04); *Y10T 137/0441* (2015.04); *Y10T 137/0491* (2015.04); *Y10T 137/8593* (2015.04); *Y10T 137/8807* (2015.04)

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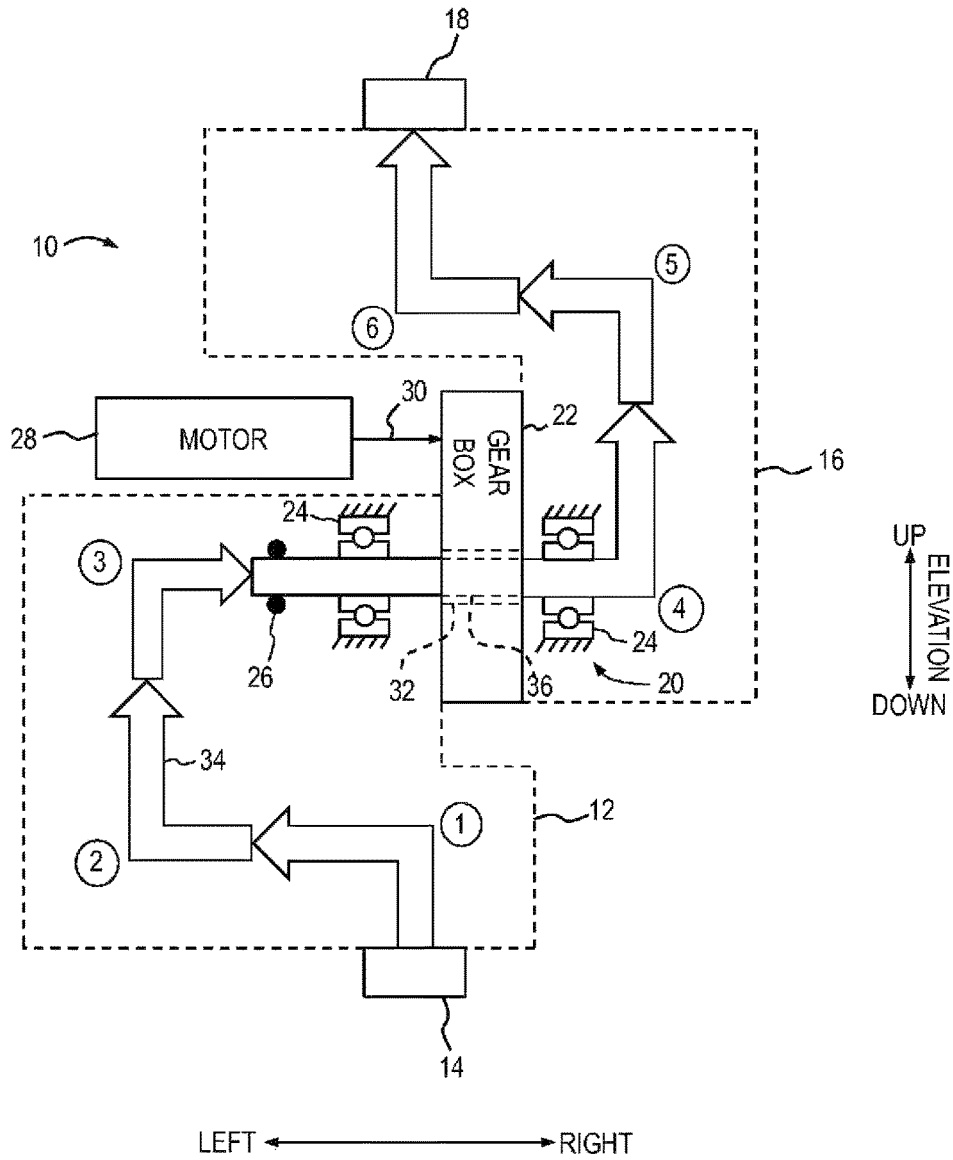
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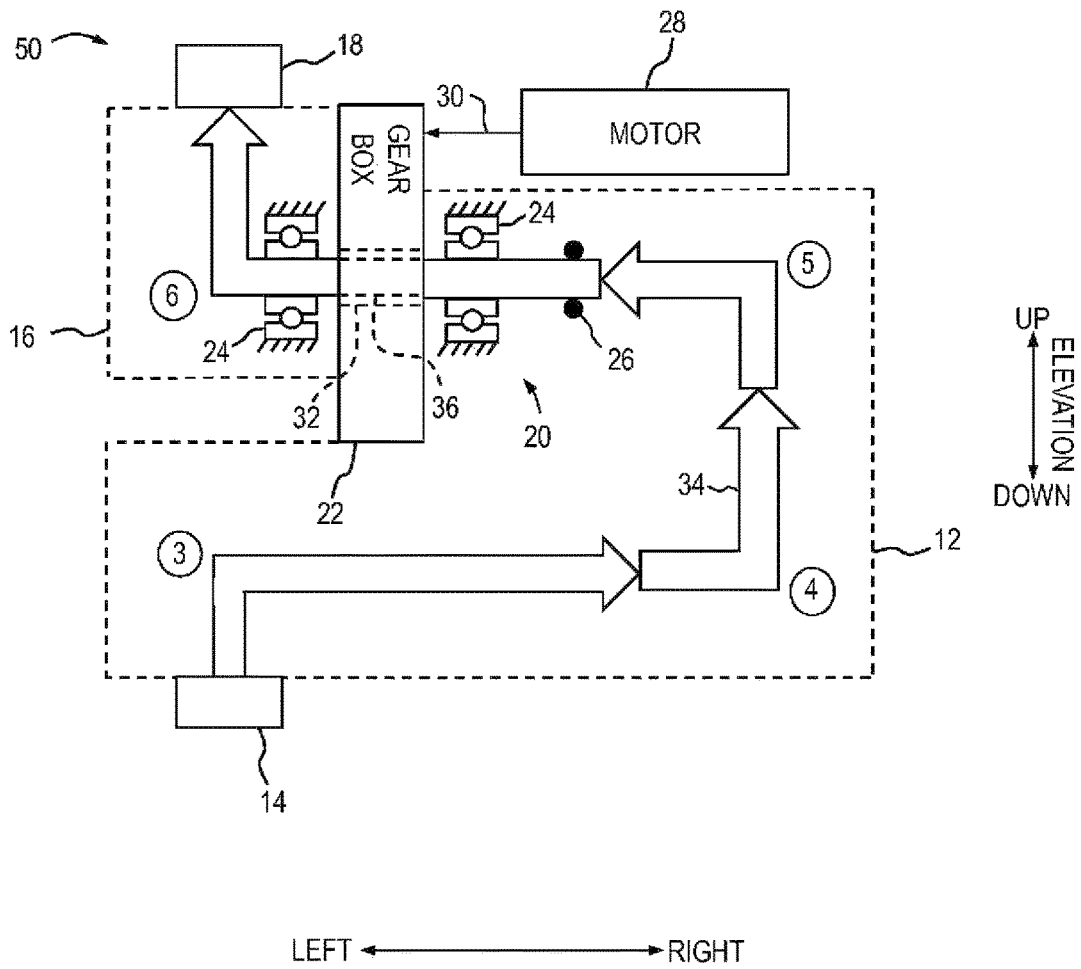
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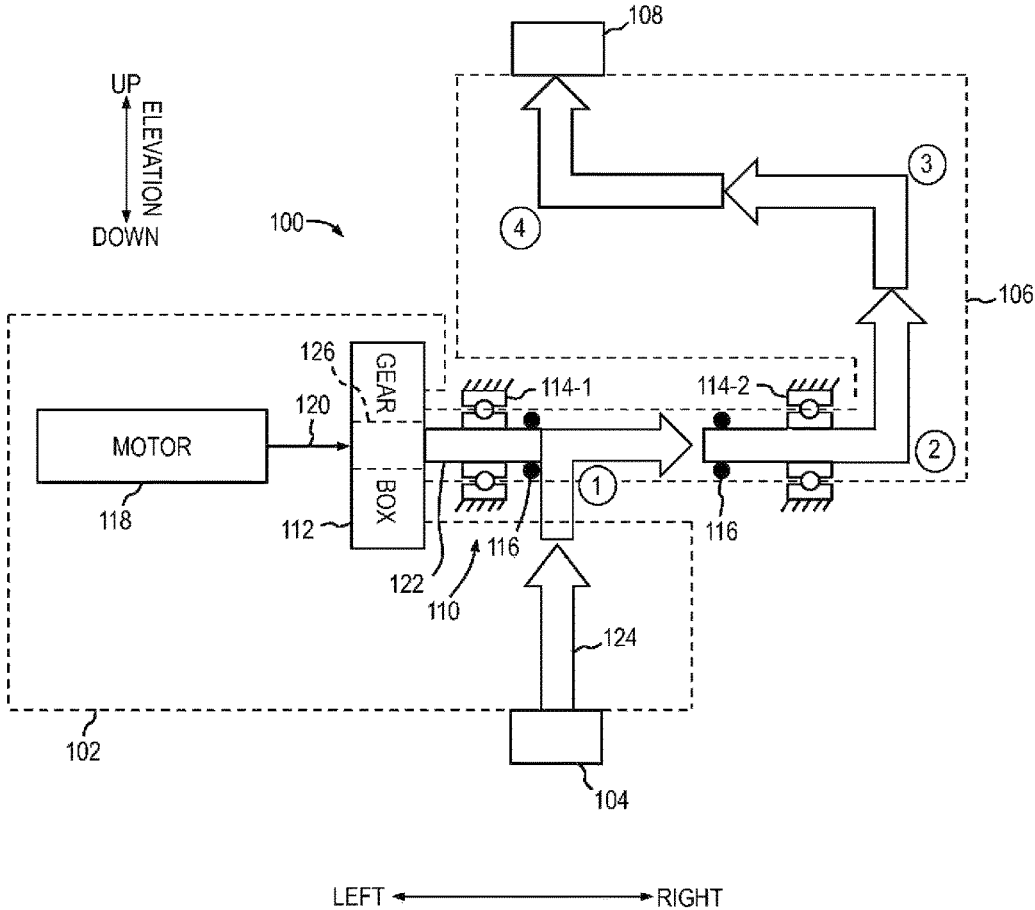
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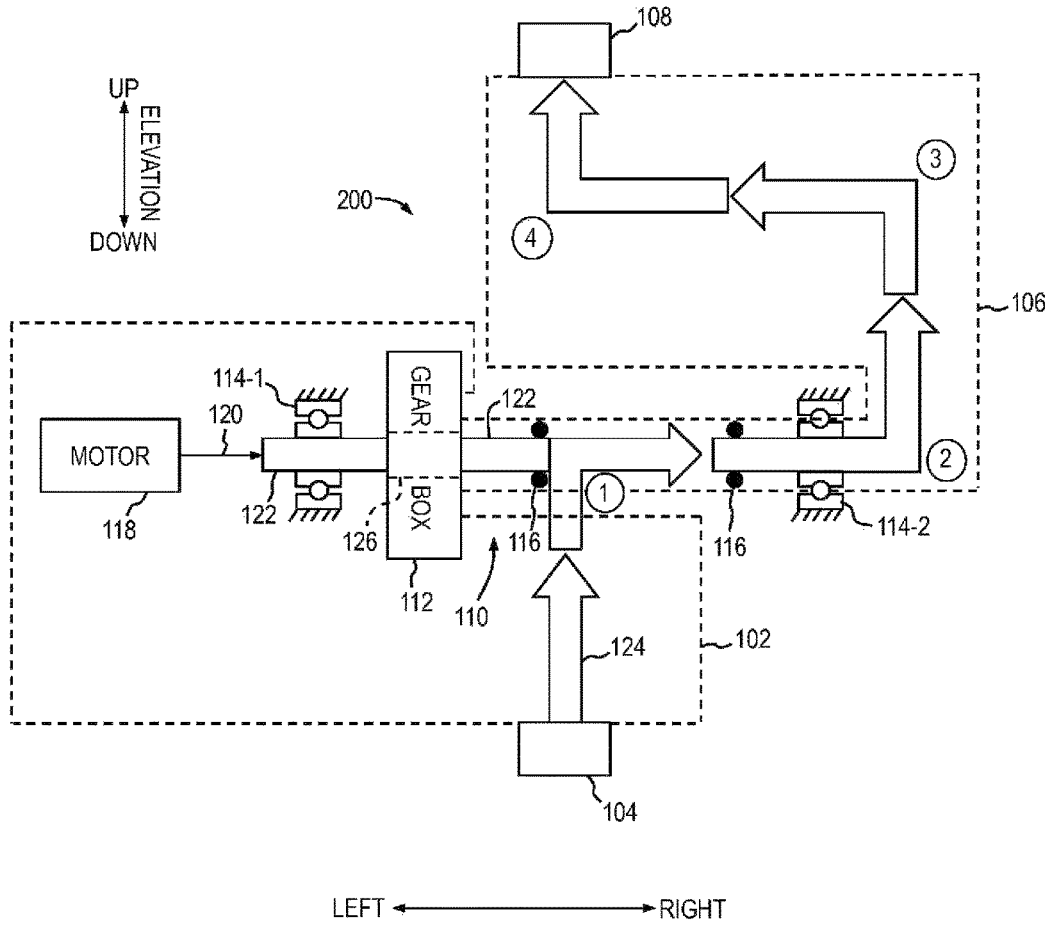
***Fig. 1***  
***Prior Art***



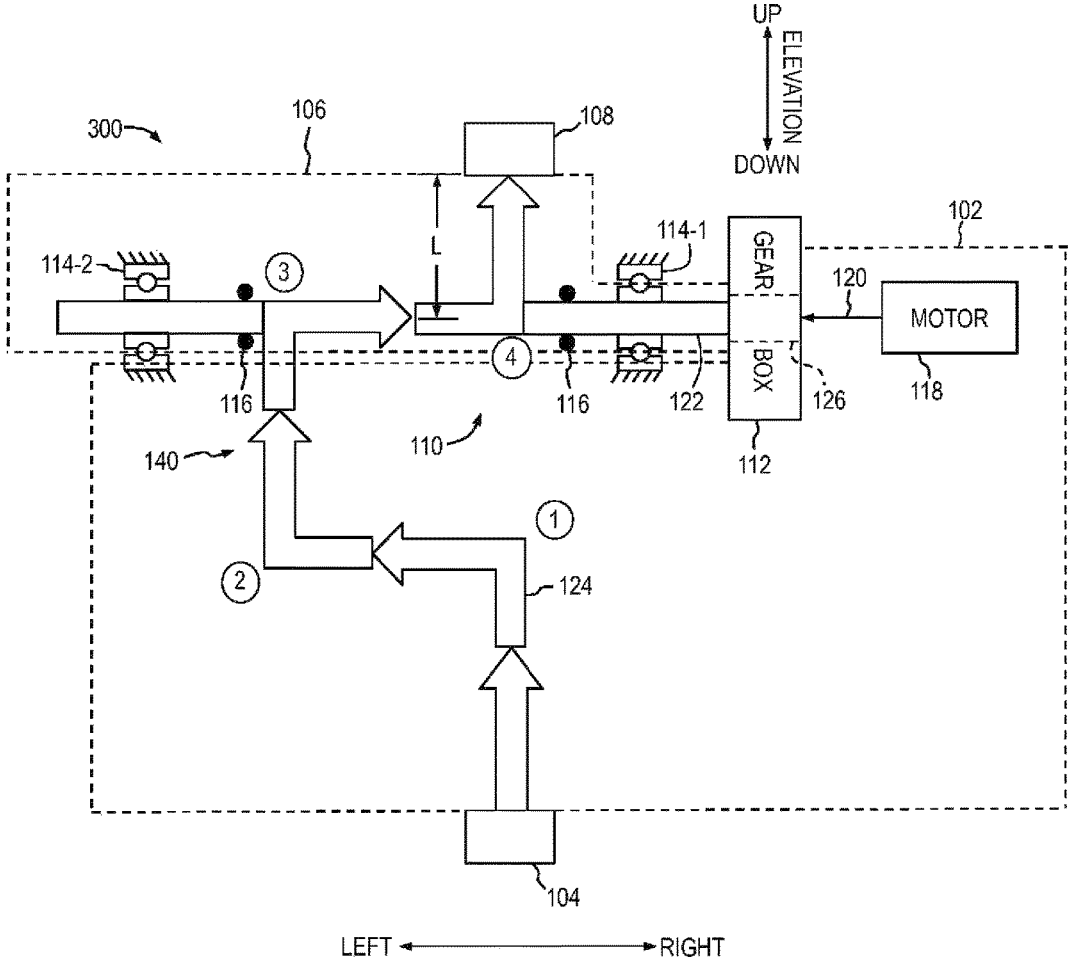
***Fig. 2***  
***Prior Art***



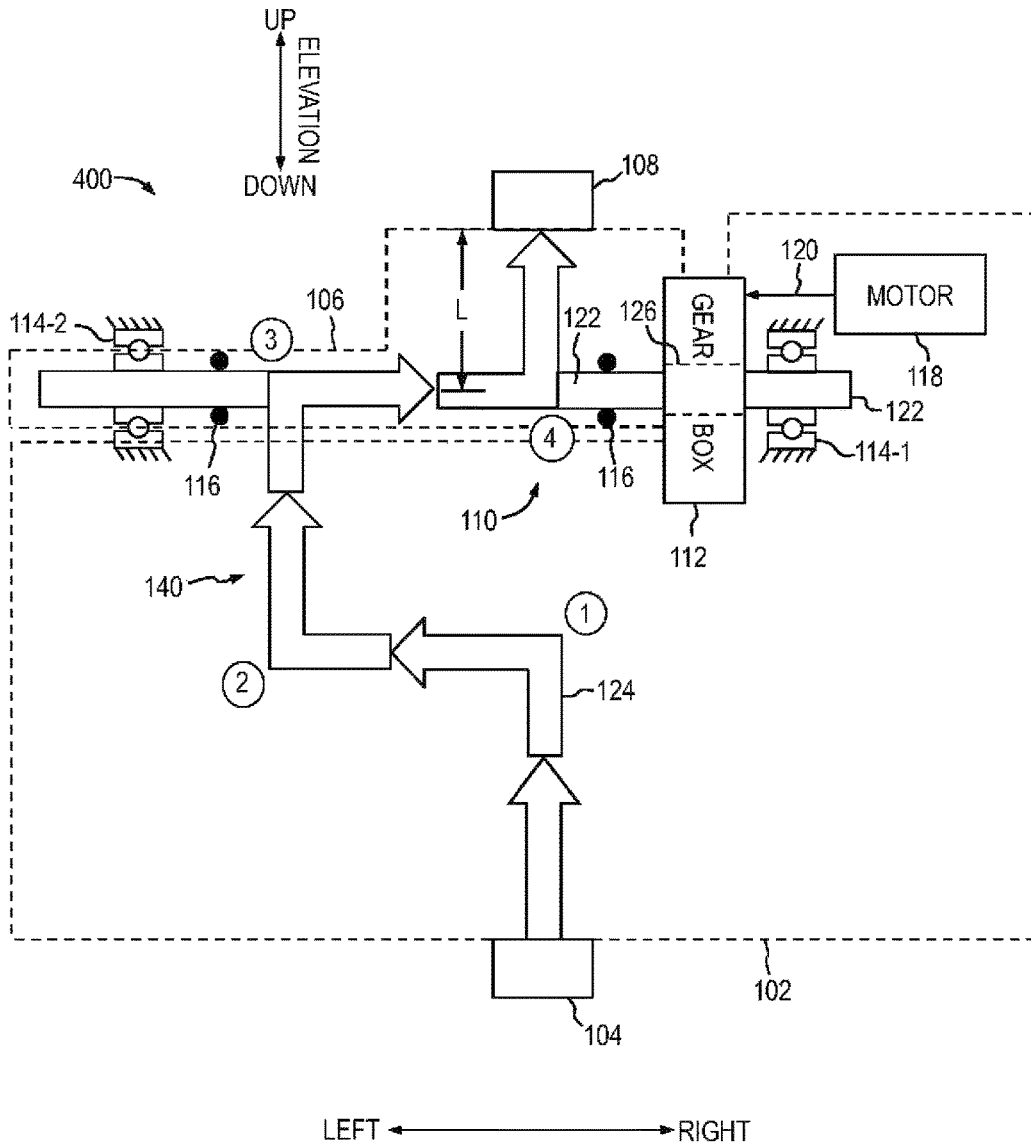
***Fig. 3***



***Fig. 4***

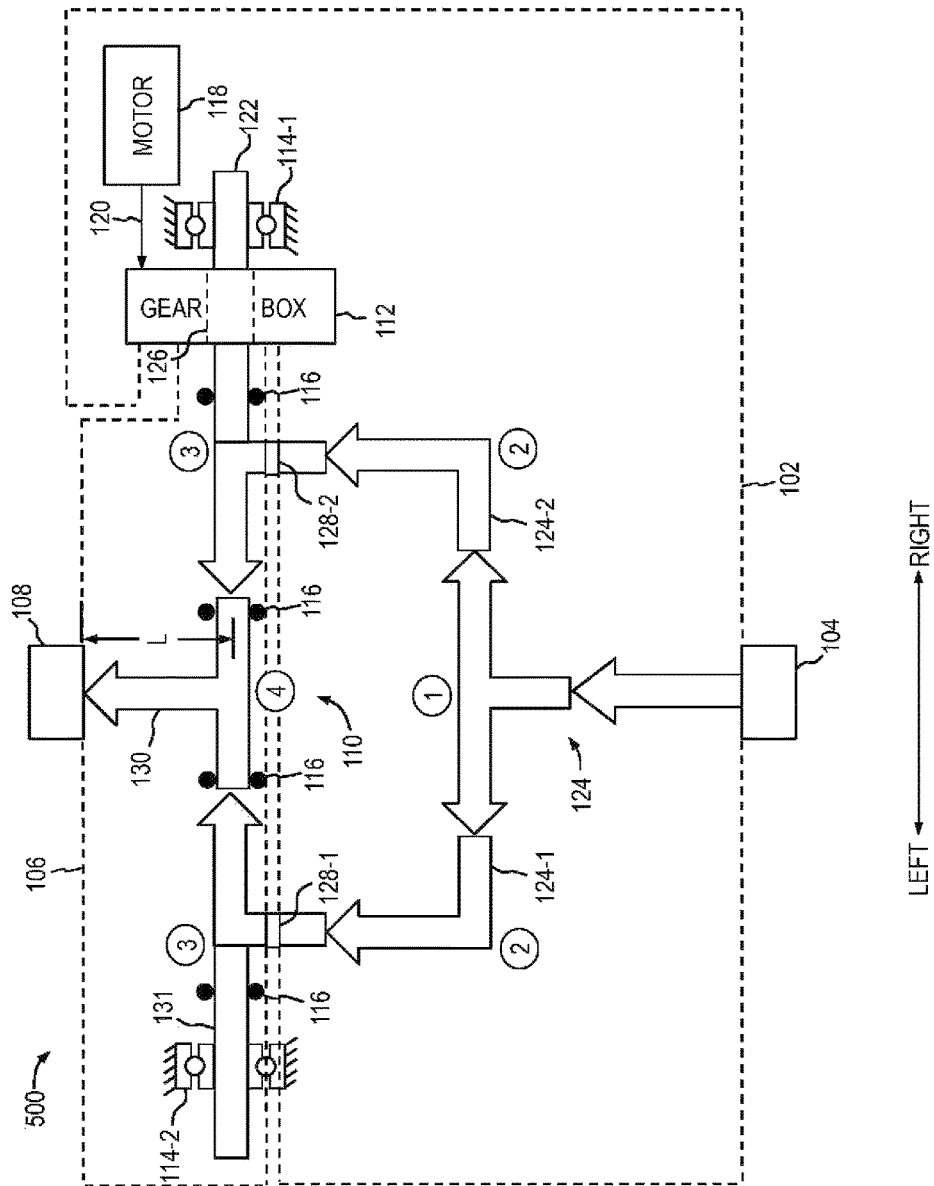


***Fig. 5***

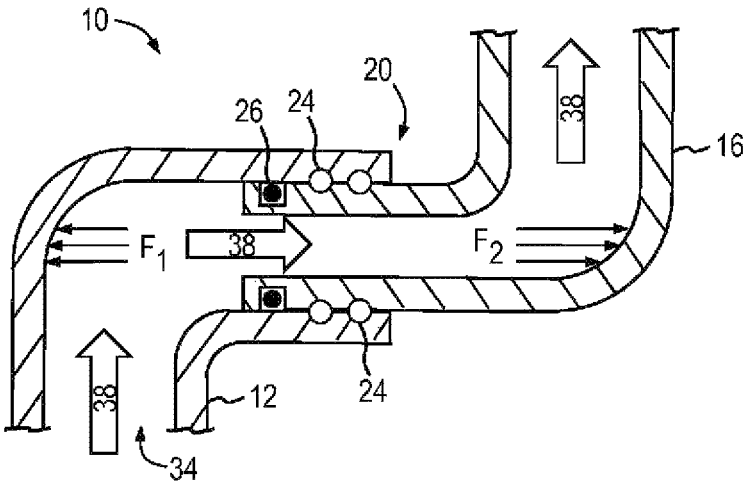


**Fig. 6**

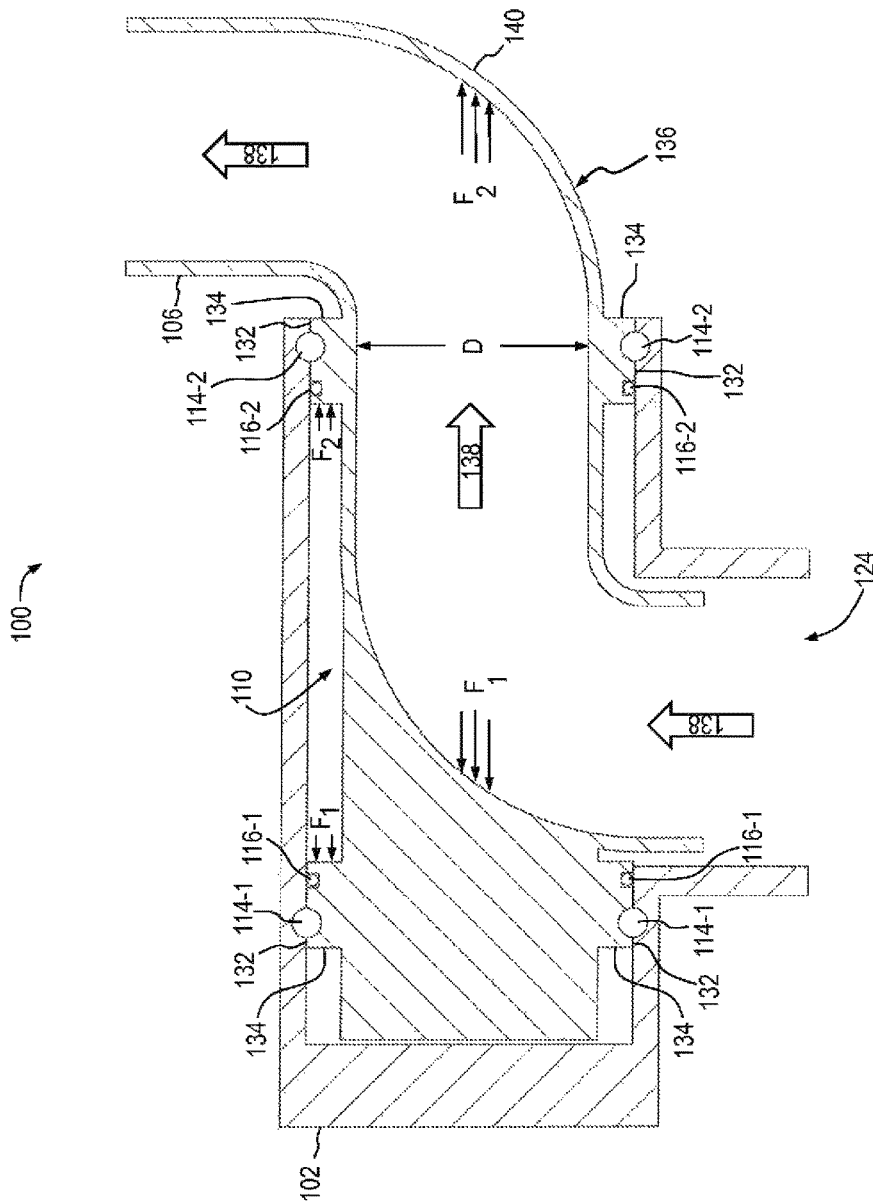




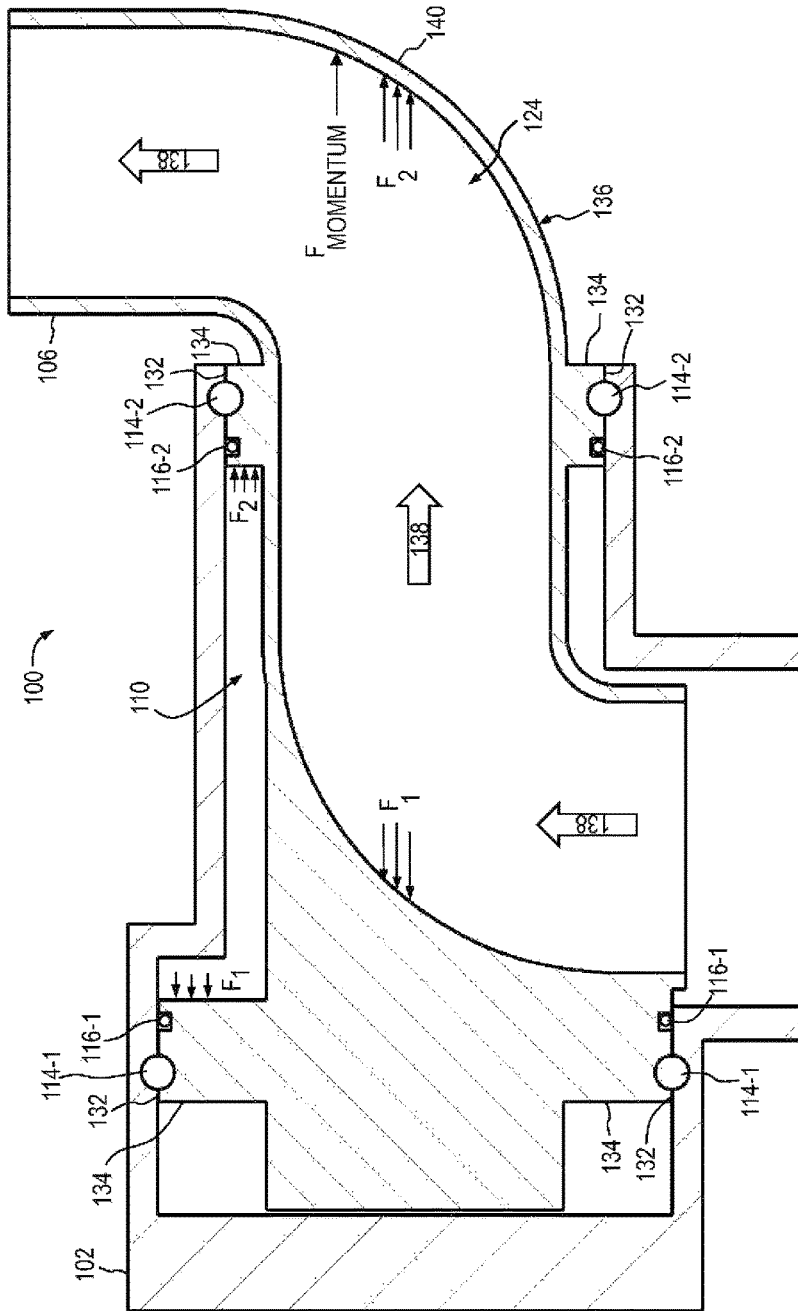
***Fig. 7***



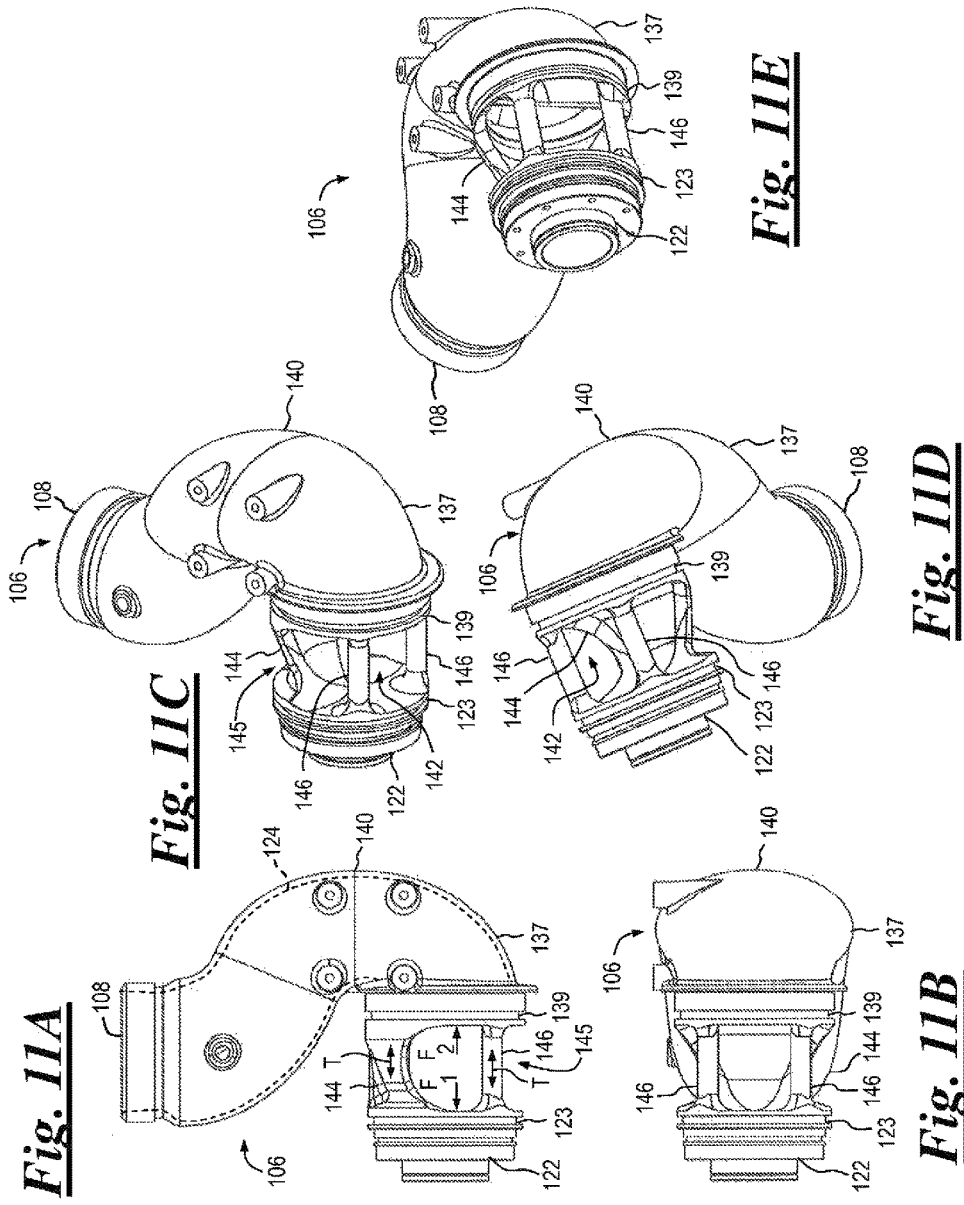
**Fig. 8**  
**Prior Art**



**Fig. 9**



**Fig. 10**



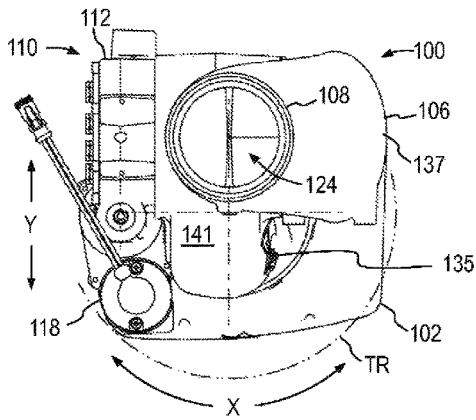
**Fig. 11A**

**Fig. 11C**

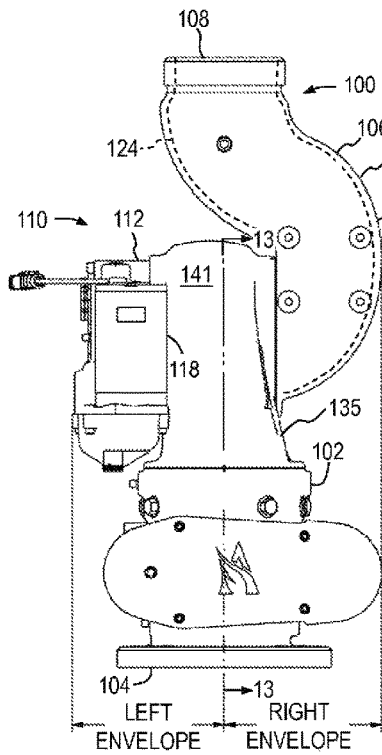
**Fig. 11B**

**Fig. 11D**

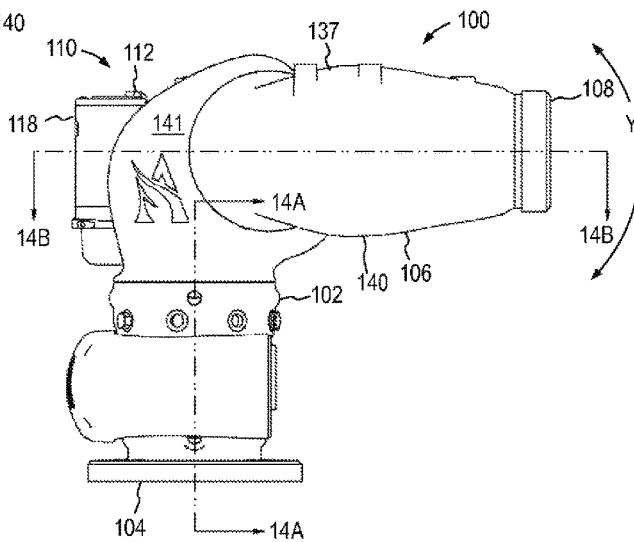
**Fig. 11E**



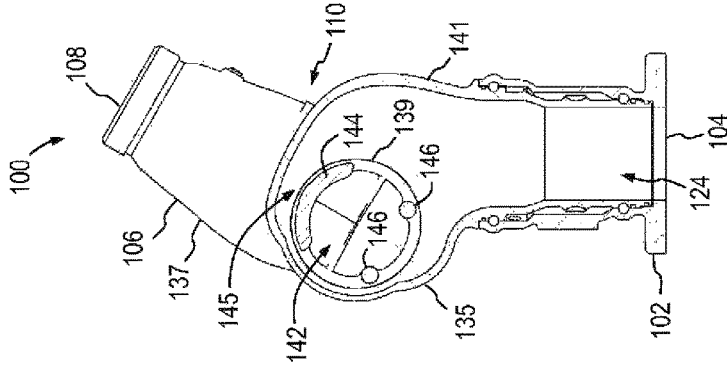
**Fig. 12A**



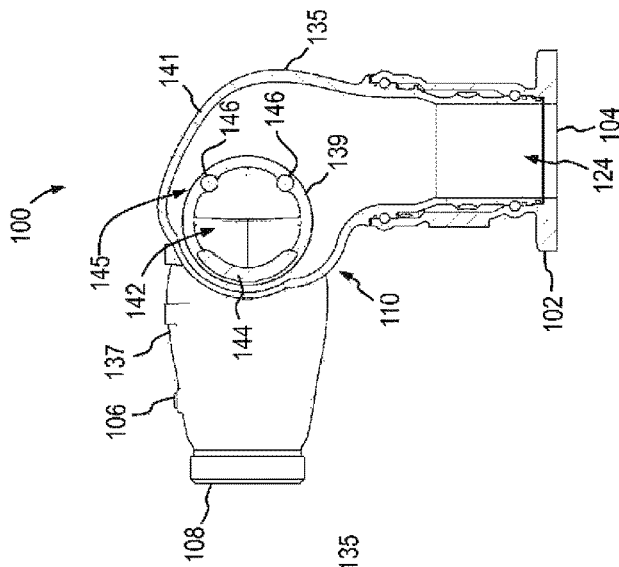
**Fig. 12B**



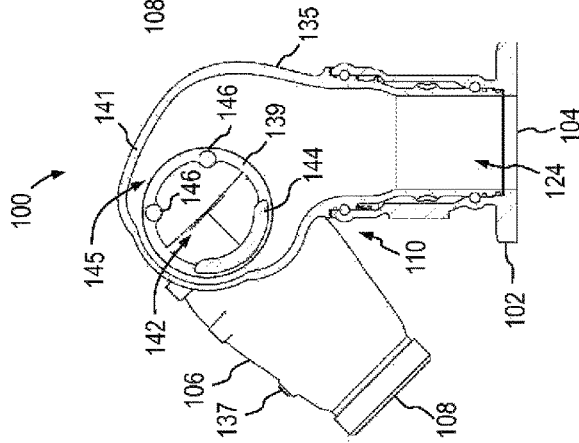
**Fig. 12C**



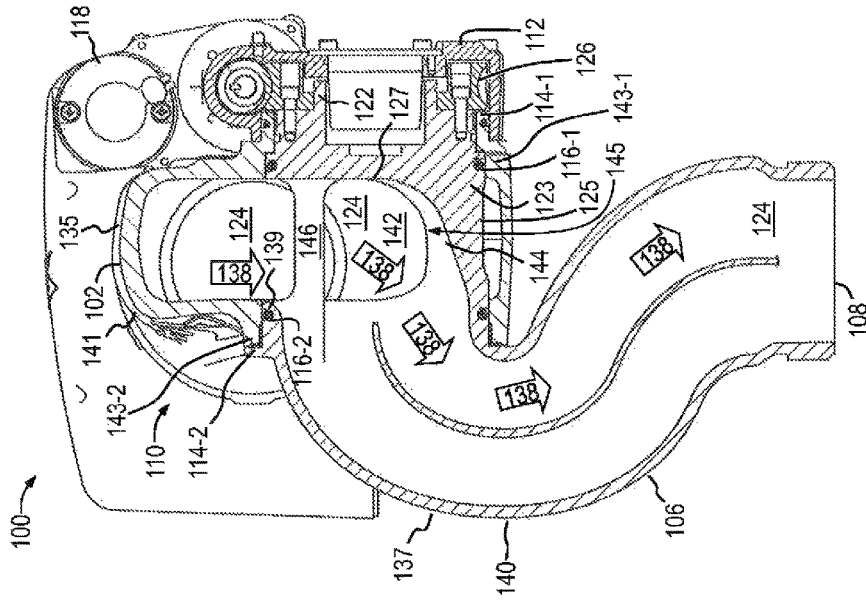
**Fig. 13A**



**Fig. 13B**



**Fig. 13C**

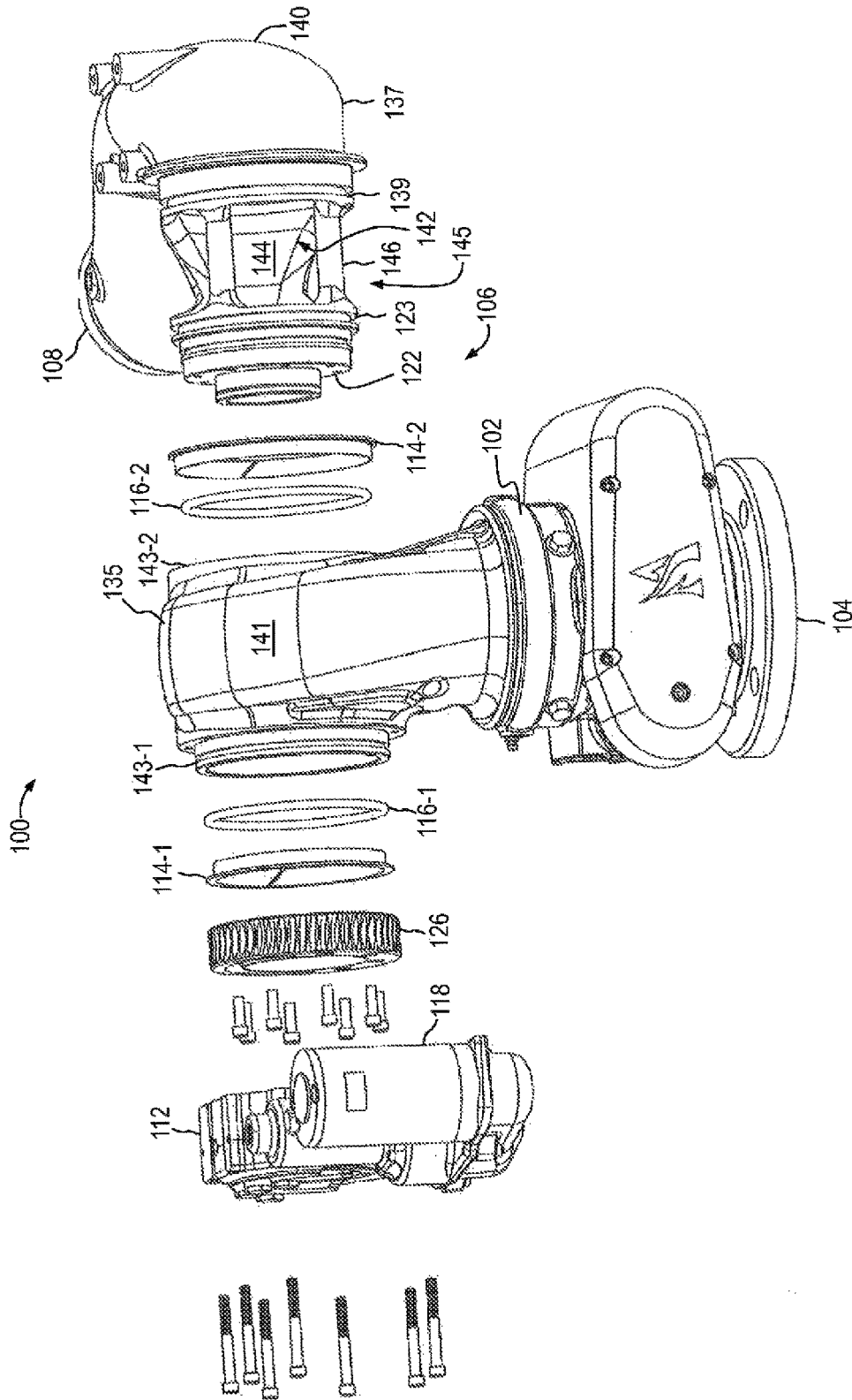


**Fig. 14B**



**Fig. 14A**





**Fig. 15**

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**POSITIONABLE OUTLET FOR A WATER MONITOR****CROSS-REFERENCE TO RELATED APPLICATIONS**

This application is a continuation of, and claims priority to, U.S. Ser. No. 14/200,589, entitled POSITIONABLE OUTLET FOR A WATER MONITOR, filed Mar. 7, 2014 now U.S. Pat. No. 9,233,265; which is a continuation of, and claims priority to, U.S. Ser. No. 13/921,696, filed Jun. 19, 2013, now U.S. Pat. No. 8,678,022; which claims priority to U.S. provisional application No. 61/663,526, filed Jun. 22, 2012; all of which are incorporated herein by reference.

**BACKGROUND**

Water monitors, also referred to as “water turrets,” “water cannons,” “fire-fighting monitors,” “fluid monitors,” “monitors” and the like are used to manually or automatically distribute high-pressure streams of foam, water, water-based foam and fire retardants over an area determined by the amount of fluid pressure, the angle of elevation of the water monitor, its arc of azimuthal oscillation, its speed of azimuthal oscillation and its pattern of azimuthal oscillation. Water monitors are primarily used to extinguish fire hazards, although other uses may include fire prevention, irrigation, crowd control, and water-cooling of objects.

Water monitors are often configured with a fluid input portion that is fixed, stationary or otherwise non-moving (hereafter generally “stationary” herein) with respect to a fluid output portion. The fluid output portion is usually movable and is positionable to a select azimuth and/or elevation. Such water monitors typically utilize one or more electric motors and reduction-gear assemblies (hereafter “gearboxes”) to convert a relatively high-speed, low-torque output of the motors to a relatively low-speed, higher-torque force for moving a fluid outlet of the water monitor to a select position.

Positionable water monitors are usually configured with ball bearings interposed between the stationary portion and the movable fluid outlet elbow to reduce rotational friction between these components and to support radial and axial loads exerted upon the movable portion. A pair of races are utilized to contain a plurality of balls and to transmit the loads through the balls, one race being formed in the stationary portion and a facially adjacent race being formed in the rotatable portion. As the race in the rotatable portion moves it causes the balls to rotate as well. Because the balls are rolling they have a lower coefficient of friction than if two flat surfaces were rotating upon each other.

A significant drawback of this arrangement is that fluids flowing through the water monitor at high pressure exert a separating force upon the bearings. This separating force adds to the mechanical load imposed upon the aforementioned electric motors and gearboxes, and can result in excess component wear and reduced service life for these components.

Utilizing electric motors and gearboxes rated for higher loads may be utilized to counter this problem, but such an approach requires components that are more expensive, physically larger, and have greater weight when compared to electric motors and gearboxes designed for smaller loads.

**SUMMARY**

This Summary is provided to introduce a selection of concepts in a simplified form that are further described

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below in the Detailed Description. This Summary is not intended to identify key factors or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

5 As provided herein, a water monitor having a positionable fluid outlet is disclosed according to an embodiment of the present invention. The water monitor includes a stationary portion having a fluid inlet and a movable portion that is rotatably coupled to the stationary portion, the movable portion having a fluid outlet. A gearbox interposed between the stationary portion and the movable portion converts a relatively high-speed, low-torque rotary motion from an electric motor to a relatively low-speed, higher-torque output. The gearbox is placed outside a fluid flow path extending between the fluid inlet and the fluid outlet of the water monitor. The water monitor utilizes a minimal number of bends in the fluid flow path, thereby reducing pressure drops in the fluid flow due to the bends, while also achieving a relatively compact size for the water monitor.

20 In one implementation, a water monitor includes a stationary portion having a fluid inlet. A movable portion having a fluid outlet is coupled to the stationary portion. A fluid flow path extends between the fluid inlet and the fluid outlet, and is configured to communicate fluids from the fluid inlet to the fluid outlet. A power transmission is coupled to the movable portion such that the fluid flow path does not extend through (i.e., “bypasses”) the power transmission. The movable portion is rotatable with respect to the stationary portion to position the fluid outlet.

30 To the accomplishment of the foregoing and related ends, the following description and annexed drawings set forth certain illustrative aspects and implementations. These are indicative of but a few of the various ways in which one or more aspects may be employed. Other aspects, advantages and novel features of the disclosure will become apparent from the following detailed description when considered in conjunction with the annexed drawings.

**BRIEF DESCRIPTION OF THE DRAWINGS**

40 What is disclosed herein may take physical form in certain parts and arrangement of parts, and will be described in detail in this specification and illustrated in the accompanying drawings which form a part hereof and wherein:

45 FIG. 1 is a schematic diagram of a prior art water monitor;

FIG. 2 is a schematic diagram of another prior art water monitor;

50 FIG. 3 is a schematic diagram of a water monitor according to an implementation of one or more systems described herein;

FIG. 4 is a schematic diagram of a water monitor according to another implementation of one or more systems described herein;

55 FIG. 5 is a schematic diagram of a water monitor according to yet another implementation of one or more systems described herein;

FIG. 6 is a schematic diagram of a water monitor according to still another implementation of one or more systems described herein;

60 FIG. 7 is a schematic diagram of a water monitor according to yet another implementation of one or more systems described herein;

FIG. 8 is a sectional representation of a portion of a prior art water monitor;

65 FIG. 9 is a sectional representation of a portion of a water monitor according to an implementation of one or more portions of one or more systems described herein;

FIG. 10 is a sectional representation of a portion of a water monitor according to an implementation of one or more portions of one or more systems described herein;

FIGS. 11A, 11B, 11C, 11D and 11E are views of an implementation of one or more portions of one or more systems described herein;

FIGS. 12A, 12B and 12C are top, side and end views respectively of an implementation of one or more portions of one or more systems described herein;

FIGS. 13A, 13B and 13C are views in section showing rotation of an implementation of one or more portions of one or more systems described herein;

FIGS. 14A and 14 B are views in section of an implementation of one or more portions of one or more systems described herein; and

FIG. 15 is an exploded view of a water monitor according to an implementation of one or more portions of one or more systems described herein.

### DETAILED DESCRIPTION

The claimed subject matter is now described with reference to the drawings, wherein like reference numerals are generally used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the claimed subject matter. It may be evident, however, that the claimed subject matter may be practiced without these specific details. In other instances, structures and devices may be shown in block diagram form in order to facilitate describing the claimed subject matter.

In the discussion that follows, like reference numerals are used to refer to like elements and structures in the various figures and embodiments of the present invention.

A schematic block diagram of a prior art water monitor 10 is shown in FIG. 1. Water monitor 10 comprises a stationary portion 12 (i.e., stationary with respect to elevational movement) and a fluid inlet 14. A movable portion 16 (i.e., movable with respect to elevational movement) is rotatably coupled to the stationary portion, the movable portion having a fluid outlet 18.

A rotating joint 20, which allows fluid outlet 18 to be selectively positioned in the elevation direction, is made up of a gearbox 22, one or more bearings 24, and one or more seals 26. Rotating joint 20 is oriented perpendicularly to fluid outlet 18 so that the fluid outlet is positionable about an elevational arc.

Gearbox 22, which is interposed between stationary portion 12 and movable portion 16, converts a relatively high-speed, low-torque rotary motion from an electric motor 28 to a relatively low-speed, higher-torque output. In operation, rotary motion from an output 30 of motor 28 is converted to a relatively low-speed, higher-torque output by gearbox 22. The output of gearbox 22 is coupled to movable portion 16 such that actuating motor 28 causes the movable portion to rotate with respect to stationary portion 12, thereby moving fluid outlet 18 to a select elevational position.

Gearbox 22 typically comprises a worm gear and a worm wheel 32 for speed reduction and torque amplification, the worm wheel being situated in a fluid flow path or "waterway" 34 (represented by block arrows in FIG. 1) extending between fluid inlet 14 and fluid outlet 18 such that fluid flowing in the fluid flow path passes through an open center 36 of worm wheel 32. Water monitor 10 suffers from undesirable pressure drop from fluid inlet 14 to fluid outlet 18 due to restrictions presented by the open center 36 of

worm wheel 32. Further restrictions to fluid flow in fluid flow path 34 are due to the number of bends in waterway 34 needed to achieve a relatively compact package size for the water monitor, the bends being shown as right angles in the block arrows of FIG. 1 and labeled with encircled numbers 1 through 6.

In order for the movable portion 16 to rotate with respect to elevation, the rotating elevation joint 20 and thus, waterway 34, must be perpendicular to the fluid outlet 18 orientation direction. Therefore, waterway 34 is turned unnecessarily between bend 1 and bend 3 to accommodate the rotating joint 20, which comprises the aforementioned gearbox 22, bearings 24, and seal 26.

It is desirable that a water monitor be provided in as small a package as possible, to conserve space on fire-fighting equipment and to maximize the portability of the water monitor. Accordingly, a minimal distance from the left side of the water monitor to the right side of the water monitor 10 is desirable in order for the water monitor to fit into tight spaces (e.g., between the rails of a fire-fighting ladder), especially as movable portion 16 is rotated. Accordingly, bends 1, 2 and 3 are utilized to position rotating joint 20 such that worm wheel 32 is generally centered in water monitor 10 to make relatively efficient use of space for a compact water monitor. However, this results in the aforementioned drawbacks with regard to pressure drop in the water monitor.

An alternate prior art water monitor 50 is shown in FIG. 2. In this arrangement bends 1 and 2 of water monitor 10 are eliminated by moving bends 4 and 5 to the right. This eliminates some undesirable pressure drop in water monitor 50 as compared to water monitor 10. However, the arrangement of water monitor 50 requires an undesirably large envelope for packaging the water monitor.

A schematic block diagram of a water monitor 100 is shown in FIG. 3 according to an embodiment of the present invention. Water monitor 100 comprises a stationary portion 102 (i.e., stationary with respect to elevational movement) having a fluid inlet 104. A movable portion 106 (i.e., movable with respect to elevational movement) is rotatably coupled to the stationary portion 102, the movable portion 106 having a fluid outlet 108.

A rotating joint 110, which allows fluid outlet 108 to be positioned about an elevational axis, comprises a power transmission in the form of a gearbox 112, one or more bearings 114, and one or more seals 116. Rotating joint 110 is preferably oriented generally perpendicularly to fluid outlet 108 so that the fluid outlet is positionable about the aforementioned elevational arc.

Gearbox 112 is coupled between stationary portion 102 and movable portion 106, and converts a relatively high-speed, low-torque rotary motion from an electric motor 118 to a relatively low-speed, higher-torque output. In operation, rotary motion from an output 120 of motor 118 is converted to a relatively low-speed, higher-torque output by gearbox 112. The output of gearbox 112 is coupled to movable portion 106 such that actuating motor 118 causes the movable portion to rotate with respect to stationary portion 102, thereby moving fluid outlet 108 to a select position.

As noted above, gearbox 112 provides speed reduction and torque amplification of a motive force, such as an electric motor, similar to gearbox 22 of water monitor 10. However, unlike the configuration of water monitor 10, gearbox 112 is placed outside a fluid flow path 124 (represented by block arrows in FIG. 3) extending between fluid inlet 104 and fluid outlet 108 and configured to communicate fluids from the fluid inlet to the fluid outlet. Accord-

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ingly, gearbox **112** is coupled to movable portion **106** such that fluid flow path **124** does not extend through (i.e., “bypasses”) the gearbox.

Although prior art water monitor **10** has a relatively compact package size it suffers from relatively high friction loss, resulting in an undesirable pressure drop between fluid inlet **14** and fluid outlet **18**. Prior art water monitor **50** has less friction loss and pressure drop than water monitor **10**, but has as a drawback a larger package size than water monitor **10**. In contrast, water monitor **100** of the present invention may include a reduced number of bends in comparison to water monitor **10** while achieving a relatively compact size, the bends being shown as encircled numbers **1** through **4** of the block arrows in FIG. **3**. A reduction in the number of bends in water monitor **100** results in less friction loss and reduced pressure drop in fluid flow path **124** between fluid inlet **104** and fluid outlet **108** in comparison to the pressure drops present in fluid flow path **34** of water monitor **10**, which has a greater number of bends. In one embodiment, the fluid flow path **124** has no more than four bends. In addition, water monitor **100** has a package size that is smaller than water monitor **50** and is comparable in package size to water monitor **10**.

In the arrangement of FIG. **3** a connector **122** may be utilized to couple gearbox **112** to movable portion **106**. A first bearing **114**, numbered **114-1**, may be placed intermediate gearbox **112** and movable portion **106**. First bearing **114-1** is preferably relatively small in physical size in order to reduce the overall package size of water monitor **100**. However, a relatively large amount of torque transmitted to first bearing **114-1** by a worm gear/worm wheel **126** of gearbox **112** must be transmitted through the relatively small diameter of the first bearing. This makes the design of a robust connector **122** coupled between the worm gear/worm wheel **126** to movable portion **106** somewhat difficult because the connection is made through a relatively small diameter at first bearing **114-1**, resulting in a relatively high force concentration at the first bearing. A larger bearing could be utilized for first bearing **114-1**, but such bearings are not always readily available. Likewise, a relatively large bearing is preferable for an optional second bearing **114**, numbered **114-2** in FIG. **3**, as fluid flow path **124** passes through the center of this bearing. Specially-constructed, relatively large bearings, while feasible, are more expensive due to the inherently smaller production volumes for such components. Specially-constructed bearings are also potentially less robust because the manufacturing advantages of large volumes cannot always be utilized (e.g. hardening, grinding, etc.).

A water monitor **200** is shown in FIG. **4** according to another embodiment of the present invention. In this arrangement a connector **122** configured to couple a gearbox **112** to a movable portion **106** extends through the gearbox. A first bearing **114**, numbered **114-1**, is placed on the opposite side of gearbox **112** with respect to the arrangement of first bearing **114-1** of FIG. **3**, such that the gearbox is intermediate the first bearing and movable portion **106**. A second bearing **114**, numbered **114-2**, is configured such that a fluid flow path **124** extends through the second bearing.

The arrangement of FIG. **4** can accommodate a physically smaller first bearing **114-1** than the arrangement of FIG. **3** because it allows the output of the worm gear/worm wheel **126** of gearbox **112** to be connected to movable portion **106** with a relatively large-diameter connector **122** without having to pass through a physically small bearing. Movable portion **106** preferably has sufficient rigidity to deter high deflections due to forces generated as a reaction force at a

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fluid outlet **108** of the movable portion due to forces generated by a worm gear of a worm gear/worm wheel **126** of gearbox **112**.

A water monitor **300** is shown in FIG. **5** according to yet another embodiment of the present invention. In this arrangement a worm gear/worm wheel **126** is placed on the opposite end of a rotating joint **110** with respect to the configurations of FIGS. **3** and **4**. A connector **122** is configured to couple a gearbox **112** to a movable portion **106**. A first bearing **114**, numbered **114-1**, is intermediate gearbox **112** and movable portion **106**. A second bearing **114**, numbered **114-2**, is configured such that a fluid flow path **124** does not extend through (i.e., “bypasses”) the second bearing.

With continued reference to FIG. **5**, a length “L” is the distance from the center of a rotating joint **110** to a fluid outlet **108** of movable portion **106**. Typically, a nozzle (not shown) is attached to fluid outlet **108**. Such nozzles typically have a significant weight associated with structural reinforcements made to withstand the forces that are present when fluid is flowing through the water monitor. This weight, multiplied by length “L,” creates a lifting moment that gearbox **112** and a motor **118**, driving the gearbox, must overcome. If the length “L” is shortened, the lifting moment required to be overcome is lowered and therefore, the torque required of gearbox **112** and motor **118** is reduced. However, gearbox **112** can be more complex to package in this arrangement due to the need to provide support structure for gearbox **112**, bearings **114**, any seals **116**, and motor **118**.

A slight re-arrangement of water monitor **300** is schematically depicted in FIG. **6** as water monitor **400**. Water monitor **400** is configured such that a first bearing **114**, numbered **114-1**, is placed on the opposite side of a gearbox **112** with respect to the arrangement of first bearing **114-1** of FIG. **5** such that the gearbox is intermediate the first bearing and a movable portion **106**. A connector **122** configured to couple gearbox **112** to movable portion **106** extends through the gearbox. A second bearing **114**, numbered **114-2**, is configured such that a fluid flow path **124** does not extend through (i.e., “bypasses”) the second bearing.

The arrangement of FIG. **6** combines the advantages of water monitor **300** (e.g., a relatively short length “L” resulting in a lower lifting moment) with the advantages of water monitor **200** (e.g., a relatively large worm gear/worm wheel **126** and connector **122** from gearbox **112** to movable portion **106**). Movable portion **106** preferably is designed to have sufficient rigidity to deter high deflections due to forces generated as a reaction force at fluid outlet **108** and due to forces generated by worm gear/worm wheel **126**.

A water monitor **500** is shown in FIG. **7** according to yet another embodiment of the present invention. In this arrangement a connector **122** configured to couple a gearbox **112** to a movable portion **106** extends through the gearbox. A first bearing **114**, numbered **114-1**, is arranged such that gearbox **112** is intermediate the first bearing and movable portion **106**. A fluid flow path **124** is divided into two smaller, generally equal paths numbered **124-1** and **124-2**. Movable portion **106** includes a pair of intakes **128**, numbered **128-1** and **128-2**, for fluid flowing in fluid flow paths **124-1**, **124-2** respectively to enter the moveable portion. The two smaller fluid flow paths **124-1**, **124-2** join one another to form a fluid flow path **130** once they have passed through joint **110** and entered moveable portion **106**. A second bearing **114**, numbered **114-2**, is coupled to a bearing support **131**. Second bearing **114-2** is preferably configured such that fluid flow path **124** does not extend through (i.e., “bypasses”) the second bearing.

An advantage of water monitor 500 is that the forces acting on moveable portion 106 due to the change of momentum of fluid flowing in fluid flow paths 124-1, 124-2 and pressure acting on elevation joint 110 are generally equal and opposite, and therefore, substantially cancel one other. Accordingly, the torque required of a motor 118 and gearbox 112 to position an outlet 108 is greatly reduced.

With reference to FIG. 8, fluid flow path 34 of prior art water monitor 10 typically comprises one or more bearings 24 and seals 26 interposed between stationary portion 12 and movable portion 16. A significant drawback of this arrangement is that fluid 38 (represented as block arrows in FIG. 8) flowing along fluid flow path 34 at high pressure exerts opposing separating forces  $F_1, F_2$  between the stationary and movable portions 12, 16 respectively, thereby increasing the load imposed upon bearings 24. This increased bearing load adds to the mechanical load imposed upon gearbox 22 and electric motor 28 (FIG. 1), and can result in increased wear and reduced service life for the bearings, motor, and gearbox components.

With reference to FIGS. 3 and 9 together, water monitor 100 may include a stationary portion 102 having a fluid inlet 104, a first portion of a fluid flow path 124 extending therethrough, and one or more first interfaces 132. A movable portion 106 includes a second portion of fluid flow path 124 extending therethrough, a fluid outlet 108, and one or more second interfaces 134. Corresponding first and second interfaces 132, 134 respectively are each rotatably coupled together by a bearing 114, first and second bearings being numbered 114-1 and 114-2 respectively. One or more seals 116 intermediate corresponding first and second interfaces 132, 134 respectively provides a barrier to deter fluid flowing in fluid flow path 124 from escaping. Movable portion 106 is rotatable with respect to stationary portion 102 to position fluid outlet 108. In addition, fluid inlet 104, fluid flow path 124, and fluid outlet 108 are each in communication with one another and are configured to conduct fluids therethrough.

With continued reference to FIG. 9, in contrast to water monitor 10 of FIG. 8, water monitor 100 includes a “force-balanced” arrangement comprising a piece 136. The force applied to first and second bearings 114-1 and 114-2 respectively due to the water pressure  $F_1, F_2$  of fluid 138 (represented by block arrows in FIG. 9) acting on a projected diameter “D” on opposite sides of fluid flow path 124 in piece 136 is minimal. Ideally, this force is nearly zero if the diameters of seals 116, first and second seals being numbered 116-1, 116-2 respectively, are equal (that is, the projected areas of both seals are equal). Typically, one seal is slightly smaller than the other seal for manufacturability to reduce the risk of cutting the seals during assembly. “Force-balanced” may also be termed “pressure-balanced” in the sense that a load applied to rotating joint 110 by the pressure of fluid 138 is balanced by a load pushing on the same member in the opposite direction.

Piece 136 may be made as a unitary component. Alternatively, piece 136 may be made from separate components that are joined together.

A slight variation on the arrangement of FIG. 9 can be seen in FIG. 10. In FIG. 10, fluid 138 flowing along fluid path 124 at high pressure exerts opposing forces  $F_1, F_2$  on a piece 136 rather than exerting a separating force upon bearings 114. When the fluid 138 flow turns at a bend or “elbow” 140 there is a force in the direction of  $F_2$  due to the change in direction of the momentum of the fluid as it turns in the elbow to exit the elbow. The momentum change creates a force in the direction of  $F_2$  which acts on movable

portion 106 and creates a load on bearings 114, a first bearing being numbered 114-1 and a second bearing being numbered 114-2. The diameter of a first seal 116, numbered 116-1, may be increased relative to the diameter of a second seal 116, numbered 116-2, to counteract this change in the direction of momentum. By increasing the diameter of first seal 116-1, the projected area upon which the water pressure is applied increases and, therefore, the force,  $F_1$  acts in the opposite direction of a force  $F_{momentum}$  created by the change in momentum.  $F_{momentum}$  may be calculated using Equation 1, below:

$$F_{momentum} = \rho Q(\mu_2 - \mu_1) \quad \text{Equation 1}$$

where:

$\rho$  = Density of fluid 137

$Q$  = Volumetric flow rate of fluid 138

$\mu_1$  = Starting velocity of fluid 138 at input to piece 136

$\mu_2$  = Final velocity of fluid 138 at output of (exit from) piece 136.

The load applied to bearings 114-1 and 114-2 can be minimized by balancing  $F_1$  and  $F_{momentum} + F_2$ . In other words:

$$F_1 = F_2 + F_{momentum} \quad \text{Equation 2}$$

where:

$F_1 = \rho A_1$

$F_2 = \rho A_2$

$\rho$  = Density of fluid 138

$A_1$  = Area inside first seal 116-1

$A_2$  = Area inside second seal 116-2

The outside diameter of seals 116-1 and 116-2 may be utilized to calculate the area.

With reference to FIGS. 9, 10 and 11A-11E, movable portion 106 is preferably configured to withstand the opposing forces  $F_1, F_2$  created from high pressure exerted on the unitary piece 106 by fluid 138. An opening 142 in an inlet portion 145 of movable portion 106 is preferably is designed to have sufficient size to allow fluid 138 to enter movable portion 106 when fluid outlet 108 is rotated to a desired elevation position with minimal restriction to the fluid flow moving from stationary portion 102 into the movable portion. With reference to FIGS. 11A-11E, 12A-12C, 13A-13C, 14A-14B and 15, in one embodiment the movable portion 106 includes a first piece 135 rotatably coupled to the stationary portion 102 and a second piece 137 rotatably coupled to the first piece 135. The first piece 135 includes a casing 141 configured as a conduit of fluid 138 as part of flow path 124. Referring to FIGS. 14A-14B, the casing 141 is configured to receive the inlet portion 145 of second piece 137. Casing 141 includes two opposing sleeves 143-1, 143-2. Inlet portion 145 is configured to extend through the first sleeve 143-1 and the second sleeve 143-2. Second piece 137 is configured to rotatably couple to and seal against sleeves 143-1, 143-2. Further, worm gear 126 of gearbox 112 (see also FIG. 15) is an annular member configured to receive inlet portion 145 and to couple to the inlet portion adjacent first sleeve 143-1. Connector 122 extends from an end of the second piece 137 and is configured to be coupled to annular worm gear 126 of gearbox 112 proximate the opening 142. As can be seen from FIG. 14B, connector 122 extends within the first piece 135 to the gearbox 112 of the power transmission. The connector 122 also includes an end portion 123 proximate the fluid path 124 at opening 142. End portion 123 is configured to receive seal 116-1 and is rotatably coupled to sleeve 143-1. The second piece 137 further includes a coupling 139 proximate the fluid path 124 at opening 142, the coupling being spaced apart from end

portion 123. Coupling 139 is configured to receive seal 116-2 and is rotatably coupled to sleeve 143-2. In one embodiment the coupling 139 is rotatably coupled to sleeve 143-2 at an angle of about 90 degrees relative to the fluid inlet 104 of the first piece 135.

With reference to FIGS. 11A-11E, 13A-13C, and 14A-14B, a structural support 144 may be utilized in movable portion 106. Structural support 144, is a generally semi-circularly shaped structure proximate the fluid flow path 124, and is preferably situated so that it does not significantly interfere with the flow of fluid 138 in fluid flow path 124 at various positions selected for movable portion 106. In one embodiment a periphery of the inlet portion 145 of second piece 137 includes structural support 144, and the structural support extends from end portion 123 to coupling 139. Structural support 144 also extends from a periphery 125 of the end portion 123 to a central region 127 of the end portion.

In some embodiments of the present invention one or more rod-like structures may be positioned proximate fluid flow path 124. For example, one or more tension rods 146 may be used in fluid flow path 124 to provide additional structural integrity to withstand the opposing forces  $F_1$ ,  $F_2$  that are applied to generate a tension "T" in movable portion 106. By adding tension rods 146, a larger opening 142 can be formed next to structural support 144. This results in less restriction to fluid 138 flow when movable portion 106 (and thus outlet 108) is moved to its extreme positions. In one embodiment a periphery of the inlet portion 145 of second piece 137 includes one or more structural tension rods 146, configured such that the tension rods extend from end portion 123 to coupling 139.

The general arrangement of an exemplary water monitor 100 is shown in FIGS. 12A-12C, 13A-13C, 14A-14B and 15 according to an embodiment of the present invention. As shown, portions 102, 106 of water monitor 100 may be made rotatable about an azimuth-adjustment axis, labeled an "X" axis and having a turning radius "TR" in the drawings, and movable portion 106 may be made further rotatable about an elevation-adjustment axis, labeled a "Y" axis in the drawings. During use of water monitor 100 the X-axis may be oriented generally horizontal while the Y-axis may be oriented generally vertical. However, this is not a requirement and other orientations of water monitor 100 are envisioned within the scope of the invention.

As described herein, an electric motor 118 is utilized to position movable portion 106 about the Y-axis. However, one skilled in the art will appreciate that any suitable form of motive power may be substituted for electric motor 118 including, without limitation, water-powered motor drives, hydraulic drives, pneumatic actuators and manual hand wheels.

One skilled in the art will also appreciate that the components of water monitor 100 may be rearranged to fit a particular need. For example, gearbox 112 and motor 118 may be moved to positions opposite that shown in the figures. Similarly, in an alternate embodiment a member may be extended from movable portion 106 to gearbox 112 through fluid flow path 124 to effect positioning of the movable portion by the gearbox.

In some embodiments of the present invention sleeve-type bearings 114 may be utilized. With reference to FIGS. 14A and 14B, a first sleeve bearing 114-1 is coupled to movable portion 106 and rides against stationary portion 102. A second sleeve bearing 114-2 is assembled to movable portion 106 and likewise rides against stationary portion 102. First sleeve bearing 114-1 may also be held captive by the

worm wheel of worm gear/worm wheel 126 of gearbox 112, as shown in FIGS. 14A and 14B. Sleeve bearings 114-1, 114-2 are preferably made of a durable, self-lubricating material for long service life and low friction.

5 Gearbox 112 is described herein as a worm-worm wheel arrangement for purposes of explanation. However, any suitable type of power transmission may be utilized within the scope of the invention. Example power transmissions include, without limitation, spur gears, planetary gears, pulleys and belts, pneumatic and hydraulic devices, and sprockets and chains in addition to a worm-worm wheel.

The various components of water monitors 100, 200, 300, 400 and 500 may be formed using any suitable materials including, without limitation, metal, composites and plastic. In addition, the components of water monitors 100, 200, 300, 400 and 500 may be fabricated using any preferred processes such as, but not limited to, machining, casting, forging, molding and spinning. Furthermore, water monitors 100, 200, 300, 400 and 500 may be finished in any desired manner such as, but not limited to, painting, plating, dyes, molded-in colors, or may be left unfinished.

The word "exemplary" is used herein to mean serving as an example, instance or illustration. Any aspect or design described herein as "exemplary" is not necessarily to be construed as advantageous over other aspects or designs. Rather, use of the word exemplary is intended to present concepts in a concrete fashion. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or." That is, unless specified otherwise, or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. Further, at least one of A and B and/or the like generally means A or B or both A and B. In addition, the articles "a" and "an" as used in this application and the appended claims may generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims. Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Of course, those skilled in the art will recognize many modifications may be made to this configuration without departing from the scope or spirit of the claimed subject matter.

Also, although the disclosure has been shown and described with respect to one or more implementations, equivalent alterations and modifications will occur to others skilled in the art based upon a reading and understanding of this specification and the annexed drawings. The disclosure includes all such modifications and alterations and is limited only by the scope of the following claims. In particular regard to the various functions performed by the above described components (e.g., elements, resources, etc.), the

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terms used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary implementations of the disclosure.

In addition, while a particular feature of the disclosure may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms “includes,” “having,” “has,” “with,” or variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term “comprising.”

What is claimed is:

1. A water monitor, comprising:
  - a stationary portion having a fluid inlet;
  - a movable portion comprising:
    - a first piece fluidly coupled to the stationary portion in rotational engagement; and
    - a second piece comprising a fluid outlet, the second piece rotationally coupled to the first piece resulting in a fluid flow path directed into the second piece from a second side of the first piece, the fluid flow path configured to communicate fluids from the fluid inlet to the fluid outlet;
  - a structural support member proximate the fluid flow path at an inlet portion of the second piece, and disposed between an end portion and a coupling portion of the inlet portion; and
  - a power transmission coupled to the second piece and disposed at an opposing, first side of the first piece, the fluid flow path bypassing the power transmission, and the movable portion being rotatable with respect to the stationary portion.
2. The water monitor of claim 1, the second piece comprising a first bend and a second bend in the fluid flow path.
3. The water monitor of claim 1, the power transmission comprising an annular gear configured to receive a connector portion of the second piece.
4. The water monitor of claim 1, comprising an electric motor coupled to the power transmission.
5. The water monitor of claim 1, the fluid flow path comprising four bends or less.
6. The water monitor of claim 1, comprising at least one bearing intermediate the coupling between the first piece and the second piece.
7. The water monitor of claim 1, comprising at least one seal intermediate the coupling between the second piece and at least one of the first side of the first piece and the second side of the first piece.
8. The water monitor of claim 1, wherein an inlet portion of the second piece comprises a coupling spaced apart from an end portion, the end portion configured to be rotatably coupled with the first piece at the first side, and the coupling configured to be rotatably coupled with the first piece at the second side.
9. The water monitor of claim 8, comprising a structural support member disposed between the end portion and the coupling portion of the inlet portion.
10. The water monitor of claim 9, the structural support member extending between a periphery of the end portion and a central region of the end portion.

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11. The water monitor of claim 1, comprising one or more tension rods disposed proximate the fluid flow path at an inlet portion of the second piece, the one or more tension rods respectively configured to structural support at the inlet portion.

12. The water monitor of claim 11, the one or more tension rods respectively extending between an end portion of the inlet portion and a coupling portion of the inlet portion, the end portion configured to be rotatably coupled to the first piece at the first side, and the coupling portion configured to be rotatably coupled to the first piece at the second side.

13. The water monitor of claim 1, the first piece comprising a first sleeve and an opposing, second sleeve, the first and second sleeves configured to rotatably couple to and inlet portion of the second piece, the inlet portion comprising a fluid opening configured to extend through the first sleeve and the second sleeve.

14. An apparatus for delivering a targeted fluid flow, comprising:

- a movable portion having a first piece rotatably coupled to a stationary fluid inlet at a first end of the first piece, and a second piece rotatably coupled to the first piece at a second end of the first piece, the second piece comprising:
  - a fluid inlet portion disposed through the second end of the first piece; and
  - a fluid outlet configured to deliver a targeted fluid flow;
- a power transmission coupled to the inlet portion at a first side of the first piece, and configured to rotate the second piece to position the fluid outlet, and
- a fluid flow path extending between the fluid inlet and the fluid outlet and configured to communicate fluids from the fluid inlet to the fluid outlet, the power transmission disposed outside the fluid flow path.

15. The apparatus of claim 14, the inlet portion comprising a connector configured to couple the power transmission to the second piece.

16. The apparatus of claim 14, comprising one or more of: a first bearing disposed between the power transmission and the movable portion at the first side of the first piece; and a second bearing disposed between the power transmission and the movable portion at an opposing, second side of the first piece.

17. The apparatus of claim 14, the power transmission comprising an annular gear configured to transfer rotational force from the transmission to a connector disposed at an end portion of the inlet portion.

18. The apparatus of claim 14, the inlet portion comprising a structural support member disposed between an end portion and a coupling portion of the inlet portion.

19. A method for making a water monitor, comprising: operably coupling a movable portion with a stationary portion, the stationary portion comprising a fluid inlet, and the movable portion comprising:

- a first piece fluidly coupled to the stationary portion in rotational engagement; and
  - a second piece comprising a fluid outlet, the second piece rotationally coupled to the first piece resulting in a fluid flow path directed into the second piece from a second side of the first piece, the fluid flow path configured to communicate fluids from the fluid inlet to the fluid outlet; and
- operably coupling a power transmission to the second piece at an opposing, first side of the first piece, the

fluid flow path bypassing the power transmission, and the movable portion being rotatable with respect to the stationary portion.

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