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(54) Title: A MAGNETIC PARTICLE BRAKE CONTROLLED VALVE ARRANGEMENT

(57) Abstract: This disclosure relates to a valve assembly (100). In one embodiment, the valve assembly (100) includes an actuator (106) configured to move a modulating element (104) in one or more predefined directions. The valve assembly further includes a braking assembly (108), such that upon activation, the braking assembly (108) is configured to resist movement of the modulating element (104) in the one or more predefined directions. The braking assembly (108) may include magnetic particles which upon activation ay bind themselves together around the modulating element (104) to thereby apply a braking effect on the modulating element (104). The valve assembly (100) further includes a controller (110) communicatively coupled to the actuator (106) and the braking assembly (108), such that the controller (110) may control the movement of the modulating element (104) by communicating with the actuator (106) and the braking assembly (108).

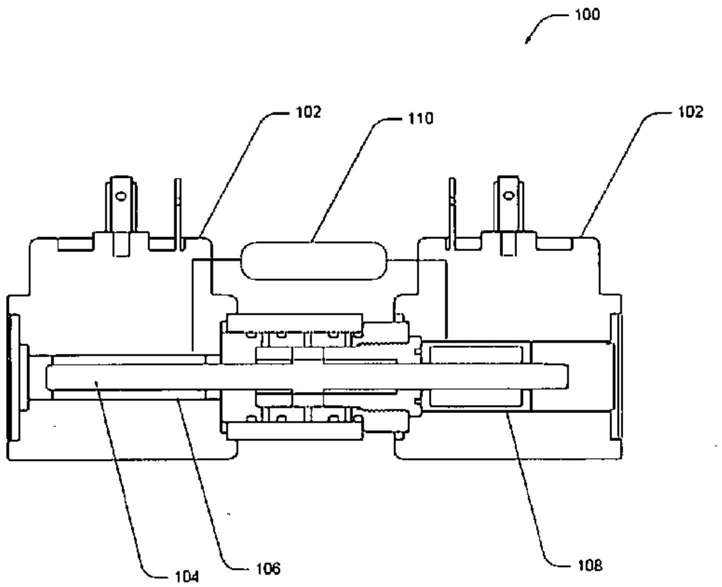
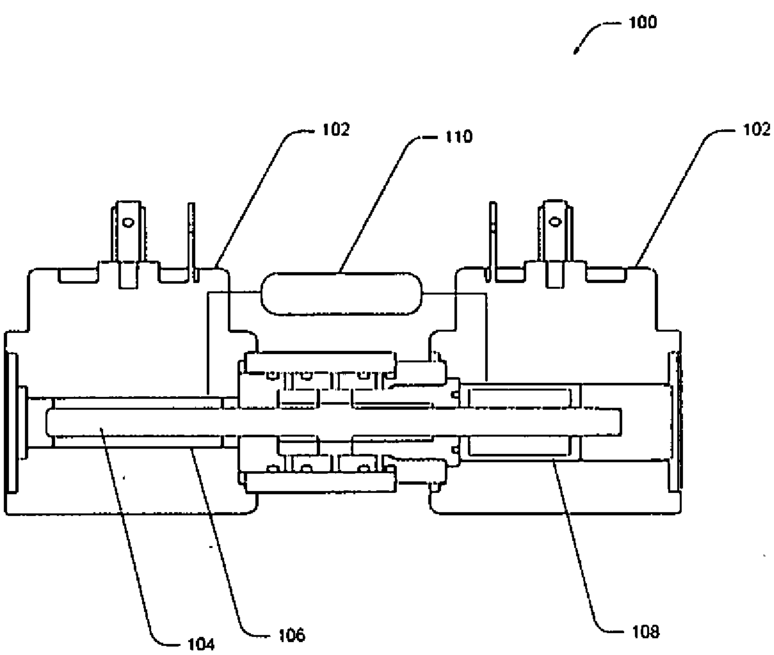


Figure 1

ABSTRACT

A MAGNETIC PARTICLE BRAKE CONTROLLED VALVE ARRANGEMENT

This disclosure relates to a valve assembly (100). In one embodiment, the valve assembly (100) includes an actuator (106) configured to move a modulating element (104) in one or more predefined directions. The valve assembly further includes a braking assembly (108), such that upon activation, the braking assembly (108) is configured to resist movement of the modulating element (104) in the one or more predefined directions. The braking assembly (108) may include magnetic particles which upon activation ay bind themselves together around the modulating element (104) to thereby apply a braking effect on the modulating element (104). The valve assembly (100) further includes a controller (110) communicatively coupled to the actuator (106) and the braking assembly (108), such that the controller (110) may control the movement of the modulating element (104) by communicating with the actuator (106) and the braking assembly (108).



We claim:

1. A valve assembly (100) comprising:

an actuator (106) configured to move a modulating element (104) in one or more predefined directions within the valve assembly (100);

a braking assembly (108), wherein upon activation, the braking assembly (108) is configured to resist movement of the modulating element (104) in the one or more predefined directions;

a controller (110) communicatively coupled to the actuator (106) and the braking assembly (108), wherein the controller (110) is configured to control the movement of the modulating element (104) by communicating with the actuator (106) and the braking assembly (108).

2. The valve assembly (100) of claim 1 comprising a shaft, wherein the modulating element (104) is configured to move in the one or more predefined directions within the shaft.

3. The valve assembly (100) of claim 1, wherein the braking assembly (108) comprises magnetic particles cooperating with at least a portion of the modulating element (104) to resist the movement of the modulating element (104) in the one or more predefined directions.

4. The valve assembly (100) of claim 3, wherein the magnetic particles are dispersed in one of a fluid form and a powder form.

5. The valve assembly (100) of claim 3, wherein upon activation of the braking assembly (108), the magnetic particles, under a magnetic field, bind themselves together, to thereby resist the movement of the modulating element (104) in the one or more predefined directions.

6. The valve assembly (100) of claim 5, wherein the controller (110) communicates with the braking assembly (108) to adjust the magnetic field to thereby control binding strength of the magnetic particles.

7. The valve assembly (100) of claim 1, wherein the one or more predefined direction of the modulating element (104) comprise at least one of a linear direction and a rotational direction.

8. The valve assembly (100) of claim 1, further comprising a sensor communicatively coupled to the controller (110), wherein the sensor is configured to:

sense a current position of the modulating element (104); and

generate a feedback signal indicating the current position of the modulating element (104).

9. The valve assembly (100) of claim 8, wherein the controller (110) is further configured to: upon receiving the feedback signal, communicate with the actuator (106) and the braking assembly (108) to control the movement of the modulating element (104).

10. The valve assembly (100) of claim 1, wherein the actuator (106) is a solenoid.

11. The valve assembly (100) of claim 10, wherein the controller (110) communicates with the actuator (106) to adjust an input electrical supply to the actuator (106).

12. A braking arrangement for a valve assembly (100), the braking arrangement comprising:

a braking assembly (108), wherein upon activation, the braking assembly (108) is configured to resist movement of a modulating element (104) in one or more predefined directions, wherein the modulating element (104) is actuated to move in the one or more predefined directions by an actuator (106); and

a controller (110) communicatively coupled to the actuator (106) and the braking assembly (108), wherein the controller (110) is configured to control the movement of the modulating element (104) by communicating with the actuator (106) and the braking assembly (108).

13. The braking arrangement of claim 12, wherein the braking assembly (108) comprises magnetic particles cooperating with at least a portion of the modulating element (104) to resist the movement of the modulating element (104) in the one or more predefined directions.

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TECHNICAL FIELD

This disclosure relates generally to a valve assembly, and more particularly to a valve assembly including a brake control mechanism.

BACKGROUND

Control valves are generally used to control the flow of fluids. A control valve employed in a flow path of the fluid, may redirect, close, or vary the amount of fluid flow by opening, closing, or partially obstructing the flow path. Typically, a valve may include a component, commonly referred to as a spool, having one or more lands and grooves, which may align with one or more fluid inlets and outlets of the valve. Various functionalities of the valve, such as opening, closing, or partially obstructing the flow path may be achieved by moving the spool to vary alignment of the lands and grooves with the inlets and outlets of the valve. The movement of the spool may either be actuated manually or through an actuator.

One type of control valve or a servo valve may be a two-stage valve that provides ON and OFF (or open and close) application by moving the spool between two positions. An example of the two-stage control valve may be an ON and OFF solenoid valve. Another example, of the two-stage control valve may be a valve that employs a flapper jet to achieve the two-stage control valve functionality. Another type of control valve may be a proportional control valve that provides precise controlling of the fluid flow by enabling precise movement of the spool through multiple positions in the flow path.

A proportional control valve may be electrically actuated (by using a solenoid coil) or hydraulically actuated. The extent of movement of the spool in an electrically actuated proportional valve may be equivalent to an input current to the solenoid coil, and therefore, the movement may be controlled by varying the input current. The proportional control valve may additionally receive a feedback signal from a sensor, such as, a Linear Variable Differential Transformer (LVDT) sensor, indicating a current position of the spool. Based on the feedback signal regarding the current position, the movement of the spool may be controlled to thereby move the spool to a desired position.

However, in a proportional control valve, the spool, under the effect of the actuator, may get over accelerated and thus may overshoot the desired position due to its own inertia. In order to obtain the desired position, the spool may subsequently have to undergo multiple shuttling. This may give rise to chattering in the valve assembly. Moreover, as a result of the iterative process of positioning the spool in a proportional control valve, the overall process of moving the spool to the desired position is slow. In other words, the proportional control valves may have a drawback of slow reaction as the spool cannot be stopped instantaneously. The proportional control valves also require spools that are perfectly pressure balanced to enable desired positioning. Furthermore, the proportional control valves that utilize proportional solenoids have a complex construction and are costly.

There is therefore a need for an improved valve assembly that does not suffer from drawbacks of conventional valves.

SUMMARY

In one embodiment, a valve assembly is described. The valve assembly includes an actuator configured to move a modulating element in one or more predefined directions within the valve assembly, a braking assembly, such that upon activation, the braking assembly is configured to resist movement of the modulating element in the one or more predefined directions, a controller communicatively coupled to the actuator and the braking assembly, wherein the controller is configured to control the movement of the modulating element by communicating with the actuator and the braking assembly.

In another embodiment, a braking arrangement for a valve assembly is described. The braking arrangement includes a braking assembly, such that upon activation, the braking assembly is configured to resist movement of a modulating element in one or more predefined directions, such that the modulating element is actuated to move in the one or more predefined directions by an actuator. The braking arrangement further includes a controller communicatively coupled to the actuator and the braking assembly, such that the controller is configured to control the movement of the modulating element by communicating with the actuator and the braking assembly.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this disclosure, illustrate exemplary embodiments and, together with the description, serve to explain the disclosed principles:

FIG. 1 illustrates a cross-section view of a valve assembly that is brake controlled, in accordance with some embodiments;

FIG. 2 illustrates a cross-section view of the valve assembly with a brake assembly in a de-activated state, in accordance with some embodiments; and

FIG. 3 illustrates a cross-section view of the valve assembly with the brake assembly in an activated state, in accordance with some embodiments.

DETAILED DESCRIPTION

Exemplary embodiments are described with reference to the accompanying drawings. Wherever convenient, the same reference numbers are used throughout the drawings to refer to the same or like parts. While examples and features of disclosed principles are described herein, modifications, adaptations, and other implementations are possible without departing from the spirit and scope of the disclosed embodiments. It is intended that the following detailed description be considered as exemplary only, with the true scope and spirit being indicated by the following claims.

Referring now to FIG. 1, a valve assembly 100 that is brake controlled is illustrated, in accordance with some embodiments. The valve assembly 100 may be employed in a flow path of a fluid, in order to control flow of the fluid, when it passes through the valve assembly 100. The valve assembly 100 may control flow of various types of fluids that may include, but are not limited to gases, such as compressed fuel gas, Liquid Petroleum Gas (LPG) and liquids, such as water, petroleum based oil, and sewage. As per requirement, the valve assembly 100 may redirect, close, or vary the amount of fluid flow passing through it.

As shown in FIG. 1, the valve assembly 100 includes a housing 102, a modulating element 104, an actuator 106, a braking assembly 108, and a controller 110 housed within the housing 102. It will be apparent to a person skilled in the art that the controller 110 is depicted merely for illustrative purpose and the controller 110 may be located anywhere within the housing 102 based on a preferred design for constructing the valve assembly 100. The housing 102 may be constructed from materials or combination of materials that may include, but are not limited to one or more of metal, alloy, plastic, and any other suitable material known in the art.

The modulating element 104, for example, may be employed in the form of a spool, poppet, gate, plug reed, pinch tube, or a diaphragm. It will be apparent to a person skilled in the art that the modulating element 104 is not limited to the above examples and other suitable implementations know in the art can also be employed. By way of an example, when the modulating element 104 is a spool, it may have a cylindrical construction and may include one or more circular and polygonal cross-sections. The modulating element 104 may further include one or more lands and grooves that may align with one or more inlets and outlets of the valve assembly 100 to thereby redirect, close, or vary the amount of fluid flow passing through the valve assembly 100. This may be achieved by moving the modulating element 104 in one or more predefined directions. A shaft (not shown in FIG. 1) in the valve assembly 100 may support the movement of the modulating element 104 in the one or more predefined directions.

The one or more predefined directions may include, but are not limited to a linear or a rotary direction. The linear direction may include to and fro movement of the modulating element 104 in horizontal, vertical, or diagonal direction along the length of the valve assembly 100 within the shaft. The rotary direction may include clockwise or counter-clockwise movement of the modulating element 104 along its axis within the shaft. Materials used to construct the modulating element 104 may include, but are not limited to one or more of metal, alloy, plastic, or any other suitable material.

The movement of the modulating element 104 may be controlled by the actuator 106, which may be configured to move the modulating element 104 in the one or more predefined directions. The actuator 106, for example, may be an electrical actuator, a hydraulic actuator, a pneumatic actuator, a mechanical actuator, or any other type known in the art. The actuator 106 may impart a linear movement or a rotational movement to the modulating element 104.

By way of an example, the actuator 106 may be an electrical actuator that is a solenoid. As it may be apparent to a person skilled in the art, the solenoid is an electromagnet that uses an electrical current to generate a magnetic field. The magnetic field may then cause the modulating element 104 to move in a linear or rotational direction. By way of another example, the actuator

106 may be an electrical actuator that is a servomotor. In this case, the servomotor may be used to impart linear or rotational movement to the modulating element 104. By way of yet another example, the actuator 106 may be an electrical actuator that includes a Direct Current (DC) motor and an Alternating Current (AC) induction motor. By way of another example, the actuator 106 may be a hydraulic actuator that includes a piston cylinder arrangement that acts under a hydraulic force to provide a linear or a rotational motion to the modulating element 104. Other examples of the actuator 106 may include, but are not limited to pneumatic actuators and mechanical actuators.

Once the actuator 106 imparts movement to the modulating element 104, the braking assembly 108, upon activation, may be configured to resist movement of the modulating element 104 in the one or more predefined directions. The braking assembly 108 may thus act to dampen or stop the linear or rotational movement of the modulating element 104. In other words, the braking assembly 108 counters the movement imparted by the actuator 106, upon activation. The braking assembly 108 may include magnetic particles that may cooperate with one or more portions of the modulating element 104 in order to resist the movement of the modulating element 104 in the one or more predefined directions.

The braking assembly 108 may include a chamber that further includes the magnetic particles. The magnetic particles may be dispersed in powder form within the chamber. Alternatively, the magnetic particles may be dispersed in fluidic form. While undergoing movement, one or more portions of the modulating element 104 may pass through the chamber, such that, one or more portions may come in contact with the magnetic particles in the chamber. In order to resist movement of the braking assembly 108, the magnetic particles need to align in such a way that they act against the movement of the modulating element 104. To this end, the braking assembly 108 may further include a magnetic field generation unit (not shown in FIG. 1) that generates a magnetic field to activate the braking assembly 108.

Upon activation of the braking assembly 108, the magnetic particles may bind themselves together to resist the linear or rotational movement of the modulating element 104. The magnetic particles may bind themselves to form chains around the modulating element 104. Alternatively, under the influence of magnetic field, the magnetic particles may align to form a solid impermeable block. As long as the braking assembly 108 is not activated, the braking assembly 108 may not provide any resistance to the movement of the modulating element 104. Thus, in this case, the modulating element 104 may complete the motion imparted by the actuator 106.

The movement of the modulating element 104 imparted by actuator 106 and resistance applied by the braking assembly 108 is coordinated by the controller 110. This enables precise positioning of the modulating element 104. The controller 110 is commutatively coupled to the actuator 106 and the braking assembly 108 to control the movement of the modulating element 104 in the one or more predefined directions. The controller 110 may communicate with the actuator 106 to cause the actuator 106 to impart movement to the modulating element 104. Simultaneously, the controller 110 may communicate with the braking assembly 108 to resist the movement of the modulating element 104. Having simultaneous control over both the actuator 106 and the braking assembly 108 enables the controller 110 to precisely position the modulating element 104 at a desired position.

In operation, the controller 110 may receive an input to move the modulating element 104 to either redirect, close, or vary the amount of fluid flow through the valve assembly 100. Accordingly, the controller 110 may communicate with the actuator 106 to cause the actuator 106 to move the modulating element 104 in one or more predefined directions to thereby align the one or more lands and grooves of the modulating element 104 with respect to the one or more inlets and outlets of the valve assembly 100. By way of an example, the actuator 106 may cause the modulating element 104 to move in a linear direction or a rotational direction or a combination of both linear and rotational directions.

Once the modulating element 104 has started to move under the effect of the actuator 106, the controller 110 may then communicate with the braking assembly 108 in order to activate the braking assembly 108. Upon activation, the braking assembly 108 may resist the movement of the modulating element 104 to thereby stop the modulating element 104 at a desired position. By way of an example, the desired position of the modulating element 104 may be decided by the controller 110, such that at the desired position, the one or more lands and grooves of the modulating element 104 are aligned with respect to the one or more inlets and outlets of the valve assembly 100 to thereby redirect, close, or vary the amount of flow of fluid in a desired manner.

To further aid the controller 110 in precisely positioning the modulating element 104, the valve assembly 100 may further include a sensor (not shown in FIG. 1) that is communicatively coupled to the controller 110. The sensor may be an LVDT sensor. The sensor is configured to sense a current position of the modulating element 104, and based on that, generate a feedback signal. The sensor may sense the current position of the modulating element 104 in real time. By way of an example, when the modulating element 104 is moving under the effect of the actuator 106, the sensor may sense the current position of the modulating element 104 in real time and may generate a feedback signal. The feedback signal may be picked up by the controller 110, which may then determine the position of the modulating element 104 with respect to the one or more inlets and outlets of the valve assembly 100.

Upon receiving the feedback signal, the controller 110 may communicate with the actuator 106 and the braking assembly 108 to control the movement of the modulating element 104. The controller 110 may communicate with the actuator 106 to adjust an input electrical supply to the actuator 106 to control the amount of moving force imparted to the actuator 106. Further, the controller 110 may communicate with the braking assembly 108 to adjust the magnetic field to control the amount of braking force applied by the braking assembly 108. The controller 110 may achieve this by controlling the binding strength of the magnetic particles in the braking assembly 108. Thus, the real-time position sensing by the sensor provides for predictive stopping of the modulating element 104. This aspect further allows for avoiding multiple shuttling between positions and chatter as experienced in the conventional proportional valves.

Referring now to FIG. 2, a cross-section view of the valve assembly 100 with the brake assembly 108 in a de-activated state is illustrated, in accordance with some embodiments. In addition to elements or components depicted in FIG. 1, the valve assembly 100 in FIG. 2 includes a retracting element 112, which may be a spring, such as, a helical spring. It will be apparent to a person skilled in the art that the retracting element 112 is not limited to the depicted implementation and other retracting means known in the art may also be employed.

The retracting element 112 may be configured to move the modulating element 104 against the effect of the actuator 106. As long as the modulating element 104 has not been acted upon by the actuator 106, the retracting element 112 may lie in an expanded state or a resting state. When the modulating element 104 is moved from its original position under the effect of the actuator 106, the modulating element 104 after reaching a predefined position starts acting against the spring force of the retracting element 112, thereby compressing it. The retracting element 112 may remain compressed as long as the modulating element 104 is displaced from its original position and remains in the predefined position or goes beyond it. However, once the actuator 106 has stopped acting on the modulating element 104, the retracting element 112 may start expanding to thereby replace the modulating element 104 to its original position.

Referring now to the de-activated state of the braking assembly 108, the magnetic field generation unit (not shown in FIG. 2) that generates a magnetic field to activate the braking assembly 108, may not generate any magnetic field in the de-activated state. As a result, in the de-activated state, the magnetic particles in the chamber within the braking assembly 108 remain in a suspended form, thereby, not forming any specific shape or pattern that would resist movement of the modulating element 104. Thus, the braking assembly 108, in the de-activated state, may not provide any resistance to the movement of the modulating element 104, thereby allowing the modulating element 104 to complete the motion imparted by the actuator 106.

Referring now to FIG. 3, the valve assembly 100 with the braking assembly 108 in the activated state is illustrated, in accordance with some embodiments. In the activated state, the braking assembly 108 resists the movement of the modulating element 104 by applying a braking effect to the movement of the modulating element 104 against the effect of the actuator 106. In this state, the magnetic field generation unit (not shown in FIG. 3) applies a magnetic field, which may cause the magnetic particles within the chamber of the braking assembly 108 to bind themselves to each other in such a way, so as to resist the linear or rotational movement of the modulating element 104. This has been explained in detail in conjunction with FIG. 1.

By way of an example, the magnetic particles may bind themselves to form chains or a solid impermeable block around the modulating element 104. Additionally, the movement of the modulating element 104 may be precisely controlled in order to stop the modulating element 104, gradually or instantaneously. Thus, the modulating element 104 may be brought to a stop at any desired intermediary position.

In an alternate embodiment, a braking arrangement for the valve assembly 100 is described. In contrast to the above mentioned valve assembly 100 that includes a brake control mechanism, the henceforth described braking arrangement may be manufactured as a separate unit. The braking arrangement includes the braking assembly 108 and the controller 110 as described in the aforementioned embodiments. The braking assembly 108, upon activation, is configured to resist movement of the modulating element 104 in the one or more predefined directions, where, the modulating element 104 is actuated to move in the one or more predefined directions by the actuator 106. Further, the controller 110 is communicatively coupled to the actuator 106 and the braking assembly 108. The controller 110 is configured to control the movement of the modulating element 104 by communicating with the actuator 106 and the braking assembly 108.

The braking arrangement may be retrofitted onto the conventional valve assemblies that do not have a brake control mechanism as described in the aforementioned embodiments. By way of an example, the braking arrangement may be fitted onto a conventional valve assembly using a suitable adapter. Thus, by fitting the braking arrangement, a conventional valve assembly without brake control mechanism can be converted in to a valve assembly having a brake control mechanism. As a result of incorporating the braking arrangement, conventional valve assemblies also incorporate one or more advantages of the valve assembly 100.

The disclosed subject matter enables a two-stage control valve to obtain a plurality of positions of the modulating element to thereby achieve a wide variety of functionalities, such as, redirecting, closing, and varying the amount of fluid flow. The disclosed subject matter further does away with the costly proportional control valves having complex construction, by achieving similar functionality using a simpler and low cost two-stage control valve. Furthermore, the valve assembly with a braking mechanism, as described by the disclosed subject matter, has quicker reaction time and can be stopped instantaneously, as compared to the conventional proportional control valves. Yet further, the disclosed subject matter allows for higher solenoid excitation force as compared to the conventional proportional control valves. By implementing real-time position sensing and controlling of the movement of the modulating element, instantaneous stopping and accurate positioning of the modulating element is also achieved. The real-time position sensing further provides for predictive stopping of the modulating element, by way of which, the multiple shuttling of the modulating element, and the resultant chatter is avoided.

The illustrated steps are set out to explain the exemplary embodiments shown, and it should be anticipated that ongoing technological development will change the manner in which particular functions are performed. These examples are presented herein for purposes of illustration, and not limitation. Alternatives (including equivalents, extensions, variations, deviations, etc., of those described herein) will be apparent to persons skilled in the relevant art(s) based on the teachings contained herein. Such alternatives fall within the scope and spirit of the disclosed embodiments.

It is intended that the disclosure and examples be considered as exemplary only, with a true scope and spirit of disclosed embodiments being indicated by the following claims.

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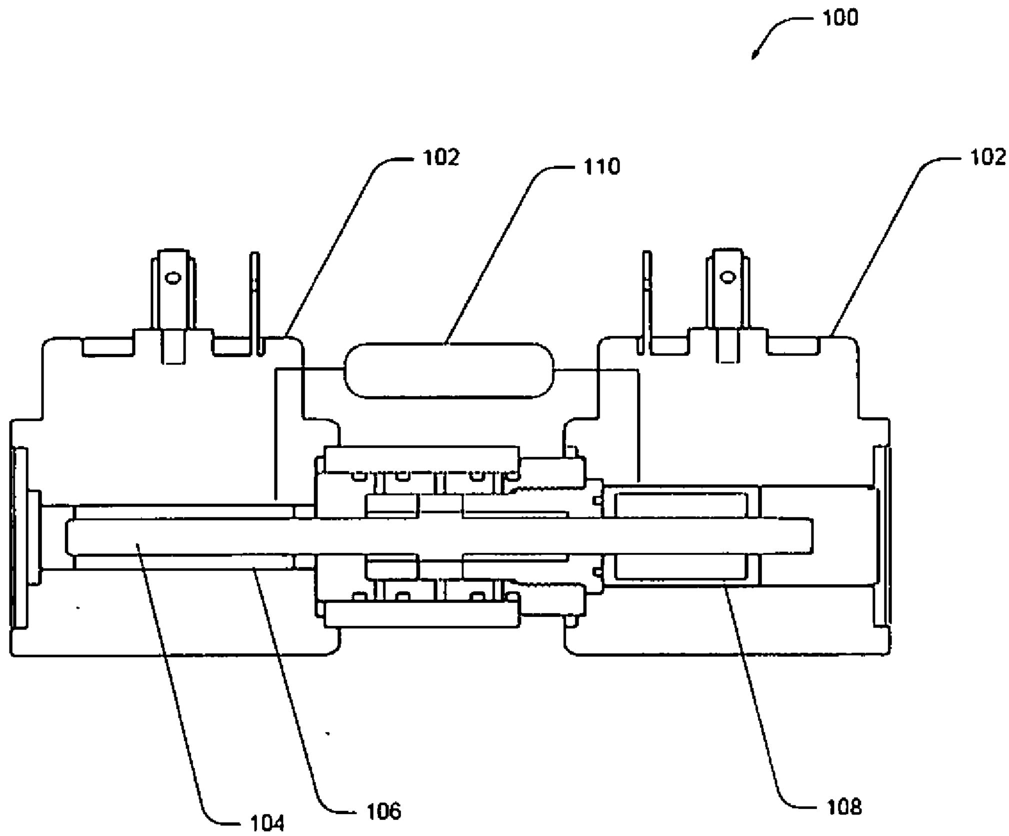

Figure 1

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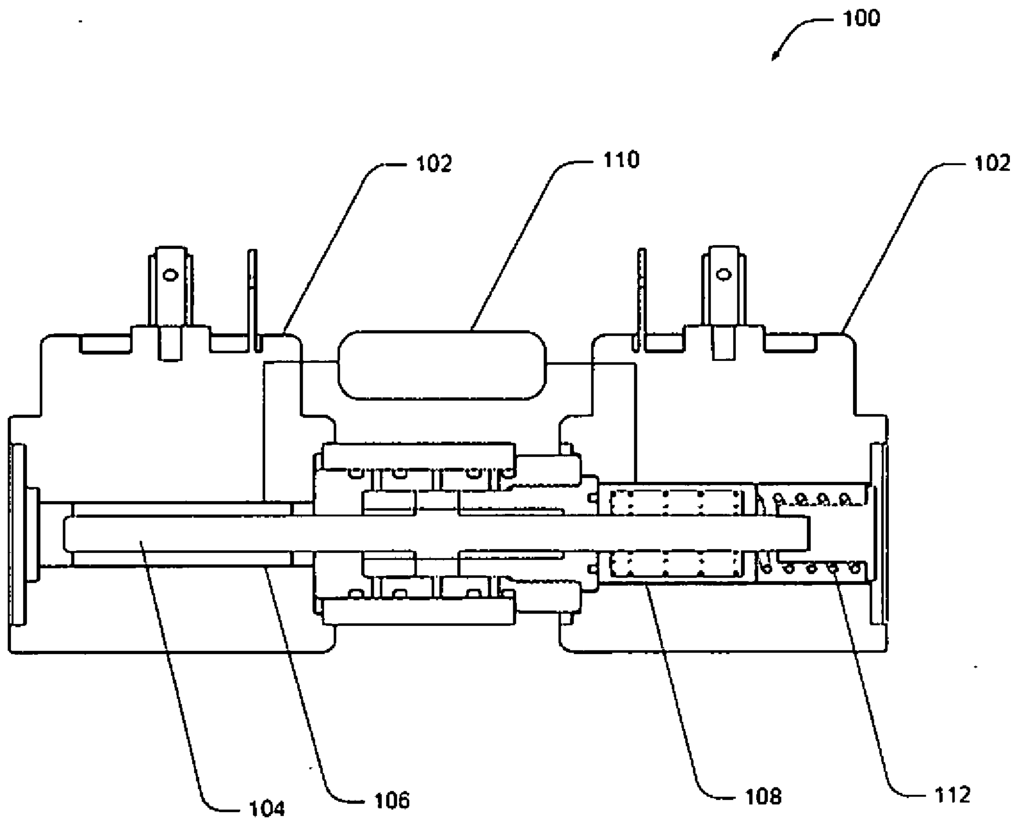

Figure 2

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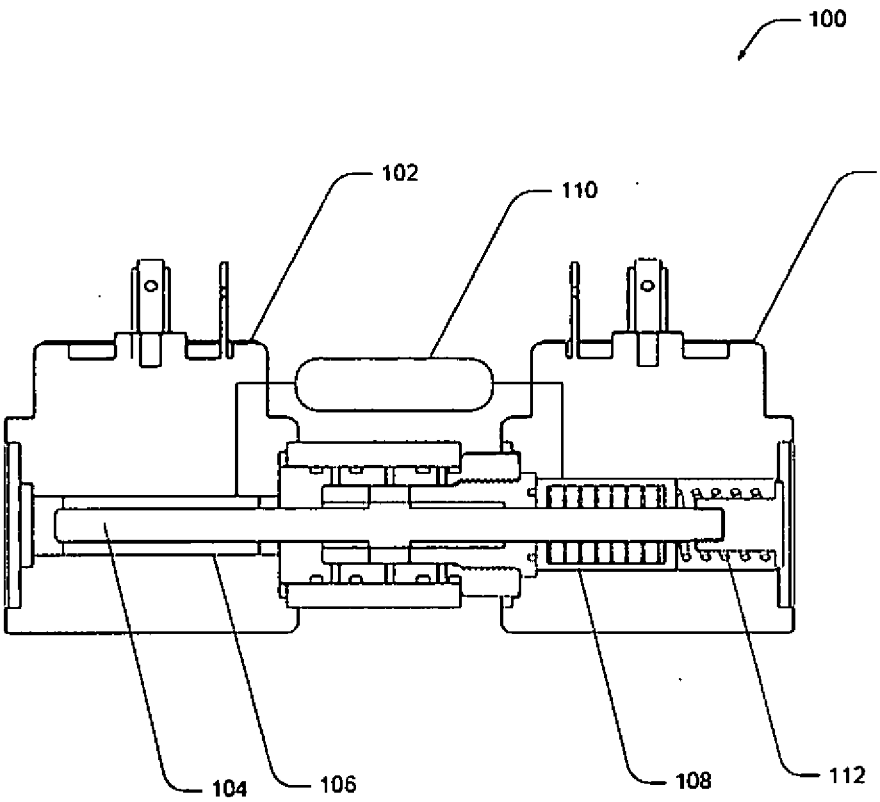

Figure 3

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