(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. AU 2018202300 B2

(54) Title
Diaphragm Valve

(51) International Patent Classification(s)
F16K 31/06 (2006.01) ***F16K 11/044*** (2006.01)

(21) Application No: **2018202300** (22) Date of Filing: **2018.03.29**

(30) Priority Data

(31) Number	(32) Date	(33) Country
15/714,320	**2017.09.25**	**US**

(43) Publication Date: **2019.04.11**
(43) Publication Journal Date: **2019.04.11**
(44) Accepted Journal Date: **2023.11.02**

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(56) Related Art
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29 Mar 2018 2018202300

ABSTRACT

A diaphragm valve includes a solenoid body having a coil and a pole piece. An armature is configured to slide in the solenoid body along a longitudinal axis between energized and de-energized positions. A valve body cartridge is connected to the solenoid body. A valve member, connected to the armature, is configured to slide within the valve body cartridge when the armature moves. A biasing member acts to normally bias the armature toward the de-energized position. A diaphragm, extending inwardly from the valve body cartridge towards the valve body, is received between the armature and the valve member. A diaphragm support sleeve includes a support sleeve wall defining a sleeve cavity that receives the armature and a support sleeve flange that extends inwardly from the support sleeve wall to abut and support at least part of the diaphragm.

DIAPHRAGM VALVE

FIELD

[0001] The present disclosure relates to solenoid operated valves and more particularly to a solenoid operated valve that is sealed by a diaphragm.

BACKGROUND

[0002] This section provides background information related to the present disclosure which is not necessarily prior art. The discussion is not an acknowledgement or admission that any of the material referred to is or was part of the common general knowledge as at the priority date of the application.

[0003] Solenoid operated valves, such as poppet valves, can be used to control the flow of a fluid, such as pressurized air, through a manifold. Such manifolds may be part of equipment such as sorters, packaging machines, food processors, and the like that are driven by the pressurized fluid. Such solenoid operated valves may be operated for millions of cycles. In order to retain the solenoid operated valve in a closed position when the solenoid is de-energized, biasing members such as springs are used. It is also known, for example in United States Patent 4,598,736 to Chorkey, that fluid pressure can be balanced within the valve to reduce a solenoid force required to move a valve member between closed and open positions.

[0004] The valve member is slidingly arranged within a valve body cartridge. In the closed position, a valve member is generally held in contact with a valve seat of the valve body cartridge by the biasing member. In the open position, the solenoid generally moves the valve member away from the valve seat forming a clearance gap therebetween. As disclosed in United States Patent 3,985,333 to Paulsen, a bellows shaped diaphragm can be used to provide a seal between the valve body cartridge and the solenoid. Such diaphragms prevent contaminants from working their way towards the solenoid while permitting longitudinal movement of the valve member.

[0005] The valve body cartridge is designed to be received in a bore provided in the manifold. The manifold usually includes multiple passageways that are arranged in fluid communication with the manifold bore. In operation, the solenoid operated valve controls fluid flow between these multiple passageways. O-ring seals are typically provided on the outside of the valve body cartridge to seal the valve body cartridge within the manifold bore.

SUMMARY

[0006] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0007] The subject disclosure provides for an improved diaphragm valve that includes a solenoid body and a valve body cartridge that is connected to the solenoid body. A coil, a pole piece, and an armature are positioned in the solenoid body. The armature can slide within the solenoid body along a longitudinal axis between an energized position and a de-energized position. A valve member is also disposed within the valve body cartridge. The valve member is connected to the armature and can slide within the valve body cartridge when the armature moves between the energized and de-energized positions. A biasing member, that acts to normally bias the armature toward the de-energized position, is also disposed in the solenoid body. A diaphragm extends inwardly from the valve body cartridge towards the valve member. The diaphragm is received between the armature and the valve member such that the diaphragm deflects in response to movement of the armature and the valve member along the longitudinal axis.

[0008] The diaphragm valve further includes a diaphragm support sleeve. The diaphragm support sleeve has a support sleeve wall and a support sleeve flange. The support sleeve wall defines a sleeve cavity that receives at least part of the armature. The support sleeve flange extends inwardly and is transverse to the support sleeve wall. The support sleeve flange abuts and supports at least part of the diaphragm.

[0009] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

[0010] The subject disclosure further provides for a diaphragm valve, comprising:

a solenoid body having a coil and a pole piece positioned in the solenoid body;

a valve body cartridge connected to the solenoid body, the valve body cartridge including a valve seat;

an armature slidably disposed in the solenoid body for movement along a longitudinal axis between an energized position and a de-energized position;

a valve member slidably disposed in the valve body cartridge, the valve member connected to the armature for movement therewith;

a biasing member disposed in the solenoid body that acts to normally bias the armature toward the de-energized position;

a diaphragm extending inwardly from the valve body cartridge that is received between the armature and the valve member such that the diaphragm deflects in response to movement of the armature and the valve member along the longitudinal axis; and

a diaphragm support sleeve having a support sleeve wall that defines a sleeve cavity and a support sleeve flange that extends inwardly and is transverse to the support sleeve wall, wherein the sleeve cavity receives at least part of the armature, wherein the support sleeve flange abuts and supports at least part of the diaphragm, wherein the diaphragm is clamped between the valve body cartridge and the diaphragm support sleeve.

[0011] The subject disclosure further provides for a diaphragm valve, comprising:

a solenoid body having a coil and a pole piece positioned in the solenoid body;

a valve body cartridge connected to the solenoid body;

an armature slidably disposed in the solenoid body for movement along a longitudinal axis between an energized position and a de-energized position, the armature including a biasing member seat that extends radially outwardly;

a valve member slidably disposed in the valve body cartridge, the valve member connected to the armature for movement therewith;

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a biasing member extending around the armature that acts against the biasing member seat of the armature to normally bias the armature toward the de-energized position;

a diaphragm extending radially inwardly from the valve body cartridge that is received between the armature and the valve member; and

a diaphragm support sleeve having a support sleeve wall and a support sleeve flange, the support sleeve wall extending annularly about the biasing member and the support sleeve flange extending radially inwardly from the support sleeve wall such that the support sleeve flange abuts and supports at least part of the diaphragm, wherein the support sleeve flange extends radially inward of the biasing member seat of the armature.

[0012] The subject disclosure further provides for a diaphragm valve, comprising:

a manifold including a manifold bore;

a valve body cartridge received in the manifold bore, the valve body cartridge including a valve seat;

a solenoid body connected to the valve body cartridge, the solenoid body having a coil and a pole piece positioned in the solenoid body;

an armature slidably disposed in the solenoid body for movement along a longitudinal axis between an energized position and a de-energized position;

a valve member slidably disposed in the valve body cartridge, the valve member connected to the armature for movement therewith;

a biasing member disposed in the solenoid body that acts to normally bias the armature toward the de-energized position;

a diaphragm extending inwardly from the valve body cartridge that is received between the armature and the valve member such that the diaphragm deflects in response to movement of the armature and the valve member along the longitudinal axis; and

a diaphragm support sleeve having a longitudinally extending support sleeve wall that defines a sleeve cavity and a transverse support sleeve flange that extends inwardly from the longitudinally extending support sleeve wall, wherein the sleeve cavity receives at least part of the armature, wherein the transverse support sleeve flange abuts and supports at least part of the diaphragm, wherein the diaphragm is clamped between the valve body cartridge and the diaphragm support sleeve.

DRAWINGS

[0013] The drawings described herein are for illustrative purposes only of selected embodiments and not all possible implementations, and are not intended to limit the scope of the present disclosure, where:

Figure 1 is a side cross-sectional view of an exemplary manifold and an exemplary diaphragm valve constructed in accordance with the present disclosure;

Figure 2 is a front perspective view of the exemplary diaphragm valve illustrated in Figure 1;

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Figure 3 is a side cross-sectional view of the exemplary diaphragm valve illustrated in Figure 1 where the armature of the exemplary diaphragm valve is shown in a de-energized position; and

Figure 4 is another side cross-sectional view of the exemplary diaphragm valve illustrated in Figure 1 where the armature of the exemplary diaphragm valve is shown in an energized position.

[0014] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

DETAILED DESCRIPTION

[0015] Example embodiments will now be described more fully with reference to the accompanying drawings. These example embodiments are provided so that this disclosure will be thorough, and will fully convey the scope to those who are skilled in the art. Numerous specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of embodiments of the present disclosure. It will be apparent to those skilled in the art that specific details need not be employed, that example embodiments may be embodied in many different forms and that neither should be construed to limit the scope of the disclosure. In some example embodiments, well-known processes, well-known device structures, and well-known technologies are not described in detail.

[0016] The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," “including,” and “having,” are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0017] When an element or layer is referred to as being "on," “engaged to,” "connected to," or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," “directly engaged to,” "directly connected to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., “between” versus “directly between,” “adjacent” versus “directly adjacent,” etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0018] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as “first,” “second,” and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0019] Spatially relative terms, such as “inner,” “outer,” "beneath," "below," "lower," "above," "upper," and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0020] Referring to Figures 1 and 2, a diaphragm valve **20** is shown installed in a manifold **22**. The diaphragm valve **20** includes a valve body cartridge **24** and a solenoid body **26** that are coaxially aligned with respect to a longitudinal axis **28**. The valve body cartridge **24** extends longitudinally between a ported end **30** and a diaphragm receiving end **32**. The solenoid body **26** extends longitudinally between an armature receiving end **34** and a pole piece receiving end **36**. It should be appreciated that the terms “longitudinal,” “longitudinally,” “axial,” and “axially,” when used herein, mean along or parallel to the longitudinal axis **28**. The diaphragm receiving end **32** of the valve body cartridge **24** and the armature receiving end **34** of the solenoid body **26** are releasably connected by threaded connection **38**. The manifold **22** includes a manifold bore **40**. The valve body cartridge **24** is slidably inserted into the manifold bore **40** of manifold **22**. One or more seal members **42**, such as O-rings, are positioned in one or more circumferential slots **44** created in valve body cartridge **24** and the solenoid body **26**. The seal members **42** abut the manifold bore **40** to create a fluid seal.

[0021] The solenoid body **26** includes first and second collars **46a, 46b** that extend radially outwardly away from the longitudinal axis **28**. The solenoid body **26** also includes external threads **50** that engage the manifold bore **40** to secure the diaphragm valve **20** to the manifold **22**. The manifold **22** includes passageways **52a, 52b** disposed in fluid communication with the manifold bore **40**. In operation, the diaphragm valve **20** controls the flow of fluid, such as pressurized air, between the passageways **52a, 52b** of the manifold **22**.

[0022] With additional reference to Figures 3 and 4, a coil **54** and a pole piece **56** are positioned in the solenoid body **26**. A bobbin **58**, also disposed in the solenoid body **26**, supports the coil **54**. An armature **62** is slidably disposed in the solenoid body **26** for movement along the longitudinal axis **28** between a de-energized position (Figure 3) and an energized position (Figure 4). At least part of the pole piece **56** and at least part of the armature **62** are slidably received in the bobbin **58**. The pole piece **56** may include a pressure equalizing passage **64** that extends through the pole piece **56** along the longitudinal axis **28**. The pole piece **56** may also include a threaded end **66** that engages internal threads **68** in the pole piece receiving end **36** of the solenoid body **26**. Accordingly, the axial position of the pole piece **56** is adjustable by rotating pole piece **56** relative to the solenoid by about the longitudinal axis **28**.

[0023] The pole piece **56** is disposed within a pole piece sleeve **70**. The pole piece sleeve **70** includes a pole piece sleeve wall **72** and a pole piece sleeve flange **74**. The pole piece sleeve wall **72** is positioned radially between the bobbin **58** and at least part of the pole piece **56**. The pole piece sleeve flange **74** extends radially outwardly from the pole piece sleeve wall **72** towards the solenoid body **26**. The pole piece sleeve wall **72** maintains coaxial alignment of pole piece **56** with the bobbin **58**, the coil **54**, and the solenoid body **26** when the axial position of the pole piece **56** is adjusted by rotating pole piece **56** relative to the solenoid about the longitudinal axis **28**.

[0024] An electrical cover **76** is releasably connected to the pole piece receiving end **36** of the solenoid body **26** by threaded connection **78**. The electrical cover **76** includes multiple electrical contacts **80** on a printed circuit board (PCB) **82** that are electrically connected to the coil **54**. The electrical contacts **80** are configured to mate with an electrical connector **84**, connected to one or more electrical wire leads **86**, that supplies electricity to the diaphragm valve **20**. Optionally, the electrical cover **76** may receive a connector seal **88** disposed between the electrical connector **84** and electrical cover **76**. The diaphragm valve **20** may also include an electrical insulator **90** disposed between the pole piece **56** and the printed circuit board **82**.

[0025] As shown in Figure 3, when the armature **62** is in the de-energized position, a clearance gap **92** is provided between the pole piece **56** and the armature **62**. The armature **62** is slidably disposed within an armature sleeve **94** in the armature receiving end **34** of the solenoid body **26**. The armature sleeve **94** includes an armature sleeve wall **96** and an armature sleeve flange **98**. The armature sleeve wall **96** is positioned radially between the bobbin **58** and at least part of the armature **62**. The armature sleeve flange **98** extends radially outwardly from the armature sleeve wall **96** towards the solenoid body **26**. The armature sleeve wall **96** maintains coaxial alignment of armature **62** with the bobbin **58**, the coil **54**, and the solenoid body **26** during sliding displacement of the armature **62** between the energized and de-energized positions. Although other configurations are possible, the armature sleeve wall **96** may be integrally connected to the armature sleeve flange **98**. The armature **62** may optionally include one or more flats **100** for holding the armature **62** during assembly of the diaphragm valve **20**.

[0026] A biasing member **102**, such as a coiled metal compression spring, is positioned around armature **62**. The armature **62** includes a biasing member seat **104** that extends radially outwardly toward the solenoid body **26**. The biasing member **102** has a first biasing member end **106** that contacts the biasing member seat **104** of the armature **62** and a second biasing member end **108** that contacts the armature sleeve flange **98**. The biasing member **102** applies a biasing force **110** to the armature **62** that acts to bias the armature **62** towards the de-energized position (Figure 3).

[0027] As shown in Figure 4, when electricity is supplied to the coil **54**, the coil **54** creates a magnetic field that causes the armature **62** to be magnetically attracted towards the pole piece **56**. The magnetic field imparts a magnetic force **112** on the armature **62** that overcomes the biasing force **110** of biasing member **102**, which results in movement of the armature **62** to the energized position (Figure 4). As long as electricity is supplied to the coil **54**, the armature **62** will be held in the energized position.

[0028] The diaphragm valve **20** includes a valve member **114** that is disposed in the valve body cartridge **24**. The armature **62** includes a connection portion **116** and the valve member **114** is connected to the connection portion **116** of the armature **62** by threaded connection **118**. Accordingly, the valve member **114** slides within the valve body cartridge **24** as the armature **62** moves between the energized and de-energized positions.

[0029] A diaphragm **120** is received in the diaphragm receiving end **32** of the valve body cartridge **24** between the connection portion **116** of the armature **62** and the valve member **114**. More specifically, the threaded connection **118** between the armature **62** and the valve member **114** permits the diaphragm **120** to be clamped between the connection portion **116** of the armature **62** and the valve member **114**. The diaphragm **120** provides an atmospheric seal for the diaphragm valve **20** to prevent a fluid, such as pressurized air, and contaminants from entering the solenoid body **26**. The diaphragm **120** extends radially inwardly from the valve body cartridge **24** in a diaphragm plane **122** that is transverse to the longitudinal axis **28** when the armature **62** is in the de-energized position (Figure 3). This means that the diaphragm **120** is substantially flat and does not have one or more bellows-like portions that have a U-shaped cross-section. The diaphragm **120** deflects away from the diaphragm plane **122** when the armature **62** moves to the energized position (Figure 4). Although various configurations and construction materials are possible, the diaphragm **120** may be made of rubber.

[0030] The ported end **30** of the valve body cartridge **24** includes at least an inlet port **124** and an outlet port **126**. As shown in Figure 1, when the valve body cartridge **24** is installed in the manifold bore **40**, the inlet and outlet ports **124, 126** are positioned in fluid communication with the passageways **52a, 52b** of the manifold **22**. A valve seat **128** is positioned between the inlet port **124** and the outlet port **126**. The valve seat **128** may be integral with the valve body cartridge **24** or may alternatively be a separate component that is made of a softer material, such as rubber. The valve member **114** includes a valve seat engagement face **130** that contacts the valve seat **128** in a valve closed position (Figure 3) and that is displaced away from the valve seat **128** in a valve open position (Figure 4).

[0031] The valve body cartridge **24** also includes a piston bore **132**. The valve member **114** has a piston **134** that is received in the piston bore **132** and is configured to slide within the piston bore **132** as the valve member **114** moves between the valve open and valve closed positions. Optionally, the diaphragm valve **20** may be configured as a pressure balanced valve. The inlet port **124** has a cross-sectional area. Where the diaphragm valve **20** has a pressure balanced configuration, the piston **134** has a piston surface area that is equal to the cross-sectional area of the inlet port **124**.

[0032] In the valve closed position shown in Figure 3, the biasing force **110** of the biasing member **102** pushes the armature **62** to the de-energized position and the valve member **114** in a valve closing direction **136**. The valve seat engagement face **130** of the valve member **114** is held in contact with the valve seat **128** by the biasing force **110** of the biasing member **102**. Accordingly, the diaphragm valve **20** prevents fluid flow between the inlet and outlet ports **124, 126** when diaphragm valve **20** is de-energized. In the valve open position shown in Figure 4, the biasing force **110** of the biasing member **102** is overcome by the magnetic force **112** acting through pole piece **56** when the coil **54** is energized, which pulls the armature **62** to the energized position and the valve member **114** in a valve opening direction **138**. The valve seat engagement face **130** of the valve member **114** moves away from the valve seat **128**, thereby providing a flow path **140** from the inlet port **124** to the outlet port **126** when diaphragm valve **20** is energized.

[0033] The armature receiving end **34** of the solenoid body **26** includes an armature cavity **142**. A diaphragm support sleeve **144** is disposed in the armature cavity **142**. The diaphragm support sleeve **144** has a support sleeve wall **146** and a support sleeve flange **148**. The support sleeve wall **146** extends longitudinally, is generally cylindrical in shape, and is co-axially aligned with the longitudinal axis **28**. The support sleeve wall **146** extends annularly around and is spaced from the armature **62** to define a sleeve cavity **150** therein. The sleeve cavity **150** receives at least part of the armature **62**. The biasing member **102** is positioned in the sleeve cavity **150** radially between the armature **62** and the support sleeve wall **146**. The support sleeve flange **148** extends radially inwardly from the support sleeve wall **146** and is transverse to the longitudinal axis **28**. More specifically, the support sleeve flange **148** extends radially inward of the biasing member seat **104** of the armature **62**, while the connection portion **116** of the armature **62** is positioned radially inward of the support sleeve flange **148**. The support sleeve flange **148** abuts and supports at least part of the diaphragm **120**.

[0034] A spacer seal **152** is positioned between and contacts the support sleeve wall **146** and the armature sleeve flange **98**. The spacer seal **152** accommodates tolerance variations between the diaphragm support sleeve **144** and the armature sleeve **94**. The diaphragm support sleeve **144** is threadably engaged with the valve body cartridge **24**. Specifically, the diaphragm support sleeve **144** includes a threaded shoulder **154** that extends radially outwardly from the support sleeve wall **146** and the valve body cartridge **24** includes internal threads **156** that engage the threaded shoulder **154** of the diaphragm support sleeve **144**.

[0035] The diaphragm **120** may optionally include a peripheral lip **158**. The peripheral lip **158** is received between the valve body cartridge **24** and the diaphragm support sleeve **144** to secure the diaphragm **120** within the diaphragm valve **20**. In the illustrated example, the peripheral lip **158** of the diaphragm **120** has a ramp shaped cross-section; however, other shapes may be utilized.

[0036] The valve body cartridge **24** according to several embodiments is created of a polymeric material and is releasably, threadably connected to the solenoid body **26**. A polymeric material is used for valve body cartridge **24** for multiple reasons, including: to reduce cost and weight of the diaphragm valve **20**; to permit the complex geometry of valve body cartridge **24** to be more easily manufactured using a molding operation; to reduce or eliminate corrosion of the valve body cartridge **24** in an installed position in the manifold **22**; and to eliminate any effects of the magnetic field on the valve body cartridge **24** during operation of the coil **54**. In accordance with another embodiment, the valve body cartridge **24** is made of metal.

[0037] The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

[0038] Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of possible implementations. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one claim, the disclosure of possible implementations includes each dependent claim in combination with every other claim in the claim set.

CLAIMS

What is claimed is:

1. A diaphragm valve, comprising:

a solenoid body having a coil and a pole piece positioned in the solenoid body;

a valve body cartridge connected to the solenoid body, the valve body cartridge including a valve seat;

an armature slidably disposed in the solenoid body for movement along a longitudinal axis between an energized position and a de-energized position;

a valve member slidably disposed in the valve body cartridge, the valve member connected to the armature for movement therewith;

a biasing member disposed in the solenoid body that acts to normally bias the armature toward the de-energized position;

a diaphragm extending inwardly from the valve body cartridge that is received between the armature and the valve member such that the diaphragm deflects in response to movement of the armature and the valve member along the longitudinal axis; and

a diaphragm support sleeve having a support sleeve wall that defines a sleeve cavity and a support sleeve flange that extends inwardly and is transverse to the support sleeve wall, wherein the sleeve cavity receives at least part of the armature, wherein the support sleeve flange abuts and supports at least part of the diaphragm, wherein the diaphragm is clamped between the valve body cartridge and the diaphragm support sleeve.

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2. The diaphragm valve of Claim 1, wherein the biasing member is positioned in the sleeve cavity of the diaphragm support sleeve between the armature and the support sleeve wall.

3. The diaphragm valve of Claim 2, wherein the armature includes a biasing member seat that extends outwardly toward the support sleeve wall and the biasing member having a first biasing member end that contacts the biasing member seat of the armature.

4. The diaphragm valve of Claim 3, further comprising:

a bobbin disposed in the solenoid body that supports the coil, at least part of the pole piece and at least part of the armature slidably received in the bobbin; and

an armature sleeve including an armature sleeve wall and an armature sleeve flange, the armature sleeve wall disposed between the bobbin and at least part of the armature, the armature sleeve flange extending outwardly from the armature sleeve wall towards the solenoid body, and the biasing member including a second biasing member end that contacts the armature sleeve flange.

5. The diaphragm valve of Claim 4, further comprising:

a spacer seal positioned between and contacting the support sleeve wall and the armature sleeve flange.

6. The diaphragm valve of any one of Claim 1 to 5, wherein the diaphragm includes a peripheral lip that is received between the valve body cartridge and the diaphragm support sleeve to secure the diaphragm within the diaphragm valve.

7. The diaphragm valve of Claim 6, wherein the peripheral lip of the diaphragm has a ramp shaped cross-section.

8. The diaphragm valve of any one of Claim 1 to 7, wherein the valve body cartridge includes at least an inlet port, an outlet port, wherein the valve seat is positioned between the inlet port and the outlet port and wherein the valve member includes a valve seat engagement face that contacts the valve seat in a valve closed position and that is displaced away from the valve seat in a valve open position.

9. The diaphragm valve of Claim 8, wherein the valve body cartridge includes a piston bore and the valve member includes a piston that is slidably received in the piston bore, wherein the inlet port has a cross-sectional area, and wherein the piston has a piston surface area that is equal to the cross-sectional area of the inlet port to create a pressure balanced condition.

10. The diaphragm valve of any one of Claims 1 to 9, wherein the diaphragm support sleeve is threadably engaged with the valve body cartridge.

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11. The diaphragm valve of any one of Claim 1 to 10, wherein the diaphragm extends in a diaphragm plane that is transverse to the longitudinal axis when the armature is in one of the energized or de-energized positions.

12. The diaphragm valve of any one of Claims 1 to 11, further comprising:

a threaded connection between the armature and the valve member that permits the diaphragm to be clamped between the armature and the valve member.

13. The diaphragm valve of any one of Claims 1 to 12, wherein the pole piece includes a threaded end that engages internal threads in the solenoid body and permits an axial position of the pole piece to be selected by rotation of the pole piece with respect to the solenoid body.

14. A diaphragm valve, comprising:

a solenoid body having a coil and a pole piece positioned in the solenoid body;

a valve body cartridge connected to the solenoid body;

an armature slidably disposed in the solenoid body for movement along a longitudinal axis between an energized position and a de-energized position, the armature including a biasing member seat that extends radially outwardly;

a valve member slidably disposed in the valve body cartridge, the valve member connected to the armature for movement therewith;

a biasing member extending around the armature that acts against the biasing member seat of the armature to normally bias the armature toward the de-energized position;

a diaphragm extending radially inwardly from the valve body cartridge that is received between the armature and the valve member; and

a diaphragm support sleeve having a support sleeve wall and a support sleeve flange, the support sleeve wall extending annularly about the biasing member and the support sleeve flange extending radially inwardly from the support sleeve wall such that the support sleeve flange abuts and supports at least part of the diaphragm, wherein the support sleeve flange extends radially inward of the biasing member seat of the armature.

15. The diaphragm valve of Claim 14, wherein the biasing member has a first biasing member end that contacts the biasing member seat of the armature.

16. The diaphragm valve of Claim 15, further comprising:

a bobbin disposed in the solenoid body that supports the coil, the bobbin extending annularly around at least part of the pole piece and at least part of the armature; and

an armature sleeve including an armature sleeve wall and an armature sleeve flange, the armature sleeve wall disposed radially between the bobbin and at least part of the armature, the armature sleeve flange extending radially outwardly from the armature sleeve wall towards the solenoid body, and the biasing member including a second biasing member end that contacts the armature sleeve flange.

17. The diaphragm valve of Claim 16, further comprising:

a spacer seal positioned between and contacting the support sleeve wall and the armature sleeve flange to accommodate tolerance variations between the diaphragm support sleeve and the armature sleeve.

18. The diaphragm valve of Claim 15, 16 or 17, wherein the support sleeve flange extends radially inward of the biasing member seat of the armature.

19. The diaphragm valve of any one of Claims 15 to 18, wherein the diaphragm support sleeve includes a threaded shoulder that extends radially outwardly from the support sleeve wall and wherein the valve body cartridge includes internal threads that engage the threaded shoulder of the diaphragm support sleeve.

20. A diaphragm valve, comprising:

a manifold including a manifold bore;

a valve body cartridge received in the manifold bore, the valve body cartridge including a valve seat;

a solenoid body connected to the valve body cartridge, the solenoid body having a coil and a pole piece positioned in the solenoid body;

an armature slidably disposed in the solenoid body for movement along a longitudinal axis between an energized position and a de-energized position;

a valve member slidably disposed in the valve body cartridge, the valve member connected to the armature for movement therewith;

a biasing member disposed in the solenoid body that acts to normally bias the armature toward the de-energized position;

a diaphragm extending inwardly from the valve body cartridge that is received between the armature and the valve member such that the diaphragm deflects in response to movement of the armature and the valve member along the longitudinal axis; and

a diaphragm support sleeve having a longitudinally extending support sleeve wall that defines a sleeve cavity and a transverse support sleeve flange that extends inwardly from the longitudinally extending support sleeve wall, wherein the sleeve cavity receives at least part of the armature, wherein the transverse support sleeve flange abuts and supports at least part of the diaphragm, wherein the diaphragm is clamped between the valve body cartridge and the diaphragm support sleeve.

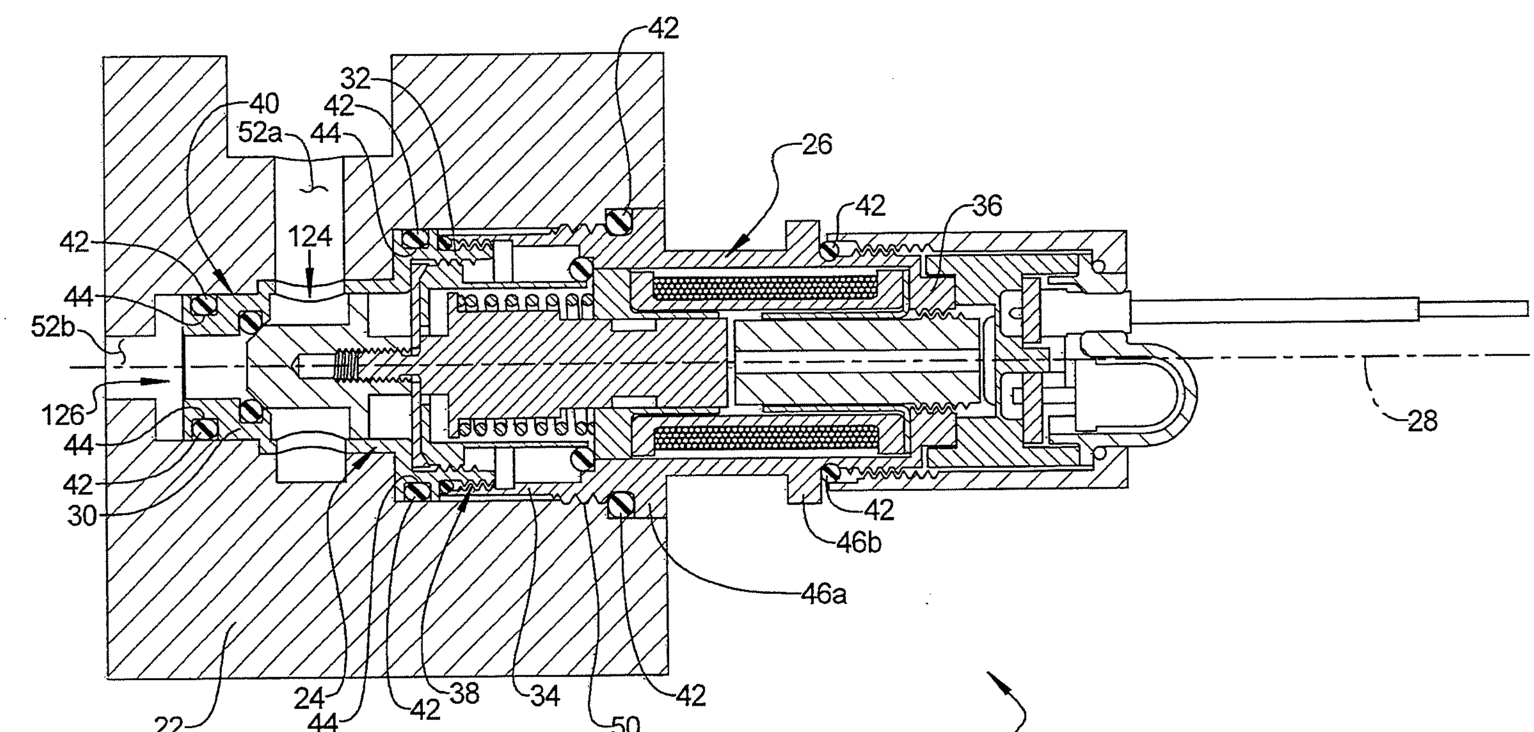
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FIG 1

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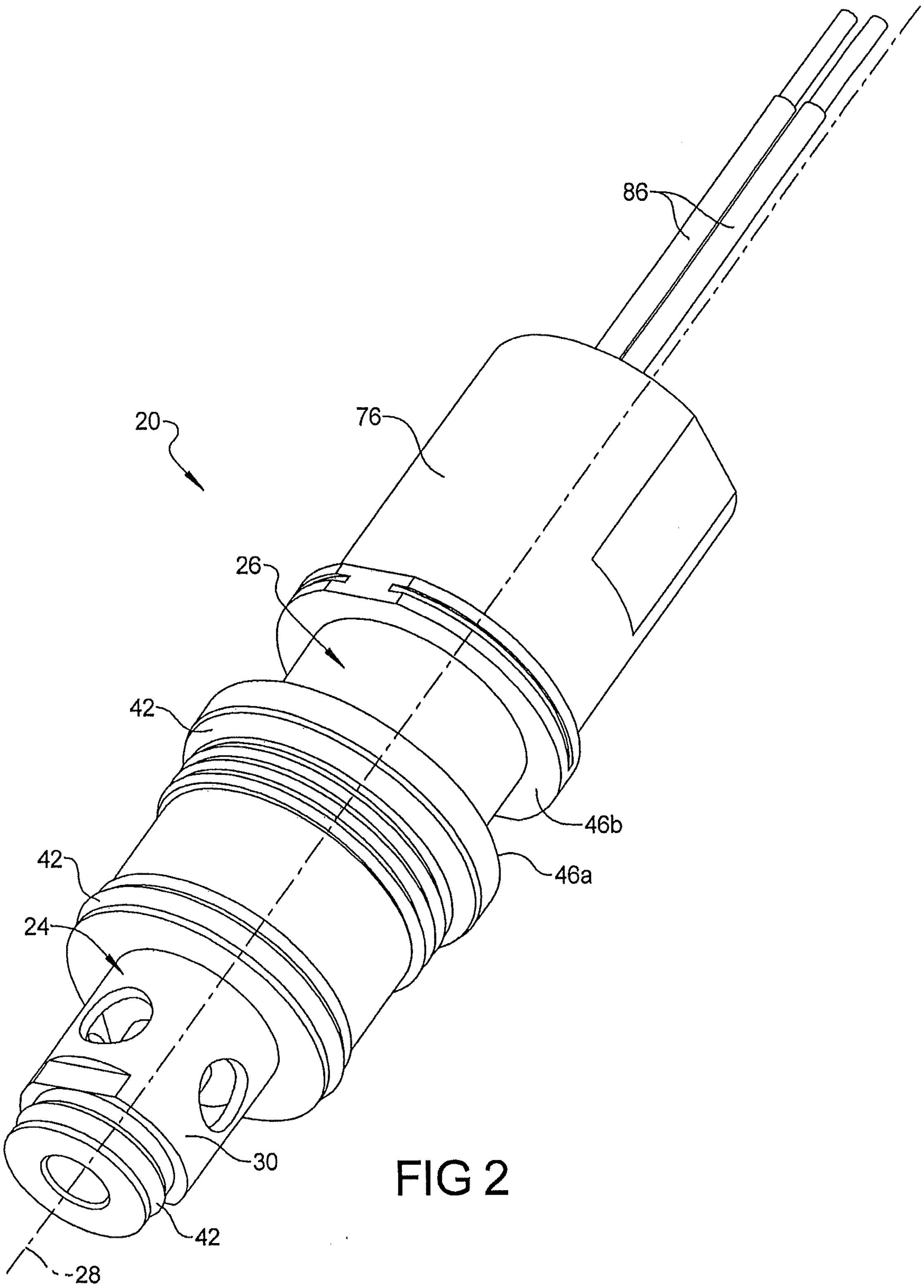

FIG 2

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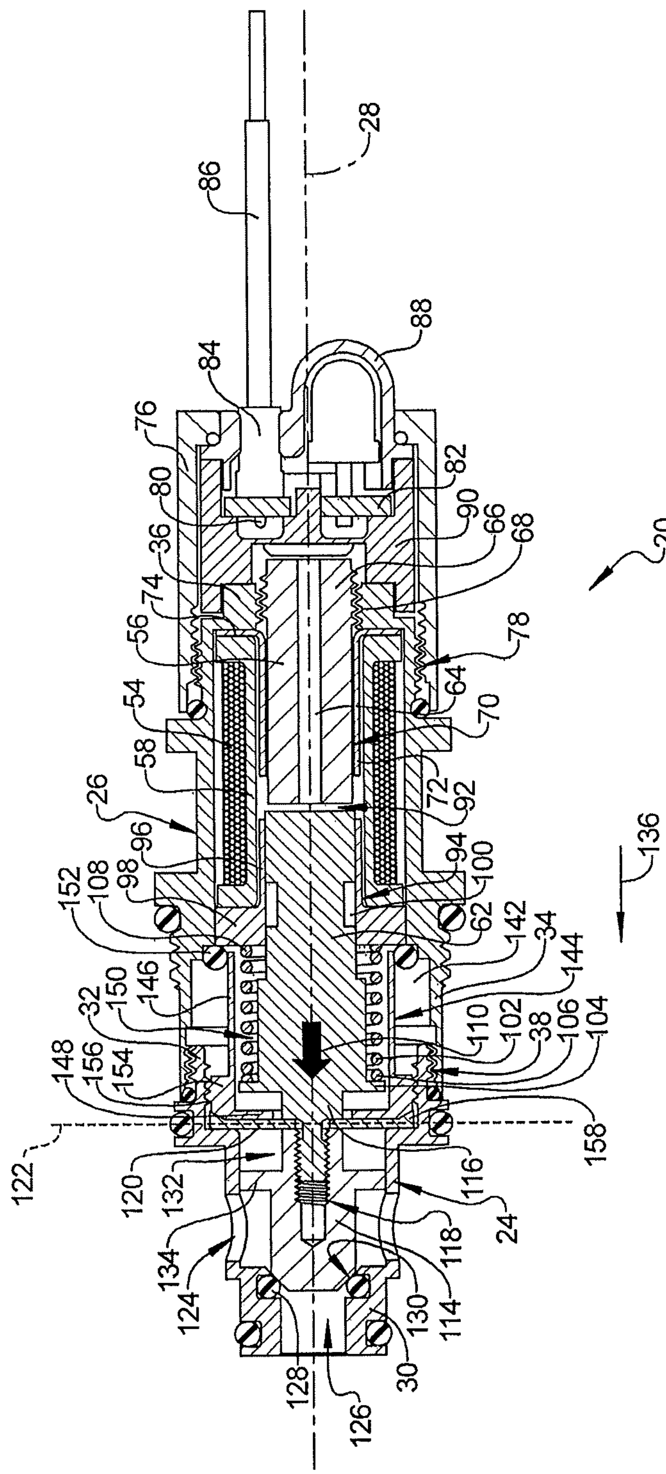

FIG 3

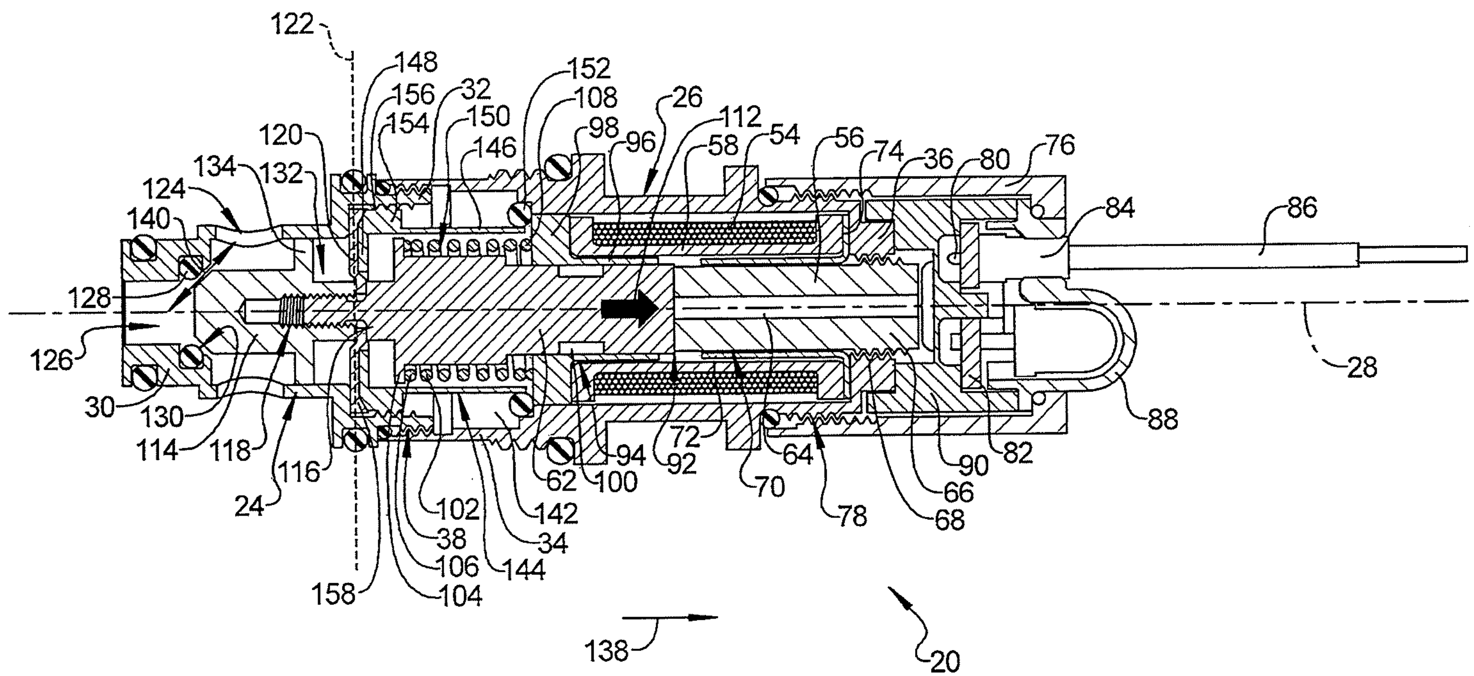
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FIG 4