US 20070241301A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2007/0241301 A1**

Wincek (43) **Pub. Date: Oct. 18, 2007**

(54) **VALVE DIAPHRAGM WITH A FLUOROPOLYMER LAYER**

(76) Inventor: **Christopher P. Wincek**, Rancho Santa Margarita, CA (US)

Correspondence Address:
LAW OFFICES OF ERIC KARICH
2807 ST. MARK DR.
MANSFIELD, TX 76063 (US)

(21) Appl. No.: **11/820,690**

(22) Filed: **Jun. 20, 2007**

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/159,009, filed on Jun. 22, 2005.
Continuation-in-part of application No. 11/182,669, filed on Jul. 15, 2005, now Pat. No. 7,243,903.

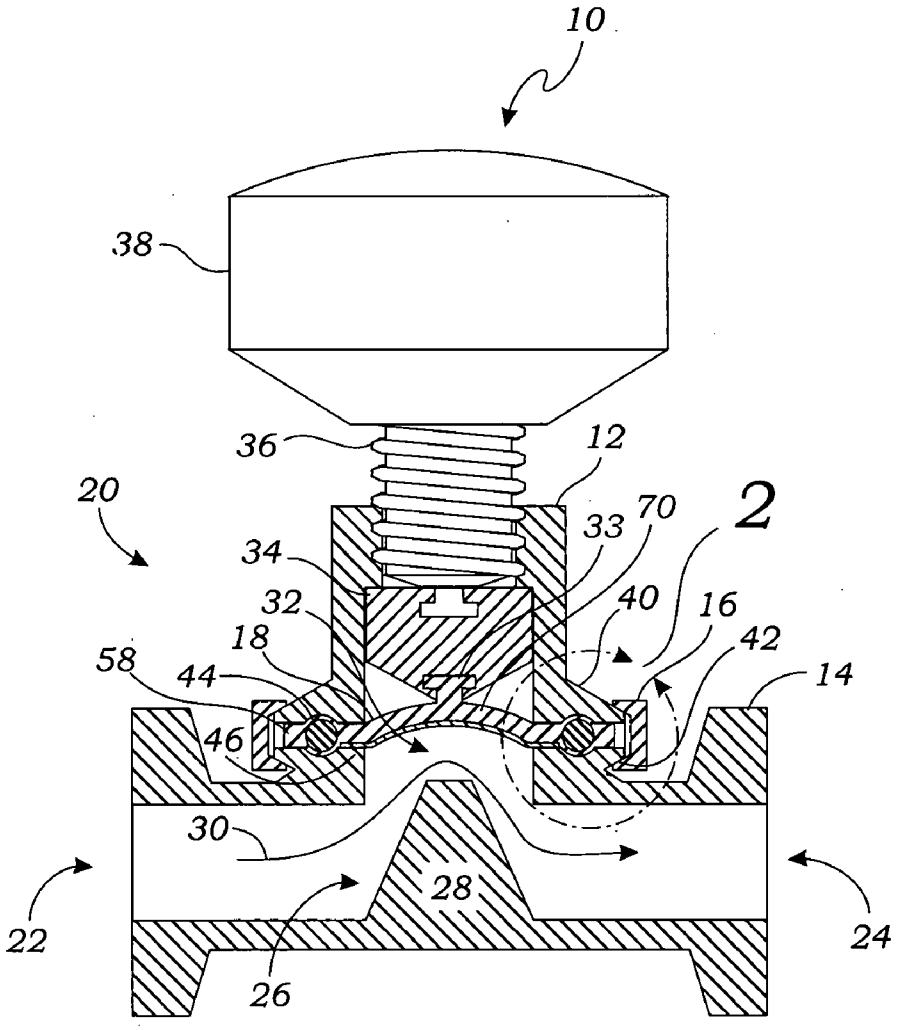
Publication Classification

(51) **Int. Cl.**
F16K 31/00 (2006.01)

(52) **U.S. Cl.** **251/335.2**; 251/285

(57) **ABSTRACT**

A flexible diaphragm has a flexible central portion, a peripheral portion surrounding the central portion formed from a flexible elastomeric or plastic material, and a substantially rigid ring extending continuously through or on the peripheral portion of the flexible diaphragm. A fluoropolymer layer molded to, bonded with, or otherwise covering the central portion of the flexible diaphragm. The flexible diaphragm is adapted to be positioned between a bonnet and a body of a valve such that the peripheral portion is clamped between the bonnet and the body.



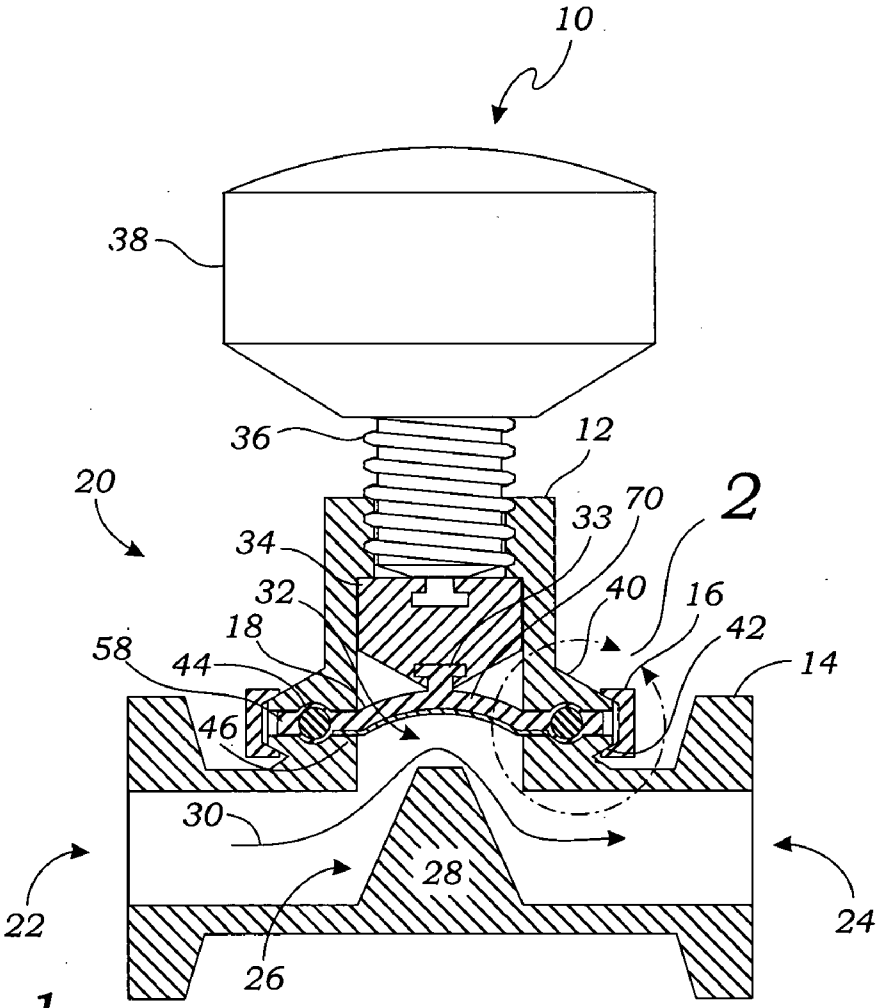

10
38
36
12
20
2
34
33
70
32
40
16
18
42
58
44
14
46
30
28
22
24
26

Fig. 1

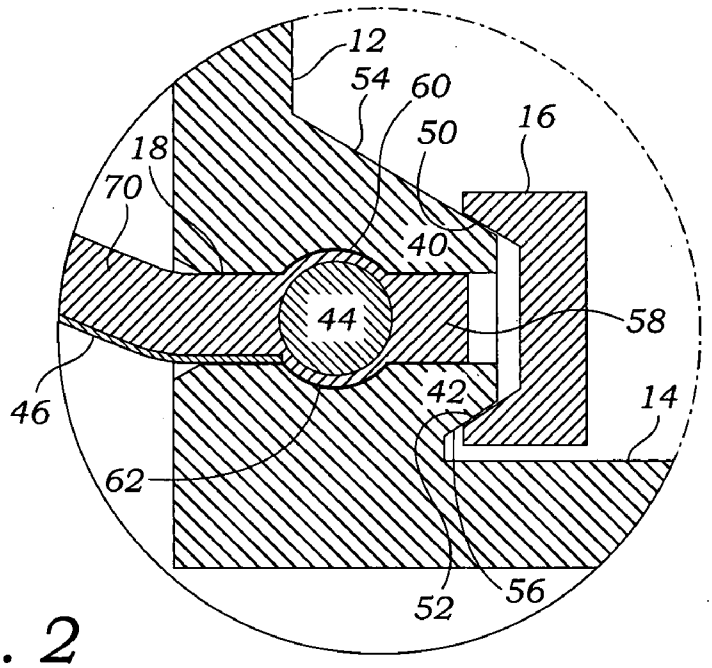

12
54
60
16
50
18
70
40
44
58
42
14
46
62
52
56

Fig. 2

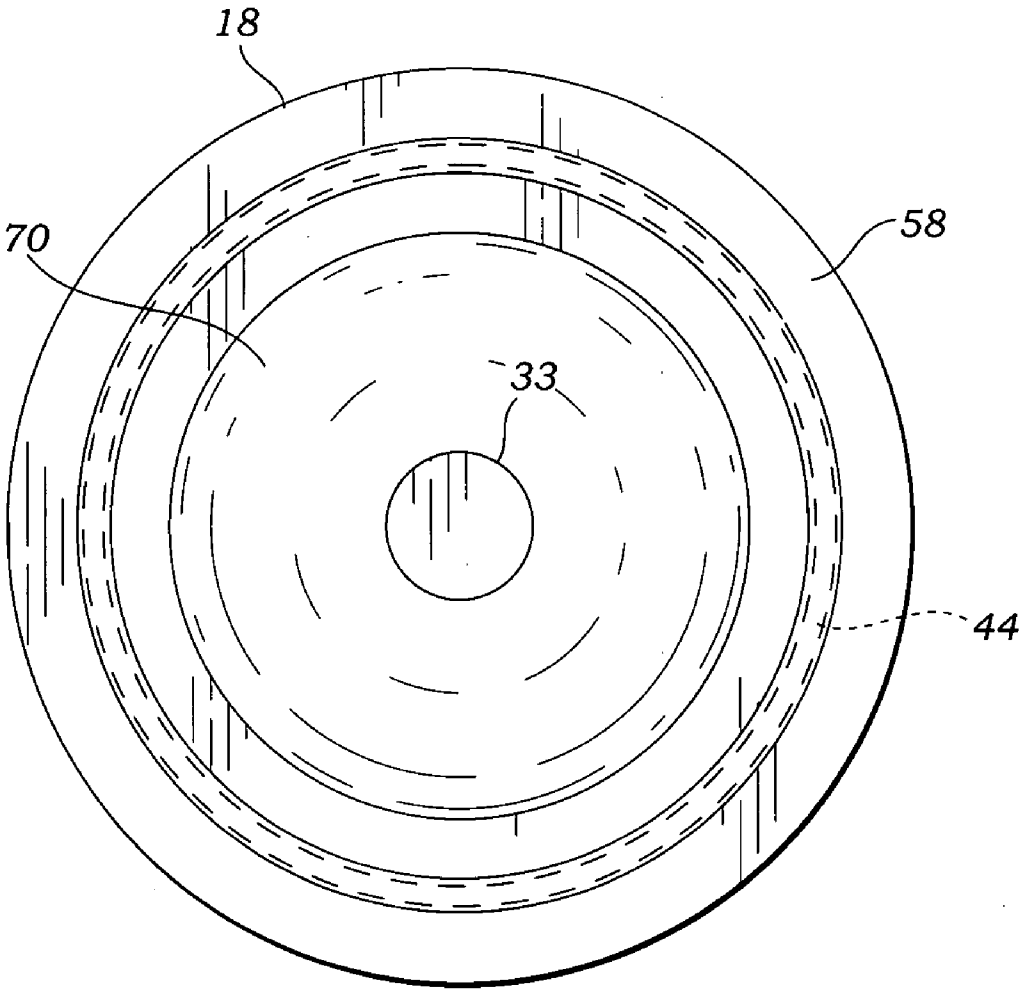


Fig. 3

VALVE DIAPHRAGM WITH A FLUOROPOLYMER LAYER

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application for a utility patent is a continuation-in-part of the following previously filed utility patents: application No. 11/159,009, filed Jun. 22, 2005; and application No. 11/182,669, filed Jul. 15, 2005. The previous applications are hereby incorporated by reference in their entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

[0002] Not Applicable

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] This invention relates generally to valves used to control flows of fluids, and more particularly to valves such as weir type diaphragm valves having moveable diaphragms to control flows.

[0005] 2. Description of Related Art

[0006] Diaphragm valves have moveable diaphragms to control fluid flows, and are commonly used for processing high purity fluids used in the pharmaceutical, biotechnical, chemical, food, and semiconductor industries. Their prevalent use is mainly due to their exceptional ability to resist damage from fluids (e.g., reactive chemicals). The diaphragms are typically the only moving parts that come in contact with the fluids, and the diaphragms typically isolate other moving parts from the fluids.

[0007] A major disadvantage with diaphragm valves is that the diaphragms wear out and require periodic replacement. The diaphragm is typically a flexible material sandwiched between a bonnet and a body drawn together by tightening several fasteners. A problem arises in that the flexible diaphragm offers little resistance to forces exerted on the diaphragm as the fasteners are tightened. During assembly of a diaphragm valve, there is a tendency to over-tighten the fasteners in an effort to assure leak-proof junctions. Over-tightening of the fasteners causes over-compression of the diaphragm, which often results in rupture and early failure of the diaphragm.

[0008] Various solutions to this problem have been attempted in the prior art. Jacob, Jr., U.S. Pat. No. 6,047,953, for example, teaches a universal diaphragm made of elastomeric material having rigid solid compression restrainers incorporated within the perimeter of the diaphragm for preventing over-compression of the diaphragm during the assembly of a diaphragm valve. The compression restrainers can be designed to occupy several positions within the area of the diaphragm that is pressed between the bonnet and valve body of the diaphragm valve. The compression restrainers are bonded or vulcanized onto the surface of the elastomeric material making up the diaphragm.

[0009] Marcilese, U.S. Pat. No. 6,155,535, illustrates the use of similar stops incorporated into the bonnet and/or valve body.

[0010] Other patents of interest include Simmons, et al., U.S. Pat. No. 6,295,918, G. E. Nicholson, et al., U.S. Pat. No. 2,578,730, Parkinson, U.S. Pat. No. 4,421,295, R. Fortune, U.S. Pat. No. 2,891,763, Greenwood, U.S. Pat. No. 5,829,472, Gilchrist, et al., U.S. Pat. No. 5,386,849, W. O. Teeters, U.S. Pat. No. 2,575,775, Maula, et al., U.S. **2004/0262562**, Zuniga, et al., U.S. Pat. No. 5,762,544, and Makoto, Japan 04310701 (diaphragm seal mechanism having a metal O-ring spacer).

[0011] It would be beneficial to have a valve with a moveable diaphragm clamped between a bonnet and a body and one or more structures that provide circumferential sealing between the bonnet and the body, and also prevent over-compression of the flexible diaphragm. It would also be beneficial to have a diaphragm covered by a fluoropolymer layer for preventing leachables from the flexible diaphragm from contaminating fluid flowing through the valve.

SUMMARY OF THE INVENTION

[0012] The present invention teaches certain benefits in construction and use which give rise to the objectives described below.

[0013] The present invention provides a flexible diaphragm for use in a valve having a body and a bonnet. The flexible diaphragm includes a flexible central portion, a peripheral portion surrounding the central portion formed from a flexible elastomeric or plastic material, a substantially rigid ring extending continuously through or on the peripheral portion of the flexible diaphragm, and a fluoropolymer layer molded to, bonded with, or otherwise covering the central portion of the flexible diaphragm. The flexible diaphragm is adapted to be positioned between the bonnet and the body such that the peripheral portion is clamped between the bonnet and the body.

[0014] A primary objective of the present invention is to provide a flexible diaphragm of a valve having advantages not taught by the prior art.

[0015] Another objective is to provide a valve that includes a flexible diaphragm having a thin fluoropolymer layer for preventing leachables from the flexible diaphragm from contaminating fluid flowing through the valve.

[0016] A further objective is to provide a valve that forms a superior seal to prevent leakage and/or contamination.

[0017] Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWING

[0018] The accompanying drawings illustrate the present invention. In such drawings:

[0019] FIG. **1** is a perspective view of one embodiment of a valve including a bonnet clamped to a body via a band clamp, wherein a flexible diaphragm is positioned between the bonnet and the body;

[0020] FIG. **2** is a view of a portion of the valve of FIG. **1** illustrating how a peripheral portion of the diaphragm is clamped between the bonnet and the body, and illustrating a

thin fluoropolymer layer disposed on the diaphragm for preventing leachables from the flexible diaphragm from contaminating fluid flowing through the valve; and

[0021] FIG. **3** is a top plan view of the diaphragm of FIGS. **1** and **2**.

DETAILED DESCRIPTION OF THE INVENTION

[0022] FIG. **1** is a perspective view of one embodiment of a valve **10** including a bonnet **12** clamped to a body **14** via a band clamp **16**. A flexible diaphragm **18** is positioned between the bonnet **12** and the body **14**. The flexible diaphragm **18** is moved between an open configuration, shown in FIG. **1**, and a closed configuration, via an actuator mechanism **20** housed in the bonnet **12**. The valve **10** of FIG. **1** is commonly referred to as a diaphragm valve.

[0023] In general, the body **14** has an input port **22**, an output port **24**, and a central portion **26** positioned between the input port **22** and the output port **24**. In the open configuration of the diaphragm **18** of FIG. **1**, the input port **22** and output port **24** are in fluid communication with each other. That is, fluid is free to flow between the input port **22** and output port **24** in the open configuration.

[0024] In the embodiment of FIG. **1**, the valve **10** has a weir **28** in one side of a passageway **30** extending between input port **22** and the output port **24**. The body **14** has a work opening **32** in a side of the passageway **30** opposite the weir **28**. The diaphragm **18** is sealed between the bonnet **12** and the body **14** and covers the work opening **32**, thereby making the passageway **30** fluid tight. In the open configuration of the diaphragm **18** of FIG. **1**, there is a space between a bottom surface of the diaphragm **18** and a top surface of the weir **28**, and the passageway **30** is open.

[0025] Generally speaking, in the closed configuration of the diaphragm **18** the diaphragm **18** blocks the central portion **26**, thereby preventing fluid flow between the input port **22** and the output port **24**. In the embodiment of FIG. **1**, in the closed configuration of the diaphragm **18**, the bottom surface of the diaphragm **18** contacts the top surface of the weir **28**, closing off the passageway **30**.

[0026] As described in more detail below, the diaphragm **18** has a central portion **70** and a peripheral portion **58** surrounding the central portion **70**. The peripheral portion **58** is adapted to be clamped between the bonnet **12** and the body **14**. The central portion **70** of the diaphragm **18** covers the work opening **32**. In general, the diaphragm **18** is preferably formed from a flexible elastomeric or plastic material. Examples of suitable elastomeric materials include but are not limited to rubber, neoprene, Hycar® (Noveon, Inc., Cleveland, Ohio), chlorobutyl, urethane, silicone, and ethylene propylene. Other suitable plastic materials include polytetrafluoroethylene (PTFE), and others known to those skilled in the art.

[0027] The flexible diaphragm **18** may also include a thin fluoropolymer layer **46** molded to, bonded with, or otherwise covering the central portion **70** of the flexible diaphragm **18**. The thin fluoropolymer layer **46** has a thickness that is small enough so that the thin fluoropolymer layer **46** flexes in conjunction with the central portion **70** of the flexible diaphragm **18**.

[0028] While thin fluoropolymer layer **46** is preferably formed of a polytetrafluoroethylene (PTFE), more commonly known as Teflon®, it may also include alternative fluoropolymers, such as perfluoroalkoxy polymer resin (PFA), fluorinated ethylene-propylene (FEP), and trifluoroethanol (TFE), that can also function to protect fluid flowing through the valve **10** from contamination, especially from leachables in the flexible diaphragm **18**.

[0029] A connector element **33** of the central portion is coupled to the actuator mechanism **20**. While the connector element **33** in the present embodiment is a T-shaped element, the term connector element **33** should be construed to include any element, feature, or location that is adapted to engage the actuator mechanism **20**. In the embodiment of FIG. **1**, the central portion of the diaphragm **18** is dome shaped, and the actuator mechanism **20** includes a compressor **34**. The compressor **34** is connected to one end of a threaded stem **36**, and a handle **38** is connected to an opposite end of the stem **36**. In general, turning the handle **38** turns the threaded stem **36**, and causes the compressor **34** to move up and down within the bonnet **12**, thereby changing a distance between the bottom surface of the diaphragm **18** and the top surface of the weir **28**.

[0030] In general, the bonnet **12** is adapted to house the actuator mechanism **20**, although this should be construed broadly to include instances wherein the actuator mechanism **20** is only partially within the bonnet **12**, or merely mounted adjacent to the bonnet **12**. In the embodiment of FIG. **1**, the bonnet **12** has a flange **40** adapted to receive one side of the peripheral portion of the diaphragm **18**. The body **14** has a flange **42** about the work opening **32** adapted to receive an opposite side of the peripheral portion of the diaphragm **18**. The flanges **40** and **42** are adapted to receive the band clamp **16**, which is preferably annular. The band clamp **16** is adapted to be positioned about the flanges **40** and **42**, and to urge the bonnet **12** and the body **14** toward one another when tightened.

[0031] The annular shape of the band clamp **16**, and the flanges **40** and **42**, provide a uniform compression against the diaphragm **18**, thereby providing an optimum seal. This is an improvement over the prior art, which has generally relied on square flanges **40** and **42**, with fastening mechanisms at the corners, which provide an uneven compressive force.

[0032] When tightened about the flange **40** of the bonnet **12** and the flange **42** of the body **14**, the band clamp **16** attaches the bonnet **12** to the body **14**. Further, the band clamp **16** advantageously generates an evenly distributed force about the outer edges of the flanges **40** and **42** that draws the bonnet **12** and the body **14** toward one another. This action of the band clamp **16** significantly contributes to circumferential sealing between the bonnet **12** and the body **14**.

[0033] In the embodiment of FIG. **1-3**, the peripheral portion of the diaphragm **18** has a substantially rigid ring **44** embedded therein. In general, the ring **44** prevents overcompression of the flexible diaphragm **18**. As described in detail below, the ring **44** arrests movement of the bonnet **12** and the body **14** toward one another when a magnitude of a force urging the bonnet **12** and the body **14** toward one another exceeds a threshold value. The ring **44** also functions to keep the diaphragm **18** in its proper position with

respect to the body **14**, without the through-bolts used in the prior art. While the ring **44** is preferably round, it could also be square or some other shape.

[**0034**] FIG. **2** is a view of a portion of the valve **10** of FIG. **1** illustrating how the peripheral portion of the diaphragm **18** is clamped between the bonnet **12** and the body **14**. As shown in FIG. **2**, the band clamp **16** has a pair of interior contact surfaces **50** and **52**. In general, the flange **40** of the bonnet **12** has an outer edge adapted to contact the interior contact surface **50**, and the flange **42** of the body **14** has an outer edge adapted to contact the interior contact surface **52**. In the embodiment of FIGS. **1** and **2**, the interior contact surfaces **50** and **52** of the band clamp **16** are angled with respect to one another so as to substantially form a "V" shape. The flange **40** of the bonnet **12** has an outer side edge **54** with an angle that is substantially equal to an angle of the corresponding interior contact surface **50** of the band clamp **16**, and the flange **42** of the body **14** has an outer side edge **56** with an angle that is substantially equal to an angle of the corresponding interior contact surface **52** of the band clamp **16**.

[**0035**] In the embodiment of FIGS. **1-3**, the ring **44** is totally encapsulated in the material of the diaphragm **18**. This may be advantageous where a fluid passing through, and having a flow rate controlled by, the valve **10** may react with, or be contaminated by, the material of the ring **44**.

[**0036**] The substantially rigid ring **44** is made of a stainless steel, other suitable metal, or other substantially rigid material, such as acetal or polyetherimide (PEI), although those skilled in the art will recognize that a large range of materials are acceptable, and should be considered within the scope of the invention as claimed.

[**0037**] In FIG. **2**, the peripheral portion of the diaphragm **18** is labeled "**58**." The peripheral portion **58** of the diaphragm **18** is clamped between the flange **40** of the bonnet **12** and flange **42** of the body **14**. The flange **40** of the bonnet **12** has a groove **60** adapted to receive one side of the ring **44**, and the flange **42** of the body **14** has a groove **62** adapted to receive an opposite side of the ring **44**.

[**0038**] In FIG. **2** the groove **60** in the flange **40** of the bonnet **12** and the groove **62** in the flange **42** of the body **14** are adapted to receive the ring **44**. When the bonnet **12** and the body **14** are subjected to a force that urges the bonnet **12** and the body **14** toward one another (e.g., by the band clamp **16**), and a magnitude of the force exceeds a threshold value, movement of the bonnet **12** and the body **14** toward one another is substantially arrested by the ring **44**, thereby preventing further deformation of the peripheral portion **58** of the diaphragm **18**.

[**0039**] The material of the diaphragm **18** covering the ring **44** so as to encapsulate the ring **44** is preferably thin enough that the ability of the ring **44** to limit movement of the bonnet **12** and the body **14** toward one another is not significantly hampered. Further, the groove **60** in the flange **40** of the bonnet **12**, and the groove **62** in the flange **42** of the body **14**, are preferably machined with sufficient precision, and made very smooth, such that the material of the diaphragm covering the ring **44** is not ruptured before the ring **44** limits movement of the bonnet **12** and the body **14** toward one another.

[**0040**] FIG. **3** is a top plan view of the diaphragm **18** of FIGS. **1** and **2**. In FIG. **3** the diaphragm **18** includes a central portion **70** and a peripheral portion **58** surrounding the central portion **70**. The peripheral portion **58** includes the substantially rigid ring **44** extending continuously through or on the peripheral portion **58**. While the ring **44** is preferably embedded within the peripheral portion **58**, in alternative embodiments it could also be mounted on the peripheral portion **58**.

[**0041**] While the invention has been described with reference to at least one preferred embodiment, it is to be clearly understood by those skilled in the art that the invention is not limited thereto. Rather, the scope of the invention is to be interpreted only in conjunction with the appended claims.

What is claimed is:

1. A valve, comprising:

a body having an input port, a central portion, and an output port;

a bonnet;

a flexible diaphragm having a central portion and a peripheral portion surrounding the central portion, wherein the peripheral portion is adapted to be positioned between the bonnet and the body, and wherein the flexible diaphragm is formed from a flexible elastomeric or plastic material;

a substantially rigid ring extending continuously through or on the peripheral portion of the flexible diaphragm;

a fluoropolymer layer molded to, bonded with, or otherwise covering the central portion of the flexible diaphragm;

an actuator mechanism operatively coupled to the diaphragm for moving the diaphragm between an open configuration wherein the input port and output port are in fluid communication with each other, and a closed configuration wherein the diaphragm blocks the central portion and prevents fluid flow between the input port and the output port; and

wherein the bonnet is adapted to house the actuator mechanism.

2. The valve of claim 1, wherein the body comprises a flange positioned about the central portion, and wherein the bonnet comprises a flange, and wherein the flange of the body is adapted to receive one side of the peripheral portion of the diaphragm, and wherein the flange of the bonnet is adapted to receive an opposite side of the peripheral portion of the diaphragm.

3. The valve of claim 2, wherein the flange of the body has a groove adapted to receive one of the two sides of the substantially rigid ring, and wherein the flange of the bonnet has a groove adapted to receive the other of the two sides of the ring.

4. The valve of claim 1, wherein the fluoropolymer layer has a thickness that is small enough such that the thin fluoropolymer layer flexes in conjunction with the flexible diaphragm.

5. A flexible diaphragm for use in a valve, the valve having a body and a bonnet, the flexible diaphragm comprising:

a flexible central portion;

a peripheral portion surrounding the central portion, wherein the flexible diaphragm is formed from a flexible elastomeric or plastic material;

a substantially rigid ring extending continuously through or on the peripheral portion of the flexible diaphragm;

a fluoropolymer layer molded to, bonded with, or otherwise covering the central portion of the flexible diaphragm; and

wherein the flexible diaphragm is adapted to be positioned between the bonnet and the body such that the peripheral portion is clamped between the bonnet and the body.

6. The flexible diaphragm of claim 6, wherein the fluoropolymer layer has a thickness that is small enough such that the fluoropolymer layer flexes in conjunction with the flexible diaphragm.

* * * * *