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DIAPHRAGM VALVE AND VALVE DISK

Abstract

A diaphragm valve including a valve disk suspended by a diaphragm airtightly sealing a valve chamber, and is moved in conjunction with a stem so that an annular seal member is at a valve closing position at which the annular seal member abuts on a valve seat surface or at a valve opening position at which the annular seal member is apart from the valve seat surface. The valve disk includes: a seal retention member including a cylindrical portion and retaining the annular seal member at a position concentric with a retention portion; and an annular cushion member sandwiched between the seal retention member and the annular seal member and retained in an annular accommodation portion at a position concentric with the retention portion. The annular seal member is retained in the annular accommodation portion so that the annular seal member extends more radially outwardly than the annular cushion member.

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Background/Summary

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a diaphragm valve and a valve disk. In particular, the present invention relates to a diaphragm valve and a valve disk, in which the valve disk suspended in a state in which a valve chamber is airtightly sealed is moved to a valve opening and closing position in conjunction with a stem.

Description of the Related Art

[0002] Conventionally, it has been required that opening and closing valves used in the gas supply piping systems of semiconductor manufacturing apparatuses, solar battery manufacturing apparatuses, liquid crystal manufacturing apparatuses, and the like have small dead spaces to suppress generation of particles. Diaphragm valves have been often used as valves meeting such requirements.

[0003] Examples of the diaphragm valves include a diaphragm valve in which a sealing element such as a valve seat is disposed on a valve disk side rather than on a body side. Such a valve disk is moved in conjunction with the movement of a stem.

[0004] For enhancing the airtightness between a valve seat and a valve disk in a valve closing state, such a valve requires improvement in the followability of a sealing element disposed on the valve disk to a valve seat surface and improvement in performance for alignment of the valve disk in a state in which the valve disk is suspended.

[0005] With current demand for high heat resistance, it has become important to maintain airtightness in cases including, for example, use under a high-temperature environment using a control fluid at a high temperature of 300° C. or more.

[0006] Various technologies have been proposed to meet such various demands.

[0007] For example, Japanese Patent Laid-Open No. 62-288786 describes a diaphragm valve including an actuation mechanism enabling a diaphragm and a valve element in cooperation with the diaphragm to be moved between an open position and a closed position without allowing the diaphragm and the valve element to receive a twisting load.

[0008] When closure movement of the diaphragm valve described in Japanese Patent Laid-Open No. 62-288786 proceeds, a compressive force exerted between a valve seat region and the sealing surface 167 of an elastic seal ring 160 is increased. A force between the valve seat region and the corner 156 of a rigid ring 152 is also increased. However, the degree of the increase is low. The reason thereof is because a ring 158 with low rigidity and still more elasticity still more easily receives a compressive force to move the rigid ring 152 backward toward a main portion 78 and the elastic seal ring 160 to a certain degree. This action enables the rigid ring 152 to continuously come into contact with the valve seat region while increasing a sealing pressure between the surface 167 and the valve seat region. A compressive force exerted in the elasticity seal ring 160 allows a downward force to be continuously exerted on a sleeve 166 by a flange 168. When the valve is finally closed, the lower edge of the sleeve 166 is brought into line contact with the valve seat region and the circumference of the elastic seal ring 160.

[0009] Japanese Utility Model Laid-Open No. 4-117971 describes a bellows seal valve in which a valve disk 9 suspended by a bellows 12 is moved to a valve opening and closing position in conjunction with a valve shaft 10 (corresponding to a stem), as a valve using a suspended valve disk rather than as a diaphragm valve.

[0010] In the bellows seal valve, the valve disk 9 supported on the valve shaft 10 that can axially reciprocate includes a sheet metal 14 that can abut on an annular valve seat 8 protruded from the wall of a valve chamber 4, and a blank 15 is disposed behind the sheet metal 14. A cushion member

16 is accommodated together with a support member 17 in the blank 15.
[0011] Like Japanese Utility Model Laid-Open No. 4-117971, Japanese Utility Model Laid-Open No. 61-168375 describes a bellows valve in which a valve disk 14 suspended by a bellows 13b is moved to a valve opening and closing position in conjunction with a spindle 16 (corresponding to a stem).
[0012] In the bellows valve, packing 30 is sandwiched between the bottom surface 14a of the valve disk 14 and the bottom surface 20a of a disk 20.

BRIEF SUMMARY OF THE INVENTION

[0013] However, the diaphragm valve described in Japanese Patent Laid-Open No. 62-288786 has had a problem that the elastic seal ring 160 which is a principal sealing element for securing the airtightness between a valve seat and a valve disk in a valve closing state is sandwiched and tightened between the rigid ring 152 and the sleeve 166, and therefore, it is difficult to sufficiently exhibit original cushioning properties, and, as a result, it is difficult to enhance airtightness.
[0014] The bellows seal valve described in Japanese Utility Model Laid-Open No. 4-117971 has had a problem that a mechanism 18 for alignment is disposed in the valve disk 9 to perform alignment, and therefore, the valve disk 9 has a complicated configuration.
[0015] In the bellows valve described in Japanese Utility Model Laid-Open No. 61-168375, the packing 30 is merely sandwiched to axially overlap with the bottom surface 14a of the valve disk 14 and the bottom surface 20a of the disk 20, a specific configuration in which the packing 30 is retained at a position concentric with the axis is not disclosed, and therefore, it is impossible to expect a function of alignment by the valve disk 14. Moreover, projections 23 and 24 protruded to the backside of the bottom surface 20a of the disk 20 are brought into press contact with the bottom surface 14a of the valve disk 14 from below to seal the surface, and therefore, it is difficult to sufficiently exhibit the cushioning properties of the packing 30.
[0016] Therefore, the bellows valve described in Japanese Utility Model Laid-Open No. 61-168375 has had a problem that it is difficult to enhance airtightness.
[0017] The present invention is developed to solve the conventional problems. An objective of the present invention is to provide a diaphragm valve and a valve disk, having simple configurations, and enabling enhancement of airtightness while having an alignment function, even under an environment at wide temperatures.
[0018] In order to achieve the objective described above, the invention according to claim **1** is a diaphragm valve including a valve disk that is suspended by a diaphragm airtightly sealing a valve chamber, includes a retention portion retaining an annular seal member in an annular accommodation portion, and is moved in conjunction with a stem so that the annular seal member is at a valve closing position at which the annular seal member abuts on a valve seat or at a valve opening position at which the annular seal member is apart from the valve seat, wherein the valve disk includes: a seal retention member including a cylindrical portion mating a cylindrical inner surface with an inner peripheral surface of the annular accommodation portion, and retaining the annular seal member at a position concentric with the retention portion; and an annular cushion member that is sandwiched between a surface, facing a bottom surface of the annular accommodation portion, of the seal retention member and the annular seal member, and the bottom surface, includes an inner peripheral surface mated with an inner peripheral surface of the annular accommodation portion, and is retained in the annular accommodation portion at a position concentric with the retention portion, and the annular seal member is retained in the annular accommodation portion in a state in which the annular seal member extends more radially outwardly than the annular cushion member, and a gap is formed between a surface of the annular seal member, facing the bottom surface of the annular accommodation portion, and the bottom surface.
[0019] The invention according to claim **2** is the diaphragm valve, wherein the annular cushion member includes a material of which a cushioning property is higher than that of the annular seal

member.
[0020] The invention according to claim **3** is the diaphragm valve, wherein the sheet retention member includes a collar portion radially outwardly protruded in a collar shape on an end of the cylindrical portion, and a stage-shaped abutment surface abutting in a stage shape on an outer peripheral surface of the cylindrical portion including the collar portion is formed on the annular seal member.
[0021] The invention according to claim **4** is the diaphragm valve, wherein a recess in which the annular cushion member is placed is formed on the annular seal member so that the surface, facing the bottom surface of the annular accommodation portion, of the annular seal member, is provided with a peripheral side slightly separated from an outer peripheral surface of the annular cushion member, and the gap is formed between the bottom surface of the annular accommodation portion and a surface of the annular seal member that is more radially outwardly than the recess.
[0022] The invention according to claim **5** is the diaphragm valve, wherein the annular seal member includes a polyimide resin, and the annular cushion member includes a perfluoroalkoxy alkane resin.
[0023] The invention according to claim **6** is a valve disk that is suspended by a diaphragm airtightly sealing a valve chamber, includes a retention portion retaining an annular seal member in an annular accommodation portion, and is moved in conjunction with a stem so that the annular seal member is at a valve closing position at which the annular seal member abuts on a valve seat surface or at a valve opening position at which the annular seal member is apart from the valve seat surface, wherein the valve disk includes: a seal retention member including a cylindrical portion mating a cylindrical inner surface with an inner peripheral surface of the annular accommodation portion, and retaining the annular seal member at a position concentric with the retention portion; and an annular cushion member that is sandwiched between a surface, facing a bottom surface of the annular accommodation portion, of the seal retention member and the annular seal member, and the bottom surface, includes an inner peripheral surface mated with an inner peripheral surface of the annular accommodation portion, and is retained in the annular accommodation portion at a position concentric with the retention portion.
[0024] In accordance with the invention according to claim **1**, the valve disk includes: the seal retention member including the cylindrical portion mating the cylindrical inner surface with the inner peripheral surface of the annular accommodation portion, and retaining the annular seal member at the position concentric with the retention portion; and the annular cushion member that is sandwiched between the surface, facing the bottom surface of the annular accommodation portion, of the seal retention member and the annular seal member, and the bottom surface, includes the inner peripheral surface mated with the inner peripheral surface of the annular accommodation portion, and is retained in the annular accommodation portion at the position concentric with the retention portion, and the annular seal member is retained in the annular accommodation portion in a state in which the annular seal member extends more radially outwardly than the annular cushion member, and the gap is formed between the surface of the annular seal member, facing the bottom surface of the annular accommodation portion, and the bottom surface.
[0025] As a result, due to a simple configuration in which the annular cushion member mated with the inner peripheral surface of the annular accommodation portion, and retained at the position concentric with the retention portion on the bottom surface side of the annular accommodation portion, and the gap between the annular seal member in the outer-diameter region of the annular cushion member and the bottom surface of the annular accommodation portion are disposed, in the case of compressing the annular cushion member toward the bottom surface of the annular accommodation portion, the annular seal member abutting on the valve seat is compressed together with the annular cushion member toward the bottom surface while effectively exhibiting the cushioning property of the annular cushion member with the use of the gap between the annular

seal member and the annular accommodation portion, and is deformed for alignment with the use of the gap.

[0026] The annular cushion member is positioned on the bottom surface side of the annular accommodation portion, and is prevented from coming into contact with a control fluid by the seal retention member and the annular seal member. Therefore, the deterioration of the cushioning property due to the influence of temperature can be prevented, and a material with a high cushioning property can be used in the annular cushion member even if the heat resistance of the material is lower than that of the annular seal member.

[0027] Therefore, in accordance with the invention according to claim **1**, performance for alignment can be improved while keeping airtightness in a simple configuration even under an environment at wide temperatures.

[0028] In accordance with the invention according to claim **2**, the annular cushion member includes the material of which the cushioning property is higher than that of the annular seal member. Therefore, the followability of the annular seal member to the valve seat surface is enhanced with the use of the cushioning property of the annular cushion member, and, as a result, airtightness can be enhanced.

[0029] In accordance with the invention according to claim **3**, the seal retention member includes the collar portion radially outwardly protruded in the collar shape on the end of the cylindrical portion, and the stage-shaped abutment surface abutting in the stage shape on the outer peripheral surface of the cylindrical portion including the collar portion is formed on the annular seal member. Therefore, in a case in which the annular seal member abuts on the valve seat and is compressed, the entry of a control fluid through the stage-shaped abutment portion between the seal retention member and the annular seal member is prevented even if the annular seal member is relatively moved in the axis direction with respect to the seal retention member, and therefore, the control fluid can be prevented from entering the gap between the annular seal member and the bottom surface of the annular accommodation portion.

[0030] In accordance with the invention according to claim **4**, the recess in which the annular cushion member is placed is formed on the annular seal member so that the surface, facing the bottom surface of the annular accommodation portion, of the annular seal member, is provided with the peripheral side slightly separated from the outer peripheral surface of the annular cushion member, and the gap is formed between the bottom surface of the annular accommodation portion and the surface of the annular seal member that is more radially outwardly than the recess. Therefore, such a minimum gap that the annular cushion member can exert cushion performance can be disposed, and, as a result, the minimum gap that enables airtightness to be enhanced can be disposed.

[0031] In accordance with the invention according to claim **5**, the annular seal member includes a polyimide, and the annular cushion member includes a perfluoroalkoxy alkane resin. Therefore, performance for alignment can be improved while keeping airtightness in a simple configuration even in use under an environment at 300° C. or more because the annular cushion member including a perfluoroalkoxy alkane resin of which the cushioning property is higher than that of the polyimide resin although the perfluoroalkoxy alkane resin has resistance to heat at less than 300° C. is used in a portion that does not come into contact with a control fluid while the annular seal member including a polyimide resin having resistance to heat at 300° C. or more is used in a portion that comes into contact with a control fluid.

[0032] In accordance with the invention according to claim **6**, the valve disk includes: the seal retention member including the cylindrical portion mating the cylindrical inner surface with the inner peripheral surface of the annular accommodation portion, and retaining the annular seal member at the position concentric with the retention portion; and the annular cushion member that is sandwiched between the surface, facing the bottom surface of the annular accommodation portion, of the seal retention member and the annular seal member, and the bottom surface,

includes the inner peripheral surface mated with the inner peripheral surface of the annular accommodation portion, and is retained in the annular accommodation portion at the position concentric with the retention portion, and the annular seal member is retained in the annular accommodation portion in a state in which the annular seal member extends more radially outwardly than the annular cushion member, and the gap is formed between the surface of the annular seal member, facing the bottom surface of the annular accommodation portion, and the bottom surface.

[0033] As a result, due to a simple configuration in which the annular cushion member mated with the cylindrical portion of the seal retention member, and retained at the position concentric with the retention portion on the bottom surface side of the annular accommodation portion, and the gap between the annular seal member in the outer-diameter region of the annular cushion member and the bottom surface of the annular accommodation portion are disposed, in the case of compressing the annular cushion member toward the bottom surface of the annular accommodation portion, the annular seal member abutting on the valve seat is compressed together with the annular cushion member toward the bottom surface while effectively exhibiting the cushioning property of the annular cushion member with the use of the gap between the annular seal member and the annular accommodation portion, and is deformed for alignment with the use of the gap.

[0034] The annular cushion member is positioned on the bottom surface side of the annular accommodation portion, and is prevented from coming into contact with a control fluid by the seal retention member and the annular seal member. Therefore, the deterioration of the cushioning property due to the influence of temperature can be prevented, and a material with a high cushioning property can be used in the annular cushion member even if the heat resistance of the material is lower than that of the annular seal member.

[0035] Therefore, in accordance with the invention according to claim **6**, performance for alignment can be improved while keeping airtightness in a simple configuration even under an environment at wide temperatures.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] FIG. **1** is a cross-sectional view illustrating the schematic configuration of a diaphragm valve according to an embodiment in a valve opening state;

[0037] FIG. **2** is a cross-sectional view illustrating the schematic configuration of the diaphragm valve according to the embodiment in a valve closing state;

[0038] FIG. **3**A is an enlarged view of the valve disk of the diaphragm valve illustrated in FIG. **1**;

[0039] FIG. **3**B is an enlarged view of a further enlarged portion in the vicinity of the annular accommodation portion of a retention portion illustrated in FIG. **3**A;

[0040] FIG. **4** is an exploded perspective view of the valve disk;

[0041] FIG. **5** is a perspective view of an annular seal member viewed from a surface facing the bottom surface of the annular accommodation portion;

[0042] FIG. **6** is a perspective view of a seal retention member viewed from a surface facing the bottom surface of the annular accommodation portion;

[0043] FIG. **7** is a view for explaining the operation of each member disposed in the retention portion of the valve disk in the valve closing operation of the diaphragm valve; and

[0044] FIG. **8** is a cross-sectional view of the valve disk of a diaphragm valve of which the configuration is different from that of the diaphragm valve according to the embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0045] An embodiment of a diaphragm valve **1** according to the present invention is described in detail below with reference to FIGS. **1** to **7**.

[0046] The present disclosure is not limited by the embodiment described below. It is necessary to note that the drawings are schematic, and the relationship of the dimension of each element, the proportion of each element, and the like may be different from reality. In the interrelationship among the drawings, the drawings may include portions of which the relationships of the dimensions, and the proportions are different from each other.

[0047] FIG. **1** is a cross-sectional view illustrating the schematic configuration of the diaphragm valve **1** according to the embodiment in a valve opening state. FIG. **2** is a cross-sectional view illustrating the schematic configuration of the diaphragm valve **1** according to the embodiment in a valve closing state. FIG. **3**A is an enlarged view of the valve disk **10** of the diaphragm valve **1** illustrated in FIG. **1**. FIG. **3**B is an enlarged view of a further enlarged portion in the vicinity of the annular accommodation portion **21** of a retention portion **20** illustrated in FIG. **3**A. FIG. **4** is an exploded perspective view of the valve disk **10**. FIG. **5** is a perspective view of an annular seal member **30** viewed from a surface facing the bottom surface **21***c* of the annular accommodation portion **21**. FIG. **6** is a perspective view of a seal retention member **40** viewed from a surface facing the bottom surface **21***c* of the annular accommodation portion **21**. FIG. **7** is a view for explaining the operation of each member disposed in the retention portion **20** of the valve disk in the valve closing operation of the diaphragm valve **1**.

[0048] The diaphragm valve **1** according to the embodiment of the present invention is used, for example, under an environment at 300° C. or more. The diaphragm valve **1** can also be used in any place other than high-temperature environments. For example, the diaphragm valve **1** can be used not only under a normal-temperature environment but also under a low-temperature environment.

[0049] The diaphragm valve **1** includes the valve disk **10**, a body **60**, and an actuator **70** that is assembled above the body **60**.

Valve Disk **10**

[0050] The valve disk **10** is suspended by a diaphragm **78** airtightly sealing a valve chamber **61***e*, includes the retention portion **20** retaining the annular seal member **30**, and is moved in conjunction with a stem **76** so that the annular seal member **30** is at a valve closing position at which the annular seal member **30** abuts on a valve seat surface **61**d or at a valve opening position at which the annular seal member **30** is apart from the valve seat surface **61***d*.

[0051] The valve disk **10** includes the retention portion **20**, the annular seal member **30**, the seal retention member **40**, and an annular cushion member **50**, as illustrated in FIGS. **3** and **4**.

Retention Portion **20** of Valve Disk **10**

[0052] The retention portion **20** includes a metallic material such as, for example, a stainless steel material, and includes the annular accommodation portion **21** that retains the annular seal member **30** and is annular.

[0053] In the annular accommodation portion **21**, an opening **21***a* is formed in a side facing the valve seat surface **61***d*, and a cylindrical portion **22** that forms the inner peripheral surface **21***b* of the annular accommodation portion **21** is disposed in the center.

[0054] An outer peripheral surface which is the inner peripheral surface **21***b* of the annular accommodation portion **21** is mated with the cylindrical inner surface **41***b* of the seal retention member **40** and the inner peripheral surface **50***b* of the annular cushion member **50**, whereby the cylindrical portion **22** functions as a portion that retains the seal retention member **40** and the annular cushion member **50** in the annular accommodation portion **21** in a state in which the seal retention member **40** and the annular cushion member **50** are located at positions concentric with the retention portion **20**.

Annular Seal Member **30** of Valve Disk **10**

[0055] In this embodiment, the annular seal member **30** includes a polyimide resin with high heat resistance, and is retained in the annular accommodation portion **21** in a state in which the annular seal member **30** extends more radially outwardly than the annular cushion member **50**, and a gap **23** is formed between the surface of the annular seal member **30**, facing the bottom surface **21***c* of

the annular accommodation portion **21**, and the bottom surface **21***c*.
[0056] The annular seal member **30** is retained in the annular accommodation portion **21** by the seal retention member **40** in a state in which the annular seal member **30** is located at a position concentric with the retention portion **20**, as described above.
[0057] A recess **31** in which the annular cushion member **50** is placed is formed on the annular seal member **30** so that the surface, facing the bottom surface **21***c* of the annular accommodation portion **21**, of the annular seal member **30**, is provided with a peripheral side **31***a* slightly separated from the outer peripheral surface **50***a* of the annular cushion member **50**, as illustrated in FIGS. **3**B and **5**.
[0058] The gap **23** is formed between the bottom surface **21***c* of the annular accommodation portion **21** and a surface of the annular seal member **30** that is more radially outwardly than the recess **31** of the annular seal member **30**.
[0059] The width of the gap **23** is adjusted so that the cushioning property of the annular cushion member **50** is effectively exhibited, and the annular seal member **30** can be deformed for alignment, when the annular seal member **30** abuts on the valve seat surface **61***d* and is compressed because the valve disk **10** is moved to the valve closing position.
[0060] The bottom surface **31***b* of the recess **31** is provided with an annular projection **31***c* that is brought into press contact with the surface of the annular cushion member **50**.
[0061] The annular projection **31***c* is a portion that increases the degree of adhesion between the annular seal member **30** and the annular cushion member **50** in a region that is more radially inwardly located than a region in which the gap **23** is formed, so that the route of the entry of a control fluid into the gap **23** described above is interrupted.
[0062] A stage-shaped abutment surface **32** abutting in a stage shape on the outer peripheral surface **41***a* of a cylindrical portion **41** including the collar portion **42**, described later, of the seal retention member **40** is formed on the annular seal member **30**, as illustrated in FIG. **3**B.
[0063] The stage-shaped abutment surface **32** includes: a first abutment surface **32***a* that abuts on the outer peripheral surface **41***a* of the collar portion **42**; a second abutment surface **32***b* that abuts on a surface of the collar portion **42**, facing the bottom surface **21***c* of the annular accommodation portion **21**; and a third abutment surface **32***c* that abuts on an outer peripheral surface of an end, facing the bottom surface **21***c* of the annular accommodation portion **21** of the seal retention member **40**.
[0064] The first abutment surface **32***a* and the third abutment surface **32***c* are the inner peripheral surfaces of the annular seal member **30**, described as surfaces that abut on the outer peripheral surface **41***a* of the seal retention member **40** when the annular seal member **30** is placed at a position concentric with the retention portion **20** by the seal retention member **40**.
[0065] When the valve disk **10** is at the valve opening position, that is, when the annular seal member **30** is in an elastically neutral state in which the annular seal member **30** is not compressed, the annular seal member **30** is in a state in which the three first to third abutment surfaces **32***a*, **32***b*, and **32***c* abut on the corresponding surfaces of the seal retention member **40**, respectively.
[0066] The outer peripheral surface **30***b* of the annular seal member **30** is disposed at a slant so that the outer diameter of the annular seal member **30** is enlarged from the vicinity of the valve seat surface **61***d* toward the bottom surface **21***c* of the annular accommodation portion **21**.
[0067] As a result, the outer peripheral surface **30***b* of the annular seal member **30** is brought into intimate contact with the outer peripheral surface **21***d* of the annular accommodation portion **21** in the vicinity of the bottom surface **21***c* of the annular accommodation portion **21** while reducing the area of the annular seal member **30**, coming into contact with the annular accommodation portion **21**, to a small area.
[0068] Therefore, a control fluid is reliably prevented from entering the gap **23** through between the outer peripheral surface **30***b* of the annular seal member **30** and the outer peripheral surface **21***d* of the annular accommodation portion **21**.

Seal Retention Member **40** of Valve Disk **10**

[0069] The seal retention member **40** includes a metal material such as, for example, a stainless steel material, includes the cylindrical portion **41** mating the cylindrical inner surface **41***b* with the inner peripheral surface **21***b* of the annular accommodation portion **21**, and retains the annular seal member **30** at the position concentric with the retention portion **20**.

[0070] The seal retention member **40** includes the collar portion **42** radially outwardly protruded in a collar shape on the end of the cylindrical portion **41**, and abuts on the stage-shaped abutment surface **32** of the annular seal member **30**.

[0071] The inner peripheral surfaces **32***a* and **32***c* are mated with the outer peripheral surface **41***a* of the cylindrical portion **41**, whereby the annular seal member **30** is retained at a position concentric with the retention portion **20** in the annular accommodation portion **21**.

[0072] The seal retention member **40** is prevented from abutting on the valve seat surface **61***d* by adjusting the seal retention member **40** so that the surface facing the valve seat surface **61***d* is at a position that is lower than the position of the valve seat abutment surface **30***a* of the annular seal member **30**, facing the valve seat surface **61***d*.

Annular Cushion Member **50** of Valve Disk **10**

[0073] The annular cushion member **50** is an annular sheet member having a cushioning property. In this embodiment, the annular cushion member **50** includes a perfluoroalkoxy alkane resin. In other words, in this embodiment, a material of which the cushioning property is higher than that of the annular seal member **30** is used as the annular cushion member **50**.

[0074] In the present embodiment, the cushioning property is a property having followability allowing an object to flexibly follow the shape of another object with which the object comes into contact, and to be deformed, and elasticity allowing the object to be restored from a state in which the object is compressed and deformed.

[0075] The high cushioning property refers to a property having high followability while having elasticity allowing an object to be restored from a state in which the object is compressed and deformed.

[0076] The annular cushion member **50** is sandwiched between the surface, facing the bottom surface **21***c* of the annular accommodation portion **21**, of the seal retention member **40** and the annular seal member **30**, and the bottom surface **21***c* of the annular accommodation portion **21**, includes the inner peripheral surface **50***b* mated with the inner peripheral surface **21***b* of the annular accommodation portion **21**, and is retained in the annular accommodation portion **21** at the position concentric with the retention portion **20**.

[0077] A material of which the cushioning property is equivalent to that of the annular seal member **30** may be used as the annular cushion member **50** as long as the material has the cushioning property. The reason thereof is because the annular cushion member **50** is placed at a position at which the annular cushion member **50** does not come into direct contact with a control fluid having a high temperature, and therefore, the deterioration of the cushioning property can be prevented even under environments at wide temperatures, including a high-temperature environment.

Body **60**

[0078] The body **60** includes a metallic material, and is provided integrally with: a main body **61** in which a flow path for a gas as a control fluid is formed; and a linkage portion **62** that is linked to the actuator **70**.

[0079] The main body **61** is provided with a primary side flow path **61***a* as a gas inflow side and a secondary side flow path **61***b* as a gas outflow side so that a valve seat **61***c* including the flat valve seat surface **61***d* with and from which the annular seal member **30** of the valve disk **10** is contacted and separated is between the primary side flow path **61***a* and the secondary side flow path **61***b*.

[0080] The linkage portion **62** is cylindrically protruded from the main body **61** and disposed at a position above the valve seat **61***c* assembled with the actuator **70**. An annular stage **62***a* seated in a state in which a bonnet **77** sandwiches the outer peripheral edge of the diaphragm **78** is formed on

the inner peripheral surface of the linkage portion **62**.

[0081] Linkage members **65** and **66** are allowed to exist between the linkage portion **62** and the actuator **70**, whereby the linkage portion **62** links the main body **61** and the actuator **70** to each other.

Actuator **70**

[0082] The actuator **70** moves the stem **76** to a valve opening and closing position in an up-and-down manner. In the actuator **70**, an elevator mechanism **71** that moves the stem **76** in an up-and-down manner, and a mechanism **80** for pulling-up and alignment, having a function of pulling up the valve disk **10** in conjunction with the operation of the rising of the stem **76** at the time of opening the valve and a function of aligning the valve disk **10** at the time of closing the valve are disposed in a case **70***a*.

Elevator Mechanism **71** of Actuator **70**

[0083] The elevator mechanism **71** includes: a bellows **72** that is provided with a bellows flange **72***a* in an lower end, internally receives air introduced from an air introduction coupling **70***b*, and includes a metallic material; a plurality of cams **73** that are provided with rollers **73***a* and **73***b* in both ends and are pivoted on the inner wall of the case **70***a*; and a spring **75** that applies a force for moving the stem **76** to the valve closing position in a lower area through a retainer **74**.

[0084] In each cam **73**, the roller **73***a* in one end is placed abuttably on the outer peripheral edge of the bellows flange **72***a*, and the roller **73***b* in the other end is placed in a groove formed in an annular shape on the upper outer peripheral surface of the stem **76**. The plurality of such cams **73** are dispersedly placed around the outer periphery of the stem **76**.

Mechanism **80** for Pulling-Up and Alignment, of Actuator **70**

[0085] The mechanism **80** for pulling-up and alignment includes a diaphragm piece **90** and a linkage member **100**.

[0086] The configuration of the mechanism **80** for pulling-up and alignment includes a lower end recess **76***a* disposed in the lower end of the stem **76**.

Diaphragm Piece **90** of Mechanism **80** for Pulling-Up and Alignment

[0087] The diaphragm piece **90** is linked to the valve disk **10**, and is ascendably and descendably retained by the bonnet **77**. The outer peripheral edge of the diaphragm **78** is sandwiched between the bonnet **77** and the body **60**. The inner circumferential edge of the diaphragm **78** is sandwiched between the diaphragm piece **90** and the retention portion **20** of the valve disk **10**.

[0088] The diaphragm piece **90** is provided with an upper end recess **91** which has a cylindrical, bottomed shape, in which the lower end of the linkage member **100** is placed in a loose-fit state, and of which the upper end is opened.

[0089] The shape of the diaphragm may be, for example, a wave shape or a dome shape.

[0090] In the present embodiment, a spacer **93** is placed on the bottom surface **91***a* of the upper end recess **91** of the diaphragm piece **90**, and the upper surface **93***a* of this spacer **93** forms the bottom surface **91***a* of the upper end recess **91**.

[0091] Therefore, the state of the bottom surface of the upper end recess **91** abutting on the linkage member **100** can be adjusted as appropriate, for example, by adjusting the shape, material, hardness, surface state, thickness, and number of such spacers **93**.

[0092] The planar state of the bottom surface of the upper end recess **91** can be adjusted to a state suitable for alignment, for example, by allowing the upper surface **93***a* of the spacer **93** to be a flat surface, or adjusting surface roughness.

[0093] The material of the spacer **93** can be adjusted to a state suitable for alignment by allowing the material of the spacer **93** to be different from that of the linkage member **100** to preclude the galling of the linkage member **100**.

[0094] A state in which the linkage member **100** and the bottom surface **91***a* of the upper end recess **91** abut on each other across the spacer **93** can be adjusted to a state suitable for alignment by adjusting the thickness or number of such spacers **93**.

[0095] A male screw portion **92** that is engaged threadedly to the retention portion **20** of the valve disk **10** through a through-hole formed in the center of the diaphragm **78** is disposed in the lower end of the diaphragm piece **90**, and the inner circumferential edge of the diaphragm **78** is sandwiched between the bottom surface of the diaphragm piece **90** around the base end of the male screw portion **92** and the upper end surface of the retention portion **20**.

Linkage Member **100** of Mechanism **80** for Pulling-Up and Alignment

[0096] The outer shell of the linkage member **100** has a generally columnar shape. In the linkage member **100**, a linkage through-hole **102***a* is formed in a direction generally perpendicular to an axis direction. The linkage member **100** is linked to the diaphragm piece **90** via a linkage pin **103** inserted through the linkage through-hole **102***a*, and is linked to the stem **76** via a stage to be locked **101***a*, which is locked at a locking stage **76***b* disposed on the lower end recess **76***a* of the stem **76**.

[0097] In the linkage member **100**, an annular recess **100***a* is formed on the outer peripheral surface of the linkage member **100**, whereby a head **101** is formed in the upper portion of the linkage member **100**, and a trunk **102** having a columnar shape is formed in the lower portion of the linkage member **100**, below the annular recess **100***a*.

[0098] The head **101** is placed in a loose-fit state in the lower end recess **76***a* of the stem **76** so that the lower surface of the head **101** is the surface to be locked **101***b* of the stage to be locked **101***a*, which is locked at the locking stage **76***b* disposed on the lower end recess **76***a* of the stem **76**.

[0099] The linkage through-hole **102***a* described above is formed in the trunk **102**. The trunk **102** is placed in a loose-fit state in the upper end recess **91** of the diaphragm piece **90** by the linkage pin **103** inserted into the linkage through-hole **102***a* through an unillustrated through-hole formed in the upper end recess **91** of the diaphragm piece **90**.

[0100] The linkage through-hole **102***a* has a long-hole shape in which the direction of elevating the stem **76** is a longitudinal direction. More specifically, a backlash in which the linkage member **100** can be moved downward so that the lower end surface of the linkage member **100** abuts on the bottom surface of the upper end recess **91** of the diaphragm piece **90**, that is, the upper surface of the spacer **93** when the stem **76** is moved down for closing the valve is disposed by setting the dimension of the linkage through-hole **102***a* in the longitudinal direction at a larger dimension than the diameter of the linkage pin **103**.

Valve Opening and Closing Operation of Diaphragm Valve **1**

[0101] The valve opening and closing operation of the diaphragm valve **1** is described below with reference to FIGS. **1**, **2**, and **7**.

[0102] First, the valve opening operation of the diaphragm valve **1** is described. The bellows **72** expands to bring the lower surface of the bellows flange **72***a* disposed in the lower portion of the bellows **72** and the roller **73***a* in one end of each cam **73** to come into contact with each other when air is supplied into the bellows **72** through the air introduction coupling **70***b* in the case of changing the diaphragm valve **1** from a valve closing state (see FIG. **2**) to a valve opening state (see FIG. **1**).

[0103] Then, the cam **73** rotates so that the other end is inclined upward. The roller **73***b* in the other end lifts stem **76**, whereby the stem **76** is moved upward.

[0104] When the stem **76** is moved upward, the locking stage **76***b* of the lower end recess **76***a* of the stem **76** abuts on the surface to be locked **101***b* of the linkage member **100** to pull up the linkage member **100**, and the lower hole inner edge surface of the linkage through-hole **102***a* of the linkage member **100** abuts on the linkage pin **103** to lift the diaphragm piece **90**, whereby the diaphragm piece **90** is moved upward.

[0105] When the diaphragm piece **90** is moved upward, the valve disk **10** linked to the diaphragm piece **90** is moved upward to achieve the valve opening state in which the annular seal member **30** is apart from the valve seat surface **61***d*.

[0106] In such a case, the diaphragm **78** is elastically restored in a state in which the periphery of the inner circumferential edge sandwiched between the diaphragm piece **90** and the retention

portion **20** of the valve disk **10** is pulled upward and swells.
[0107] Moreover, the annular seal member **30** that abuts on the valve seat surface **61***d* and is compressed and the annular cushion member **50** that is compressed through the annular seal member **30** are elastically restored.
[0108] Next, the valve closing operation of the diaphragm valve **1** is described.
[0109] When the diaphragm valve **1** is changed from the above-described valve opening state to the valve closing state, supply of air into the bellows **72** through the air introduction coupling **70***b* is stopped, the retainer **74** is pushed down by the elastic force of the spring **75**, and the stem **76** locked at the retainer **74** is moved down.
[0110] When the stem **76** is moved down, the bottom surface of the lower end recess **76***a* of the stem **76** abuts on the arc-shaped curved surface **102***c* of the upper end surface of the linkage member **100** to push down the linkage member **100**. Thus, the arc-shaped curved surface **102***c* of the lower end surface of the linkage member **100** abuts on the upper surface of the spacer **93** to push down the diaphragm piece **90**.
[0111] The diaphragm piece **90** is pushed down in such a manner, whereby the valve disk **10** linked to the diaphragm piece **90** is moved down to achieve the valve closing state in which the annular seal member **30** abuts on the valve seat surface **61***d*.
[0112] When the annular seal member **30** is moved down in such a manner, the downward movement of the stem **76** allows the linkage member **100** to abut on both the bottom surfaces of the lower end recess **76***a* of the stem and the upper end recess **91** of the diaphragm piece **90** to transfer the force of the stem **76** in the axis direction to the diaphragm piece **90**.
[0113] This is because the linkage member **100** is placed in a loose-fit state on each of the lower end recess **76***a* of the stem **76** and the upper end recess **91** of the diaphragm piece **90**, the bottom surface of the lower end recess **76***a* of the stem **76** abuts on an upper end surface **101**c forming the arc-shaped curved surface of the linkage member **100**, and the bottom surface of the upper end recess **91** of the diaphragm piece **90**, more specifically, the upper surface of the spacer **93** abuts on the lower end surface **102***c* forming the arc-shaped curved surface of the linkage member **100**, regardless of the posture of the diaphragm piece **90**.
[0114] Therefore, the diaphragm piece **90** is aligned, and the annular seal member **30** abuts on the valve seat surface **61***d* in a state in which the valve disk **10** is aligned, even in a case in which the diaphragm piece **90** wobbles toward the bonnet **77**, whereby the diaphragm piece **90** inclines with respect to the axis of the stem **76**, whereby the valve disk **10** linked to the diaphragm piece **90** inclines.
[0115] When the annular seal member **30** abuts on the valve seat surface **61***d* in such a manner, and then, the valve disk **10** is further moved down in conjunction with the stem **76**, the annular seal member **30** is compressed by a reaction force received from the valve seat surface **61***d*, and the annular cushion member **50** overlapping with the annular seal member **30** on the bottom surface side of the annular accommodation portion **21** is compressed, as illustrated in FIG. **7**.
[0116] The annular cushion member **50** is elastically compressed and deformed while flexibly following the annular seal member **30** when the annular cushion member **50** is pressed by the annular seal member **30**. In other words, the annular cushion member **50** is compressed and deformed in a state in which the annular cushion member **50** comes into intimate contact with the annular seal member **30**, and in a state in which the annular cushion member **50** is pressed by the bottom surface **21***c* of the annular accommodation portion **21**, without generation of a gap between the annular cushion member **50** and the annular seal member **30**.
[0117] Therefore, the annular seal member **30** coming into contact with the valve seat surface **61***d* further adds the cushioning property of the annular cushion member **50** to the cushioning property of the annular seal member **30** in itself to enhance cushion performance, and is deformed to follow the valve seat surface **61***d*.
[0118] The disposition of the above-described gap **23** enables the cushioning property of the

annular cushion member **50** to be effectively utilized in a period from the abutment of the annular seal member **30** on the valve seat surface **61***d* to the abutment of the annular seal member **30** on the bottom surface **21***c* of the annular accommodation portion **21** while compressing the annular seal member **30**.

[0119] Moreover, the annular seal member **30** is deformed to align the valve disk **10** with the use of the gap **23**.

[0120] In other words, in this embodiment, performance for alignment is further enhanced in the valve disk **10** together with the mechanism **80** for pulling-up and alignment that is disposed independently of the valve disk **10**.

[0121] A gap **24** is generated between the annular seal member **30** and the seal retention member **40**, as illustrated in FIG. **7**, when the annular seal member **30** and the annular cushion member **50** are compressed by a reaction force received by the annular seal member **30** from the valve seat surface **61***d*. However, except that the gap **24** is formed, the stage-shaped abutment surface **32** of the annular seal member **30** swells toward the corresponding surface of the seal retention member **40**, whereby the stage-shaped abutment surface **32** further comes into intimate contact with the corresponding surface of the seal retention member **40**. Therefore, a control fluid can be prevented from entering the gap.

Effects of Embodiment

[0122] As described above, in accordance with the diaphragm valve **1** according to the embodiment, the valve disk **10** includes: the seal retention member **40** including the cylindrical portion **41** mating the cylindrical inner surface **41***b* with the inner peripheral surface **21***b* of the annular accommodation portion **21**, and retaining the annular seal member **30** at the position concentric with the retention portion **20**; and the annular cushion member **50** that is sandwiched between the surface, facing the bottom surface **21***c* of the annular accommodation portion **21**, of the seal retention member **40** and the annular seal member **30**, and the bottom surface **21***c* of the annular accommodation portion **21**, includes the inner peripheral surface **50***b* mated with the inner peripheral surface **21***b* of the annular accommodation portion **21**, and is retained in the annular accommodation portion **21** at the position concentric with the retention portion **20**, and the annular seal member **30** is retained in the annular accommodation portion **21** in a state in which the annular seal member **30** extends more radially outwardly than the annular cushion member **50**, and the gap **23** is formed between the surface of the annular seal member **30**, facing the bottom surface **21***c* of the annular accommodation portion **21**, and the bottom surface **21***c* of the annular accommodation portion **21**.

[0123] As a result, due to a simple configuration in which the annular cushion member **50** mated with the inner peripheral surface **21***b* of the annular accommodation portion **21**, and retained at the position concentric with the retention portion **20** in the vicinity of the bottom surface **21***c* of the annular accommodation portion **21**, and the gap **23** between the annular seal member **30** in the outer-diameter region of the annular cushion member **50** and the bottom surface **21***c* of the annular accommodation portion **21** are disposed, in the case of compressing the annular cushion member **50** toward the bottom surface **21***c* of the annular accommodation portion **21**, the annular seal member **30** abutting on the valve seat surface **61***d* is compressed together with the annular cushion member **50** toward the bottom surface **21***c* while effectively exhibiting the cushioning property of the annular cushion member **50** with the use of the gap **23** between the annular seal member **30** and the annular accommodation portion **21**, and is deformed for alignment with the use of the gap **23**.

[0124] The annular cushion member **50** is positioned in the vicinity of the bottom surface **21***c* of the annular accommodation portion **21**, and is prevented from coming into contact with a control fluid by the seal retention member **40** and the annular seal member **30**. Therefore, the deterioration of the cushioning property due to the influence of temperature can be prevented, and a material with a high cushioning property can be used in the annular cushion member **50** even if the heat resistance of the material is lower than that of the annular seal member **30**.

[0125] Therefore, in accordance with the diaphragm valve **1** according to the embodiment, performance for alignment can be improved while keeping airtightness in a simple configuration even under environments at wide temperatures, including a high-temperature environment.
[0126] In accordance with the diaphragm valve **1** according to the embodiment, the valve disk **10** is aligned with the further use of the function of alignment of the valve disk **10** in itself, while aligning the valve disk **10** by the mechanism **80** for pulling-up and alignment that is disposed independently of the valve disk **10**. Therefore, performance for alignment can be improved, and, in particular, performance for alignment for a large-sized valve difficult to align can also be improved.
[0127] In accordance with the diaphragm valve **1** according to the embodiment, the annular cushion member **50** includes the material of which the cushioning property is higher than that of the annular seal member **30**. Therefore, the followability of the annular seal member **30** to the valve seat surface **61***d* is enhanced with the use of the cushioning property of the annular cushion member **50**, and, as a result, airtightness can be enhanced.
[0128] In accordance with the diaphragm valve **1** according to the embodiment, the seal retention member **40** includes the collar portion **42** radially outwardly protruded in the collar shape on the end of the cylindrical portion **41**, and the stage-shaped abutment surface **32** abutting in the stage shape on the outer peripheral surface **41***a* of the cylindrical portion **41** including the collar portion **42** is formed on the annular seal member **30**. Therefore, in a case in which the annular seal member **30** abuts on the valve seat **61***c* and is compressed, the entry of a control fluid through the stage-shaped abutment portion between the seal retention member **40** and the annular seal member **30** is prevented even if the annular seal member **30** is relatively moved in the axis direction with respect to the seal retention member **40**, and therefore, the control fluid can be prevented from entering the gap **23** between the annular seal member **30** and the bottom surface **21***c* of the annular accommodation portion **21**.
[0129] In accordance with the diaphragm valve **1** according to the embodiment, the recess **31** in which the annular cushion member **50** is placed is formed on the annular seal member **30** so that the surface, facing the bottom surface **21***c* of the annular accommodation portion **21**, of the annular seal member **30**, is provided with the peripheral side **31***a* slightly separated from the outer peripheral surface **50***a* of the annular cushion member **50**, and the gap **23** is formed between the bottom surface **21***c* of the annular accommodation portion **21** and the surface of the annular seal member **30** that is more radially outwardly than the recess **31**. Therefore, such a minimum gap **23** that the annular cushion member **50** can exert cushion performance can be disposed, and, as a result, the minimum gap **23** that enables airtightness to be enhanced can be disposed.
[0130] In accordance with the diaphragm valve **1** according to the embodiment, the annular seal member **30** includes polyimide, and the annular cushion member **50** includes a perfluoroalkoxy alkane resin. Therefore, performance for alignment can be improved while keeping airtightness in a simple configuration even in use under an environment at 300° C. or more because the annular cushion member **50** including a perfluoroalkoxy alkane resin of which the cushioning property is higher than that of the polyimide resin although the perfluoroalkoxy alkane resin has resistance to heat at less than 300° C. is used in a portion that does not come into contact with a control fluid while the annular seal member **30** including a polyimide resin having resistance to heat at 300° C. or more is used in a portion that comes into contact with a control fluid.
[0131] In accordance with the valve disk **10** according to the embodiment, the valve disk **10** includes: the seal retention member **40** including the cylindrical portion **41** mating the cylindrical inner surface **41***b* with the inner peripheral surface **21***b* of the annular accommodation portion **21**, and retaining the annular seal member **30** at the position concentric with the retention portion **20**; and the annular cushion member **50** that is sandwiched between the surface, facing the bottom surface of the annular accommodation portion **21**, of the seal retention member **40** and the annular seal member **30**, and the bottom surface **21***c* of the annular accommodation portion **21**, includes the inner peripheral surface **50***b* mated with the inner peripheral surface **21***b* of the annular

accommodation portion **21**, and is retained in the annular accommodation portion **21** at the position concentric with the retention portion **20**, and the annular seal member **30** is retained in the annular accommodation portion **21** in a state in which the annular seal member **30** extends more radially outwardly than the annular cushion member **50**, and the gap **23** is formed between the surface of the annular seal member **30**, facing the bottom surface **21***c* of the annular accommodation portion **21**, and the bottom surface **21***c* of the annular accommodation portion **21**.

[0132] As a result, due to a simple configuration in which the annular cushion member **50** mated with the cylindrical portion **41** of the seal retention member **40**, and retained at the position concentric with the retention portion **20** in the vicinity of the bottom surface **21***c* of the annular accommodation portion **21**, and the gap **23** between the annular seal member **30** in the outer-diameter region of the annular cushion member **50** and the bottom surface **21***c* of the annular accommodation portion **21** are disposed, in the case of compressing the annular cushion member **50** toward the bottom surface **21***c* of the annular accommodation portion **21**, the annular seal member **30** abutting on the valve seat surface **61***d* is compressed together with the annular cushion member **50** toward the bottom surface **21***c* of the annular accommodation portion **21** while effectively exhibiting the cushioning property of the annular cushion member **50** with the use of the gap **23** between the annular seal member **30** and the annular accommodation portion **21**, and is deformed for alignment with the use of the gap **23**.

[0133] The annular cushion member **50** is positioned in the vicinity of the bottom surface **21***c* of the annular accommodation portion **21**, and is prevented from coming into contact with a control fluid by the seal retention member **40** and the annular seal member **30**. Therefore, the deterioration of the cushioning property due to the influence of temperature can be prevented, and a material with a high cushioning property can be used in the annular cushion member **50** even if the heat resistance of the material is lower than that of the annular seal member **30**.

[0134] The embodiment of the present disclosure is described above. However, the present disclosure is not limited to the embodiment described above but can be subjected to various modifications without departing from the gist of the present disclosure.

[0135] For example, an example in which the annular seal member **30** includes a polyimide resin, and the annular cushion member **50** includes a perfluoroalkoxy alkane resin is described in the embodiment described above. However, materials included in the annular seal member **30** and the annular cushion member **50** are not limited to the resins. Other materials may be used in the annular seal member **30** and the annular cushion member **50** as long as the annular seal member **30** is a sealant, and the annular cushion member **50** is a member with a cushioning property.

[0136] In the embodiment described above, an example in which the mechanism **80** for pulling-up and alignment is disposed is described. However, it is also acceptable that the mechanism **80** for pulling-up and alignment is not disposed but alignment is performed only using the function of alignment of the valve disk **10**. In other words, in the diaphragm valve **1**, the valve disk **10** may be linked to the stem **76** without the intervention of the mechanism **80** for pulling-up and alignment.

[0137] The present inventors conducted a high-temperature endurance test on a diaphragm valve of which the configuration of the valve disk is different from the configuration of the valve disk of the diaphragm valve **1** of the embodiment described above.

[0138] FIG. **8** is a cross-sectional view of a valve disk **210** used in a diaphragm valve of which the configuration is different from that of the diaphragm valve according to the embodiment.

[0139] In the diaphragm valve, the valve disk **210** includes an annular cushion member **250** that is sandwiched between a surface, facing the bottom surface **221***c* of an annular accommodation portion **221**, of an annular seal member **230**, and the bottom surface **221***c* of the annular accommodation portion **221**, includes an inner peripheral surface **250***b* mated with the inner peripheral surface **221***b* of the annular accommodation portion **221**, and is retained in the annular accommodation portion **221** at a position concentric with a retention portion **220**.

[0140] In the diaphragm valve, the retention portion **220** includes a caulking portion **220***a*, and the

annular seal member **230** is retained in the annular accommodation portion **221** by the caulking portion **220***a*.
[0141] The test conditions of the high-temperature endurance test are described below. [0142] Test conditions: [0143] Annular seal member: polyimide resin [0144] Annular cushion member: perfluoroalkoxy alkane resin
[0145] The opening and closing operation of a valve is performed 200000 times under an environment at a temperature of 300° C.
[0146] As the results of the high-temperature endurance test, the diaphragm valve had no problem in a case in which the number of times of opening and closing was 100000, but contact between the annular seal member **230** and the caulking portion **220***a* caused particles to be generated in a case in which the number of times of opening and closing was 200000.
[0147] In contrast, in the diaphragm valve **1** of the present embodiment, the retention portion **20** is not provided with the caulking portion **220***a*, the annular seal member **30** is retained by the seal retention member **40** which is a member different from the retention portion **20**, and therefore, the diaphragm valve **1** is also effective at preventing generation of particles.
[0148] Moreover, the outer peripheral surface **30***b* of the annular seal member **30** is disposed at a slant so that the outer diameter of the annular seal member **30** is enlarged from the vicinity of the valve seat surface **61***d* toward the bottom surface **21***c* of the annular accommodation portion **21**, and the contact area between the annular seal member **30** and the annular accommodation portion **21** is reduced to a small area. Therefore, the annular seal member **30** can be effectively prevented from coming into contact with the annular accommodation portion **21** and resulting in generation of particles.
[0149] Moreover, a slight gap **25** (see FIG. **3**B) is formed in the vicinity of the opening **21***a* of the annular accommodation portion **21** between the outer peripheral surface **30***b* and the outer peripheral surface **21***d* of the annular accommodation portion **21** by disposing the outer peripheral surface **30***b* of the annular seal member **30** at a slant. Therefore, deformation for alignment can be further facilitated with the use of the gap **25** when the annular seal member **30** is aligned with the use of the gap **23**.
[0150] Each embodiment disclosed herein should be considered to be exemplary in every respect, and not to be limiting. The embodiments described above may be omitted, substituted, or modified in various forms without departing from the appended claims and the gist of the claims.

Claims

1. A diaphragm valve comprising a valve disk that is suspended by a diaphragm airtightly sealing a valve chamber, comprises a retention portion retaining an annular seal member in an annular accommodation portion, and is moved in conjunction with a stem so that the annular seal member is at a valve closing position at which the annular seal member abuts on a valve seat surface or at a valve opening position at which the annular seal member is apart from the valve seat surface, wherein the valve disk comprises: a seal retention member comprising a cylindrical portion mating a cylindrical inner surface with an inner peripheral surface of the annular accommodation portion, and retaining the annular seal member at a position concentric with the retention portion; and an annular cushion member that is sandwiched between a surface, facing a bottom surface of the annular accommodation portion, of the seal retention member and the annular seal member, and the bottom surface, comprises an inner peripheral surface mated with an inner peripheral surface of the annular accommodation portion, and is retained in the annular accommodation portion at a position concentric with the retention portion, and the annular seal member is retained in the annular accommodation portion in a state in which the annular seal member extends more radially outwardly than the annular cushion member, and a gap is formed between a surface of the annular seal member, facing the bottom surface of the annular accommodation portion, and the bottom

surface.

2. The diaphragm valve according to claim 1, wherein the annular cushion member comprises a material of which a cushioning property is higher than that of the annular seal member.

3. The diaphragm valve according to claim 1, wherein the seal retention member comprises a collar portion radially outwardly protruded in a collar shape on an end of the cylindrical portion, and a stage-shaped abutment surface abutting in a stage shape on an outer peripheral surface of the cylindrical portion comprising the collar portion is formed on the annular seal member.

4. The diaphragm valve according to claim 1, wherein a recess in which the annular cushion member is placed is formed on the annular seal member so that the surface, facing the bottom surface of the annular accommodation portion, of the annular seal member, is provided with a peripheral side slightly separated from an outer peripheral surface of the annular cushion member, and the gap is formed between the bottom surface of the annular accommodation portion and a surface of the annular seal member that is more radially outwardly than the recess.

5. The diaphragm valve according to according to claim 1, wherein the annular seal member comprises a polyimide resin, and the annular cushion member comprises a perfluoroalkoxy alkane resin.

6. A valve disk that is suspended by a diaphragm airtightly sealing a valve chamber, comprises a retention portion retaining an annular seal member in an annular accommodation portion, and is moved in conjunction with a stem so that the annular seal member is at a valve closing position at which the annular seal member abuts on a valve seat surface or at a valve opening position at which the annular seal member is apart from the valve seat surface, wherein the valve disk comprises: a seal retention member comprising a cylindrical portion mating a cylindrical inner surface with an inner peripheral surface of the annular accommodation portion, and retaining the annular seal member at a position concentric with the retention portion; and an annular cushion member that is sandwiched between a surface, facing a bottom surface of the annular accommodation portion, of the seal retention member and the annular seal member, and the bottom surface, comprises an inner peripheral surface mated with an inner peripheral surface of the annular accommodation portion, and is retained in the annular accommodation portion at a position concentric with the retention portion.