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(54) A BUTTERFLY VALVE

(71) We, TOMOE TECHNICAL RESEARCH COMPANY, a joint-stock company duly organised and existing under the laws of Japan, of 2-91-1 Honjyo-Naka, Higashi-Osaka-Shi-Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

The present invention relates to a butterfly valve and is particularly concerned with a butterfly valve body, and a valve seat with which a valve closure member in the valve body is intended to make a seal.

Prior proposals concerned with the field of the invention are directed to a butterfly valve of a type in which a disc-like valve closure member is rotatable in the valve passage between an open and closed position. When in the closed position, the valve closure member engages a valve seat with which it cooperates to provide a seal against leakage of the fluid in the pressurized line intended to be controlled by the valve. It is essential in valves of this type that the seal should be effective on each occasion of valve closing for the life of the valve to continuously provide positive shut off of the fluid without frequent maintenance and servicing of the seat.

According to the present invention there is provided a butterfly valve comprising a ringlike valve body consisting of first and second segmental portions together defining a passage through the body which a disc-like valve closure member is adapted to close, the closure member including valve stem means rotatably supported in the valve body; an annular valve seat on the inner peripheral surface of the valve body in the passage for engagement by the outer periphery of the valve closure member, and including diametrically opposed valve stem-receiving openings therein in each of which is disposed an annular sealing assembly through which the valve stem means extends in sealing manner;

and wherein the valve body has an annular projection at the inner peripheral surface thereof disposed substantially centrally of the length of the passage, and the valve seat comprises a first layer the outer peripheral surface of which includes an annular groove in which the annular projection of the valve body is received, a second layer adhered to the first layer and overlying the inner peripheral surface and each side surface of the first layer, and a third layer adhered to the second layer and overlying the inner peripheral surface and each side surface of the second layer.

By the present invention it is possible to ensure that the valve seat is tightly engaged with the inner peripheral surface of the valve body.

Preferably the first layer is formed from a hard synthetic resin, the second layer from a resilient material, and the third layer from fluororesin, so that the valve seat has a degree of resistance to corrosive fluid in the passage. Further the effect of temperature changes in the valve seat may be alleviated by such a construction. The three layers may be integrated such as by moulding the second layer between the first and third layers. The second layer of the valve seat may be formed so that its barrel or central portion overlying the inner peripheral surface of the first layer is thick compared to the side portions overlying the side surfaces of the first layer, and preferably the first layer has a substantially uniform thickness, the barrel portion of the second layer is more than twice as thick as its side portions and the third layer is formed as a thin film which is adhered to the inner peripheral surface and the two side surfaces of the second layer.

The third layer may extend to define the valve stem-receiving openings and preferably respective annular projections are provided on the opening-defining third layer, each of said annular projections, in their unstressed state, causing the valve stem-receiving openings to have an inner

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diameter slightly smaller than the diameter of said valve stem means.

5 The central portion of the inner peripheral surface of the valve seat may project inwardly so as to provide a convex contour thereon, whereby the inner diameter of the valve seat corresponding to said convex portion is smaller in its unstressed state than the diameter of the valve closure member, whereby there is
10 tight sealing engagement between the valve seat and the valve closure member in the closed position of the latter.

15 Each sealing assembly may comprise a rubber ring having a resilient property and seal ring means disposed nearer to the valve closure member than the rubber ring. The seal ring means may comprise an O-ring or at least one ring of V-shaped cross-section and may be made of fluororesin.
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25 The valve closure member may be made of a synthetic resin and may include a cylindrical member of metal inserted therein in which the valve stem means is located. Such cylindrical member and the valve stem means may have correspondingly splined surfaces.

30 Preferably, the length of the valve seat (along the length of the passage) is slightly greater than that of the valve body whereby, when the valve body is fixedly mounted in a conduit, the valve seat provides a seal between the valve body and the opposed conduit ends.

35 Various embodiments of a butterfly valve in accordance with the present invention will be described below by way of example only, with reference to the appended drawings, in which:

40 Figure 1 is a longitudinal cross-section of the butterfly valve showing a valve closure member in a position where a flowway passing through a valve seat is closed;

45 Figure 2 is an explanatory view, partly broken away to show interior construction, of a valve body, the valve seat and the valve closure member of the valve of Figure 1 removed from between the end faces of tubular flange members, the valve closure member being shown in an open position;

50 Figure 3 is a fragmentary cross-sectional view of the valve body, the valve seat and a sealing assembly of the valve of Figure 1 with the valve stem and the valve closure member removed, and taken along the central line of the valve stem;

55 Figure 4 is an enlarged sectional view similar to Figure 2, but showing the valve seat modified in the area of a valve stem-receiving opening;

60 Figure 5 is a cross-sectional view of the valve seat of the embodiments shown in Figures 1 to 3 or 4;

Figure 6 is a sectional view of a further modified embodiment of the valve seat and a portion of the valve closure member;

Figure 7 is a partially cutaway view in perspective of a modified embodiment of the valve closure member.

Figure 8 is a front view of the butterfly valve shown in Figure 1 with the valve closure member in position where the flow way passing through the valve seat is closed; and

Figure 9 is an enlarged sectional view of a portion of a modified valve seat of the butterfly valve provided also with a modified sealing assembly.

With reference to the embodiment of a butterfly valve 10 shown generally in Figures 1 and 2, it comprises a valve body 11, a valve seat 12, a valve stem 13, a valve closure member 14 and sealing assemblies 15 and is disposed between two tubular flange members 16, to control the fluid flow by opening and closing a flowway 17.

The valve body 11, which is formed from metal such as ductile cast iron, to withstand the internal pressure and anticorrosive properties of the fluid, is provided substantially centrally of the inner peripheral surface thereof defining the passage therethrough with an annular projection 21, as shown in Figure 1 and Figure 3. As best seen in Figure 2, the valve body 11 comprises two halves, which are held together by bolts 20. The numeral 22 designates a neck of the valve body. The valve stem 13 is disposed on a straight line that connects the center of the neck 22 with that of the valve body 11, extending through the valve seat 12 and the valve body 11. Located between the valve stem 13 and the valve body 11 are stem guides 23 and 24, for rotatably supporting the valve stem 13, which are made of fluororesin or a similar material.

The valve seat 12, as best seen in Figure 3 comprises a first layer 27, a second layer 28 and a third layer 29 and is shaped like a ring as a whole. The general center portion of the outer peripheral surface of the first layer 27 is formed into an annular groove 30 for receiving the projection 21 of the valve body 11, whereby the first layer conforms to the inner peripheral surface of the valve body 11. The first layer 27, which is made of hard synthetic resin, such as phenolic resin, melamine resin or the like, has a uniform thickness and embraces the projection 21 of the valve body 11.

The second layer 28 of the valve seat 12 is adhered to the inner peripheral surface of the first layer 27, its barrel portion 28a contacting the inner peripheral surface of the first layer being more than twice as thick as its side peripheral portions 28b contacting the two side surfaces of the first

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layer. The second layer is preferably formed so that the thickness of its side peripheral portions 28b is about 1/10 of that of its barrel portion 28a. That is to say, the side peripheral portions 28b are preferably formed thin, thereby permitting an effective sealing between the butterfly valve and the tubular flange members. The second layer 28 is made of a resilient material, such as synthetic rubber or plastics material having superior impact, resilient and durable properties.

The third layer 29 comprises a thin film made of fluororesin such as polyfluoroethylenic resin. The third layer, having uniform thickness, is adhered to the inner and side peripheral surfaces of the second layer 28, and extends to define the valve receiving openings 31 of the valve seat 12 through which the valve stem 13 is passed. The opening-defining parts 29a, 29b of the third layer are formed integrally with other parts of the same, the portions of the openings 31 defined by the parts 29b of the third layer having a greater cross-sectional area than those portions defined by the parts 29a and having one of the sealing assemblies 15 located in each such portion. The inner diameter of the portion defined by a respective part 29a is determined so as to provide a close fit of the valve stem.

Figure 4 shows a modified embodiment of the opening-defining parts 29a and 29b of the third layer, in which the part 29a is provided with an annular projection 29c to effect sealing more completely between the valve stem and the valve seat, while the part 29b is extended outwardly of the passage 17 to contact the first layer for easy insertion of the sealing assembly 15 and the stem guide 23.

The valve seat 12, which can be tightly fixed in the interior of the metal valve body 11, since the outer peripheral surface of the seat 12 conforms to the inner peripheral surface of the valve body 11 with the projection 21 of the body 11 fitted in the groove 30, is longer (dimension in the longitudinal direction of the passage 17) than the valve body 11, thereby slightly protruding beyond the latter, so that when the butterfly valve 10 is inserted between the tubular flange members 16 and is bolted therebetween, the seat 12 is pressed by the distance corresponding to said protrusion by means of the tubular flange members 16 whereby both sides 34 of the valve seat 12 and the tubular flange members are brought into close contact with each other due to the resiliency of the material of the second layer 28. Therefore, a seal between the butterfly valve and the tubular flange members can be provided without the need for a gasket for piping.

Figure 5 shows a sectional view of the

valve seat 12 taken substantially along a plane passing through the center of the valve member but not along the axis of the valve stem. The valve seat 12 comprises three layers, the second layer 28 of which is produced for example by way of vulcanization molding in such a manner that unvulcanized resilient material is preheated to be softened, and then injected between the coaxially disposed and preformed first and third layers 27 and 29 to be heated. The first, second and third layers of the valve seat 12 thus produced are tightly contacted with one another in a mould by effecting vulcanization of resilient material of the second layer, as well as by means of adhesives. Further, the first layer is provided with a plurality of radially extending injecting holes, through which said resilient material is injected.

The inner peripheral surface of the cylindrical valve seat 12 shown in Figures 1, 3, and 5 provides a seat face for the valve closure member 14. The engagement of a valve seat having a smooth inner peripheral surface with the valve closure member makes it possible to provide a seal. However, a more effective seal can be achieved by providing an inwardly convex contour on the inner peripheral surface of the valve seat 12, as shown in Figure 6.

Referring to Figure 6, the valve seat 12 is not of uniform inner diameter, but a central portion 32 of the inner peripheral surface thereof projects inwardly and thus has a smaller diameter than the side portions 33. The central portion 32 of convex section meets each of the side portions 33 by way of a gradual slope and the edge of each side portion 33 is rounded, said edges leading to respective side surfaces 34.

The smallest inner diameter of the valve seat 12 shown in Figure 6 is smaller than the diameter of the valve closure member 14 when unstressed by the member 14, whereby when the valve closure member 14 is in the closed position, the convex portion 32 of the valve seat is resiliently pressing against the peripheral edge of the valve closure member, so that fluid is prevented from flowing therethrough. When the valve closure member is closed, the valve seat is deformed at the boundaries between the convex portion 32 and each of the side portions 33, and any deformation is not produced in the valve seat which might otherwise prevent sealing between the valve seat and other parts. A further advantage of the above-described structure of the valve seat 12 is that seat deformation, i.e., deformation which is produced in the side portions 33 of the third layer (Figure 6) when the seat 12 is inserted between the tubular flange members 16 and pressed thereby, can be moderated by the provision

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of said gradual slope of the side portions 33.

As best seen in Figures 1 and 2, the butterfly valve is provided with two sealing assemblies 15 into which the valve stem 13 is fitted to form a seal. Each of the sealing assemblies 15 (Figures 3 and 4) comprises an O-ring 36 made of fluoro-resin and a rubber ring 37. The rubber ring 37, which is disposed outside the O-ring 36, i.e., nearer to the valve body 11, is pressed inwardly by means of the stem guide 23. The O-ring 36 is pressed inwardly by the rubber ring 37 located thereon, thereby forming the seal between the valve seat 12 and the valve stem 13. The rubber ring 37 is interposed between the O-ring 36 and the stem guide 23 to prevent the O-ring 36 from being damaged by the stem guide.

The provision of the sealing assemblies 15 allows a seal between the valve seat 12 and the valve stem 13 to be effective and complete. In other words, the simple structure of the sealing assemblies is such as to provide an effective seal against leakage of the fluid.

Referring to Figure 9, which shows a modified embodiment of the sealing assembly, a sealing assembly 51 comprises four rings 52 each of V-shaped cross-section and a rubber ring 53, which are disposed within the valve stem-receiving opening defined by the third layer 29. Each of the rings 52, which may be formed from a resilient material similar to that of the rubber ring, has an annular generally V-shaped groove 54 which has a flat base. It is sufficient to provide only one said rings 52, and the or each ring 52 is urged by the rubber ring 53, so that it deforms radially outwardly (relative thereto) as well as radially inwardly, thereby providing a seal against leakage of the fluid between the valve stem and the valve seat.

The valve stem 13 rotatably supported by the valve body 11 and the valve seat 12 comprises (Figure 2) a first short stem 13a, which is guided by means of the stem guide 23, and a second short stem 13b, which is guided by the stem guide 24. One end of the first short stem 13a protrudes outwardly beyond the valve body 11, and is either keyed as at 26 in Figure 1, or suitably shaped so as to receive a handle (not shown) or the like. The valve stem 13 may be formed integrally with the valve closure member or as a one-piece shaft that extends therethrough.

The first short stem 13a and the second short stem 13b shown in Figure 2 are so constructed that their opposed ends are squared-off, and inserted in the valve closure member 14 to extend diametrically thereof.

The valve closure member 14 is disc-like, as best seen in Figure 2, and is provided

with cylindrical portions 39 through which the short stems 13a, 13b are inserted respectively. The valve closure member 14 is so formed that it becomes thinner toward its periphery and its peripheral edge is of substantially convergent form as shown in Figure 6. This peripheral edge 40 is formed convergent by chamfering the same from either side. Alternatively, the valve closure member may be molded using a metal mold adapted to form the peripheral edge 40 in a convergent form with a round top.

Referring to Figure 2, the numeral 41 designates a press plate (urging downwardly) the upper sealing assembly 15 and the stem guide 23, which is secured to the neck 22 of the valve body 11 by means of a plurality of bolts 42. A bottom cover 43, which is adapted to urge upwardly the lower sealing assembly 15 and the stem guide 24 from the lower portion of the valve, is secured to the valve body 11 by means of a plurality of bolts 44, thereby preventing dislodgement of the second short stem 13b.

Referring to Figure 7 showing a modified embodiment 61 of the valve closure member which is provided with a diametrically formed cylindrical portion 62 through which is passed the valve stem comprising a one-piece shaft. In the interior of the cylindrical portion 62 is contained and fixed a cylindrical member 63 of metal, the inner peripheral surface of which is provided with splines 64 of a desired length. The valve stem 13 having preformed splines (not shown) for engaging the splines 64 is inserted into the cylindrical member 63 of the valve closure member 61, so that both sets of splines are engaged with each other, thereby permitting the valve stem 13 and the valve closure member 61 to be tightly secured to each other.

The valve closure member is formed from synthetic resin, such as fluoro-resin or the like and is therefore useful especially when a valve closure member of metal cannot be used because of corrosive fluid in the passage 17. The cylindrical metal member 63 serves to reinforce the valve closure member.

At the ends of the cylindrical portion 62 of the valve closure member 61 intersecting the peripheral edge 68 thereof, there are provided flat portions 69 extending perpendicular to the valve stem 13. Further, part of the peripheral edge 68 adjacent to each of the ends of the cylindrical portion 62 are formed in planes or lobes 70 extending from the flat portions 69. The formation of these planes 70 permits other parts of the peripheral edge to be chamfered in a convergent form without any damage to the flat portions 69. The flat portions 69 are

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adapted to closely contact with flat parts (not shown) of the valve seat 12 so as to seal against leakage of the fluid from between the valve closure member and the valve seat, even if the valve closure member is rotated. Leakage might otherwise occur if a notch or the like is accidentally formed on the flat portions 69 when the latter are chamfered but by providing the planes 70 an effective sealing area between the valve seat and the valve closure member is provided. This structure of the valve closure member 61 may be applied to the valve member 14.

The butterfly valve 10 is fixed between the tubular flange members 16 by means of a plurality of bolts 45. The butterfly valve 10 is clamped by means of the tubular flange members 16 thereby permitting the valve 10 to be fixed sufficiently. However, the valve 10 is apt to rotate axially and to prevent this, two fixing sections 47 having bolt-inserting holes 46 are provided at the upper and lower portions of the valve body 11 respectively, and a plurality of recesses 48 (Figure 8) for receiving the bolts 45 are formed at intervals in the outer peripheral surface of the valve body 11. The numeral 49 seen in Figure 2 designates hook holes for hanging the valve body, which are disposed at either side of the upper portion of the valve body. The butterfly valve 10 shown in Figures 2 and 8 is secured to the tubular flange members with sixteen bolts. The number of bolts is not limited to sixteen, of course, and the butterfly valve can be mounted not only on the tubular flange members, but it may be mounted directly onto other devices.

WHAT WE CLAIM IS:—

1. A butterfly valve comprising a ring-like valve body consisting of first and second segmental portions together defining a passage through the body which a disc-like valve closure member is adapted to close, the closure member including valve stem means rotatably supported in the valve body; an annular valve seat on the inner peripheral surface of the valve body in the passage for engagement by the outer periphery of the valve closure member, and including diametrically opposed valve stem-receiving openings therein in each of which is disposed an annular sealing assembly through which the valve stem means extends in sealing manner; and wherein the valve body has an annular projection at the inner peripheral surface thereof disposed substantially centrally of the length of the passage, and the valve seat comprises a first layer the outer peripheral surface of which includes an annular groove in which the annular projection of the valve body is received, a second layer

adhered to the first layer and overlying the inner peripheral surface and each side surface of the first layer, and a third layer adhered to the second layer and overlying the inner peripheral surface and each side surface of the second layer.

2. A butterfly valve as claimed in Claim 1, wherein said first layer of said valve seat is formed from hard synthetic resin, said second layer from resilient material, and said third layer from fluoro-resin, said second layer of resilient material being integrated between said first and third layers.

3. A butterfly valve as claimed in Claim 1 or Claim 2, wherein said first layer embracing the annular projection of the valve body is formed so as to have a substantially uniform thickness, wherein the barrel portion of the said second layer contacting the inner peripheral surface of said first layer is more than twice as thick as its side peripheral portions contacting the two side surfaces of said first layer, and wherein said third layer is formed from a thin film and adhered to the inner peripheral surface and the two side surfaces of said second layer.

4. A butterfly valve as claimed in any one of the preceding claims, wherein said third layer of said valve seat extends to define said valve stem-receiving openings through which said valve stem means extends, so that respective annular projections are provided on the opening-defining third layer, each of said annular projections, in their unstressed state, causing the valve stem-receiving openings to have an inner diameter slightly smaller than the diameter of said valve stem means.

5. A butterfly valve as claimed in any one of the preceding claims, wherein the central portion of the inner peripheral surface of the valve seat projects inwardly so as to provide a convex contour thereon, whereby the inner diameter of the valve seat corresponding to said convex portion is smaller in its unstressed state than the diameter of the valve closure member.

6. A butterfly valve as claimed in any one of the preceding claims, wherein each of said sealing assemblies comprises a rubber ring having a resilient property and seal ring means disposed nearer to the valve closure member than said rubber ring.

7. A butterfly valve as claimed in Claim 6, wherein said seal ring means of each sealing assembly is an O-ring made of fluoro-resin.

8. A butterfly valve as claimed in Claim 6, wherein said seal ring means comprises at least one ring of V-shaped cross-section.

9. A butterfly valve as claimed in any one of the preceding claims, wherein the valve closure member is made of synthetic resin and includes a cylindrical member of metal

adapted to closely contact with flat parts (not shown) of the valve seat 12 so as to seal against leakage of the fluid from between the valve closure member and the valve seat, even if the valve closure member is rotated. Leakage might otherwise occur if a notch or the like is accidentally formed on the flat portions 69 when the latter are chamfered but by providing the planes 70 an effective sealing area between the valve seat and the valve closure member is provided. This structure of the valve closure member 61 may be applied to the valve member 14.

The butterfly valve 10 is fixed between the tubular flange members 16 by means of a plurality of bolts 45. The butterfly valve 10 is clamped by means of the tubular flange members 16 thereby permitting the valve 10 to be fixed sufficiently. However, the valve 10 is apt to rotate axially and to prevent this, two fixing sections 47 having bolt-inserting holes 46 are provided at the upper and lower portions of the valve body 11 respectively, and a plurality of recesses 48 (Figure 8) for receiving the bolts 45 are formed at intervals in the outer peripheral surface of the valve body 11. The numeral 49 seen in Figure 2 designates hook holes for hanging the valve body, which are disposed at either side of the upper portion of the valve body. The butterfly valve 10 shown in Figures 2 and 8 is secured to the tubular flange members with sixteen bolts. The number of bolts is not limited to sixteen, of course, and the butterfly valve can be mounted not only on the tubular flange members, but it may be mounted directly onto other devices.

WHAT WE CLAIM IS:—

1. A butterfly valve comprising a ring-like valve body consisting of first and second segmental portions together defining a passage through the body which a disc-like valve closure member is adapted to close, the closure member including valve stem means rotatably supported in the valve body; an annular valve seat on the inner peripheral surface of the valve body in the passage for engagement by the outer periphery of the valve closure member, and including diametrically opposed valve stem-receiving openings therein in each of which is disposed an annular sealing assembly through which the valve stem means extends in sealing manner; and wherein the valve body has an annular projection at the inner peripheral surface thereof disposed substantially centrally of the length of the passage, and the valve seat comprises a first layer the outer peripheral surface of which includes an annular groove in which the annular projection of the valve body is received, a second layer

adhered to the first layer and overlying the inner peripheral surface and each side surface of the first layer, and a third layer adhered to the second layer and overlying the inner peripheral surface and each side surface of the second layer.

2. A butterfly valve as claimed in Claim 1, wherein said first layer of said valve seat is formed from hard synthetic resin, said second layer from resilient material, and said third layer from fluororesin, said second layer of resilient material being integrated between said first and third layers.

3. A butterfly valve as claimed in Claim 1 or Claim 2, wherein said first layer embracing the annular projection of the valve body is formed so as to have a substantially uniform thickness, wherein the barrel portion of the said second layer contacting the inner peripheral surface of said first layer is more than twice as thick as its side peripheral portions contacting the two side surfaces of said first layer, and wherein said third layer is formed from a thin film and adhered to the inner peripheral surface and the two side surfaces of said second layer.

4. A butterfly valve as claimed in any one of the preceding claims, wherein said third layer of said valve seat extends to define said valve stem-receiving openings through which said valve stem means extends, so that respective annular projections are provided on the opening-defining third layer, each of said annular projections, in their unstressed state, causing the valve stem-receiving openings to have an inner diameter slightly smaller than the diameter of said valve stem means.

5. A butterfly valve as claimed in any one of the preceding claims, wherein the central portion of the inner peripheral surface of the valve seat projects inwardly so as to provide a convex contour thereon, whereby the inner diameter of the valve seat corresponding to said convex portion is smaller in its unstressed state than the diameter of the valve closure member.

6. A butterfly valve as claimed in any one of the preceding claims, wherein each of said sealing assemblies comprises a rubber ring having a resilient property and seal ring means disposed nearer to the valve closure member than said rubber ring.

7. A butterfly valve as claimed in Claim 6, wherein said seal ring means of each sealing assembly is an O-ring made of fluororesin.

8. A butterfly valve as claimed in Claim 6, wherein said seal ring means comprises at least one ring of V-shaped cross-section.

9. A butterfly valve as claimed in any one of the preceding claims, wherein the valve closure member is made of synthetic resin and includes a cylindrical member of metal



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inserted therein, through which the valve stem means is inserted in the diametrical direction.

5 10. A butterfly valve as claimed in Claim 9, wherein said cylindrical member has a splined inner surface.

10 11. A butterfly valve as claimed in any one of the preceding claims, in which the length of the valve seat is slightly greater than that of the valve body whereby, when the valve body is fixedly mounted in a conduit, the valve seat provides a seal between the valve body and the opposed conduit ends.

15 12. A butterfly valve as claimed in any one of the preceding claims, in which opposed generally annular surfaces of the valve closure member and valve seat, around the valve stem means and the valve stem-receiving opening respectively, are flat.

20 13. A butterfly valve substantially as herein described with reference to Figures 1 to 3, 5 and 8 of the accompanying drawings.

25 14. A butterfly valve as claimed in Claim 1 and including a valve stem-receiving opening in the valve seat, substantially as

herein described with reference to Figure 4 of the accompanying drawings.

15. A butterfly valve as claimed in Claim 1 and including a valve seat substantially as herein described with reference to Figure 6 of the accompanying drawings.

16. A butterfly valve as claimed in Claim 1 and including a valve closure member substantially as herein described with reference to Figure 7 of the accompanying drawings.

17. A butterfly valve as claimed in Claim 1 and including a valve stem-receiving opening in the in the valve seat, substantially as herein described with reference to Figure 9 of the accompanying drawings.

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