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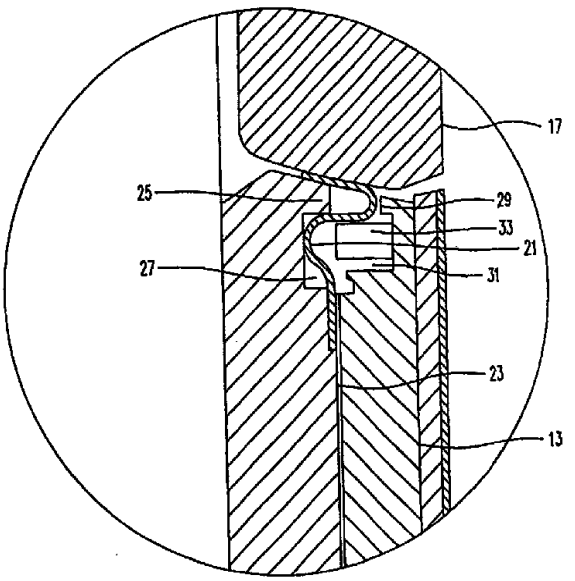
(57) Abstract

A valve (1) comprising a valve body (13) having a centrally disposed aperture (15), an annular recess (27) disposed about an outer circumference of the aperture, and a moment arm (25) disposed between the annular recessed portion and the aperture; a rotatable valve shaft (9); a valve disc (17) with a convex-shaped outer edge disposed about a circumference of the valve disc; an annular seating ring (21) having a serpentine configuration, a first end portion and a second end portion, wherein the first end portion has a concave-shaped surface which is in substantially full contact with an adjacent convex-shaped outer edge of the valve body when the valve disc is in the closed position in the aperture; and an annular seating ring retainer (23) comprising an annular recess, and a moment arm disposed between the annular recess of the retainer and the aperture.



BI-DIRECTIONAL VALVE SEAL MECHANISM

The present invention relates to a sealing mechanism used for valves, primarily butterfly valves, which provides tight seals under extreme conditions and which resists leakage when pressure is applied to the valve disc either in the direction of intended fluid flow or in the opposite direction. This sealing mechanism comprises an annular seating ring having a unique concave surface designed to engage with the convex outer surface of a valve disc, thereby providing a uniquely tight and bi-directional seal.

Valves such as butterfly valves are used to control the flow of fluids, e.g., liquids and gases, in a wide variety of industrial applications such as chemical, power, paper, air conditioning, petroleum and refining industries. Moreover, they are designed to handle clean, viscous and corrosive liquids; clean and corrosive gases; and steam. They are also designed for use in high temperature applications. These valves typically comprise a valve body having a central aperture, and a valve disc mounted within the aperture which can be rotated about an axis to shut off the aperture and halt the flow of fluid therethrough. In further refinements, the valves additionally comprise a sealing gasket or member to make the seal more fluid-tight and leak-proof. In certain applications, flexible rubber or plastic gaskets have been used. Under more extreme conditions, thin metal sealing members have been used to tighten the seal.

Nevertheless, particularly under high pressure and high temperature, leakage continues to be a considerable problem for such valves. The valves of the prior art have not provided sufficient sealing to reduce leakage to desirable levels. One failing of the prior art has been its use of seating rings which effectively contact the valve disc at only one point between the valve disc and seating ring. This occurs when the seating ring contacts the surface of the valve disc, which surface is typically curved, with an end which is flat or which curves away from the surface of the valve disc. This leaves only a single point of contact between the surfaces, which is vulnerable to pressure extremes and is especially apt to leak when fluid flows in an opposite direction. Such an arrangement is shown in FIG. 1, which itself comprises figures from U.S. Patent No. 4,796,857 to Hayes et al., issued January 10, 1989, incorporated herein by reference (numbers are retained from the original figures, with the addition of a prefix of "1" for clarity). As shown therein, the sealing end 120 of the seating ring is

flat or curves away from sealing edge 116 of valve disc 114. Only single radial point contact exists between the sealing surfaces. This structure permits greater disc and seat alignment tolerances, but as discussed above, it does not provide an acceptable seal, particularly under extreme operating conditions.

The present invention discloses a unique seal mechanism which provides improved leak resistance, even under extreme conditions of temperature, pressure, and the like. The sealing member, or seating ring, of the present invention, has an inner surface which conforms substantially to the shape of the valve disc. Thus, when the two surfaces are brought together, they form a band of sealing contact which is far more resistant to leakage than the seals of the prior art. The seating ring also has a bent or ridged construction which allows a spring-type loading of the seal. This is an aid to sealing, particularly at lower pressures.

Another advantage of the present invention is the location of this sealing surface more centrally on the edge of the valve disc. Other sealing mechanisms have been disposed substantially toward one face or the other of the valve disc. Such a location makes the seal far more vulnerable to slippage, displacement and leakage. The seal of the present invention is located substantially equidistant from the two faces of the valve disc. This ensures maximum protection, and in conjunction with the enhanced sealing surface area of the present invention, provides a seal which is much more impervious to leakage, even under extreme conditions.

Another problem which has not been resolved by the prior art is the integrity of the seal when pressure is applied in a direction opposite that of the intended flow of the fluid. The sealing mechanisms of the prior art do not provide means to resist pressure in this opposite direction, and are particularly vulnerable to leakage when fluid generates pressure in this direction. Nonetheless, under operating conditions, pressure is often generated in this direction due to vacuum creation, process shut-off, system maintenance, etc. Leakage in the reverse direction is particularly undesirable because of the risk of contamination and fouling by down-stream reaction products which may be contained in such leakage.

In addition, the seating ring retainer design disclosed herein can be modified directly to change face to face joinder dimensions. Such a change is required when the valve is used to connect to a variety of pipes of differing diameters, for

instance, or when federal or industry safety or utility standards change. This modified seating ring retainer is much less costly and provides more operational flexibility than the prior art, which uses separate, intermediate bodies to change face to face dimensions. Another limitation of the prior art is the required maintenance of torque forces on the valve disc when the disc is closed to maintain even a marginal seal. The discs typically used in butterfly valves are double-offset, i.e., they sit on shafts which are offset in two spatial directions from the center of the aperture of the valve. Thus, the shaft is disposed, for example, out of the plane of the disc and closer to one side of the disc than the other. This arrangement theoretically provides some improvement in the seal generated. In use, however, these seals are prone to leaks, and when fluid is forced against the valve disc, torque must be maintained on the disc to keep it shut. This torque is required because the disc is accepting greater force on one side of the shaft than the other, due to the fact that more disc surface area lies on one side of the shaft than the other. This makes a seal difficult to maintain, increases the energy requirements of the seal, and also makes opening and closing the disc more difficult, which can constitute a safety hazard under operating conditions. In addition, the useful life of such a seal is limited by the repeated application of torque to the disc required to make the valve seal.

It is the object of the present invention to substantially overcome or at least ameliorate one or more of the above disadvantages.

Accordingly, in a first aspect, the present invention provides a valve comprising:

(a) a valve body having a centrally disposed aperture, an annular recess disposed about an outer circumference of said aperture, and a moment arm disposed between said annular recess and said aperture;

(b) a rotatable valve shaft;

(c) a valve disc with a convex-shaped outer edge disposed about a circumference of said valve disc, said valve disc being disposed about said shaft such that said valve disc rotates via said shaft to an open position and a closed position within said aperture;

(d) an annular seating ring having a serpentine configuration, a first end portion, a first bend connected to the first end portion, and a second end portion, said seating ring being partially disposed within said recess of said valve body, wherein said first end portion has a first surface which is in contact with an adjacent convex-shaped outer edge of said valve disc when said valve disc is in said closed position within said aperture; and

(e) an annular seating ring retainer comprising an annular recess disposed about said outer circumference of said aperture such that at least a portion thereof adjoins said annular recess of said valve body, and a moment arm disposed between said annular recess of said retainer and said aperture and extending into a concave side of the first bend in the annular seating ring such that the first end portion of the seating ring is positioned between said moment arm and said outer edge of said valve disc when said valve disc is in said closed position, wherein said second end portion of said seating ring is securely disposed between said valve body and said retainer.

A preferred embodiment of the invention uses a single-offset valve disc mount, together with the sealing mechanism. Thus, the valve disc rotates on a shaft which is offset from the center point of the valve body aperture in one direction only. The shaft is disposed, for example, out of the plane of but equidistant from the sides of the valve disc. Thus, the surface area on one side of the shaft is substantially equal to the area on the other side, so the forces and torques created by fluid pressure on each side are the same. This greatly reduces or eliminates the torque which must be maintained on the disc during use to keep it closed, and contributes to the integrity and durability of the seal. The preferred embodiment also positions the shaft as close as possible to the seating ring. This further minimizes the amount of torque required to operate the valve.

Preferred embodiments of the present invention provide a unique sealing mechanism which employs cooperating seating ring, ring retainer, valve body and valve disc structures to create a seal which resists leakage in both forward and reverse flow directions (i.e., a bi-directional seal). The seating ring is supported in both fluid flow directions by ring retainer and valve body moment arms, which project from recesses in the ring retainer and valve bodies and engage the seating ring. This moment arm construction both supports the body of the seating ring and gives its sealing surface greater elasticity and flexibility within the supported range, which in turn allows a tighter conformational seal with the valve disc.

A preferred embodiment of the invention provides a valve wherein the moment arm of the valve body is directly adjacent to or in contact with a convex surface of a first bend of the seating ring, which bend is connected to the first end portion, to stabilize the seating ring and to allow the first end portion of the seating ring to flex toward the valve disc about the moment arm of the valve body when pressure is applied to the valve disc in a first direction when the disc is in the closed position and the pressure is transferred by the disc to the first end portion of the seating ring.

Another preferred embodiment provides a valve wherein the moment arm of the seating ring retainer engages with a concave surface of the first bend of the seating ring to stabilize the seating ring and to allow the first end portion of the seating ring to flex toward and about the moment arm of the retainer when pressure is applied to the valve disc in a direction substantially opposite the first direction when the disc is in the closed position and the pressure is transferred by the disc to the first end portion of the seating ring, and wherein the moment arms of the retainer and of the valve body thus cooperate to create a bi-directional valve seal.

Another preferred embodiment is disclosed, comprising a valve wherein the first end portion of the seating ring retainers is conformed to and gapped sufficiently from the edge of the valve disc to accept the first end portion of the seating ring and to press the first end portion of the seating ring against the edge of the valve disc.

In a preferred embodiment the valve disc has a spherical shape such that the shaft is offset in only one direction from the center point of the aperture of the valve door, thereby requiring application of less torque to close said valve disc than is required by for double-offset valve discs and essentially no torque to keep said valve disc in a closed and substantially non-leaking position. This contrasts with the substantial torque that is required to close double-offset valve discs and keep them closed.

In a preferred embodiment the valve disc has two disc faces, and the first end portion of the seating ring contacts the edge of the valve disc substantially equidistantly from both valve disc faces.

A further preferred valve is disclosed wherein a convex surface of a second bend of the seating ring, which bend is situated between the first bend and the second end portion, is engaged by either or both the recess of the valve body or the recess of the seating ring retainer, and another is disclosed wherein the first end portion of the seating ring and the edge of the valve disc create a band of sealing contact.

Preferred forms of the present invention will now be described by way of example only with reference to the accompanying drawings, wherein:

FIG 1 is a side cutaway view of a valve sealing mechanism of the prior art.

FIG. 2 is a front perspective view of a preferred butterfly valve of the present invention.

FIG. 3 is a side perspective view of a preferred butterfly valve of the present invention.

FIG. 4 is a cross-sectional, enlarged view of area "A" of FIG. 3 according to one embodiment of the present invention.

FIG. 5 is a cross-sectional, enlarged view of area "A" of FIG. 3 according to another embodiment of the present invention.

FIG. 6 is a cross-sectional, enlarged view of "A" of FIG. 3 according to a further embodiment of the present invention.

FIG. 7 is a top perspective view of the valve of a preferred embodiment of the present invention.

FIG. 8 is a side perspective view of the valve of FIG. 7.

FIG. 9 is a cross-sectional, enlarged view of area "B" of FIG. 8.

As can be seen with reference to FIGS. 2 and 3, the preferred embodiment butterfly valve 1 comprises a valve body 13 having a central tubular aperture 15 through which gas or liquid fluids may pass. Valve disc 17, which has a spherical shape, is mounted on shaft 19 so that it sits at least partially in aperture 15. The valve disc 17 is not a sphere; the term "spherical" is used in the valve art to describe a disc 17 which is a section or slice of a sphere. Thus, its outer edges define a sphere in space. This can best be seen with reference to FIGS. 7-9. As seen in FIGS. 7 and 8, the centerline of the sphere is located at the center of the shaft and the center of the valve disc from top to bottom, and the radius R of the sphere is the radius of the sphere and the radius of the sealing surface (note that FIGS. 7-9 do not depict the valve body). Typically, then, the circumference of one circular face will be greater than the circumference of its other circular face (when the valve disc is single - or double-offset). This construction provides for a tighter seal, particularly when combined with the seating ring 21 of the present invention. Valve disc 17 rotates about the axis of shaft 19. When aligned with aperture 15, it is in a closed position. When ajar, it is open and fluids are free to pass.

Seating ring 21 is formed, in this preferred embodiment, of electroless nickel plated stainless steel. Seating ring 21 is mounted about the edge of the aperture 15 and has a first, inner end, a second, outer end, and a serpentine, bent section in proximity to the first end. The second end is immobilized against valve body 13 by the annular seating ring retainer 23. Seating ring retainer 23 is removably affixed to valve body 13 to secure the seating ring 21. This arrangement allows seating ring 21

to be replaced easily when necessary due to wear or changed seal requirements. The effective seal of the present invention is due in part to the unique configuration of the first end of seating ring 21. It has a curved, concave configuration, which conforms substantially to the convex shape of the edge of valve disc 17. The radius of the sphere defined by the valve disc 17 and the radius of the sphere defined by the sealing surface are substantially equal. This provides sealing contact between valve disc 17 and seating ring 21 over the whole width of the upper end of seating ring 21. In fact, spherical geometry makes the seal less position-sensitive because the seat can seal at any range of points where it is in contact with the sphere defined by the mating part. If the upper end of the seating ring had a flat configuration, as disclosed in the prior art, it would effectively contact the valve disc at only one point in each radial direction. This would provide only a circular seal, which would be much less impervious to leakage, especially under extreme operating conditions.

As can be seen with reference to FIG. 4, seating ring retainer 23 has a moment arm 25 at its innermost edge. Immediately interior to the moment arm 25 is recess 27. Recess 27 can be defined by two or three planar surfaces. The valve body 13 has a structure analogous to that of the seating ring retainer 23. Moment arm 29 sits at the innermost edge of valve body 13. Immediately interior to the moment arm 29 is recess 31.

When seating ring retainer 23 is adjoined to valve body 13, corresponding recesses 27 and 31 create an annular space which accepts part of the seating ring 21. In the preferred embodiments of FIGS. 4 and 5, the second end of the seating ring 21 is compressed and immobilized between the abutting faces of valve body 13 and seating ring retainer 23. One or more gaskets may also be placed between the seating ring and the valve body or between the seating ring and the seating ring retainer. In the preferred embodiment of Fig. 6, the second end of the seating ring 21 is abutted and immobilized against recess 31. In the preferred embodiments of FIGS. 5 and 6, this immobilization is performed in cooperation with recess 27, which accepts a second bend of seating ring 21 to further stabilize the assembly. The second bend of seating ring 21 may or may not accept an annular gasket or seating ring support 33 into engagement with its concave surface.

With reference to FIGS. 4-6, it can be seen that valve body moment arm

29 performs a stabilizing and seal-strengthening function as well. It contacts the convex surface of the innermost bend of seating ring 21 to prevent any substantial lateral movement of the first, sealing end of the seating ring, particularly when it is subject to force in the direction of the valve body. This preserves seal integrity when fluid flows in the normal, anticipated direction.

Seating ring retainer moment arm 25 provides a stabilizing force in the opposite direction. Moment arm 25 engages the concave surface of the innermost bend of seating ring 21. This insures tight sealing when valve disc 17 is closed, because the first, sealing end of seating ring 21 is effectively wedged between moment arm 25 and valve disc 17. Moment arm 25 also functions, as its name suggests, as a moment arm about which the first end of the seating ring 21 can flex. This allows the upper end of seating ring 21 to conform even more perfectly to the contours of the valve disc. Moment arm 25 provides an additional benefit, as well. When fluid flow is reversed, and begins to travel in a direction opposite its normal flow, moment arm 25 insures that the seal remains tight by maintaining the lateral position of seating ring 21. This structure, in combination with moment arm 29 discussed above, provides the unique bi-directional seal of the present invention.

CLAIMS

1. A valve comprising:

(a) a valve body having a centrally disposed aperture, an annular recess disposed about an outer circumference of said aperture, and a moment arm disposed between said annular recess and said aperture;

(b) a rotatable valve shaft;

(c) a valve disc with a convex-shaped outer edge disposed about a circumference of said valve disc, said valve disc being disposed about said shaft such that said valve disc rotates via said shaft to an open position and a closed position within said aperture;

(d) an annular seating ring having a serpentine configuration, a first end portion, a first bend connected to the first end portion, and a second end portion, said seating ring being partially disposed within said recess of said valve body, wherein said first end portion has a first surface which is in contact with an adjacent convex-shaped outer edge of said valve disc when said valve disc is in said closed position within said aperture; and

(e) an annular seating ring retainer comprising an annular recess disposed about said outer circumference of said aperture such that at least a portion thereof adjoins said annular recess of said valve body, and a moment arm disposed between said annular recess of said retainer and said aperture and extending into a concave side of the first bend in the annular seating ring such that the first end portion of the seating ring is positioned between said moment arm and said outer edge of said valve disc when said valve disc is in said closed position, wherein said second end portion of said seating ring is securely disposed between said valve body and said retainer.

2. The valve of claim 1, wherein said moment arm of said valve body is directly adjacent to or in contact with a convex surface of the first bend of said seating ring, which bend is connected to said first end portion, to stabilize said seating ring and to allow said first end portion of said seating ring to flex toward said valve disc about said moment arm of said valve body when pressure is applied to said valve disc in a first direction when said disc is in said closed position and said pressure is transferred by said disc to said first end portion of said seating ring.

3. The valve of claim 1, wherein said first end portion of said seating ring retainer is conformed to and gapped sufficiently from said edge of said valve disc to accept said first end portion of said seating ring and to press said first end portion of said seating ring against said edge of said valve ring.

4. The valve of claim 1, wherein said valve disc has a spherical shape such that said shaft is offset in only one direction from a center point of said aperture of said valve door, thereby requiring application of less torque to close said valve than is required by for double-offset valve discs and essentially no torque to keep said valve disc in a closed and substantially non-leaking position.

5. The valve of claim 1, wherein said valve disc has two disc faces, and said first end portion of said seating ring contacts said edge of said valve disc substantially equidistantly from both valve disc faces.

6. The valve of claim 1, wherein a convex surface of a second bend of said seating ring, which bend is situated between said first bend and said second end, is engaged by either or both said recess of said valve body or said recess of said seating ring retainer.

7. The valve of claim 1, wherein said first end portion of said seating ring and said edge of said valve disc create a band of sealing contact.

8. A valve, substantially as hereinbefore described with reference to Figures 2, 3 and 4; Figures 2, 3 and 5 or Figures 2, 3 and 6 of the accompanying drawings.

9. A valve, substantially as hereinbefore described with reference to Figures 7 to 9 of the accompanying drawings.

Dated 4 February, 1999
General Signal Corporation
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

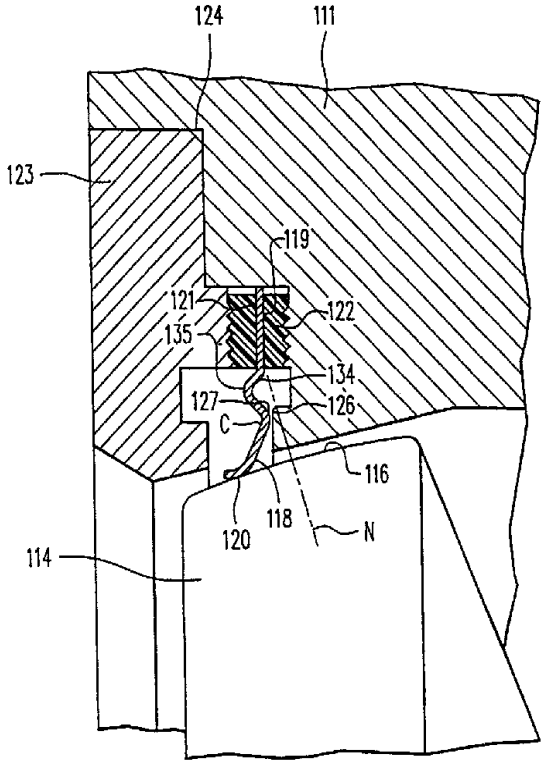


FIG. 1
(PRIOR ART)

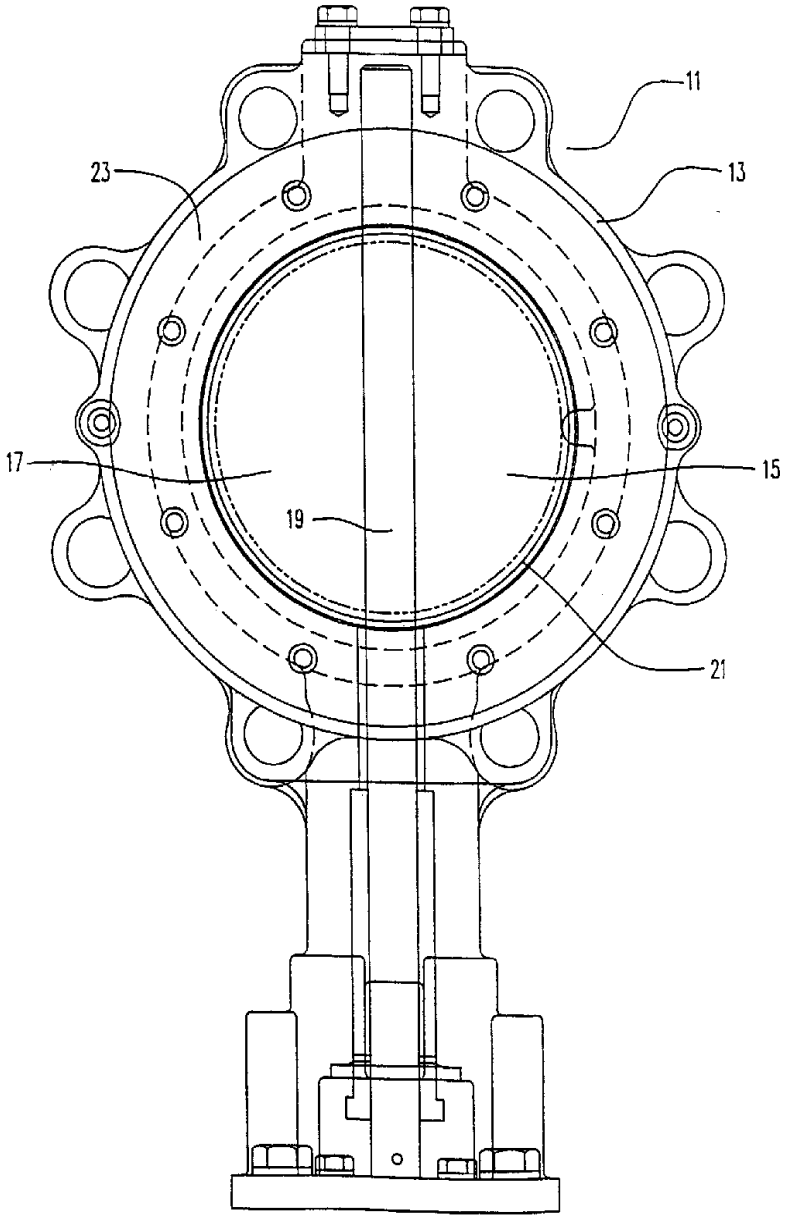


FIG. 2

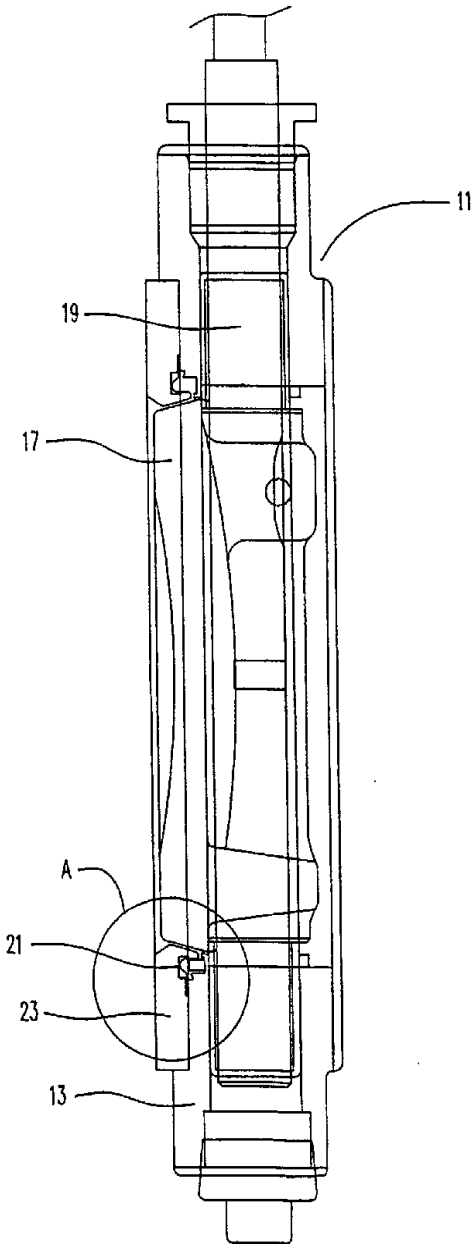


FIG. 3

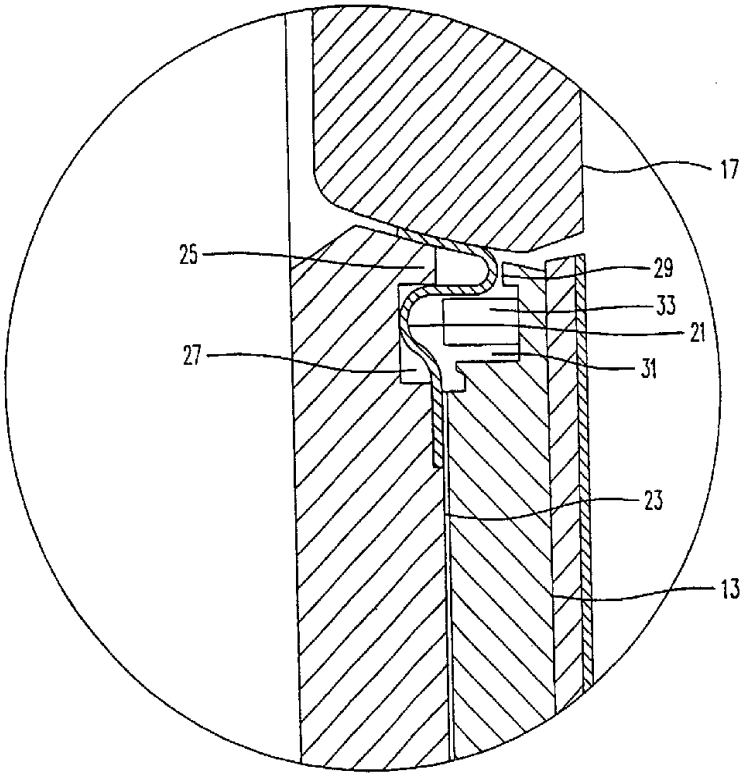


FIG. 4

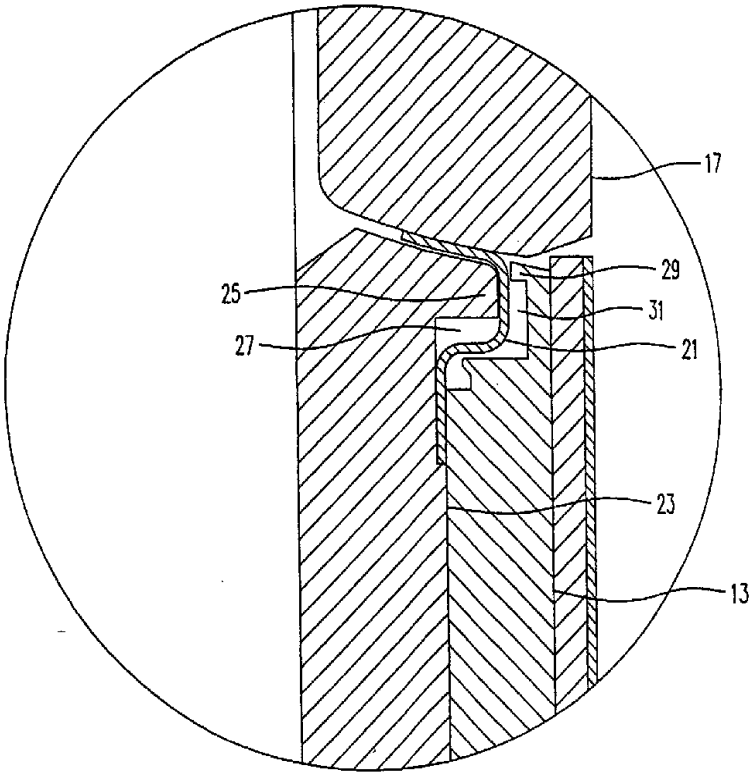


FIG. 5

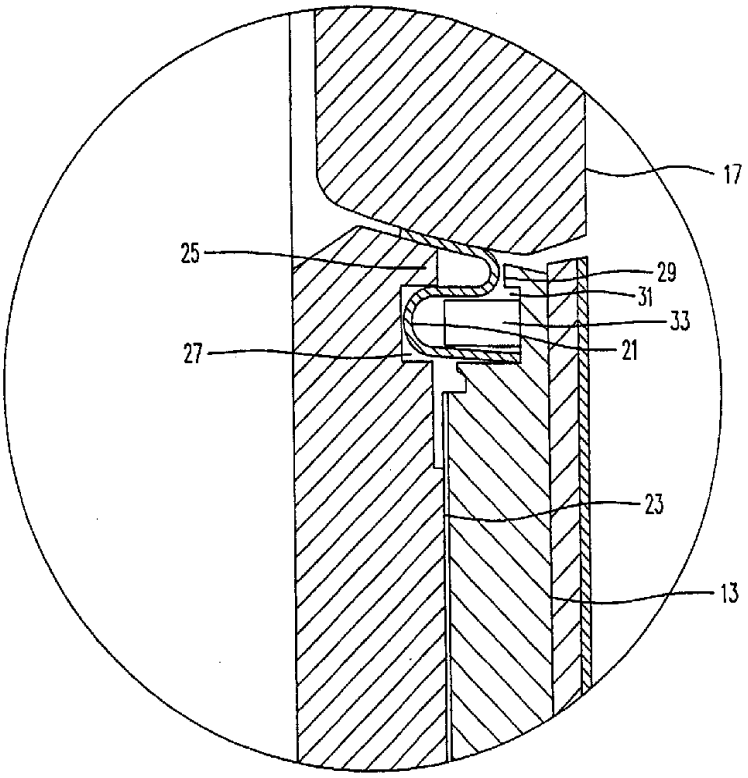


FIG. 6

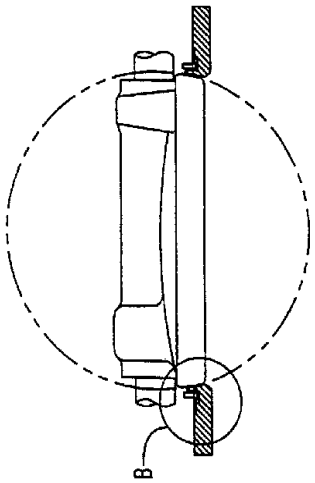


FIG. 8

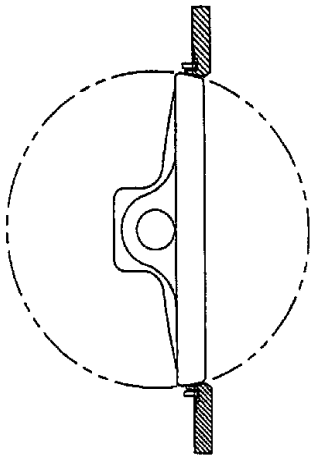


FIG. 7

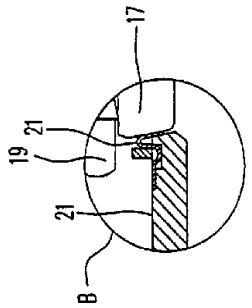


FIG. 9