United States Patent

Jacobellis

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[45] **Aug. 1, 1972**

[54] ROTARY ACTUATOR

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[52] **U.S. Cl.** **417/392,** 417/481, 418/45

[51] **Int. Cl.**.....**F04b 17/00,** F04b 35/00, F04c 21/00, F01c 5/00

[58] **Field of Search**.....417/392, 481, 482, 483, 485; 418/45, 151, 152, 153, 154, 155, 156

[56] **References Cited**

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Primary Examiner—Robert M. Walker
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[57] **ABSTRACT**

The invention relates to a rotary actuator of the type having a movable vane positioned in a cylindrical casing and secured to and extending radially outward from a shaft extending axially through the casing and a fixed vane extending radially in the casing toward the axial shaft, so that the fixed vane and the movable vane define two variable volume cavities in each of which a deformable bladder is positioned, with means being provided to permit fluid under pressure to pass into and out of said bladders, to effect expansion of one of the bladders for consequent movement of said movable vane and the shaft to which it is secured, with resultant compression of the other bladder and expulsion of the fluid therefrom.

8 Claims, 6 Drawing Figures

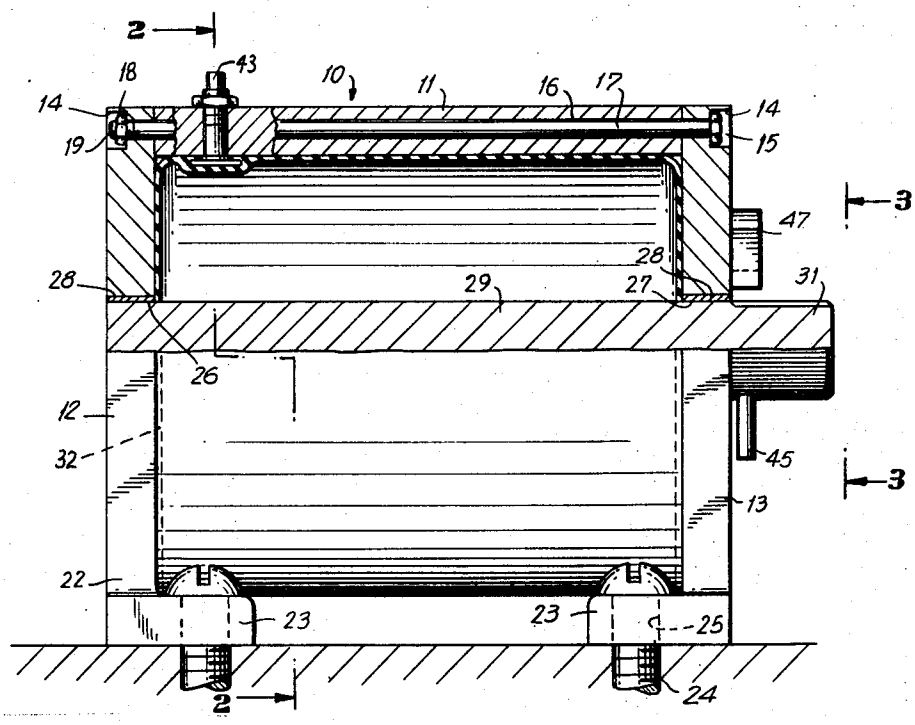
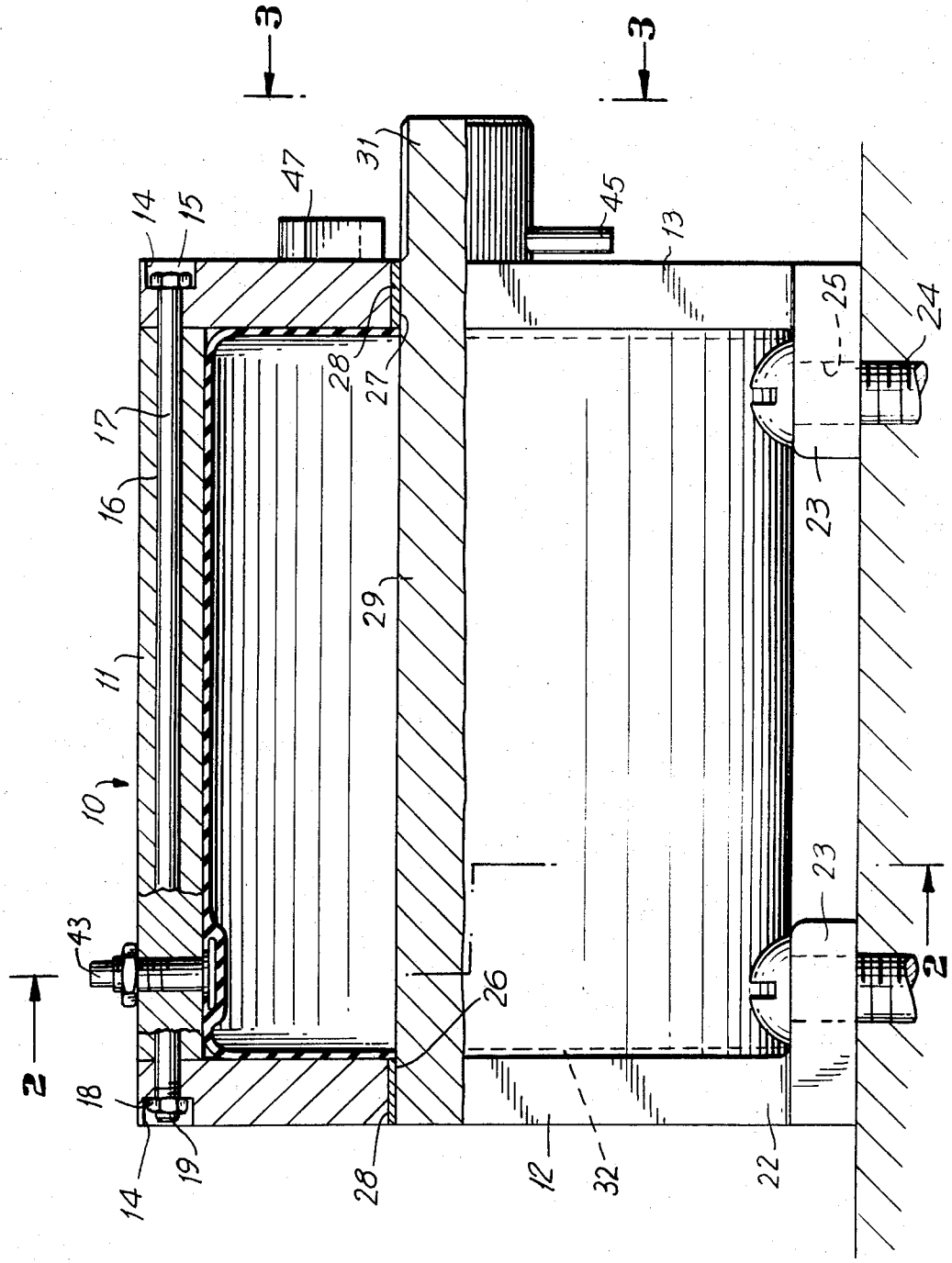


FIG. 1



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FIG. 2

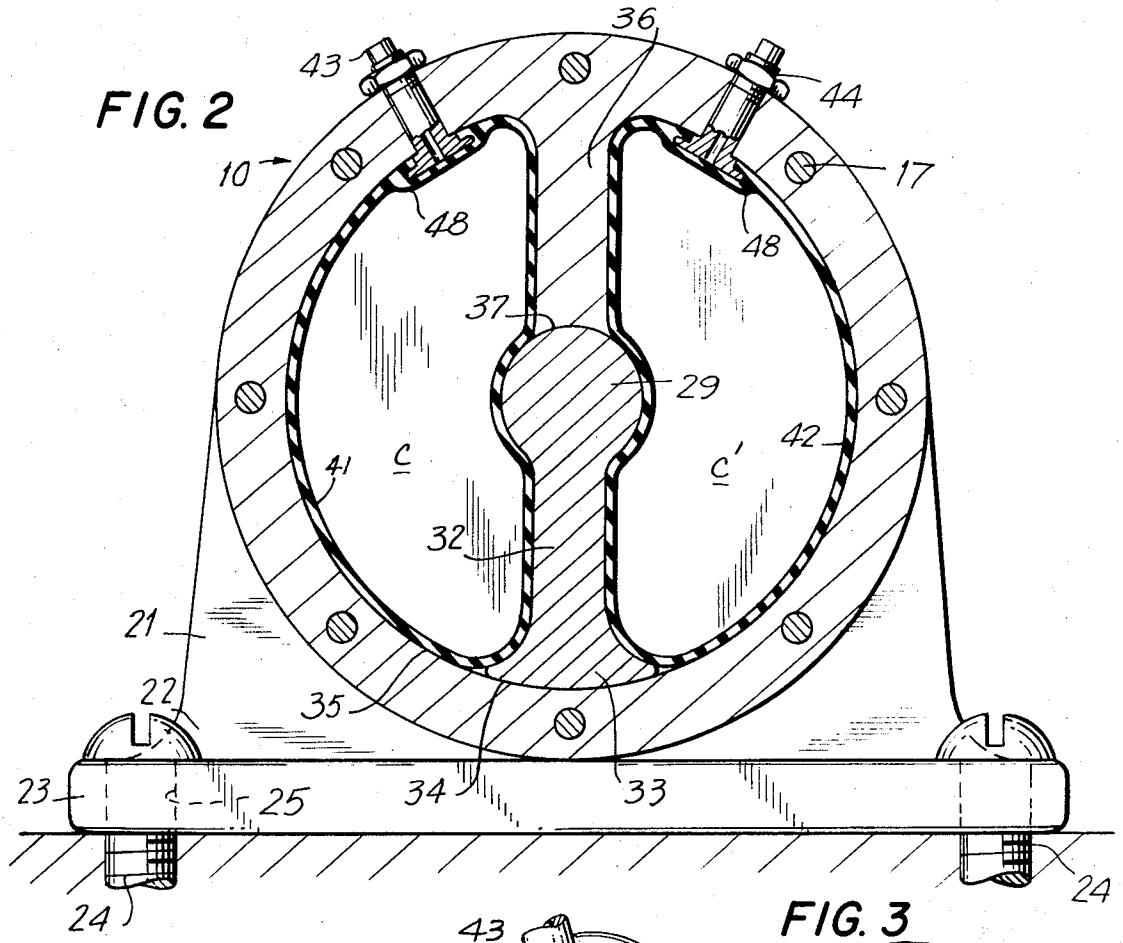


FIG. 4

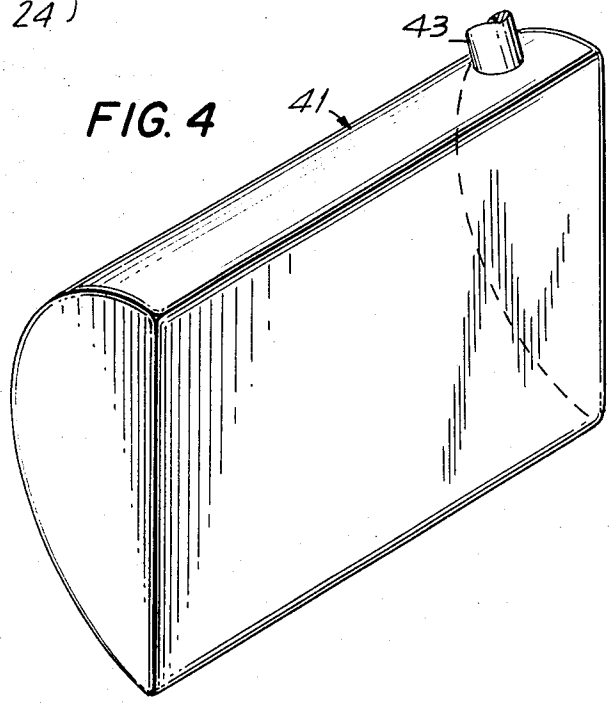
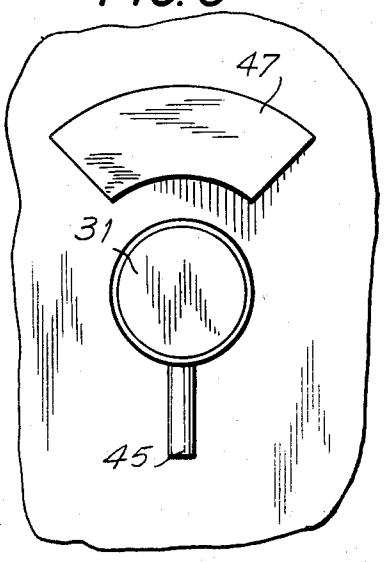


FIG. 3



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FIG. 5

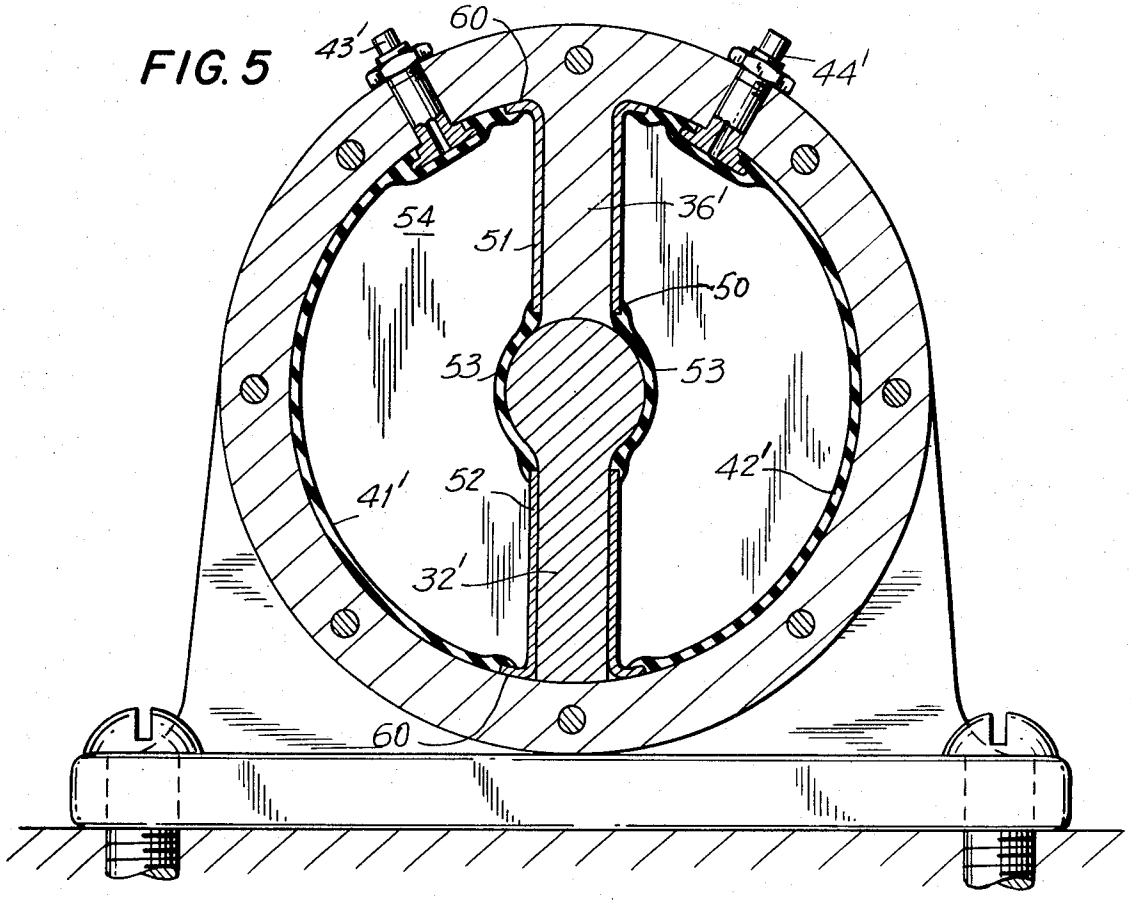
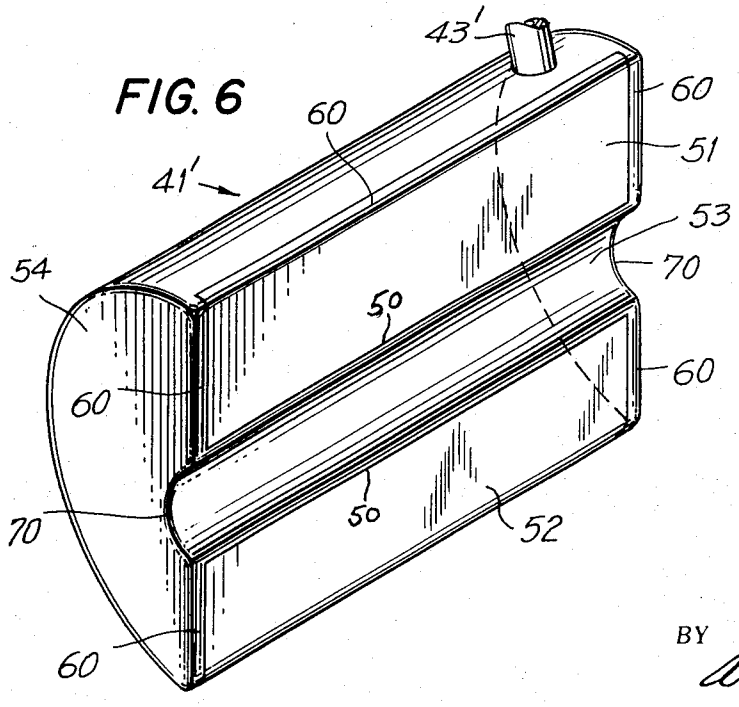


FIG. 6



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ROTARY ACTUATOR

As conducive to an understanding of the invention, it is noted that where an actuator utilizes a movable vane positioned in a cylindrical casing and which is connected to and extends radially from a rotary shaft and which is subjected to the force imparted by the introduction of fluid such as liquid under pressure into a cavity defined on one side of the movable vane to effect rotary movement of the vane and the shaft, by causing the fluid in a cavity defined on the other side of the vane to be expelled from said cavity, leakage of fluid between the free end of the vane and the adjacent surface of the cylinder in which the vane is rotating, results in a high degree of inefficiency of the unit.

Where, to prevent leakage, close tolerances are established between the free edges of the vane and the associated surfaces of the cylinder in which it is rotating, the cost of machining the edges of the vane and the surface of the cylinder is extremely high and at best leakage still occurs due to the requirement that sufficient clearance be provided to permit free rotation of the vane.

It is accordingly among the objects of the invention to provide a rotary actuator which is relatively simple to fabricate at low cost and which will positively avoid leakage from one side of the movable vane to the other without need for machining or close tolerances being maintained.

According to the invention, these objects are accomplished by the arrangement and combination of elements hereinafter described and more particularly recited in the claims.

In the accompanying drawings in which are shown one or more of various possible embodiments of the several features of the invention;

FIG. 1 is a longitudinal sectional view of the rotary actuator according to one embodiment of the invention;

FIG. 2 is a transverse sectional view taken along line 2—2 of FIG. 1;

FIG. 3 is a fragmentary end view taken along line 3—3 of FIG. 1;

FIG. 4 is a perspective view of a bladder used with the embodiment of FIG. 1;

FIG. 5 is a transverse sectional view of another embodiment of the invention, and

FIG. 6 is a perspective view of a bladder used with the embodiment of FIG. 5.

Referring now to the drawings, as shown in FIG. 1, the actuator 10 comprises a cylindrical casing 11 having end plates 12 and 13 secured to each end of the casing 11. More particularly, each of the end plates has a plurality of circumferentially spaced openings 14 of enlarged diameter at their outer end as at 15 and the casing 11 has a plurality of circumferentially spaced bores 16 extending through the wall thereof and complementary to the openings 14, so that when bolts 17 are passed through the openings 14 of the end plates and through the associated bores 16 and nuts 18 are screwed on the threaded ends 19 of the bolts 17 and tightened, the end plates 12, 13 will be rigidly secured to the casing 11. As is clearly shown in FIGS. 1 and 2, each of the end plates has a depending portion 21, the lower end 22 of which has an inwardly extending mounting flange 23, by means of which the actuator may be secured to a support base, by bolts 24 extending through openings 25 in the flanges 23.

Each of the end plates 12, 13 has a bore 26, 27 therethrough which are axially aligned with the axis of the casing 11 as is clearly shown in FIGS. 1 and 2. Each of the bores 26, 27 has a bushing 28 therein rotatably to mount a shaft 29, the end 31 of said shaft extending through the bore 27 in end plate 13.

As is clearly shown in FIG. 2, the axial shaft 29 has a vane 32 formed integral therewith and extending radially outward from the axis of said shaft 29, the free end 33 of said vane 32 being convex as at 34 to conform with the curvature of the inner surface 35 of the cylindrical casing 11. As shown in FIG. 2, the curved end 34 of the vane 32 is positioned closely adjacent said inner surface 35 of the casing 11 to provide a minimum of clearance just sufficient to permit free movement of such inner end with respect to the inner surface 35. As is clearly shown in FIG. 1, the length of the vane 32 is just slightly less than the longitudinal distance between the side walls 12 and 13 to provide a minimum clearance therebetween for free movement of said vane.

Referring to FIG. 2, it is to be noted that the casing has a fixed vane 36 which extends radially inward from the inner wall of casing 11 and more particularly as shown in FIG. 2, is aligned with the vertical diameter of said casing. The fixed vane 36 is of length substantially equal to the longitudinal distance between the side walls 12 and 13 and extends radially inward so that the inner concave end 37 of the fixed vane 36 defines a seat for the cylindrical portion of shaft 29 so that the shaft may readily rotate in said seat.

With the arrangement above described, and with the movable vane 32 illustratively positioned along the vertical diametric line of the fixed vane 36, two cavities or chambers C and C' will be provided in the casing 11. Positioned in each of the cavities C and C' is a deformable sealed bladder 41, 42 (FIG. 4) which may be of any suitable material capable of stretching or expanding in the manner hereinafter to be described and more particularly is preferably of natural or synthetic rubber having like capabilities. When the movable vane 32 is in the position shown in FIG. 2, at such time the bladders 41, 42 will substantially fill each of the chambers C, C' with no folds or creases in the bladder and with the bladder preferably in unextended unstretched position.

As shown in FIGS. 1 and 2, each of the bladders has a fitting 43, 44 secured at one end thereto which extends outwardly through the wall of the casing 11 adjacent the upper end of the fixed vane 36. More particularly, the fittings 43, 44 extend radially outward as shown.

The protruding portion 31 of the shaft 29, for example, may have a pin 45 extending outwardly therefrom aligned with the mid line of movable vane 32. The pin 45 is designed to strike an abutment 47 secured to end wall 13 so as to limit the rotary movement of the vane 32 in a clockwise or counterclockwise direction to prevent the free end 33 of the latter from striking the region 48 of the bladder to which the fittings 43, 44 are secured. Thus, in the illustrative embodiment shown, the vane may move through an angle of approximately 160° on each side of the vertical.

The embodiment shown in FIGS. 5 and 6 is similar to the embodiment shown in FIGS. 1 and 2 and corresponding parts have the same reference numerals primed.

In the embodiments shown in FIGS. 5 and 6, each of the bladders 41' and 42' has a pair of rigid plates 51, 52 which normally lie along the fixed vane 36' and the movable vane 32' respectively. The inner edges 50 of the plates 51, 52 are secured as by bonding to a rubber strip 53 and the outer edges 60 of each of the plates 51, 52 as well as the ends 70 of the strip 53 are bonded to the adjacent edges of a substantially cup-shaped rubber member 54. Thus, the plates 51, 52, the rubber strip 53 and the cup-shaped member 54 when assembled form a sealed container or bladder, each of which has a fitting 43', 44' associated therewith.

In the operation of the actuator shown in FIGS. 1 to 4 for example, the shaft 29 may be connected to a valve (not shown) for example, which has a neutral closed position and two operating positions. When the vane 32 is in the position shown in FIG. 2, the valve will be in the neutral position. Assuming that each of the bladders 41, 42 is fully charged with a fluid such as oil, and thereupon a source of fluid under pressure is applied to fitting 43 and fitting 44 is connected to a reservoir, as the fluid under pressure enters fitting 43, the bladder 41 will expand and stretch exerting force against vane 32 so that the latter will rotate in a counterclockwise direction, the oil in bladder 42 being expelled from the fitting 44. As a result, the three-way valve controlled by the shaft 29 will be moved from neutral position to an operating position. To either close the three-way valve or move it to its other operating position, it is merely necessary to connect the source of fluid under pressure to fitting 44 and connect the fitting 43 to a reservoir.

Due to the relatively large surface area of the vane 32 against which the expanding bladder will react, it is apparent that even if the fluid forced into one of the bladder is under a relatively low pressure, a considerable force will be exerted to rotate the shaft 29 and operate the valve controlled thereby.

By reason of the fact that the bladders 41, 42 form a completely sealed chamber in which the fluid under pressure is received, the leakage problem past the movable vane 32 is completely eliminated and hence there is no need for precision machining of the interior of the cylindrical casing 11 and the portions of the movable vane 32 adjacent thereto.

The operation of the embodiment shown in FIG. 5 and FIG. 6 is identical to that of the embodiment of FIGS. 1 to 4 and need not be described.

As a result of the constructions above described, a rotary actuator is provided which eliminates any likelihood of leakage past the movable vane, yet dispenses with the need of expensive machining to prevent leakage.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. A rotary actuator comprising a cylindrical casing closed at both ends, a shaft extending axially through said casing and rotatably mounted with respect thereto, said casing having a vane fixed at one end thereto and extending radially inward from the inner wall of the casing toward the axis thereof, said vane extending the entire length of said casing, the inner end of said vane defining a seat for said shaft, said shaft having a vane rigid at one end therewith and extending radially outward from the axis of said shaft, the free end of said shaft vane being positioned closely adjacent the inner surface of said cylindrical casing, whereby said shaft and the vane carried thereby is free to rotate in both a clockwise or counterclockwise direction, said fixed vane and said movable vane defining a chamber on each side thereof, a deformable bladder positioned in each of said chambers, each of said bladders having a port leading thereinto.

2. The combination set forth in claim 1 in which said shaft vane is of width slightly less than the longitudinal distance between the closed ends of said casing and of radial length just slightly less than the radius of said casing thereby providing minimum clearance between the side edges of said vane and said closed ends of said casing and between the outer end of said vane and said casing wall.

3. The combination set forth in claim 2 in which the outer end of said vane is arcuately curved to conform to the curvature of the inner surface of said cylindrical casing.

4. The combination set forth in claim 1 in which each of said bladders is of resilient material capable of stretching and contracting and a fitting is secured at one end to each of said bladders adjacent the outer end of said fixed vane, said fitting extending through the wall of said casing and defining said port.

5. The combination set forth in claim 1 in which means are provided to limit the angular rotation of said movable vane in both a clockwise and a counterclockwise direction.

6. The combination set forth in claim 1 in which said shaft has a portion protruding from one of the closed ends of said casing, said protruding portion having a radially extending rigid member aligned with the movable vane, and the closed end of said casing through which the shaft extends, has an abutment extending outwardly therefrom aligned with the rigid vane, engagement of said abutment by said rigid member limiting rotation of said movable vane in a clockwise and counterclockwise direction.

7. The combination set forth in claim 1 in which said cylindrical casing has end plates removably secured to the associated ends of said casing to close the ends thereof.

8. The combination set forth in claim 1 in which said bladder comprises a cup-shaped portion of resilient material having end walls adapted to be positioned near the closed ends of said casing and having a floor adapted to be positioned against the associated curved portion of the inner surface of said cylindrical casing, each of said bladders having a pair of rigid strips adapted to be aligned with one side of said fixed vane and said movable vane respectively, means connecting the periphery of said cup-shaped member to the outer edges of said rigid strips and a strip of resilient material connected to the inner edges of said rigid strips and to the associated portion of the end walls of said cup-shaped member.

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