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ROTARY DIAPHRAGMED PNEUMATIC ACTUATOR

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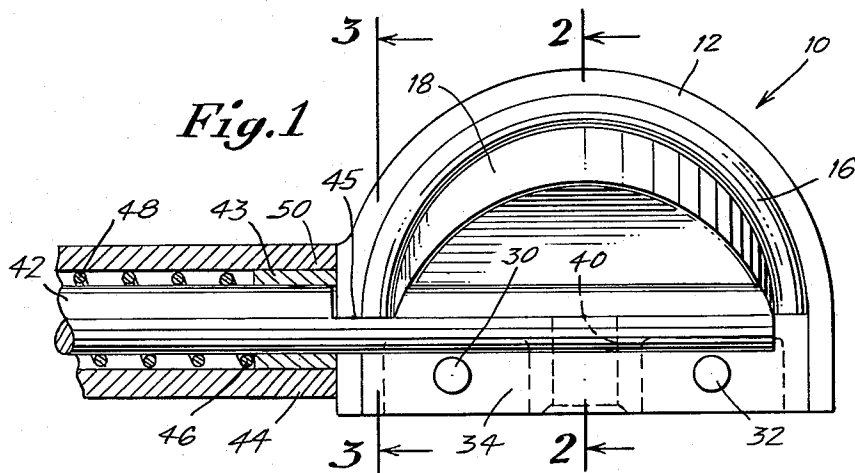


Fig. 4

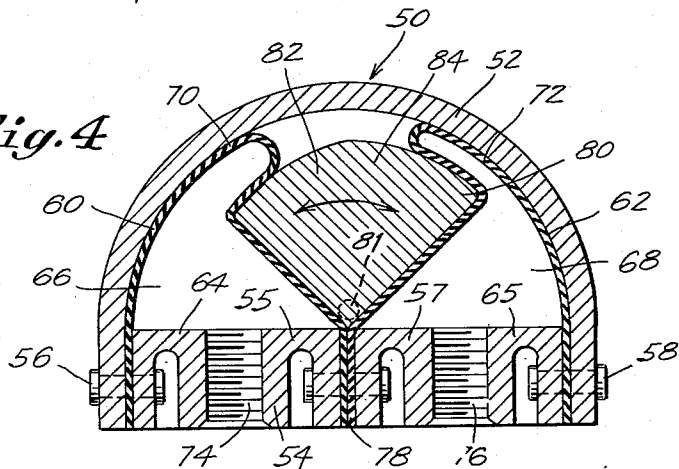


Fig. 2

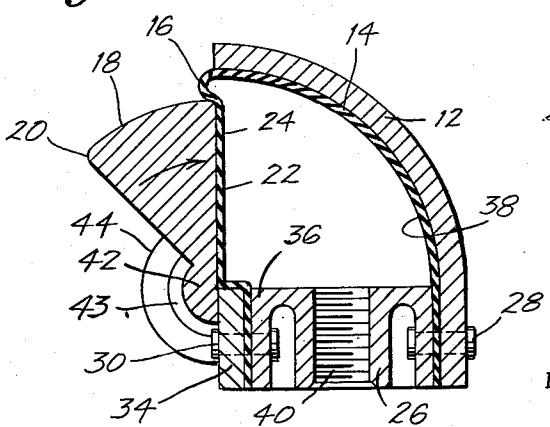
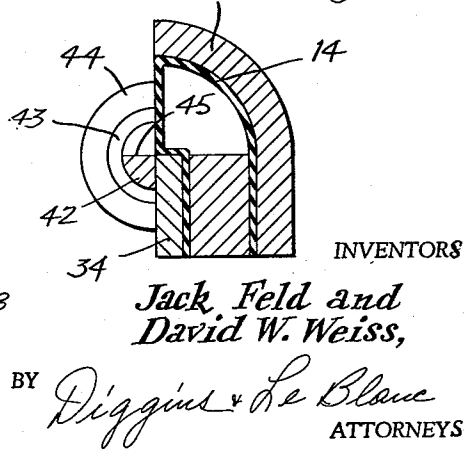


Fig. 3



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ROTARY DIAPHRAGMED PNEUMATIC ACTUATOR

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5 Claims. (Cl. 92-48)

This invention relates to pneumatic actuators and more particularly to a fluid operated device for imparting rotary motion to a controlled element.

Although rotary fluid operated actuators are well known they almost uniformly suffer from serious leakage problems and generate a substantial amount of undesirable friction. Reciprocating diaphragmed actuators on the other hand generally involve elongated structures and necessitate the conversion of longitudinal or reciprocating motion into rotary motion when it is desired to operate rotary elements.

The present invention provides a rotary diaphragmed fluid driven actuator which combines the compact envelope of a rotary actuator with the leakage free and friction free action of a reciprocating diaphragmed actuator. When operating a rotary load such as a butterfly valve the necessity of converting linear to rotary motion is completely eliminated.

It is therefore a primary object of the present invention to provide a rotary diaphragmed fluid controlled actuator.

Another object of the present invention is to provide a novel rotary diaphragmed pneumatic actuator.

Another object of the present invention is to provide a diaphragmed actuator requiring no conversion from linear to rotary motion.

Another object of the present invention is to provide a novel diaphragmed actuator which combines the compact envelope of a rotary actuator with the leakage free and friction free action of a diaphragmed actuator.

These and other objects and advantages of the invention will be more apparent upon reference to the following specification, claims and appended drawings wherein:

FIGURE 1 is an elevational view of the novel actuator of the present invention;

FIGURE 2 is a cross section taken along line 2-2 of FIGURE 1;

FIGURE 3 is a cross section taken along line 3-3 of FIGURE 1; and

FIGURE 4 shows a modified embodiment of the novel actuator of the present invention.

Referring to the drawings, the actuator generally indicated at 10 comprises a housing or shell 12 within which is received a flexible diaphragm 14. The shell or housing 12 is in the form of a quarter of a sphere. Diaphragm 14 is similarly shaped to enclose a volume defining a quarter of a sphere but includes a small convolution 16 extending outwardly over the upper surface 18 of a rotary piston 20. Piston 20 is shaped in the form of a segment of a sphere and includes a flat face 22 which bears against the front web 24 of diaphragm 14.

Shell 12 is connected to a base 26 by means of a plurality of circularly spaced pins or rivets one of which is indicated at 28. These rivets not only secure the shell to the base but in addition act to clamp the lower edge of the diaphragm 14 between the base and shell, the diaphragm being provided with suitable apertures through which the pins 28 pass. Connected to base 26 by means of a pair of similarly spaced pins 30 and 32 is a flat elongated clamping plate 34 which acts to clamp the lower edge of the front face 24 of the diaphragm to the front edge of the base. As can be seen the diaphragm 14 in conjunction with the upper surface 36 of the base defines

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a control pressure chamber 38 in the form of a quadrant of a sphere. A threaded aperture 40 provides means for attaching a fluid pressure inlet line to the actuator so that control pressure may gain access through aperture 40 into the interior of control chamber 38.

Mechanical output from the actuator is taken by way of a rotary shaft 42 connected to one end of segmental piston 20. Shaft 42 is suitably journaled in a bearing support housing 44 enclosing bearing 43 and is surrounded by helical torsion spring 46 suitably connected at one end 48 to the shaft and at its other end 50 to the stationary housing 44. Shaft 42 is cut away at 45 to provide rotary clearance for the housing and diaphragm as best shown in FIGURES 1 and 3.

As can be seen the actuator consists of spherical rather than cylindrical components in order to eliminate the problem of end sealing so prevalent in a cylindrical construction. As shown, the housing and diaphragm are each in the form of a quarter of a sphere. The piston is also a segment of a sphere and rotates inside the housing. The axis of rotation of the piston 20 is coincident with the diameter of the spherical portion of the housing and also coincident with the center of rotation of the shaft 42. The control pressure force is exerted against the flat side of the piston by front face or web 24 of the diaphragm 14. As the piston rotates under the influence of a pressure rise in chamber 38, the diaphragm rolls on the spherical portion of the piston and movement is resisted by twisting of the torsion spring 46 which acts to apply a restoration force in the direction of the arrow in FIGURE 2.

The actuator of FIGURES 1-3 may be made proportional by the opposing pressure of spring 46. FIGURE 4 shows another way of obtaining proportionality through the use of a second diaphragm of variable area.

In FIGURE 4 the actuator generally indicated at 50 comprises a housing or shell 52 in the shape of a hemisphere. Shell or housing 52 similarly is attached to the circular split base 54 comprising halves 55 and 57 by circularly spaced pins such as pins 56 and 58 which also serve to clamp the edges of segmental diaphragms 60 and 62 to the base 54. Diaphragms 60 and 62 in conjunction with the upper surfaces 64 and 65 of the split base each define quadrants of a sphere and enclose a reference pressure fluid in a reference chamber 66 and a control pressure fluid in control chamber 68. The diaphragms additionally include convolute portions 70 and 72. Access to reference pressure chamber 66 is through an inlet aperture 74 in the base section 55 while access to the control pressure chamber 68 is through a similar threaded aperture 76 in base section 57. Diaphragms 60 and 62 are sealed to the base and the section 55 and 57 joined together by a series of spaced pins such as that indicated at 78 in FIGURE 4.

Spaced between diaphragm 60 and 62 is a single rotary piston 80 having one hemispherical segment section 82 for reference chamber 66 and another hemispherical segment section 84 for control pressure chamber 68. In order to obtain proportionality the surface of segmental section 82 is formed so that it is not concentric with the inner surface of the shell 52 so that rotation of the piston varies the effective area of diaphragm 60 exposed to the reference pressure in chamber 66. Piston 80 is supported on a pair of pivot pins journaled in opposite sides of the housing. One pin is indicated by dashed lines at 81. Power take off is from one of these pins in the same manner as from shaft 42 in the previous embodiment.

The curvature of one or both sections 82 and 84 of the piston in FIGURE 4 may be modified as desired in order to obtain the particular rate wished. A reference pressure supplied to chamber 66 tends to rotate the piston in a clockwise direction in FIGURE 4 whereas an increase in control pressure in chamber 68 tends to rotate the piston in the opposite direction. Reference chamber 66 and

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diaphragm 60 take the place of the torsion spring in FIGURE 1 as the means for opposing the action of the control pressure.

It is apparent from the above that the present invention provides a novel fluid controlled actuator for imparting movement to rotary devices. While described as a pneumatic actuator utilizing pressurized air it is apparent that liquids as well as compressible fluids including gases and vapors may also be utilized to actuate the device. While having general utility the rotary actuator of the present invention is particularly suited for driving a butterfly valve and when used with a valve for high temperature gases the shell 12 or 52 as the case may be, may be formed of thermal insulating material to isolate the interior of the actuator from the hot gases. Furthermore, the actuator's motion may, if desired, be transmitted through a thermal barrier in such instances.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A rotary actuator comprising a shell in the form of a segment of a sphere, a flexible inelastic diaphragm having a spherical portion conforming to and in contact with the inner surface of said shell, said diaphragm having an integral flat radially extending wall, a flat base plate clamped between the lower edge of said wall and the lower edge of said spherical segment portion of said diaphragm, said segmental portion, said flat radial wall and said base plate defining a fluid enclosure, means for supplying pressure fluid to the interior of said enclosure, a piston in the shape of a segment of a sphere, said piston having a flat surface in engagement with the radially extending wall of said diaphragm, said diaphragm forming a convolution between the surface of said piston and said shell, and said piston being rotatable into said shell, an output shaft connected to said piston and rotatable therewith, and a

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torsion spring resiliently biasing said piston for rotation into said shell.

2. A rotary actuator according to claim 1 wherein said shell is in the form of a quarter of a sphere.

3. A rotary actuator comprising a shell in the form of a segment of a sphere, a pair of flexible inelastic diaphragms each having a spherical portion conforming to and in contact with the inner surface of said shell at opposite ends thereof, each said diaphragm having an integral radially extending wall, a flat base plate clamping the edges of said spherical segment portions of said diaphragm to said shell and the edges of said radially extending portions of said diaphragm to said base plate along the center line thereof, each said segmental portion of said diaphragm and the corresponding radial wall portion thereof together with the base plate defining a fluid enclosure, a piston in the shape of a segment of a sphere, said piston having a flat surface in engagement with each of said radially extending walls of said diaphragm, said piston being rotatable in said shell, said diaphragm forming convolutions between the spherical surfaces of said piston and said shell, means in each portion of said base for supplying pressure fluid to one of said enclosures, and an output shaft connected to said piston and rotatable therewith.

4. A rotary actuator according to claim 3 wherein said shell is in the form of a hemisphere.

5. A rotary actuator according to claim 4 wherein said piston is provided with two spherical segment surfaced portions of different radius, and said second diaphragm includes a convolute portion between said piston and said shell.

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