ABSTRACT: This disclosure relates to a valve assembly including a pair of valve cylinders interconnected by pairs of involuted and opposed bands fixed at the opposite ends to the cylinders. One pair of bands is connected to the first cylinder and extends between the cylinders and around the generally opposite surface of the opposite cylinder. The second pair of bands extend in the opposite direction between the two members. Relative movement between the two cylinders is a rolling action with the opposed bands engaging the peripheral surface of the two cylinders. By providing selective openings in the cylinders in alignment with the bands, the flow between the interior and exterior of any one or both members can be controlled.
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POSITIONING APPARATUS AND VALVE

This invention relates to a valve and particularly to a novel band-type valve employing rolling contact between a valve seat and a valve band.

Fluid flow control devices or valves are provided to open and close passageways between full open and full close states as well as intermediate variable positions to throttle the flow. In many applications, a very minimal operating force requirement is desired. This requires that the valve unit operate in a relatively frictionless manner. Further, it is, of course, often important that the closed position be sufficiently tight to absolutely prevent any leakage. For example, in liquid petroleum dispensing systems, air eliminators may be employed to automatically eliminate air or other gas from the stream of flowing liquid. Thus, free air or other entrained gases which pass through the meter result in an erroneous reading of the actual volumetric flow of liquid. Under certain abnormal situations, the flow may desirably be terminated in response to a selected accumulation of a foreign substance or fluid in the flowing liquid.

Float activated valve systems have been suggested for incorporation into the flow line with a separating chamber within which the air or other similar fluid accumulates to actuate a float valve and provide the desired functioning. For example, U.S. Pat. No. 3,252,473 discloses a float operated air eliminating valve structure. A somewhat similar system is shown in U.S. Pat. No. 3,131,709 wherein a float valve actuates a flexible flat band which is connected to the float and caused to selectively open and close an aperture in a flat wall in response to the positioning of the float.

The present invention is particularly directed to a highly novel and improved valve unit which may be employed in a flow system to separate gas or other fluid from the liquid, and if desired, to actuate a pilot control system for terminating or otherwise controlling the flow in response to selected accumulation of the foreign fluid. However, the valve assembly which forms the subject matter of this present invention in its broadest aspects is not restricted in any way to this particular application.

Generally, in accordance with the present invention, a pair of valve members are provided, both of which have generally curved surfaces arranged in physically opposed relationship. The valve members are interconnected by a pair of involuted opposed bands fixed at the opposite ends to the members, and in particular, being curved over the opposed curved surfaces of the valve members. Thus, the one band is connected to the first member and extends over the first curved surface and around the generally opposite curved surface of the opposite fixed member. The second band is oppositely disposed with respect to the two members and extends therebetween and over the opposite side of the curved surface of the one member and the opposite side of the surface of the second member. Thus, relative movement between the two members is a rolling action with the opposed bands inversely engaging the peripheral surface of two members. By providing selective openings in the curved surfaces in alignment with the valves, the flow between the interior and exterior of any one or both members can be controlled. The opposing bands establish counter forces which virtually eliminate the input force requirements. Further, by making one of the members fixed and moving the other, the rolling contact interengagement and release virtually eliminates friction and thus requires minimal operating force.

The curved surface of the band, however, provides substantial resistance with respect to relative high pressures across the band for any given band thickness. The peeling affect of the band with respect to the curved surface, and particularly during the progressive opening of the bands, permits a relatively high pressure fluid to be discharged through the valve openings.

The valve band may be preloaded through a suitable spring or other resilient tensioning means. Tensioning of the band will impart an initial load on the valve seat to insure a liquid tight seal at zero pressure. Further, by applying the high pressure side to the exterior of the curved surface any increasing relative pressure increases the sealing effectiveness of the valve system.

In the construction of the device, the interconnecting bands may be formed of an unequal thickness to insert a bias in either direction on the relative movement of the two members. Any number of individual or multiple port control bands might be employed. Further, the valve openings under any given band may include one or more openings for sequential or progressive of opening. The shape of the apertures may be varied to establish a linear or nonlinear response. Similarly, the bands themselves may be shaped to control the bias or the bias rate with the relative position of the two valve members at any given time.

In a highly satisfactory valve construction, which has been applied to an air eliminating and control assembly in a liquid flow unit, a pair of cylinders were employed. The one cylinder was mounted as a fixed member with the opposite ends interconnected to an output flow system. A pair of apertures were provided in axially spaced relation, each in an outer quarter section of the cylinder. A pair of valves were secured respectively to the fixed cylinder in alignment with the apertures. Each of the valve bands extended over the apertured surfaces and in an inviolated or inversed manner about the generally opposite portion of the adjacent second cylinder which was mounted to move as a band control. Interconnection to the control cylinder included a coil spring means to place the valve bands under tension. A pair of opposing or balancing bands were secured in board of the valve bands to the fixed cylinder and to the moveable cylinder. The balancing bands were generally secured in an oppositely disposed manner to the two cylinders. The balancing bands were generally secured to the diametrically opposite side of the fixed cylinder from the attachment of the valve bands. They extended about the fixed cylinder in the direction opposite that of the valve bands and outwardly between the two cylinders to the opposite side of the moveable control cylinder. The moveable cylinder was connected to a valve control. For example, in the air eliminator assembly the control cylinder was attached to a float device connected in the flow line through a suitable chamber arrangement and operably to selectively open and close the associated valve openings.

The present invention thus provides a highly improved valve or flow control assembly which can be readily employed in any flow control system.

The drawings furnished herewith illustrate the best mode presently contemplated by the inventor for carrying out the present invention, and clearly disclose the above advantages and features as well as others which will be readily understood from the following description.

In the drawings:

FIG. 1 is a side elevational view of a separating device connected in a metering flow line for a petroleum product or the like;

FIG. 2 is an enlarged side elevational view of the separator constructed in accordance with the present invention with parts broken away to show internal details of construction;

FIG. 3 is a vertical section taken generally on line 3-3 of the separator shown in FIG. 2;

FIG. 4 is a fragmentary horizontal section taken generally on line 4-4 of FIG. 2;

FIG. 5 is a vertical section taken generally on line 5-5 of FIG. 4 with the valve in a closed position established by the raising of a valve assembly control float;

FIG. 6 is a plan view of the valve assembly shown in FIGS. 2-5;

FIG. 7 illustrates an alternative construction of a valve in accordance with the present invention employing a single valve opening.

FIG. 8 illustrates a multiple aperture valve assembly constructed in accordance with the present invention and illustrating nonlinear sequentially spaced multiple valve openings.

FIG. 9 is a further view illustrating a band construction employing unequal banding bias, and
FIG. 10 is a view, similar to FIG. 9, illustrating a band construction providing a changing rate of bias in the spring structures.

Referring to the drawing and particularly to FIGS. 1 and 2, the present invention is shown as a liquid flow system including a flow line 1 incorporating a meter 2 to record the volumetric flow of liquid through the line. An air eliminator and strain unit 3 is interconnected upstream of the meter, and is adapted to remove free air or other entrained gases which may be present in the flowing liquid before its entry into the meter. In the illustrated embodiment of the invention, a gas separator or air eliminator 3 is interconnected to actuate a pilot valve 4 and control the flow through line 1 and to a suitable air vent 5 to remove the entrained air or other gases.

As most clearly shown in FIGS. 2 and 3, the gas separator generally includes an outer flow casing or housing 6 having a lower outlet portion 7 and a laterally extending inlet portion 8 immediately above the outlet portion. A tubular filter screen 9 is secured in the laterally extending inlet portion. The screen is a strainer and diffuser which serves to remove foreign material from the liquid and to further diffuse the liquid stream in accordance with known practice. A float chamber 10 is disposed immediately adjacent the inlet chamber and thus in communication with the inlet and outlet chamber. A float 11 is disposed within the float chamber 10 and is connected to a valve assembly 12, which particularly illustrates a valve unit in accordance with the present invention, located immediately above the float 11. A valve head 13 is secured to the housing 6 immediately above the float chamber 10 and defines an extension of chamber 10 to enclose the valve assembly 12. The head 13 includes oppositely disposed outlets connected respectively to the pilot valve 4 via a conduit 14 and the air vent 5.

The liquid in the float chamber 10 will normally support the float 11 in a raised position corresponding to a closure of the valve assembly 12, as more fully described hereinafter. Air or other gas which may be entrained within the liquid is released with the casing 6 and accumulates within the upper end of the float chamber 10 and causes the float 11 to drop or lower in the float chamber, to the position of FIG. 2-4. This results in an opening of the valve assembly 12 and exhausts air to the air vent 5 and to the pilot valve 4. If there is an unusual or sudden accumulation of air or other gas, the exhaust through vent 5 will not be sufficiently rapid to normally prevent the flow from the gas separator through the flow line 1. This, however, will result in a rapid and full opening of assembly 12 with an application of sufficient pressure to the pilot valve 4 to terminate the flow until the air has been completely exhausted.

More particularly in the illustrated embodiment of the invention, float 11 is sealed chamber built-up member disposed within the float chamber 10. A guide rod 15 is secured to the underside of the float 11 and extends downwardly through a guide wall 16 formed in the lower portion of the float chamber.

A generally rectangular valve attachment bracket 17 is secured to the upper end of the float 11 with the side arms of the bracket 17 extending upwardly into the valve assembly head 13 and connected to position the valve assembly 12. The valve assembly 12 is shown in FIGS. 1-5 in a preferred construction as applied to a gas separator for a petroleum flow line or the like. Generally, the assembly includes a fixed valve cylinder 18 extending laterally of the head 13 and a plunger parallel control cylinder 19 interconnected by a plurality of bands to cylinder 18. Cylinder 19 is interconnected to the bodies 22, 23 for positioning relative to float 11 in accordance with relative levels of the gas and liquid in chamber 10.

The fixed valve cylinder 18 is provided with a pair of axially spaced and circular circumferentially extending valve openings or apertures 20 and 21. Cylinder 19 is interconnected to the fixed valve cylinder 18 by a pair of valve bands 22 and 23 which are aligned with the apertures or valve openings 20 and 21 respectively. The valve bands 22 and 23 are adapted to progressively engage and disengage the fixed cylinder 18 to correspondingly open and close the aligned aperture valve apertures 20 and 21. A pair of bias or balancing bands 24 and 25 are secured in an inverse or opposite manner to the cylinders 18 and 19 to provide an automatic and guided movement of the two cylinders with the valve bands in rolling engagement with respect to the adjacent curved surfaces of the cylinders.

More particularly, the sealing bands 22 and 23 and the balancing bands 24 and 25 are resilient, flexible strips which may be formed of a suitable spring metal, a rubber-like material, or an equivalent material. The bands are preferably such that they will tend to assume a planar configuration in the absence of any restraint.

The bands 22 and 23 are similarly secured to the cylinders 18 and 19 in a generally inverted or inviolated manner. Thus, referring particularly to band 22 and FIGS. 2 and 5, the one end of the band 22 is fixed to the bottom side or surface of the fixed cylinder as by a set screw 26. The band 22 is aligned with the aperture 20 and extends over the curved surface including the aperture 20 and then outwardly over and around the surface of the float activated cylinder 19.

The cylinder 19 is provided with a circumferential opening 27 and a coil spring 28 having hook ends 29 and 30 hooked to the adjacent end of the band 22 and to the cylinder at the remote end of the opening 27 to resiliently tension the band 22 against the cylinder 18. The float activated cylinder 19 is of a slightly lesser width than the fixed cylinder 18 but extends outwardly beyond the axial position of the apertures 20 and 21, as most clearly shown in FIGS. 2 and 5, to permit attachment of the bands 22 and 23 to the outer portions thereof.

The band 23 is secured to cylinders 18 and 19 in the same manner as band 22. The balancing bands 24 and 25 are disposed in laterally spaced relationship between the valve, bands 22 and 23. The balancing bands 24 and 25 are similarly secured to the cylinders in fixed relationship thereto. Thus, the band 24 has its one end secured or fixed to the upper end of the fixed cylinder 18 as set by screw 31 generally diametrically opposite from the attachment of the band 22 by a set screw 26. The band 24 extends over the top surface of the cylinder 18 in the direction of the valve openings 20 and 21 and then downwardly between the fixed and the float activated cylinders 18 and 19. The lower end of the band 24 curves over the adjacent underportion of the cylinder 19 and is secured to the cylinder by a set screw 32. Thus, the bands 24 and 25 similarly pass between the cylinders 18 and 19 in the direction opposite that of bands 22 and 23 and are fixed thereto.

The several flexible bands, therefore, intending to assume their normal unstressed position, determine the position of the cylinders 18 and 19 with respect to each other. The band tension holds the moveable cylinder 19 adjacent to the fixed cylinder 18 and thereby defines a self-contained and self-tracking valve mechanism. This eliminates the requirement for auxiliary supports and guide structures which have generally been employed in float activated valve assemblies and the like.

The opposite ends of the moveable cylinder 19 are closed by orificed end walls 33 and 34 having central bearing pins or shafts 35 which project outwardly and into the side arms of the encircling supporting bracket 17. The float activated cylinder 19 is secured to the bracket by suitable snap rings 36 which snap suitable recesses in the outer ends of the bearing pins or shafts.

As most clearly shown in FIG. 5, the fixed cylinder 18 is aligned with a pair of outlet hubs 37 and 38 to the opposite sides of the housing and interconnected thereto by similar outlet couplers 39 which are bolted or otherwise secured to the housing and project inwardly into the cylinders. The coupler 39 is provided with an outlet aperture or opening 40 communicating directly with the adjacent portion of the cylinder 18 with a coupling portion 41 extending inwardly therefrom into a recessed portion of the adjacent end of the fixed cylinder 18. At first, O-ring seal 42 is disposed between the hub 37 and the adjacent portion of the outlet coupler 39. A second inner O-ring seal 43 is disposed between the inner projection or port-
tion 41 of the coupler 39 and the interior surface of the cylinder 18. In this manner, the couplers 39 are interconnected to the opposite ends of the fixed cylinder 18 to provide intercommunication between the adjacent portion of the cylinder and the air vent 5 and the poppet valve 4, respectively.

The fixed cylinder 18 is provided with an integral central wall 44 having a central opening which is sealed by a pipe plug 45. The seal central wall 44 defines a pair of separate signal chambers aligned with respect to the valve openings or apertures 22 and 21 to provide separate signals to the air vent 5 and valve 4.

The surface of the fixed cylinder 18 is provided with a sealing cover 46 in the form of a sheet-like member which is secured to the external surface of the cylinder. The sealing member or cover 46 may be a resilient rubber-like material which is provided with suitable slots 47 aligned with the apertures 20 and 21 of the cylinder 18. In the illustrated embodiment of the invention, the sealing member 46 is of a width slightly less than the length of the cylinder 18 and the opposite longitudinal ends are clamped within generally U-shaped connecting plates 48 and 49 respectively. The connecting plates 48 and 49 are disposed to the back of the cylinder and open towards each other with the crimped edges of the sealing member bent backwardly into the U-shaped connecting plates. Suitable coil springs 50 interconnect the plates 48 and 49 at laterally spaced locations to resiliently clamp the sealing member 46 to the face of the cylinder 18. Although not essential, the sealing member 46 will provide a highly effective sealing in the presence of foreign matter. The thickness of the sealing member 46 is preferably held to a minimum such that the valve seat is not excessively raised with a corresponding change in the curvature of the sealing bands.

The spring loaded tension of the bands 22 and 23 imparts an initial loading on the valve seat to assure a highly effective, liquid tight seal with zero pressure differential across the unit. Further, as the outer external pressure applied to the cylinder 18 increases, the sealing effectiveness increases.

In the operation of the illustrated gas separator, the liquid flow passes through the casing 6 between the inlet and outlet portions 8 and 7. The float 11 is normally in a raised or upper position with the valve activated cylinder 19 in a corresponding raised position, as shown in FIG. 5. In this position, the valve bands 22 and 23 are tightly clamped against the cylinder 18 and apertures 20 and 21 in the fixed cylinder 18 to positively seal the valve openings. The float 11 in moving the cylinder 19 upwards causes the sealing bands 22 and 23 to essentially freely roll over the sealing surface to affect the desired closure of the valve openings. The curved sealing bands permit them to resist a greater internal pressure for any given band thickness when compared with a relatively planar or flat type band seal. The reverse interconnection of the sealing bands 22 and 23 and the balancing bands 24 and 25 maintain the illustrated fixed relation and positively insure the rolling interengagement of the sealing bands with the fixed cylinder and the release of the balancing bands with respect to the fixed and moveable cylinders.

If a charge of air or a liquid-air mixture enters into the gas separator housing 6, the air rapidly rises into the higher portion of the float chamber 10 and displaces the liquid around the float 11. As the liquid level drops, it approaches the buoyancy limit level of the float 11 and at a selected level determined by the construction of the float causes the float to move downwardly with the liquid level. This results in a lowering of the float activated cylinder 19 with a rotation of the cylinder 19 accompanied by progressive release of the sealing bands 22 and 23 from the fixed cylinder 18 and a corresponding intersurface engagement of the balancing bands 24 and 25 with the surface of the cylinder 18. Simultaneously, bands 22 and 23 engage cylinder 19 and disengage cylinder 18, to establish the condition shown in FIGS. 4 and 5. As a result, the valve openings or apertures 20 and 21 are opened and the pressure from the valve assembly chamber 10 permits the accumulated air or other gas passes through the respective chambers of cylinder 13 to the air vent 5 and the pilot valve 4 to permit release of the accumulated air and to simultaneously provide a signal to the pilot valve 4. If there is sudden accumulation, the float 11 drops rapidly and the signal to pilot valve 14 terminates flow until a selected amount of the air escapes through vent 5.

As previously noted, the opposite or involuted bands interconnecting a pair of members having the curved surfaces is not self-contained and self-tracking valve assembly. Consequently, the operation of the gas separator does not depend on a preselected traveling of the float on a predescribed path. The float 11 is therefore allowed to travel freely between the upper attachment of the cylinder and the lower guide provided by the shaft guide 15.

Generally, the moveable cylinder 19 will roll freely and essentially frictionless because the energy released by unbinding of the one set of bands is equal to the energy required to bend the opposite set of bands.

The valve may be readily biased with a constant force to operate in either direction by changing the relative spring dimensions or spring characteristics of the band members. Such bias may be desirable in order to decrease the float operating load and respectively, the time to allow the valve to open more freely against pressure and the like.

Generally, the band material is to be selected in accordance with the life and duty cycle requirements. The band material may be subjected to a corrosive action as the result of moisture condensation should have a normally long life in excess of 10 years. An 18-chrome, 8-nickel alloy steel has been found to be suitable for a petroleum product system.

Although the invention as illustrated above has been found to provide a highly desirable action in connection with a gas separator for a petroleum product line, the invention can be employed in any other desired application and in other desired configuration. For example, the cylindrical construction is selected as providing a convenient method of formation of the assembly. However, it is obvious from the previous description of the invention that it is merely necessary to provide a curved contact surface for the bands, and that the configuration of the balance of the illustrated housing is not essential. Further, the cylindrical surface need only be that over which the bands engage and disengage. Further, the radii of the surfaces may be varied with respect to each other and the position and the configuration of the bands may be varied to obtain a desired result. For example, a series of different band and port arrangements are shown in FIGS. 7—10 for illustrating a limited number of possible variations which might be employed.

Referring particularly to FIG. 7, a single central band 5 is interconnected in fixed relation at its opposite end by suitable such screw attachment 52 and 53 to a pair of cylinders 54 and 55. The cylinder 54 is provided with a valve slot 56 aligned with the band 51. A pair of outward opposing bands 57 and 58 are (at the one end) secured to the cylinder 55 by similar spring 59 and 60 with the opposite ends fixed to the valve cylinder 54 by suitable screw attachment units 61 and 62. The bands 57 and 58 correspond to band 51 except that each is one-half the width of band 51. The cylinders are mounted for relative movement with respect to each other. Regardless of which cylinder is moving with respect to the other at any given time, the relative folding and unfolding of the band 51 with respect to bands 57 and 58 upon the surfaces of the cylinders produce a balanced action to thereby control the opening and closing of the valve aperture 56, generally similar to the previously described action of FIGS. 1—6.

A further modified embodiment of the invention is shown in FIG. 8, wherein three fixed inner and laterally spaced bands 63 aligned with corresponding slots 64 in a first cylinder 65. The bands are fixed to the cylinder 65 and a second cylinder 66. A pair of outward balancing bands 67 are secured to the cylinder 65 and resiliently interconnected by spings 69 to the cylinder 66. In the illustrated embodiment of the invention of FIG. 8, the pair of outward balancing bands 67 are each equal
to 1¼ times the width of each of the fixed port bands 63. Thus, the two outboard balancing bands 67 and 68 in total are equal to the dimensional configuration defined by the three fixed porting bands 63. Further, the slots or ports 64 are formed of a different configuration to provide a non-linear response. Thus, the one port 64, shown to the left in Fig. 8, is a generally triangular configuration while the intermediate port 64 is provided with an elliptical configuration. The shape of the valve ports will vary the response of the unit.

In Fig. 9, an unequal band bias construction is shown wherein a pair of inner central port bands 10 are secured in fixed relation to a pair of cylinders 71 and 72. Pairs of sequential ports 73 and 74 in alignment with the cylinder 71 includes bands 76 to further control the porting or valving characteristics. A pair of outboard balancing bands 75 are interconnected to the cylinders 71 and 72 with the one end fixed to the one cylinder 71 and the opposite end resiliently connected to the opposite cylinder 72. In the embodiment of Fig. 9, however, each of the outboard bands 75 is of somewhat greater width than the width of the porting bands. Consequently, there is an unequal bias tending to position the moveable cylinder 72 with respect to the fixed cylinder 71 to open the ports. This would allow easier opening of the valve structure and decrease the opening load on a float operated operator or the like.

A further embodiment of the invention is shown in Fig. 10 having a changing bias rate on the bands, which is otherwise similar to illustration of the first embodiment of FIGS. 1—6.

In Fig. 10, the porting bands 76 and the balancing bands 77 are similarly formed with tapered side which will change the bias force at different varying rates at each relative position of the cylinders.

In the illustrated embodiments of the invention, the valve ports have been shown in a fixed cylinder. The valve ports may be provided in the opposite or both cylinders by providing suitably sealing means and input output connections. Further, although one cylinder has been shown moveable and the opposite fixed, within the broadest aspect of the invention both may be movable mounted if required for a particular application.

The present invention thus provides a reliable and low force valve assembly which may have long service life with minimal maintenance.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is required as the invention.

I claim:

1. A fluid valve assembly comprising:
   a pair of valve members having cylindrical surfaces, at least one of said valve members having a valve opening within the corresponding cylindrical surface;
   a first band means having a normal position and resiliently bendable therefrom, said band means passing between said members in a fixed direction and bent about the curved end connected at spaced portions to said valve members and aligned to cover and uncover said valve opening; and
   a second band means having a normal position and resiliently bendable therefrom, said second band means passing between said members in the opposite direction from said first band means and connected at spaced portion to said valve members, said band means defining essentially the sole interconnection therebetween and having the path of said members defined by said band means.

2. The fluid valve assembly of claim 1 wherein said one valve member is relative to the second valve member, said fixed valve member including said valve opening.

3. The fluid valve assembly of claim 1 wherein:
   said first band means includes a pair of laterally spaced flat metal strips passing between said members, said metal strips being formed of a resilient metal and fixed to the members; and
   said second band means includes a pair of laterally spaced similar metal strips and disposed to the opposite sides of the first band means and passing between said members in an opposite direction.

4. The fluid valve assembly of claim 1 wherein said valve opening is shaped to a nonlinear response.

5. The fluid valve assembly of claim 1 wherein said band means are constructed with different spring characteristic to bias said valve member to a preselected position.

6. The fluid valve assembly of claim 1 wherein said valve member includes a plurality of laterally spaced valve openings, said band means being aligned with said plurality of valve openings, and internal wall means disposed between selected valve openings to define separate internal pressure chambers.

7. A fluid valve assembly comprising:
   a first fixed cylinder having opposite end sealing members to define an internal output chamber, said cylinder having at least one valve opening;
   a second cylinder;
   a resilient flexible band extending between said cylinders in alignment with said valve opening;
   a first securing means connecting said flexible band to said first cylinder to one end of said valve opening;
   a second securing means connecting said flexible band to said second cylinder;
   a second flexible band extending between said cylinders to one side of said first band, said second flexible band extending over the first and second cylinders in the opposite direction from said first flexible band;
   a third securing means connecting said flexible band to said first cylinder in spaced relative to said first securing;
   a fourth securing means connecting said flexible band to said second cylinder with said second flexible band extending over said second cylinder in the opposite direction of said first flexible band; and
   at least one of said securing means including a resilient tensioning means acting between the corresponding flexible band and cylinder.

8. The fluid valve assembly of claim 7 wherein said first cylinder includes an internal wall dividing the internal output chamber into a pair of output chambers, said first cylinder having valve openings extending circumferentially of the cylinder in alignment with each of said output chambers:
   said first flexible band being aligned with a first of said valve opening;
   a third flexible band connected to said first and second cylinders in alignment with the second of said valve openings in accordance with the connection of the first flexible band;
   a fourth extending between said cylinders in the direction of said second flexible band and connected to said cylinders in accordance with the connection of said second flexible band; and
   said securing means including corresponding resilient tensioning means for the corresponding acting bands.

9. The fluid valve assembly of claim 8 wherein said internal wall includes a releasable opening for selectively connecting said output chambers in direct communication.

10. A fluid valve assembly comprising:
   a fixed valve cylinder having a circumferential valve opening;
   a movable valve cylinder disposed adjacent the fixed valve cylinder;
   a pair of bands formed of resilient flexible strips passing between said members;
   a second band means passing between said members in an opposite direction from said first pair of bands; and
   means connecting the first pair of bands and the band means to said valve cylinders and defining essentially the sole interconnection therebetween and having the path of said movable cylinder defined solely by said bands and
9 band means, said valve opening being aligned with one of said band means and said pair of bands for progressive opening and closing as said movable cylinders moves relative said fixed cylinder.

11. The fluid valve assembly of claim 10 having securement means including a resilient tensioning means connecting said band means to one of said cylinders to preload said movable cylinder.

12. The fluid valve assembly of claim 10 wherein said second band means includes at least a pair of balancing bands formed of resilient flexible strips, said bands being formed with a progressively varying cross section to vary the spring characteristic.
UNIVERS STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,536,099 Dated October 27, 1970

Inventor(s) CHARLES D. ERICKSON

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:
Column 4, line 36, "as set by" should read --as by set--
Column 8, line 54, after "fourth" insert --flexible band--

Signed and sealed this 23rd day of March 1971.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents