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Easton

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[54] **HIGH PRESSURE EXPANSIBLE CHAMBER DEVICE**

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[52] **U.S. Cl.** .... **418/61 B;** 418/270; 251/175

[51] **Int. Cl.** **F01c 1/02;** F03c 3/00; F16k 25/00

[58] **Field of Search** .... 418/61 B, 270; 251/175; 91/180, 485, 487

[56] **References Cited**

UNITED STATES PATENTS

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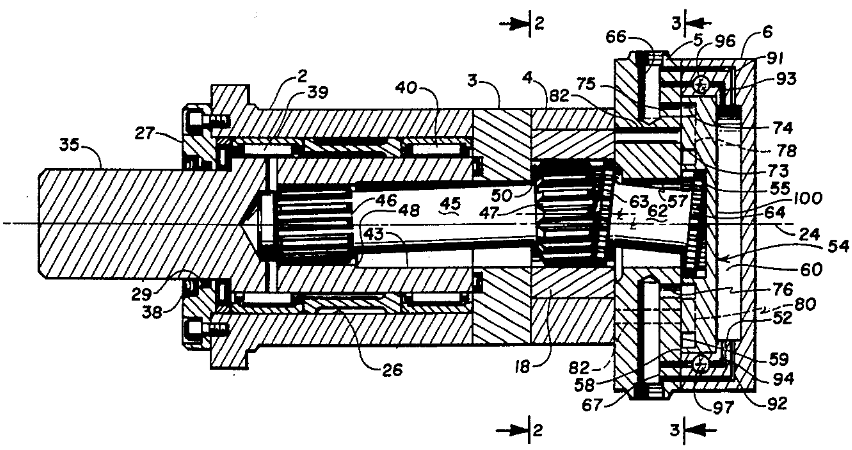
Primary Examiner—John J. Vrablik

[57] **ABSTRACT**

The invention relates to an expansible chamber type of device which is especially adapted for use with high pressure operating fluids. The device has a valve which directs pressurized fluid from an inlet port to the expanding chambers thereof and non-pressurized fluid from the contracting chambers thereof to an outlet port. A valve sealing arrangement is provided whereby pressurized fluid is utilized to bias the valve into sealing engagement with a valve block which contains passages leading to the expanding and contracting chambers. A main feature is that the inlet and outlet ports are reversible from the standpoint that either port may be used as the inlet port to obtain a desired direction of rotation without adversely affecting the operativeness of the sealing arrangement. Another feature is that the valve biasing forces are balanced so that the net force which biases the valve is only slightly larger than the axially directed opposing force regardless of the direction of rotation of the main shaft of the device.

3 Claims, 4 Drawing Figures



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SHEET 1

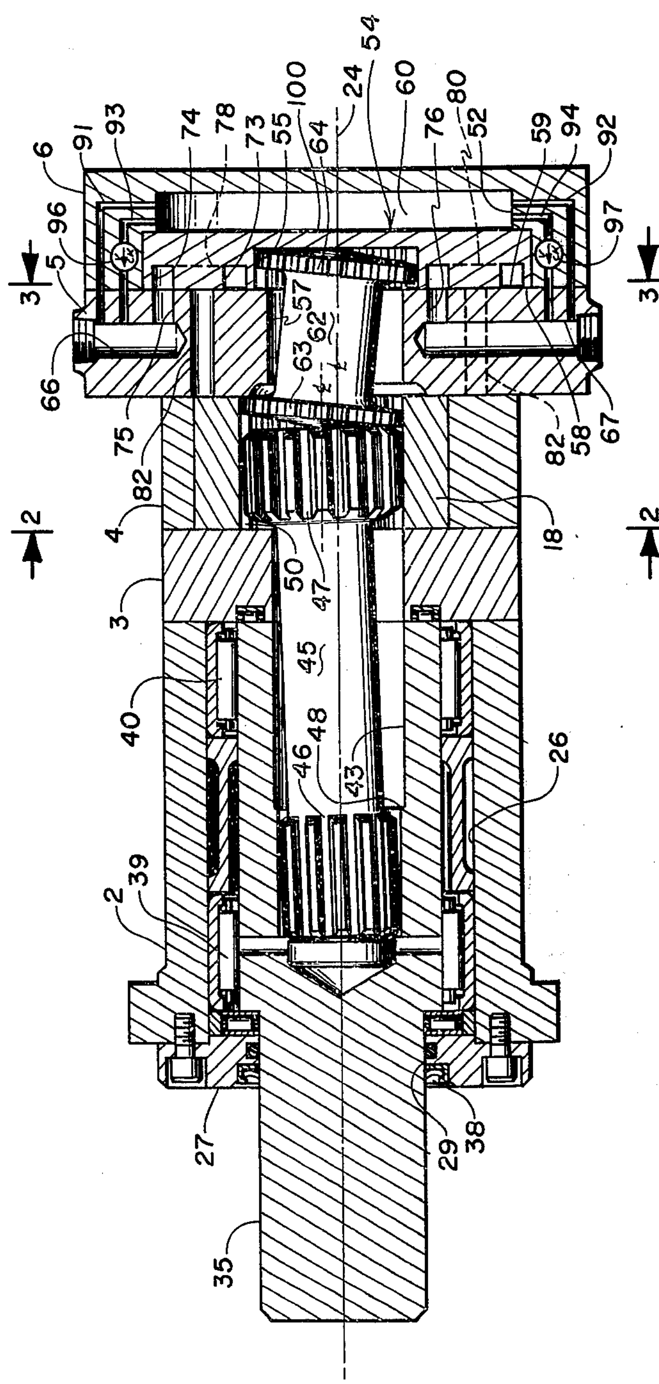


Fig. 1

Fig. 3

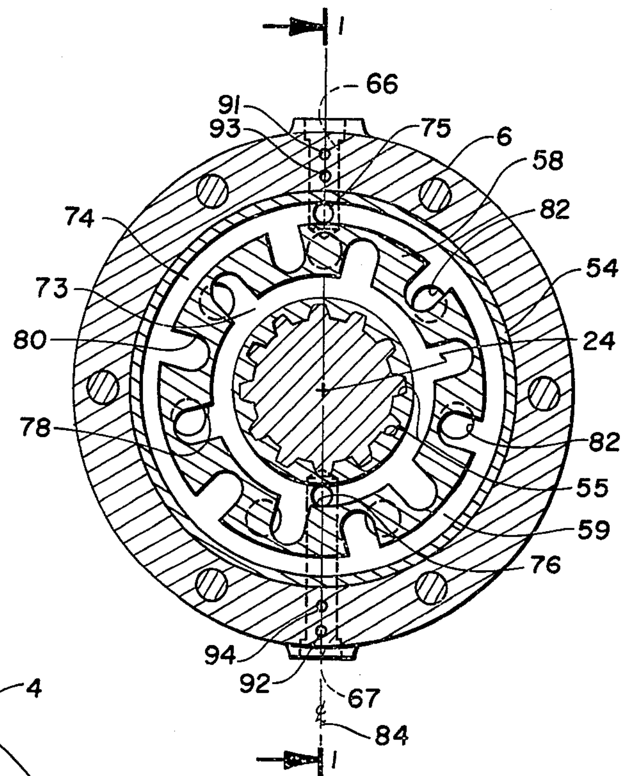


Fig. 2

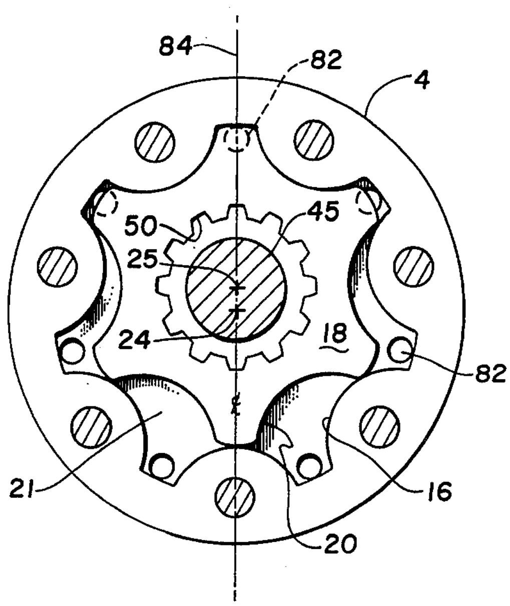
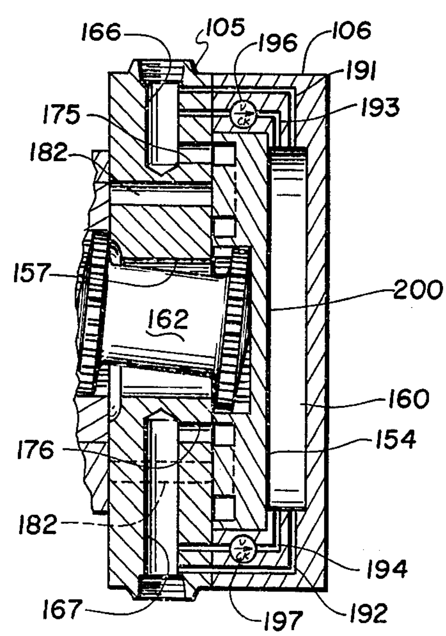


Fig. 4



HIGH PRESSURE EXPANSIBLE CHAMBER DEVICE

The invention relates to an expansible chamber type of device which is especially adapted for use with high pressure operating fluids. Such devices commonly have a valve which directs pressurized fluid from an inlet port to the expanding chambers thereof and non-pressurized or spent fluid from the contracting chambers thereof to an outlet port.

A sealing arrangement must be provided for and in connection with such a valve to prevent or deter the short circuiting of pressurized fluid from the high pressure side to the low pressure side or from the high pressure side through a shaft seal to a point externally of the device.

The expansible chamber device of the present invention is provided with a sealing arrangement in which (1) the high pressure fluid is transferred across only one pair of relatively movable surfaces which are the surfaces of a valve, (2) the valve surfaces are biased together by the pressurized operating fluid, (3) the inlet and outlet ports are reversible from the standpoint that either port may be used as the inlet port to obtain a desired direction of rotation without adversely affecting the operativeness of the sealing arrangement, and (4) the forces developed for biasing the valve into sealing engagement are only slightly larger than the axially directed opposing forces regardless of the direction of rotation of the device.

The object of the invention is to provide an expansible chamber type of device having a new and improved valve biasing the sealing arrangement.

Other objects and advantages of the invention will become apparent from the following specification, drawings and appended claims.

In the drawings:

FIG. **1** is a longitudinal sectional view of a fluid pressure device embodying the invention, taken on line I—I of FIG. **3**;

FIG. **2** is a slightly enlarged transverse sectional view taken on line II—II of FIG. **1**;

FIG. **3** is a transverse sectional view taken on line III—III of FIG. **1**; and

FIG. **4** is a fragmentary sectional view similar to the right hand end of FIG. **1** but altered to illustrate a modification of the invention.

In the illustrated embodiment of the invention there is provided a casing assembly comprising a generally cylindrically and annularly shaped shaft housing **2**, a cylindrically shaped spacer disk **3**, a cylindrically shaped gerotor section **4**, a cylindrically and annularly shaped valve block section **5** and a cylindrically shaped valve housing section **6**. Casing sections **2** to **6** are held together in axial alignment by a plurality of circumferentially spaced bolt means in a known manner.

With reference to FIG. **2**, the gerotor casing section **4**, which may be referred to as a ring member **4**, has a plurality of internal teeth **16**. An externally toothed star member **18**, having at least one fewer teeth **20** than ring member **4**, is disposed eccentrically in the chamber of space formed and surrounded by ring member **4**. Star member **18** is movable in an orbital path about the axis **24** of ring member **4** and rotates about its own axis **25**. During orbital movement of star member **18** the teeth **20** thereof intermesh with the ring member teeth **16** to form expanding and contracting cells **21** which are equal in number to the number of teeth **20** of star member **18**.

The generally cylindrically shaped shaft housing **2**, has an axial bore **26** concentric with axis **24**. An end cap **27** is connected to shaft housing **2** and has an axial opening **29** adapted to receive an output shaft **35**. Output shaft **35** is positioned in shaft housing **2** for rotation within bore **26** about axis **24**. Bearing assemblies **39** and **40** are positioned in housing **2** to receive shaft **35**. Shaft **35** has an internal, axially extending receiving bore **43**.

The shaft connection between the star gear **18** and the output shaft **35** is provided by a universal type of drive or wobble shaft **45** having splined end portions **46** and **47**. Output shaft **35** has an internal spline **48** which is engaged by the splined end **46** of the shaft **45**. The splined portion **47** of shaft **45** meshes with an internal spline **50** of the star gear member **18**.

Casing section **6** is cylindrically shaped and has an internal bore **52**. Rotatably journalled in valve casing section **6** for rotation about the main axis **24** of the motor is a valve **54**. Valve **54** is illustrated as having an internally splined central bore **55** opening towards valve block **5**. Valve **54** is illustrated as being journalled relative to and having rotary sliding engagement with casing bore **52** but the precise mounting arrangement is entirely optional.

Valve block **5** has a central bore **57** and valve **54** has a radially extending, annularly shaped surface **58** which is cooperable in rotational sliding engagement with the adjacent radially extending, annularly shaped surface **59** of valve block **5**. The enclosure defined by valve block **5** and casing section **6** defines a valve chamber **60**.

A drive or wobble shaft **62** extends through valve block bore **57** and mechanically connects star **18** and valve **54** in driving relation. Heads **63** and **64** at opposite ends of shaft **62** are splined with the head **63** having meshing engagement with the internal spline **50** of star **18** and head **64** having meshing engagement with the internal spline **55** of valve **54**. Valve **54**, by reason of the shaft connection between it and star **18**, will rotate at the same speed as the star **18** but in the opposite direction from the orbiting direction of the star **18**. Shaft **35** will, for the same reason, rotate at the same speed as star **18** but in the opposite direction from the orbiting direction of star **18**.

Valve block **5** is provided with inlet and outlet ports **66** and **67**, either of which may be the inlet or the outlet. Valve **54** and valve block **5** are provided with fluid passage means, which are described in detail further on herein, through which fluid is conveyed from the port **66** or **67** to the cells **21** of the gerotor and returned to the other of the ports **66** or **67**. Ports **66** or **67** will be the inlet depending on the direction of rotation desired for shaft **35**.

Recessed inner and outer annular channels **73** and **74** are provided in the face **58** of valve **54** which are concentric relative to ring axis **24**. Either or both of the channels **73** and **74** may be in either the face **59** of valve block **5** or the face **58** of valve **54** although both channels **73** and **74** are illustrated as being in the face of valve **54**. Channels **73** and **74** are radially aligned respectively with axially extending passages **75** and **76** in casing section **5** which have respective fluid communication with inlet and outlet ports **66** and **67**.

With reference to FIG. 3, valve **54** has a plurality of radially extending, circumferentially arranged and spaced grooves which are illustrated herein as a set of six grooves **78** which intersect and are in fluid communication with annular channel **73** and a set of six grooves **80**, alternately spaced relative to grooves **78**, which intersect and are in fluid communication with annular channel **74**. In the fluid pressure device illustrated the grooves **78**, and the grooves **80** are equal in number to the number of teeth **20** on the star **18**.

Casing section **5** has a plurality of generally axially extending, circumferentially arranged and spaced passages **82** illustrated as being seven in number which is equal to the number of teeth **16** of the ring member **4**. Passages **82** open into the radial face **59** of casing section **5** which face slidingly engage the radial face **58** of valve **54**.

Upon rotation of valve **54**, each of the grooves **78** and **80** thereof successively registers in fluid communication with each of the passages **82** in casing section **5**. Fluid is supplied to and withdrawn from the gerotor through passages **82** which terminate at points which constitute junctions (see FIG. 2) between the teeth **16** of ring member **4**.

Assuming that the fluid pressure device is functioning as a motor, pressurized fluid may be introduced into port **66** or port **67**, depending on the direction of rotation desired for shaft **35**. Assuming fluid is introduced into port **66**, it would flow from there through casing passage **76** to annular channel **74** and all of the grooves **80** in valve **54**, through certain of the passages **82** in casing section **5** on the right sideof the line of eccentricity **84** as viewed in FIG. 3, to certain gerotor cells **21** which, for an instant, as viewed in FIG. 2, are on the left side of the line of eccentricity **84**. The expansion of the cells **21** on the left side of the line of eccentricity **84** causes star **18** to orbit in a clockwise direction and causes collapsing of the cells **21** on the right side of the line of eccentricity **84**. Fluid from the collapsing cells **21** flows through casing passages **82** on the right side of the line of eccentricity **84**, as viewed in FIG. 2 (on the left side of the line of eccentricity as viewed in FIG. 3) through annular channel **73** to passage **75** and out port **67**. The above description of fluid flow is only for an instantaneous condition in that the line of eccentricity **84** rotates about the axis **24** of ring member **4**. As long as pressurized fluid is admitted through port **66**, however, the pressurized fluid will always be admitted to cells **21** on the same side of the line of eccentricity **84** and fluid will always be exhausted on the other side of said line.

Valve **54** is a commutating type valve in that it rotates at the same speed the star **18** rotates but it functions to supply and exhaust fluid to and from the gerotor at the orbiting frequency of the star.

Valve **54** is illustrated with a known type of fluid flow distribution pattern (referred to herein for convenience as FFDP) formed in the valve face **58** as may be best seen in FIG. **2.** The FFDP of any valve used must have separate and distinct fluid feeding and exhausting sections and either of such sections will be the feeding section (and the other and exhausting section) depending upon which of the ports **66** or **67** is the inlet port. In valve **54**, feeding and exhausting sections are formed with two sections **73, 78** and **74, 80** which are recessed relative to the valve face **58.** Assuming port **66** to be the inlet port, section **74, 80** will be the feeding section and section **74, 78** will be the exhausting section.

If port **66** is used as the inlet port, valve block passages **66** and **76** and valve section **74, 80** form fluid inlet path means; concomitantly, valve section **73, 78** and valve block passages **75** and **67** form fluid outlet path means. If port **67** is used as the inlet port, valve block passages **67** and **75** and valve section **73, 78** form fluid inlet path means; concomitantly, valve section **74, 80** and valve block passages **76** and **66** form fluid outlet path means.

Reference is now made to the manner in which the valve **54** is biased into sealing engagement with the face **59** of valve block **5.** For this purpose there are provided restrictor passages **91** to **94** in the casing sections **5** and **6** which extend from the inlet and outlet passages or ports **66** and **67** to the valve chamber **60.**

A restrictor passage, as that term is used herein, means a relatively small fluid flow passage which presents substantial resistance to the flow of pressurized fluid therethrough so as to effectively throttle the flow of fluid. As illustrated, restrictor passages **93** and **94** have check valves **96** and **97** which prevent the flow of fluid through these passages from the ports **66** and **67** into the chamber **60.** The restrictor passages **91** to **94** and the check valves **96** and **97** are shown in a more or less schematic form in that it is their functions rather than the specific forms they take that is of importance as far as the invention is concerned.

The matter of biasing the valve **54** is intimately related to the configuration of the fluid pressure distribution pattern defined between the faces **58** and **59** of the valve **54** and the valve block **5.** In the illustrated embodiment of the invention the recessed annular feeding and exhausting channels **73** and **74**, and the respectively associated grooves **78** and **80**, are of unequal area and the unequalness of these areas is of significance. The area of annular channel **73** and the associated grooves **78** is about **20** percent of the area of the surface **100** on the opposite side of the valve. The area of annular channel **74** and the associated grooves **80** is greater by reason of having a greater diameter and is about **30** percent of the area of the valve surface **100.**

Depending on whether pressurized fluid is admitted to the port **66** or the port **67**, the force biasing the valve **54** to the right will be proportional to either the combined area of channel **73** and the associated grooves **78** or the combined area of channel **74** and the associated grooves **80.** If pressurized fluid having the same pressure as the inlet pressure were admitted to the valve chamber **60**, the pressure acting over the whole area of the rear valve surface **100** would result in a force biasing the valve to the left which will be on the order of three to five times greater than the force biasing it to the right. This would result in a net force to the left which would cause a substantial resistance to turning the valve and substantial wear to the valve surface **58.**

Assuming that pressurized fluid is admitted through port **66**, pressurized fluid in annular channel **74** and grooves **80** would react against the valve block **5** to bias the valve towards the right with a force corresponding to **30** percent of the valve area **100.** If only restrictor passages **91** and **92** were present, and each such passage had a restrictor value of unity, the pressure drops across the restrictor passages **91** and **92** would be equal and the pressure in the chamber **60** would be about one-half the pressure of pressurized fluid in port **66.** By way of comparison, one-half the supply pressure acting over the entire area of valve surface **100** results in a force which is substantially greater than the opposing force which results from substantially the full supply pressure in annular channel **74** and grooves **80** acting on an area which is only 30 percent of the area on the front side of the valve **54.**

In order to achieve precise balancing of the opposing forces there must be a still lower pressure in chamber **60** and such a lower pressure is achieved by adding the restrictor passage **94.** If the supply pressure were 1000 psi, a pressure of 300 psi in chamber **60** would cause the opposing forces to be approximately equal. This pressure of 300 psi may be realized by making the combined restrictor value of the parallel restrictors **92** and **94** equal to three-sevenths of the restriction value of restrictor passage **91.** Assuming restrictor passages **91** and **92** each has a relative value of unity, the value of restrictor passage **97** would be three-fourths of unity.

When reversed operation is desired, pressurized fluid is admitted to port **67.** The annular channel **73** and the associated grooves **78** would be pressurized and a force corresponding to about 20 percent of the valve area **100** would bias the valve towards the right. Assuming again that the supply pressure is 1,000 psi, a pressure of 200 psi in chamber **60** would cause the opposing forces to be approximately equal.

With pressurized fluid admitted to port **67,** restrictor passage **94** is made ineffective by providing the check valve **97** therein which allows fluid flow out of the chamber **60** to the port **67** but prevents flow into the chamber. With restrictor passage **94** being inactive, a pressure of 200 psi in chamber **60** is realized by making the combined restriction value of the parallel restrictors **91** and **93** equal to one-fourth the restriction value of restrictor passage **92.** If restrictor passages **91** and **92** each had a relative value of unity, the value of restrictor passage **93** would be one-third of unity.

Restrictor passage **93** is provided with check valve **96** so that restrictor passage **93** is ineffective when pressurized fluid is supplied to port **66** in the same manner that restrictor passage **97** is made inactive when pressurized fluid is supplied to port **67.**

Referring to FIG. **4,** the fragmentary section thereshown has elements corresponding generally to elements of the unit shown in FIG. **1** and such corresponding elements are referenced with the same numerals increased by one hundred.

In FIG. **4,** there is shown a valve housing section **106** which is similar to the corresponding valve housing section **6** of the invention embodiment shown in FIG. **1.** The difference generally is that one way valves **196** and **197** in restrictor passages **191** and **192** are oppositely positioned so that they permit the flow of pressurized fluid into the valve chamber but prevent the flow of fluid out of the chamber.

The arrangement of FIG. **4** is to provide for precisely determined pressures for the valve chamber which are greater than 50 percent of the value of the supply pressure. Assuming that the resistance values of restrictors **191** and **192** are equal, the total resistance to the flow of fluid through restrictors **191** and **193** is less than the resistance presented by restrictor **192** and hence the pressure in the valve housing will be greater than 50 percent of the supply pressure by any desired amount.

The restrictor passages **91** to **94** and **191** to **194** could be provided in the valve instead of the casing in the event that circumstances would make such a design feasible or desirable. From the standpoint of the theory of the invention it is only important that one set of restrictor passages be provided between the inlet flow path and the chamber **60** and that another set of restrictor passages be provided between the outlet flow path and the chamber **60.** As explained above, the inlet and outlet flow paths extend from the inlet casing passages to the inlet valve passages and from the outlet valve passages to the outlet casing passages. It will thus be understood that the inlet and outlet flow paths include the movable valve passages as well as the stationary casing passages.

In the operation of the device, pressurized fluid admitted through the port **66** or **67** and exhausted through the opposite port supplies the energy for driving the shaft **35** through the gerotor mechanism in a known manner as described. A novel innovation, however, is in the use of restrictor passages for pressurizing the valve chamber **60** to predetermined intermediate values which provide precise balancing of the valve **54** regardless of which port **66** or **67** is used as the inlet port. The restrictor passages may take various forms and may even be large passages equipped with throttle valve means which substantially restrict the flow of pressurized fluid through the passages. By way of example, it is expected that the flow rate of fluid through the restrictor passages may be on the order of 1 percent or less of the flow rates through the ports **66** and **67** but practical design considerations may require some deviation from these anticipated values.

I claim:

1. A fluid pressure operated device of the expansible chamber type comprising a casing, expansible chamber means, a valve block having a fluid transfer surface, said valve block having a plurality of expansible chamber feeding and exhausting passages having fluid communication with said expansible chamber means and having openings in said transfer surface, a valve having a surface engaging said transfer surface, said valve surface having recessed feeding and exhausting sections,- reversible inlet and outlet passages in said valve block having openings in said transfer surface and respective constant fluid communication with said feeding and exhausting sections of said valve, said valve block inlet passage and said valve feeding section forming fluid inlet path means, said valve block outlet passage and said valve exhausting section forming fluid outlet path means, said valve being cyclically movable relative to said transfer surface with said feeding and exhausting sections thereof sequentially feeding and exhausting said expansible chamber passages, said casing forming a valve biasing pressure chamber for said valve, first restrictor passage means between said inlet path and said chamber and second restrictor passage means between said outlet path and said chamber to provide a predetermined valve biasing pressure in said chamber intermediate the fluid pressures in said inlet and outlet passages, the magnitude of said biasing pressure being dependent on which one of said reversible inlet and outlet passages is used as an inlet passage, said first and second restrictor passage means each including at least two passages with at least one passage thereof being a one-way passage and at least one other passage thereof being a two-way passage and drive means between said expansible chamber means and said valve.

2. A fluid pressure device according to claim **1** wherein each of said one-way passages precludes the flow of fluid therethrough into said chamber.

3. A fluid pressure device according to claim **1** wherein each of said one-way passages precludes the flow of fluid therethrough out of said chamber.

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