# United States Patent

**Woodling**

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[45] **Apr. 25, 1972**


[54] **BALANCED FLUID PRESSURE VALVE MEANS**


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[52] **U.S. Cl.** .......... **418/61,** 251/175

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

[58] **Field of Search** .......... 418/61; 251/175, 180, 185, 251/192; 91/484, 485


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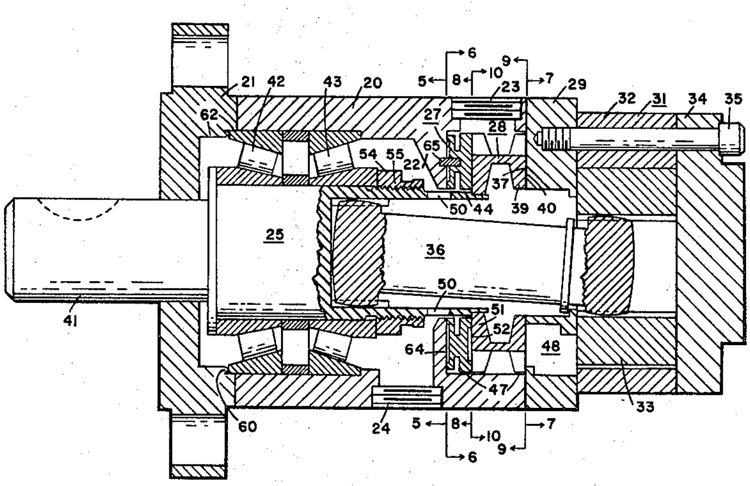
*Attorney*—Woodling, Krost, Granger and Rust


[57] **ABSTRACT**


Stationary valve means and rotary body means are provided with bushing means including pressure balancing pattern means. The rotary body means has first and second opposed body sides. The first opposed body side constitutes rotary valve means confrontingly engaging the stationary valve means. The second opposed body side constitutes rotary pattern means having a rotary pattern face axially spaced from and facing a stationary reaction wall. The bushing means is non-rotatively mounted between the stationary reaction wall and the rotary pattern face and has first and second end portions. Said first end portion includes a self-prevailing resilient flange confrontingly engaging the stationary reaction wall. The second end portion constitutes non-rotative pattern wall means having a non-rotative pattern face confrontingly engaging said rotary pattern face of said rotary body means. The resilient flange is under axial restraint and transmits an axial thrust to constrain said rotary valve face against said stationary valve face. The bushing means also has pressure responsive means for transmitting an axial fluid force to the rotary body means. Said non-rotative pattern wall means and said rotary pattern means constitute said pressure balancing pattern means to substantially balance said rotary body means between said stationary valve face and said non-rotative pattern face.


**33 Claims, 21 Drawing Figures**



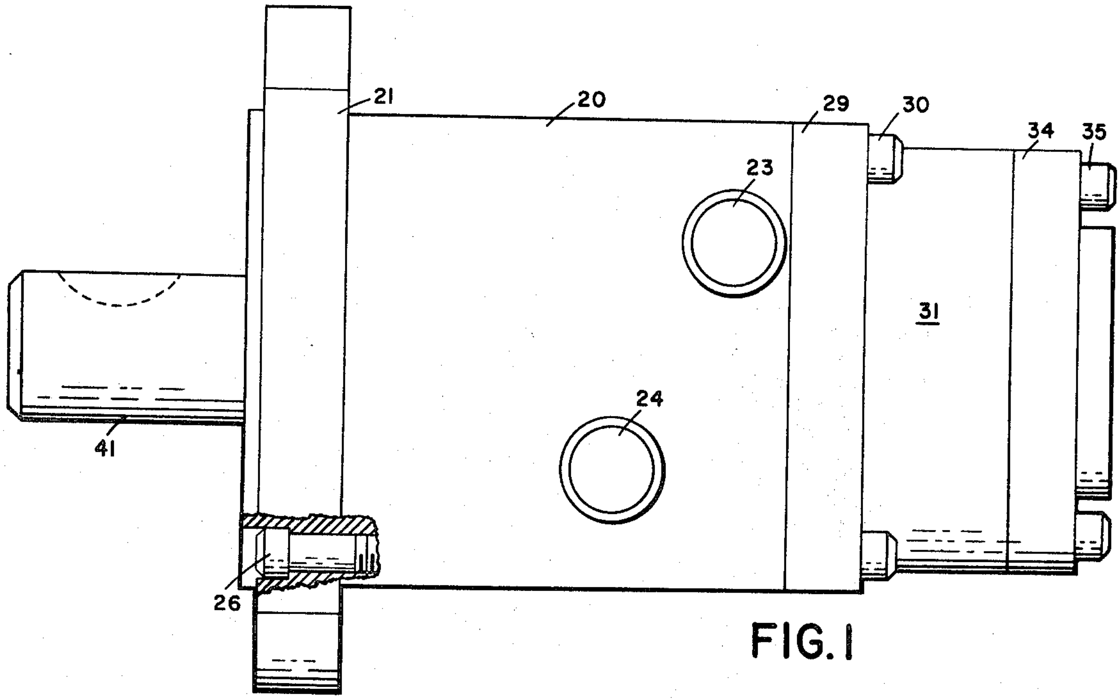



FIG. 1

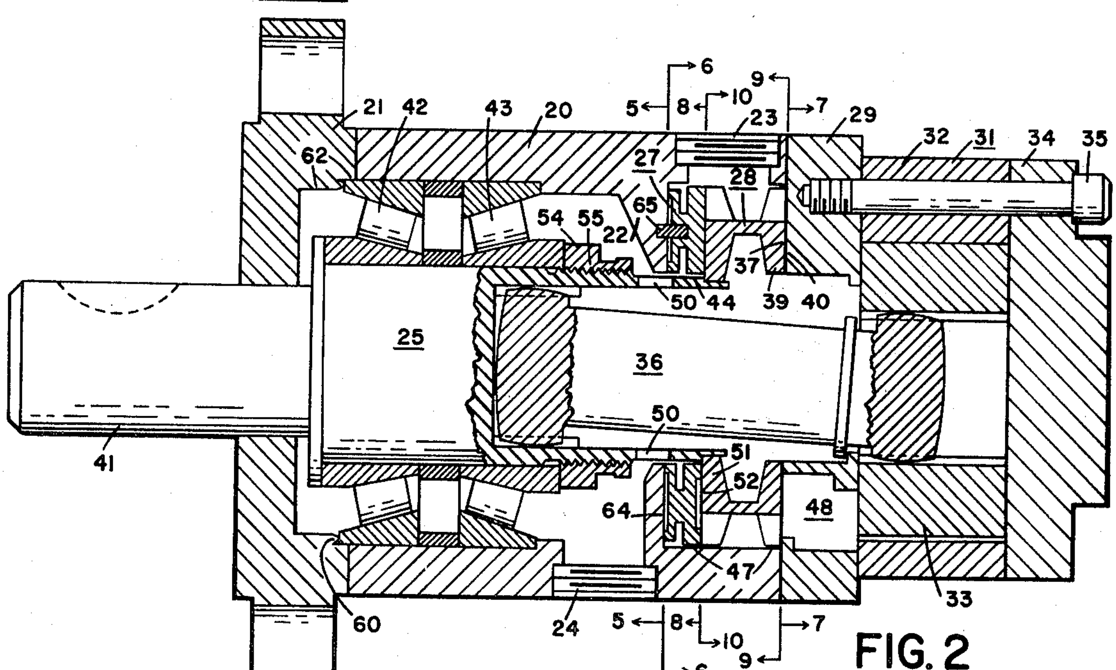



FIG. 2

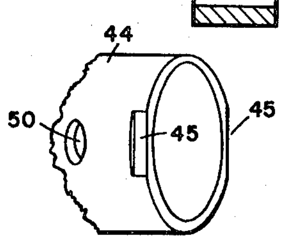



FIG. 3

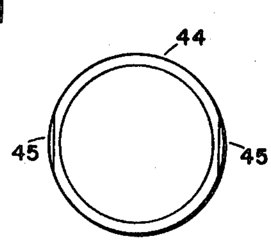



FIG. 4

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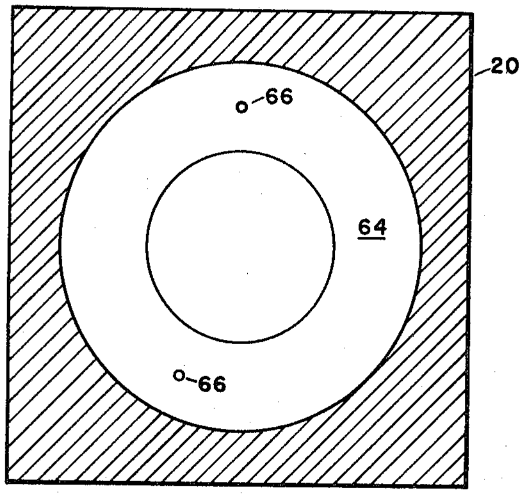


FIG.5

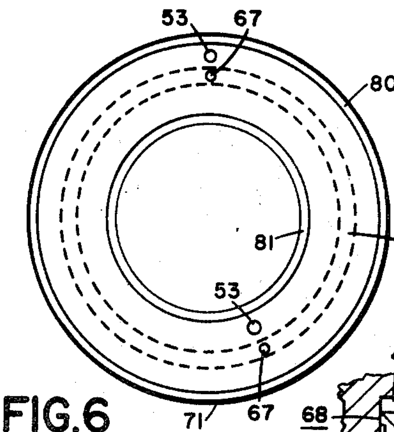


FIG.6

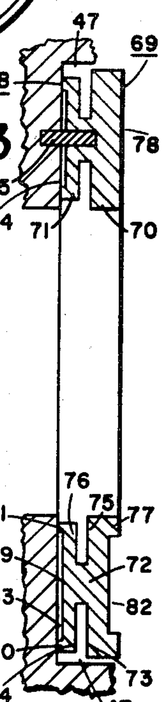


FIG.13

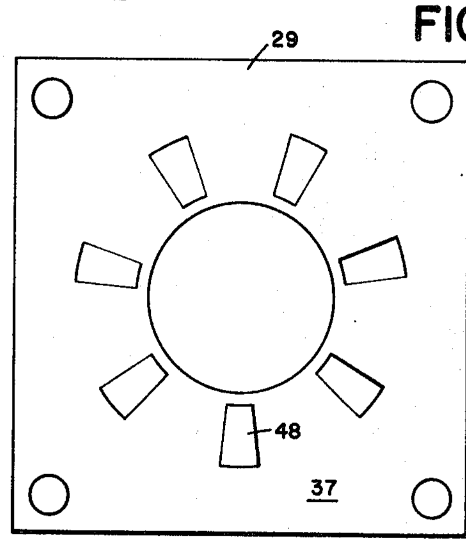


FIG.7

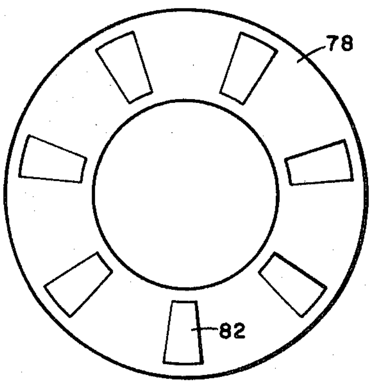


FIG.8

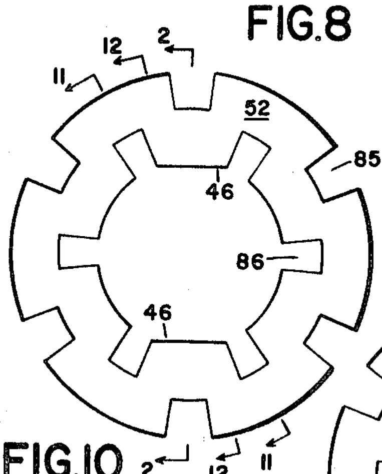


FIG.10

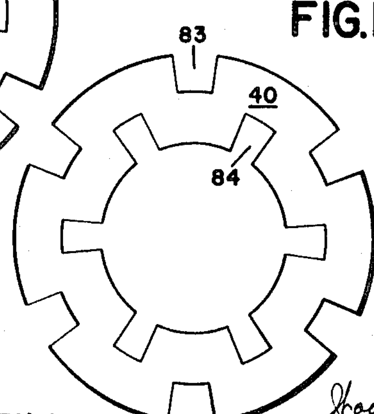


FIG.9

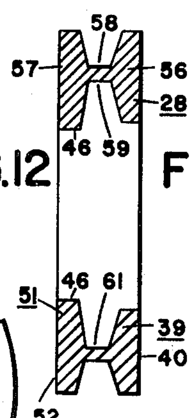


FIG.12

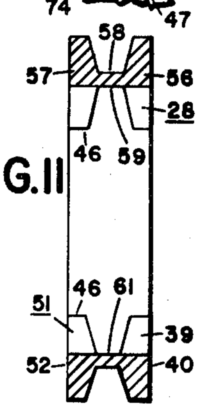


FIG.11

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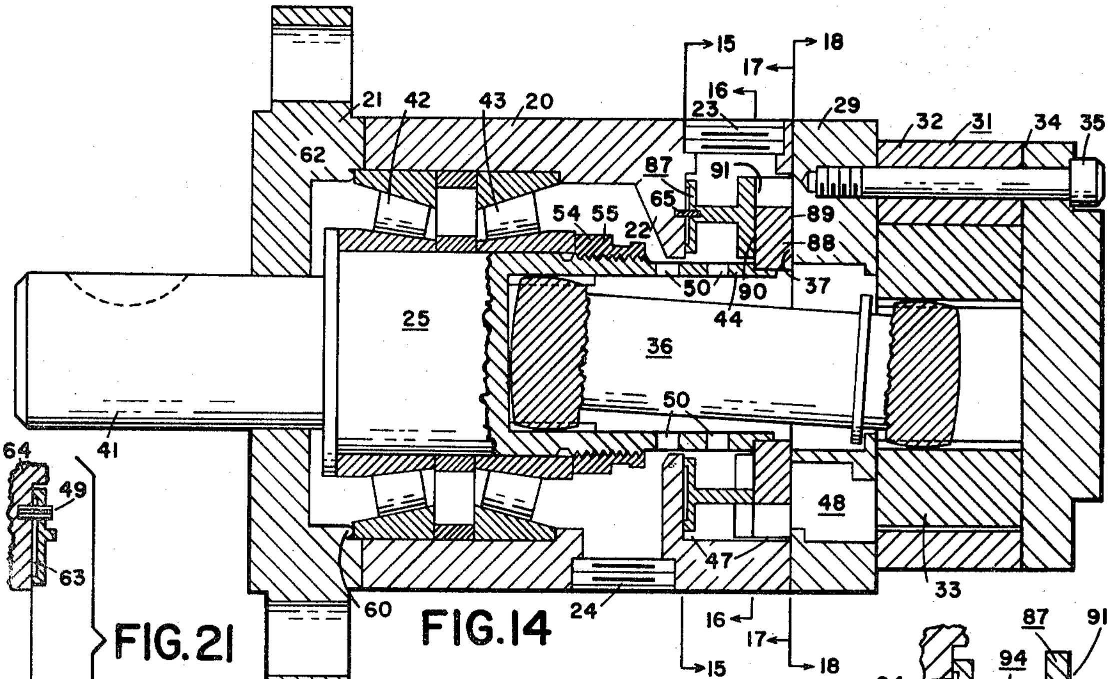


FIG.14


FIG.21

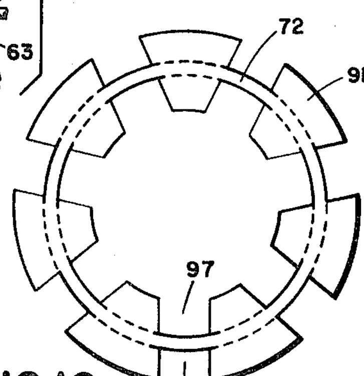


FIG.16

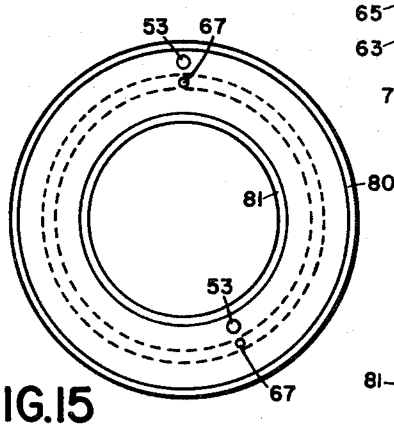


FIG.15

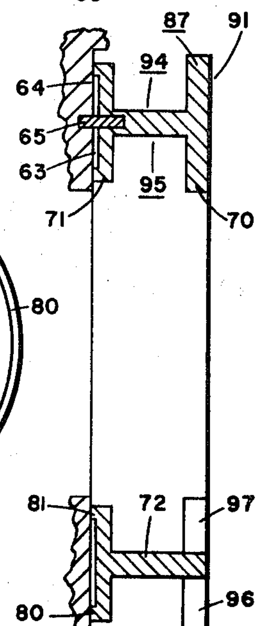


FIG.19

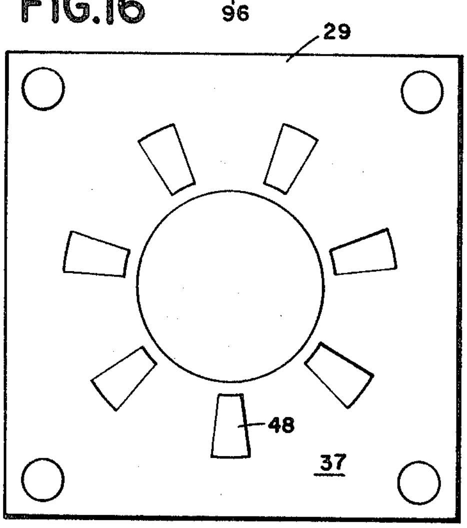


FIG.18

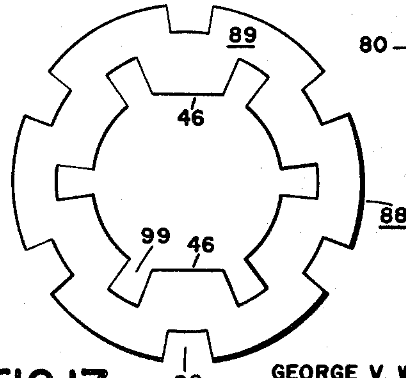


FIG.17


FIG.20

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## BALANCED FLUID PRESSURE VALVE MEANS

### BACKGROUND OF THE INVENTION

Mutually engaging fluid valve faces, such as the faces between a stationary valve and a rotary valve are prone to fluid leakage which reduces the effectiveness of the valve action. Attempts to overcome this leakage usually involves a manufacturing effort to maintain close mechanical tolerances between the mutually engaging fluid valve faces to a value in the order of approximately 0.0005 of an inch, which of course, is difficult to accomplish consistently, let alone being expensive. This manufacturing procedure allows no provision for wear between the mutually engaging faces which induces more leakage.

Accordingly, it is an object of my invention to provide for axially constraining the mutually engaging valve faces together.

Another object is to provide for means to accomplish such constraining action with a minimum of cost.

Another object is to provide for balancing the valve action by a first fluid axial force produced by pressure responsive means and by a second fluid axial force produced by a piston-effect.

Another object is to provide for axially constraining the mutually engaging valve faces together by a simple one-piece, all metal bushing having self-prevailing resilient means for producing a resilient axial force.

Another object is the provision of a rotary body which constitutes both a rotary valve and a rotary pattern.

Another object is the provision of pressure balancing pattern means for hydraulically balancing the rotary body in an axial direction.

### SUMMARY OF THE INVENTION

The invention constitutes axial-thrust bushing means for urging a relatively movable body means against a stationary valve face of stationary valve means, said bushing means and said body means being operatively disposed between stationary reaction wall means and said stationary valve face, said relatively movable body means having first body side means constituting movable body valve means having a body valve face confrontingly engaging said stationary valve face and having second body side means constituting movable body wall means having a movable body face confronting said bushing means, said bushing means having first and second end portion means, said first end portion means including resilient wall means confrontingly engaging said reaction wall means, said second end portion means including bushing wall means having a bushing wall face confrontingly engaging said movable body face, and actuating means for said relatively movable body means for actuating said body valve means relative to said stationary valve means and said body face means relative to said bushing wall means, said resilient wall means being under axial restraint and transmitting an axial thrust to said relatively movable body means and thereby urging said body valve face axially against said stationary valve face.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top plan view of a fluid pressure device embodying the features of my invention;

FIG. 2 is a longitudinal sectional view of FIG. 1, the section being taken along a line 2—2 of FIG. 10, except that the sectional view, for clarity, is taken as if it were extended through both of the fluid port means which are located on opposite sides of the longitudinal section;

FIG. 3 is a representation of a male shank provided on a terminal end portion of a hollow shaft adapted to slidably fit within a female socket of the rotary body means, the male shank being rotated 90° from the position shown in FIG. 2 to show the interfitting flat pads on opposite sides thereof;

FIG. 4 is an end view of the hollow male shank of FIG. 3;

FIG. 5 is a cross-sectional view of FIG. 2, taken along the line 5—5 thereof and showing principally an annular confronting face of a stationary reaction wall;

FIG. 6 is a left-hand end view of the face only of the bushing in FIG. 2, taken along the line 6—6 thereof;

FIG. 7 is a left-hand side view of a stationary valve in FIG. 2, taken along the line 7—7 thereof, showing principally a plurality of circumferentially disposed fluid valve openings therein and constituting fluid valve area-way means;

FIG. 8 is a right-hand end view of the face only of the bushing which is non-rotative, the view being taken along the line 8—8 of FIG. 2 and shows principally a plurality of circumferentially disposed fluid balancing pattern area-way recesses provided in the face of the bushing, and being in substantially straight axial alignment with the fluid valve area-way means in FIG. 7 to create fluid balancing forces in opposition to those created by the valve area-way means;

FIG. 9 is a right-hand side view of the face only of the rotary body means, taken along the line 9—9 of FIG. 2, showing principally the rotary valve face which confrontingly engages the stationary valve face of FIG. 7;

FIG. 10 is a left-hand side view of the face only of the rotary body means, taken along the line 10—10 of FIG. 2, showing principally the rotary pattern face which confrontingly engages the balancing non-rotative pattern face of FIG. 8;

FIG. 11 is a cross-sectional view of the rotary body means of FIG. 10, taken along the line 11—11 thereof;

FIG. 12 is a cross-sectional view of the rotary body means of FIG. 10, taken along the line 12—12 thereof;

FIG. 13 is an enlarged sectional view of the axial-thrust bushing in FIG. 2, and shows a modification, in that the diameter of the left-hand flange is somewhat smaller than that for the right-hand flange to give a resultant piston-effect to produce an axial thrust;

FIG. 14 is a view similar to FIG. 2, showing a modification of the rotary body means and the axial-thrust bushing;

FIG. 15 is a left-hand end view of the face only of the bushing in FIG. 14, taken along the line 15—15 thereof;

FIG. 16 is a right-hand end view of the face only of the bushing of FIG. 14, taken along the line 16—16 thereof;

FIG. 17 is a right-hand side view of the face only of the rotary body means of FIG. 14, taken along the line 17—17 thereof, the opposite side of the rotary body means being identical thereto;

FIG. 18 is a left-hand side view of the stationary valve face in FIG. 14, taken along the line 18—18 thereof;

FIG. 19 is an enlarged sectional view of the axial-thrust bushing of FIG. 14; and,

FIGS. 20 and 21 show principally split stop pin means.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

The fluid pressure device in which my invention may be incorporated may comprise a fluid motor, a fluid pump, a fluid transmission, a fluid servomotor and/or any other related device.

The fluid pressure operating means may be of the type usually referred to in the trade as a stator-rotor orbital mechanism, and may be the same as that shown in my U.S. Pat. No. 3,405,603.

In this application, the term "stator" and "rotor" are not used in a limited sense. The term "stator" is applied to the element which has a fixed axis and the term "rotor" is applied to the element which has a movable axis characterized in that said rotor is disposed for rotational movement about its own movable axis and for orbital movement about the fixed axis of the stator. Thus, in this application, the outer surrounding element, usually referred to as the stator, may be either the stator or the rotor, depending upon whether it has a fixed axis or a movable axis and the inner element, usually referred to as the rotor, may be either the rotor or the stator depending upon whether it has a movable axis or a fixed axis.

For clarity of invention, the usual static seals and the seal for the rotating shaft are not shown. Also, all wear parts are made of hardenable surfaces and are well lubricated by the operating fluid.

With reference to the drawing, the fluid pressure device in which my invention may be incorporated, comprises generally a main housing **20** having substantially a square cross-section. A mounting flange **21** may be secured to the left-hand end of the housing by means of suitable screws **26** (one of which is shown in FIG. **1**). The housing is hollow from end-to-end, and intermediate the ends of the hollow housing there is provided an annular internal rim **22** which generally separates the hollow-housing into a left-hand end compartment and a right-hand end compartment. Rotatively mounted in the left-hand end compartment is a main load shaft **25** having an axis substantially coinciding with the longitudinal axis of the fluid pressure device. An axial-thrust bushing **27** and a rotary body **28** are mounted in the right-hand end compartment. On the right-hand end of the hollow housing, there is mounted a square stationary valve member **29** by means of suitable screws **30**. The rotary body is adapted to be rotated relative to the stationary valve member **29** for controlling the entrance of fluid to and the exit of fluid from a stator-rotor mechanism **31** comprising a stator **32** and a rotor **33**. An end cap **34** encloses the stator-rotor mechanism **31**. The stator-rotor mechanism **31** and the end cap **34** are secured to the stationary valve member **29** by means of screws **35**. Fluid is delivered to and from the housing **20** through a pair of fluid ports **23** and **24**. An interconnecting shaft **36** interconnects the main shaft **25** with the rotor **33** of the stator-rotor mechanism **31** and is adapted to transmit torque therebetween.

The main shaft **25** comprises an enlarged internal portion having a reduced external portion **41** extending axially outwardly of the main housing **20** through the mounting flange **21**. The enlarged internal portion of the main shaft is supported preferably by tapered roller bearings **42** and **43** disposed side-by-side with the bearing **42** disposed oppositely to that of the tapered roller bearing **43**. Thus, the tapered roller bearings **42** and **43**, in combination with each other, provide for radial thrust as well as for end thrust in both axial directions, with the tapered roller bearing **42** disposed to take the greater part of the radial load. A tightening nut **54** which threadably engages male threads **55** secures the bearings **42** and **43** against axial movement upon the main shaft. The tightening nut **54** may be provided with a built-in locking feature to prevent loosening.

As shown, the bearings **42** and **43** are secured against axial movement in the housing by axial fixation means, indicated by the reference character **60**. The axial fixation means **60** is located within a bore **62** of the flange and comprises an annular V-shaped or pointed rib which axially abuts against a transversely disposed solid abutment wall of the bearing **42**. The rib may be constructed either integrally with or as a separate part from the flange **21**. By pressing the flange **21** against the end of the housing **20** during assembly, the pointed rib is coined against the bearing **42**, with the result that the fixation means accommodates for axial tolerance in matching the position of the bearings in the housing. The pressure required to coin the axial fixation means is greater than the end-wise thrust load to which the bearing means **42** may be subjected in operation, in which case the bearings **42** and **43** are resisted against axial movement in operation. The main shaft is entirely supported by the two tapered roller bearings **42** and **43**. The reduced external shaft portion **41** where it passes axially through the end mounting flange **21** is not journalled therein but rotates therein with a small radial clearance which is adapted to be sealed off by suitable shaft seal means, not shown. The axial fixation-means **60**, after being coined, provides a fluid seal between the housing and the flange.

The bearings **42** and **43** constitute common bearing means for the main shaft **25** and the rotary body **28**. The common bearing means directly support the main shaft **25** and indirectly support the rotary body **28** through extension drive means comprising a hollow shaft **44** carried by the load shaft **25**. The hollow shaft **44** extends axially from the load shaft **25** in the left-hand compartment into the right-hand compartment for driving connection with the rotary body **28** for rotating same relative to the stationary valve **29**. The hollow shaft **44** terminated with a male shank **45** which slidably fits within a female socket **46** provided in the rotary body **28**, see FIGS. **10** and **12**. This connection comprises a non-rotatable connection and rotates the rotary body upon rotation by the main shaft. The connection also provides slidable axial movement between the rotary body **28** and the hollow shaft **40** to accommodate for axial movement of the load shaft without interfering with the operation of the rotary body **28**. The axial slidable movement which is permitted between the male shank **45** and the female socket **46** is greater than the maximum distance that the load shaft **25** may move in an axial direction during operation. As illustrated in FIGS. **2** and **13**, the rotary body **28** and the second compartment means in which it is mounted has a radial clearance **47** therebetween to accommodate for radial movement of the load shaft **25** without interfering with the operation of the rotary body. The radial clearance **47** is greater than the maximum distance that the load shaft **25** may move in a radial direction during operation. The radial clearance **47** also extends between the bushing **27** and the main housing **20**. The rotary body **28** has first and second opposed body sides or flanges **56** and **57**, see FIGS. **11** and **12**. As shown, the rotary body **28** has generally an H-shaped cross section with the flanges **56** and **57** being interconnected by an annular cross-bar **61**. The first opposed body side or flange **56** constitutes a rotary valve **39** having a rotary valve face **40** (FIG. **9**) which confrontingly engages a stationary valve face **37** of the stationary valve **29**. The second opposed body side or flange **57** constitutes rotary pattern means **51** having a rotary pattern face **52** (FIG. **10**) which is axially spaced from, and which faces, a stationary reaction wall **64**, see FIGS. **2** and **5**.

The operation of the rotary valve **39** relative to the stationary valve **29** provides for controlling the entrance of fluid to and the exit of fluid from the stator-rotor mechanism. The action of the rotary valve **39** in commutation with the stationary valve **29** is such that there is a first series of commutating fluid connections between the fluid port **23** and the stator-rotor mechanism and a second series of commutating fluid connections between the stator-rotor mechanism and the fluid port **24**. The stationary valve **29** has a plurality of circumferentially disposed openings **48** which extend therethrough to provide for fluid communication between the rotary valve **39** and the stator-rotor mechanism. The commutating valve action, and the flow of fluid between the fluid ports **23** and **24** and the stator-rotor mechanism is substantially the same as that shown and described in my U.S. Pat. No. 3,405,603. Thus, in the present application, the annular external channel **58** around the outside of the rotary valve constitutes a first fluid chamber and is in constant communication with the fluid port **23** and the central space or internal channel **59** inside the rotary valve constitutes a second fluid chamber and is in constant communication with the fluid port **24** through opening means **50** in the hollow shaft **44**.

As shown and described in the present disclosure, the rotary valve **39** functions without interference from axial and radial thrust loads on the load shaft **25**, even though it is rotatively supported by the same bearings that support the load shaft.

In the present invention, the rotary valve face **40** is axially constrained against the stationary valve face **37** by the axial-thrust bushing **27**. This constraining action prevents fluid leakage between the rotary valve face and the stationary valve face. As shown in FIGS. **2**, and **5** to **13**, the axial-thrust bushing **27** is mounted between the stationary reaction wall **64** and the rotary pattern face **52**, and is held against rotation by stop pin means **65** which interconnects the stationary reaction wall **64** and the bushing **27**. One end of the stop pin **65** fits into a hole **66** in the stationary reaction wall **64** and the other end of the stop pin fits into a hole **67** in the bushing **27**.

The bushing **27** has first and second end portions **68** and **69** (see FIG. **13**), and has generally an H-shape cross-section including first and second axially spaced flange legs 70 and 71 and an interconnecting annular cross-bar 72. The flange legs 70 and 71 each have an outer flange leg portion with inside opposing faces 73 and 74 defining an external fluid channel around the cross-bar 72. Also, each of the flange legs 70 and 71 have an inner flange leg portion with inside opposing faces 75 and 76 defining an internal fluid channel within the annular cross-bar 72. The flange leg 70 comprises non-rotative pattern means 77 having a non-rotative pattern face 78 (FIG. 8) confrontingly engaging the rotary pattern face 52 (FIG. 10). The rotary body 28 is disposed between the stationary valve face 37 and the non-rotative pattern face 78. The flange leg 71 is resilient and has an outer annular rim portion 80 and an inner annular rim portion 81 with an annular restraint portion 79 therebetween, which is integrally connected to the cross-bar 72. The outer and inner rim portions 80 and 81 confrontingly engage the stationary reaction wall 64 with the annular restraint portion 79 spaced from and yieldably movable in an axial direction relative to the stationary reaction wall 64. The annular restraint portion 79 defines with the stationary reaction wall 64 a space chamber 63 and the restraint portion 79 is under restraint for transmitting an axial resilient force through the cross-bear 72 to resiliently urge the rotary valve face 40 against the stationary valve face 37 to prevent fluid leakage. The outer and inner annular rim portions 80 and 81 make a metal-to-metal engagement with the stationary reaction wall 64 and act as metal fluid seals to prevent pressurized fluid from entering into and from otherwise pressurizing the space chamber 63. Thus, the piston effect of the space chamber 63 is substantially nullified. The opposing faces 73 and 74 and the opposing faces 75 and 76 of the outer and inner flange legs portions respectively are yieldingly spreadable relative to each other in an axial direction under influence of pressurized fluid and respectively constitute pressure responsive means for transmitting a fluid force to urge the rotary valve face 40 against the stationary valve face 37. The opposing faces 73 and 74 are in constant fluid communication with the fluid port 23 and the opposing faces 75 and 76 are in constant fluid communication with the fluid port 24.

The amount of the axial thrust of the bushing 27 for urging the rotary body 28 against the stationary valve 29 is, of course, determined by the leakage factor. It need not be any greater than that required to prevent excessive leakage. If the axial thrust is too great, it may impose an excessive drag on the rotation of the rotary body. The axial thrust may be calibrated to the correct value by providing a piston-effect to the bushing in addition to the combined forces of the resilient flange 71 and the pressure responsive means. The piston-effect may be provided by making the effective diameter of the resilient flange 71 less than the effective diameter of the right-hand flange 70, such as is shown in FIG. 13, being in contrast to that shown in FIG. 2, where the diameters are substantially the same. The diameters may be readily varied in manufacture to provide the correct calibrated piston-effect. The amount that the resilient flange 71 is under axially restrain may be in the order of approximately 0.005 inch to accommodate for wear.

In the present invention, the rotary body 28 is axially balanced hydraulically between the stationary valve faces 37 and the non-rotative pattern face 78 by pressure balancing pattern means including a plurality of area-way recesses 82 extending from the pattern face 78. Preferably, the area-way recesses 82 are directly in straight axial alignment with the plurality of fluid openings 48 defining valve area-way means in the face 37 of the stationary valve 29. The size and shape of the pattern area-way means or recesses 82 are disposed to match the size and shape of the fluid opening 48 which constitute the valve area-way means, whereby hydraulically they create substantially equal and opposite balancing forces to balance the rotary body 28 between the stationary valve face 37 and the non-rotative pattern face 78.

In my invention, the valve system means, which comprises the rotary valve 39 and the stationary valve 29, is disposed to provide a first series of commutating fluid connection means between the first fluid port 23 and the expanding fluid chambers in the stator-rotor mechanism and a second series of commutating fluid connection means between the contracting fluid chambers in the stator-rotor mechanism and the second fluid port 24. To this end, the stationary valve 29 has seven fluid openings 48 (FIG. 7) communicating respectively with the spaces between the internal teeth of the stator element. The first series of commutating connection means comprise six fluid slot means 83 in constant fluid communication with the first fluid port 23. The second series of commutating fluid connection means, likewise comprising six fluid slot means, are identified by the reference character 84 and are in constant fluid communication with the second fluid port 24.

In operation as a fluid motor, high pressure fluid from the high pressure port 23 commutatively flow through the first series of commutating fluid connection means 83 of the rotary valve into the fluid openings 48 of the stationary valve 29 and thence into the expanding pressure fluid chambers in the stator-rotor mechanism and drives the rotor 33 within the stator 32. As the rotor is driven, the exhaust fluid in the low pressure contracting chambers commutatively flows through the fluid openings 48 of the stationary valve 29 into the second series of fluid commutating connection means 84 of the rotary valve and thence to the low pressure port 24. As the rotor is driven by the high pressure fluid, it operates the main shaft 25 through the interconnecting shaft 36.

The registration of the fluid connection means 83 and 84 provided by the rotating valve face 40 in sealing engagement with the stationary valve face 37 is such that there is a first series of commutating fluid connections between the high pressure port 23 and the expanding fluid chambers in the stator-rotor mechanism and a second series of commutating fluid connections between the contracting fluid chambers and the low pressure port 24.

The pressure balancing pattern means operates in substantially the same manner as that described with reference to the first and second series of fluid conduction means 83 and 84, and to this end, the rotary pattern face 52 (FIG. 10) is provided with six slot means 85 and 86 characterized as first and second series of fluid transit means. The first series of fluid transit means 85 communicatingly interconnect the fluid port 23 (pressurized fluid) with the area-way recesses 82 and the second series of fluid transit means 86 communicatingly interconnect the area-way recesses 82 (exhaust fluid) with the fluid port 24. Thus, the pattern area-way recesses 82 provide an axial fluid force which directly opposes the axial fluid force created by the valve area-way means 48 to hydraulically balance the rotary body 28. As shown, the rotary pattern face 52 (FIG. 10) and the rotary valve face 40 (FIG. 9) are identical, except for the female socket 46, but this difference is slight and does not affect the axial hydraulic balancing of the rotary body 28. The rotary pattern face 52 and the rotary valve face 40 are identical in all other respects. Thus, the view taken along the line 2—2 of FIG. 10 and shown in FIG. 2, shows like sections on opposite sides of the longitudinal center-line. Similarly, the view taken along the line 11—11 of FIG. 10 and shown in FIG. 11, shows like sections on opposite sides of the longitudinal center-line. The line 12—12 of FIG. 10 passes through the lands between the slots 85 and 86 and the sections shown thereby in FIG. 12 are alike on opposite sides of the longitudinal center-line.

FIGS. 14 to 19 show a modification of the axial thrust bushing and the rotary body, now identified by the reference characters 87 and 88, respectively. Like parts in FIGS. 14 to 19 to those in FIGS. 1 to 13 are identified by the same reference characters and the description with reference to FIGS. 1 to 13 apply equally well to the FIGS. 14 to 19.

The rotary body 88 comprises a flat disk and opposing body sides are identical. A right-hand body side is shown in FIG. 17 and constitutes a rotary valve having a rotary valve face 89 (FIG. 17) confrontingly engaging the stationary valve 29. The opposite body side constitutes a rotary pattern having a rotary pattern face 90 confrontingly engaging a non-rotative pattern face 91 (FIG. 16) constituting the right-hand end face of the bushing 87. As shown in FIG. 14 and 19, the bushing 87 has generally an H-shaped cross-section, but is wider than the bushing 27, providing an enlarged external annular fluid channel 94 and an enlarged internal fluid channel 95. The right-hand face 91 of the bushing 87 (FIG. 16) is provided with six fluid slots 96 which communicate with the external fluid channel 94 and with six fluid slots 97 which communicate with the internal fluid channel 95. The fluid slots 96 and 97 have equal areas and constitute open pattern area-way means which oppose the valve area-way means 48 in the stationary valve 29. The area of the respective slots 96 and 97 are equal and each have an area equal to the area of each of the valve area-way means 48.

The rotary body 88 has six outside slots 98 and six inside slots 99. The portion of the slots 98 where they pass through the rotary valve face 89 may be designated as the first series of fluid conduction means and the portion of the slots 99 where they pass through the rotary valve face 89 may be designated as the second series of fluid conduction means. The registration of the first and series of fluid conduction means with the valve area-way openings 48 provide for controlling the flow of fluid to and from the stator-rotor mechanism. The portion of the slots 98 where they pass through the rotary pattern face 90 (body side opposite to that shown in FIG. 17) may be designated as the first series of fluid transit means and the portion of the slots 99 where they pass through the rotary pattern face 90 may be designated as the second series of fluid transit means. Thus, the first series of fluid transit means and the first series of fluid conduction means provide for through conduction of fluid from the external fluid channel 94 to the stationary valve 29. Similarly, the second series of fluid transit means and the second series of fluid conduction means provide for through conduction of fluid from the internal fluid channel 95 to the stationary valve 29. The fluid pressure thrust acting upon the left-hand body side of the rotary body 88 in FIG. 14 through the slots 96 is substantially equal to and opposes the fluid pressure thrust acting upon the right-hand body side of the rotary body 88 through the valve area-way means 48. The fluid slots 97 act in a corresponding way but provide for exhaust fluid. As shown in FIG. 19, the diameter of the resilient flange 71 may be somewhat smaller than the diameter of the flange 70 to provide a piston-effect to give a calibrated value to the axial thrust of the bushing 87. In FIG. 14, the diameters of the flanges 70 and 71 are the same. Thus, it is seen that the bushing 87 and the rotary body 88 operate to provide substantially the same results as that provided by the bushing 27 and the rotary body 28. The two stop pins 65 which fit in the holes 66 and 67 are shown as being solid and extend into the cross-bar of the bushing. They have a diameter which is smaller than the thickness of the cross-bar, see FIGS. 6 and 15, and there is no leakage of fluid into the space chamber 63. This construction nullifies any piston-effect which would otherwise occur if the space chamber 63 were pressurized. If full fluid pressure were admitted to the space chamber 63, the piston-effect would excessively over-power the piston-effect produced between the rotary valve face and the stationary valve face due to leakage fluid therebetween. An excessive over-powering of the leakage piston-effect between the rotary valve face and the stationary valve face would impose too heavy a drag against rotation of the rotary valve relative to the stationary valve. However, the space chamber 63 may be moderately pressurized to produce a reduced piston-effect to aid in axially balancing the rotary valve face against the stationary valve face. To this end, the two stop pins may be split, one of which being shown in FIG. 20 and being identified by the reference character 49. The split pins may comprise split dowel pins which are readily available on the market. For moderate pressurization of the space chamber 63, the two split pins are located where the two circles 53 are shown in FIGS. 6 and 15 and illustrated by the fragmentary views in FIG. 21, whereby they provide a restricted interleakage of fluid into the space chamber 63 from either one of the two annular fluid chamber extending externally around or internally within the annular cross-bar, depending upon which is pressurized. Let it be assumed that the external annular chamber is pressurized and under this situation, fluid flows through the split pin located outwardly of the annular cross-bar into the space chamber 63, from whence it flows through the split pin located inwardly of the annular cross-bar into the internal annular chamber. The width or gap of the space chamber 63 may be in the order of approximately 0.010 inch (being sufficient to accommodate for the axial restraint of the resilient flange 71) and thus the orifice provided by the split pin in association with the 0.010 inch space gap is relatively small. The amount of the restriction of the orifice may be varied by varying the width of the space gap. In practice, the orifices of the two split pins are substantially the same so as to provide a moderate pressurization of the space chamber 63. The fluid flows into the space chamber 63 through substantially the same amount of restriction as it flows out of the space chamber. This action produces a reduced fluid pressure in the space chamber. The action is the same, but reversed, when the internal annular chamber is pressurized. Of course, the solid stop pins need not be used when the split pins are used, and vice versa. The fluid in the space chamber may be characterized as leakage space fluid and the piston effect produced thereby is sufficient to overpower the piston effect produced by leakage fluid between the rotary valve face and the stationary valve face. Thus, leakage space fluid is utilized to prevent leakage fluid between mutually engaging valve faces.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. Axial-thrust body means disposed between first and second side wall means, said first side wall means constituting reaction wall means, said second side wall means constituting rotary face means, said axial-thrust body means having first side body means confrontingly engaging said reaction wall means and having second side body means confrontingly engaging said rotary face means, said axial-thrust body means comprising generally an H-shaped cross-section and including first and second axially spaced flange legs and an interconnecting annular cross-bar having external and internal annular surfaces, said first and second axially spaced flange legs each having an outer flange leg portion with opposing inside faces defining an external annular fluid channel around said external annular surface of said cross-bar, each of said first and second axially spaced flange legs also having an inner flange leg portion with opposing inside faces defining an internal annular fluid channel within said internal annular surface of said cross-bar, said first flange leg having an outside surface constituting said first side body means, said second flange leg having an outside surface constituting said second side body means, one of said axially spaced flange legs being under axial restraint and transmitting an axial force towards said rotary face means.

2. First and second body means disposed between first and second side wall means, said first side wall means constituting reaction wall means, said second side wall means constituting stationary valve wall means, said first body means having first side rotary valve face means confrontingly engaging said stationary valve wall means and having second side rotary wall face means axially spaced from said reaction wall means, said second body means having first and second axially interconnected end flange portions, said first end flange portion having first side face means confrontingly engaging said reaction wall means, said second end flange portion having second side face means confrontingly engaging said rotary wall face means, one of said end flange portions being under axial restraint for producing an axially directed thrust toward said stationary valve wall means.

3. First and second body means disposed between first and second side wall means, said first side wall means constituting reaction wall means, said second side wall means constituting stationary valve wall means, said first body means having first side rotary valve face means confrontingly engaging said stationary valve wall means and having second side rotary wall face means axially spaced from said reaction wall means, said second body means having first and second axially interconnected end flange portions, said first end flange portion having first side face means confrontingly engaging said reaction wall means, said second end flange portion having second side face means confrontingly engaging said rotary wall face means, one of said end flange portions being under axial restraint for producing an axially directed thrust toward said stationary valve wall means, means for providing space chamber means between said first side face means and said reaction wall means, and first and second means for providing flow of entrance fluid into, and flow of exit fluid from, said space chamber means.

4. First and second body means disposed between first and second side wall means, said first side wall means constituting reaction wall means, said second side wall means constituting stationary valve wall means, said first body means having first side rotary valve face means confrontingly engaging said stationary valve wall means and having second side rotary wall face means axially spaced from said reaction wall means, said second body means having first and second axially interconnected end flange portions, said first end flange portion having first side face means confrontingly engaging said reaction wall means, said second end flange portion having second side face means confrontingly engaging said rotary wall face means, one of said end flange portions being under axial restraint for producing an axially directed thrust toward said stationary valve wall means, said second side face means having a plurality of recess portions disposed therein and located at annularly spaced intervals therearound.

5. In valve means, stationary valve means having a stationary valve face, reaction wall means opposing said stationary valve face and axially spaced therefrom, bushing body means having first and second end portions with said first end portion facing said reaction wall means and with said second end portion including face wall means disposed substantially parallel to and spaced axially from said stationary valve face, rotary valve body means disposed between said face wall means and said stationary valve face and having a rotary valve face sealingly engaging said stationary valve face, said rotary valve face and said stationary valve face having leakage fluid therebetween producing a valve piston effect, said first end portion of said bushing body means and said reaction wall means defining space chamber means, first and second orifice means to admit flow of entrance fluid into, and flow of exit fluid from, said space chamber means for producing a piston effect opposing said valve piston effect, said orifice means respectively including split pin means extending across said space chamber means and having an axially extending slot communicating with said space chamber means.

6. A rotary body disposed for rotation between first and second side wall means, said first side wall means constituting stationary valve means, said rotary body having first side body means constituting rotary valve means having a rotary valve face confronting engaging said stationary valve means and having second side body means constituting rotary wall means having a rotary wall face confrontingly engaging said second side wall means, said rotary body comprising generally an H-shaped cross section and including first and second axially spaced flange legs and an interconnecting annular cross-bar having external and internal annular surfaces, said first and second axially spaced flange legs each having an outer flange leg portion with opposing inside faces defining an external annular fluid channel around said external annular surface of said cross-bar, each of said first and second axially spaced flange legs also having an inner flange leg portion with opposing inside faces defining an internal annular fluid channel within said internal annular surface of said cross-bar, said first flange leg having an outside annular surface constituting said rotary valve face, said second flange leg having an outside annular surface constituting said rotary wall face.

7. In valve system means, stationary valve means having a stationary valve face, opposed wall means facing said stationary valve face and disposed axially therefrom, bushing body means having first and second end portions with said first end portion facing said opposed wall means and with said second end portion including face wall means disposed substantially parallel to and spaced axially from said stationary valve face, rotary valve body means disposed between said face wall means and said stationary valve face and having a rotary valve face making a sealing engagement with said stationary valve face, first and second fluid port means, first and second fluid connection means including said rotary valve body means for communicatingly interconnecting said first and second fluid port means with said stationary valve means, said first fluid connection means including first fluid chamber means in constant fluid communication with said first fluid port means, said second fluid connection means including second fluid chamber means in constant fluid communication with said second fluid port means, one of said body means including common annular body means common to both said first and second fluid chamber means, said common annular body means having external wall means and internal wall means, said first fluid chamber means having chamber wall means including said external wall means, said second fluid chamber means having chamber wall means including said internal wall means, said first fluid chamber means being disposed externally around said common annular body means and said second fluid chamber means being disposed internally of said common annular body means, axial compression means, said common annular body means under restraint of said compression means being movable in an axial direction, said opposed wall means constituting reaction wall means for said compression means, said rotary valve face and said stationary valve face being constrained against each other under restraint of said compression means.

8. In valve means, stationary valve means having a stationary valve face, reaction wall means opposing said stationary valve face and axially spaced therefrom, bushing body means having first and second axially interconnected end flange portions, said first end flange portion having outside flange wall means confrontingly engaging said reaction wall means, said second end flange portion having outside flange face wall means disposed substantially parallel to and spaced axially from said stationary valve face, rotary valve body means disposed between said flange face wall means and said stationary valve face and having a rotary valve face sealingly engaging said stationary valve face, said rotary valve face and said stationary valve face having leakage fluid therebetween producing a separating force tending to separate said rotary valve face and said stationary valve face, said first end flange portion being under axial restraint and transmitting an axial force to said rotary valve body means for axially constraining said rotary valve face against said stationary valve face, and means for providing space chamber means between said first end portion of said bushing body means and said reaction wall means, means for providing flow of entrance fluid into, and flow of exit fluid from, said space chamber means for producing an axial force opposing said separating force.

9. The structure of claim 8, wherein said first end flange portion of said bushing body means and said reaction wall means define space chamber means, and first and second orifice means to admit flow of entrance fluid into, and flow of exit fluid from said space chamber means.

10. Axial-thrust bushing means for urging a relatively movable body means against a stationary valve face of stationary valve means, said bushing means and said body means being operatively disposed between stationary reaction wall means and said stationary valve face, said relatively movable body means having first body side means constituting movable body valve means having a body valve face confrontingly engaging

said stationary valve face and having second body side means constituting movable body wall means having a movable body face confronting said bushing means, said bushing means having first and second end portion means, said first end portion means including resilient wall means confrontingly engaging said reaction wall means, said second end portion means including bushing wall means having a bushing wall face confrontingly engaging said movable body face, and actuating means for said relatively movable body means for actuating said body valve means relative to said stationary valve means and said body face means relative to said bushing wall means, said resilient wall means being under axial restraint and transmitting an axial thrust to said relatively movable body means and thereby urging said body valve face axially against said stationary valve face.

11. The structure of claim 10, wherein said bushing wall means and said movable body face means constitute pressure balancing wall means for balancing said relatively movable body means between said bushing wall means and said stationary valve means.

12. The structure of claim 10, wherein said bushing means comprises a one-piece, all metal annular body.

13. The structure of claim 10, wherein said bushing means includes pressure responsive means for producing an axial thrust, said pressure responsive means including said resilient wall means.

14. The structure of claim 13, wherein said bushing means has first and second axially interconnected end flange portions with inside opposing faces, said first flange portion constituting said resilient wall means and having outside flange face means making a confronting engagement with said reaction wall means, said second flange portion having outside flange face means constituting said bushing wall means, said inside opposing faces being yieldably spreadable in an axial direction and constituting said pressure responsive means for producing an axial thrust, said first flange portion having a smaller diameter than that for said second flange portion to provide a piston-effect for producing an axial thrust.

15. The structure of claim 13, wherein said bushing means has first and second axially interconnected end flange portions with inside opposing faces, said first flange portion constituting said resilient wall means and having outside flange face means making a confronting engagement with said reaction wall means, said second flange portion having outside flange face means constituting said bushing wall means, said inside opposing faces being yieldably spreadable in an axial direction relative to each other under influence of pressurized fluid and constituting said pressure responsive means for producing an axial thrust.

16. The structure of claim 15, wherein said first flange portion includes inner and outer annular rim portions and a yieldable body portion therebetween axially spaced from and yieldably movable in an axial direction relative to said stationary reaction wall means, said yieldable body portion comprising said resilient wall means and defining with said stationary reaction wall means a space chamber.

17. The structure of claim 16, wherein said stationary reaction wall means and said bushing means are composed of metal, said inner and outer rim portions each making a metal-to-metal engagement with said stationary reaction wall means and thereby opposing pressurized fluid from entering into and otherwise pressurizing said space chamber.

18. Fluid pressure pattern balancing means for pressure balancing a relatively movable body means between a stationary valve face of stationary valve means and a wall pattern face of wall pattern means, said relatively movable body means having first side body means constituting movable body valve means having a body valve face confrontingly engaging said stationary valve face and having second side body means constituting movable body pattern means having a movable body pattern face confrontingly engaging said wall pattern face, and actuating means for said relatively movable body means for actuating said body valve means relative to said stationary valve means and said body pattern means relative to said wall pattern means, said stationary valve means having valve area-way means under influence of fluid pressure producing an axially directed valve area-way force tending to separate said body valve face from said stationary valve face, said wall pattern means having pattern area-way means under influence of fluid pressure producing an axially directed pattern area-way force tending to separate said body pattern face from said wall pattern face, said pattern area-way force opposing said valve area-way force to substantially pressure balance said relatively movable body means between said stationary valve face and said wall pattern face.

19. The structure of claim 18, including fluid chamber means, said wall pattern means having open pattern area-way means in constant fluid communication with said fluid chamber means, fluid transit means and fluid conduction means communicatingly interconnecting said fluid chamber means and said valve area-way means through said wall pattern means and said body valve means.

20. The structure of claim 18, including fluid chamber means in constant fluid communication with said movable body valve means and said movable body pattern means, said wall pattern means having closed pattern area-way means defining recess means extending from said wall pattern face, fluid conduction means extending through said body valve face and communicatingly interconnecting said fluid chamber means and said valve area-way means, and fluid transit means extending through said body pattern face and communicatingly interconnecting said fluid chamber means and said pattern area-way means.

21. The structure of claim 20, wherein said fluid transit means has a cross-sectional size and shape substantially matching the cross-sectional size and shape of said fluid conduction means and being in substantially straight axial alignment therewith.

22. The structure of claim 18, including stationary reaction wall means facing said stationary valve face and being axially spaced therefrom, and axial-thrust bushing means having first end portion means confrontingly engaging said stationary reaction wall means and having second end portion means constituting said wall pattern means for urging said wall pattern face axially against said body pattern face and, in turn, said body valve face axially against said stationary valve face.

23. The structure of claim 22, wherein said axial-thrust bushing means including resilient means and pressure responsive means for respectively transmitting an axially directed resilient force and an axially directed fluid force to said wall pattern face with said stationary reaction wall means constituting stationary reaction means therefor.

24. The structure of claim 23, wherein said axial-thrust bushing means comprises an annular body having generally an H-shaped cross-section and including first and second axially spaced flange legs and an interconnecting annular cross-bar having external and internal annular surfaces, said first and second axially spaced flange legs each having an outer flange leg portion with inside opposing faces defining an external annular fluid channel around said external annular surface of said cross-bar, each of said first and second axially spaced flange legs also having an inner flange leg portion with inside opposing faces defining an internal annular fluid channel within said internal annular surface of said cross-bar, said first flange leg having an outside annular surface constituting said wall pattern face, said second flange leg constituting said resilient means and having an outer annular rim portion and an inner annular rim portion with an annular restraint portion therebetween, said outer and inner annular rim portions confrontingly engaging said stationary reaction wall means with said annular restraint portion spaced from and yieldingly movable in an axial direction relative to said stationary reaction wall means, said annular restraint portion defining with said stationary reaction wall means a space chamber and transmitting an axial resilient force through said cross-bar to said first flange leg to urge said wall pattern face sealingly

against said body pattern face, said inside opposing faces respectively of said outer and inner flange leg portions being yieldingly spreadable relative to each other in an axial direction under influence of pressurized fluid and constituting said pressure responsive means for transmitting said fluid force.

**25.** The structure of claim **18**, wherein said relatively movable body means comprises rotary body means having a rotary valve face and wherein said wall pattern face comprises a non-rotative pattern face and said movable body pattern face comprises a rotary pattern face, said stationary valve face having fluid opening means extending therefrom, said fluid opening means constituting valve area-way means, said rotary valve face having fluid conduction means extending therethrough and being communicatingly registrable with said valve area-way means, said valve area-way means under influence of fluid pressure producing an axially directed valve area-way force tending to separate said rotary valve face from said stationary valve face, said non-rotative pattern face having pattern area-way means extending therefrom, said rotary pattern face having transit means extending therethrough and being communicatingly registrable with said pattern area-way means, said pattern area-way means under influence of fluid pressure producing an axially directed area-way force tending to separate said rotary pattern face from said non-rotative pattern face to substantially balance said rotary body means between said stationary valve face and said non-rotative pattern face.

**26.** The structure of claim **25**, including stationary reaction wall means and an axial-thrust bushing means non-rotatively disposed between said reaction wall means and said rotary pattern face, said bushing means having first and second axially interconnected end flange portions with inside opposing faces, said first flange portion having outside flange face means making a confronting engagement with said rotary pattern face, said second flange portion constituting resilient means and having outside flange face means making a confronting engagement with said reaction wall means, said second flange portion being under axial restraint and transmitting an axial force to said rotary body means for axially constraining said rotary valve face against said stationary valve face.

**27.** In fluid pressure means including first and second fluid port means and fluid pressure operating means, first and second fluid connection means for communicatingly interconnecting said first and second fluid port means with said fluid pressure operating means, said first fluid connection means including first fluid chamber means in constant fluid communication with said first fluid port means, said second fluid connection means including second fluid chamber means in constant fluid communication with said second fluid port means, said first and second fluid connection means including stationary valve means and rotary valve means, said stationary valve means having a stationary valve face, said rotary valve means having a rotary valve face sealingly engaging said stationary valve face, actuating means to rotate said rotary valve means relative to said stationary valve means, said stationary valve means having a plurality of circumferentially disposed fluid openings extending from said stationary valve face and communicating with said fluid pressure operating means, said rotary valve means having first and second alternate series of commutating fluid conduction means extending through said rotary valve face, said first series of fluid conduction means communicatingly interconnecting said first fluid chamber means and said stationary valve face, said second series of fluid conduction means communicatingly interconnecting said second fluid chamber means and said stationary valve face, said first and second series each commutating with and being one less in number than said plurality of fluid openings, and axial-thrust means for urging said rotary valve face sealingly against said stationary valve face, said axial-thrust means including self-prevailing resilient means for producing an axially directed force to said rotary valve face and urging same against said stationary valve face.

**28.** The structure of claim **27**, wherein said fluid pressure operating means includes stator means and rotor means defining operating fluid chamber, said stator means having a stator axis, said rotor means having a rotor axis, said rotor means having a rotational movement about its own rotor axis and an orbital movement about said stator axis.

**29.** The structure of claim **28**, wherein said rotary valve means is driven by said rotor means.

**30.** The structure of claim **28**, including main shaft means, bearing means rotatively supporting said main shaft means, interconnecting shaft means operatively interconnecting said main shaft means and said rotor means, said rotary valve means being carried by said main shaft means and driven thereby.

**31.** In fluid pressure means including first and second fluid port means and fluid pressure operating means, first and second fluid connection means for communicatingly interconnecting said first and second fluid port means and said fluid pressure operating means, said first fluid connection means including first fluid chamber means in constant fluid communication with said first fluid port means, said second fluid connection means including second fluid chamber means in constant fluid communication with said second fluid port means, said first and second fluid connection means including fluid valve means and fluid pressure pattern balancing means communicatingly connected together, said valve means including stationary valve means having a stationary valve face, said fluid pressure pattern balancing means including non-rotative wall pattern means having a non-rotative wall pattern face axially spaced from and facing said stationary valve face, rotary body means disposed between said stationary valve face and said non-rotative wall pattern face, said rotary body means having first and second opposed body sides, said first opposed body side constituting rotary valve means having a rotary valve face making a confronting engagement with said stationary valve face, said second opposed body side constituting rotary pattern means having a rotary pattern face making a confronting engagement with said non-rotative wall pattern face, actuating means for said rotary body means to actuate said rotary valve face relative to said stationary valve face and said rotary pattern face relative to said non-rotative wall pattern face, said stationary valve means having a plurality of fluid opening means therein and extending from said stationary valve face and communicating with said fluid pressure operating means, said plurality of fluid opening means constituting valve area-way means, said rotary valve means having first and second alternate series of commutating fluid conduction means extending through said valve rotary valve face and being communicatingly registrable with said valve area-way means, said first series of fluid conduction means communicatingly interconnecting said first fluid chamber means and said stationary valve face, said second series of fluid conduction means communicatingly interconnecting said second fluid chamber means and said stationary valve face, said first and second fluid conduction series each commutating with and being one less in number than said plurality of fluid openings, said valve-way means under influence of pressurized fluid producing an axially directed valve area-way force tending to separate said rotary valve face from said stationary valve face, said non-rotative wall pattern means having a plurality of pattern area-way means extending from said non-rotative wall pattern face, said rotary pattern means having first and second alternate series of commutating fluid transit means extending through said rotary pattern face and being communicatingly registrable with said pattern area-way means, said first series of fluid transit means communicatingly interconnecting said first fluid chamber means and said non-rotative wall pattern face and said second series of fluid transit means communicatingly interconnecting said second fluid chamber means and non-rotative wall pattern face, said first and second fluid transit series each commutating with and being one less in number than said plurality of pattern-way means, said pattern area-way means under influence of pressurized fluid producing an axially directed pattern area way force tending to separate said rotary pattern face from said non-rotative wall pattern face, said pattern area-way force opposing said valve area-way force to substantially balance said rotary body means between said stationary valve face and said non-rotative wall pattern face.

**32.** The structure of claim **31**, wherein said fluid pressure operating means including stator means and rotor means defining operating fluid chamber, said stator means having a stator axis, said rotor means having a rotor axis, said rotor means having a rotational movement about its own rotor axis and an orbital movement about said stator axis.

**33.** The structure of claim **32**, including mainshaft means, bearing means rotatively supporting said main shaft means, interconnecting shaft means operatively interconnecting said main shaft means and said rotor means, said rotary body means being carried by said main shaft means and driven thereby.

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