United States Patent

Eickmann

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[54] **FLUID FLOW MACHINE WITH AXIALLY BIASSED ROTOR ASSEMBLY**

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[52] **U.S. Cl.**......................**418/82,** 418/132, 418/173

[51] **Int. Cl.**.........**F01c 19/08,** F03c 3/00, F04c 15/00

[58] **Field of Search**.........418/82, 131, 132, 133, 173

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Assistant Examiner—John J. Vrablik
Attorney—Michael S. Striker

[57] **ABSTRACT**

The rotor assembly of a pump, compressor, or like fluid flow machine, is provided with first passages connecting expanding and contracting working chambers successively with the high pressure and low pressure ports of a stationary valve plate at one end of the rotor assembly, and also with cylinder chambers at the other end of the rotor assembly, provided with pistons pressed against a rotary ring of a thrust bearing so that the rotor assembly is compressed, and pressed against the valve plate to reduce leakage. Other passages connect the high pressure and low pressure ports, and also additional control ports, successively with the inner ends of slot chambers for balancing the inward pressure exerted by the fluid in the working chambers on vanes in the slot chambers.

10 Claims, 16 Drawing Figures

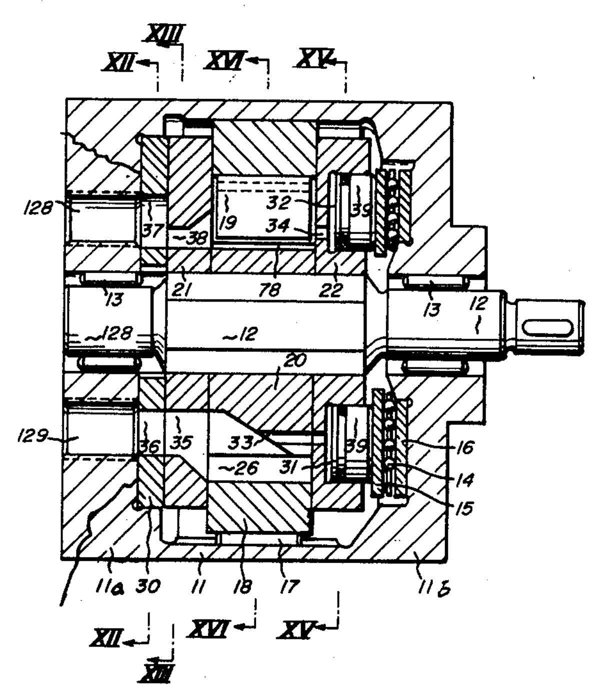

Fig.16

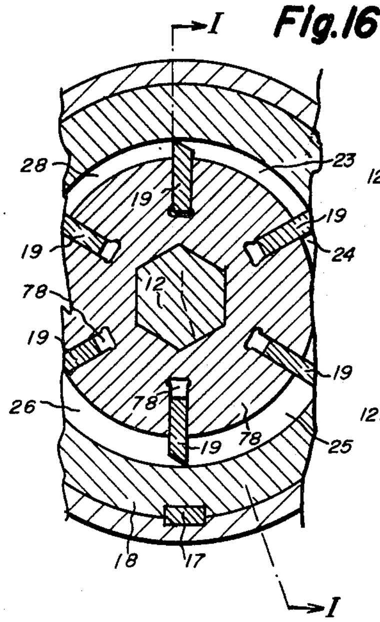

Fig. 1

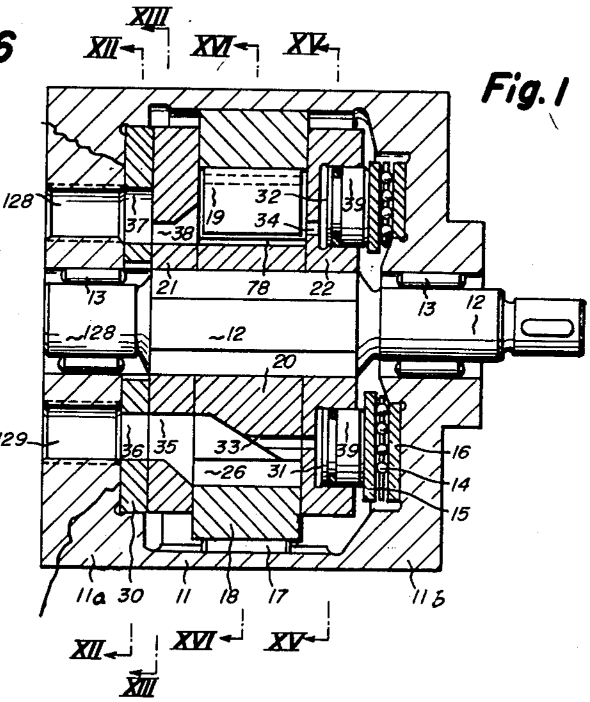

Fig. 12

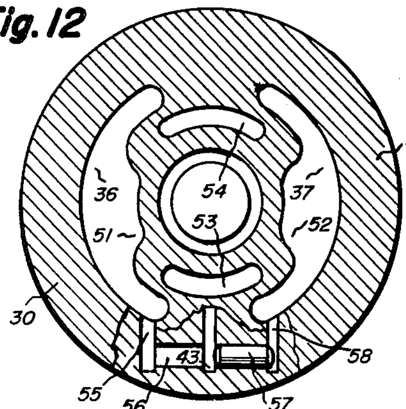

Fig. 13

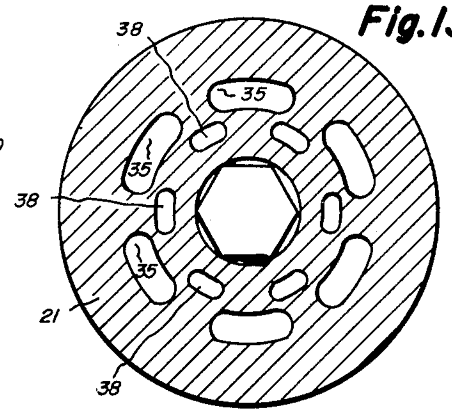

Fig. 14

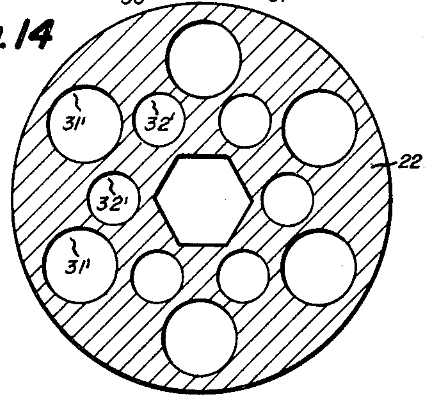

Fig. 15

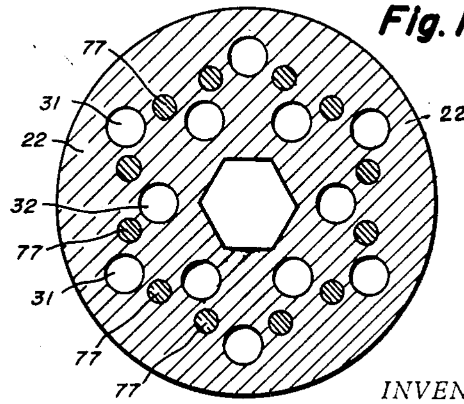

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Fig. 2

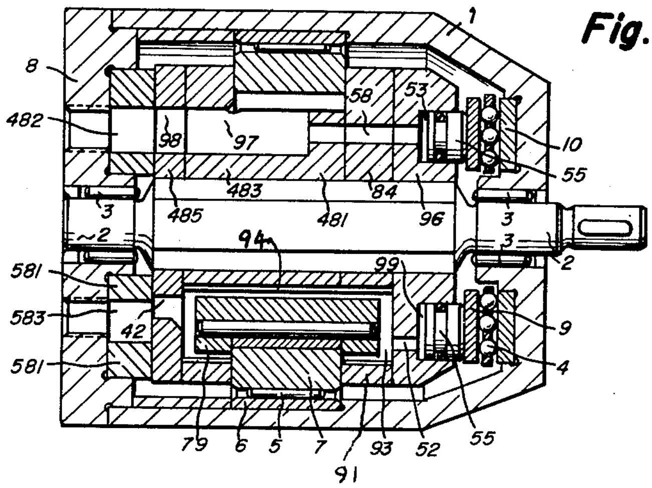


Fig. 3

Fig. 4

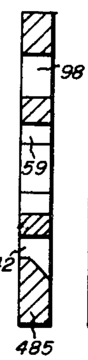


Fig. 5

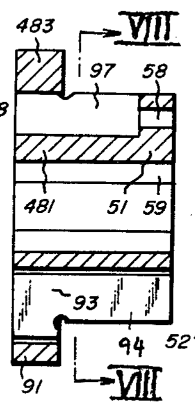


Fig. 6

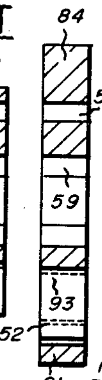


Fig. 7

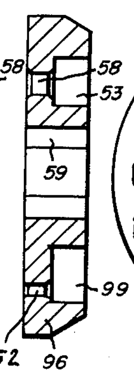


Fig. 8

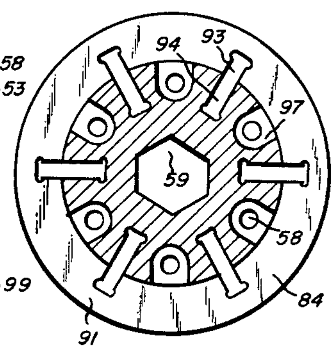


Fig. 9

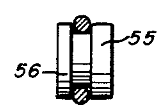


Fig. 10

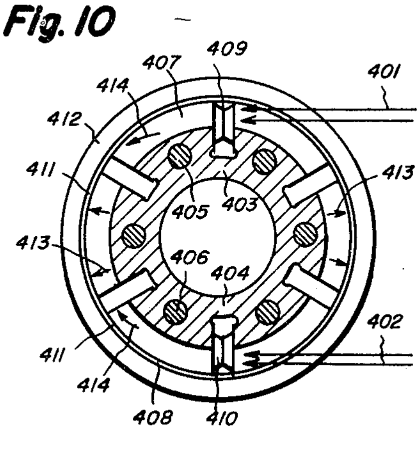
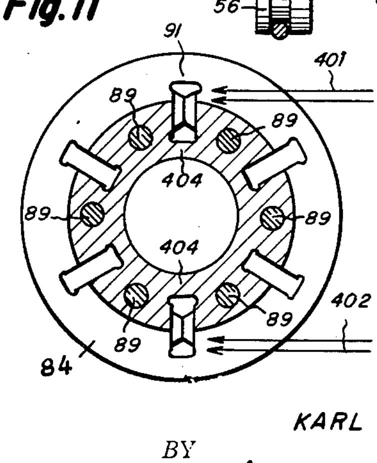


Fig. 11



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FLUID FLOW MACHINE WITH AXIALLY BIASSED ROTOR ASSEMBLY

BACKGROUND OF THE INVENTION

The present invention is concerned with fluid flow machines of the type in which expanding and contracting working chambers are formed during rotation of the rotor in a stator housing. Machines of this type include vane pumps, vane compressors, vane engines, vane transmissions, gear pumps, gear motors, trochoid pumps, trochoid motors, and like machines in which the rotor assembly, by which the expanding and contracting working chambers are formed, is pressed against the valve plate located at one end of the rotor assembly in order to reduce the leakage losses in the gap between the rotor assembly and the valve plate.

Machines of this type are disclosed in my U.S. Pat. Nos. 2,975,716 and 3,417,706. The machines include rotor assemblies which can be operated at high pressure, and are comparatively tightly sealed. However, comparatively high volumetric leakage losses occur in the gap between the rotor assembly and the valve plate. Other leakage losses occur because vanes are not pressed outward with sufficient force against a surrounding cam ring by which they are moved into and out of corresponding slot chambers.

SUMMARY OF THE INVENTION

It is one object of the invention to provide the fluid flow machine in which leakage losses are reduced by pressing the rotor assembly against a valve plate.

Another object of the invention is to reduce leakage losses by pressing vanes outward by fluid from high and low pressure ports in the valve plate.

Another object of the invention is to provide a fluid flow machine which is tightly sealed and has very low leakage losses, but can be manufactured at comparatively low cost.

With these objects in view, in accordance with the invention, a rotor assembly which is located within a ring and forms with the same expanding and contracting working chambers, has in one end wall thereof, passages which successively communicate with the high pressure port and low pressure port of a stationary valve plate, and supply the fluid to the working chambers which communicate with cylinder and piston means at the other end of the rotor assembly. Since the pistons engage a rotary member of a thrust bearing, the rotor assembly is pressed against the valve plate, while at the same time, separate parts of the motor assembly are pressed together.

Furthermore, in accordance with the invention, other passages in the end wall of the rotor assembly communicate with the high pressure port and low pressure port successively, and supply pressure fluid to the inner ends of slot chambers in which vanes are mounted for radial movement. The slot chambers are also connected with cylinder and piston means at the other end of the rotor assemble, and the pistons cooperate with the same rotary member of the thrust bearing as the pistons which are influenced by the varying pressure in the working chambers.

Preferably additional control ports are provided in the valve plate for supplying high pressure fluid to the inner ends of the slot chambers during the reversal of the flow into and out of the same by the high pressure and low pressure ports of the valve plate.

One embodiment of the invention comprises a valve plate mounted in a housing and having a control face with high pressure and low pressure ports communicating with the inlet and outlet of the housing. A rotor assembly is mounted in the housing and includes means for forming working chambers expanding and contracting during rotation, such as vanes in radial slot chambers.

The rotor assembly has a first end portion, preferably a separate first end wall, sliding on the control face during rotation, and having passages therethrough cooperating with the high pressure and low pressure ports and communicating with the working chambers for connecting the same successively with the high pressure and low pressure ports.

The rotor assembly has a second end portion, preferably a second end wall, including cylinder chambers communicating with the working chambers, respectively, and pistons in the cylinder chambers so that the varying pressure in the working chambers urges the respective pistons out of the cylinder chambers.

A thrust bearing is mounted in the housing opposite the second end portion or end wall, and includes a rotary member against which the pistons are pressed so that the first end portion of the rotor assembly is pressed against the valve plate and leakage from the same is reduced.

In the preferred embodiment of the invention, in which the rotor assembly includes radial slot chambers and vanes in the same, the first end portion has other passages communicating with the inner ends of the slot chambers and connecting the same successively with the high pressure and low pressure ports so as to balance the pressure at the inner and outer ends of the vanes, the pressure at the outer ends of the same corresponding to the pressure of the adjacent working chamber. In this embodiment, the second end portion of the rotor assembly has other cylinder chambers communicating with the slot chambers, and pistons in the same are pressed against the rotary member of the thrust bearing so that the rotor assembly is pressed tightly against the control face of the valve plate.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is an axial sectional view taken along the line I—I of FIG. **16** and illustrating a first embodiment of the invention;

FIG. **2** is an axial sectional view illustrating a second embodiment of the invention;

FIGS. **3** to **7** are axial sectional views illustrating the parts of the rotor assembly of the embodiment of FIG. **2** in separated positions;

FIG. **8** is a cross-sectional view taken on line VIII—VIII in FIG. **5**;

FIG. **9** is a side elevation illustrating a detail of FIG. **2** on an enlarged scale;

FIGS. 10 and 11 are schematic cross-sectional views illustrating the action of forces acting on the vanes of the machine;

FIG. 12 is a cross-sectional view taken on line XII—XII in FIG. 1;

FIG. 13 is a cross-sectional view taken on line XII—XIII in FIG. 1;

FIGS. 14 and 15 are cross-sectional views taken on line XV in FIG. 1 and illustrating modifications of the embodiment of FIG. 1; and

FIG. 16 is a cross-sectional view taken on line XVI—XVI in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the embodiment illustrated in FIG. 1, and FIGS. 12 to 16, in this embodiment, expanding and contracting working chambers are formed between the central rotor portion 20, and separate end walls 21 and 22, together with the inner surface of the eccentric cam ring 18. Working chambers 23 to 28 are shown in FIG. 16, and while the illustrated embodiment includes vanes 19 mounted in slot chambers 78 in the central rotor portion 20, the working chambers could also be trochoid chambers, or gear chambers, or be formed by other means. The working chambers 23 to 28 are separated from each other by the vanes 19. The cam ring 18 is mounted on the housing 1 eccentric to the axis of the rotor shaft 12, so that during rotation of the rotor assembly 20, 21, 22 and 12, the working chambers 23 to 28 successively expand and contract during each revolution of the rotor assembly. Shaft 12 is mounted in bearings 13 supported in end walls 11*a* and 11*b* of the housing 11. Housing wall 11*a* is provided with inlet 128 and outlet 129 through which a working fluid is supplied and discharged. A stationary valve plate 30 is mounted on housing wall 11*a* and has a control face confronting the rotor assembly, and cooperating with a first end wall 21 of the same, The shape of the high pressure and low pressure ports 36 and 37 in valve plate 30 is best seen in FIG. 12, and it is apparent that these ports communicate with the inlet and outlet 128 and 129.

The second end wall 22 at the other end of the rotor assembly, has cylinder chambers 31 and 32 in which pistons 39 are disposed. The outer ends of pistons 39 abut a rotary circular ring 15 which is part of a ball bearing 14 having a stationary ring 16 mounted on housing wall 11b. The rotor assembly 20, 21, 22 with vanes 19, is mounted between the thrust bearing 14, 15, 16 and valve plate 30, and it will be seen that pressure in the cylinder chambers 31, 32 will cause movement of the rotor assembly toward and against the control face of valve plate 30, while the parts 21, 20, 22 of the rotor assembly are pressed together.

The eccentric cam ring 18 could be mounted for rotation in the housing, but in the illustrated embodiment, cam ring 11 is secured by a key 17 against turning movement, but is mounted in housing 11 for limited axial movement together with the rotor end walls 21 and 22 which abut against lateral annular faces of cam ring 18.

The vanes 19 move inward and outward in the slot chambers 78, and divide the space between the rotor assembly and the cam ring 18 into working chambers 23 to 28. During rotation of the rotor assembly, the working chambers expand and contract cyclically, while fluid, partly under pressure flows through the working chambers.

In accordance with the invention, cylinder chambers 31 are provided in the end wall 22, and passages 33 between each working chamber and a corresponding cylinder chamber 31, connect the working chamber with the cylinder chamber. Pistons 39, preferably provided with sealing rings as best shown in FIG. 9 for the embodiment of FIG. 2, are axially slidable in the cylinder chambers 31, and abut the rotary ring 15 of the thrust bearing 14, 15, 16.

Passages 35 extend through the end wall 21, and have open ends cooperating with the valve plate 30, and with the ports 36 and 37, so that fluid enters the working chambers and is discharged from the same by means of ports 36 and 37 which communicate with the inlet and outlet 128, 129.

Due to this arrangement according to the invention, at the same time prevails the same pressure in the spaces 129, 36, 35, the respective communicating working chambers of the working chambers 23 to 28, and also in spaces 31 and 33. The cylinder chamber 32 is differently connected, as will be explained hereinafter. During the other half of a revolution of the rotor assembly, the same pressure prevails at the same time in the respective communicating working chambers of the working chambers 23 to 28, and also in the spaces 128, 37, 35, 31 and 33. In the cylinder chambers 31, the fluid pressure acts in one axial direction against the pistons 39 in cylinder chambers 31 so that the respective pistons are pressed against the rotary ring 15 of the thrust bearing, and in the opposite axial direction toward the rotor end wall 22 so that the same is pressed against the central rotor end portion 20, which is pressed against the other rotor end wall 21 which is pressed against the control face of the valve plate 30.

Due to this pressure in axial direction, the gap between rotor end wall 21 and the control face of valve plate 30 is reduced to such an extent that minimal leakage occurs from this gap.

It is only necessary to dimension the effective cross-section of the cylinder chambers 31 correctly, and to place cylinder chambers 31 in the correct radial position.

The dimension of the cylinder chambers 31, and particularly the effective cross-section, can be selected so that the axial pressure is sufficient for holding the parts 21, 20, 22 of the rotor assembly together, so that no axially extending connecting bolts 77 are required. The axial pressure also reduces the gap between the vanes 19 and the end walls 21, 22, and also the gaps between central rotor portion 20 and rotor end walls 21 and 22 to a minimum.

In the cross-section shown in FIG. 15, a standard construction is shown in which circumferentially spaced bolts 77 pass through rotor 20 and the rotor end walls 21 and 22, and provided with nuts, not shown, so that the parts of the rotor assembly are fixedly secured to each other. In this arrangement, the cylinder chambers 31 and/or 32 can be relatively small, since the effective area of the gap between the rotor parts 21 and 30 can also be comparatively small.

A modification is illustrated in FIG. 14 in which the bolts 77 are omitted, which is possible by selecting the effective cross-sections of the cylinder chambers 31 and/or 32 accordingly rather large. The effective cross-sections of the cylinder chambers 31 and/or 32 must be so great that the total sum of the effective pressure area results in an axially acting pressure which is greater than the axial fluid pressure in the gap between valve plate 30 and rotor end wall 21. Under such circumstances, the parts of the rotor assembly 20, 21, 22 are pressed together only by the fluid pressure in the cylinder chambers 31 and/or 32 and bolts 77 can be omitted. The entire rotor assembly 20, 21, 22 is pressed as a whole against the control face of the valve plate, as in the embodiment of FIG. 15. In the arrangement of FIG. 15, the cross-sections of the cylinder chambers 31 and 32 are shown to be comparatively small, since bolts 77 are provided through the rotor assembly. In the modification of FIG. 14, the end wall 22′ has much larger cylinder chambers 31′, and also cylinder chambers 32′ greater than the cylinder chambers 32 in the embodiment of FIG. 15.

The embodiment illustrated in the drawing employs slot chambers 78 in which vanes 19 controlled by cam ring 18 move in axial direction. However, the rotor assembly can be constructed as a trochoid rotor, and the cam ring 18 can be replaced by a rotary ring having an inner trochoid surface so that between the rotating inner and outer trochoid rotors, trochoid working chambers are formed in a known way, whose volume is cyclically increased and decreased during rotation of the inner and outer rotors together. In a trochoid arrangement, the rotor end wall 21 may be omitted, since the trochoid working chambers directly communicate with the high pressure and low pressure ports 36 and 37 of the valve plate 30. The trochoid rotor assembly is pressed against the valve plate 30 by the axial pressure exerted by pistons 39 due to the fluid pressure in cylinder chambers 31 in end wall 22.

The rotor assembly can also be constructed as a gear rotor in which event the cam ring 18 is replaced by a rotary inner gear ring. In this manner, a gear pump or motor is obtained, in which the inner and outer rotors are pressed in axial direction against the control face of the valve plate 30 due to the pressure in the cylinder chambers 31, and the resulting axial pressure of pistons 39 against the thrust bearing 14, 15, 16. The gear rotor assembly need not have an end wall 21, since the working chambers of the gear rotor assembly cyclically communicate directly with the ports 36 and 37 in valve plate 30. A partition by which the high pressure working space and the low pressure working space of the gear rotor assembly are divided from each other, can be fitted between the inner and outer rotors, and secured to the valve plate 30.

In vane machines of the type with which the present invention is concerned, leadage occurs between the outer ends of the vanes and the eccentric cam ring. This is due to the fact that the pressure in the working chambers between the vanes, acts in radial inward direction on the vanes so that unstable and uncontrolled pressures occur in the slot chambers.

In order to overcome this disadvantage of the prior art, in accordance with the present invention, each slot chamber 78 is in communication with a passage 38 passing through the rotor end wall 21, and having an open end cooperating with the ports 36 and 37 of the valve plate 30, so that during rotation of the rotor assembly, the passages 38 and their respective slot chambers 78 cyclically communicate with ports 36 and 37. The ports of passages 38, which are best seen in FIG. 13, cooperate with additional ports provided in the valve plate 30.

A simple construction, which is not illustrated in the drawing, is to provide an annular channel in valve plate 30 with which the passage 38 are connected during the entire revolution of the rotor assembly. This annular channel, not shown, must have such a radius as not to interfere with the passages 35, but is connected with the high pressure port 36 or 37. In this arrangement, the slot chambers 78 are at a all times filled with high pressure fluid, so that vanes 19 are continuously pressed outward against the inner surface of cam ring 19, so that the working chambers 23 to 28 between the vanes 19 are always separated from each other in the region of the outer ends of the vanes 19 so that leakage along the outer ends of the vanes 19 is eliminated. While this construction, not shown, is reliable and durable, the preferred construction of the invention shown in FIG. 12 provides a connection of the slot chambers 78 with high pressure fluid only during a part of each rotor revolution. The cross section of FIG. 13 shown that the passages 35 are located along a circle outward of the passages 38, which are staggered to the passages 35. As noted above, the passages 35 communicate with the working chambers 23 to 28, and the passages 38 communicate with the slot chambers 78, respectively, and more particularly with the inner ends of the same.

When the rotor end wall 21 with the ports of passages 35 and 38 passes over the control face of valve plate 30 in sealing contact, the passages 35 are connected with the port 36 during about one-half of a revolution, and with the port 37 during the other half of a revolution.

FIG. 13 shows the passages 38 radially inward of the passages 35, but it is also possible to place the ports of passages 38 radially outward of the ports of passages 35.

In the illustrated embodiment, the passages 38, and thereby the respective slot chambers 78, are alternately provided with high pressure fluid and low pressure fluid since the ports 36, 37 are formed with radial bulges 51 and 52 which are swept by the ports of passages 38. Between the bulges 51 and 52 of ports 36 and 37, additional control ports 53 and 54 are provided so that not only bulges 51 and 52, but also control ports 53 and 54 are swept by the ports of passages 38.

While a passage 38 receives pressure fluid from the bulge 51, the respective slot chamber 78 is supplied with fluid having the pressure of port 36, and when the respective passage 38 passes over the bulge 52, the respective communicating slot chamber 78 has the pressure of the port 37. As a result, the vanes 19 are subjected to the same inner and outer pressure in radial direction, and friction between the outer ends or vanes 19 and the inner surface of cam ring 18 is reduced.

While the passages 35, which are connected with the working chambers 23 to 28, pass the regions between the ports 36 and 37, the fluid in the working chambers exerts an inwardly directed pressure on the vanes **19**. In order to oppose this inward force, the control ports **53** and **54** are provided which are located in the same circle as the bulges **51** and **52** and the ports of passages **38**, and are consequently passed by the same. As shown in FIG. **12**, the ports **36** and **37** are connected by ducts **55** and **58** with a double cylinder chamber **56** whose center portion is connected by a conduit **53** with control ports **54** and **53**. The piston **57** is operated by the pressures in ports **36** and **37**, so that ports **53** and **54** are always connected with the port **36** or **37** which has the higher pressure since such higher pressure displaces the piston **57** in the double piston chamber **56** to an outward position disconnecting the respective low pressure port from ports **53** and **54**.

The ports of passages **38** which lead to the slot chamber **78**, successively sweep during each revolution of the rotor assembly, the ports **51**, **54**, **52**, **53** so that during three parts of a revolution, slot chambers **78** are provided with high pressure fluid, and during the fourth part of the revolution provided with low pressure fluid. Ports **53** and **54** are effective during reversal of flow in the working chambers.

Each slot chamber **78** is connected with a cylinder chamber **32** by a conduit **34** in rotor end plate **22**. As shown in FIGS. **14** and **15**, the cylinder chambers **31** and **33** alternate in circumferential direction and are staggered in radial direction. While cylinder chambers **32** communicate with slot chambers **78**, cylinder chambers **31** communicate through ducts **33** in the central rotor portion **20** and the end wall **22** with the respective working chamber of working chambers **23** to **28**. A piston **39** is mounted in each cylinder chamber **32** and is pressed by the pressure in the same against the rotary ring **13** of the thrust bearing **15**, **14** and **16** so that the action of piston **39** in the cylinder chamber **32** urges the rotor assembly toward the control face of the valve plate **30** in the same manner as the piston **39** in the cylinder chambers **31**. During each revolution of the rotor assembly, the spaces **38**, **78**, **34**, **32** are successively connected with ports **51**, **54**, **52**, and **53**. Due to the fact that high pressure prevails at the inner end of each slot chamber **78** which is located in the region of high pressure working chambers, the vanes **19** are pressed outward so that the outer ends of vanes **19** slide on the inner surface of the cam ring **18** with exactly the right pressure, while at the same time, the rotor assembly **20**, **21**, **22** is pressed against the control face of the valve plate **30** for reducing leakage losses.

In the embodiment shown in FIGS. **2** to **9**, the rotor assembly **481** includes a central rotor having a fixed side wall **483**, a separate side wall **84**, and two end walls **485** and **96**. The parts of the rotor assembly are best seen in FIGS. **3** to **7**. The slot chambers **93** for the vanes **79** extend into the side walls **84** and **483**, and the ends of the vanes are located in these slot extensions. Cylinder chambers **53** and cylinder chambers **99** are provided in end wall **96**, together with portions of conduits **58** and **52**. Pistons **55** are mounted in cylinder chambers **53** and **99** for axial movement, and abut the rotary ring **9** of a thrust bearing **4** which has a stationary ring **10** secured to the housing **1**. The cylinder chambers **53** are connected by a conduit **58** passing through side wall **84** with the channels **97** which are part of the working chamber. Rotor channels **97** are connected by passages **98** in the end wall **83** with the control face of the valve plate **581** whose ports **482** and **583** communicate with the inlets and outlets of cover wall **8** of housing **1**. The parts of the rotor assembly **481** are mounted on a shaft **2** rotating in bearings **3** supported in the housing **1**. During rotation, the high pressure and low pressure ports **482** and **583** of valve plate **581** are alternately connected by the passages **98** with the rotor channels **97** which communicate with the respective working chambers between the vanes **79**.

According to the invention, each slot chamber **94** communicates with a passage **42** in end wall **485**, and with a conduit **52** in the other end wall **96** communicating with the cylinder chamber **99**. The rotor channel **42** connected with the slot chamber **93** is radially staggered to the passages **98** which communicate with the working chambers and rotor channels **97**. The high pressure and low pressure ports **482** and **583** of the valve plate **581** are correspondingly shaped and arranged, as explained with reference to the embodiment of FIG. **1**.

The embodiment illustrated in FIGS. **2** to **9** is particularly suited for high pressure operations which is due to the fact that the vanes **79** have the axial ends thereof supported in the rotor side walls **483** and **84**, as best seen in the lower portion of FIG. **2**. Furthermore, the pressure in cylinder chambers **53** which corresponds to the pressure in the working chambers obtained under control of the valve plate **581**, and the pressure in cylinder chambers **99**, which corresponds to the pressure in the slot chambers **93**, passages **42** and the corresponding port in valve plate **581**, urge the rotor assembly toward and into abutment with the stationary valve plate **581**. Due to the fact that pressure fluid having the right pressure is supplied through passages **42** to the inner ends of the slot chambers **93**, the vanes **79** are pressed outward with the pressure necessary to overcome the inward directed pressure in the working chambers adjacent respective vane **79**. Leakages at the outer ends of the vanes and in the gap between end wall **485** and valve plate **581** are reduced to a minimum, and friction is also reduced. A cam ring **7** cooperates with the outer ends of the vane **79** and is mounted by rollers **5** for rotations in the sleeve **6** in housing **1**.

In both embodiments of the invention, the slot chambers **79** or **93** may be used only for guiding the vanes, but it is also possible to use the same as hydraulic motors or pumps. The construction shown in FIGS. **12** and **13** can also be used in the embodiment of FIG. **2**. The amount of fluid flowing through the slot chambers is added to the amount of fluid flowing through the working chambers and the output of the machine is correspondingly increased. In the embodiment of FIGS. **2** to **9**, it is possible to secure the parts of the rotor assembly **481** to each other by bolts and nuts or rivets, or the flow cross-sections of the cylinder chambers **53** and **93** are selected so that the axial pressure on the end wall **96** presses all parts of the rotor assembly together, and also the entire rotor assembly against the control face of the valve plate **581**. It is necessary to dimension the effective cross-section of the cylinder chambers **53** and **99** in accordance with the pressure exerted by the ports **482** and **583** of the valve plate **581** on the end wall **485** and the rotor assembly. The total of the axial forces acting in cylinder chambers **53** and **99** should not exceed the opposing axial force acting in the gap between valve plate **581** and end wall **485**, to such a degree that the friction creates excessive heat on the control surface of valve plate **581**.

FIGS. **10** and **11** respectively correspond to FIGS. **30** and **31** of my U.S. Pat. No. 3,417,706. FIG. **10** shows the rotor of a fluid handling device in accordance with my earlier U.S. Pat. No. 3,275,716. Vanes **409** are mounted in slots of the rotor side walls, and fluid under lower pressure acts from the left on the rotor and vanes, while fluid under high pressure, indicated by arrows **401** and **402** acts tangentially on the vanes on opposite sides of the rotor. The force of this pressure tends to brake the rotor segments toward the left. Rotor sectors between the slots are not held together on the outer periphery, and secured only by one bolt **405** or **406** and one integral portion **403** or **404**. Sectors **407**, **408** are deflected toward the left in the direction of the arrows **414**. A small clearance opens a vent between the right face of vanes **409**, **410** and the slot wall of the sector on the right thereof. Therethrough leakage fluid escapes out of the working chambers and slots, reducing the efficiency of the machine. Fluid forces also act outwardly against the inner faces of the ring **412** in the direction of the arrows **413**. Ring **412** radially surrounding the end walls of the rotor is deformed so that a small clearance appears so that leakage flow takes place.

In the construction shown in FIG. **11**, which is a cross-section of FIG. **2**, an uninterrupted outer annular peripheral portion **91** of side wall **84** is provided which, together with the uninterrupted annular inner portion **404** keeps the whole rotor assembly together. The uninterrupted portion **91** is short in tangential direction so that it cannot be deformed in radial outward or inward direction. The bolts **89** fit into axial bores in the rotor assembly. Fluid forces **402** acting on the rotor assembly cannot tilt a sector of the same because there are no sectors. The fitting bolts **89**, and the uninterrupted inner and outer wall portions hold the rotor body and the end walls rigid in tangential direction, preventing clearances and leakages.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of fluid flow machines differing from the types described above.

While the invention has been illustrated and described as embodied in an axially biassed rotor assembly for a fluid flow machine and means for balancing the inward and outward pressures acting on the vanes of the machine, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. Fluid flow machine with axially biassed rotor assembly, comprising a housing having an inlet and an outlet for a fluid; a valve plate mounted in said housing and having a control face with high pressure and low pressure ports communicating with said inlet and outlet; an actuating cam ring in said housing; a rotor assembly mounted in said housing for rotation about an axis, and being formed with angularly spaced substantially radial slot chambers, said rotor assembly including vanes mounted in said slot chambers for radial movement, respectively, and having outer ends sliding on said cam ring during rotation so that expanding and contracting working chambers are formed between said rotor assembly and said cam ring, said rotor assembly having a first end portion formed with first passages for connecting during rotation said high pressure and low pressure ports successively with said working chambers, said first end portions being formed with second passages connecting during rotation said high pressure and low pressure ports successively with the inner ends of said slot chambers so as to balance the pressures at the inner and outer ends of said vanes, a thrust bearing mounted in said housing opposite the second end portion of said rotor assembly and including a rotary member; said second end portion of said rotor assembly being formed with cylinder chambers communicating with said inner ends of said slot chambers, respectively, and including pistons mounted in said cylinder chambers, respectively, and urged by the pressure in said cylinder chambers against said rotary member of said thrust bearing so that said rotor assembly is pressed together and said first end portion is pressed against said control face of said valve plate whereby leakage from the same is reduced.

2. A machine as claimed in claim **1** wherein said valve plate has in said control face additional control ports communicating with said high pressure port; and wherein said second passages cooperate with said additional control ports during rotation so that during reversal of the flow through said pressure ports, high pressure fluid flows through said control ports to said slot chambers.

3. Fluid flow machine with axially biassed rotor assembly, comprising a housing having an inlet and an outlet for a fluid; a valve plate mounted in said housing and having a control face with high pressure and low pressure ports communicating with said inlet and outlet; a rotor assembly mounted in said housing for rotation about an axis, and including means for forming working chambers expanding and contracting during rotation, said rotor assembly having a first end portion sliding on said control face, and having passages therethrough cooperating with said high pressure and low pressure ports, and communicating with said working chambers, respectively, for connecting the same successively with said high pressure and low pressure ports, and a second end portion including cylinder chambers communicating with said working chambers, respectively, and pistons in said cylinder chambers so that the varying pressure in said working chambers urges the respective pistons out of said cylinder chambers; and a thrust bearing mounted on said housing opposite said second end portion and including a rotary member against which said pistons are pressed whereby said first end portion of said rotor assembly is pressed

against said valve plate and leakage from the same is reduced.

4. A machine as claimed in claim 3 wherein said rotor assembly includes a plurality of axially adjacent separate parts; and wherein the effective cross sections of said cylinder chambers have such a pressure area that the axial pressure acting on said rotor assembly in one direction to urge the same toward said control face of said valve plate is greater than the axial pressure exerted on said rotor assembly in the opposite axial direction by fluid in the gap between said control face and said first end portion of said rotor assembly whereby said parts are pressed together and against said control face.

5. A machine as claimed in claim 3 wherein said rotor assembly includes a rotor, and at least one end wall forming said first end portion; and wherein said passages penetrate said first end wall and open into said working chambers, respectively.

6. A machine as claimed in claim 5, comprising an eccentric cam ring mounted in said housing surrounding said rotor; wherein at least said rotor has angularly spaced substantially radial slot chambers; wherein said chamber forming means of said rotor assembly include vanes mounted in said slot chambers and having outer ends sliding on said cam ring during rotation; and wherein said one end wall has other passages therethrough communicating with the inner ends of said slot chambers, respectively, and connecting the same successively with said high pressure and low pressure ports so as to balance the pressure at the inner and outer ends of said vanes.

7. A machine as claimed in claim 6 wherein said valve plate has in said control face additional control ports communicating with said high pressure port; and wherein said other passages cooperate with said additional ports during rotation so that during reverse of the flow through said pressure ports, high pressure fluid flows through said control ports to said slot chambers.

8. A machine as claimed in claim 6 wherein said second end portion includes other cylinder chambers communicating with said slot chambers, respectively, and wherein said rotor assembly includes other pistons in said other cylinder chambers pressed against said rotary member of said thrust bearing at a pressure depending on the pressure in the respective slot chambers.

9. A machine as claimed in claim 8 wherein said rotor assembly includes a central rotor, side walls at the ends of said central rotor having a greater diameter than the same, and first and second separate end walls forming said first and second end portions of said rotor assembly, said first end wall having said passages and said other passages, and said second end wall having said cylinder chambers and said other cylinder chambers; wherein said slot chambers are formed in said central rotor and in said side walls; wherein said vanes have end portions located in said side walls; wherein said working chambers are formed by the central portions of said vanes around said central rotor between said side walls; and wherein said central rotor and said side walls have conduits connecting said working chambers with said passages in said first end wall and with said cylinder chambers in said second end wall.

10. A machine as claimed in claim 9 wherein the effective cross sections of said cylinder chambers and said other cylinder chambers have such a pressure area that the axial pressure acting on said rotor assembly in one axial direction to urge the same toward said control face of said valve plate, is greater than the axial pressure exerted on said rotor assembly in the opposite axial direction by fluid in the gap between said control face and said first end wall of said rotor assembly.

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