

Aug. 27, 1968

K. EICKMANN

3,398,698

ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY
IN SUBSTANTIAL AXIAL DIRECTION

Filed June 4, 1965

17 Sheets-Sheet 1

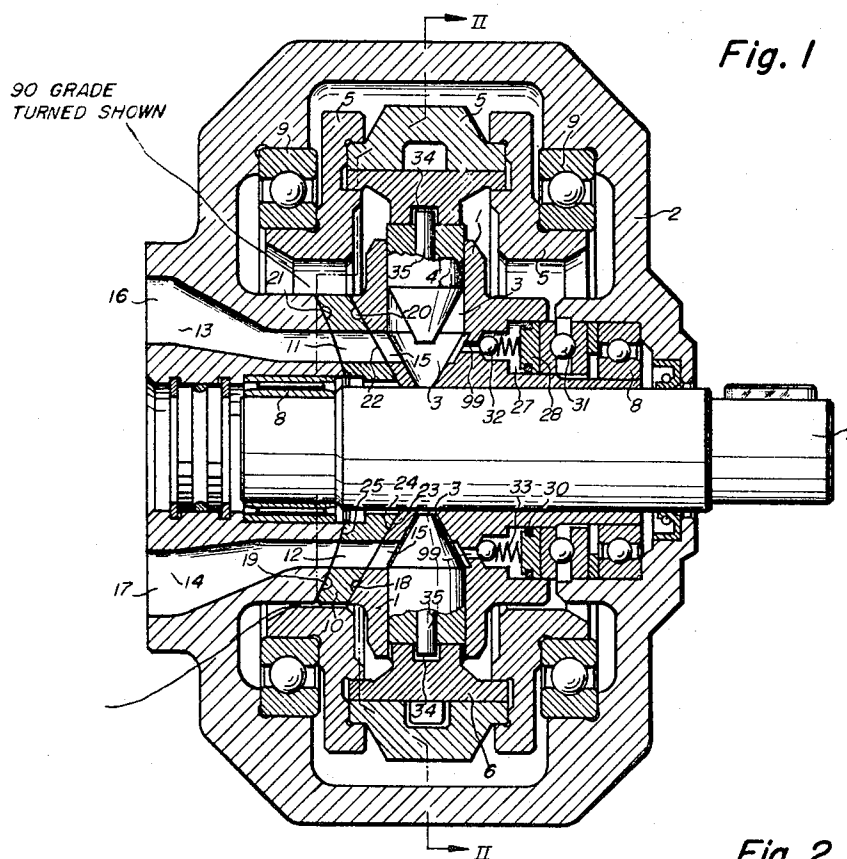


Fig. 1

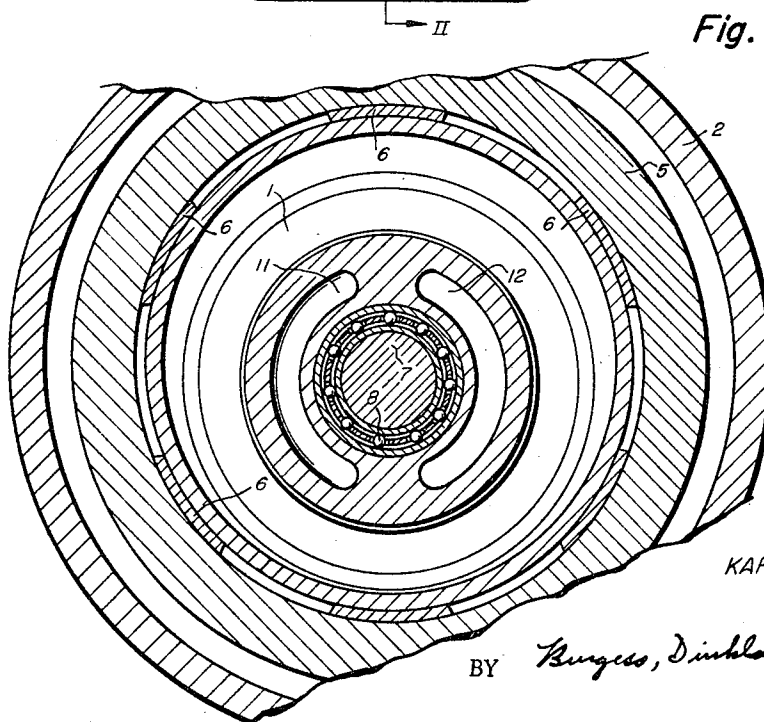


Fig. 2

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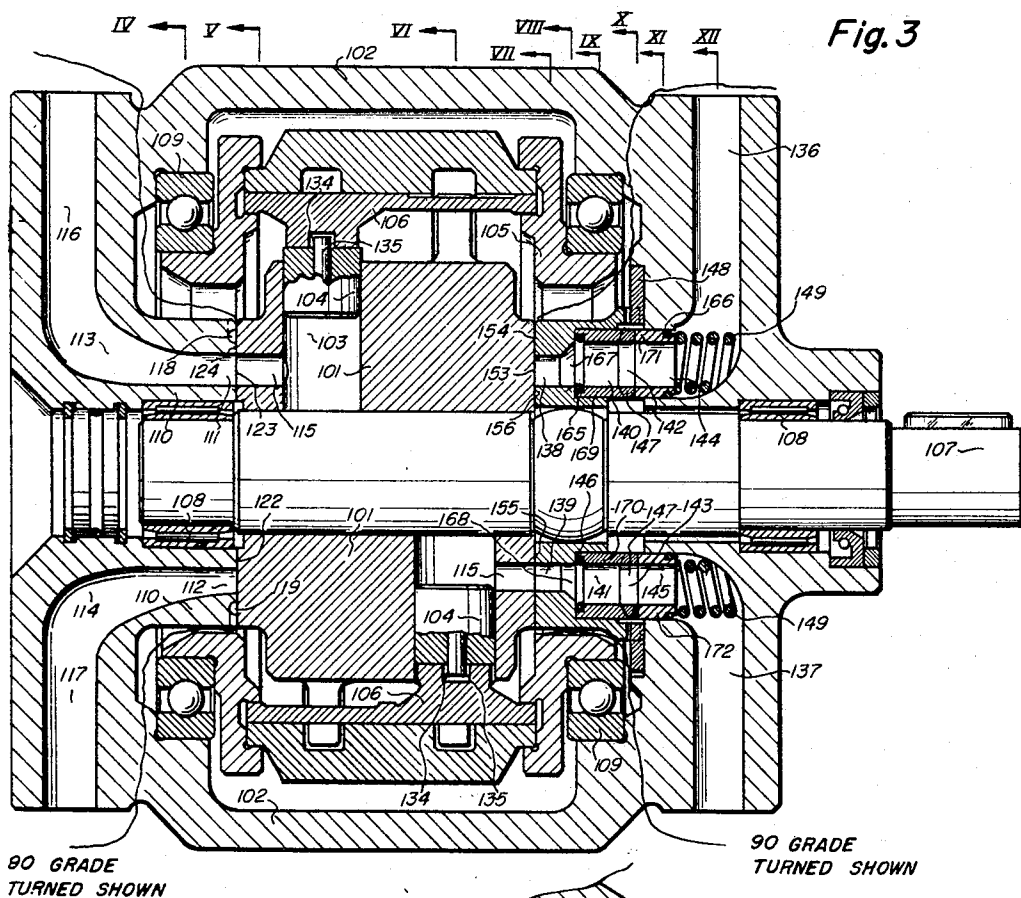


Fig. 3

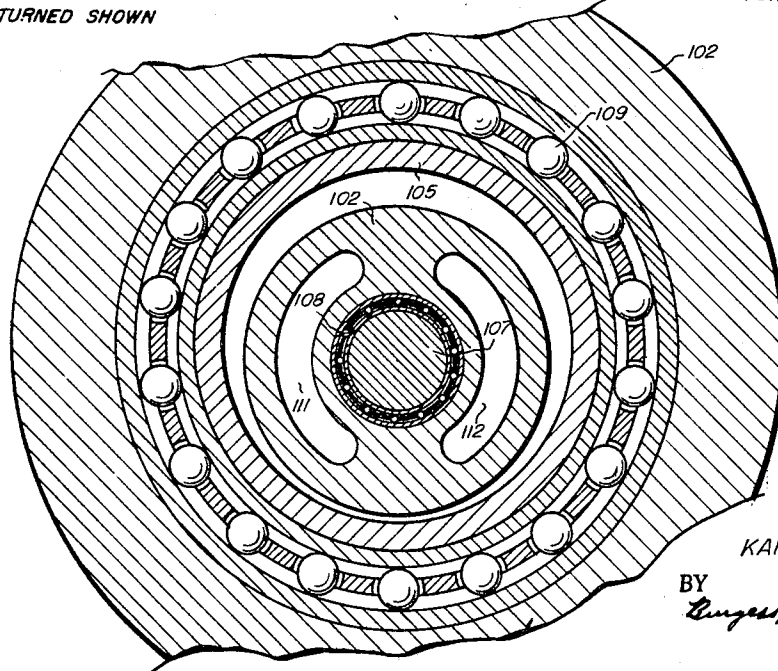


Fig. 4

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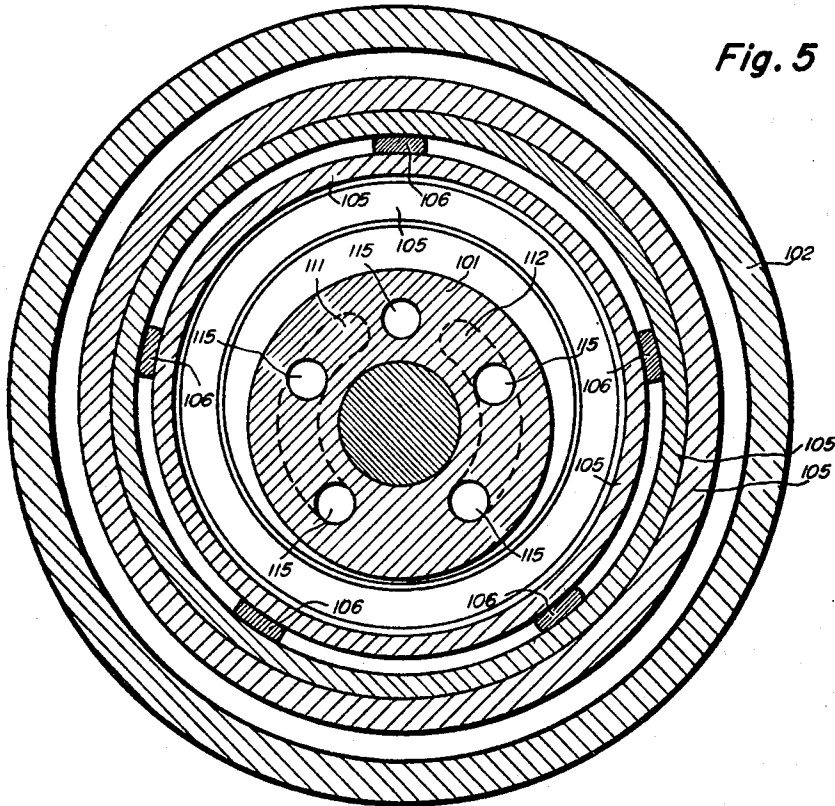


Fig. 5

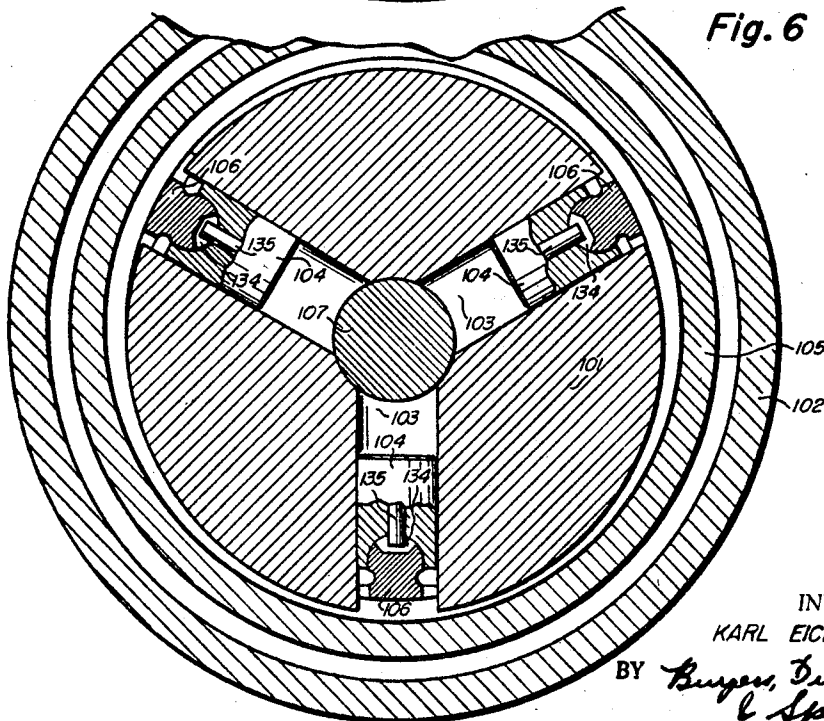


Fig. 6

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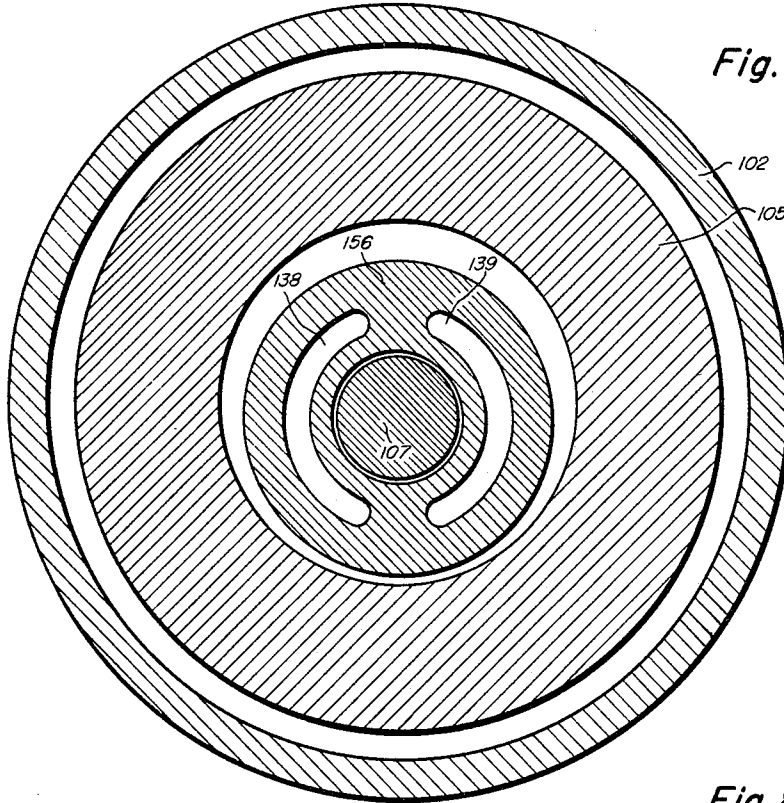


Fig. 7

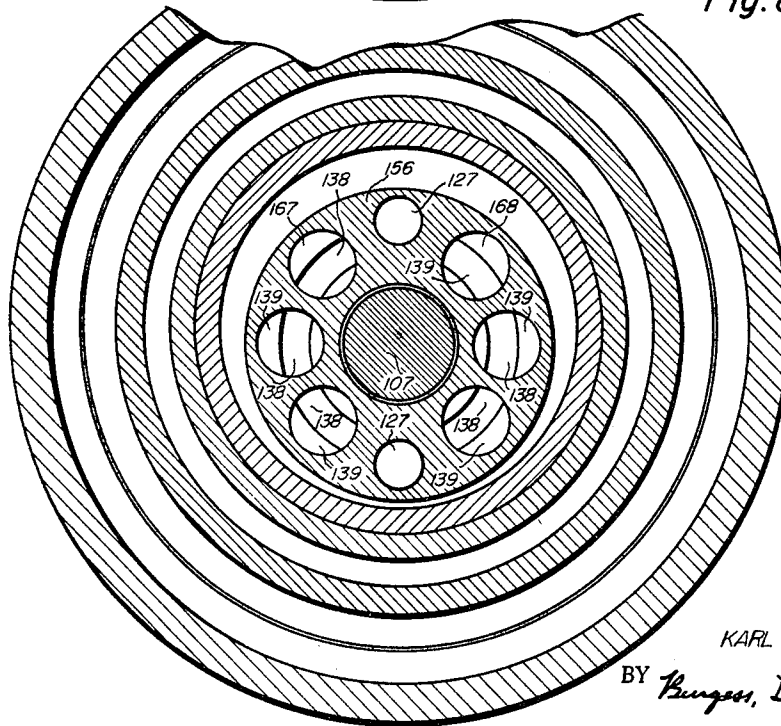


Fig. 8

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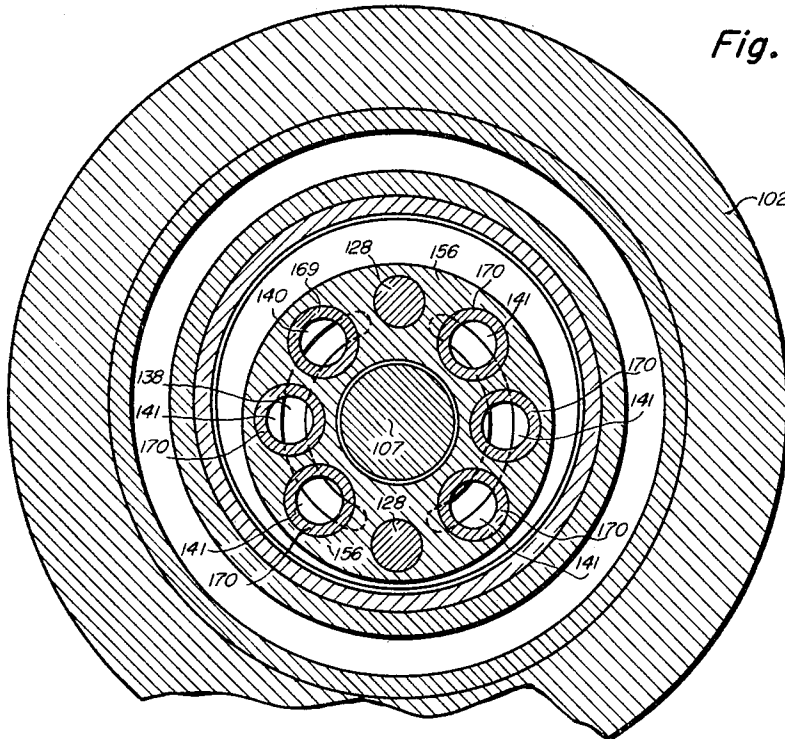


Fig. 9

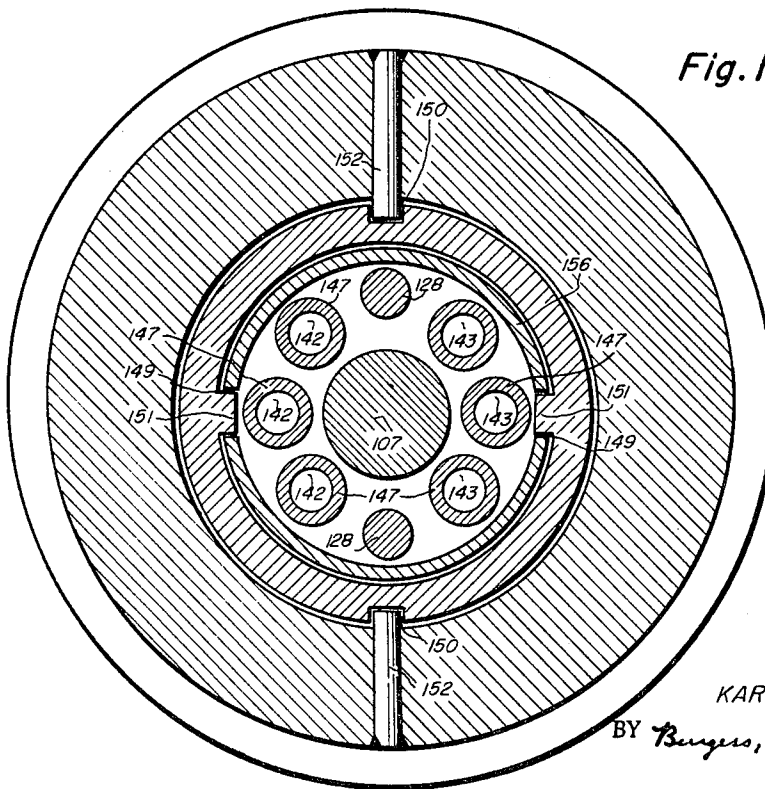


Fig. 10

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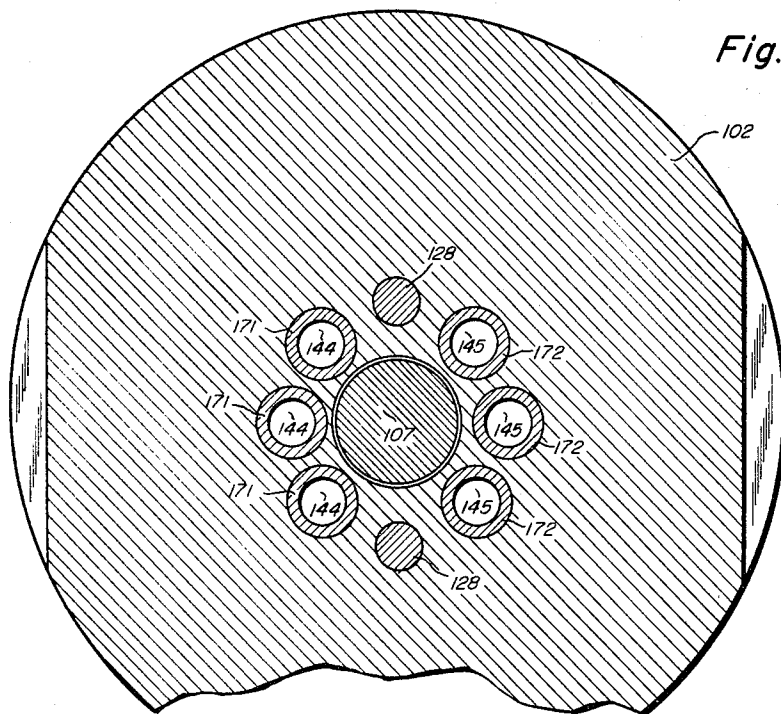


Fig. 11

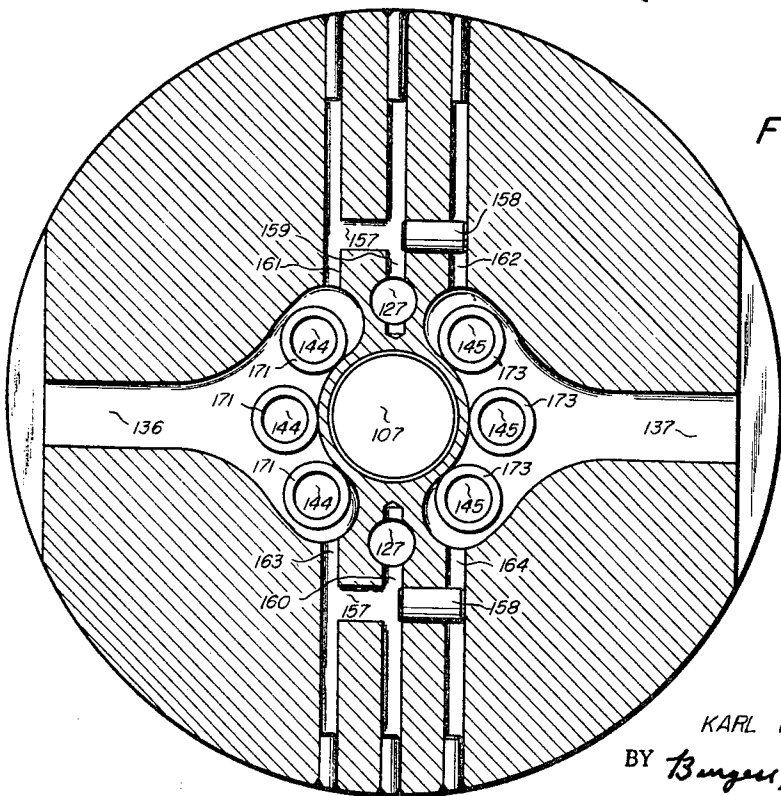


Fig. 12

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Fig. 13

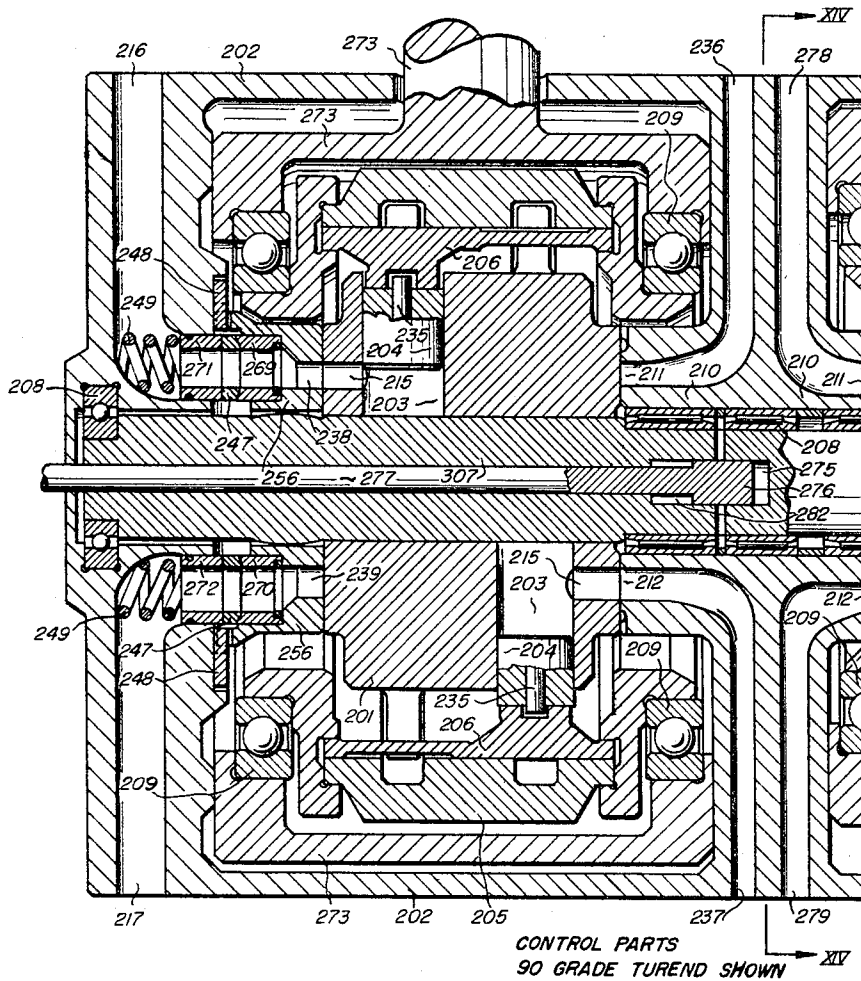
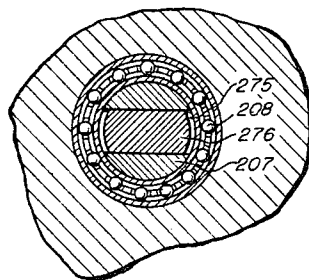


Fig. 14



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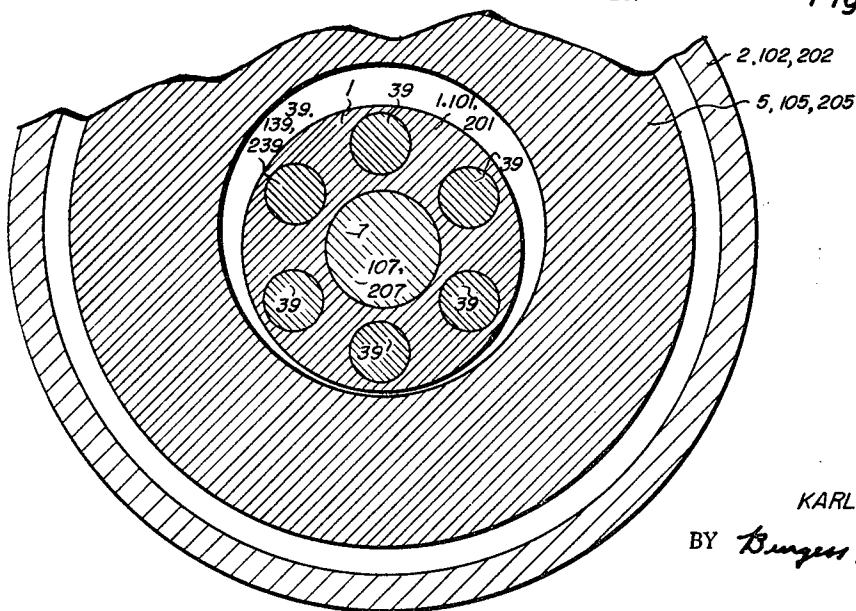
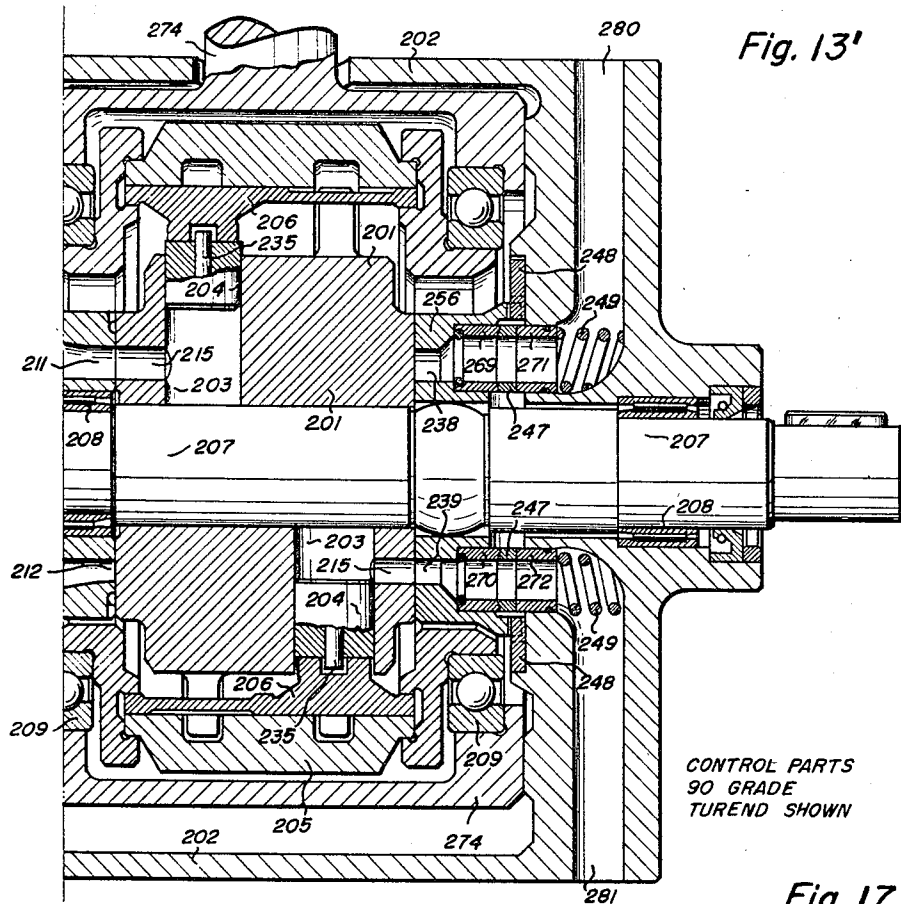
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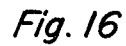
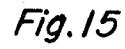
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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY IN SUBSTANTIAL AXIAL DIRECTION		

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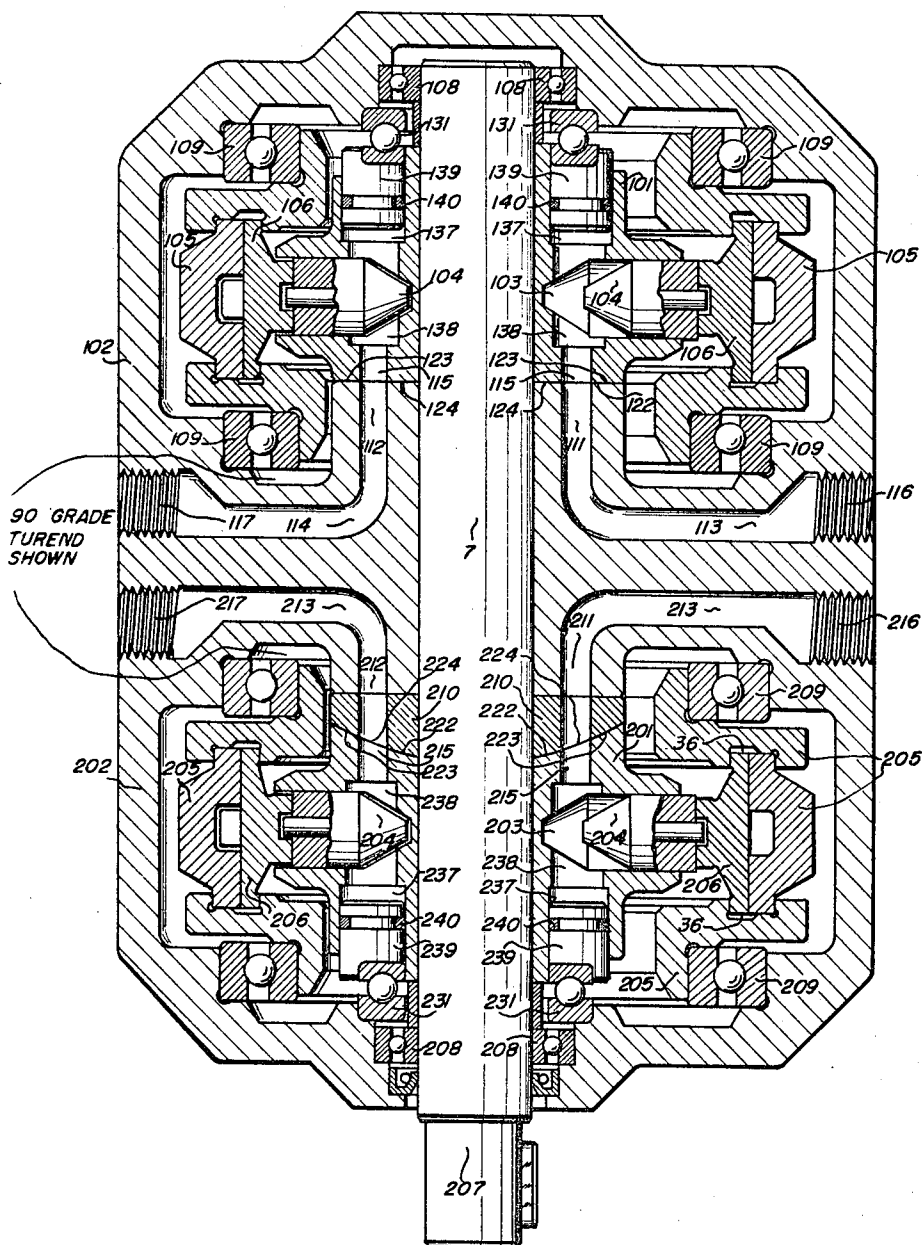
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Fig. 18



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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY
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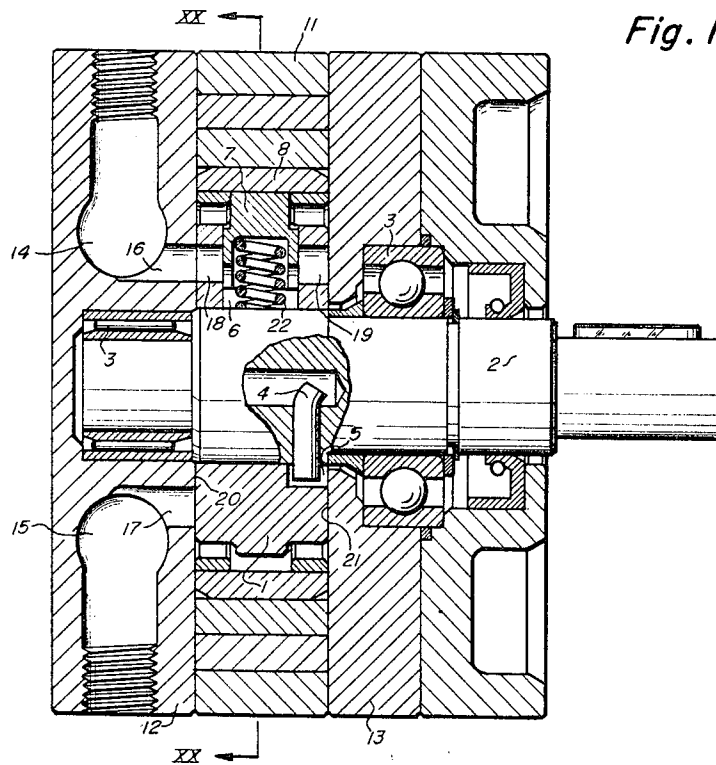


Fig. 19

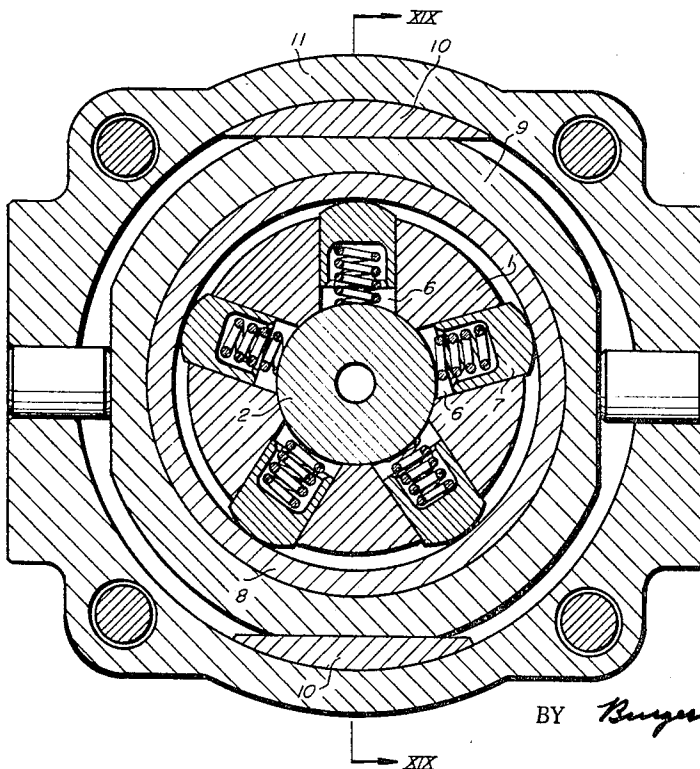


Fig. 20

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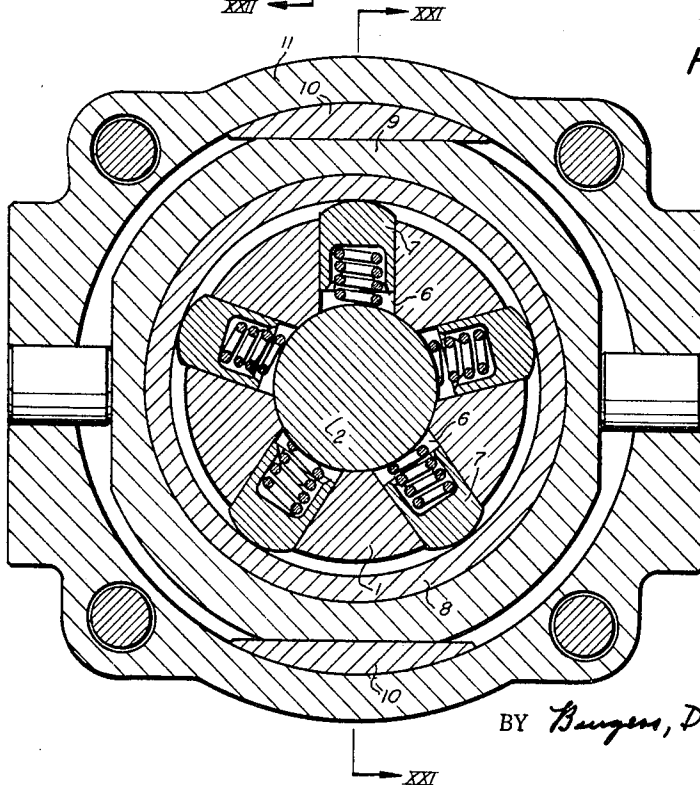
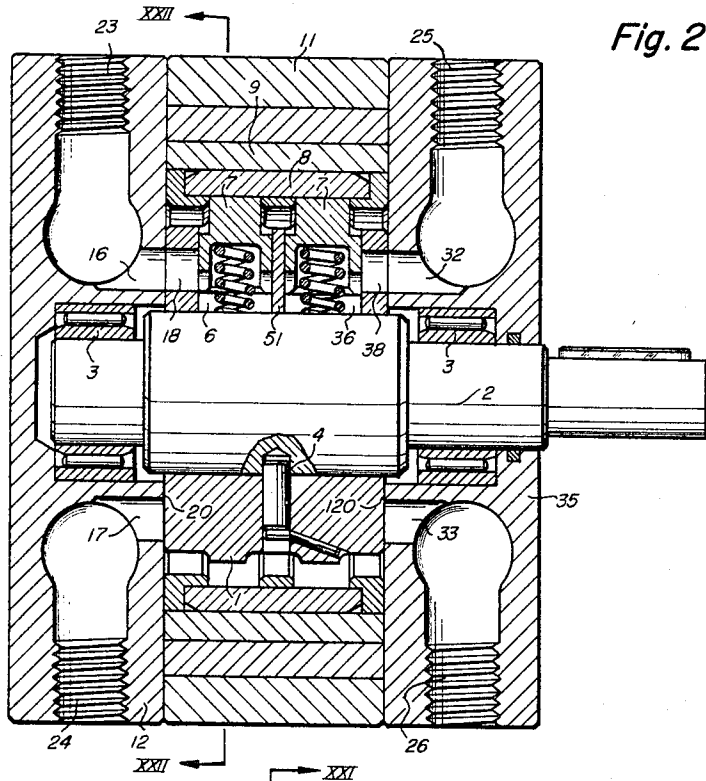
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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY
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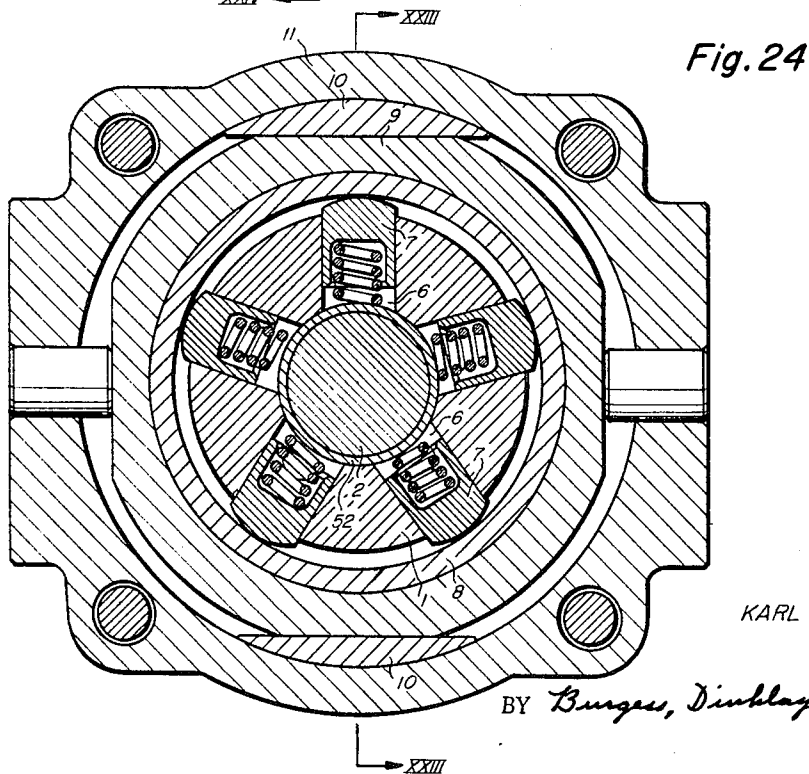
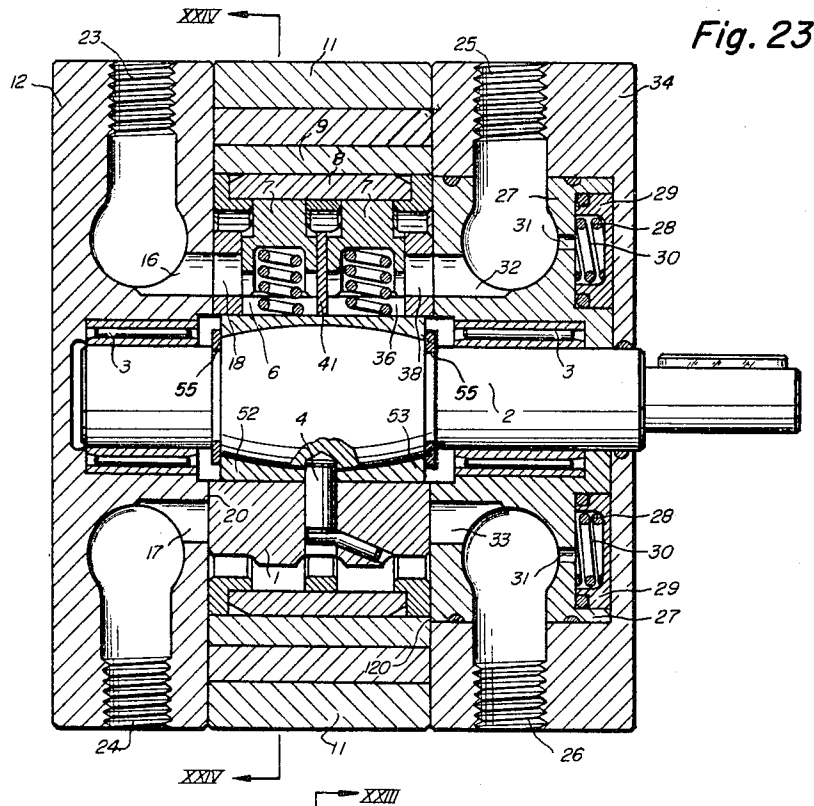
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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY
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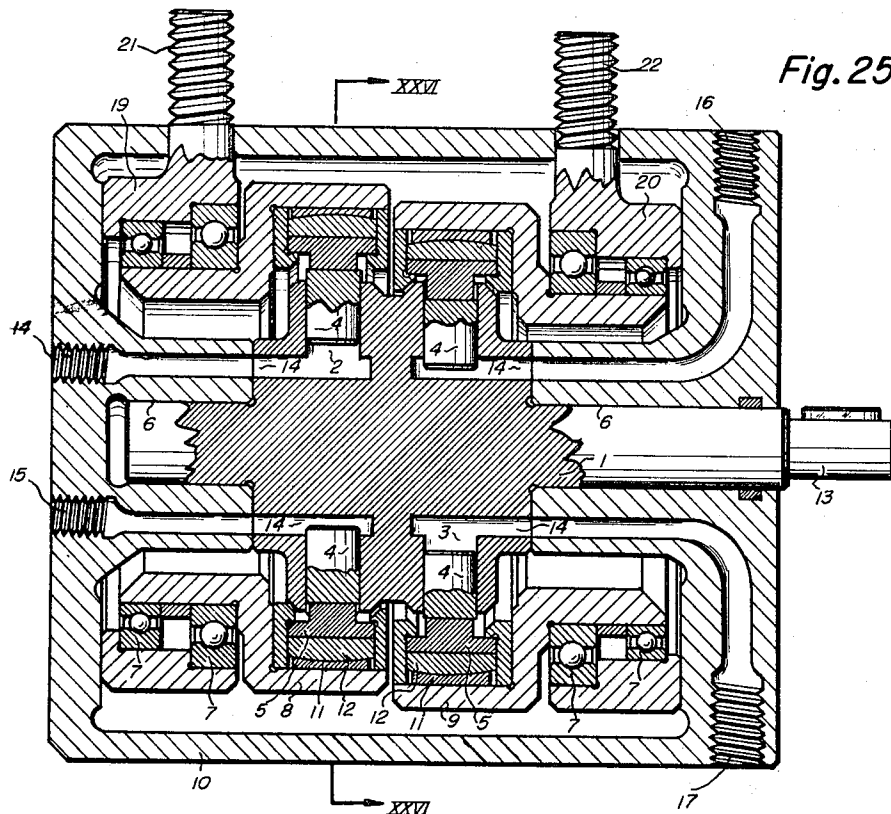


Fig. 25

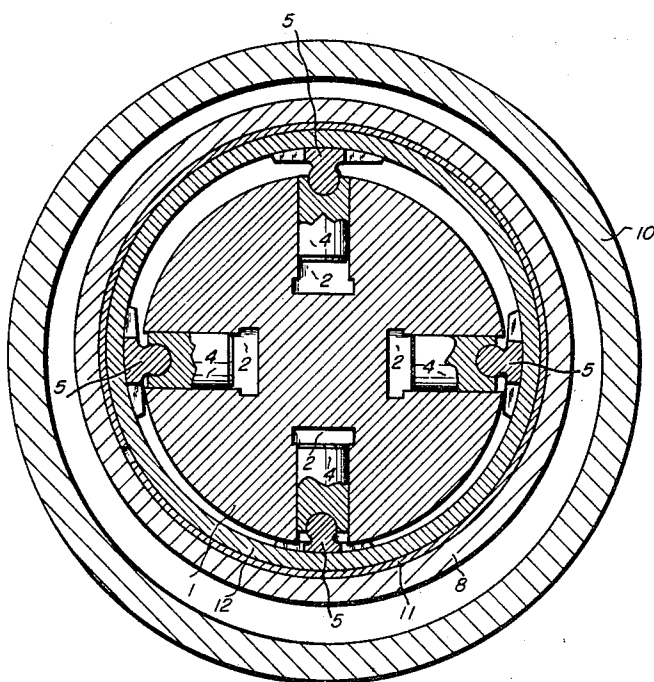


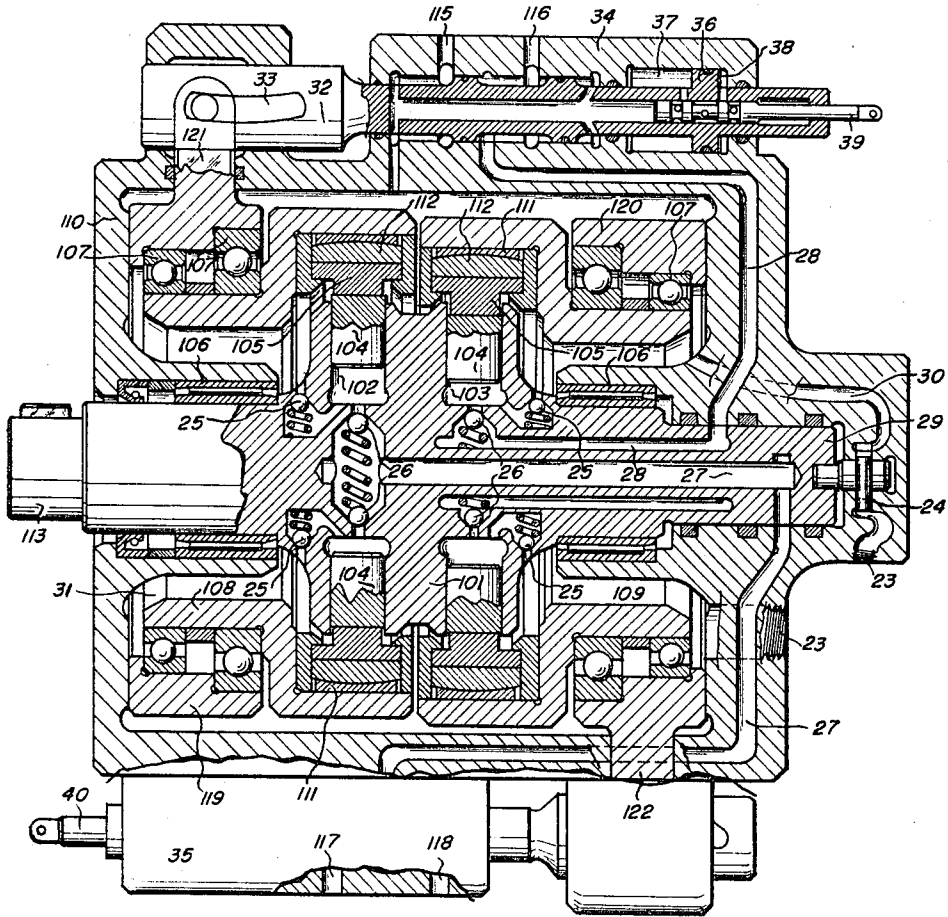
Fig. 26

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Aug. 27, 1968 **K. EICKMANN** **3,398,698**
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Fig. 27



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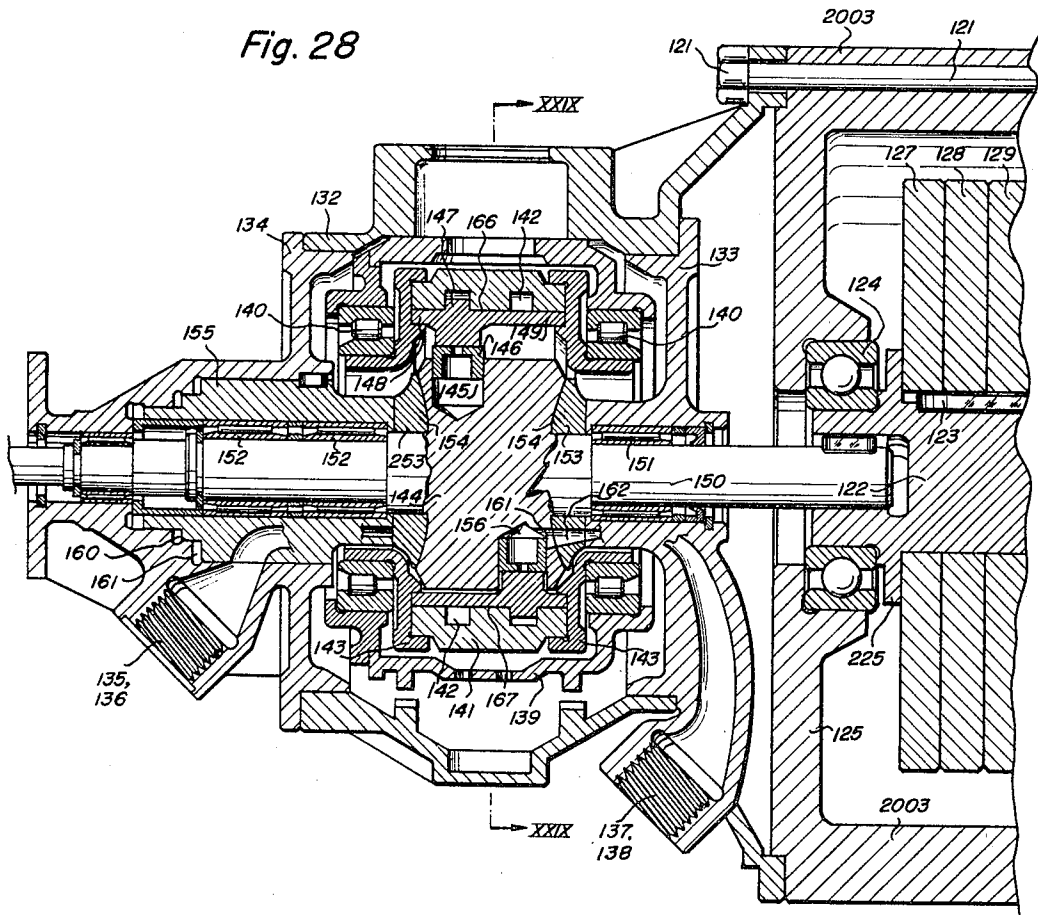
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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY
IN SUBSTANTIAL AXIAL DIRECTION

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Fig. 28



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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY
IN SUBSTANTIAL AXIAL DIRECTION

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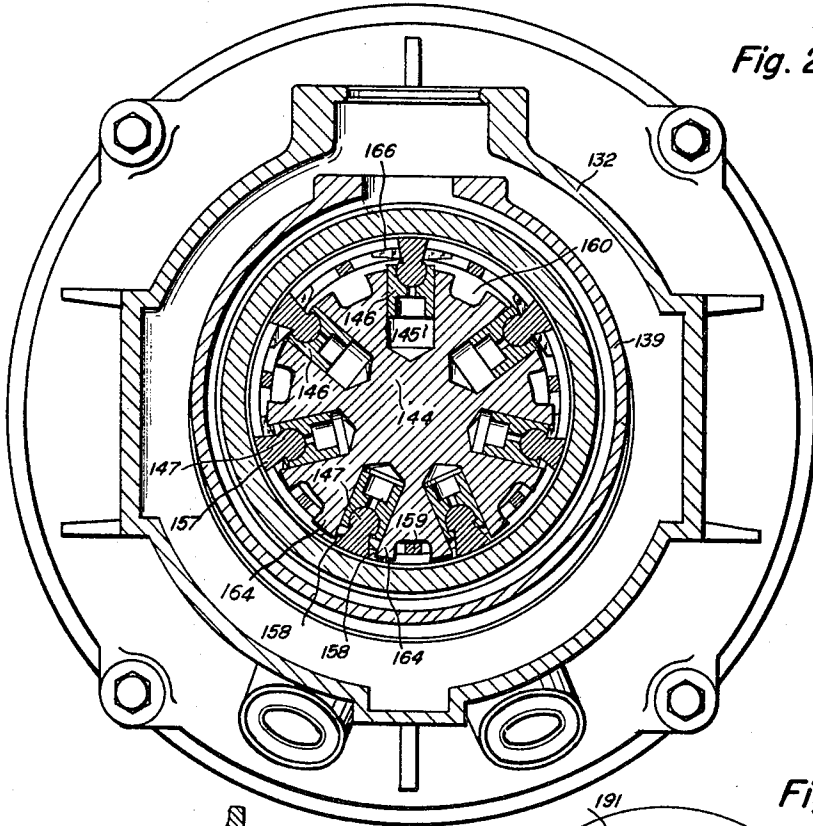


Fig. 29

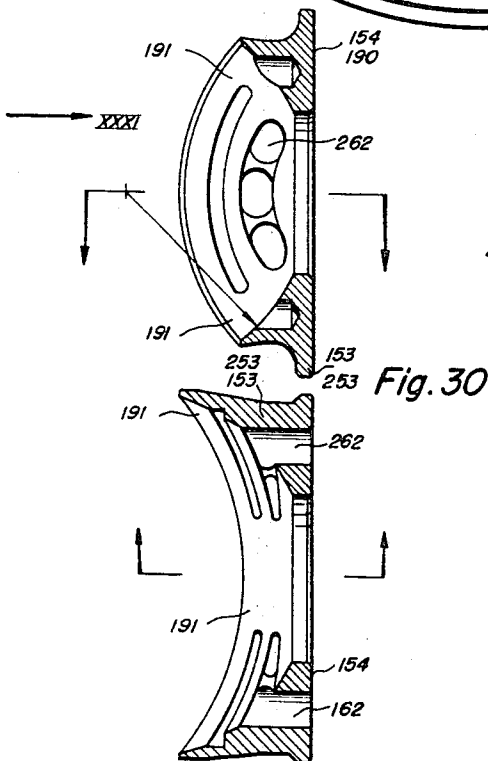


Fig. 30

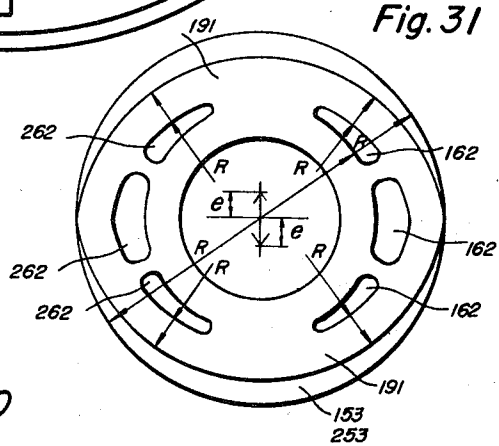


Fig. 31

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ROTARY RADIAL PISTON MACHINE WITH FLUID FLOW SUPPLY IN SUBSTANTIAL AXIAL DIRECTION

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Filed June 4, 1965, Ser. No. 461,483

Claims priority, application Switzerland, June 11, 1964,
7,664/64, 7,665/64; July 10, 1964, 9,137/64

5 Claims. (Cl. 103—161)

ABSTRACT OF THE DISCLOSURE

A rotary fluid-handling machine which can be operated either as a motor or a pump, and having a rotor provided with radial pistons and cylinders, and wherein the working fluid passes to and from the rotor through axially facing control ports provided on the rotor which pass into alignment with matching control ports on a body which is stationary with respect to the rotor, the rotor and such stationary body being disposed for limited relative movement to maintain minimum operating clearance therebetween to reduce fluid leakage.

This invention relates to rotary radial piston machines wherein the working fluid flow is in the axial direction, and wherein radial cylinders are provided in a revolving rotor in which pistons move periodically outwardly and inwardly for intaking and expelling fluid supplied from a stationary part, containing axially facing control ports which pass into alignment with axially facing control ports on the rotor.

Such machines can operate as pumps to produce a flow of fluid or flows of fluid, either liquid or gas, or they can be driven as motors by a flow of flows of fluid.

Such machines are therefore especially suitable for use as compressors, pumps, combustion engines, air motors, gas motors, hydraulic pumps, hydraulic motors or the like.

Where such machines are supplied with working fluid which flows into the rotor from control ports of a stationary part such that the fluid flow is primarily in the axial direction, there arises the problem of maintaining the fluid forces on the rotor such that the rotor ports and those on the stationary control body are pressed together for minimum operating clearances to reduce fluid leakage.

It is therefore an important object of this invention, to provide a control and balance means for the axial flow of fluid to and from the rotor in a rotary radial piston machine which operates in such a way, that the respective stationary and rotor control faces are pressed against each other with the correct force to avoid or at least considerably reduce wearing, tilting, leakage and friction.

Another object of the invention is to provide one fluid containing balancing chamber or a plurality of fluid containing balancing chambers on that axial end of the rotor, which is located oppositional respective to the axial end of the rotor, wherethrough the fluid passes to or from the working chambers.

That axial end of the rotor, wherethrough the fluid flows, is called hereafter the "control face end of the rotor" and the other end of the rotor will be called hereafter "the opposite rotor end."

Another object of the invention is, to close said fluid containing balancing chamber or chambers by cover means.

Another object of the invention is to provide a combined fluid containing balancing chamber on one axial end or on the opposite rotor end of the rotor and to close

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this chamber in the axial direction by an axially movable cover means.

Still another object of the invention is to provide one combined fluid containing balancing chamber on one axial end of a rotor of a radial piston machine; and to close this balancing chamber by a movable cover means and to provide a checkvalve in a passage from respective radial cylinder chambers in the rotor to the combined fluid containing balancing chamber.

A further object of the invention is, to provide a fluid containing balancing chamber for each one of the radial cylinders or working chambers in the rotor; and to provide a passage between respective working chambers and the fluid containing balancing chambers and to close each of the fluid containing balancing chambers by a moveable cover means.

A further object of the invention is to provide a thrust bearing between the cover means of the fluid containing balancing chamber and a stationary housing member.

It is a further object of the invention to provide a control body on one axial end of the rotor which is moveable to a limited extent in the axial direction.

A further object of the invention is to thereby fasten an axially moveable control body on one axial end of the rotor by a ring means with engagement means therein so that the control body is prevented from revolving around its own axis but yet remains flexible as to movement spherically and axially.

Another object of the invention is to provide control bodies with entrance passages and exit passages on both axial ends of the rotor means or at least one on each axial end of a radial piston fluid machine.

Another object of the invention is to provide a plurality of flexible and/or spherical or radial and axial or partially axial, moveable control passages, control passage means or sealing means in connection with the control body which passes fluid to or from a rotor of a radial piston fluid machine.

Further objects of the invention are directed to balancing means for the control bodies to achieve an almost floating control body in the axial fluid flow direction.

Still another object of the invention is to provide a control body on an axial end of a rotor means for rotary radial fluid machines which narrows the internal compression losses in fluid in the working chambers in the machine; and thereby maintains a configuration of the control body and the rotor which narrows the dead spaces in the rotor passages and working chambers.

Another object of the invention is to provide a rotary radial piston fluid machine wherein the supply of fluid passes axially to and from the working chambers in the rotor means in such a way that the pump, motor or compressor operates as a two flow machine.

A still further object of the invention is to adopt a pair of dual flow rotors in a single rotary radial piston fluid machine to provide four flows of equal or proportional delivery of fluid when operated as a pump or to operate the machine as a motor.

Still another object of the invention is to provide two or more rotor means axially arranged in tandem wherein each rotor supplies at least one flow of fluid at equal proportional delivery.

Other objects of the invention are directed to the fastening of the rotor means to a shaft means and the limited axial moveability of these parts relative to each other.

Still another object of the invention is to provide a very simple and inexpensive rotary piston machine.

Another object of the invention is to provide a simple rotary radial piston machine with at least one plane radially extending control face and balancing chambers in the rotor for the axial balancing of the rotor means wherein

the balancing chambers are closed in one axial direction by a stationary control face or a casing or cover means.

Still another object of the invention is to provide a simple rotary radial piston machine which has two radial cylinder groups and which supplies two separated flows of fluid, or which is driven by two flows of fluid and wherein one cylinder group is supplied with fluid through rotor windows in one axial direction while the other of the cylinder groups is supplied with fluid through rotor windows in the other axial direction or wherein the two flows of fluid communicate within the rotor.

Still a further object of the invention is to provide a very simple rotor means for a rotary radial piston machine wherein the rotor means floats axially under fluid pressure, and wherein the rotor means revolves between stationary end plates.

A further object of the invention is to provide simple radial pistons in rotary radial fluid machines.

Another object of the invention is to provide a rotor means which is pivotable to a limited extent in a spherical way and moveable axially to a limited extent, relative to the drive shaft or driven shaft of the machine.

Still another object of the invention is to provide rotary radial piston machines which operate with two separated flows of fluid and wherein each flow is independent of the other, and adjustable to vary the delivery or intake flow rate.

Still a further object of the invention is directed to the separate control of the displacement adjustment device for the working spaces of separated actuator groups in rotary radial piston machines.

Other objects of the invention are directed to other separate control possibilities for the separate control of rotary radial piston machines having or producing separate flows of fluid and having independent displacement volume adjustment devices.

Other objects of the invention are directed to a combination control means for controlling the delivery rate of separated flows of rotary radial piston pumps or compressors in combination with flow direction controllers.

And still other objects of the invention are to provide rotary radial piston machines with highest efficiency and durability, which minimize friction between relatively moving parts and which assure that tilting between relatively moving parts is prevented by flexible mounting means and/or wherein other means are provided to improve the working ability or efficiency of rotary radial piston fluid machines and to provide simpler manufacturing or design possibilities and features for such machines.

Other objects and features of the invention will become apparent from the following description, taken in connection with accompanying drawings which illustrate several embodiments of the invention.

In the drawings:

FIGURE 1 is a longitudinal sectional view through one embodiment of the rotary radial piston machine of the invention.

FIGURE 2 is a cross sectional view through FIGURE 1 along the line II—II.

FIGURE 3 is a longitudinal sectional view through another embodiment through the rotary radial piston machine.

FIGURE 4 is a cross sectional view through FIGURE 3 taken along the line IV—IV of FIGURE 3.

FIGURE 5 is a cross sectional view through FIGURE 3 taken along the line V—V.

FIGURE 6 is a cross sectional view through FIGURE 3 taken along the line VI—VI of FIGURE 3.

FIGURE 7 is a cross sectional view, taken along line VII—VII of FIGURE 3.

FIGURE 8 is a cross sectional view taken along the line VIII—VIII of FIGURE 3.

FIGURE 9 is a cross sectional view taken along the line IX—IX of FIGURE 3.

FIGURE 10 is a cross sectional view taken along line X—X of FIGURE 3.

FIGURE 11 is another cross sectional view through FIGURE 3 and it is taken along the line XI—XI of the said figure.

FIGURE 12 is another cross sectional view taken along the line XII—XII of FIGURE 3.

FIGURE 13 is a longitudinal sectional view through another embodiment of another rotary radial piston machine of this invention.

FIG. 13' is a longitudinal sectional view through a rotary radial piston machine showing a further valving embodiment providing relative movement between the pump rotor and pump housing.

FIG. 14 is a cross sectional view through FIGURE 13 taken along the line XIV—XIV of FIGURE 13.

FIGURE 15 is a longitudinal sectional view through still another embodiment of the rotary radial piston machine of this invention.

FIGURE 16 is a cross sectional view taken along the line XVI—XVI of FIGURE 15.

FIGURE 17 is a cross sectional view taken along the line XVII—XVII of FIGURE 15.

FIGURE 18 presents a longitudinal sectional view through still another embodiment of the invention which illustrates another rotary radial piston machine.

FIGURE 19 is a longitudinal sectional view through another embodiment of a rotary radial piston machine.

FIGURE 20 is a cross sectional view through FIGURE 19 taken along the line II—II while FIGURE 19 was a sectional view taken along the line I—I of FIGURE 19.

FIGURE 21 is a longitudinal sectional view through another embodiment of the invention taken along the line III—III of FIGURE 22.

FIGURE 22 is a cross sectional view taken along the line VI—VI of FIGURE 21.

FIGURE 23 is a longitudinal sectional view through still another embodiment of a rotary radial piston machine of this invention and it is taken along the line V—V of FIGURE 24.

FIGURE 24 is a cross sectional view through FIGURE 23 taken along the line VI—VI.

FIGURE 25 is a longitudinal sectional view through still another embodiment of the invention, which represents another type of rotary radial piston machines and constitutes another embodiment of the invention.

FIGURE 26 is a cross sectional view through FIGURE 25 taken along the line II—II of FIGURE 25.

FIGURE 27 is a longitudinal sectional view through still another embodiment of a rotary radial piston machine of this invention.

FIGURE 28 is a longitudinal sectional view through still a further embodiment of the invention which represents another rotary radial piston machine.

FIGURE 29 is a cross sectional view through FIGURE 28 taken along the line XXIX—XXIX of FIGURE 28.

FIGURE 30 shows a control body of the invention which is another embodiment of the invention and which is a part of FIGURE 28 shown in a separate illustration.

FIGURE 31 shows the control body of FIGURE 30 in another view taken along the line XXXI—XXXI of FIGURE 30.

In the figures are such parts with the same function or which fulfill equivalent or similar functions cited by reference numerals having similar end digits. This is at least the case for FIGURES 1 to 12. In FIGURES 3 to 12 positions which are fulfilling equivalent functions have obtained the first digit 1 or 2 and then they are fulfilling the same functions or they are the same parts as in FIGURES 1 and 2 with equal end digits.

In FIGURE 1 it can be seen that rotor 1 is rotatably borne in the bearings 8 and is able to revolve in housing 2. Within rotor 1 there are a plurality of working cham-

bers 3 provided which are substantially radially extending cylinders wherein the pistons 4 are moveable periodically outward and inward when the machine operates. The displacement volumes, i.e. the fluid volumes in the working chambers 3 periodically increase and decrease according to the angular position of the rotor. The pistons 4 are provided with piston shoes 6 which are guided by the actuator means or guide means 5. The actuator means 5 are provided in order to actuate the radial outward and inward movement of the piston shoes 6 relative to their respective pistons 4. The rotor 1 is provided with a shaft means 7. Shaft means 7 extends out of the housing of the machine. The actuator means 5 may also be borne in bearings 9 and it is preferred that they rotate together with rotor 1 in the casing or housing 2. However it is also possible to make actuator means 5 stationary. In accordance with this invention from each working chamber or cylinder space 3 extends a rotor passage 15 in one axial direction through the rotor. This extension is preferably exactly axial but can be substantially axial, for instance, it can be inclined in a limited extent. On one axial end of the rotor is a face 24 which may be a conical, spherical or radial plane and which is called the rotary control face 24. It is a part of the control interface 22. The other part of the control interface 22 is a stationary control face 23 which is not a part of the rotor but a part of a control member or of the housing.

In the embodiment of FIGURE 1 the control face 24 is of a conical configuration. On one axial end of rotor 1 is the control body pin which is borne or fastened on a part of housing 2. Control body 10 has an endface which is configured to work as a stator stationary control face or stator control face 23. This is substantially in the same form as the rotary control face 24 but of complementary configuration so that it is able to slide relatively to the rotary control face 24. Through rotor 1 are provided the control port passages 11 and 12, which extend therethrough preferably from one axial end to the other. One of the control ports acts as a fluid entrance port while the other acts as an exit port. This action can be reversed. During the operation of the machine, the rotor 1 and the control body 10 are slightly pressed against each other so that between the stator or stationary control face 23 and the rotary control faces 24 only a very small clearance remains. The stationary control face 23 and the rotary control face 24 together define the control interface 22 of the rotary radial piston machine of the invention and this control interface 22 acts as the fluid flow control of the machine.

During each revolution of the rotor 1 every rotor passage 15 moves once over control port 11 and once over control port 12 of control body 10 whereby fluid passes out of one of the control ports through rotor passage 15 into the respective cylinder 3, and during the other half of the revolution fluid flows out from the respective cylinder 3 through the respective rotor passage 15 and into the other of the control ports.

Control body 10 is in this embodiment of the invention provided on its backward end with a spherical face which is borne on a part of housing 2 or by a cover means of housing 2.

Instead of bearing the control body 10 on a part of housing 2 it would also be possible to form a part of the housing 2 or of a cover means thereof directly as a control body.

The bearing of control body 10 on a part of housing 2 is achieved by the spherical faces 25 which are provided one on a part of the housing 2 and the other on the backward end of the control body 10. During operation of the machine fluid like liquid or gas is flowing through fluid ports 16 and fluid passage 13 into the control port 11 and from control port 11 into the respective rotor passages 15 and therethrough into the respective working chambers or cylinders 3 when those are increasing their volume while during the other half of a revolution the flow of fluid is

reversed and is through control port 11 and fluid passage 14 and fluid port 17. In the rotary control face 24, or in the stationary control face 23, or in the backward face of control body 10, or on the respective cooperating face of housing 2, or in one of the faces which are cited by reference numeral 25, recesses for containing fluid under pressure as identified by 20 and 21 or 18 and 19 are preferably provided. Into such recesses, which are balancing recesses 19, 18, 20 and 21, fluid under pressure is passed and the forces of fluid which are acting inside of the fluid containing balancing recesses against the neighbouring spaces or parts are acting contrary to other forces or components so that the fluid under pressure in the balancing recesses 18, 19, 20 or 21 exerts either partial or total balancing or counterbalancing forces against other forces on the respective neighbouring parts. The passage of fluid into the respective balancing recesses 18, 19, 20 or 21 may be done by communication passages or fluid passages from the control windows or from the rotor or from other parts of the machine, and such passages are not shown in the drawing since they can be varied in location depending on the axial design configuration.

In order to obtain a high efficiency of the machine and to have minimum fluid leakage in the machine it is according to this invention desirable that rotor 1 be under all conditions pressed against the control body 10 so that the control interface 22 between the stationary control face 23 and the rotary control face 24 has only a very small clearance in the order of 0.01–0.001 mm. depending on the size of the control faces and on their relative rotary velocity.

The embodiment of FIGURE 1 can be almost perfectly obtained according to this invention by providing on the opposite rotor end, a fluid containing balancing chamber or pressure chamber 27, which revolves with rotor 1. Fluid containing balancing chamber 27 is closed by a rotary cover means 28 which preferably extends into the balancing chamber 27 and which is sealed thereagainst and which is preferably capable of limited axial movement with respect to fluid containing balancing chamber 27. Between the cover means 28 and the walls of the fluid containing balancing chamber 27 there may be a seal means 30 provided which is preferably of plastic or flexible material, to prevent fluid leakage from balancing chamber 27. Within the rotor means 1 there can be fluid passages 99 provided. From each of the respective working chambers or cylinders 3 fluid can pass through the respective fluid passage 99 into the balancing chamber 27. Balancing chamber 27 may under certain circumstances be stationary but in accordance with embodiment of FIGURE 1, balancing chamber 27 is rotary and it revolves together with rotor 1 and forms a chamber within rotor 1.

Between each of the fluid passages 99 and the fluid containing balancing chamber 27 it is preferred to set a valve or a check valve or a one way valve means 32. This can be preferably pressed into its seats or into its closed position by a spring means 33. If now during the rotation of the rotor in one or some of the cylinder chambers or working chambers 3 a higher pressure than in the rotary fluid containing balancing chambers 27 exists, then fluid under pressure can escape from the respective working chambers 3 through the valve means 32 into the rotary fluid containing balancing chambers 27 and it can thereby within the rotary fluid containing balancing chamber 23 build up a field of fluid under pressure. This field of fluid under pressure presses the rotor in an axial direction against the stationary control face 23 and it presses the cover means 28 in the opposite direction away from rotor means 1. Cover means 28 is preferably borne on the thrust bearing 31 while thrust bearing 31 is preferably borne on housing 2 or cover means thereof. Therefore cover means 28 can not move away from the rotor 1 then until it is completely borne and contained by the thrust bearing 31 and borne thereby. As already mentioned the reaction forces of fluid containing rotary balancing chamber 27

press the rotor 1 in the other axial direction against the control body 10. In order to achieve the effect and efficiency of the invention, it is necessary that the cover means 28 is movable axially to a limited extent relative to rotor 1. Otherwise the effect of the invention can not be obtained. It is further important that the sectional area of the fluid containing balancing chamber 27 normal to the rotor axis is so dimensioned and located that the rotor means 1 is not too strongly pressed against the control body 10, and it must be so dimensioned that the pressure of fluid exerts a force on rotor 1 which is strong enough to press rotor 1 against the control body 10 of the other end of the rotor so that the most suitable clearance of control interface 22 is created and maintained during the operation of the machine.

The provision of a thrust bearing 31 as an anti-friction bearing like an axial roller bearing or an axial ball bearing is especially favored since this eliminates friction between stationary and rotary parts and since the anti-friction bearing or thrust bearing 31 then takes over completely the function of closing the rotary fluid containing balancing chamber 27 together with the cover means 28 and respective seal means 30. FIGURE 1 also shows an example of the application of radial bearings 8 for bearing shaft means 7 or rotor means 1 and via a spacing ring means bearing the thrust bearing 31 on the outer ring of bearing means 8. This assembly is however only by way of example and can be modified according to design for actual application considerations.

It is further important to locate and dimension the balancing recesses 18, 19, 20 and 21 so and in such a way that together with the pressure in the rotary fluid containing balancing chamber 27 an almost perfect pressure balancing in the axial direction and also radially can be obtained so that inclination of the axis of the rotor means 1 or of control body 10 can be prevented.

In the figures, the casing or housing 2, 102 or 202 is drawn as a one piece body in order to demonstrate the important parts of the invention clearly. In the practical application and building of such machines it is however necessary to design the casing or housing or to provide on casing or housing 2, 102, or 202 respective covers, so that the parts of the machine can be assembled into the housing.

In FIGURE 1, the pistons 4 are provided with piston shoes 6 and with piston shoe retaining means 35. The piston shoes retaining means 35 is preferably provided in a centerbore in each respective piston 4 and extends into a respective piston shoe recess 34 and thereby movement of the shoes 6 relative to piston 4 in the rotor axial direction is prevented.

On the axial ends of the trunnion of piston shoe 6 clearance is provided so that the piston shoe 6 is able to move in axial direction to a limited extent relative to the piston 4. Excessive movement of the piston shoe 6 relative to piston 4 is however prevented by the piston shoe retaining means 35 which extends into the piston shoe recess 34 so that only a limited clearance remains between the piston shoe retaining means 34 and the walls of the recess 34. The latter is necessary in order to make it possible that rotor 1 is able to move within the machine to a limited extent axially so that enough bearing surface remains between the respective connection faces of the piston 4 and the respective piston shoe 6.

If such a limited axial moveability of the pistons relative to the piston shoe 6 is not provided, this would necessarily or most likely lead to bearing and sticking between the rotor means 1 and the control body 10, and the piston shoes would wear or tilt with respect to the pistons 4 or on the walls of the radial cylinders or working chambers 3.

In addition to the spring means 33 of the embodiment there may be additional spring means between the thrust bearing 31 and the rotor 1 be provided in order that the rotor 1 also remains pressed with limited pressure

against the control body 10 also at such times when no fluid under pressure is present in the fluid containing rotary balancing chamber 27. This could be the case at the start of the respective rotary fluid machine when no fluid is present in the working spaces and the co-operating chambers and passages.

It is preferred according to this invention to provide control body 10 on housing 2 or to fasten it thereon in such a way that it can not, or only to a limited extent pivot or revolve around its own axis. This is necessary in order to achieve a perfect workable control of the flow of fluid into and from the working chamber 3.

It is also necessary in order to achieve a clear control and closing of the respective working chambers and rotor passages 15 at the inner and outermost points during movement of the respective pistons 4 when the flow of fluid to the respective cylinder 3 reverses.

In FIGURES 3 to 12, the working chamber 103, pistons 104, piston actuator means 105 and piston shoe 6 as well as shaft 107 and bearings 108 and 109 operate similarly to their corresponding parts in FIGURES 1 and 2.

The embodiment of FIGURES 3 to 12 however differs from the embodiment of FIGURES 1 and 2 especially in that the rotor 101 not only one cylinder group is provided but that two radially extending cylinder groups are provided therein and that two piston groups are provided in the respective cylinder groups, one piston in each cylinder so that each piston group is provided for each radial cylinder group.

Piston shoes 106 have therefore a somewhat different configuration than those of FIGURE 1.

According to the fact that there are two cylinder groups provided in the rotor 101 of this embodiment of the invention there are also two groups of rotor passages 115. One group of rotor passages extends from one of the cylinder groups in one axial direction through rotor 101 while the other extends in the other axial direction from the other cylinder group through rotor 101. Each cylinder 103 is preferably provided with one rotor passage 115. Each rotor passage 115 extends from a respective cylinder or working chamber 103 through the rotor means 1103 into the respective rotary control face 124 or 155.

On each axial end of rotor 101 is provided a rotary control face which one axial end of rotor 101 is cited by referential number 124 while on the other end by referential number 155.

On one axial end of the rotor, the housing 102 can be integrally constructed with control body 110 or provided with a control body 110 from fluid port 116 where-in fluid passes through the housing 102 and through the control body part 110 of the housing 102 into the control window or control port 111 and flows thereafter through the respective rotor passage 115 into the respective cylinder 103 of the cylinder group within the rotor 101 into such cylinders 103 to increase the fluid volume therein while other cylinders of the cylinder group 103 decrease their fluid volume as fluid flows through the respective rotor passages 115 out of the rotor 101 and into the control port 112 and therethrough and then through fluid passage 115 to fluid port 117 and thereby out of the machine.

The flow of fluid can also occur in the reverse direction between control port 111 and fluid port 116 via fluid passage 113 provided. Between control port 112 and fluid port 117 there is a fluid passage 114. On housing 102 or one of the covers thereof, or on control body 110 there is a stator control face 123 provided. The stator control face 123 and the rotary control face 124 define together the control interface 122. Also in this embodiment of the invention the rotor 101 becomes with its rotary control face 124 pressed against the stator control face 123 in a suitable amount of force maintaining a suitable clearance. Balancing recesses 118 or 119 or others can be provided in the respective control faces or on the

respective parts on the control body 110 or of the housing 102 or in special cases also on control body 110 or on the rotor means or other places of the machine. In the embodiment shown in these figures the control interface 122 is of radial plane configuration but it could also be possible to make it conical or spherical instead of making it radially plane.

Instead of making control body 110 out of one piece together with the cover part or part of housing 102 it would be possible to make the control body part 110 separate and to fasten or bear it for suitable operation as by a flexible mounting bearing or the like.

On the opposite rotor end of rotor 101 there is the other rotary control face 155. On control face 155 bears the second control body 156. The second control body 156 has a stator control face 154 and the stator control face 154 and the rotary control face 155 are of matching configuration to define the second control mirror 153. The second control body 156 is provided with control passages 138 and 139 in one or both of the control faces there may be recesses for balancing purposes for containing fluid under pressure in order to prevent one-sided engagement or overloading or one-sided opening clearances or one-sided acting fluid forces between the respecting adjacent or co-operating parts.

Axially outwards, the control window 138 extends into fluid port 136 and the control port 139 extends via respective fluid passages into the fluid port 137.

During operation of the machine fluid flows from fluid port 136 and a fluid passage into control port 138 and then through respective rotor passages 115 into working chambers 103 and during the other half of the cycle out from the working chambers 103 through the respective rotor passages 115 into control port 139 and therefrom via control passages to fluid port 137 and therefrom out of the machine. This flow of fluid can also flow in the reverse direction.

In order to assure that the second control body 153 is and remains pressed in a suitable amount against rotor 101 and in order that rotor 101 is pressed and remains pressed with a suitable amount against the control body 110 it is necessary that rotor 101 as well as the second control body 156 as well are able to a limited extent to move in an axialward direction. They must be movable in both axial directions in order to prevent tilting and sticking between moving parts. Further it is also necessary that means for pressing this second control body 156 against the rotor 101 is provided. Such a pressure means, for instance, can be a spring means. In the embodiments of FIGURES 3 to 12 the second control body 156 is pressed against rotor means 101 by fluid in pressure on the opposite axial end of the second control body 156. The second control body 156 is pressed with its stator control face 154 against the rotary control face 155 of rotor 101 and rotor 101 is pressed with its rotatable control face 124 against the stationary control face 123 of the control body part 110 and thereby the sealing between the control faces of the control interfaces 122 and 155 is provided and assured in accordance with this invention.

Between control body 156 and casing or cover means 102 and the fluid ports 136 and 137 there are provided flexible control passage bodies. These fluid passage bodies are axially moveable relative to housing 102 so that they at all times cooperate with control body 156 and remain pressed against it. For this purpose, the spring means 149 are provided axially outward of the fluid passage bodies 171 and 172 to press them against the control body 156.

The fluid passage bodies 171 and 172 located in recesses in casing means 101 or 1 and they are therein borne for axial movement. Against the housing 102 they are preferably sealed by plastic seal means 166. On the inward end of the fluid passage body 171 are end faces whereon the ring means 147 abuts for movement to a limited extent in radial directions but in sealing engagement with

bodies 171 and 172. The other end of the rings 147 abuts against a matching face on the outward end of a fluid passage body 169 or 170. The fluid passage bodies 169 or 170 are provided in respective bores of control bodies 156, and are preferably sealed thereagainst for instance by plastic seal means 165. The fluid passage bodies 169, 170, 171 and 172 as well as the rings 147 are provided with fluid passage means for instance in the form of bores or channels which are cited by reference numerals 140, 142, 141, 143 or 145 so that fluid may pass through these bodies and from the respective passages in casing 102 or of covers thereof or from fluid ports 136 or 137 or from control ports 138 or 139 or to them.

As consequence of the pressing and sealing of the surfaces between the respective fluid passage bodies 169 and the rings 147 the fluid passage bodies 170 and the rings 147 those parts can move relative to each other in spherical direction while at the same time they are retained in sealing engagement with each other by the spring means 149.

As far as the leakages are not completely prevented they are at least considerably minimized.

The provision of the rings 147 is by way of example only. Such rings are preferred in machines which must operate at high efficiency. In some cases, the fluid passage bodies 169 and 171 may be one piece and also the fluid passage bodies 170 and 172 may be made together with the one piece. In some applications it is also possible to build simple machines without flexible control bodies.

The fluid passages 140 are in communication with the control body 138 so that between the control passage 138 and the fluid passages 140 a free flow of fluid is assured. The fluid passages 141 or the fluid passage 141 is in communication with the control port 139 so that a free flow of fluid is possible between the control port 139 and the fluid passage or passages 141 in the reverse direction.

In this embodiment of the invention there are three fluid passage bodies 169 adapted to the control port 138 and three fluid passage bodies 170 are adapted to the control port 139. Thereby it is possible to obtain a very good balance and guided passage of fluid to control port 138 or 139 or out of those. Instead of providing a plurality of fluid passage bodies to one control port it would also be possible to provide only one. According to the invention it is however important that the cross sectional area through the fluid passages 140 and 141 is dimensioned in such a size that the fluid pressure which acts out of it against the control body 156 is large enough to balance out the pressure of fluid which acts in opposite direction out from the rotor means against the control body 156 and it is necessary that the pressure of fluid out of the cross sectional areas to fluid passages 140 and 141 is at least a little larger than the contrary acting pressure on control-body 156 so that it is assured that the control body 156 under all circumstances remains pressed with a certain but limited pressure against the rotor 101.

Furthermore it is important that the cross sectional area through the fluid passage bodies 171 and 172 is also dimensioned so that it is larger than the opposite pressure area which acts out from the fluid ports 136 and 137 against the end of the fluid passage bodies 171 and 172 and the pressure must remain larger than the forces of fluid which are acting in the opposite direction in order to assure and provide that the passing of the fluid passage bodies 171 and 172 against the other bodies in axial direction is definitely assured.

In the designing and calculation of the cross sectional areas it is also necessary to take into consideration the pressure drop in the fluid.

After such considerations, the respective cross sectional areas in the fluid passage bodies are to be dimensioned accordingly in order to be able to adjust the forces of fluid in the said clearances.

Since in rotary fluid machines from time to time inaccurate rotary movements occur, it is of convenience and

of feature to build the control body 156 in such a way that it is not only axially moveable but so that it is also moveable about a spherical radius to a limited extent.

For this purpose the shaft 107 is provided with a spherobearing 146 wherein the control body 156 may swing.

Furthermore a cardanic or universal joint type body 148 is provided and borne in such a way in housing 102 so that it remains swingable and radially moveable to a limited extent, and control body 156 is moveably fastened within or to universal joint body 148 according to FIGURES 3 to 12. As can be seen from FIGURES 1 and 10, the control body 156 has a pair of slots 149. The slots 149 are diametrically located with respect to the axis of control body 156. Universal joint body 148 is provided with extending engagement portions 151 which extend into the slots 149 of control body 156. In housing 102 there is a pair of slots 150 provided and on the universal joint body 148 there are portions 152 provided which extend respective slots 150 of the housing means 102. The engagement portions or extending portions 151 and 152 are in the respective slots 147 and 150 moveable to a limited extent in radial directions so that universal joint body 148 is able to move in radial directions to a limited extent and so that control body 156 is also able to move radially within body 148 to a limited extent. The provision of the slots and the engagement elements or extending elements 149 and 152 could also be provided in a reversed arrangement.

Another object of the invention is as appears from the FIGURES 3 to 12, the provision of a fluid chamber 127 or of a pair of fluid chambers 127 or of a plurality of such fluid chambers in the control body 156. The fluid chamber 127 extends from the outward face of control body 156 into the control body 156. The fluid chamber 127 is closed by the respective fluid chamber cover means 128. The fluid cover chamber means 128 is moveable axially within the fluid chambers 127. According to the invention, fluid under pressure is led into the fluid chambers 127 so that the pressure acting therefrom presses the control body 156 against the rotor 101. The pressure inside of fluid chambers 128, 127 also acts to press the fluid chamber cover means 128 in the opposite direction away from the rotor or control body 156 and against a respective face of the cover or housing 102. Instead of providing fluid chambers 127 in control body 156 it would also be possible to provide them in housing 102 or cover means or a part thereof, and to press the fluid chamber cover means 128 axially against the control body 156. Such modifications are possible depending on the choice of design and assembly.

It is important however, that the fluid pressure which acts in and out of chamber 127 is transferred directly or indirectly against the control body 156 in order to press the control body 156 against the rotor 101. In order to achieve this, there are as can be seen from FIGURE 12, control chambers 157 provided wherein the control bodies 158 are located and able to move. To control chamber 157 are leading the fluid passages 161, 162, 159, 163, 160 and 164. The fluid passages 160 or 159 are leading from the middle of the control chamber 157 into the fluid pressure chambers 127. The fluid passages 161 and 163 provide the communication between the control chamber 157 and the fluid ports 136, while the fluid passages 162 and 164 provide the communication between the other ends of the fluid chamber 127 and the fluid port 137.

If a higher pressure is present in fluid port 136 or 137, the respective control body 158 moves in the respective control chamber 127 to the one or the other end position and thereby the respective communication between the fluid ports of higher pressure and the control chamber 157 with the respective passage chamber 127 is established.

Thereby it is assured that at all times and situations the higher pressure of that fluid port which contains the higher pressure is acting and effective in the fluid chambers 127. The respective control chambers 157 might

also be provided inside of control body 156 or on other places of the machine depending on the situation.

The embodiment of the invention which is shown in FIGURES 3 to 12 not only realizes a two flow pump or a two flow machine for the delivery of two flows of fluid under pressure with equal or proportional delivery rates it also provides a motor with two fluid streams of equal or proportional fluid rates, and with only a very little leakage so that in cases of very high differences of pressure in the two different fluid streams, the flow rate in each of the separate flows remains in the same proportion regardless of the difference in pressure therebetween.

In the figures the fluid port parts with the respective control body or control ports and the respective stator control ports and the balancing fields or recesses are shown turned 90 degrees. This was done in order to make it possible in a longitudinal sectional view to show the intake flow and exhaust flow while at the same time the location and positioning of the working chambers of highest fluid volume and of smallest fluid volume are shown.

In the FIGURES 13, 13' and 14 a continuously variable four flow rotary radial piston machine with axial loading of flow is shown as another additional embodiment of the invention. Two rotors or rotor means as 201 are provided in the same housing 202. The central part of housing 202 extends radially inward and the shaft of the respective rotor means 201 is borne therein in bearing means 208. In the medial central housing portion 202 there are respective fluid passages provided which lead to the fluid ports 236 for communicating it with the control port 211 and another passage which communicates the fluid port 237 with a control port 212 and another passage which communicates the fluid port 278 with control body 211 while another passage communicates the fluid port 279 with another control port 212. The respective control body parts 210 are also in this example formed as part of the housing and in this special case as a part of the central radially inward extending ventral portion of the housing means 202. They operate accordingly as the control body 110 of FIGURES 3 to 12. Instead of making the control bodies 210 integral with the medial portion of the housing 202 it would also be possible to separate them therefrom and to bear them thereon or fasten them therein for instance for a limited spherical movement or the like. Each rotor 201 has one of its axial ends pressed against a central medial portion of the housing 202, i.e., against their control body parts thereon. The respective control interfaces between the rotors 201 and the control body parts 210 are also again made up by respective rotary control faces and stationary control faces.

In the rotors 201 there are in each of them two separated radial cylinder groups 203 provided with corresponding groups of pistons 204. The pistons 204 have also piston shoes 206 and the pistons 204 are actuated by respective guide actuator means. In this example also the actuator means are revolving and they are borne in bearing means 209. But the actuator means may also be stationary depending on the situation.

The embodiment shown in the FIGURES 13, 13' and 14 shows a variable pump or a variable motor or a variable compressor. The variation or fluid rate adjustment means is shown by the fluid rate adjustment devices 273 or 274. Depending on the design considerations, each one of the adjustment devices 273 or 274 can be controlled or varied separately or both can be provided with a combination means or clutch means so that they are both moving or working parallel to each other or together. Depending upon what type of the above fluid flow adjustment devices are selected, the rotary radial piston machine provides two fluid flows of variable delivery rate. In such cases a four flow machine is provided wherein the flow through quantity of all four flows is proportional or equal or variable relative to each other depending on the situation and the predetermined design or assembly of

the machine. Such four flow machine is especially suitable to work as pump and to act as a four wheel drive for vehicles or as a four propeller drive for driving hydraulic motors in aircraft or helicopters.

On each axial outer end of each of the rotors 201 there is a respective control body 256 provided. These correspond to respective control bodies 156 of other figures. There are also respective control ports 238 and 239 provided as well as fluid passage bodies 269, 270, 271 and 272 as well as rings 247. There are also respective fluid passages provided in or through the fluid passage bodies so that the communication between the respective control windows 238 or 239 and corresponding fluid ports is similarly assured as in other figures.

The rotary radial piston machine of the embodiment of FIGURES 13, 13' and 14 has accordingly 8 fluid ports which are 216, 236, 278, 280, 271, 237, 279 and 281. Each set of four fluid ports are working as entrance ports while the four other fluid ports are working as exit ports because the machine is a four flow machine. The exit ports and entrance ports can be reversed by reversing the flow. Accordingly the fluid flow machine of this embodiment has also as many control ports 238, 239, 211 and 212 so that each set of four control ports act as entrance control ports and another four control ports act as exit control ports. The entrance or exit function of control ports can be reversed by reversing the flow or by reversing the machine.

The rotors 201 of this embodiment of the invention are similarly pressed against the control faces of the respective control ports by fluid, under pressure similarly as shown in the FIGURES 3 to 12. Thereby the rotors 201 are by the respective means pressed against the center part of the machine. It would however also be possible to provide the stationary fixed parts with the respective control bodies on the outer ends or outer covers of the machine and to set the flexible control bodies which are axially moveable to a limited extent into the middle of the machine. In such case, the rotors would not be pressed in a direction to the center of the machine but in a direction outwardly.

It is again preferred to make the control bodies or a part of the control bodies or some control bodies, for instance, the control bodies 256 movable in axial and spheric or axial and radial directions to a limited extent. For this purpose again, universal joint bodies 248 may be provided. The provision of such bodies 248 is however by way of example only. In simple machines such could also be prevented and stationary control means might be provided.

Another feature and object of the invention, as shown in FIGURES 13, 13' and 14, is, that one of the rotors 201 can be disengaged or declutched from the other rotor 201 of the machine. For this purpose the shaft 201 is made up of two pieces so that one rotor 201 has one shaft 207 while the other rotor 201 is provided with another shaft 307. The shaft 307 is provided with a respective passage through which the clutching drive or clutching control means 277 is provided. The innermost end of shaft 207 is provided with a clutching recess 275 while the engagement body 277 extends into the clutching body 276. The clutching drive 277 with its clutching body 276 of the fluid machine of this example is in axial direction moveable. Thereby the clutching body 276 can be moved into a respective recess 282 in shaft 307 and it can therein be completely contained and extend so far that the clutching extension means 275 also engages additionally into shaft 207.

If in the example of this embodiment clutching drive or control means 277 moves to the right then the clutching body 276 engages into the clutching recess 276 and thereby clutches the shafts 207 and 307 together so that both are revolving together and so that then both rotors 201 of the machine are revolving together and that then four flows of fluid are flowing through the machine if an eccentricity is present between the fluid flow adjustment

devices 273 and 274 and the rotor means. If on the other hand the clutching drive of control means 277 is moved to the left, then the shaft 307 becomes declutched or disengaged from shaft 207. The clutching body 276 is completely contained in clutching space 278 or 282 and the shaft 307 is disengaged or declutched on shaft 207. In such case only the shaft 207 together with one rotor 201 revolves in the machine then works as a two flow machine.

The latter has many features especially for driving vehicles, machines or aircraft or helicopters. If the machine, vehicle, aircraft or the like is in normal operation then very often the drive of two wheels or propellers is enough to run the vehicle.

This can then be done by that part of the pump which is driven by shaft means 207. In such cases the complete friction in the machine for instance, the frictions in bearings and the friction between relatively moveable parts like control interfaces or pistons or piston shoes is relatively less because the complete friction which would otherwise be present in the less half of the machine can completely be spared. Due to the fact that the left part of the machine with its shaft 307 is declutched or disengaged from the right part of the machine. On the other hand if the vehicle needs a four wheel drive or four propeller drive for instance during the start or landing of the machine of the aircraft or helicopter or during high speed flight or upwards flight of the airborne vehicle or during the movement of the four wheel vehicle through rough country the four wheel drive or four propeller drive can be used by clutching or engaging shaft 307 together to or with shaft 207. Accordingly, the use of two flows or the use of four flows and the drive of four wheels or of four propellers or of a plurality thereof can be selected according to the situation by clutching or declutching shafts 207 and 307 together or disengaging them from each other.

As can be seen from FIGURES 13 and 13', it is possible to provide the radial cylinders 203 as through bores into the rotor or central bores of the rotor 201 so that the manufacturing of the cylinders becomes very simple and so that the cylinders are closed thereafter by a suitable fit of the shaft 207 or 307 inside of the rotor bore of rotor 201. This feature can also apply to other similar rotors of the invention.

According to this invention the rotary radial piston fluid machine is so precisely or perfectly or almost perfectly sealed that the volumetric losses through the control interfaces etc., are so relatively less that the machines are able to work with a very high efficiency with only very little leakage losses or volumetric losses.

The latter is especially convenient for proportional delivery two flow pumps or four flow pumps which are needed for instance in construction machines, power shovels, cranes, ships, hydrofoil boats for propeller drives wherein each of the left hydrofoil motor and of the right side hydrofoil motor have to revolve with equal rotary velocity and the latter is also very convenient and advantageous for two flow aircraft or two flow helicopters or for all kinds of two flow vehicles. The possibility to let each two flows work at different flow rates than the other two fluid flows of a four flow or multi-flow machine according to the embodiment of FIGURES 13, 13' and 14 is an additional feature of this invention. This is especially convenient and beneficial for the drive of construction machines, aircraft, helicopters, air cushion vehicles or other kinds of vehicles for instance also like power shovels, cranes, four wheel or multi-wheel vehicles two flow or four flow aircraft or helicopters, crawlers wheels, winches cylinders, lift cylinders or the like.

The possibility to combine the both fluid flow delivery quantity adjustment devices 273 and 274 together so that both can do only the same movements parallel to each other with the same velocity and with the same stroke additionally makes the feature for drive of four flow aircrafts or four flow helicopters or four flow vehicles with

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a plurality of propellers for instance with a plurality of propellers 8 or 12 or more in series so that all propellers of such vehicles aircrafts, hovercrafts, air cushion vehicles bottom effect vehicles are revolving all together with the same or with definite proportional rotary velocity. Which provides a stable location or movement of the vehicle through fluid in or whereon it moves. The same possibility is also very beneficial for ships or for hydrofoil boats racing boats or hydrofoil ships or hydrofoil aircraft carriers or battle ships and also for vehicles which have four or more wheels wherein the rotary velocity of such revolving members are to be proportional or equal.

Therefore according to this invention it is possible to drive rotary members of vehicles or machines if they are connected in series with each other 8 or 12 or more with substantial the same rotary velocity.

Due to the almost perfect sealing of the rotary machines of this invention and due to the negligible leakage between the control faces, only a very little or almost no slip is present between one flow of fluid and any other.

In FIGURE 15, the reference numeral 1 shows another example of an embodiment of a rotor of this invention. Reference numeral 2 shows the casing which is similar to other figures for instance with such of FIGURE 1. Reference numerals 3, 4, 5, 6, 7, 8, 9, 31 and 36 are also similar to those in FIGURE 1 and they show the working chamber or cylinder, 4 the piston, 5 the actuator means, 6 the piston shoe, 7 the shaft, 8 the rotor bearings, 9 the actuator bearings, 31 the axial bearing or thrust bearing, 36 the space or axial clearance of the piston shoe while reference numerals 11 and 12 show control ports 13 and 14 fluid passages, 16 and 17 fluid ports, 22 the control interface, 23 the stationary control face and 34 the rotary control face. The machine works similar to that of FIGURE 1. It will however be recognized from study of FIGURE 1 that the valve means 32 are provided in the rotor passage 99 and that the fluid containing balancing chamber 27 is a rotary fluid containing balancing chamber which substantially extends over the whole end area of the rotor and which is the combined chamber containing or receiving the high pressure fluid of such cylinders 3 which are just under the highest pressure. The fluid containing balancing chamber 27 acts therefore also in that area or on that half cycle of a revolution of the rotor means 1 which is the low pressure side for instance the suction side in a pump or the exit side in a fluid motor. In these areas the pressure out of the rotary fluid containing balancing chamber 27 in the axial direction against rotor means 1 is commonly higher than the contrary pressure out of the control ports on the other side of the rotor if there would not be any high pressure in respective balancing recesses 20, 21, 18 or 19.

Also the provision of the valve means 32 is sometimes difficult or disadvantageous. It is therefore the purpose of the embodiment which is shown in FIGURE 15 to provide still a more simple and still a more effective rotary radial piston fluid machine than that of FIGURE 1 or of FIGURES 1 to 12.

The improvement of FIGURE 15 consists therein that to each separated cylinder 3 in the rotor 1 there is a fluid containing balancing chamber 37 on the oppositional end of the rotor means 1 provided and each fluid containing balancing chamber 37 is closed in axially outward direction by a cover means 39 which in turn is preferably borne on an axial outer bearing means. Such bearing means may be stationary or rotary but it is preferably rotary and cited by 31 which in turn is borne in casing 2. Cover means 39 may be provided with seal means 40 for sealing the fluid containing balancing chamber 37 in the axially outward direction and seal means 40 may be of flexible material. The cross section in the radial direction through balancing chamber 37 is so dimensioned that the fluid pressure which acts against the control body

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10 is higher than the opposite acting fluid pressures in or on rotor means 1. It is therefore important that the cross section through the fluid containing balancing chamber 37 is dimensioned larger than the cross section through the rotor passage 15 which is connected to the same respective cylinder 3. For manufacturing purposes it is the most simple means to provide a rotor passage 15 with a certain diameter and make a medial bore 38 of a bigger diameter than the rotor passage 15 and to make the fluid containing balancing chamber 37 of a still bigger diameter. Cover means 39 may be so configured, that it adopts with its outward end against a rotary part of an antifriction thrust bearing 31 and it may be so configured that it can not revolve around its own axis because such revolving or movement would be prevented by an extension of cover means 39 which is kept by the revolving part of the bearing means 31.

Instead of forming rotor passage 15 as a bore it is also possible to make it as a peripherally extending passage. However, it is necessary that the cross section through fluid containing balancing chamber 37 is larger than the cross section through the respective rotor passage 15.

In dimensioning the cross section of the fluid containing balancing chamber 37 it is necessary to take also in consideration the fluid pressure which acts out of the respective control port 11 or 12 against the rotor means 1 in the opposite axial direction. The number of fluid containing balancing chambers 37 which are filled with pressure out of control port 11 must all together have such a large cross sectional area that the pressure thereout is stronger than the pressure out of control port 11 against the rotor. The same applies also to the control port 12 and the therewith during operation of the machine connected respective fluid containing balancing chambers 37.

The control interface is in the case of FIGURE 15 made as a spherical control interface having respective spherically configured stationary and rotary control faces. Shaft 7 is borne in bearing 8 and rotor 1 is borne on shaft 7 and connected thereto by respective arresting means which are not shown in the drawings.

The special feature of the embodiment of FIGURE 15 is that only the fluid containing balancing chambers 37 are supplied with high pressure which are just in communication with the respective high pressure control port while the respective fluid containing balancing chambers 37 which are in connection with the low pressure control port are under the low pressure. During the movement of the respective cylinder 3 over an inner or outer point of the piston movement of the machine a respective compression or decompression takes place in the cylinder 3 and the thereto connected rotor passage and in the thereto connected fluid containing balancing chambers 37, if the said chambers are closed by the closing portion of the stationary control face while the respective chambers revolve thereover, and if they remain closed over some degree of revolution past the inner or outer point.

Therefore with increase of pressure in the rotor passage 15 and cylinder 3 a respective increase of pressure occurs also in the fluid containing balancing chamber 37 and in the respective chambers a decrease in pressure takes place.

The feature thereof is, that the rotor 1 is always pressed against a stationary control part or control body or casing control part only with such a pressure which is just needed to press the respective part of the rotor against the control face. The difference between the embodiment of this invention which is demonstrated in FIGURE 1 and the embodiment which is demonstrated in FIGURE 15 is mainly that in the case of FIGURE 15 to each cylinder or working chamber 3 a respective fluid containing balancing chamber 37 is adopted while on the contrary in the embodiment of FIGURES 1, 2, 12 there is one common balancing fluid containing balancing chamber 27 which extends all around the rotor end cir-

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cumferentially and which is common to a plurality or all of the cylinders or working spaces 3.

The embodiment of FIGURE 15 is therefore superior in so far as a detailed balancing takes place with respect to each of the cylinders or working chambers 3 while in FIGURES 1 to 12 a common fluid balancing response takes place for the whole rotor and for some or a plurality or all of the respective working chambers in common but not separately.

Another feature of the embodiment of FIGURE 15 is that this is most effective in so far as the prevention of leakage and friction that this pump is able to obtain the most high efficiency. Furthermore the balancing of this system is by a separate fluid containing balancing chamber 39 co-operating with each cylinder 3 and rotor port 15 and control port 11 or 12 is most immediate and most responsive and also most highly advanced and most effective compared to all other systems known heretofore.

A still further feature of the embodiment of FIGURE 15 is that this can be most easily machined and perfectly manufactured.

The system of FIGURE 15 is therefore also most inexpensive.

Another feature is to make the medial space 38 of such a size peripherally or in diameter that it is a little wider than the diameter of the respective cylinder chamber 3. The feature thereof is that then the cylinder 3 can be easily machined by boring machines or reamers.

A still further feature shown in the embodiment of FIGURE 15 is, that there are free clearance spaces 36 provided axially of the respective piston shoes 6. The said free clearance spaces 36 expand into the respective actuator means 5 in order to make it possible that the piston shoes 6 can move axially to a limited extent if the rotor 1 moves axially. Axial movements of the rotor 1 are to a limited extent mostly present and necessary because over a long life time the control faces wear a little by lapping and thereby the faces may be gradually adopted more and more close together which naturally results in a little movement of rotor 1 in a direction against the control body or stationary control face. Also the pressure out of the respective fluid containing balancing chambers 37 is different depending on the total pressure or pressures in the machine. If therefore no free clearance spaces 36 would be provided on the axial ends of piston shoe 6 then piston shoe 6 might tend to wear or stick along the respective actuator means 5. This is now clearly prevented by providing the free clearance spaces 36 in such a radial and axial extent that the piston shoe 6 can freely move thereinto to such extent as rotor 1 may move axially.

Other parts of the machine of FIGURES 15 to 17 work similarly to those of FIGURE 1. For instance, the rotor 1 is retained on shaft 7 and shaft 7 is borne with rotor 1 together in the bearing 8 which are located in housing 2 to revolve therein. The pistons and piston shoes 4 and 6 are actuated by the actuator means 5 for the radial inwards and outwards movement of the pistons and piston shoes. Fluid flows from fluid port 16 through fluid passage 13 and through control port 11 and thereafter through the respective rotor passages 15 into the respective cylinders 3 and moves out therefrom through the respective rotor passages 15 into control port 12 and therefrom through fluid passage 14 to fluid port 17 and therefrom out of the machine.

The flow of fluid can also be reversed depending on the situation. The actuator means 5 may be stationary or may be rotatably mounted in respective bearings 9 in housing 2.

FIGURES 16 and 17 are cross sectional views through FIGURE 1 and they are provided in order to demonstrate more clearly how the respective parts are located and how they may work and act. FIGURES 16 and 17 are however not only cross sectional views through FIGURE 15 but also through FIGURE 18. Therefore in FIG-

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FIGURE 16 there is not only one reference numeral shown for each position, but three reference numbers for each position because these figures are cross-sectional views through different figures. Therefore, it is from FIGURE 16 clearly seen where rotor 1 is located, how the pistons are moving in the cylinders, and where the medial chambers 38, 138 or 238 are located. It is also clearly seen that the medial spaces 38 are extending in peripheral direction somewhat over the diameter of the cylindrical bore 3 so that a bore through is obtained and so that a part of a respective medial chamber 38 form the respective intersecting recesses or groups 338. This is especially seen from FIGURE 16.

From FIGURE 17 it becomes clear that an eccentricity is present between the actuator means 15 and the rotor means 1 which causes the piston shoes and pistons to move radially inward and outward during the revolution of the rotor 1. It is further clearly seen that there is not a combined balancing chamber, but rather there are separated fluid containing balancing chambers for each respective cylinder 3, 103, or 203 of FIGURES 15 and 18. This becomes clearly visible from the section of FIGURE 17 which clearly shows the cover means 39 in a sectional view inside of the respective parts of rotor 1. Therefore it is clear that a plurality of separated cover means are provided and consequently since each cover means 39 is located in one fluid containing rotary balancing chamber 39 it is clear that there are separated fluid containing balancing chambers 37 in these embodiments of the invention.

In FIGURE 18 there are two fluid machines as in FIGURE 15, but they are made in such a way that both are adopted against each other. Therefore the left side of FIGURE 18 contains a fluid machine as shown as in FIGURE 15 and the parts are cited by reference numbers which have the first digit 1. On the right side of FIGURE 18 there is the same machine provided as that of FIGURE 15 but the referential numbers are cited by a first digit 2. The medial part is a part of the casing which extends radially inward and wherein the respective fluid ports are provided. So from fluid port 16 fluid passage 13 extends into control port 11 of the left part. From fluid port 117 the fluid passage 114 extends to the fluid port 112.

From the fluid port 216 the fluid passage 213 extends through fluid port 211 of the rightwards located fluid machine, from fluid port 217 the fluid passage 213 extends through fluid port 212 of the right fluid machine of FIGURE 18. The difference between the right side machine and the left side machine consists therein that the left machine has a plain control interface 124 with a rotary control face 124 on rotor 101 and a stationary control face 123. The control interface and its control faces are of radially plane configuration on the left side machine. In the right part of the fluid machine there is a plane surface radially extending provided on the radially extending part of the housing 2. Adopted thereon is a control body 210. Control body 210 has a backwards radially plane face. Therewith it is adopted and borne by the respective plane face of the medial part of the housing and it is radially movable thereon. On the other end of the control body 210 there is stationary control face 223 provided which is adopted against the rotary control faces 224 of rotor 201. The said control faces are spherical and extend on its inner part into the rotor 201 and they are providing together the control interface 222. The inwardly extending spherical configuration of the control interface has feature that the rotor passages 215 are shortened and that therefore the dead spaces are narrowed and internal compression losses are prevented in each of the respective cylinders 203 and its passages.

Referring to the heretofore discussed figures and comparing the therein used control faces, control interfaces and control bodies it can be easily seen that different kinds of configurations of control bodies or control faces

are possible ranging from spherical configurations to radially plane configurations. It is also possible to separate the control bodies from the housing or cover means parts and it is on the contrary also possible to use housing means or a portion thereof or a cover means thereof directly as a control body by providing a stationary control face on it. In the different figures different control bodies or control interfaces may be used depending on the situation and FIGURE 18 is a typical example therefore that in the same kind of machine different configurations of control bodies can be used.

Referring now to FIGURES 19 to 24 the embodiments of fluid handling devices shown therein have the common feature that at least one cover means or housing portion is provided on the backward end of the machine while on the forward end of the machine another cover means or housing portion is provided and that each of the said housing portions or cover means is provided with a respective innermost head face so that both head faces are facing against each other and the other means in common is that in all of these six figures a rotor means is provided between the said head faces and that the rotor means has axial end faces and that the axial end faces of the rotor means are fitted between the innermost head faces of the housing portions or cover means and that the rotor end faces are slidable thereagainst.

The rotor end faces may be rotor control faces and the head faces may be formed or act as stationary control faces so that each head face and rotor end face together constitute a control interface.

There are however, also different functions for rotor end faces or head faces of the housing portions or cover means possible, for instance, it is possible or convenient to use an innermost head face of a cover means or housing portion for closing fluid containing balancing chambers in the rotor means.

In the embodiment of FIGURES 19 and 20 the housing 11 is provided and it has a hollow inner space. The guide means 10 are located in casing 11 for guiding the movement of the actuator means 9. The housing 11 is provided with axial end faces which are radially plane with respect to the housing axis and which are parallel to each other. On one end of housing 11 the cover means 12 is provided. Cover means 12 has an innermost axial end face which is plane and which is adopted to one end face of the housing 11. It is also provided with the control ports 16 and 17 and fluid passages and fluid ports 14 and 15. It further contains in a center space the bearing means 13 for bearing one end of the shaft 2.

On the other end of the housing 11 the medial plate 13 is provided. Medial front plate or cover plate 13 has two axially located plane end faces which are preferably parallel to each other and the innermost of the end faces adopted against the other end face of the housing 11. Cover means 13 contains the space wherein the bearing means 3 is located for bearing the other end of shaft means 2. Front cover means is provided on the other end on the front end of cover means 13 and bears a seal means to close the machine in the forward axial direction. The front cover and the medial cover 13 may be made together of one piece depending on the situation. The back cover 12 is provided with the innermost head face 20. The front cover 13 is provided with the innermost head face 21. The actuator means 9 is able to be moved radially between the guide means 10 and between the cover means 12 and 13 of the fluid handling device within the inner space of housing 11. Shaft means 2 bears the rotor means 1. Rotor means 1 is connected by connecting means 4 to shaft means 2 and arresting means 5. Arresting means 4 is axially moveable within arresting groove means 5 and relative thereto to a limited extent within rotor 1 so that a limited axial movement is possible between rotor 1 and shaft means 2. The arresting means 4 however prevents the rotor means 1 from revolving

around the axis of shaft means 2 and relative to shaft means 2.

The rotor means 1 is provided with rotor end faces on both axial ends of the rotor means 1, furthermore the rotor means 1 has a central bore and the shaft means 2 is fitted into the rotor. The rotor means 1 is also provided with radially extending working chambers or cylinder means 6. These working chambers are closed in the radially inward direction by the fit of the outer surface of shaft means 2 within the inner surface of the rotor bore. Inside of cylinder means 6 there are piston means 7 provided which are moveable radially outward and inwards and which constitute the displacement means. The displacement means 7 may be pushed radially outward by spring means 22 and they may be guided by respective guide means in order to prevent the rotation of the actuator means 2 around their axes. A guide or actuator guide means 8 may be provided within the actuator means 9 in order to get a respective surface contact or a more smooth guide means between the actuator means 9 and the piston heads or displacement means member heads of the displacement means 7.

The axial end faces of rotor means 1 are radially plane and normal to the axis of shaft means 2. The axial distance of the end faces of rotor 1 is a little bit less than the axial distance of the end faces of the housing 11 so that after the cover means 12 and 13 are adopted against the end faces of housing 11 a very slight clearance remains between the end faces of rotor means 1 and the innermost head faces of cover means 12 and 13 which enables the rotor 1 to revolve therebetween but which maintains a seal against leakage between the relatively moving faces. The axial dimensioning of the actuator means 9 or its insertion 8 may also be in the axial direction that they are able to move between the innermost head faces back cover means 12 and 13 within the housing 11 of the fluid handling device.

In FIGURE 19 it can be seen that the left end face of rotor means 1 is a rotary control face. It slides along the stationary control face 20 which is a part of the innermost head face 20 of cover means 2.

The rotor has rotor passages 18. At least each one rotor passage 18 extends from a respective working chamber in the left axial direction through the rotor means 1 into and through the rotary control face of rotor means 1. So during revolving of rotor means 1 the rotor passages 18 are moving periodically once over control port 16 and during the other half of the cycle over control port 17 and the rotor passages 18 are provided in order to pass fluid into the respective working chambers 6.

From the working chamber 6 extends a fluid containing balancing chamber 19 in the opposite axial direction through rotor means 1 and through the right end face of rotor means 1. The cross sections through control means 19 may be equal to that of the rotor passage 18.

But in the embodiment of FIGURES 19 and 20 the cross section area normal to the axis of shaft 1 through the fluid containing balancing chambers 19 is a little bit larger than the cross sectional area through the respective co-operating fluid passage 18. The fluid containing balancing chambers 19 are closed in the right axial direction by the innermost head face 21 of cover means 13 wherealong the right axial end face of rotor means 1 slides if rotor means 1 revolves. Due to the fact that the fluid containing balancing chambers 19 are larger in cross sectional area than the cooperating rotor passages 18, forces acting by pressure of fluid out from the balancing chambers 19 in the left direction against rotor means 1 are greater than the force of fluid which is acting outside of the respective rotor passage 18 in the right direction against the rotor means 1. Therefore the rotor means 1 would be pressed in the left direction with its rotary control face against the stationary control face 20 of control means 12.

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This is however not the case because the control ports 16 and 17 are larger in cross sectional area than the cross sectional area through the respective rotor passages 18 which are just moving over the respective control port would be. Therefore out from the fluid ports 16 or 17 a force due to fluid under pressure is acting in the right direction against the rotor means 1 and attempts to push the rotor means 1 in the opposite direction to the force out of the fluid containing balancing chambers 19 which attempts to press the rotor means 1 to the left. During each half cycle of a revolution of the rotor means only a limited number of working chambers 6 and therewith co-operating fluid passages 18 and fluid containing balancing spaces 19 are in communication with the respective cooperating control port 16 or 17. It is now especially suitable to design the cross sectional area of the respective fluid containing balancing chambers 19 so large but not larger that its area is almost equal to that of the number of fluid containing balancing chambers 19 which are in communication with the respective control port so that the forces of fluid under pressure out of the fluid containing balancing chambers 19 and of the respective adjacent control port 16 or 17 are about equal. In designing the cross sectional areas of the respective fluid ports or control ports 16 and 17 as well as of the rotor passages 18 and of the fluid containing balancing chambers 19 it must be considered that there is also a certain pressure of fluid in the clearances in the axial ends of the rotors especially between the end faces of the rotors 1 and the innermost head faces 20 and 21 of the cover means 12 and 13. Also the forces acting out of the clearances are to be brought in equilibrium together with the forces of fluid which are acting out of the fluid containing balancing chambers 19 and out of the respective fluid ports 16 or 17 and out of the respective rotor passages 18.

After all of these forces are in axial equilibrium, the rotor means 1 floats freely between the head faces 20 and 21 of the cover means 12 and 13 and thereby any sticking or tilting of the rotor means 1 between the cover means 12 or 13 or the respective head faces 20 or 21 is definitely prevented according to this embodiment of this invention.

It is therefore most convenient and in most practical cases necessary that the cross sectional area through the fluid containing balancing chambers 19 is to a certain extent larger than the cross sectional area through the respective fluid passage 18 in order to achieve the mentioned equilibrium of axial fluid forces.

For each of the working chambers 6 one rotor passage 18 and one fluid containing space 19 is provided. But it is also possible to provide a plurality of rotor passages 18 and fluid containing balancing chambers 19 to each respective working chambers 6.

The embodiment of this invention shown in FIGURES 19 and 20 is especially simple for manufacturing and very safe in operation. It is very convenient to manufacture the cover means, the housing, the actuator means and the rotor means of plates which have end faces which can simply be machined by milling cutters or by surface grinder machines. It is therefore also especially convenient to machine the clearances between the end faces of the rotor and the innermost head faces of the cover means by most simple machining means like surface grinders. The machines of the embodiments of FIGURES 19 and 20 is therefore not only inexpensive in manufacturing but it also is perfect in operation and can be built very inexpensively and in mass production.

Also the rotor passages 18 can be made in mass production because they extend into the working chambers 6 so that parts of working chamber 6 may form intersecting grooves on the innermost ends of the fluid passage 18 and also of the innermost ends of the fluid containing balancing spaces 19.

The fluid containing balancing spaces 19 can also be

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easily machined because they can easily be pressed or milled or bored from one axial end into the rotor means 1 and so can the rotor passages 18. The working chambers 6 can also be very easily machined because they may be simple radially extending bores which extend into the rotor so that parts of the rotor form intersecting grooves.

The embodiment of this invention which is shown in FIGURES 21 and 22 has many parts which are substantially equivalent to those in FIGURES 19 and 20. However the rotor means 1 differs from the rotor means 1 of FIGURE 19 therein, in that the rotor means contains two working chamber groups 6 and 36. The working chamber groups 6 and 36 are separated from each other and sealed against each other by the medial rotor portion 51 which prevents leakage therebetween. The rotor means 51 may be integral with rotor means 1 or the rotor means 1 may be machined of three or more parts then thereafter fixed together depending on the situation. Rotor means 1 may be fixed by arresting means 4 to shaft means 2 in a similar way or so especially shown in this figure and it may be secured by a respective retaining means and disassembly of arresting means 4 may thereby be prevented. Each of the working chamber groups 6 and 36 consists of a plurality of substantially radially extending working chambers and each of the working chambers 6 or 36 has a respective displacement means 7 which during the operation of the machine increases and decreases substantially during one revolution of the rotor means 1 the volume of the respective working chamber. The actuator means 7 are actuated for inward and outward movement in the respective working chambers 6 or 36 by the actuator means 7 with its guide means 8. There may be special guide means provided for preventing rotation of the displacement means 7 around the axis.

The specialty of rotor means 1 of this invention is, that from each of the working chamber groups 6 and from each of the respective working chambers therein at least one rotor passage 18 extends in axially through the rotor means 1 and through the respective rotary control face on the axial end of the rotor means 1. At least one other rotor passage 38 extends from each of the respective working chambers 36 in the other axial direction through rotor means 1 and through the other rotary control face on the other end of rotor means 1.

Another specialty of the invention as shown herein is that cover means 12 is provided with fluid ports 23 and 24 as well as with control ports 16 and 17 and with an innermost head face which acts as a stationary control face 20. The other cover means which is cited by reference number 35 is also provided with an innermost head face which acts also as a stationary control face 120 and which has fluid ports 25 and 26 and fluid control ports 32 and 33. Thus the rotor means 1 floats with its end faces which constitute rotary control faces between the innermost head faces or stationary control faces 20 and 120 of cover means 12 and 35 and the said stationary control faces and the said rotary control faces form together control interfaces so that each stationary control face and each rotary control face forms together one control interface. The axial length of the housing means 11 and of the rotor means 1 are so dimensioned that the rotor means is a little bit shorter than the housing means 11 and the difference in length provides the desired clearance of the control interfaces between the stationary control faces and the rotary control faces.

The embodiment of FIGURES 21 and 22 is therefore able to supply two flows of fluid with equal or proportional delivery when the fluid handling device acts as a pump or compressor, or two flows of fluid may flow through this fluid handling machine or rotary radial piston machine when the machine acts as a hydraulic or pneumatic motor.

In this special embodiment both flows are separated from each other and are not in communications with each other, but it could also be possible to communicate both

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together so that both of them would constitute a combined flow if a hole would be drilled in the medial part 51 of rotor 1 so that each respective adjacent working chamber 6 and 36 would communicate together and constitute together two communicated working chambers.

The embodiment of a fluid machine of this invention which is demonstrated in FIGURES 23 and 24 is substantially similar to that demonstrated in FIGURES 21 and 22 but has especially two differences. The first difference is, that the rotor means 1 of the machine of FIGURES 23 and 24 is fastened to the shaft means 2 in such a way that the rotor means 1 can swing relatively to shaft means 1 and that it is also able to move axially to a limited extent. For this purpose the rotor means 1 has a rotor job which is preferably a rotor central bore of substantially constant diameter throughout its whole length and according to this embodiment of the invention a bushing means or a pair of bushing means 53 is or are provided within the rotor job of rotor means 1. The outer faces of spherical bearing means 52 and 53 are fitting within the inner surface of the rotor central bore rotor 1. In this embodiment it is preferred to provide two bearing means 52 and 53 within the rotor central bore. Each one bearing means 52 and 53 has an inner ball formed part of a hole and therefore a ball part formed innerface. The rotor means 2 has a center portion which is a ball formed center part of shaft 2 is so dimensioned that it is cooperative and complementary to the respective ball formed part inner faces of the bearing means or spherical bearing means 52 and 53. For assembling the machine each one of the spherical bearings 52 and 53 is moved from one axial end over respective shaft means 2 until the inner face of the respective bearing means 52 or 53 is adopted and fitted against the central ball form part portion of shaft means 2. After this fit is assured then each of the respective bearing means 52 or 53 is retained in this location by the retaining means 55. Retaining means 55 engage into respective grooves of shaft means 2.

Disassembly of the spherical bearings or 52 or 53 from shaft means 2 is thereby prevented. Thereafter the shaft means 2 together with its bearing means 53 and 52 becomes pushed from one axial direction into the rotor central bore 2 and thereby closes the working chambers 6 or 36 in the radially inward direction and closely fits in the inner face of the rotor means 1 to bear same. The bearings 52 and 53 can swing around the center portion of shaft means 2 and the rotor means 1 can move in axially relatively to the bearings 52 and 53 if the respective clearances are proper dimensioned and fitted. Under such circumstances the embodiment of a machine of FIGURES 23 and 24 provides a rotor which is able to move axially with respect to shaft means 2 and which is able to swing spherically therearound so that any tilting between the respective innermost head faces or stationary control faces 120 and 20 of the cover means 12 and 34 is definitely prevented.

An arresting means 4 may be provided to prevent shaft means 2 and rotor means 1 from rotating relative to each other.

This embodiment of the invention may also act as a two flow machine and the rotor means 1 has therefore rotor passages 18 and rotor passages 38 extend from respective working chambers 6 or 36 in the axial direction. The cross sectional areas through rotor passages 18 and 38 are preferably equal so that a complete equilibrium of pressure axially is maintained on rotor means 1.

According to another object and feature of this embodiment of the invention, cover means 34 is provided with an inner space and inside of that inner space there is an axially moveable control body 27 provided.

Axially outward of control body 27, there are preferably at least two fluid containing balancing chambers 30 provided. Communication passages 31 extend from a respective fluid port or fluid passage into the respective fluid containing space. From cover means 34 extends a

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fluid passage from port 25 into the axially moveable cover means or balancing cover 27 and into a respective fluid port or control port 32 therein. Also from the cover means 34 extends another fluid passage from another fluid port 26 into cover means 27 and into a respective fluid or control port 33 therein. The balancing body or control body 27 may be provided with seal means so that a sealing between the outer face of the body 27 and the inner face of the cover means 34 is assured. Inside of the fluid containing balancing spaces 30 there are cover bodies 29 provided. The cover bodies 29 may be sealed by respective seal means against the walls of the fluid containing balancing chambers 30. Spring means 28 may be provided in the cover bodies 29 or between the cover bodies 29 and the balancing or control body 27 and press the said parts axially away from each other. The cover bodies 29 may be borne on a portion of the cover means 34. Inside of the balancing chambers 30 that fluid pressure is acting which is present in the adjacent fluid passage where-to the balancing chamber is connected by the passage means 31. Therefore out from the balancing chamber 30 a pressure is exerted in one axial direction against the cover body 29 and in the other axial direction against the control body or cover body 27. Thereby the control body or cover body 27 is pressed axially inward so that the innermost head face of control body 27 which acts as stationary control face is pressed against the end face or rotary control face of rotor 1. Thereby the clearances between the end faces or rotary control faces of rotor 1 and the adjacent innermost head faces or stationary control faces of cover means 12 or cover body 27 are so pressed together that the clearances are substantially narrower in to prevent leakage.

It is therefore necessary that the cross sectional areas through the balancing chambers 30 are so dimensioned that the forces acting thereout in axially inward direction against the control body 27 are larger than the opposite acting fluid forces out of the control ports 32 and 33 and of the clearance between the stationary control face 120 and the rotary control face of rotor 1, so that a pressure force still is maintained for moving the control body 27 inwards against the rotor means 1 for providing suitable clearances and forces between the stationary control faces and rotary control faces of the fluid machine of this embodiment of the invention. The special feature of this embodiment is also that only that fluid port 30 contains high pressure which is connected by a communication passage 31 to a space and fluid port containing fluid under high pressure while on the other half side of the machine the other fluid containing balancing chamber 30 is connected via the communications passage 31 to a fluid port which contains less pressure.

The axially acting forces of fluid pressure are therefore in equilibrium in the embodiment of FIGURES 23 and 24 the control body 27 is moveable in axialward direction within the respective face in cover means 34 it is preferred to make the inner space in cover means 34 and the outer diameter of balancing cover 27 in cylindrical configuration.

The embodiment of FIGURES 23 and 24 is therefore not only in axial equilibrium of forces, but has leakages which are very small due to the fact that the control body 27 is pressed against the rotor means 1 and thereby rotor means 1 is pressed against the stationary control face 20 of the back cover means 12.

Means for preventing revolution of control body 27 in the cover means 34 may also be provided but is not shown in the drawing. It is also possible to provide radial balancing means in the outer surface such as radial balancing recesses in the outer surfaces in the cover means 27 or in the inner surface of the inner face of cover means 24 in order to balance the control body 27 radially.

In the embodiment of FIGURES 25 and 26 a fluid machine has the feature that there are two working chamber groups 2 and 3 provided in this embodiment of the

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invention and that in each of these working chamber groups a plurality of working chambers are provided wherein a plurality of displacement means are moving inwards and outwards, each displacement means group in the respective working chamber group and wherein two separated adjustment devices and two separated actuator means are provided in order to make the displacement adjustment of each of the displacement devices groups separately and independently from each other possible. This feature provides the possibility that at least two separate flows of fluid can flow through the machine and that each flow of fluid which flows through this machine can be varied in its flow rate separately from the other and independently from the other by adjusting the displacement adjustment devices of the respective displacement groups.

In the left side of FIGURE 25 there is inside of the respective rotor means 1 the first working chamber group 2 provided which has a plurality of working chambers 2. From each of the working chambers at least one respective rotor passage 14 extends in one axial direction through rotor means 1 and through the rotary control face on the axial end thereof. It cooperates with stationary control face on the respective control part or control portion or body of the housing 10.

Fluid ports 14 and 15 are provided in the control portion of housing 10 and they are passing fluid to and from the respective rotor passage 14. The working chambers 2 of this working chamber group are provided with displacement means 4 therein and displacement means 4 are moveable inwards and outwards in the working chambers thereby increasing and decreasing periodically the volume of the respective working chamber. Displacement means 2 are in this embodiment shown as a preferred type of pistons which have piston shoes 5 and the piston shoes 5 are having outer faces which are adopted to inner faces of a bearing 12. The bearing 12 which is a guide member is located in another radial flexible or divided bearing means 11 which has an inner face which corresponds complementary to the spherical outer face of the bearing 12. Bearing means 11 has an outer face which is preferably cylindrical and which is fixed in an inner face of the rotary guide means or rotary guide member 8. Bearing means 11 is axially moveable within the hollow rotary guide member 8. Rotary guide member 8 is borne in radial anti-friction bearings 7, preferably in a plurality of such bearings, which are axially spaced from each other by a spacer ring means provided between the two respective bearings 7. Bearings 7 are borne in the moveable adjustment device 19. Adjustment device 19 may be provided or is in this embodiment preferably provided with an adjustment connection means 21 and the actuation of the adjustment means 21 therefore leads to radial movements of adjustment device 19 and thereby radial movement of all parts which are borne therein including the actuator means. Therefore if the machine or the rotor of the machine revolves and if an eccentricity is present between the axis of the rotor and the axis of the adjustment device 19 then the relatively inward and outward movement of the displacement means 4 is the working chambers 2 terminates. Rotor means 1 may have rotor shaft portions which may have outer faces 6 and which may be rotatably borne in respective bearings or inner faces of respective housing portions or cover means.

Rotor means 1 may also extend in a shaft means 13 whereby it may be driven or whereby the rotor drives another machine part. On the other axial portion of the rotor means 1 is the other working chamber group 3 provided which also contains a plurality of working chambers 3 wherein also displacement means 4 are moving radially outward and inward when the rotor 1 of the machine revolves. The operation of the actuator means 4 is similar to that of the other displacement means group but the ring 11 is located in the rotary guide member 9 instead of in the rotary guide member 8 wherein the other

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ring 11 of the other working chamber groups or displacement means groups was located. From each of the working chambers 3 in the working chamber group 3 of rotor means 1 a respective rotor passage 14 extends in the other axial direction through rotor means 3 and through the rotary control face on the respective end of the rotor means 1 for cooperation with the respective stationary control face on the portion of the housing 10 or cover means 1. Rotary guide member 9 is again borne in radial anti-friction bearings 7 and bearings 8 are borne in the second adjustment device 20. Second adjustment device 20 has a adjustment device communication means 22. If the communication means 22 is actuated then the adjustment device 20 moves radially to the axis of the rotor and if an eccentricity is present between the axis of the adjustment device 20 and the axis of rotor means 1, when rotor means 1 revolves then respective inward and outward movement of the respective displacement means 4 in the respective working chambers 3 terminates and a flow of fluid is flowing therethrough. Therefore according to this embodiment of the invention two flows of fluid are flowing through the machine or are actuated in the machine and both flows of fluid can be varied in its quantity independently from each other by the independent fluid flow adjustment control devices or displacement adjustment control devices 19 or 20 with communication or connection members 21 or 22.

From the rotor passages 14 on the right side of rotor 1 there are extending respective control ports and fluid passages to respective fluid ports 16 and 17 of the housing 10.

A special feature of this embodiment of the invention is that both flows are variable and that both flows are reversible and that both flows can be independently varied by separate fluid flow quantity adjustment devices. A further feature is that the rotor means 11 is axial pressure balanced by pressure acting out of fluid in respective chambers. A further feature is, that the piston means 4 and the guide shoes 5 thereon are prevented from any tilting and sticking to the guide means because the guide means are spherically swingable. The guide members 12 are self-adjusting in order to have axes which are exactly parallel to the axes of the piston shoes 5 of the pistons 4. Therefore between these respective members any tilting is prevented. The supply of such a spherical adjustment means and axially moveable adjustment means is very important since the rotary guide members 8 and 9 of this embodiment of the invention are borne in bearings which are provided in one axial end thereof only. Such bearings might therefore during a longer life of the machine get different radial clearances and therefore the axes of the rotary guide members 8 and 9 may during a longer life or operation of the machine tend to tilt or incline a little with respect to the rotor axis. That would then in turn result of inclination between the outer faces of the piston shoes and the inner faces of the guide members if no adjustable bearings and axially moveable rotary members 12 and 11 would be provided. By the provision of the several means a perfect fluid handling device for two flows of variable and reversible fluid flow is assured and created by this embodiment of the invention.

In FIGURE 27 there is another embodiment of the invention demonstrated which also shows a two flow fluid handling device. There are two working chamber groups 102 and 103 provided in the rotor means 101 of this embodiment of the invention and both working chamber groups are actuating or actuated each one of separated flow of fluid. Valve means 25 are provided for the entrance of fluid into the respective working chambers while exit valve means 26 are provided after each working chamber in order to open or close the respective passages to or from the respective working chambers. Separate fluid passages 27 and 28 are provided in order to pass two separated flows of fluid out of the rotor means 101 of the machine. An axially extending portion is provided

on rotor means 11 wherethrough the respective fluid passages 27 and 28 extend and this portion revolves in a bearing portion of the housing 110 of the machine. The rotor means 101 with its shaft 113 is borne in respective bearing means 106 and makes a revolution of the rotor means possible. The actuator means are similar to those in the embodiment of FIGURES 25, 26. The use of a valve in the inlet means and outlet means to the fluid chambers assures that no leakage through control interfaces or through stationary and rotary control faces will happen. The disadvantage thereof is on the contrary that such a fluid machine like shown in FIGURE 27 can only act as a fluid pump or as a compressor and that it can deliver flows only one delivery direction. Therefore according to this invention directional controllers or control housings 34 with control means or control pistons 32 therein are provided for the directional control of the respective delivered flows. One flow or fluid is delivered through passage 27 while the other is delivered to passage 28 and one of the flows is controlled directly or indirectly by control means 34 while the other is controlled by control means 35.

The control pistons of the directional control valves 34 and 35 may have connection means for the connection of the respective fluid flow adjustment devices 121 or 122 with the respective directional control piston 32. A gearing means or transmission means may be provided between the respective directed control pistons 32 and the respective fluid flow adjustment device 121 or 122 so that an axial movement of the control piston 32 out of its central neutral position results in a displacement increase in the respective working chambers while the displacement of the respective displacement means put to Zero if the control piston of the directioned control valve 32 is moved into its neutral position. For this purpose the transmission means 33 are provided between a respective control piston 32 of a respective directional control valve 34 or 35 and a respective fluid flow adjustment device 121 or 122. It may for instance be a corresponding formed recess or retaining means and a respective connection means in bold or the like may be provided therein for connection with the respective fluid flow adjustment device 121 or 122.

FIGURES 28 and 29 show another embodiment of the invention in which the machine has a very high efficiency and in which the machine is very safe in operation and very economical. In this embodiment all moving parts are so stably guided that all pressure is concentrated on the faces, which prevents sticking or tilting. Between relatively moving parts are provided facing planes, so that they cannot touch each other.

There have been tests carried out according to the German Patent application 281,323 which provides control means for suddenly adjusting the delivery quantity of a pump from zero to maximum delivery quantity and in the laboratories where those tests were carried out and were automatically recorded, the time required for adjusting such pump from delivery zero to delivery maximum was only about 0.01 second.

On the other hand there were two flow pumps which correspond to FIGURES 28 to 31 designed which with an inner diameter of 248 mm. of the actuator ring means 141 will give more than 100,000 HP and those pumps shall be able suddenly for instance in fractions of a second to be adjusted from delivery power zero of 1000 HP or more or less or they may be reversibly controlled. Between the electric motor which in such case gives 200 HP for example and the pump which has shaft 150 is in this example of the invention rotary shaft 122 provided and borne in bearing 124 and is able to revolve therein. On said shaft or rotary shaft 122 there are provided fastening means such as flanges 225, key means 123 or other means and therebetween there are discs as mass concentrations or flywheels provided such as shown by 127, 128 or 129. The electric motor of the other power plant or driving means

takes care that the rotary shaft 122 revolves with full speed and that the rotor of the pump revolves with full speed. This however does not happen suddenly, but the build up of the rotary velocity occurs gradually depending upon how strong the power plant is. If for instance the discs 127 have a diameter of about 600 mm. then the energy storage in the mass concentration or flywheels which is stored therein may be several times of 10,000 HP. When then suddenly the pump becomes adjusted from delivery zero or from delivery of less quantity to the full delivery quantity of the pump then very suddenly out of the energy storage of rotary wheels a power of about 1000 HP or probably more is transferred suddenly into the rotor and actuator means of the pump and these in turn transform the received power into fluid power in a fluid stream or in a plurality of fluid streams. This sudden increase or adjustment of the pump power from almost zero to a thousand HP can happen in about a hundredth of a second. Due to this embodiment of a combination of this invention it is possible to set a plurality of such sets of powerplants in combination with energy storages and pumps to a battery of such fluid flow producing devices and to supply the fluid power out of them to one or a plurality of common hydraulic lines and these may then be used for the sudden catapulting or arresting of heavy aircraft or other heavy objects such as rockets or heavy jet aircraft.

The displacement means 146 and 147 are in the working chambers 145 of the rotor. The displacement actuator means 166, 167, 142, 143, 149, 140, the shaft 150, the rotor means 144 and the bearings 151 and 152 of FIGURES 28 and 29 are in principle about the same as in the embodiments which are shown in FIGURE 3 etc. and they are most similar to German patent application 373,121 and substantially equal to the means which are partially described in Patent No. 1,345,785 which was issued on my invention in France. The specialty of this example however consists therein that the control bodies 153 and 253 are provided in this embodiment of the invention and one of these control bodies on one axial end of the rotor 144 while the other of these control bodies is provided on the other axial end of the rotor 144. These control bodies have in the middle a partial ball form configuration which extends axially in the middle against the rotor and these ball faces are the stationary control faces which are facing the complementary round rotary control faces of rotor 144. Thereby it is assured that the rotor passages 161 which are leading to the working chambers 145 or 156 are very short and that thereby dead spaces are prevented and consequently that losses of internal compression in fluid are prevented. On the axial outer end of the respective control bodies there are provided plane faces. These plane faces extend radially normal to the rotor axis and these plane bed faces are borne on accordingly formed and located head faces of casing members or cover means or the like.

Through control ports which are provided in the respective control bodies and which are for instance shown by reference number 162 fluid is let to the working chambers or out of them. Backwards of control body 253 there is a back cover space provided and inside of this back cover space there is a cover body 155 provided. The cover body 155 has on its front side a head face on which the plain back face of control body 253 is borne. The body 155 is axially moveable, in said space of back cover 134. Backwards of the bearing body 155 there are provided two fluid chambers 160 and 161 and both are separated from each other and both are sealed against each other so that no communication between them takes place. From one of the fluid passages or fluid ports a communication passage extends into one of the fluid chambers 160. From the other of the fluid passages or fluid ports another communication passage extends into the fluid pressure chamber 161. Those communication passages are not shown in

the drawings because it is assumed that those skilled in the art would be able to design them. The pressure in the fluid chambers 160 or 161 acts against the end of the bearing body 155 and presses the bearing body 155 axially against the rotor so that a clear sealing between the control faces and of the control interface is assured. Accordingly it is necessary that the cross sectional areas through the fluid chambers 160 and 161 must be located and dimensioned properly and also the communication passages must be set properly so that the whole assembly works. It is preferred that both fluid chambers 160 and 161 are annular but eccentric so that in a high pressure area the fluid is acting from a greater area and that a similar effect takes place in the low pressure area. In the practical usage or application one of the fluid chambers 160 is supplied with higher pressure while the other of the fluid chambers 161 is supplied with less pressure.

The FIGURES 30 and 31 show alternative embodiments for the control bodies 153 or 253. The feature and specialty of these embodiments consists first therein, that those faces which are facing the rotor and which therefore are providing the stationary control face 190 is radially plane. On such a radially plane surface there are no radially acting forces of fluid remaining because they balance completely. Such radial balance is not in any case given on conical or spherical control bodies. The backside of the control body according to FIGURES 30 and 31 is however spherical and hollow. The feature thereof that the back side of the control body is spherical and hollow is that it can be borne and that it will be borne on a complementary configured ball part outer face of an adjacent part for instance of a back cover or of a housing member. If now as in this embodiment of the invention the backwards face 191 of the control body and the complementary ball form face of the cooperating stationary part have a relatively little radius compared to the outer diameter of the control body then it can be achieved that the control body can suitably, exactly and easily swing on the ball part head to a limited extent and so that it is at the same time radially and axially borne upon the ball form part head of the mentioned stationary part. Into the face 191 there could also be respective radially or axially acting balancing recesses be provided.

The backwards configuration and provision of a ball form configuration provides according to this invention a specially stable bearing of the control body for highest loads and a very effective swing ability around the center point of the ball and this is very important in fluid machines which are suddenly adopted to very high loads or power or wherein the power from high to little changes suddenly or wherein the pumps are cooperating with energy storages of the fly wheel type.

Through the control body 155 there are provided at least two fluid passages and they are forming fluid ports. Balancing channels or balancing fields for the radial or axial balancing may be provided. Important is however in any case that such balancing means are correctly placed in dimensions and that they are probably located opposite to fluid chambers 160 and 161. Only with the correct location and dimensioning as well as the correct communication to the correct spaces under high pressure an effective work of this embodiment of the invention will be achieved.

It would however be possible to add objects or features of one or some of the embodiments to others or to make any other desired modifications without leaving the scope of this invention.

The means and objects of this invention can not only be used in such machines which have working chambers formed as radial cylinders but under certain circumstances also in such machines wherein the working chambers have other configurations than those of radial cylinders.

The invention disclosed and claimed in this application can be applied by those skilled in the art equally or similarly to pumps, compressors, internal combustion en-

gines, gas engines, compressed air engines, fluid motors or the like.

It is intended that the patent shall cover, by suitable expression in the appended claims, whatever features of patentable novelty reside in the invention.

What I claim is:

1. A rotary fluid-handling machine which comprises in combination, a housing means, a rotor means disposed within said housing means for rotation relative thereto about a predetermined axis, a guide ring means disposed within said housing means in surrounding relation to said rotor means and having a circumferential guide surface extending in parallel relation to said axis, said rotor means having a plurality of radial cylinders, a plurality of pistons each carried by a corresponding cylinder, and a plurality of guide shoes each pivotally connected to a corresponding piston and disposed for sliding contact engagement with the guide surface of said guide ring means to regulate the reciprocatory movement of the pistons against working fluid within their respective cylinders to effect an exchange of energy between such fluid and said rotor means, said rotor means having a plurality of internal passages each communicating with a corresponding cylinder and with an open port located on an axial end face of the rotor means to accommodate intake of working fluid into said cylinder and expulsion of working fluid therefrom, fluid flow control means disposed within said housing means to regulate the intake and expulsion of working fluid from said cylinders, said control means having an axial end face disposed in adjacent oppositely facing relation to said rotor means axial end face and a first internal passage disposed for communication with a first open port located on said control means end face and for communication with a pressurized fluid supply means, and a second internal passage disposed for communication with a second open port located on said control means end face and for communication with a fluid return means, said first and second ports of the control means end face being arranged to pass into communicating alignment with said ports on the rotor means end face in accordance with the angular position of the rotor means relative to the control means to communicate said cylinders to the supply means at predetermined angular positions of the rotor means and to communicate said cylinders to the return means at other predetermined angular positions of the rotor means, said control means and rotor means being disposed for limited axial movement relative to each other to allow adjustment of the clearance space between their respective end faces, said guide shoes being disposed for correspondingly limited axial movement relative to said guide surface and with the rotor means to permit such relative axial movement between the rotor means and control means for adjustment of said clearance space without changing the reciprocatory motion of said pistons, and resilient means disposed within said housing means to urge said rotor means toward said control means to minimize the clearance between their end faces and thereby minimize leakage of working fluid therebetween.

2. The rotary fluid-handling machine according to claim 1 wherein said rotor means has two axially spaced groups of cylinders carrying pistons and a pair of opposite axial end faces, and wherein the internal rotor means passages communicating with respective cylinders of one group communicate with corresponding open ports located on one of said end faces, and the internal rotor means passages communicating with respective cylinders of the other group communicate with corresponding open ports located on the other of said end faces, and wherein said fluid flow control means includes a first control body disposed within said housing means and having an axial end face disposed in adjacent oppositely facing relation to one rotor means end face, and a second control body disposed within said housing means and having an axial end face disposed in adjacent oppositely facing relation

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to the other rotor means end face, said first and second control bodies each having a first internal passage disposed for communication with a first open port located on their respective end faces, and a second internal passage disposed for communication with a second open port also located on their respective end faces, said first passages being also disposed for communication with respective pressurized fluid supply means, said second passages also being disposed for communication with respective fluid return means, the first and second ports on each control body end face being arranged to pass into communicating alignment with the ports on the respectively adjacent rotor means end face during rotation thereof and in accordance with the angular position of the rotor means relative to the housing means to communicate to the respective fluid supply means and fluid return means in sequence, the cylinders of the group associated with each control body end face and rotor means end face combination, said first control body being stationary with respect to the housing means and said second control body being disposed for limited axial movement relative to said housing means and first control body to allow adjustment of the clearance spaces between the end face of each control body and respective end faces of the rotor means, said resilient means being disposed for engagement with said second control body to urge same into axially bearing contact with the rotor means and to urge said rotor means toward said first control body to minimize the clearances between each combination of control body and rotor means end faces to thereby minimize leakage of working fluid therebetween.

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3. The rotary fluid-handling machine according to claim 2 wherein said second control body is also disposed for limited radial movement relative to said rotor means.

4. The rotary fluid-handling machine according to claim 1 wherein said rotor means includes a shaft extending axially through said control means for rotation relative thereto.

5. The rotary fluid-handling machine according to claim 4 wherein said shaft has a spherical bearing portion and wherein said second control body is disposed for engagement with said spherical bearing to accommodate spherically limited movement of said second control body relative to said rotor means shaft.

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