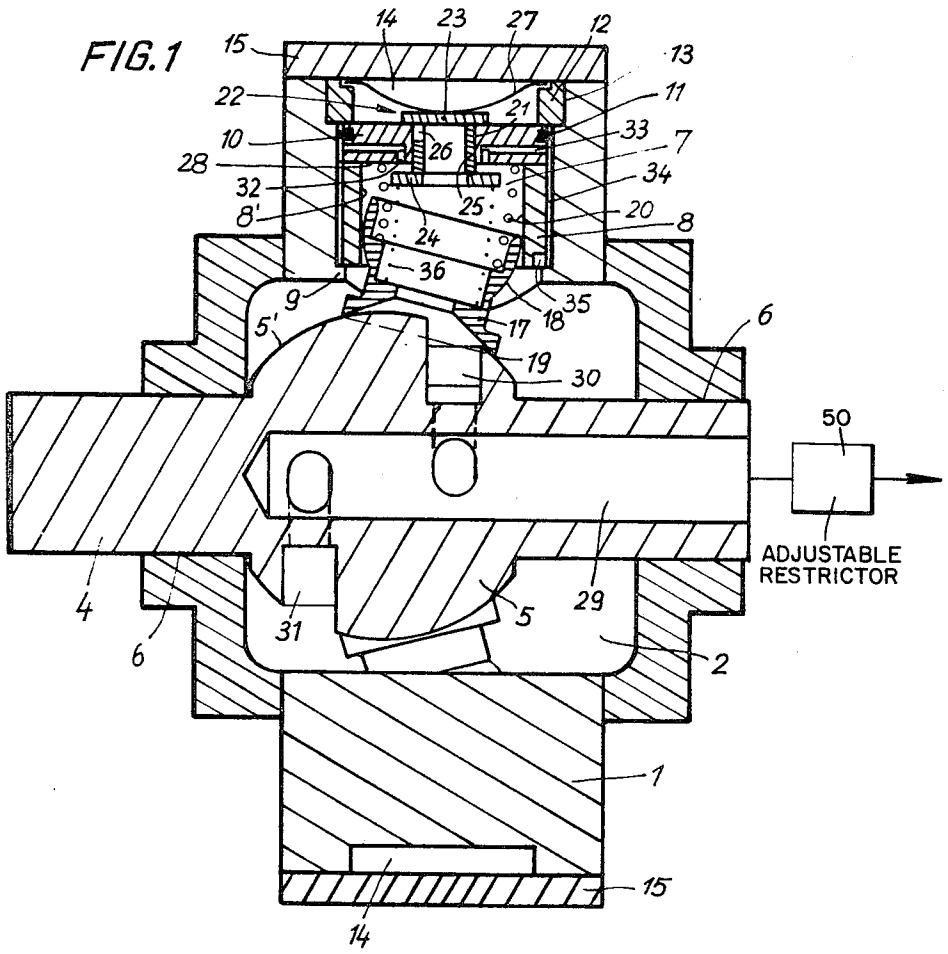
Nov. 26, 1968 HANNS-DIETER PASCHKE 3,412,647

ROTARY PISTON TYPE FLUID MOTOR

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FIG. 1



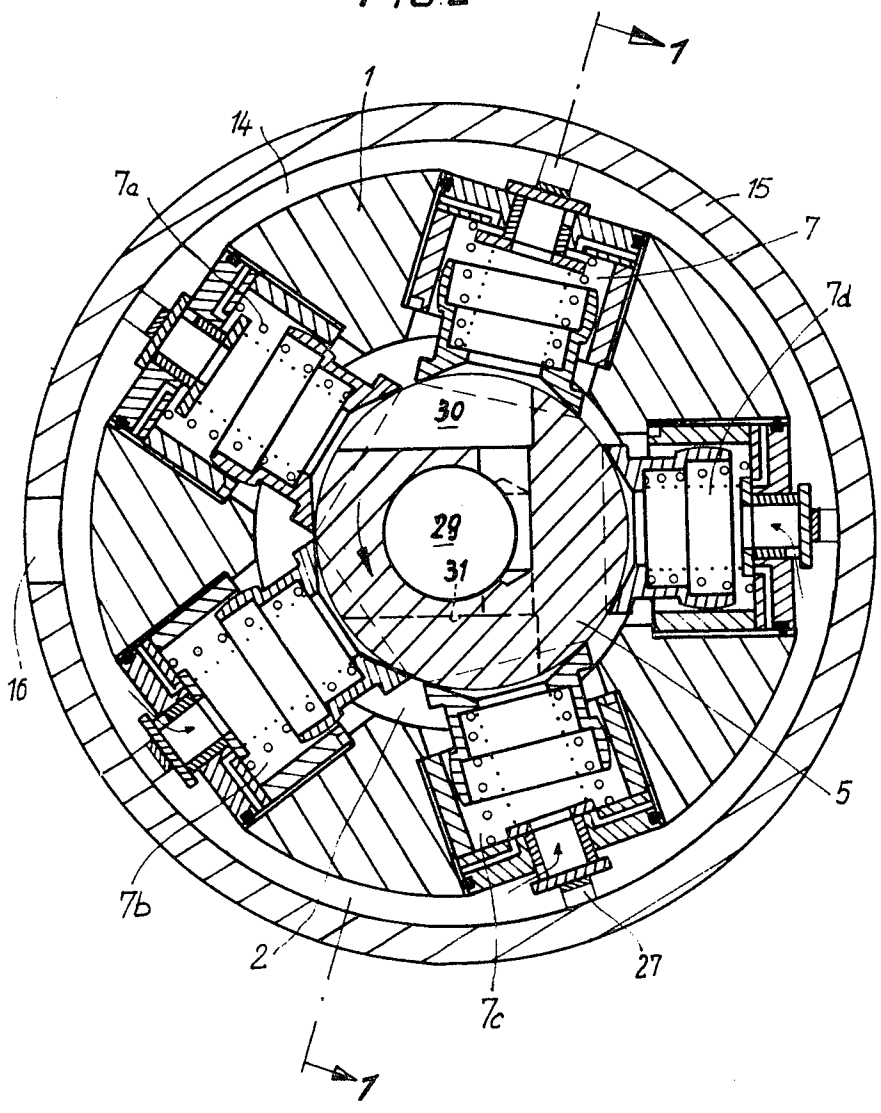
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ROTARY PISTON TYPE FLUID MOTOR

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FIG. 2



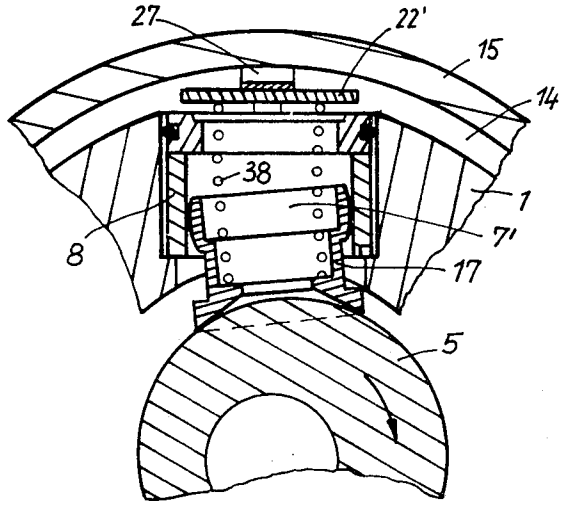
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FIG. 3



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3,412,647

ROTARY PISTON TYPE FLUID MOTOR

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ABSTRACT OF THE DISCLOSURE

A rotary piston type fluid motor which includes an eccentric mounted on a shaft within a casing. A working chamber is in the casing and is open toward the eccentric. A seal element is positioned in the working chamber so as to be in sealing engagement with the eccentric and the wall of the chamber. A valve is positioned at the outer end of the working chamber and the eccentric has a control port which is periodically in cooperation with the working chamber. The valve is designed as an inlet valve on which the pressure of the supplied fluid acts in the closing sense and the pressure of the fluid in the working chamber acts in the opening sense. The control port on the eccentric is designed as an outlet port which is arranged so that it comes out of communication with the working chamber before the eccentric reaches its top dead-center position with respect to the working chamber.

Background of the invention

This invention relates to a rotary piston machine comprising a casing, an eccentric mounted on a shaft for rotation within said casing, at least one cylindrical working chamber in said casing and open toward the eccentric, an annular seal element with a spherical outer surface loosely arranged within said working chamber and in sealing engagement with the cylindrical wall of the working chamber on one hand and with the peripheral surface of the eccentric on the other hand. In a known machine of this kind working as a pump, the working medium is supplied through a control port within the eccentric and the outer end of the working chamber opposite to the eccentric is provided with an outlet valve. A machine of this type is disclosed in Patent No. 3,320,902, which issued to me on May 23, 1967. It would be advantageous to provide simple means and to operate this type of rotary piston machine as a fluid motor.

Summary of the invention

It is therefore an object of the invention to provide such simple means and to operate the above mentioned type of rotary piston machine as a fluid motor. According to the invention, the valve provided at the outer end of the working chamber is designed as an inlet valve on which the pressure of the supplied working fluid acts in the closing sense, and on which the pressure of the working fluid in the working chamber acts in the opening sense. The control port in the eccentric is designed as an outlet port which is arranged in such manner that it comes out of communication with the working chamber before the eccentric reaches its top dead-center (TDC) position with respect to that working chamber. By this arrangement, the residual working fluid present within the working chamber is pressurized on further rotation of the eccentric until the eccentric reaches its TDC position and this pressure is sufficient to open the inlet valve against the pressure of the supplied fluid.

When the valve is opened at first a pressure balance takes place between the pressure of the fluid within the working chamber and the pressure of the supplied fluid. As soon as the eccentric has passed its TDC, the volume of the working chamber increases and a flow of fluid

into the working chamber commences. This flow causes the pressure within the working chamber to fall. The flow velocity is dependent on the valve lift and on the momentary speed of the eccentric with the latter being dependent on the eccentricity and on the rotational speed of the eccentric. The higher the flow velocity the lower is the pressure within the working chamber and the earlier the inlet valve closes. The moment of closing for a predetermined rotational speed can be determined by suitable selection of the differences in the effective areas of the valve subjected to the pressure prevailing in the working chamber and subjected to the pressure of the supplied fluid respectively, and/or by suitable spring load loading of the valve or by the size of the valve lift.

The fluid motor of the invention has torque characteristics like an electrical series motor such that it has its highest torque at low speed and its smallest torque at high speed. When combined with a positive displacement pump this fluid motor can form a transmission in which the output torque and output speed are adaptable automatically to the desired values. When using a transmission of this type in automotive vehicles, an additional advantage is gained if a fluid motor is used in which the moment of closure of the inlet valve is determined by a predetermined difference in area of the valve. This advantage is based on the fact that the force which is necessary for keeping the inlet valve opened is also proportional to the pressure of the supplied fluid. The lower this pressure, the lower is the flow velocity at which the valve closes and, consequently, at a constant speed the lower the pressure of the supplied liquid, the earlier the valve is closed. The earlier the valve closes the smaller is the consumption of the working fluid which means that in a power transmission for vehicles the speed of the engine can be reduced after the vehicle has been accelerated up to cruising speed. Therefore, at constant performance, the torque must be increased which corresponds to an overdrive operation in which the engine is running at low speed and high load, that means in the region of economic fuel consumption.

The inlet valve preferably comprises a valve plate, one surface of which is being acted upon by the pressure of the supplied fluid in the closing sense and the other surface is being acted upon by the pressure of the fluid within the working chamber in the opening sense. Either a spring tending to open the valve is provided or the effective surface area of the plate subjected in the closing sense is smaller than the effective surface area subjected in the opening sense.

The valve plate may comprise a disc which in the closed position of the valve covers an opening in the wall of the working chamber from the outside, and a member arranged within the working chamber and connected to the disc by a lifter projecting through said opening. On upward movement of the eccentric the working fluid remaining in the working chamber is pressurized and lifts this member if the force eventually developed by the pressure together with a spring force acting in the same direction exceeds the force developed by the pressure of the supplied fluid. The member then lifts the disc off its seat. In order to ensure that no pressure can build up at the rear side of the member, venting recesses may be provided in the surface of the working chamber wall on which the member rests when the valve is in the open position. These recesses are in communication with a low pressure space.

In order to facilitate the starting of the fluid motor it is advisable to provide a spring which tends to keep the valve open as long as no working fluid under pressure is supplied. As soon as the pump supplies fluid to the motor the fluid can flow into the working chamber. Since it is possible at this moment for the eccentric to occupy a position in which the outlet port is in communication with the

working chamber, it is preferable to arrange a plurality of working chambers equally spaced around the eccentric. It is also preferable to provide a common return pipe comprising an adjustable restrictor which is narrowed when the motor is started so that a pressure can build up in the working chambers thereby keeping the valves open. By suddenly opening the restrictor the pressure drops in those chambers which communicate with the outlet port and the inlet valves of these chambers are closed while in the other working chambers the pressure can act on and rotate the eccentric and its shaft.

As has been explained above, on constant pressure of the supplied fluid, the moment of closing of the valve is dependent on the effective difference in area and the rotational speed. In a motor with a plurality of working chambers, in order to prevent the valves of all working chambers from closing at the same rotational speed, it is desirable to provide the valves of at least some of the working chambers with different ratios of effective area so that the individual working chambers are cut off at different speeds.

If the valves are kept open by springs until the pressure of the supplied fluid closes the valves, it is desirable that the spring force be different for different valves. Furthermore, the size of the valve size may be made different valves.

The time over which the valves are open, along with other factors, depends on the rotational speed so that the higher the speed the shorter the time. In order to prevent a closing of all valves and consequent stalling of the pump and engine at high speed, for instance when driving downhill, it is desirable that at least one working chamber remain working. This can be effected by choosing an effective ratio of valve area for at least one working chamber so that the valve closes not earlier than at the moment at which the outlet port comes in communication with that working chamber. In this way, a consumption of working fluid is always ensured.

The leading edge of the outlet port can be arranged obliquely to the axis of rotation of the eccentric and the eccentric can be made shiftable axially. In this manner, the working characteristics of the motor can be altered.

In order to realize rotation of the motor shaft in both directions, two axially spaced outlet ports may be provided within the eccentric. These ports may be arranged in mirror-like relationship to each other with respect to a plane passing through the center of the eccentric and the axis of rotation of the shaft carrying the eccentric. By shifting the eccentric axially the one or the other of said ports cooperates alternatively with a working chamber whereby rotation in the one or the other direction of the motor shaft is obtained.

The fluid motor is preferably supplied with a liquid working medium such as oil, however, the use of a gaseous or vaporous working material is likewise acceptable.

Brief description of the drawing

The invention will be explained in detail with the assistance of the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view taken along line 1—1 in FIGURE 2 of a fluid motor with five working chambers whereby the moment of closing of the inlet valves is determined by selection of the effective differences in area of valves;

FIG. 2 is a cross sectional view of the fluid motor shown in FIGURE 1; and

FIG. 3 is a partial cross sectional view similar to FIGURE 2 of a fluid motor in which the inlet valves are subjected to spring force in the opening sense.

Description of the preferred embodiments

FIGURES 1 and 2 show a fluid motor comprising a casing 1 with an internal cavity 2 within which a spherical eccentric 5 is mounted on a rotatable shaft 4. Shaft 4 is supported in the casing 1 by bearings 6. Casing 1 comprises five generally radially, cylindrical working chambers 7 which are open towards the eccentric 5. Each working chamber 7 is provided with a liner 8 which has radial play and which abuts on an annular boss 9 of the casing. The outer end of each working chamber 7 is closed by a cylinder head 10 which lies upon liner 8 and which is sealed toward the inner wall of working chamber 7 by a sealing ring 11. Cylinder head 10 is secured in position by cylindrical bolts 12 which are inserted in boss 13 of casing 1. Outside of cylinder head 10, an annular space 14 is arranged within casing 1. Space 14 is closed towards the outside by a ring 15. Space 14 constitutes an inlet passage and its connections 16, as shown in FIGURE 2, is continuously connected to the pressure side of a pump.

An annular sealing element 17 is loosely inserted in each working chamber 7. Element 17 has a spherical outer surface 18 for sealing cooperation with the cylindrical inner surface 8' of liner 8. The annular end face 19 of each sealing element 17 is maintained in sealing engagement with the peripheral surface 5' of the spherical eccentric 5 with the assistance of a spring 20.

Cylinder head 10 has a central aperture 21 which accommodates an inlet valve generally indicated as numeral 22. Inlet valve 22 comprises a disc 23 covering the aperture 21, and a member or plate 24 arranged within working chamber 7. Plate 24 is connected with the disc 23 by a hollow lifter 25 which extends through aperture 21. Lifter 25 is longer than the thickness of cylinder head 10 at this point and comprises one or several openings 26 which bring annular space 14 in communication with the interior of working chamber 7 when valve 22 is opened. Valve disc 23 is positively or non-positively connected to lifter 25 and to member 24 respectively. In the shown embodiment a non-positive connection is provided by spring 27. The outer surface of disc 23 is acted on by the pressure of the fluid within space 14 in the closing sense. The pressure of the working fluid within working chamber 7 acts in an opening sense on the lower surface of member 24 and through the hollow lifter 25 on the lower surface of disk 23.

Shaft 4 includes a central outlet passage 29 which communicates with two control ports 30 and 31 in the peripheral surface 5' of eccentric 5. Control ports 30 and 31 are spaced axially and are arranged mirror like to each other with respect to a plane passing through the center of eccentric 5 and the axis of rotation of shaft 4. Eccentric 5 is axially shiftable so that, alternatively, one or the other of ports 30, 31 cooperates with working chamber 7. Depending on which port 30 or 31 is in action, shaft 4 rotates in one or the other direction. Therefore, the direction of rotation of shaft 4 can be changed by axially shifting eccentric 5. If the leading edge of ports 30, 31 is arranged obliquely to the axis of rotation of eccentric 5, the moment at which the outlet opens can be altered by axial shifting of eccentric 5.

As can be seen from FIGURE 2, the motor comprises five working chambers 7, 7*a*, 7*b*, 7*c* and 7*d*. The eccentric rotates in the direction of the arrow whereby the volume of the working chambers 7–7*d* varies with corresponding phase displacement. In the position of eccentric 5 as shown in FIGURE 2, the working chambers 7 and 7*a* perform their exhaust stroke whereby the control port 30 is in communication with said chambers. The valve discs 23 of these working chambers 7 and 7*a* are sealingly urged against their cylinder heads 10 by the pressure prevailing in the annular space 14 and close the inlet apertures 21.

Working chamber 7*b* is still performing its working stroke with its valve disc 23 being lifted by member 24 and lifter 25 so that the supplied fluid can enter working chamber 7*b*. At the latest in that moment in which port 30 comes in communication with this chamber, the pressure in this chamber 7*b* falls and the pressure in space 14 can urge valve disc 23 against cylinder head 10 whereby inlet aperture 21 is closed.

Ports 30, 31 are arranged in the peripheral surface 5'

of eccentric 5 so that the respective port 30 or 31 comes out of communication with a respective working chamber before eccentric 5 has reached its TDC with respect to that working chamber. This can clearly be seen for working chamber 7*d*. With respect to working chamber 7*d*, eccentric 5 is in its TDC but port 30 has previously left that chamber. The result is that a residual fluid remained in working chamber 7*d* which has been pressurized until eccentric 5 has reached its TDC as shown in FIGURE 2. This pressure acts upon the lower side of member 24 and on the lower side of disc 23 whereby disc 23 is lifted against the action of the pressure in space 14 and the force of spring 27 so that working fluid can enter working chamber 7*d* from space 14 through opening 26. When the valve is open, at first a pressure balance takes place between working chamber 7*d* and space 14. As soon as eccentric 5 has passed its TDC relative to that chamber 7*d* and the volume of chamber 7*d* increases again, a flow of fluid commences into the working chamber. The result is that the pressure within chamber 7*d* falls. The flow velocity is depenudent on the momentary speed of eccentric 5 which is itself dependent on the rotational speed and on the size of the eccentricity. The higher the flow velocity, the smaller becomes the pressure in working chamber 7*d* and the earlier inlet valve 22 closes. Therefore, the moment of closure for a predetermined speed is determined by appropriate selection of the difference of the effective areas of the valve on which acts the pressure of the supplied fluid on one hand and the pressure of the fluid within the working chamber on the other hand. The larger the area pressurized in the opening sense of valve 22, the later the valve will close.

In order to prevent a pressure to build up behind member 24, an annular venting groove 32 is provided in the internal surface 28 of cylinder head 10. Groove 32 is in communication with the internal cavity 2 of casing 1 by way of passages 33, gap 34 between liner 8 and the inner wall of chamber 7, and groove 35 at the lower end of liner 8.

In order to facilitate the starting of the motor, each working chamber 7–7*d* includes a spring 36 which acts in the opening sense on valve 22. In this manner all valves 22 are open as long as no working fluid is supplied through space 14. As soon as the pump works, the working fluid can enter all working chambers 7–7*d*. By throttling the return passage 29 with the aid of an adjustable restrictor 50, a pressure can be built up in all working chambers. This pressure holds inlet valves 22 open. When the restrictor is suddenly opened, the pressure falls in those working chambers which are connected through port 30 with return passage 29, while in the other working chambers the pressure can act on and turn eccentric 5. To prevent the valves of all working chambers from being closed at the same rotational speed, it is desirable to provide different ratios of effective areas for at least some of the valves so that the valves of the individual working chambers close at different speeds.

FIGURE 3 shows a working chamber 7′ corresponding to chamber 7c in FIGURE 2, in which valve 22′ is kept open by a spring 38. The force of spring 38 determines the moment at which valve 22′ is closed at a predetermined speed. The closing of valve 22′ takes place at that moment when the force of spring 27 and the force exerted by the pressure in space 14 exceeds the force of spring 38 and the force exerted by the pressure within working chamber 7′. The pressure in chamber 7′, however, is dependent on the flow velocity and, therefore, on the rotational speed of eccentric 5. The opening of valve 22′ takes place in the same manner as described in connection with FIGURES 1 and 2. This means port 30 is separated from working chamber 7′ before TDC of accentric 5 with respect to that working chamber. In this manner, the residual fluid within chamber 7′ is pressurized on further rotation of the eccentric in the direction of the arrow until at the latest on TDC the pressure is high enough to exert a force on valve 22′. This force, together with the force of spring 38, is sufficient to open valve 22′ against the force of the pressure in space 14 and against the force of spring 27. At the same time, spring 38 takes over the task of spring 36 in FIGURES 1 and 2. Also in this embodiment, in order to prevent a closing of valves 22′ of all working chambers at the same speed, it is desirable to choose a different force of springs 38 for each working chamber.

Thus, the above mentioned objects of the invention, among others, are achieved. The range and scope of the invention are defined in the following claims.

I claim:

1. A fluid motor of the rotary piston type comprising a casing, an eccentric mounted on a shaft for rotation within said casing, at least one cylindrical working chamber in said casing and open toward the eccentric, an annular sealing element with a spherical outer surface loosely arranged within said working chamber and in sealing engagement with the cylindrical wall of the working chamber on one hand and with the peripheral surface of the eccentric on the other hand, a valve at the outer end of the working chamber and at least one control port in the eccentric periodically cooperating with the interior of the working chamber, characterized in that said valve is designed as an inlet valve on which the pressure of the supplied fluid acts in the closing sense and on which the pressure of the fluid in the working chamber acts in the opening sense, and that the control port in the eccentric is designed as an outlet port which is arranged in such manner that it comes out of communication with the working chamber before the eccentric reaches its top dead-center position with respect to that working chamber.

2. A fluid motor according to claim 1, in which the valve comprises a valve plate the effective area pressurized in the closing sense being smaller than the effective area pressurized in the opening sense.

3. A fluid motor according to claim 1, in which the valve comprises a valve plate and that a spring is provided which tends to keep the valve open.

4. A fluid motor according to claim 3 and having an adjustable restrictor in the return pipe.

5. A fluid motor according to claim 2 in which the valve comprises a disc which covers an opening in the working chamber wall from outside when the valve is closed, and a member arranged within the working chamber and connected to the disc by a lifter projecting through said opening.

6. A fluid motor according to claim 5 in which the surface of the working chamber wall on which the member rests in the open position of the valve is provided with venting means which are in communication with a low pressure space.

7. A fluid motor according to claim 2 and comprising a spring which in addition acts on the valve in the opening sense.

8. A fluid motor according to claim 7, and having an adjustable restrictor in the return pipe.

9. A fluid motor according to claim 2 in which a plurality of working chambers is provided and in which at least some of the inlet valves of the individual working chambers have different ratios of effective area.

10. A fluid motor according to claim 3 in which a plurality of working chambers is provided and in which the spring force for different inlet valves is different.

11. A fluid motor according to claim 9 in which the ratio of the effective areas for at least one working chamber is chosen in such a way that the valve closes not earlier than at the moment at which the control port is in communication with the working chamber.

12. A fluid motor according to claim 10 in which the force of at least one spring is chosen such that the valve closes not earlier than at that moment at which the control port is in communication with that working chamber.

13. A fluid motor according to claim 1 characterized in that the control edge of the port leading with respect to the direction of rotation of the eccentric is inclined to the axis of rotation of the eccentric, and that the eccentric is axially shiftable.

14. A fluid motor according to claim 1 in which the eccentric is provided with two control ports axially spaced from each other and being mirror-like arranged relative to each other with respect to a plane passing through the center of the eccentric and the axis of rotation of the eccentric, and in which the eccentric is axially shiftable in such a way that alternatively the one or the other of said ports cooperates with a working chamber.

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