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[54] **REGULATED PUMP WITH CONSTANT DISPLACEMENT VOLUME**

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[52] **U.S. Cl.** **417/220**, 418/26, 418/30

[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** 91/475, 486; 417/213, 219, 220, 221; 418/27, 30

[56] **References Cited**

UNITED STATES PATENTS

2,775,946	1/1957	Hufferd	417/220
2,635,551	4/1953	De Lancey	417/220
3,028,814	4/1962	Rumsey et al.	417/219
3,067,693	12/1962	Lambeck	417/219
2,716,945	9/1955	Presnell	417/213
3,626,810	12/1971	Morey	91/486

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[57] **ABSTRACT**

A pump has a housing with a housing ring, a rotor with pistons, and a control ring between the housing ring and the rotor so that a working space is formed between the rotor and the control ring, and an annular space is formed between the control ring and the housing ring. The annular space is divided into first and second control spaces, connected by throttling means. The first control space receives high pressure fluid, and the second control space discharges into a consumer line. When at high rotary speed, the pressure differential becomes great, the control ring is displaced to reduce the working space so that a substantially constant volume is pumped at different speeds. A compensating device responds to the pressure in the consumer line to urge the control ring to increase the working space so that the influence of the fluid pressure and of the piston friction on the control ring is compensated.

12 Claims, 7 Drawing Figures

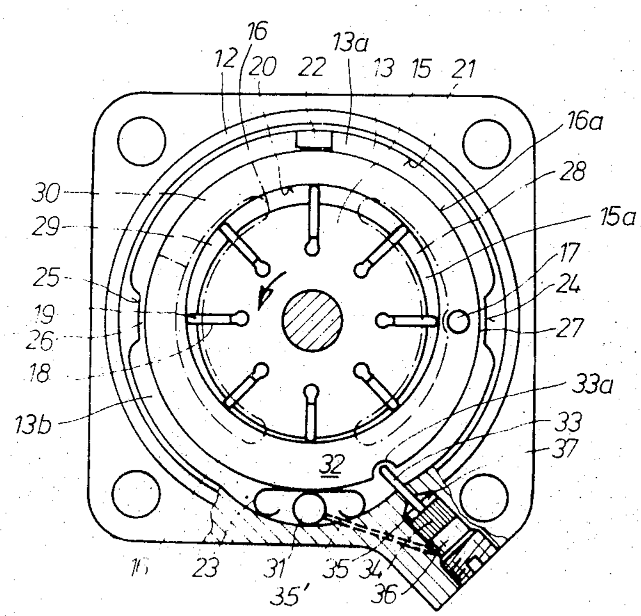

Fig.1

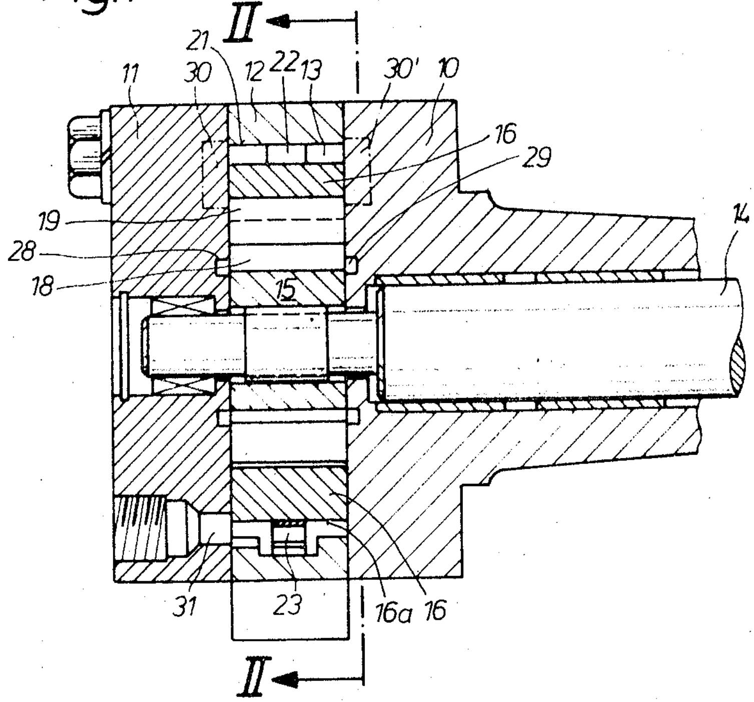

Fig.2

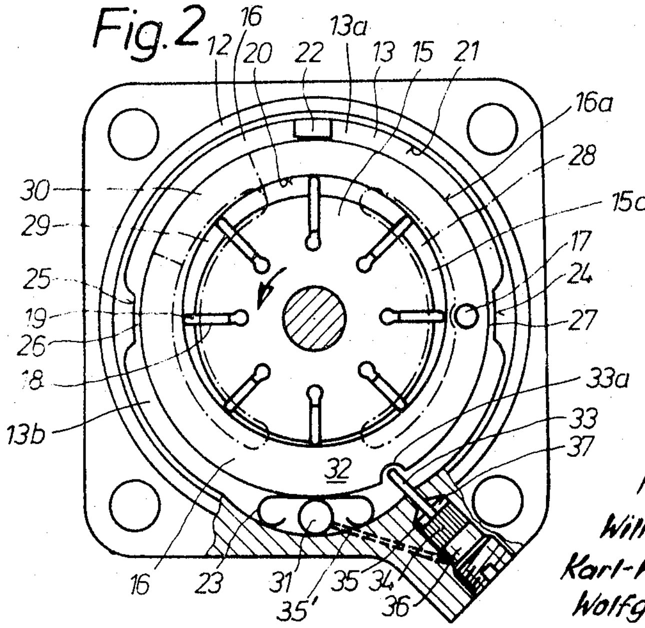

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Fig.3

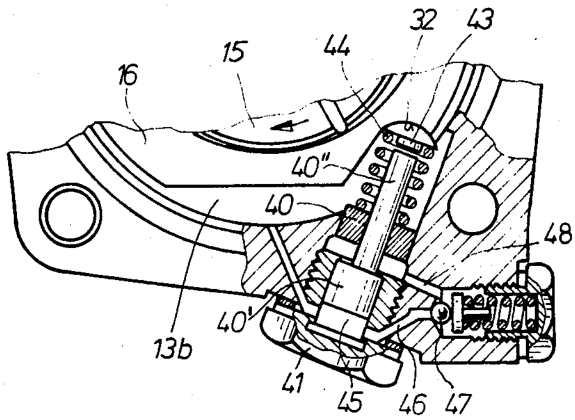

Fig.4

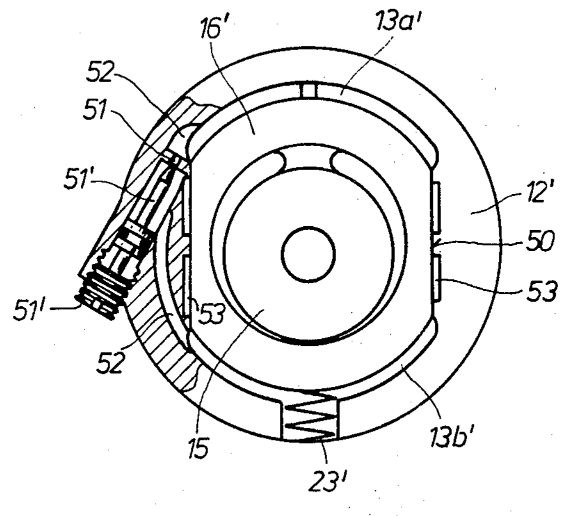

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Fig.5

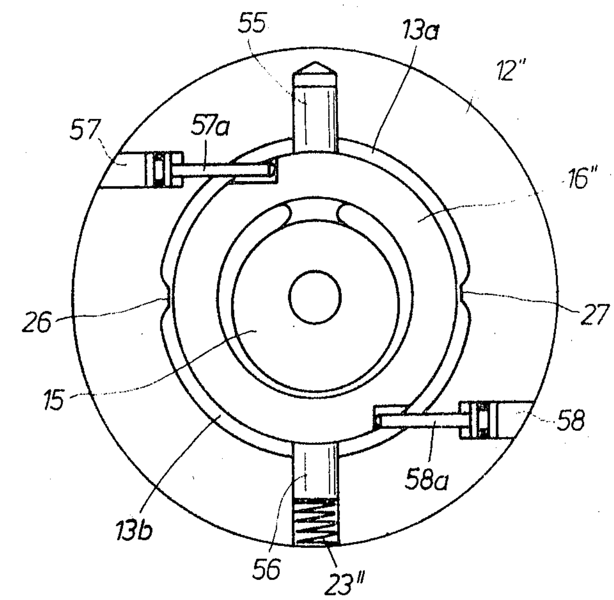

Fig.6

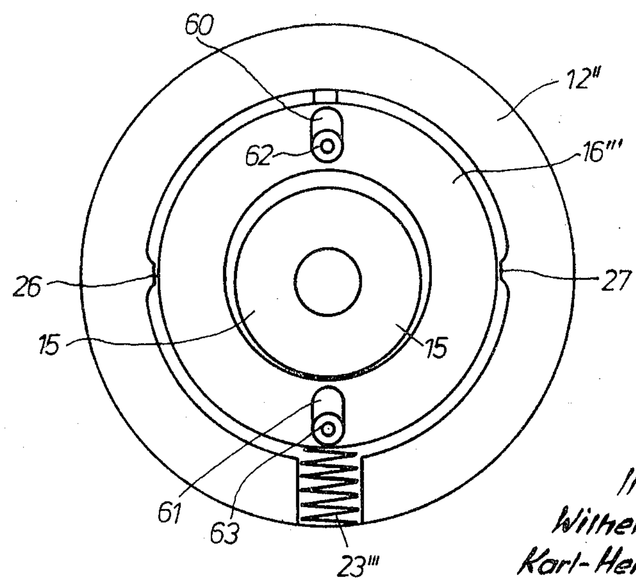

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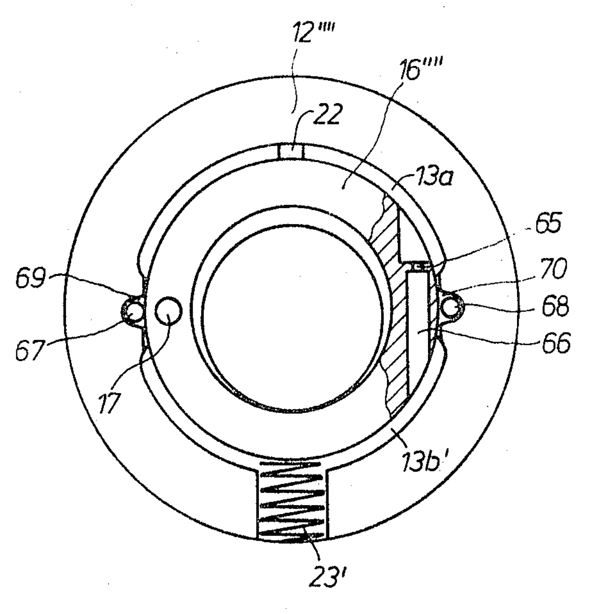
Fig.7



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REGULATED PUMP WITH CONSTANT DISPLACEMENT VOLUME

SUMMARY OF THE INVENTION

It is one object of the invention to provide a regulated pump which has a substantially constant displacement volume, independently of the rotary speed of the pump.

Another object of the invention is to provide a pump of this type which is of simple construction, inexpensively manufactured, and operates reliably.

With these objects in view, the present invention arranges a throttle in such a manner that the differential pressure upstream and downstream of the throttle acts directly on the control means which influences the pump volume.

As a result, a pump is obtained which does not require any additional parts for a regulation depending on the pressure. Preferably, the throttle is formed at least partly by the control means, or by gaps between the control means and the housing means. It is also possible to provide the throttle passage in a control ring or in a housing ring.

In order to obtain a very exact regulation to a constant displacement volume, irrespective of the rotary speed of the rotor, it is advantageous to apply to the control means an additional force which is proportional to the pressure in a consumer line connected to the outlet of the pump, and opposes the torque exerted by the rotor on the control means due to the fluid pressure and friction of the rotor pistons on a control ring.

A pump of this type is particularly suited for the power steering of motorcars. Hydraulic power steering apparatus requires that the amount of fluid necessary for steering is already pumped at idling speed, without being substantially increased at the highest rotary speed of the pump.

An embodiment of the regulated pump, according to the invention, comprises housing means including a housing ring; a rotor mounted in the housing means and including radial piston means; a control ring mounted in the housing ring for movement in first and second direction transverse to the axis of the rotor, and surrounding the rotor so that the inner surface of the control ring is slidingly engaged by the piston means, and so that the outer surface of the control ring and the inner surface of the housing ring define first and second control spaces located on opposite sides of a plane passing through the rotor axis transverse to the first and second directions; biassing means mounted in the housing means for biassing the control ring to move in the first direction to a first end position abutting the rotor on one side so that a working space is formed on the other side between the rotor and the inner surface of the control ring, the housing means having inlet and outlet ports in the working space, and a conduit connecting the outlet port with the first control space; outlet means for a consumer apparatus communicating with the second control space; and throttling means. The throttling means are either formed by the control ring, or by the housing ring, or by a gap between portions of both rings, and directly connect the first and second control spaces so that at high rotary speeds, the pressure differential between the first and second control spaces becomes so high that the control ring is moved by the pressure in the first control space against the action of the biassing means toward the other side of the rotor whereby the working space is reduced to maintain the displaced volume constant at different rotary speeds of the rotor. A compensating device is biased by pressure fluid to engage the control ring and to bias the same in the first direction.

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

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view illustrating a first embodiment of the invention;

FIG. 2 is a cross-sectional view taken on line II—II in FIG. 1;

FIG. 3 is a fragmentary cross-sectional view partially in section, illustrating a modification of the embodiments of FIGS. 1 and 2;

FIG. 4 is a cross-sectional view illustrating a second embodiment;

FIG. 5 is a schematic cross-sectional view illustrating a third embodiment of the invention;

FIG. 6 is a schematic cross-sectional view illustrating a fourth embodiment of the invention; and

FIG. 7 is a fragmentary cross-sectional view illustrating a fifth embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1 and 2, a housing includes two covers 11 and 10, and a housing ring 12 between the same. A rotor shaft 14 is mounted on bearings in covers 10 and 11, and has a rotor 15 located centrally in the housing ring 12.

A control ring 16 is located within the housing ring 12, surrounding rotor 15. In the embodiment of FIGS. 1 and 2, control ring 16 is mounted on a pivot 17 which is supported by the covers 10 and 11, so that control ring 16 can perform a limited angular movement relative to the rotor 15 and to the housing ring 12. Control ring 16 is slightly narrower in axial direction than housing ring 12, and the diameter of its inner surface 20 is slightly greater than the diameter of the outer surface of rotor 15.

Rotor 15 has a series of substantially radial slots 18 in which pistons 19 are mounted for radial movement. The outer ends of pistons 19, which are advantageously constructed as vanes, slidingly abut the inner circular surface 20 of control ring 16.

A spring 23 is provided in the annular space formed between housing ring 12 and control ring 16, and urges control ring 16 to turn about pivot 17 so that control ring 16 moves in one direction to an end position abutting a stop 22 on the inner surface 21 of housing ring 12. In this end position, the control ring 16 is located directly adjacent one side of rotor 15 so that at the other side of the rotor, a crescent-shaped work space 15a is formed between the inner surface of control ring 16 and the outer surface of rotor 15.

In a plane passing through the axes of rotor 15 and pivot 17 transverse to the direction of movement of control ring 16, housing ring 12 has two inner projections 24 and 25 forming throttle gaps 27 and 26 with the outer surface 16*a* of control ring 16. The throttle passages 26 and 27 form between control ring 16 and housing ring 12, first and second control spaces 13*a*, 13*b* which communicate with each other through the throttling means 24,25,26,27. The first control space 13*a*, in which stop 22 is located, is disposed on the same side as the working space 15*a*, and the second control space 13*b* is connected with an outlet 31 to a consumer line which may lead to power steering apparatus, not shown.

In the housing cover 11, two arcuate ports 28,29 are provided, shown in chain lines in FIG. 2. The port 28, which extends over an angle of about 150°, is located on the same side as pivot 17, while the corresponding port 29 is located on the other side of the rotor.

The port 29 is connected by conduits 30 and 30 in covers 10 and 11 with the first control space 13*a*. Conduit 30 is shown in chain lines in FIG. 2.

The outer surface 16*a* of control ring 16 has in the second control space 13*b*, a recess 33a engaged by a projecting part 33 of a piston 34 mounted in a cylinder bore 35 of housing ring 12. The axis of piston 34 and projection 33 is substantially tangential to a circle having its center in the axis of pivot 17, and passing through the rotor axis. Consequently, pressure of piston means 34,37 on control ring 16 will turn the same efficiently about pivot 17 in the same direction as spring 23.

A duct 35′ in housing ring 12 connects consumer line 31 and the second control space 13b with cylinder 36 on the free side of the differential piston 34. The cylinder portion 37 on the other side of piston 34 is without pressure.

In a position of rest of the pump, spring 23 urges control ring 16 to turn about pivot 44 towards an end position abutting stop 22, in which position the eccentricity of the circular control ring 16 in relation to the rotor axis is a maximum. If control ring 16 is turned in the opposite direction against the action of spring 23, the center of control ring 16 may be brought to a position coinciding with the axis of rotor 15.

When shaft 14 and rotor 15 are driven by a prime mover, for example, a combustion engine on a motorcar, the inlet port 28 receives pressure fluid which is pumped by the pistons 19 sweeping the working space 15*a*, into the outlet port 29, from where it is displaced through the conduit 30 into the first control space 13*a*. The fluid flows then through the throttle passages 26 and 27 into the second control space 13*b*, and from the same through the consumer outlet 31 to consumer apparatus, such as power steering motor.

When the rotary speed of the drive motor is low, so that the pump volume is small, the pressure drop at the throttle passages 26 and 27 is only low, and the entire pump fluid flows without great resistance to the consumer line. When the rotary speed increases so that a greater volume is pumped, the pressure differential at the throttle passages 26,27 becomes greater, and the pressure in the first control space 13*a* becomes substantially greater than the pressure in the second control space 13*b* downstream of the throttling means 24 to 27.

Since the force exerted by the pressure fluid in the first control space 13a on the control ring 16 is greater than the force exerted by the fluid in the second control space 13*b* on control ring 16, the same turns about pivot 17, compressing spring 23, and reducing the area of the working space 15*a* between rotor 15 and control ring 16.

Due to the reduction of the suction and pressure areas of the working space 15*a*, the amount pumped into consumer line 31 remains substantially the same, irrespective of the increase of the rotary speed of the rotor 15. In other words, the increase of the pumped volume due to the increase of the rotary speed, and the reduction of the pumped volume due to displacement of control ring 16 and reduction of working space 15*a*, compensate each other so that a condition of equilibrium is obtained in which the pumped volume is almost constant.

The pistons or vanes 19 of rotor 15 exert on control ring 16 a torque, partly due to friction, so that the same is urged to turn about pivot 17 to a position reducing the working space 15*a* while compressing spring 23. The influence of this torque is undesirable, since it constitutes a regulation of the output volume not only depending on the rotary speed of rotor 15, but also on the pressure. This torque is compensated by the compensating device including differential piston 34,35 since the force exerted by projection 33 on control ring 16 is proportional to the pressure in the consumer line 31 and in the second control space 13*b*. The force exerted by projection 37 produces a compensating torque tending to turn control ring 16 in clockwise direction about pivot 17 for increasing again the working space 15*a*. Due to the position of the compensating device, the regulation of the pump is only speed depending, and not pressure depending.

The use of portions 25,24 of the housing ring, and the corresponding portions of control ring 16 for providing the throttling means creating the necessary differential pressure, results in an extremely simple and inexpensive construction.

Since spring 23 and the piston means 34,33 act in the same direction on control ring 16, it is possible to combine the biassing means for the control ring 16 with the compensating device, and such a modification is illustrated in FIG. 3. Parts of the pump not shown in the fragementary view of FIG. 3, are constructed as illustrated in FIGS. 1 and 2.

A differential piston 40 has a piston part 40′ of great diameter guided in a cylinder bore provided in a screw 41 which is screwed into a bore in the housing. The smaller piston portion 40″ extends tangential to the control ring 16. In axial direction of the differential piston 40,40′, a separate head 43 is provided which is located in recess 32 of control ring 16, and can be slightly displaced due to the rounded shape of head 43. Between head 43 and the housing, a spring 44 is arranged which performs the function of the spring 23 shown in FIG. 2, but the force of the spring is directed in the same direction as the force of the differential piston 40,40′,40″.

The cylinder space 45 is connected by a duct with the second control space 13*b*, where the pressure of the consumer line 31 prevails due to the provision of the throttling means 24 to 27.

A safety valve 47, which opens into a return duct 48, is connected by a conduit 46 with the pressure chamber 45. When the pressure in the consumer line 31 exceeds a predetermined maximum pressure, safety valve 47 opens, and the pressure in cylinder space 45 drops, together with the pressure in control space 13*b*. Since the pressure acting on control ring 16 in the first control space $13a$ is higher, control ring 16 is turned about pivot 17 against the action of spring 44, if necessary to a position in which its center coincides with the rotor axis, so that no fluid is pumped.

The embodiment of FIG. 4 is schematically illustrated, and it will be understood that the omitted parts corresponds to the construction shown in FIGS. 1 and 2. The housing ring 12' has two confronting straight parallel guide faces 50, engaged by corresponding straight opposite guide faces provided on control ring 16'. The pivot 17 of FIGS. 1 and 2 is omitted, and the movement of control ring 16' due to the action of spring 23', or due to the fluid pressure in the control space $13a'$, is rectilinear. A conduit 52 is provided in the housing ring 12', and has a narrow throttle passage 51. Conduit 52 is arranged in housing ring 12' to connect the first control space $13a'$ with the second control space $13b'$ so that a pressure differential is created between the two control spaces on opposite sides of control ring 16'. Adjusting means are provided for varying the free cross section of the throttling passage 51, and include a needle 51' having a threaded head $51a'$ engaging a threaded bore in the housing ring 16' so that the point of the needle can be moved into and out of the throttling passage 51 for adjusting the throttle.

The torque exerted by rotor 15 on the control ring 16', which may cause jamming, is balanced by the pressure in balancing chambers 53 provided in the guide faces 50. The pressure differential between the control spaces $13a'$ and $13b'$, directly acts on the control ring 16', without any intermediate or conduit linkage. When the cross section or throttle passage 51 is adjusted by needle 51', the differential pressure acting on control ring 16' is also adjusted, so that any desired constant displacement volume can be obtained by adjustment of the throttle.

Another embodiment of the invention is schematically illustrated in FIG. 5. The projections 26 and 27 on the inner surface of housing ring 12' cooperate with the outer surface of control ring 16' to form two throttling passages, as described with reference to FIG. 2. Instead of the pivot 17, control ring 16' has two diametrically projecting piston portions 55 and 56 provided in cylinder bores of housing ring 12'', and spring 23''' acts on piston 56 to urge control ring 16'' in one direction. The control spaces $13a$ and $13b$ operate as described with reference to FIGS. 1 and 2.

Two compensating devices 57 and 58 are diametrically arranged and have piston portions $57a$ and $58a$ movable in substantially tangential direction of control ring 16'', which is engaged by the piston portions $57a$ and $58a$. The compensating devices 57 and 58 are connected with the second control space $13b$. The provision of two diametrically arranged compensating devices 57 and 58, instead of only one, as in FIGS. 1 and 2, has the advantage that jamming of the pistons 55 and 56 in the corresponding bore of housing ring 12', is prevented.

In the schematically illustrated embodiment of FIG. 6, the pivot 17 is also omitted, and the aligned slots 60 and 61 are provided in the control ring 60'''. Guide pins 62,63 are secured to the housing, not shown, and project into the slots 60 and 61 so that the control ring 60''' is guided for rectilinear movement. Compensating devices, as shown in FIG. 5, may be provided, but are not shown. The arrangement of the throttling gaps 26 and 27 correspond to the construction described with reference to FIG. 2.

In the embodiment of FIG. 7, the throttling means is provided in the control ring 16'''. A straight conduit 66 extends along a chord in control ring 16'''', and opens into control spaces $13a$ and $13b$. A narrow throttle passage 65 produces a pressure differential between the control spaces $13a'$ and $13b'$. Sealing means 67 and 68 are located in recesses 69,70 of housing ring 12''. The differential pressure between control spaces $13a'$ and $13b'$ urges the sealing means 67 and 68 into fluid-tight engagement with the outer surface of control ring 16'''' and the surfaces of recesses 69,70, so that the control spaces are fluid tightly separated from each other. A pivot 17 supports the control ring 16'''' for angular movement, as described with reference to FIG. 2. Spring 23' urges control ring 16'''' into abutment with stop 22 on housing ring 12''''. Sealing means 67,68 may be constructed as elastic rolls, or as sealing lips.

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

While the invention has been illustrated and described as embodied in a regulated pump with constant displacement volume irrespective of the rotary speed, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

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

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

We claim:

1. Regulated pump with constant displacement volume, comprising housing means including a housing ring; a rotor mounted in said housing means for rotation about an axis, and including radial piston means; a control ring mounted in said housing means within said housing ring for movement in first and second opposite directions transverse to said axis, and surrounding said rotor so that the inner surface of said control ring is slidingly engaged by said piston means, and so that the outer surface of said control ring and the inner surface of said housing ring define first and second control spaces located on opposite sides of a plane passing through said axis transverse to said first and second directions; biasing means mounted in said housing means for biasing said control ring to move in said first direction to a first end position adjacent to said rotor on one side so that a working space is formed on the other side between said rotor and the inner surface of said control ring; said housing means having inlet and outlet ports in said working space, and a conduit connecting said outlet port with said first control space; outlet means for a consumer apparatus communicating with said second control space; throttling means formed by at least one of said rings and directly opening into said first and

second control spaces so that at high rotary speeds the pressure differential between said first and second control spaces moves said control ring in said second direction against said biasing means toward the other side of said rotor whereby said working space is reduced for maintaining the displaced volume constant at different rotary speeds of said rotor, and whereby fluid pressure and friction of said piston means on said control ring produces a force acting in said second direction on said control ring; and a compensating device mounted in said housing ring and including a pressure responsive means communicating with said second control space and biased by the pressure in the same to engage said control ring and to bias the same in said first direction for compensating said force produced by said fluid pressure and friction of said piston means on said control ring.

2. Regulated pump as claimed in claim **1** wherein said throttling means includes two diametrically disposed throttles located in said plane and formed by portions of said housing ring and of said control ring.

3. Regulated pump as claimed in claim **1** comprising a pivot located in said plane and mounted in said housing means eccentric to said axis for supporting said control ring for angular movement between said first and second end positions.

4. Regulated pump as claimed in claim **1,** wherein said throttling means includes adjusting means for varying the throttling flow cross section.

5. Regulated pump as claimed in claim **1,** wherein said biassing means includes a spring acting on said pressure responsive means.

6. Regulated pump as claimed in claim **1** wherein said compensating device including a cylinder formed in said housing ring, a pressure responsive piston in said cylinder having a portion projecting into engagement with said control ring, and a duct formed in said housing means connecting said cylinder with said second control space so that said control ring is biassed to move in said first direction for compensating a torque produced thereon by fluid pressure, and by friction of said piston means and acting in said second direction on said control ring.

7. Regulated pump as claimed in claim **6,** wherein said projecting portion of said piston of said compensating device acts on said control ring in substantially tangential direction.

8. Regulated pump as claimed in claim **6** comprising at least two compensating devices located on opposite sides of another plane passing through said axis perpendicularly to said plane; wherein said control ring has two diametrically disposed outward projecting piston portions located in said other plane; wherein said housing ring has two diametrically disposed bores receiving said piston portions for guiding said control ring for straight movement in said first and second directions; and wherein said biassing means is a spring located in one of said bores for urging said control ring to move in said first direction.

9. Regulated pump as claimed in claim **1,** comprising a pivot located in said plane and mounted in said housing means eccentric to said axis for supporting said control ring for angular movement between said first and second end positions; and wherein said throttling means includes two diametrically disposed throttles located in said plane.

10. Regulated pump as claimed in claim **1,** comprising a pivot pin located in said plane supported in said housing; and wherein said control ring has a bearing bore in which said pivot pin is located eccentric to said axis for supporting said control ring for angular movement between said first and second positions.

11. Regulating pump as claimed in claim **10,** wherein said compensating device includes means for guiding said pressure responsive means tangentially to a circle having the center in said pivot pin and passing through said axis.

12. Regulated pump as claimed in claim **1,** wherein said throttling means include two diametrically disposed throttles located in said plane.

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