# United States Patent [19]

**Ital et al.**

[11] **3,847,057**

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[54] **PRECHARGING ARRANGEMENT FOR A HYDRAULIC DISPLACEMENT MACHINE**


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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **91/6.5,** 91/490

[51] **Int. Cl.** ..... **F01b 3/00**

[58] **Field of Search** ..... 91/485–490, 91/6.5, 4.99, 6.5, 489; 417/269, 270



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[57] **ABSTRACT**

An axial piston pump or motor whose rotary cylinder block has cylinder chambers and pistons therein, has an end face with cylinder ports cooperating with a stationary control face having high pressure and low pressure ports. A closed inner space in the housing is maintained by pressure limiting throttle means at an intermediate pressure when filled with leakage fluid. Control means including ducts connect the closed inner space with a cylinder chamber when the respective cylinder port is located on a control face portion between the high pressure and low pressure ports to fill the respective cylinder chamber with fluid at said intermediate pressure, and disconnecting the closed inner space from the cylinder chambers when the cylinder ports communicate with the high pressure and low pressure ports in the control face.


**10 Claims, 6 Drawing Figures**

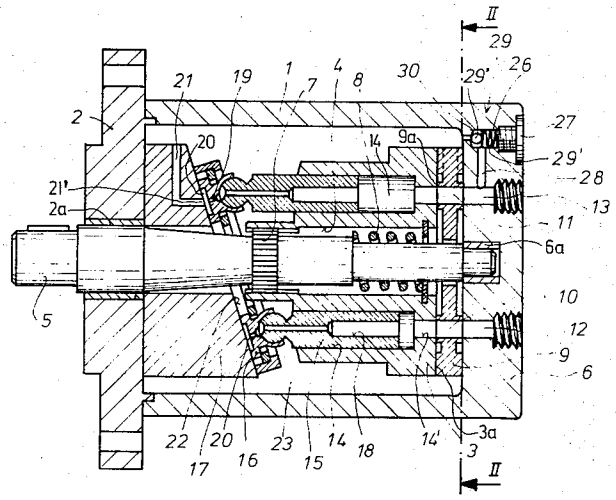

Fig.1

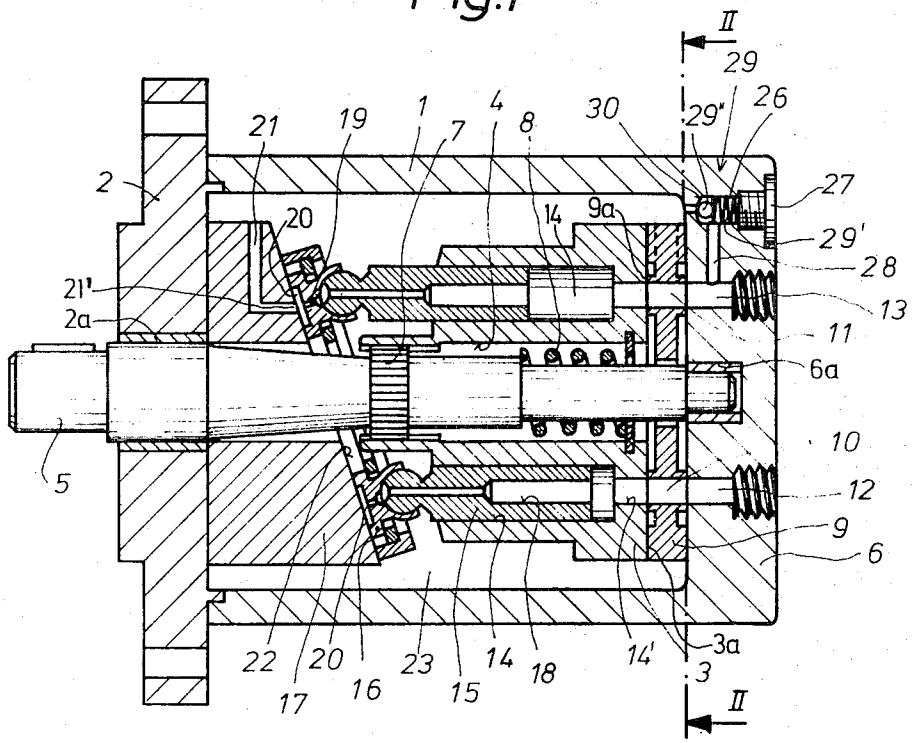
II
29
29'
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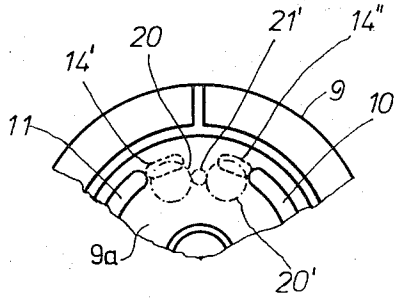
Fig.2


14'
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9a
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Fig.3b

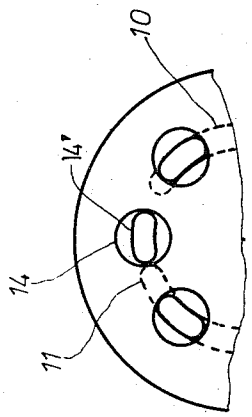



Fig.4b

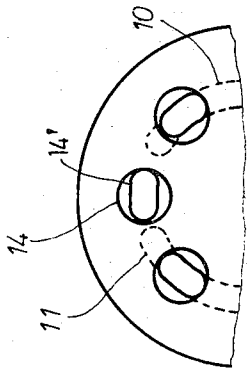



Fig.3a

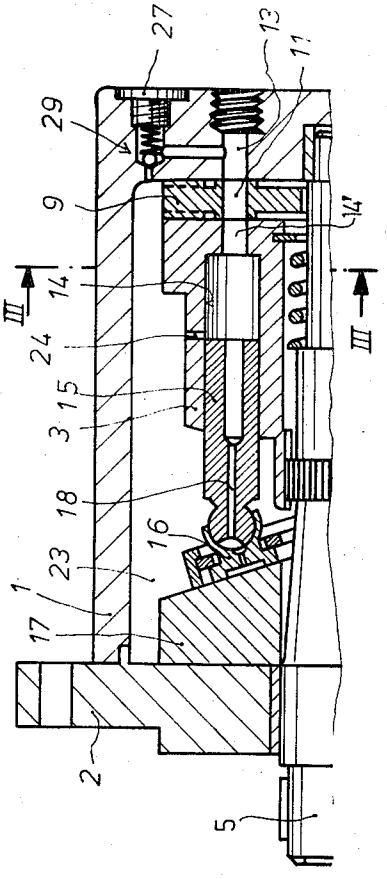
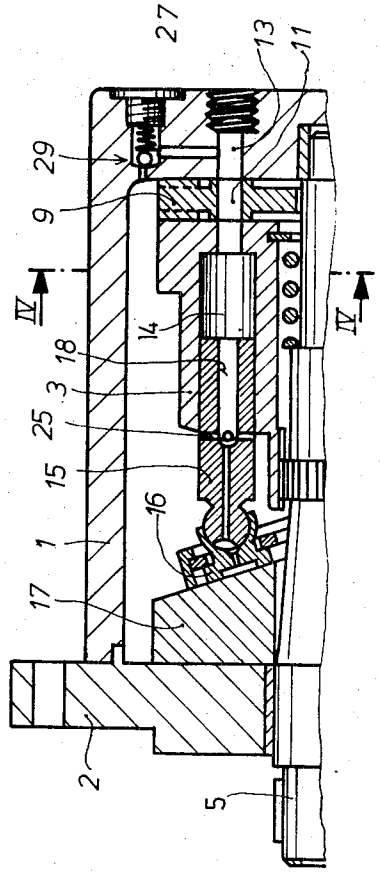



Fig.4a



# PRECHARGING ARRANGEMENT FOR A HYDRAULIC DISPLACEMENT MACHINE

## BACKGROUND OF THE INVENTION

The present invention relates to a rotary displacement pump which has a cylinder block arranged in a closed housing and having working chambers in which displacement members are guided for reciprocating movement caused by engagement of projecting end portions of the displacement members with an actuating means. The machine may be an axial or radial piston pump or hydraulic motor, or a vane pump or motor.

The German OS 1,453,452 disclosed an axial piston hydraulic machine in which the end face of the cylinder block is pressed, in addition to the force of a spring, by hydraulic force against a stationary control face in order to avoid a separation or relative tilting of the slidingly engaging recess. In accordance with the prior art, pressure fluid leaking from the gap between the two faces is accumulated in the inner closed space of the housing, and discharged through a throttle. The throttle produces a predetermined pressure in the inner space of the housing, which also acts on the cylinder block for increasing the pressure by which the end face of the cylinder block is pressed against the stationary control face which is provided with high pressure and low pressure ports.

As compared with the prior art, it is an object of the invention to use the pressure developing in the closed inner space of the housing due to leakage flow, for obtaining a better filling of the working chambers or cylinder chambers of the cylinder block.

Another object of the invention is to fill the cylinder chambers of the cylinder block with fluid at an intermediate pressure during the time when the cylinder ports communicate neither with the high pressure port nor the low pressure port in the stationary control face, and the respective cylinder chamber is neither filled with high pressure fluid nor with low pressure fluid.

Another object of the invention is to provide control means for disconnecting the closed inner space in the housing from the cylinder chambers while the cylinder chambers are filled with high pressure fluid, so that no discharge of high pressure fluid into the closed inner space is possible.

## SUMMARY OF THE INVENTION

With the above objects in view, an embodiemnt of the invention comprises closed housing means having an inner control face formed with part-circular high pressure and low pressure ports; actuating camming means secured to the housing means; cylinder block means mounted in the housing means and having an end face slidingly cooperating with the control face, throttle means connecting the closed inner space with the outside of the housing when leakage fluid at a predetermined pressure fills the inner space; and control means for disconnecting the closed inner space from the working chambers of the cylinder block means when the cylinder ports in the block end face are located on the high pressure and low pressure ports in the control face, and also for connecting the closed inner space with the respective working chamber when the respective cylinder port is located between the high pressure and low pressure ports on the control face so that the respective working chamber is filled with fluid from said closed inner space having a predetermined pressure.



In accordance with the invention, each cylinder bore communicates with a duct which communicates with the closed inner space of the housing, but is only opened when the respective displacement member or piston is located in the proximity of the lower dead center position of the reciprocating piston.

A cylinder chamber which is about to be changed from the low pressure port to the high pressure port, and whose piston is in the proximity of the lower dead center position, is not completely filled with fluid due to the throttling effect of the low pressure port, which means that the degree of filling is less than 100 percent. Through the duct means which connect the cylinder bore with the closed inner space of the housing, and which is opened shortly before the piston arrives in the lower dead center position, additional pressure fluid from the closed inner space of the housing flows into the cylinder chamber and improves the degree of filling with fluid. In addition to an improvement of the total efficiency of the machine, the noise of operation is reduced since pressure fluid enters an insufficiently filled cylinder chamber in the prior art construction, and causes cavitation and fluid oscillations, which are avoided by the precharging of the cylinder chambers in accordance with the invention with fluid at an intermediate pressure. The arrangement of the invention is particularly suited for displacement pumps having a suction inlet.

The arrangement according to the invention can be advantageously used with adjustable and unadjustable axial piston pumps with rotary cylinder block and stationary swash plate, and also for axial piston pumps with stationary cylinder block and rotary swash plate, but it is possible to apply the novel features of the invention to radial piston pumps of various types.

In one embodiment of the invention, the control duct means include a duct through the swash plate opening in the closed inner space. In another embodiment of the invention the control duct means are provided in the cylinder block, and are connected with the respective cylinder chambers only when the piston is in the end position in which the cylinder chamber has the greatest volume. In a third embodiment of the invention, the control duct is provided in the pistons, and communicates with the closed inner space in the housing only when the piston is in the end position in which the volume of the respective cylinder chamber is largest.

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 advantags 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 an axial piston pump in accordance with the invention;

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

FIG. 3*a* is a fragmentary axial sectional view illustrating a second embodiment of the invention;

FIG. 3*b* is a fragmentary cross-sectional view taken on line III—III in FIG. 3*a*;

FIG. 4*a* is a fragmentary axial sectional view illustrating a third embodiment of the invention; and

FIG. 4*b* is a fragmentary cross-sectional view taken on line IV—IV in FIG. 4*a*.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the embodiment of FIGS. 1 and 2, a housing 1 is closed at one end by a bottom plate 6 and at the other end by a cover 2 which having bearings 6a and 2a supporting a drive shaft 5 which is connected by an annular set of teeth 7 with a corresponding engaging set of inner teeth in the inner cavity 4 of a cylinder block 3. A coil spring 8 surrounds a thin portion of shaft 5, abutting at one end a shoulder of shaft 5 and at the other end a spring ring secured to the cylinder block 3. The force of spring 8 urges the end face 3*a* of cylinder block 3 against the stationary control face 9a of a control valve member 9 which is secured to bottom wall 6, and consequently stationary.

As best seen in FIG. 2, the valve plate 9 and its stationary control surface 9*a* is formed with part-circular high pressure and low pressure ports 10 and 11 which communicate with bores 12 and 13 in housing bottom wall 6.

Cylinder block 3 has cylinder chambers or working chambers 14 arranged along a circle concentric with the axis of shaft 5, and having cylinder ports 14′ cooperating with the high pressure and low pressure ports 10, 11. Displacement members in the form of pistons 15 are mounted in the cylinder chambers 14 for axial movement, and are provided at the free outer end portions thereof, with slide shoes 16 which slidingly engage a circular annular surface portion of the surface 22 of swash plate 17 during rotation of the cylinder block 3 relative to the swash plate 17, which is secured to the housing cover 2.

The pistons 14 have axially extending stepped ducts 18 communicating with ducts 19 in the respective slide shoes 16, and ending in a recess 20 in the end face of the slide shoe 16 which slides on surface 22 of the swash plate 17. Another duct 21 is formed in the swash plate 17 which has one end in the circular annular surface portion swept by the end face and recess 20 of the slide shoes, and which opens at the other end in the closed inner space 23 of the housing. Consequently, in one relative position between the rotary cylinder block 3 and the stationary swash plate or other actuating means 17, the stepped duct 18, the slide shoe duct 19, the recess 20, and the duct 21 connect the respective cylinder chamber 14 with the closed inner space 23.

FIG. 2 shows that the part-circular high pressure and low pressure ports 10 and 11 have ends spaced from each other so that a cylinder port moving from the position 14′ to the position 14″ is disconnected from the pressure ports 10 and 11. The ports 21′ of duct 21 in the surface 22 is located in an axial plane which is equidistant from the ends of the pressure ports 10 and 11, and the diameter of the recesses 20′ in the slide shoes 16 is selected so that the same do not cover the port 21′ before separated from the pressure ports 10 and 11.

It will be seen that the circumferential distance between the ends of the high and low pressure ports 10 and 11 is selected so that the communication of a cylinder port 14′ of a cylinder bore 14 with the port 11 is interrupted, before the recess 20 in the face of the slide shoe 16 covers the port 21′ of the duct 21. In the same manner, the recess 20′ in the slide shoe 16 of another piston 15 has already uncovered the port 21′ before the cylinder port 14″ of the respective cylinder chamber 14 begins to cover the pressure port 10 during rotation of the cylinder block 3 in clockwise direction.

A stepped bore 26 in the bottom wall 6 is connected by a discharge passage 28 with the bore 13, and closed by a screw 27. The stepped bore 26 houses a pressure limiting throttle valve 29 having a closure element 29″ biassed by spring 29′ against a frusto-conical seat 30 formed in bore 26 so that flow of pressure fluid from the closed inner space 23 to the passage 13 is closed. The pressure required for opening the pressure limiting valve 29 is very low, for example four bar.

During rotation of the cylinder block 3, the slide shoes 16 slide on the surface 22 of the swash plate 17 along a circular annular surface portion, and force pistons 15 to reciprocate. When a piston 15 moves from the dead center position of the lower portion of FIG. 1. to the dead center position shown in the upper portion of FIG. 1, and assuming a rotation of the cylinder block 3 in clockwise direction as viewed in FIG. 2, fluid is sucked through the low pressure port 11 out of the inlet 13 until shortly before the dead center position in which the cylinder chamber 14 has the greatest volume, the communication between port 14′ and the low pressure port 11 is interrupted.

Directly thereafter, the recess 20 in the slide face of slide shoe 16 covers the port 21′ of the duct 21 which opens in the surface 22 of the swash plate 17 so that the cylinder bore 14 is connected with the closed inner space 23 in the housing by the ducts 18, 19, 21.

Due to leakage, pressure fluid enters the closed inner space 23 where a pressure develops whose maximum depends on the pressure limiting throttle valve 29. When the pressure in the closed inner space 23 reaches a maximum determined by the valve 29, the valve opens so that pressure fluid can be discharged through discharge passage 28.

Due to the pressure prevailing in the closed inner space 23, pressure fluid flows through the ducts 21, 19, 18 into the respective cylinder bore 14, improving its filling, and pre-compressing the fluid in the cylinder chamber. Shortly after the reversal of the piston stroke during further rotation of the cylinder block 3, the recess 20 in the slide show 16 uncovers the port 21′ of duct 21 in the slide surface 22, and only then the cylinder port 14″ of the cylinder bore 14 covers the high pressure port 10, so that the discharge of the pressure fluid can begin. In this manner it is assured that due to the temporary duct connection between the cylinder chamber 14 and the inner space 23, no pressure fluid can flow from the high pressure inlet 12 to the closed inner space 23, or from the same through the cylinder chambers 14 to the low pressure passage 13.

Shortly before the piston 15 arrives in its upper dead center position, the connection with the high pressure port 10 is interrupted so that the discharge of the pressure fluid is terminated, and after passage through the dead center position, a new cycle of reciprocation of the piston 15 starts.

In order to improve the operation, a small overlapping of the suction operation with the pre-compression and/or the discharge with pre-compression, may occur

if a small reduction of the efficiency due to the above-described discharge of pressure fluid is permissible.

In the embodiment of FIGS. 3and 3*b*, the control duct means include no duct in the swash plate **17** or other actuating means. Radial ducts **24** are provided for connecting each cylinder chamber **14** with the closed inner space **23**, each duct **24** having an inner end communicating with the respective cylinder chamber **14**, and an outer end communicating with the inner space **23**. While the opening and closing of the control duct means is obtained in the embodiment of FIGS. **1** and **2** by the relative movement between the slide shoes **16** and the stationary duct **21**, a corresponding opening and closing of the control ducts **24** is effected by the reciprocating movement of piston **15**. It will be seen that in the end position of piston **15** shown in FIG. 3*a*, the control duct **24** is open, so that the fluid can flow from the inner space **23** into the respective cylinder chamber **14**. When the piston **15** moves out of the illustrated dead center position, it covers the inner end of the control duct **24** and separates the inner space **23** from the cylinder chamber **14**. This is necessary during communication of the cylinder ports **14'** with the high pressure and low pressure ports **10** and **11**, as shown in FIG. 3b, in order to prevent flow from the high pressure duct **10** into the closed inner space **23**. However, in the end position of piston **15** shown in FIG. 3*a*, the respective cylinder chamber **14**, and its ports **14'** are located between the ends of the part-circular cylinder ports **10** and **11**, so that cylinder port **14'** is closed, and the cylinder chamber **14** can be filled through control duct **24** from the closed inner space **23**.

During a revolution of the cylinder block **3**, pistons **15** uncover, shortly before arriving at the dead center position, the control duct **24**, after disconnecting cylinder port **14'** of cylinder bore **14** from the suction passage **11**. Pressure fluid from the closed inner space **23** flows into the cylinder chamber **14** so that its degree of filling is improved, while the fluid in the cylinder chamber is pre-compressed. After reversal of its stroke, the piston **15** closes the control duct **24** before a cylinder port **14'** of the respective cylinder bore covers the high pressure port **10**. In this manner, it is prevented that pressure fluid flows from the closed inner space **23** to the suction low pressure port **11**, or from the high pressure port **10** into the inner closed space **23** in the housing. A third embodiment of the invention is illustrated in FIGS. 4*a* and 4*b*. A diametrical control duct **25** connects an axial duct portion **18** in each piston **15** with the closed inner space **23**. The control ducts **25** are located directed adjacent an edge of a wall of the cylinder block **3**, as shown in FIG. 4*a*. When piston **15** is in the illustrated dead center position in which the volume of the cylinder chamber **14** is greatest, the control duct means **25, 18** connect the closed inner space **23** with the respective cylinder chamber **14**. In this position, the cylinder port **14'** registers neither with the high pressure port **10** nor with the low pressure port **11**, as shown in FIG. 4*b*, but is closed by the face portion between the ends of the pressure ports **10** and **11** so that no fluid can flow into and out of cylinder chamber **14** which is being filled through the control ducts **25** and **18**. When the cylinder ports **14'** move to a position communicating with the pressure ports **10** and **11**, the turning of the cylinder block **3** has caused the swash plate **17** to push the respective piston **15** into the respective cylinder chamber **14** so that the control duct **25** is closed by the wall of the cylinder block **3**, and no communication between the cylinder chamber **14** and the closed inner space **23** is possible during the filling and discharging of the cylinder chamber **14** by means of the pressure ports **10** and **11**.

During a rotation of cylinder block **3**, pistons **15** perform reciprocating motions during which the radial control ducts **25** are uncovered by the cylinder block **3** when, as shown in FIG. 4*b*, the communication between the cylinder port **14'** of cylinder chamber **14** with the suction low pressure port **11** is interrupted, and the piston **15** is shortly before the respective dead center position. Pressure fluid flows now through the control duct **25** and duct **18** from the inner space **23** into the cylinder chamber **14** so that its degree of filling is improved, and the fluid in cylinder chamber **14** is pre-compressed to the pressure prevailing in the closed inner space **23**. Upon the reversal of the reciprocating motion of piston **15**, the control duct **25** is closed by the cylinder block **3** before the cylinder port **14'** of the respective cylinder **14** overlaps with the high pressure port **10**.

The embodiment of FIGS. 4*a* and 4*b* prevents the flow of fluid through the control ducts out of the cylinder chambers, or the flow of fluid out of the high pressure port **10** into the inner space **23** of the housing.

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 precharging arrangement for a hydraulic displacement machine differing from the types described above.

While the invention has been illustrated and described as embodied in a precharging arrangement for an axial piston pump or motor, 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.** Precharging arrangement for a hydraulic displacement machine, comprising closed housing means having an inner control face formed with part-circular high pressure and low pressure ports; actuating means secured to said housing means; cylinder block means mounted in said housing means and having a cylinder block end face slidingly cooperating with said control face, said cylinder block means including working chambers opening in cylinder ports on said end face so that said high pressure and low pressure ports communicate with said cylinder ports during relative rotation of said housing means and said cylinder block means, said cylinder block means including displacement members in said working chambers having free end portions cooperating with said actuating means so that said displacement members are reciprocated between a suction stroke and a compression stroke, and fluid

from said working chambers flows through said high pressure and low pressure ports, said actuating means and said cylinder block means forming in said housing means a closed inner space; throttle means connecting said closed inner space with said low pressure port when leakage fluid at a predetermined pressure fills said inner space; and control means, including openings in said free end portions of said displacement members communicating with the associated working chambers, and channel means in said actuating means cooperating at one end with said closed inner space and at the other end with said openings, for disconnecting said closed inner space from said working chambers when said cylinder ports are located on said high pressure and low pressure ports, and for connecting said closed inner space with a respective working chamber when the cylinder port of the respective working chamber is located between said high pressure and low pressure ports on said control face and as the displacement member in said respective working chamber approaches the end of its suction stroke so that the respective working chamber is filled with fluid from said closed inner space having said predetermined pressure.

**2.** Arrangement as claimed in claim **1,** wherein said actuating means reciprocates said displacement members between a first end position corresponding to the end of said suction stroke and a second end position corresponding to the end of said compression stroke in which the respective working chambers have a large volume and a small volume, respectively; and wherein said control means includes ducts in said cylinder block means connecting said working chambers with said closed inner space shortly before said displacement members reach said first end position, and being closed by said displacement members when said displacement members move out of said first end position, said displacement members being in said first end position when the respective cylinder ports are located on said control face between the ends of said high pressure and low pressure ports.

**3.** Apparatus as claimed in claim **1,** wherein said actuating means reciprocates said displacement members between a first end position corresponding to the end of said suction stroke and a second end position corresponding to the end of said compression stroke, in which the respective working chambers have a large volume and a small volume respectively; and wherein said control means include duct means in said displacement members connecting said working chambers with said closed inner space shortly before said displacement members reach said first end position, and being closed by said cylinder block means when said displacement members move out of said first end position, said displacement members being in said first end position when the respective cylinder ports are located on said control face between the ends of said high pressure and low pressure ports.

**4.** Arrangement as claimed in claim **1,** comprising a drive shaft for rotating said cylinder block means relative to said actuating means and said housing means; wherein said hydraulic machine is an axial piston machine; wherein said actuating means is a swash plate secured to said housing means and being engaged by said free end portions of said displacement members.

**5.** Arrangement as claimed in claim **4** wherein each displacement member includes a piston axially movable in the respective working chamber, and a slide shoe movably mounted on the respective piston and forming said free end portion, said slide shoe having a face formed with a recess sliding engaging an annular circular surface portion of said swash plate; and wherein said control means include a first duct in said piston communicating with said working chamber, a second duct in said slide shoe opening into said recess, and a third duct in said swash plate connecting said annular surface portion with said closed inner space, said second and third ducts registering when said cylinder ports are located between said high pressure and low pressure ports on said control face during rotation of said cylinder block means so that fluid at said predetermined pressure flows from said closed inner space into the respective working chamber.

**6.** Arrangement as claimed in claim **5** wherein the ends of said part-circular high pressure and low pressure ports are circumferentially spaced by control face portions; and wherein said third duct is located in an axial plane equidistant from said ends and passing through at least one of said control surface portion.

**7.** Arrangement as claimed in claim **6** wherein said recesses in said slide shoes have the same circumferential dimensions, two recesses being located on opposite sides of said third duct disconnected therefrom when said cylinder ports are located on said control face portions adjacent said ends of said high pressure and low pressure ports.

**8.** Apparatus as claimed in claim **2** wherein said displacement members are pistons axially movable in said working chamber, and having end faces in said working chambers located adjacent and axially outward of said ducts, respectively, in said first end positions; and wherein said ducts extend in radial directions through said cylinder block means.

**9.** Arrangement as claimed in claim **3** wherein said displacement members are pistons, and said working chambers are cylinder chambers in which said pistons are axially movable; and wherein said duct means include radial ducts diametrically passing through said pistons, and axially extending ducts connecting the central portions of said radial ducts with said cylinder chambers, respectively.

**10.** Arrangement as claimed in claim **1** wherein said control means include duct means connecting said closed inner space with said working chambers when the respective cylinder ports are closed by said control face, and being closed when said cylinder ports communicate with said high pressure and low pressure ports during relative rotation of said cylinder block means and said control face so that pressure fluid cannot flow into said closed inner space.

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