United States Patent

[11] 3,604,314

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[33] **Germany**
[31] **P 17 03 347.5**

[54] **HYDROSTATIC AXIAL PISTON MACHINE**
4 Claims, 10 Drawing Figs.

[52] U.S. Cl. **91/485, 91/505**
[51] Int. Cl. **F04b 1/02**
[50] Field of Search ..... 103/162; - 91/198–200, 485, 486–489; 92/57

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ABSTRACT: A hydrostatic axial piston machine has a control block, a mirror surface thereon, a cylinder drum rotatably supported by said mirror surface, and dosing means assuring a metered supply of lubricating liquid to the mirror surface.

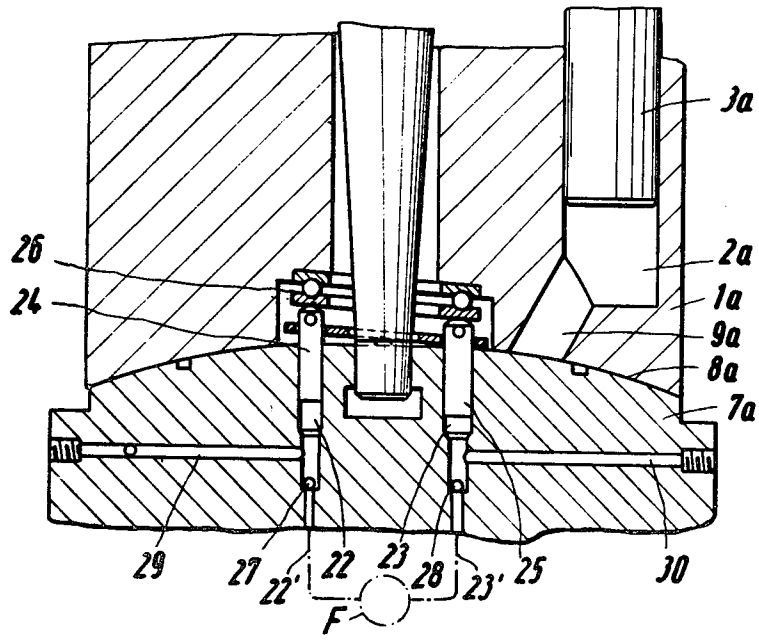

Fig. 1

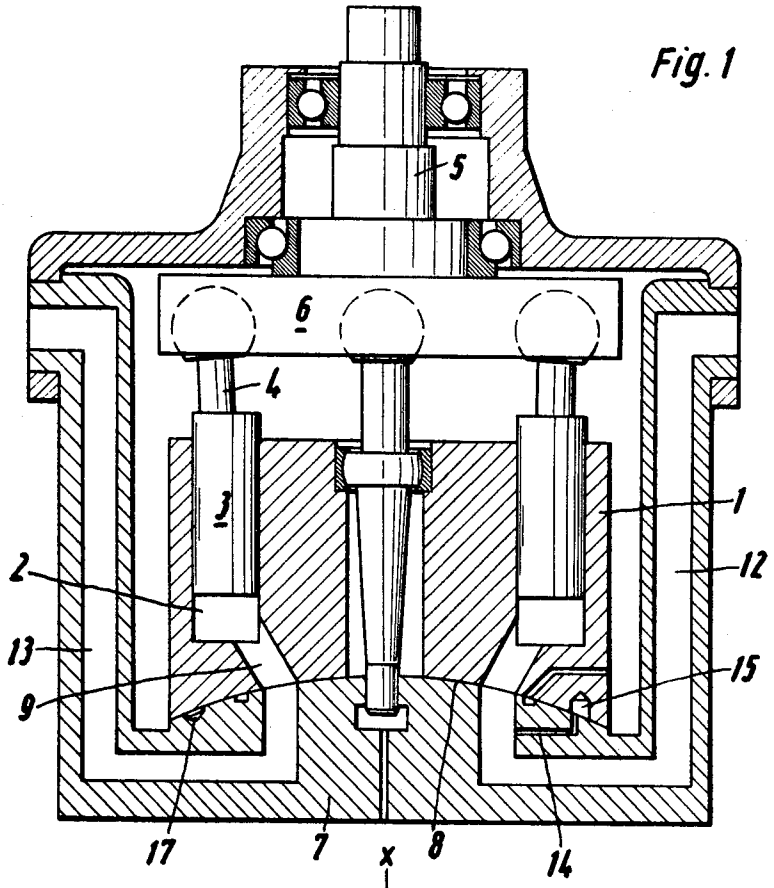

Fig. 2

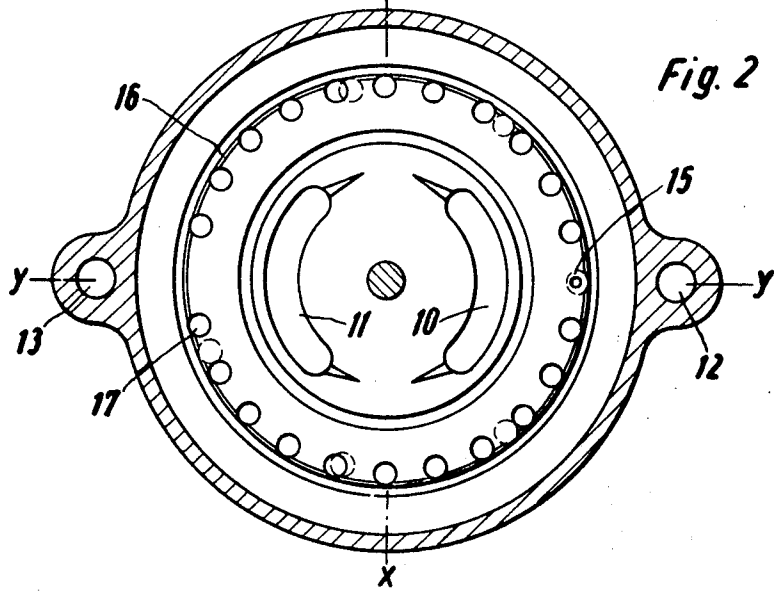

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Fig. 3

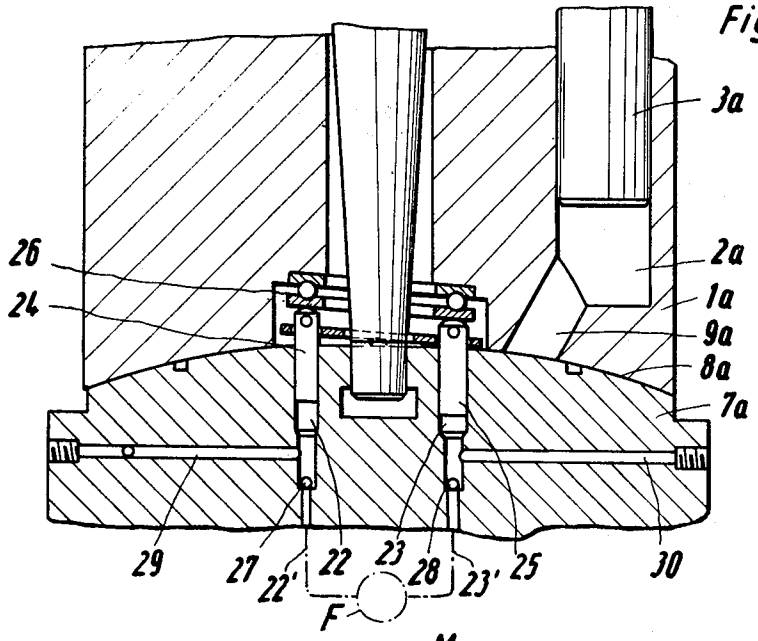

Fig. 4

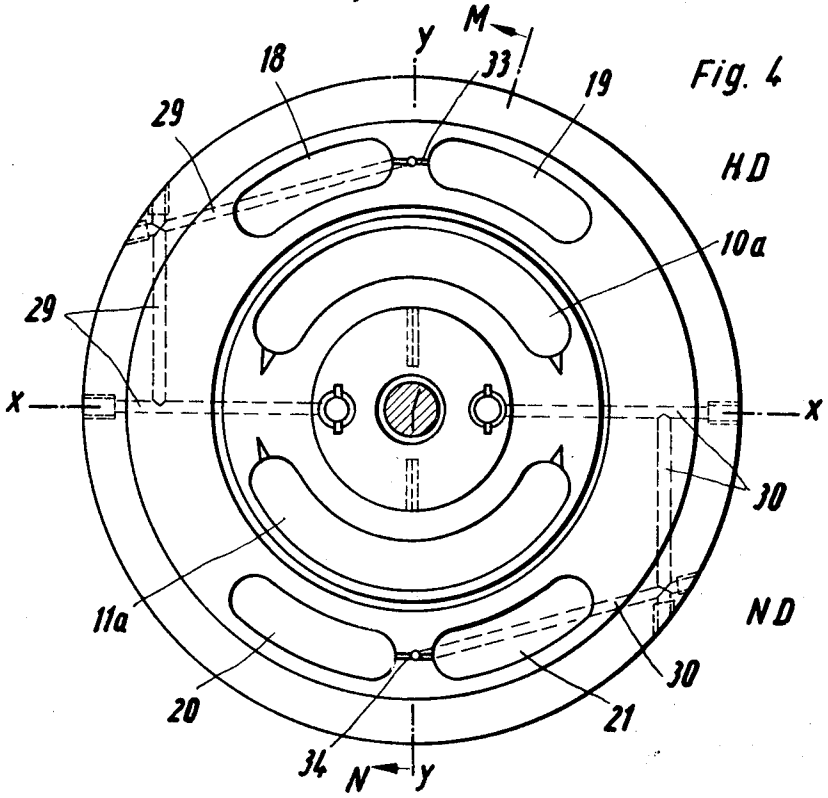

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Fig. 5
(M-N)

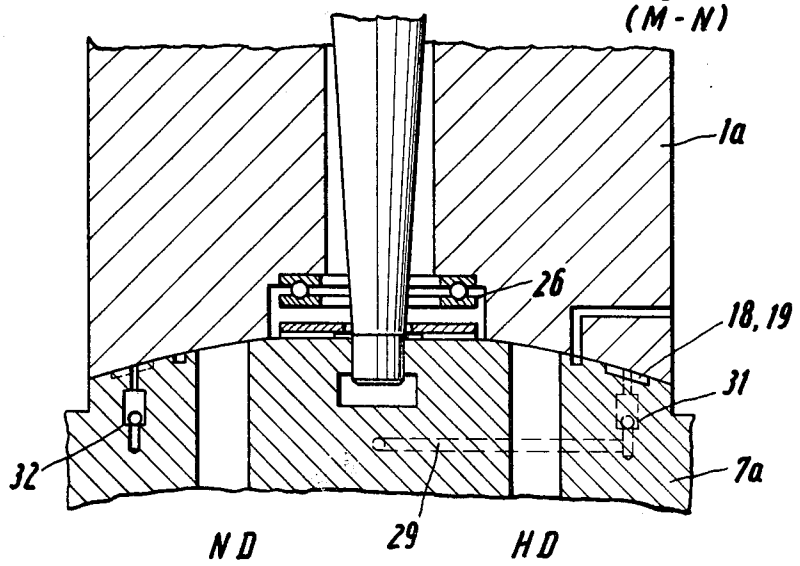

Fig. 6

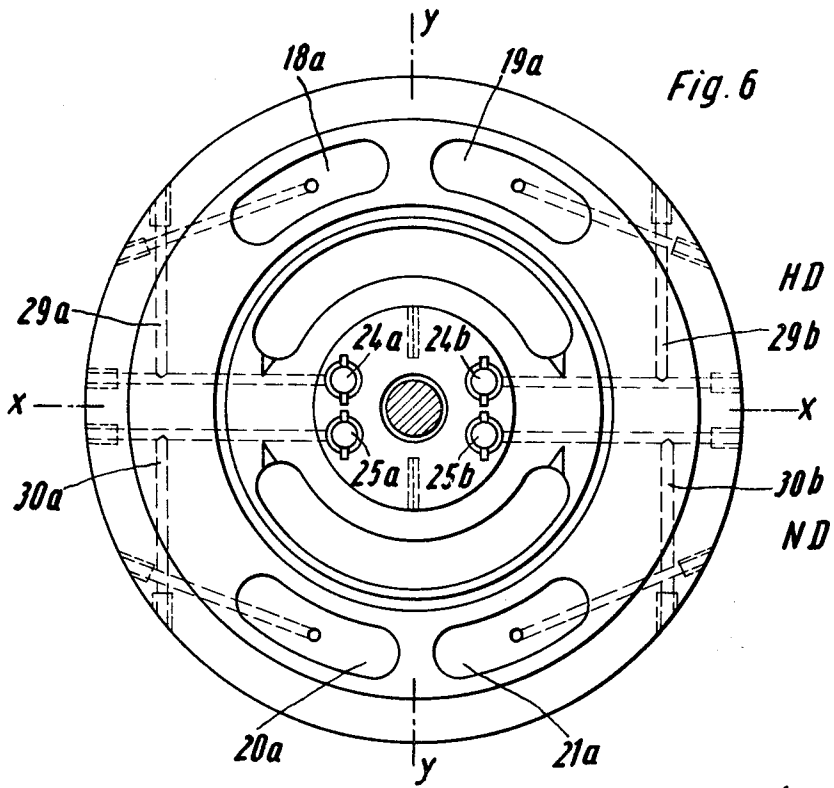

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Fig. 7

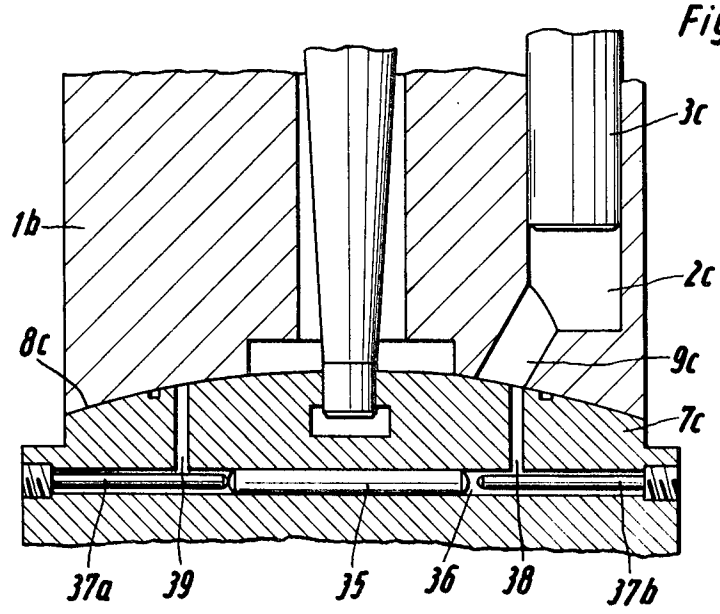

Fig. 8

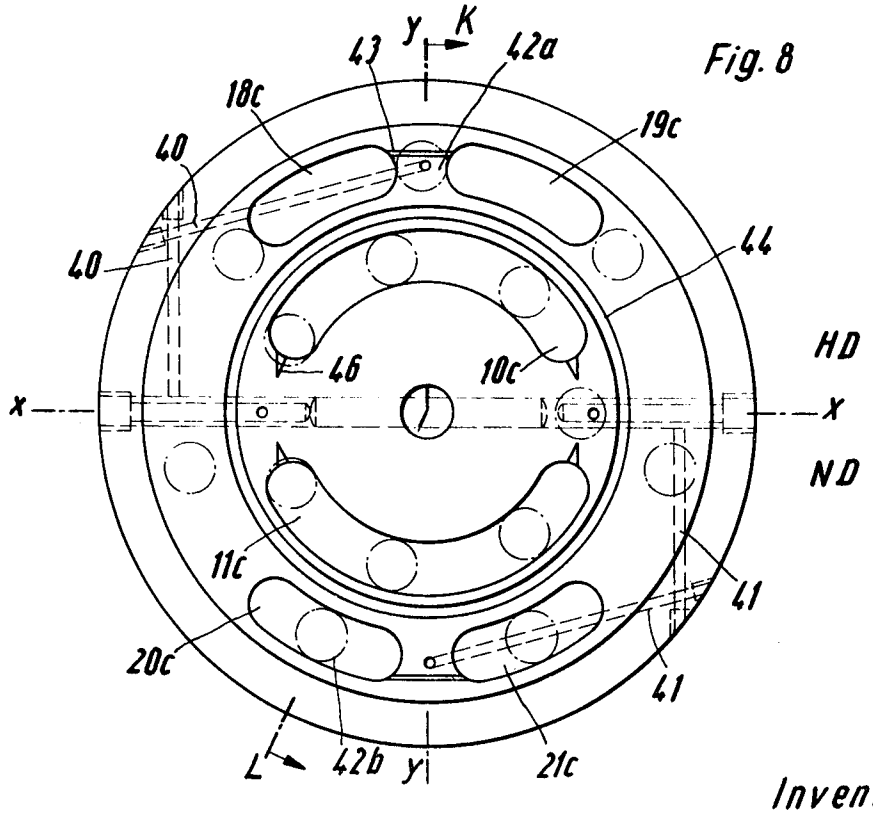

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Fig. 9
(K - L)

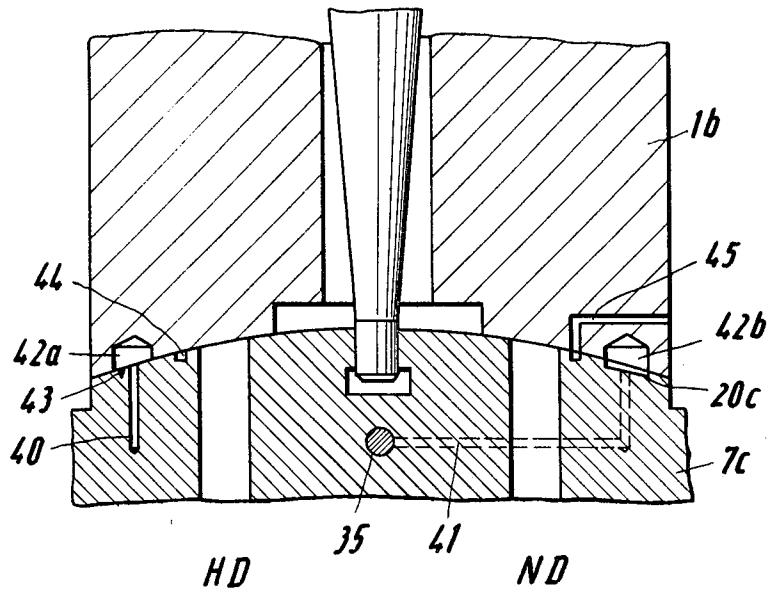
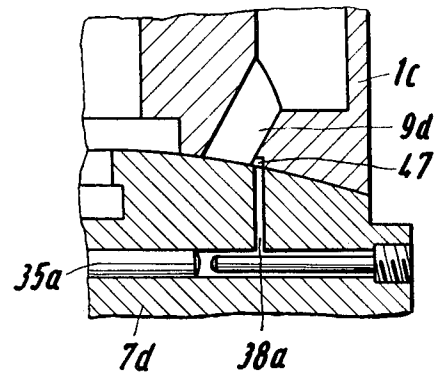


Fig. 10



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HYDROSTATIC AXIAL PISTON MACHINE

This application relates to a hydrostatic axial piston machine comprising a cylinder drum wherein cylinders are rotation-symmetrically arranged, and a control block having a mirror surface axially supporting the cylinder drum. The mirror surface is spherical or plain and has recesses, so-called control kidneys, which control the flow of the operating liquid, for example oil. Relief areas formed by lubricating pockets are provided whereto lubricating liquid is supplied in order to prevent wear by friction between the cylinder drum and the mirror surface of the control block.

It is the object of the invention to provide a hydrostatic axial piston machine wherein the mirror surface is completely relieved, lubricated and cooled at all operating conditions, that is, at all speeds and pressures, in both directions of rotation, also at intermittent or pulsating loads and at counterpressure from the discharge, suction or low-pressure side.

This object is obtained by providing means for closing the quantity of lubricant supplied to the relief areas, at least proportionately to the relative rotational speeds of the cylinder drum and the mirror surface.

The dosing means may be arranged in parts of the axial piston machine or may be placed outside thereof.

The lubricant for the relief areas may be kept either in a special reservoir which is connected to the dosing means by conduits, or lubricating liquid is taken from a conduit conducting operating liquid under high pressure.

Various kinds of dosing means may be used. In one embodiment of the invention a constant-stroke piston pump is used whose speed is rigidly proportional with the speed of the axial piston machine.

The pistons of the piston pump may be placed in the control block, and a swashplate for actuating the pistons may be arranged in the cylinder drum.

If a positive-displacement pump is arranged outside of the axial piston machine the pump has at least two separate pressure liquid spaces.

In a special embodiment a piston is freely movable to-and-fro between two limit abutments in a bore in the control block, which bore is connected at each end, outside of the limit positions of the piston, to a conduit terminating in the mirror surface.

The position of the limit abutments for the free piston is adjustable for controlling the stroke of the piston.

The relief areas which are connected for lubricant supply to the dosing device, are so arranged on the outer periphery of the mirror surface that they occupy about one-fourth of the size of the support portions of the mirror surface at the high-pressure side and at the low-pressure side.

The relief areas on the high-pressure side and the relief areas on the low-pressure side are supplied with lubricant by separate dosing devices.

Each of the relief areas on the high-pressure side and on the low-pressure side comprises two or more partial relief areas. Each partial relief area may be connected to an individual dosing device.

The novel features which are considered characterized of the invention are set forth with particularity in the appended claims. The invention itself, however, and additional objects and advantages thereof will best be understood from the following description of embodiments thereof when read in connection with the accompanying drawing, wherein:

FIG. 1 is a schematic longitudinal sectional view of a conventional axial piston machine.

FIG. 2 is a schematic cross-sectional view of the machine shown in FIG. 1, at the mirror surface.

FIG. 3 is a schematic partial longitudinal sectional view of an axial piston machine according to the invention having two axial pistons in the control block.

FIG. 4 is a schematic cross section of the machine shown in FIG. 3, at the mirror surface.

FIG. 5 is a partial schematic longitudinal sectional view of the machine shown in FIGS. 3 and 4, taken at an angle different from the angle FIG. 3 is taken.

FIG. 6 is a schematic cross-sectional view of a machine similar to that shown in FIG. 4 and provided with dosing means having four axial pistons.

FIG. 7 is a schematic part longitudinal sectional view of a modified axial piston machine according to the invention comprising a dosing device placed in the control block.

FIG. 8 is a schematic cross-sectional view of the machine shown in FIG. 7, the section being made at the mirror surface.

FIG. 9 is a partial schematic longitudinal sectional view of the machine shown in FIGS. 7 and 8, the view being taken at a different angle from that of FIG. 7.

FIG. 10 is a part longitudinal sectional view of a modification of the machine shown in FIGS. 7–9, the view being taken at the same angle as FIG. 7.

The conventional axial piston engine shown in FIGS. 1 and 2 comprise a rotating cylinder drum 1 having, for example, seven cylinder bores 2 equally distributed on the periphery of the drum and adapted to receive working piston 3 arranged paraxially with the drum. Each of the pistons 3 is connected by means of an articulatedly supported piston rod 4 to a driving disc 6 on a shaft 5. Rotation of the shaft 5 causes a stroke movement of the working pistons 3 when the drum 1 is swung to a certain extent out of its midposition. The cylinder drum rests axially on a control block 7 which is stationary relative to the rotating cylinder drum and has a spherical mirror surface 8. For admitting and draining the liquid moved by the pressure and suction strokes of the working pistons channels are provided in the cylinder drum 1 and in the control block 7 which channels meet on the mirror surface 8.

Inclined terminal bores 9 extend from the working cylinders 2 to two kidney-shaped recesses 10, 11 in the mirror surface 8 of the control block 7, recess 10 being connected to a high-pressure conduit 12 and recess 11 being connected to a low-pressure conduit 13.

To avoid wear by friction and for producing a lubricating film on the mirror surface 8 direct reception of lubricating liquid from the high-pressure system is provided. The lubricating liquid moves from the high-pressure recess 10 through bores 14 underneath the cylinder drum 1. If recesses 15 in the cylinder drum 1 run over the bores 14, the latter are short circuited by a rotating throttle groove 16. Whenever this happens some liquid arrives through the throttle groove 16 in lubricating pockets 17 and builds up a hydrostatic relief above the pockets 17 and in the sealing surface therearound.

The relief of the mirror surface must be so great that the remaining forces are received from the pressure of the cylinder drum 1 against the mirror surface 8. The reliability of the operation of the hydraulic drive depends on the design of the cross section and the accuracy of manufacture of the rotating throttle groove 16. Rate of flow through a throttle depends on the viscosity and consequently on the pressure and temperature of the liquid. In the arrangement described above the rate of flow is correct for one operating condition only. This results in a great uncertainty at different operating conditions. Too small a rate of flow causes a mixed sliding friction which may cause damage. If the rate of flow is too great, this may cause swinging away of the cylinder drum 1 from the mirror surface 8.

In the embodiment of the invention shown in FIGS. 3, 4 and 5 relief of a mirror surface 8*a* is made independent of the pressure of the working fluid by providing an auxiliary relief liquid which is supplied proportionately to the rotational speed of the axial piston machine, i.e. of a cylinder drum 1*a*. In the arrangement according to FIGS. 3, 4 and 5 the relief liquid arrives at the relief areas of the mirror surface from a liquid reservoir through positive-displacement pumps having constant stroke. An independent pump is provided for each of two control sides which are separated from each other by the axis *x*—*x* shown in FIG. 4, each pump comprising a cylinder bore 22, 23 and a piston 24, 25 axially slidable therein. Both pistons

are actuated by a swashplate **26** arranged on the cylinder drum *1a* and coacting with a piston return device. Stroke and diameter of the pistons **24** and **25** are alike so that the rates of flow of both pumps are equal. There would be no difficulty to make the diameter of the piston and of the cylinder bore on the high-pressure side of the machine larger for increasing the the output of the auxiliary pump for the high-pressure side. Check valves **27, 28** are provided in the suction conduits **22'** and **23'**, respectively, which connect the cylinder bores **22** and **23** to a reservoir F indicated by dotted lines. Pressure conduits **29, 30** connected to the cylinder bores **22, 23**, respectively, terminate in the relief areas of the mirror surface on each control side. Check valves **31, 32** (FIG. **5**) are provided in the pressure conduits **29, 30**, respectively.

The relief areas of the high-pressure and of the low-pressure side are arranged symmetrically with respect to the *x—x* axis and the *y—y* axis. The partial relief areas **18** and **19** of the high-pressure side have the same shape and size as the partial relief areas **20, 21** of the low-pressure side. The partial relief areas of each control side are individually connected by short grooves **33** and **34**, respectively, terminate the pressure conduits **29** and **30**, respectively.

In the embodiment of the invention shown in FIG. **6** four auxiliary pistons **24***a*, **24***b*, **25***a* and **25***b* are provided in lieu of two auxiliary pistons as in embodiment shown in FIGS. **3, 4** and **5**. Each auxiliary piston supplies one of the partial relief areas **18***a*, **19***a*, **20***a* and **21***a* which are independent of one another. With this arrangement different quantities of relief liquid can be supplied to the relief areas of one and the same control side by suitable dimensioning of the auxiliary pistons.

The machine shown in FIGS. **7, 8** and **9** comprises a dosing device which supplies a quantity of relief liquid which is proportionate to the rotational speed of the machine, to the relief areas, the liquid being taken from the high-pressure working fluid of the machine. When the cylinder drum *1b* is rotated, the terminal bore of a cylinder **2***c* runs over a bore or channel **38** or **39** terminating in the mirror surface **8***c* of a control block **7***c* in the neutral zone on the *x—x* axis i.e. between the control recesses **10***c* and **11***c*. The bores **38** and **39** lead to a cylinder bore **36** arranged transversely in the control block **7***c*, a free piston **35** being axially movable in the bore **36** between adjustable abutments **37***a* and **37***b* for limiting the stroke of the piston **35**. During the brief time the terminal bore **9***c* is connected to the bore **38** high-pressure liquid arrives in front of the free piston **35** and pushes said piston to the abutment **37** *a*. The free piston pushes a quantity of liquid commensurate with its stroke and cross section and supplies the liquid to a channel **40** which terminates between the partial relief areas **18***c* and **19***c* on the mirror surface **8***c*. Escape of liquid through the bore **39** is not possible because, due to the odd number of working cylinders **2***c*, the bore **39** is closed at the mirror surface **8***c* by the cylinder drum *1b* during supply of liquid to the free piston through the channel **38**.

Recesses **42***a* and **42***b* provided in the cylinder drum *1b* momentarily connect the channel **40** terminating in the mirror surface **8***c*, to the relief areas **18***c* and **19***c* or to a groove **43** connecting the two areas so that at each stroke of the free piston a quantity of liquid which is independent of the pressure of the working fluid is alternatingly supplied to the relief areas of the high-pressure and low-pressure control side. The relief liquid which is supplied to the relief areas must flow off over sealing barriers surrounding the relief areas. The portion of the relief liquid flowing toward the center of the mirror surface **8***c* arrives through an annular groove **44** in a discharge channel **45** (FIG. **9**). A pressure will prevail in the relief areas which adjusts itself automatically according to the load on the mirror surface.

When the free piston **35** moves in the opposite direction, namely to the right as seen in FIG. **7**, the relief areas of the low-pressure side are supplied whereby the bore **39** already receives pressure liquid when the cylinder discharge bores **9***c* are connected to an advance control groove **46**.

In the machine shown in FIGS. **7, 8, 9** which has seven cylinders, the free piston reciprocates seven times during one revolution of the cylinder drum *1b*. If in high-speed machines the frequency of the free piston would become too great it can be easily arranged that the free piston is actuated by liquid from only one or some of the cylinder discharge bores and not from all discharge bores **9***c*.

As seen in FIG. **10** small connecting spaces **47** may be provided in the cylinder drum adjacent the cylinder discharge bores **9***d* which spaces are used for supplying the relief areas with liquid and the channels **38***a* and **39***a* terminate in the mirror surface in such manner that they are connected to the connecting spaces **47** only and not directly to the discharge bores **9***d*.

What is claimed is:

1. A hydrostatic axial piston machine comprising a cylinder drum, cylinders rotation-symmetrically arranged in said drum, a control block having a mirror surface having portions axially supporting said cylinder drum, recesses in said mirror surface, liquid discharge bores in said drum and individually connected to said cylinders and arranged to communicate said recesses at predetermined relative positions of said drum and said mirror surface, lubrication pockets forming relief areas in said mirror surface, means for supplying lubrication liquid to said pockets for preventing wear by friction between said cylinder drum and said mirror surface, said lubrication liquid supply means comprising dosing means so constructed and arranged as to maintain the rate of liquid supplied to said relief areas at least proportionate to the relative rotational speed of said cylinder drum and said mirror surface, said dosing means is a constant-stroke piston pump and drive means are provided for said pump including means for maintaining the speed of said pump positively proportional to the speed of the axial piston machine, and said piston pump comprises pistons placed in said control block and a swashplate placed in said cylinder drum for driving said pistons.

2. A hydrostatic axial piston machine comprising a cylinder drum, cylinders rotation-symmetrically arranged in said drum, a control block having a mirror surface having portions axially supporting said cylinder drum, recesses in said mirror surface, liquid discharge bores in said drum and individually connected to said cylinders and arranged to communicate said recesses at predetermined relative positions of said drum and said mirror surface, lubrication pockets forming relief areas in said mirror surface, means for supplying lubrication liquid to said pockets for preventing wear by friction between said cylinder drum and said mirror surface, said lubrication liquid supply means comprising dosing means so constructed and arranged as to maintain the rate of liquid supplied to said relief areas at least proportionate to the relative rotational speed of said cylinder drum and said mirror surface, Said dosing means comprises a bore in said control block, a free piston reciprocatable in said bore, abutment means in said bore for limiting the stroke of said free piston, channels individually terminating in said mirror surface and individually connected to the ends of said bore extending beyond the limit positions of said free piston.

3. A hydrostatic axial piston machine according to claim **2** wherein said abutment means are adjustable for adjusting the stroke of said free piston.

4. A hydrostatic axial piston machine according to claim **2** comprising terminal bores in said cylinder drum individually connected to said cylinders and terminating opposite a predetermined area of said mirror surface, said channels terminating in said last-mentioned area of said mirror surface, and second channels individually connected to the ends of said bore in said control block extending beyond the limit positions of said free piston, said second channels individually terminating in said lubrication pockets.