



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
11.04.2007 Bulletin 2007/15

(51) Int Cl.:
F04B 1/20 (2006.01)

(21) Application number: **06121256.9**

(22) Date of filing: **26.09.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(71) Applicant: **SAMHYDRAULIK S.p.A.**
42100 Reggio Emilia (IT)

(72) Inventor: **Ferretti, Orles**
42100, Reggio Emilia (IT)

(74) Representative: **Modiano, Micaela Nadia**
Dr. Modiano & Associati SpA
Via Meravigli 16
20123 Milano (IT)

(30) Priority: **04.10.2005 IT RE20050110**

(54) **Distribution system for a hydrostatic piston machine**

(57) A distribution system for a hydrostatic piston machine which comprises a rotating body (7) provided with cylindrical chambers (8) in which the pistons (9) can slide and which are arranged parallel and concentrically with respect to the rotation axis (A) of the body and are connected to respective ports (11) which are distributed concentrically around the axis on a face of the body, and a stationary plate (5) which has a surface which makes contact against the face and is provided with two open-

ings (14, 15) which are connected to a first duct and a second duct for a working fluid, the openings (14, 15) being arranged concentrically with respect to the axis (A) and opposite with respect to the ports (11), so as to form a passage section for the fluid between one of the chambers (8) and one of the ducts, the openings (14, 15) and the ports (11) being sized so that at the dead center of the stroke of the pistons (9) the incremental ratio between the passage section of the fluid and the rotation angle of the body is different from zero.

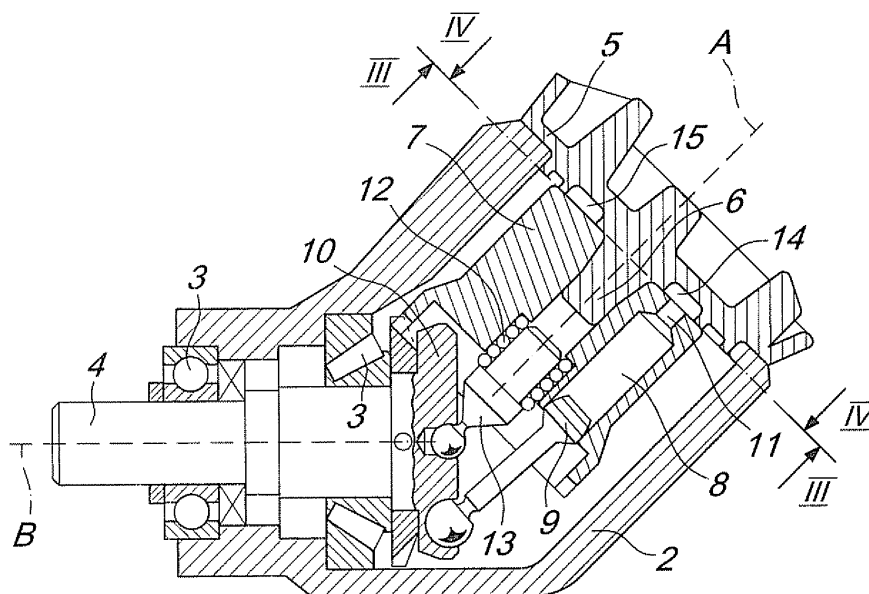


Fig. 2

Description

[0001] The present invention relates to a distribution system for a hydrostatic piston machine which is provided with a fixed distributor and a rotary distributor.

[0002] Hydrostatic machines of the type with coaxial pistons are known which comprise a rotating cylindrical body provided with cylindrical chambers which are arranged concentrically with respect to the rotation axis and in which respective pistons can slide.

[0003] The chambers are provided with ports which lie on one face of the cylindrical body, concentrically with respect to the rotation axis, and define a rotary distributor. The face is hermetically in contact with a supporting surface of a stationary plate, in which two openings are provided which lie concentrically with respect to the axis of rotation of the cylinder and opposite with respect to said ports. The openings form a stationary distributor for the alternating connection of the ports to a first duct and respectively to a second duct for a working fluid.

[0004] In known hydrostatic machines, the variation of the fluid passage section formed by the mutual opposition of the ports and by the openings during the rotation of the cylindrical body has a nonlinear behavior depending on the rotation angle.

[0005] Figure 1 of the accompanying drawings is a typical chart of a machine according to the background art, which shows that the variation of the area of the passage section (S_d) according to the rotation angle (α) of the cylindrical body can be represented by a curve in which the concavity is directed upward. In particular, the curve is substantially tangent, around zero, to the axis of the abscissas on which the values of the rotation angle (α) are plotted, i.e., when the area of the passage section (S_d), since the pistons have reached the dead center of their stroke and are about to change the direction of their stroke, is equivalent to zero. The nonlinear behavior of the variation of the fluid passage section, in particular due to the narrowing of the area of the passage sections, causes vibrations, high noise and cavitation phenomena.

[0006] In order to reduce these drawbacks, various solutions have been proposed to reduce the speed of the fluid which consist essentially in providing grooves for extending the openings of the stationary plate (US-6,640,687, JP-10-122129, DE-10 343 222) or ducts for mutually connecting the openings and/or the ports (JP-07-189887). However, these refinements are associated with volumetric losses and therefore to a reduced efficiency of the machine.

[0007] The aim of the present invention is to provide a distribution system for a hydrostatic piston machine which allows to overcome the drawbacks noted above in known machines.

[0008] Within this aim, an object of the present invention is to provide a system which is constructively simple and therefore capable of offering economic advantages and reliability in operation.

[0009] This aim and this object are achieved with a distribution system for a hydrostatic piston machine which comprises a rotating body provided with cylindrical chambers in which said pistons can slide and which are arranged parallel and concentrically with respect to the rotation axis of said body and are connected to respective ports which are distributed concentrically around said axis on a face of said body, and a stationary plate which has a surface which makes contact against said face and is provided with two openings which are connected to a first duct and a second duct for a working fluid, said openings being arranged concentrically with respect to said axis and opposite with respect to said ports, so as to form a passage section for said fluid between one of said chambers and one of said ducts, characterized in that said openings and said ports are sized so that at the dead center of the stroke of the pistons the incremental ratio between the passage section of the fluid and the rotation angle of said body is different from zero.

[0010] Further characteristics and advantages of the invention will become better apparent from the following detailed description of an embodiment thereof, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a passage section-rotation angle chart of a hydrostatic machine of the prior art;

Figure 2 is a sectional view of a hydrostatic piston machine provided with a distribution system according to the invention;

Figure 3 is a sectional view, taken along the line III-III of Figure 2, which shows part of the fixed distributor;

Figure 4 is a sectional view, taken along the line IV-IV of Figure 2, which shows part of the rotary distributor;

Figure 5 is a chart which plots the linear behavior of the variation of the fluid passage section according to the rotation angle of the cylindrical body within the machine of Figure 2;

Figure 6 is a view of the overlap position of the ports with respect to the openings when the pistons are proximate to the dead center of their stroke; and finally

Figure 7 is a view of a variation of the geometry of the openings and ports of the fixed and rotary distributors.

[0011] With reference to Figures 2-4, the reference numeral 1 generally designates a hydrostatic piston machine of the rotary-reciprocating type with an inclined axis. However, it should be noted that the invention can also be applied to all kinds of hydrostatic machine in which the pistons are accommodated in a rotating body and are engaged by an inclined plate.

[0012] The machine comprises a casing 2, in which bearings 3 support a shaft 4, which is a driven or driving shaft depending on whether the machine is a pump or a motor.

[0013] The casing 2 is closed, on one side, by a cover which is constituted by a plate 5, from which a pivot 6 protrudes on which a cylindrical body 7 provided with cylindrical chambers 8 rotates about an axis A which is inclined with respect to an axis B of the shaft 4. The chambers 8 are arranged concentrically with respect to the pivot 6 and pistons 9 slide therein which are actuated axially by a flange 10 which is rigidly coupled to the shaft 4 to which they are coupled by way of spherical joints.

[0014] In the plate 5 there are two openings 14, 15, which in Figure 2, for the sake of clarity, are shown along a sectional plane which is offset by 90°. The function of these openings is to connect alternately the ports 11 of the chambers 8 for every half turn of the cylindrical body 7 to first and second working fluid ducts, thus providing a stationary distributor. Said ducts are not shown in the drawing, but are understood to be provided in the cover according to known methods. For example, said ducts can be the delivery and intake ducts of a pump.

[0015] The pistons 9 therefore perform two back-and-forth strokes, by means of which they aspirate and expel from the chambers 8 a working fluid which is aspirated and expelled through ports 11 which provide a rotary distributor.

[0016] The cylindrical body 7 is pushed axially against the plate 5 by a spring 12, which reacts against the flange 10 by means of a stem 13 which is coupled to the center of the flange, like the pistons, by means of a spherical joint.

[0017] As shown by Figures 2 and 3, the ports 11 and the openings 14, 15 run concentrically around the rotation axis A of the body 7. In particular, the ports 11 and the openings 14, 15 are shaped like an annular segment which is formed by an inner arc-like edge and by an outer arc-like edge, which are concentric with respect to the axis A and are joined at the ends by two straight radial edges. The inner and outer arc-like edges of the openings 14, 15 and of the ports 11 have the same radius, so that the openings and the ports can be superimposed perfectly.

[0018] Further, as shown by Figure 3, the circular length of the ports 11 is equal to the length of the portions 16 that lie between the openings 14, 15. In this manner, during the rotation of the cylindrical body 6 the ports 11 can be interposed between the openings 14, 15 and can overlap perfectly the portions 16. However, it should be noted that the radial dimensions of the ports may be different from the dimensions of the openings.

[0019] The operation of the described machine repeats the known operation of traditional machines and therefore is not described further.

[0020] The inventive feature of the described distribution system resides in that differently from what one might expect, the particular geometric shape of the openings 14, 15 and of the ports 11 allows to achieve a linear variation of the passage section of the fluid from the chambers 8 toward the first and second ducts for the working fluid which, being accompanied by a reduced flow-rate of the piston when said piston is proximate to the dead center of its stroke toward the plate 5, keeps the speed of the fluid constant, consequently reducing the load losses, vibrations and noise.

[0021] The result that is achieved is explained as follows.

[0022] With the particular geometric configuration of the ports 11 and of the openings 14, 15, the passage section S_d of the fluid during the rotation of the body 7, for small rotation angles α (Figure 6), i.e., for angles in which $\sin \alpha$ is confused with α expressed in radians (rad), is given by the following relation:

$$S_d \simeq K \sin \alpha \simeq K \alpha [rad]$$

where K is a constant which is different from zero.

[0023] As it is evident, this relation is a first-degree equation which, in a system of perpendicular axes (Figure 5), represents a straight line which passes through the origin, of which K is the angular coefficient that indicates the incremental ratio.

$$\frac{(\Delta S_d)}{(\Delta \alpha [rad])}$$

[0024] It should be noted that this incremental ratio coincides with the first derivative of the straight line.

[0025] According to the present invention, with the particular geometric configuration that corresponds to said incremental ratio, the speed of the fluid that passes through the passage section S_d is practically independent of the angle of rotation of the body 7 and remains substantially constant along the entire angular path that lies proximate to the dead center of the stroke of the pistons.

[0026] Indeed, if one indicates with:

$\alpha[rad] \simeq \sin \alpha$ the rotation angle of the body 7
 ω [rad/s] the angular velocity of the body 7
 c [m] the stroke of the piston 9

5 the speed v_p in [m/s] of the piston 9 is:

$$v_p = \omega \frac{c}{2} \sin \alpha \simeq \omega \frac{c}{2} \alpha [rad]$$

10 **[0027]** Using S_p to indicate the area of the piston 9, the instantaneous flow-rate of the piston is:

$$Q_p = S_p v_p \simeq S_p \omega \frac{c}{2} \alpha [rad]$$

20 **[0028]** If one indicates with

S_d the passage area of the fluid determined by the overlap of the ports 11 with respect the openings 14, 15 and with
 μ_d the restriction coefficient of the fluid,

the speed of the fluid is

$$v_f = \frac{(Q_p)}{(S_d \mu_d)} \simeq \frac{(S_p \omega \frac{c}{2} \alpha [rad])}{(S_d \mu_d)} \simeq \frac{(S_p \omega \frac{c}{2} \alpha [rad])}{(K \alpha [rad] \mu_d)} = \frac{(S_p \omega \frac{c}{2})}{K \mu_d}$$

[0029] It is thus confirmed that in the position that lies proximate to the dead center position the speed of the fluid v_f in the passage section, by being independent of the rotation angle, can be considered constant.

35 **[0030]** In particular, this result confirms that with the invention it is possible to avoid excessive speeds of the fluid in the positions proximate to the dead center positions, with the advantages mentioned above, such as limitation of load losses, of pressure peaks, of noise and of cavitation phenomena.

[0031] In the practical embodiment of the invention, the geometric configuration of the ports and of the openings of the rotary distributor and respectively of the fixed distributor may be any, provided that the incremental ratio $\Delta S_d / \Delta \alpha$ [rad] is different from zero at the dead center of the stroke of the pistons 9.

40 **[0032]** Figure 7 is a view of an embodiment in which the edges that connect at the ends the concentric edges of the ports 11 and of the openings 14, 15 are formed by circular arcs which are mutually complementary, so that the shape of the ports 11 is substantially identical to the shape of the portions 16 comprised between the adjacent ends of the openings 14, 15.

45 **[0033]** The disclosures in Italian Patent Application No. RE2005A000110 from which this application claims priority are incorporated herein by reference.

[0034] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

- 55 1. A distribution system for a hydrostatic piston machine which comprises a rotating body (7) provided with cylindrical chambers (8) in which said pistons (9) can slide and which are arranged parallel and concentrically with respect to the rotation axis (A) of said body and are connected to respective ports (11) which are distributed concentrically around said axis on a face of said body, and a stationary plate (5) which has a surface which makes contact against said face and is provided with two openings (14, 15) which are connected to a first duct and a second duct for a

working fluid, said openings (14, 15) being arranged concentrically with respect to said axis (A) and opposite with respect to said ports (11), so as to form a passage section for said fluid between one of said chambers (8) and one of said ducts, **characterized in that** said openings (14, 15) and said ports (11) are sized so that at the dead center of the stroke of the pistons (9) the incremental ratio between the passage section of the fluid and the rotation angle of said body is different from zero.

2. The system according to claim 1, **characterized in that** said openings (14, 15) and said ports (11) are shaped like an annular segment which is formed by two edges which are concentric with respect to said axis (A) and are joined at the opposite ends by two edges which have a radial orientation, the inner and outer edges of said openings (14, 15) being joined at the opposite ends by edges shaped complementarily to the edges that join the outer and inner edges of said ports (11), said ports (11) having a circular extension which is substantially equal to the portion (16) that lies between said openings (14, 15), so that during the rotation of said body (7) said ports (11) are interposed exactly between said openings (14, 15).
3. The system according to claim 2, **characterized in that** said edges that join at the opposite ends the concentric edges of said openings (14, 15) and ports (11) are radial and straight.
4. The system according to claim 2, **characterized in that** the edges that connect at the ends the concentric edges of the ports and of the openings are formed by circular arcs which are mutually complementary, so that the shape of the ports (11) is substantially identical to the shape of the portions (16) comprised between the adjacent ends of the openings (14, 15).

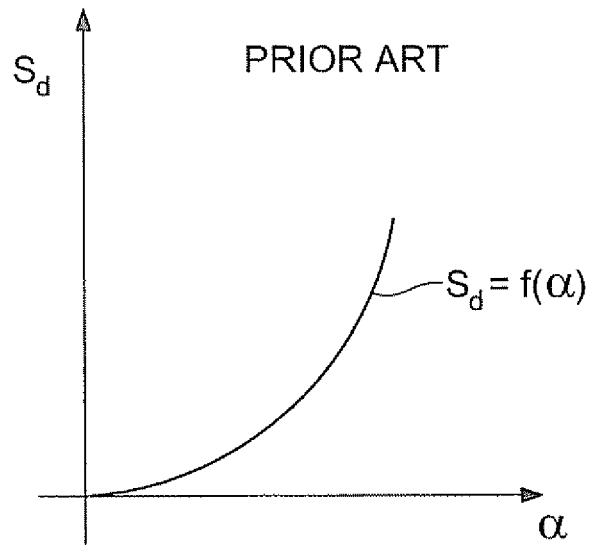


Fig. 1

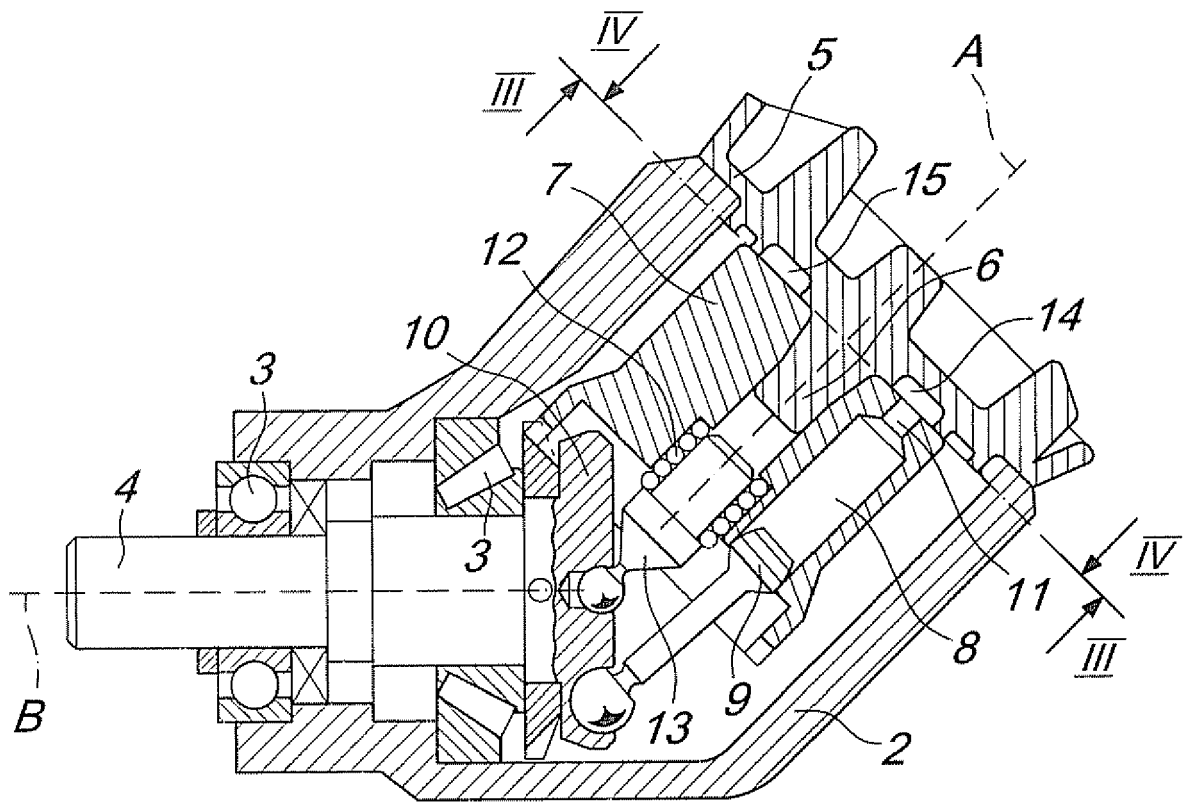
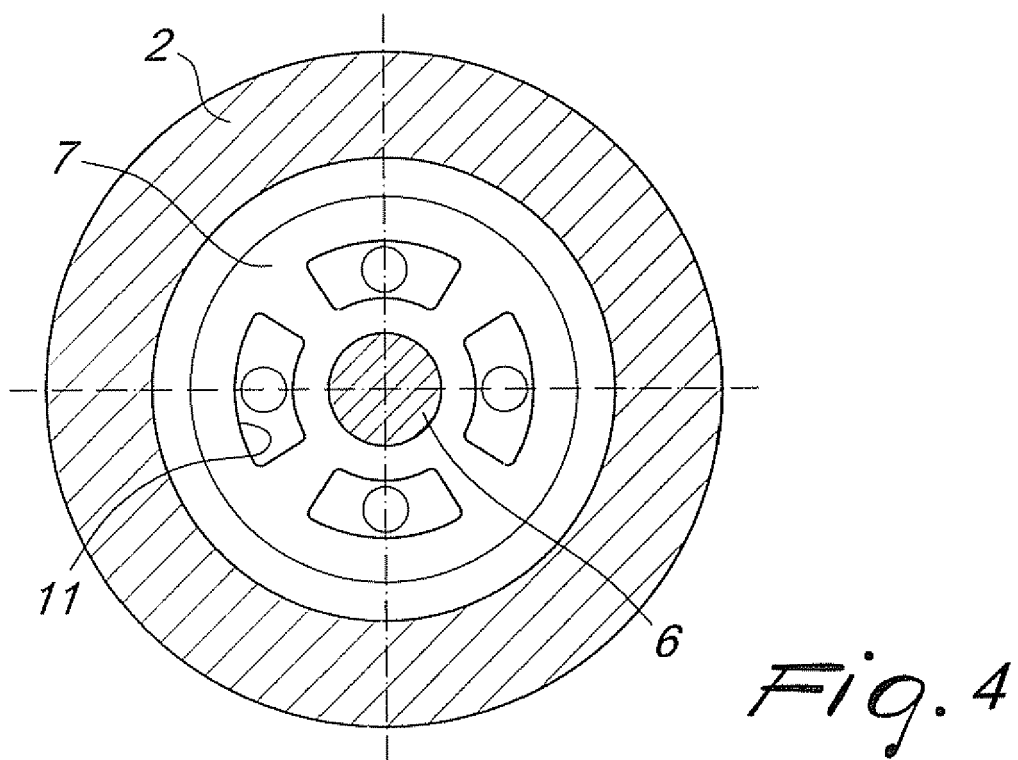
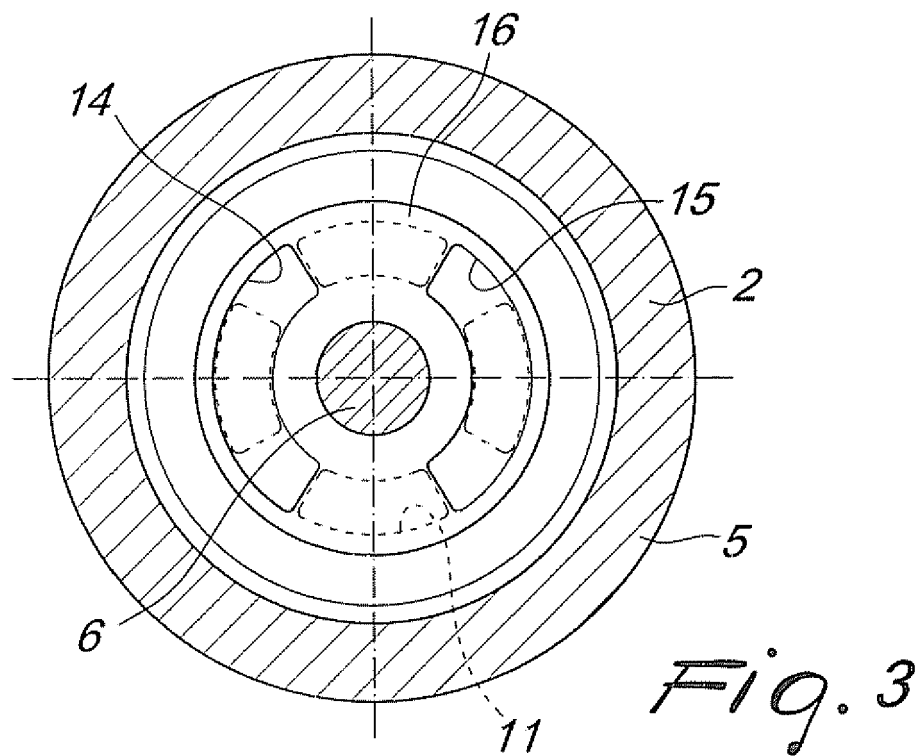


Fig. 2



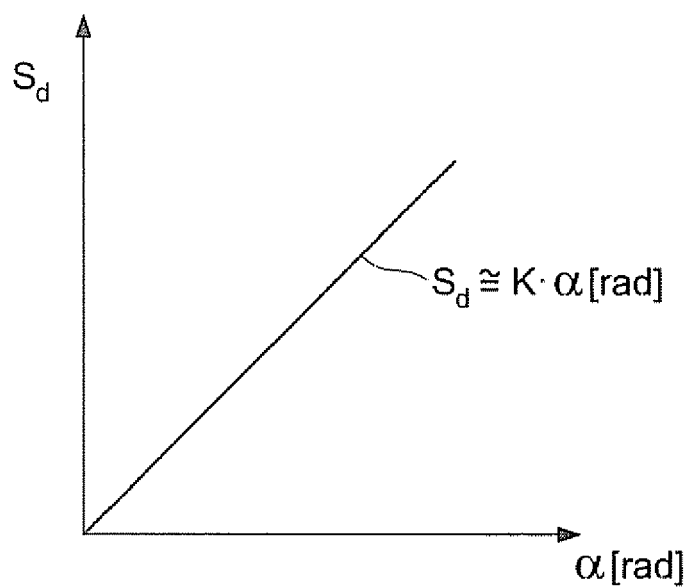


Fig. 5

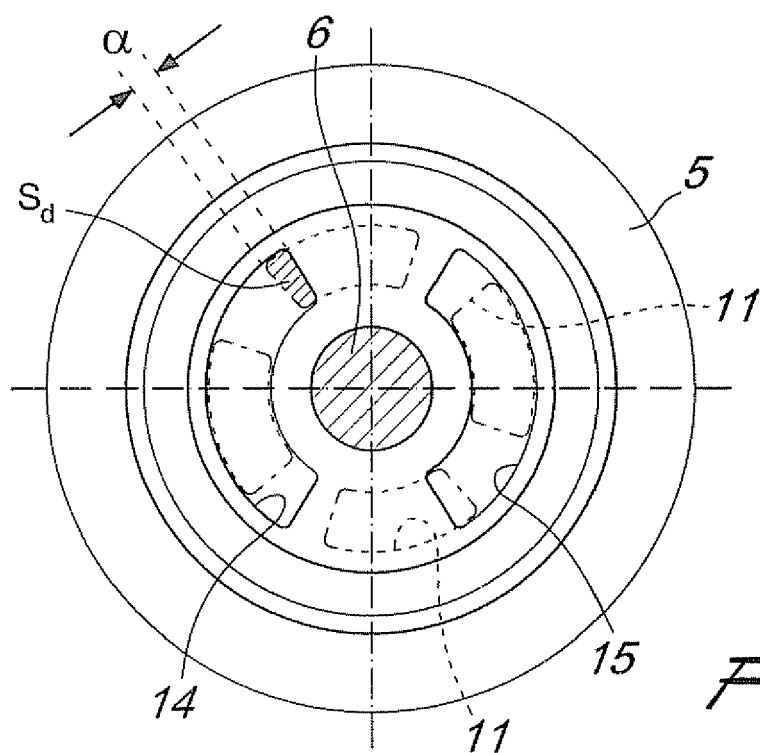


Fig. 6

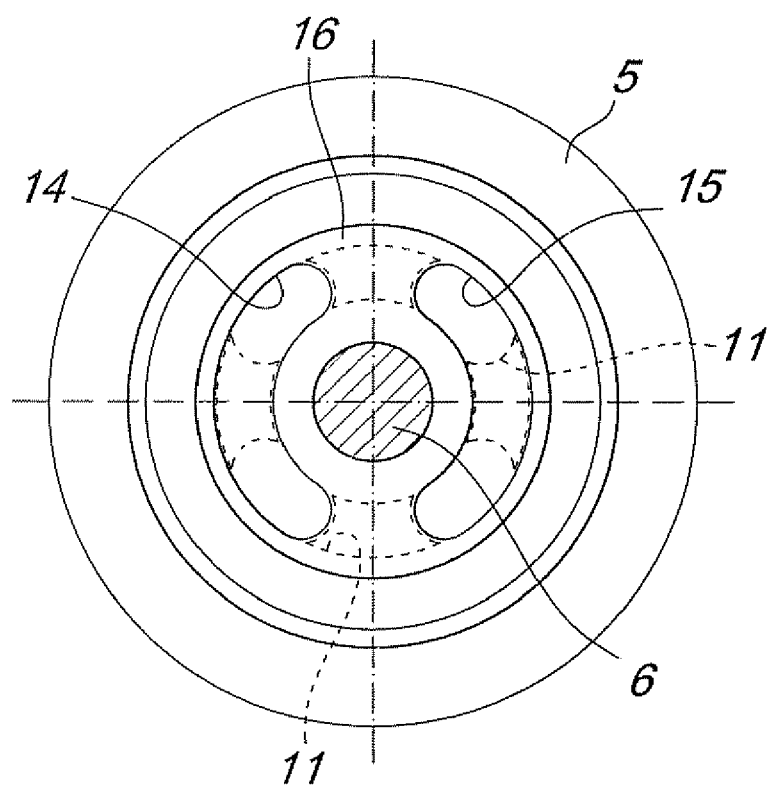


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 6640687 B [0006]
- JP 10122129 A [0006]
- DE 10343222 [0006]
- JP 7189887 A [0006]
- IT RE20050110 A [0033]