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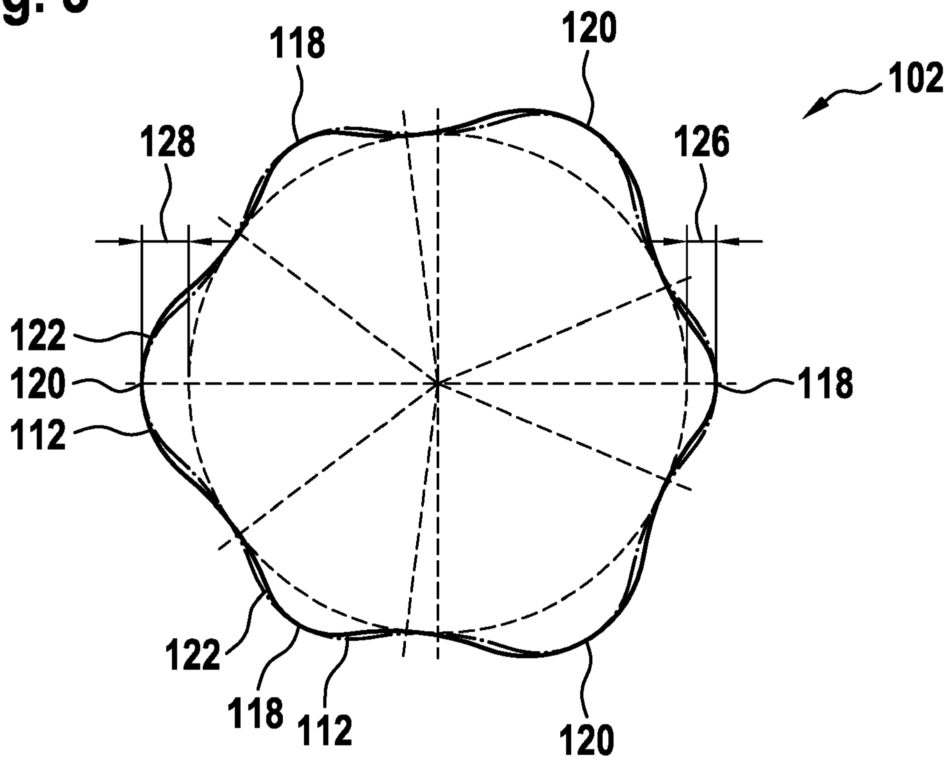
(54) **CAM PROFILE FOR A HYDROSTATIC RADIAL PISTON MACHINE, AND HYDROSTATIC RADIAL PISTON MACHINE**

(57) A cam profile for a hydrostatic radial piston machine comprises lobes arranged in a circumferential direction, each lobe comprising a lobe portion of rising type and a lobe portion of falling type, wherein as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type, and mostly decreases in each portion of falling type; the shapes of at least two lobe portions of the same type are different.

Fig. 3



EP 3 489 509 A1

Description

Field of the Invention

[0001] The present invention relates to a cam profile for a hydrostatic radial piston machine, and to a hydrostatic radial piston machine.

Background of the Invention

[0002] Hydrostatic radial piston machines ("machines") typically comprise a plurality of pistons pushing out via rollers against a cam having a plurality of lobes on the cam's periphery. In addition, machines are known that can operate in different displacement modes (e.g. two speed operation); an example is the radial piston motor Rexroth MCR-H. Two speed operation can be achieved by turning off the pressure supply to only some of the pistons or lobes. The latter is achieved by interrupting the pressure to each piston in turn as it passes through the angular extent of a predetermined lobe.

[0003] The two operation modes can be defined by a "natural ratio" which is the ratio between full and reduced displacement. For example if the machine has six lobes and three of these can be turned off in reduced-displacement mode, the reduced displacement is naturally 50% of full displacement. If two lobes are turned off in reduced-displacement mode, then the reduced displacement is naturally 67% of full displacement. In principle, i.e. with no other limiting design constraints, the choice of natural ratios is determined by the respective proportions between the numbers of lobes that remain on in reduced-displacement mode, and the total number of lobes.

[0004] It can be desired to provide constant machine displacement per degree of rotation and this can limit the number of lobes that can be turned off. Specifically, the choice of ratios is limited depending on the number of pistons and the number of lobes. For example: if the numbers have a common factor of two (e.g. six lobes and eight pistons) then the natural ratio is 50%. If the common factor is three then the usable natural ratios are 33% and 67%. So the usable natural ratios are determined in addition by said common factor. Due to this constraint a limited number of natural ratios are usable, which do not necessarily comprise the ratio required for a particular application.

Summary of the Invention

[0005] It is an object of the invention to allow a greater choice of ratio between reduced- and full-displacement modes ("actual machine ratio") and to maximise the machine displacement for a given ratio. It is a further object to optimize the life in particular in a predetermined rotation direction. The object is achieved by the subject-matter of claims 1 and 7. Advantageous further developments are subject-matter of the dependent claims.

[0006] A cam profile for a hydrostatic radial piston machine, according to the invention comprises lobes arranged in a circumferential direction, each lobe comprising a lobe portion of rising type and a lobe portion of falling type, wherein as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type, and mostly decreases in each portion of falling type; the shapes of at least two lobe portions of the same type are different. Therefore when the machine operates in reduced displacement mode and certain lobes are turned off, the turned off lobes can have different shapes from the always-tuned-on lobes, giving greater choice of performance characteristics e.g. ratio between full-displacement and reduced-displacement mode. Also the shapes of each portion can now be adapted to suit the various surface wear regimes on the respective lobe portions, in particular in view of any preferred rotation direction. Machine life can be improved.

[0007] Preferably the lobe depths of at least two lobe portions of the same type may be different. Since lobe depth influences displacement, a greater choice of actual machine ratios is possible. So the actual machine ratio can be varied from the natural ratio by making the lobes which get turned off different depth to the lobes which remain on.

[0008] Preferably the angular extents of at least two lobes may be different. Since contact stress on a lobe depends partly on the lobe's angular extent, the balance in wear performance between the always-turned-on lobes and of the lobes that are turned off in reduced displacement mode can be adapted according to operational requirements, and machine life can be optimized.

[0009] Further preferably the angular extents of at least two lobe portions of the same type may be different. The balance in wear performance between directions of rotation, and also the actual machine ratio, can be adapted with independence and according to operational requirements.

[0010] Preferably the cam profile may comprise at least one first lobe and at least one second lobe, wherein each second lobe has a greater angular extent and a greater lobe depth than each first lobe. Therefore the curvature of a deep lobe is kept low, contact stresses on the lobe are kept low, and the machine life is improved.

[0011] Preferably the lobes may be arranged in a symmetrical fashion, such as rotationally symmetric, further preferably alternating, with respect to their angular extents. Rotational imbalances and vibration are kept low; the construction is simplified.

[0012] According to a preferable embodiment the cam profile may additionally comprise sectors into which the lobes are divided by whole lobes, wherein lobes in at least one sector have greater angular extents than lobes in at least one other sector. In this way at least one reduced displacement mode can be provided in which the lobes of one of the sectors are turned off. The angular extents can now be configured to maintain constant motor displacement per degree of rotation, providing smoothness of operation (e.g. reduced ripple torque and/or vibration); actual machine ratios other than the natural ratios are achievable without having to reduce lobe depths; the choice of lobes for turning off is greater, and machine displacement can be enhanced. Further preferably a sector having first lobes and no second lobes, and another sector having second lobes and no first lobes, may join directly at their ends, wherein the second lobes have greater angular extent, and preferably also greater lobe depth, than the first lobes. The above advantages are achieved with a simplified construction.

[0013] Preferably the angular extents of at least two lobe portions of different type may be different. Thus wear performance can be enhanced in one direction, for one or both operating modes. For example it is possible to provide a longer-life machine having a mode combining slow speed with reverse rotation.

[0014] A cam profile for a hydrostatic radial piston machine, according to the invention comprises lobes arranged in a circumferential direction, each lobe comprising a lobe portion of rising type and a lobe portion of falling type, wherein as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type and mostly decreases in each portion of falling type; the angular extents of at least two lobe portions of different type are different. The machine can have enhanced wear performance in one direction.

[0015] Preferably one of above cam profiles may be configured so that, as it extends in a circumferential direction, its radial dimension increases only in each portion of rising type, and/or decreases only in each portion of falling type.

[0016] Preferably the lobes of one of above cam profiles may be directly joined together.

[0017] A hydrostatic radial piston machine, according to the invention comprises a cam body having the cam profile. The advantages indicated above can be achieved in a hydrostatic radial piston machine.

[0018] A hydrostatic radial piston machine, according to the invention, comprises a cam body having a cam profile according to the preferable embodiment; and pistons rotatable relative to and engaging with the cam profile, wherein the number of pistons engaging with at least one sector does not change with rotation angle. The advantages for the preferable embodiment can be achieved in a hydrostatic radial piston machine.

Description of Figures

[0019] Preferable exemplary embodiments of the invention are explained in more detail in the following, with the help of schematic drawings, wherein like numerals are used to represent like elements and wherein:

Fig. 1 shows a hydrostatic radial piston machine, according to a first embodiment serving as background to the invention;

Fig. 2 shows a cam profile of a hydrostatic radial piston machine of a second embodiment;

Fig. 3 shows a cam profile of a hydrostatic radial piston machine of a third embodiment;

Fig. 4 shows a cam profile of a hydrostatic radial piston machine of a fourth embodiment; and

Fig. 5 shows a cam profile of a hydrostatic radial piston machine of a fifth embodiment.

Detailed Description of Embodiments

[0020] A first embodiment serving as background to the invention is described in the following, with reference to Fig. 1 which shows a hydrostatic radial piston machine 401. The machine 401 is executed as a motor having a rotor comprising a cylinder block 403 rotatable in a stationary and annular cam body 402 which may preferably be a housing element. The cylinder block 403 comprises a plurality of equispaced cylinders arranged around the axis of rotation with their open ends directed radially outwards, the cylinders forming a star shape around the rotation axis. The angles between the cylinders are preferably fixed. The cylinder block 403 has a splined hole provided at its centre for transferring torque to and from an external apparatus. A piston 404 is slidably accommodated in each cylinder, so the pistons 404 are arranged in a symmetric star shape around the rotation axis. Each piston 404 confines together with the respective cylinder a working chamber 430 communicable alternately with high pressure or low pressure lower than the high pressure. To this end each cylinder is provided with a timing hole (cylinder hole 407, shown hatched in Fig. 1) to allow the chamber 430 to be (de)pressurized. The cylinder holes 407 cooperate with a plurality of timing holes (distributor holes 408) of a fluid distributor 406. The cylinder holes 407 and the distributor holes 408 are provided at a pitch circle diameter so as to allow the holes to overlap during rotation.

[0021] The cam body 402 has an undulating cam surface on its inner periphery so as to comprise identical lobes which are equispaced around the rotation axis. Each piston 404 is provided with a rolling element (which is a roller 5 in the present embodiment) provided on the radially outer end of the piston 404. The pistons 404, under appropriate pressurization, can radially actuate so as to engage with the cam surface via the rollers 405. Thus the rollers 405 are supportable on the cam surface so as to roll thereon as the cylinder block 403 rotates relative to the cam body 402. When the machine operates as a motor the contact force transferred to each piston 404 results in a turning force on the cylinder block 403 which then rotates in the direction of arrow 413. When the machine operates as a pump the rotation of the cylinder block 403 causes the pistons 404 to reciprocate to generate pressure in the working chambers 430.

[0022] The lobes have uniform lobe depth. "Lobe depth" is understood to mean the peak-to-trough radial dimension of the lobe, i.e. measured from the lobe's furthest point from the rotation axis to the lobe's nearest point to the rotation axis. Each lobe has a falling portion 412 and a rising portion 422 (shown exemplarily for one lobe in Fig. 1, the reference signs 412, 422 pointing to dashed lines for indicating the angular extents of the respective portions). When a roller 405 passes through the angular extent of the rising portion 422, it is fluidly connected to high pressure so that it actuates a working stroke. When the roller 405 crosses the boundary 414 between the two portions 412, 422 and starts to pass through the angular extent of the falling portion 412, it becomes fluidly connected to low pressure so that it actuates a return stroke in the opposite radial direction to the working stroke. The number of high-pressure distributor holes (shown as cross-hatched circles) is equal to the number of low-pressure distributor holes (shown as unfilled circles), and are each equal to the number of lobe portions 412, 422, so that one high-pressure distributor hole 408 is assigned to one portion 422, and one low-pressure distributor hole 408 (e.g. 408a) is assigned to the other portion 412. Angular extent of a lobe portion is understood to mean the angle between a minimum radial point to an adjacent maximum radial point, or vice versa.

[0023] For example when the machine is a motor, the working stroke of a piston 404 is one in which the volume of the working chamber 430 increases. When the machine is a pump, the working stroke of a piston 404 is one in which the piston 404 actuates so that the volume of the working chamber 430 decreases.

[0024] The portions 412, 422 have uniform (the same) angular extent. The pitch of the distributor holes 408 is uniform. The distance between adjacent distributor holes 408 may be equal to the diameter of each cylinder hole 407, or be slightly larger, e.g. to allow for tolerances or to reduce noise, so that a section of each lobe portion 412, 422 is inactive. The section may be at a boundary 414, 415 between lobe portions 412, 422, and may optionally have an angular extent of about one degree, or less or more than one degree; the cam profile may be adapted accordingly. The timing holes 407, 408 may be circular, and their sizes and pitch circle diameter may be adapted in view of reducing flow resistance.

[0025] Therefore as the cylinder block 403 rotates, each cylinder hole 407 is exposed to high/low pressure based on the position of each piston 404 relative to a lobe portion 412, 422. More specifically, the distributor holes 8 are located and sized such that when the cylinder block 403 rotates, a cylinder hole 407 starts to overlap with a distributor hole 408 (e.g. 408a) as a roller 405 reaches the start of a lobe portion 412. The overlap finishes as the roller 405 leaves that portion 412. When executed as a motor the aforementioned timing of high and low pressure urges the rollers 405 against the cam profile so as to create a turning force. When executed as a pump, the cam profile's urging of the piston 404 into its cylinder under rotation causes fluid pressurization.

[0026] The machine is configured to operate in a full-displacement mode or a reduced-displacement mode, and to change between these two. In the full-displacement mode all lobes and pistons 404 are turned on, i.e. the pistons 404 are each pressurized so as to bear on each lobe. In the reduced-displacement mode a proportion of the lobes are turned off, that is to say as each piston 404 passes through the angular extent of one of the turned-off lobes, its cylinder is not fluidly connected to a pressure source but instead fluid can recirculate. The total displacement of the pistons 404 for a predetermined rotation is reduced in this so-called "reduced-displacement mode".

[0027] Fig. 1 shows also a hydraulic circuit 416 comprising a distributor 406 which includes four mutually isolated galleries 409 are each formed as a groove. The distributor holes are fluidly connected to the galleries 409 via channels 410, so that each gallery 409 is in fluid connection with three distributor holes 408 as well as to one of two working ports A, B, wherein one is configurable as a high pressure port and the other is a configurable as a low pressure port. Two galleries 409 are fluidly connected to these ports via a valve 411. The valve 411 has two simultaneously interruptible flow paths.

[0028] In full-displacement mode the valve 411 is set to allow flow, while in reduced-displacement mode the valve 411 is set to interrupt the flow causing some lobes to turn off.

[0029] Fig. 2 shows the cam profile according to a second embodiment. Differences from the first embodiment are indicated in the following.

[0030] The cam body 2 comprises first lobes 18 and second lobes 20 having a depth 28 greater than the depth 26 of the first lobes 18, and that are arranged rotationally symmetrically, more specifically in an alternating circumferential pattern. The angular extents of the lobes are uniform; the lobe depths are non-uniform. Each lobe comprises a falling portion 12 and a rising portion 22 (shown exemplarily for one lobe in Fig. 2).

[0031] The rotor elements and the hydraulic circuit correspond with the rotor elements and hydraulic circuit 416 of the embodiment of Fig. 1.

[0032] The second embodiment has the following advantages. The actual machine ratio (the ratio between full and partial displacement) is now dependent not just on the natural ratio but also on the proportions of the lobe depths 26, 28. So an actual machine ratio can be more freely selected than if the lobes were to have uniform depth.

[0033] To demonstrate the advantage, a modification to the present embodiment is now described. The number of pistons is ten and the number of lobes is eight, giving a common factor between these of two which yields a usable natural ratio of 50%, wherein four of the eight lobes are turned on only in full-displacement mode. An actual machine ratio of 60% is now possible by reducing the lobe depths of some lobes so that the total motor displacement is 83% of the theoretical maximum.

[0034] Fig. 3 shows schematically a cam profile (solid line) on a cam body 102, according to a third embodiment, comprising first 118 and second 120 lobes having have the same non-uniformity in lobe depth 126, 128 as the second embodiment (shown in Fig. 3 with a dash-dot line). Differences from the second embodiment are explained in the following. The second lobes 120 have an angular extent greater than (are wider than) the first lobes 118, i.e. the pitch between the lobe portions is non-uniform, measured as the angle between the mid-points of two adjacent lobe portions. Each lobe comprises a falling portion 112 and a rising portion 122 which are indicated exemplarily for one lobe in Fig 2.

[0035] The third embodiment differs further from the first and second embodiments in that the distributor holes of the third embodiment are not equispaced but are arranged in a pattern corresponding to the non-uniform pitch of the lobe portions 112, 122. In this way an appropriate timing of high-pressurization and low-pressurization corresponding to the different angular extents of the lobes 118, 120 is achieved.

[0036] The present exemplary embodiment has the following additional advantages. Increasing the angular extent of a second lobe 120 reduces surface wear due to its reduced curvature, so motor life increases. Decreasing the angular extent of the first lobes 118 will not reduce motor life substantially because the first lobes 118 can be configured to be turned off in reduced-displacement mode, and so operate for only a proportion of the machine's operating life. Thus the expected lives of the two lobe types 118, 120 are brought closer and the total cam life is improved. This will also decrease wear on the rollers and the pistons, and therefore further increase machine life generally.

[0037] The advantage of increased motor life through wear optimization of the lobe-types can be achieved even if the lobes have uniform depths, or even if the deeper lobes are also the narrower lobes. Preferably the lobes that are always turned on may have a greater angular extent than other lobes. Since some of the lobes will be turned off in reduced displacement mode, it may be advantageous for these to have a lower running life in order to optimise full motor life. This is achieved by further modification of the angular extents of the various lobes.

[0038] Fig. 4 shows schematically a cam profile (solid line) according to a fourth embodiment, comprising first 218 and second 220 lobes having greater angular extent than the first lobes 218. The differences from the third embodiment are explained in the following.

[0039] The lobes preferably have uniform depth. The lobe profile is divided circumferentially into a first sector 232 comprising first lobes 218, and a second sector 234 (indicated with a dotted area in Fig. 4) comprising second lobes 220. The first sector 232 does not comprise any second lobes, and the second sector 234 does not comprise any first lobes 218. In other words the cam profile is divided by whole lobes into two sectors. Preferably one sector (e.g. first sector 232) may be assigned to always-turned-on lobes 18 and another sector (e.g. second sector 234) may be assigned to lobes 20 turned on only in full-displacement mode. The lobes 220 of the second sector 234 have a mean average angular extent which is greater than the mean average angular extent for the lobes 218 of the first sector 232. The falling portion and the rising portion of each lobe are indicated exemplarily for one lobe in Fig. 4 with the reference signs 212 and 222 respectively. A comparative example comprising six lobes having uniform lobe depths and uniform angular extents is represented with a dash-dot line. Each piston is represented in Fig. 4 by a respective roller 205a-205h.

[0040] The machine 201 of the fourth embodiment may be controlled by the hydraulic circuit of the third embodiment, with the following differences. The distributor holes for the lobes 220 in the second sector 234 are in communication with the interruptible galleries 409. The remaining distributor holes are fluidly connected to the remaining galleries 409; the routing of the channels 410 is adapted accordingly. The distributor holes are arranged to correspond with the angular extents of each lobe portion 212, 222.

[0041] The present embodiment has the following further advantages in addition to those of the third embodiment. In the third embodiment the requirement of constant motor displacement per degree of rotation limits the usable natural ratios to 50%; in order to achieve an actual machine ratio that differs from 50% it is necessary to reduce the depths of some lobes, which limits the total motor displacement. However the present embodiment can operate with a natural ratio of 67%, yet the requirement of constant motor displacement per degree of rotation is nonetheless fulfilled, without having to reduce any of the lobe depths. So by varying the angular extent of some lobes it is possible to ensure that each sector has a constant number of pistons active for any rotation angle. For example as one roller 205f leaves the second sector 234 and enters the first sector 232, another roller 205a leaves the first sector 232 and enters the second sector 234, assuming counter-clockwise rotation, represented by the arrow 213. So constant motor displacement is achieved by slightly increasing the angular extent of lobes 220 in the second sector 234 and slightly decreasing the angular extent of lobes 218 in the first sector 232, relative to the comparative example of equal extents.

[0042] In summary, it is possible to turn off different numbers of lobes (and thus access a greater range of natural ratios) whilst maintaining constant displacement per degree of rotation in both full and reduced displacements. This is achieved by setting design characteristics in a way which does not require additional structural elements. The design and manufacture of the machine 201, wherein a non-standard number of lobes can be turned off, is simplified. The lobe depths may be adapted in view of further modifying lobe life and/or actual machine ratio. The machine of the present embodiment can have a higher total machine displacement for a predetermined actual machine ratio.

[0043] A fifth embodiment will now be described with reference to Fig. 5 which shows a cam profile (solid line) of a cam body 302 and rollers 305 representing the pistons. As in the first embodiment: the lobes have uniform depths and uniform angular extents so as to share a common depth and a common width; and each lobe has a falling portion 312 in which a roller 305 engaging therewith moves radially inwards as said roller 305 rotates with its respective piston in one direction 313, and a rising portion 322 in which a roller 305 engaging therewith moves radially outwards as said roller 305 rotates with its respective piston in the one direction 313.

[0044] Differences from the first embodiment are indicated in the following. The machine is configured to rotate in one direction (clockwise 313) with increased motor life and/or performance compared to the other direction. The rising portions 322 each have greater angular extent than the angular extent of each falling portion 312. In Fig. 5 the reference signs 312, 322 point to dashed lines which indicate the extents of the respective portions 312, 322. When the machine is a motor, each piston actuates under high pressure when its corresponding roller 305 passes through a rising portion 322, and actuates under a low pressure lower than the high pressure when its corresponding roller 305 passes through a falling portion 312. Preferably the rising portions 322 share a common angular extent, and the falling portions 312 share a common angular extent. In this way the portions 312, 322 of each lobe are non-uniform with respect to angular extent, although the lobes themselves may be uniform with respect to each other.

[0045] The profile of the present embodiment may be used with a hydraulic circuit of the third embodiment, adapted as follows. The pitch of the distributor holes are non-uniform so as to correspond to the non-uniform pitch of the portions 312, 322. Alternatively the machine of the present embodiment may be operated in a reduced-displacement mode by turning off pressure to predetermined pistons.

[0046] The cam profile of the first embodiment is shown with a dash-dot line in Fig. 5 as a comparative example.

[0047] The present exemplary embodiment has the following advantages. When the machine is provided as a motor and rotates in a direction 313, the piston actuates radially outward through the rising portion 322 under high pressure higher than the pressure in the falling portion 312. This will tend to increase the contact stresses on the rising portions 322. The angular extent of the rising portion 322 is comparatively larger, resulting in a reduced curvature of the cam profile. The contact angle between the cam surface and the roller 305 is reduced, leading to lower contact stresses. Therefore the wear on the rising portion 322 is reduced, increasing its operational life, while the wear on the falling portion 312 is increased, reducing its operational life, but not substantially since the contact stresses are already low here, in comparison to the contact stresses in the rising portion 322. Therefore the respective operational lives of the portions 312, 322 are brought closer to each other, and the overall operation life of the cam profile can be optimized. Machine life and performance in the one direction 313 can improved. Total machine life can be improved when the machine rotates in one direction 313 more often than in the other direction. The present embodiment may be combined with any of the other embodiments, e.g. so as to provide non-uniform lobes, wherein the portions of each lobe have non-uniform angular extents.

[0048] The invention is not limited to hydrostatic radial piston machines in which the number of pistons is greater than the number of lobes by two, but this arrangement (in particular eight pistons and six lobes) can bring benefits of simplicity of construction and operational performance.

[0049] A "lobe" according to the invention need not be understood to be only a radially rising portion followed by a radially falling portion of the cam profile in the direction of rotation. A lobe may equally be understood to be a radially falling portion followed by a radially rising portion of the cam profile in either circumferential direction. Further optionally the pistons, cylinders and rollers may be provided radially outside of a cam body whose cam surface is on its outer periphery. Further optionally the cylinders may be provided as individual elements rather than in an integral cylinder body. Further optionally the pistons may bear directly on the cam surface, rather than via rollers. The machine of the invention may be a motor and/or a pump. The invention may be configured to operate in two or more reduced-displacement modes.

[0050] Disclosed is a cam body for a hydrostatic radial piston machine, including a cam profile comprising lobes arranged in a circumferential pattern. Each lobe is divided into a rising portion whose radius increases along a circumferential direction, and a falling portion whose radius decreases along the circumferential direction. The portions are non-uniform, preferably non-uniform in maximum radial depth, and/or in angular extent. Preferably the radial extents of the lobes are non-uniform and/or their lobe depths are non-uniform.

<u>Reference Signs</u>

[0051]

401 .... hydrostatic radial piston machine
2; 102; 202; 302; 402.......... cam body
403 ....cylinder block
404 ....piston
205; 305; 405.....................roller
406 ....distributor
407 ....cylinder hole
408, 408a...........................distributor hole
409 ....gallery
410 ....channels

411 ....valve
12; 112; 212; 312; 412........ falling lobe portion
213; 313; 413...................... a direction of rotation
414 .... start of overlap between rotor hole and distributor hole 408a
415 .... end of overlap between rotor hole and distributor hole 408a
416 .... hydraulic circuit
18; 118; 218; 318................ first lobe
20; 120; 220........................ second lobe
22; 122; 222; 322; 422........ rising lobe portion
26; 126 .... depth, first lobe
28; 128 .... depth, second lobe
430 .... working chamber
A .... working port
B... working port

Claims

1. Cam profile for a hydrostatic radial piston machine, comprising lobes (18, 20) arranged in a circumferential direction, each lobe comprising a lobe portion of rising type (22) and a lobe portion (12) of falling type, wherein
as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type (22), and mostly decreases in each portion of falling type (12), **characterized in that**
the shapes of at least two lobe portions (12, 22) of the same type are different.

2. Cam profile according to claim 1, wherein
the lobe depths (22, 26; 122, 126) of at least two lobe portions of the same type are different.

3. Cam profile according to claim 1 or 2, wherein
the angular extents of at least two lobes (118, 120) are different.

4. Cam profile according to one of the previous claims, comprising at least one first lobe (118) and at least one second lobe (120), wherein
each second lobe (120) has a greater angular extent and a greater lobe depth (126) than each first lobe (118).

5. Cam profile according to one of the previous claims, comprising sectors (232, 234) into which the lobes (218, 220) are divided by whole lobes, wherein
lobes (220) in at least one sector (234) have greater angular extents than lobes (218) in at least one other sector (232).

6. Cam profile according to one of claims 2 to 5, wherein the angular extents of at least two lobe portions of different type are different.

7. Cam profile for a hydrostatic radial piston machine, comprising lobes (318) arranged in a circumferential direction, each lobe comprising a lobe portion (322) of rising type and a lobe portion (312) of falling type, wherein
as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type (322) and mostly decreases in each portion of falling type **(312),characterized in that**
the angular extents of at least two lobe portions (312, 322) of different type are different.

8. Hydrostatic radial piston machine comprising a cam body having a cam profile according to one of the above claims.

9. Hydrostatic radial piston machine comprising:

a cam body (202) having a cam profile according to claim 5; and
pistons rotatable relative to and engaging with the cam profile, wherein
the number of pistons engaging with at least one sector (232, 234) does not change with rotation angle.

Fig. 1

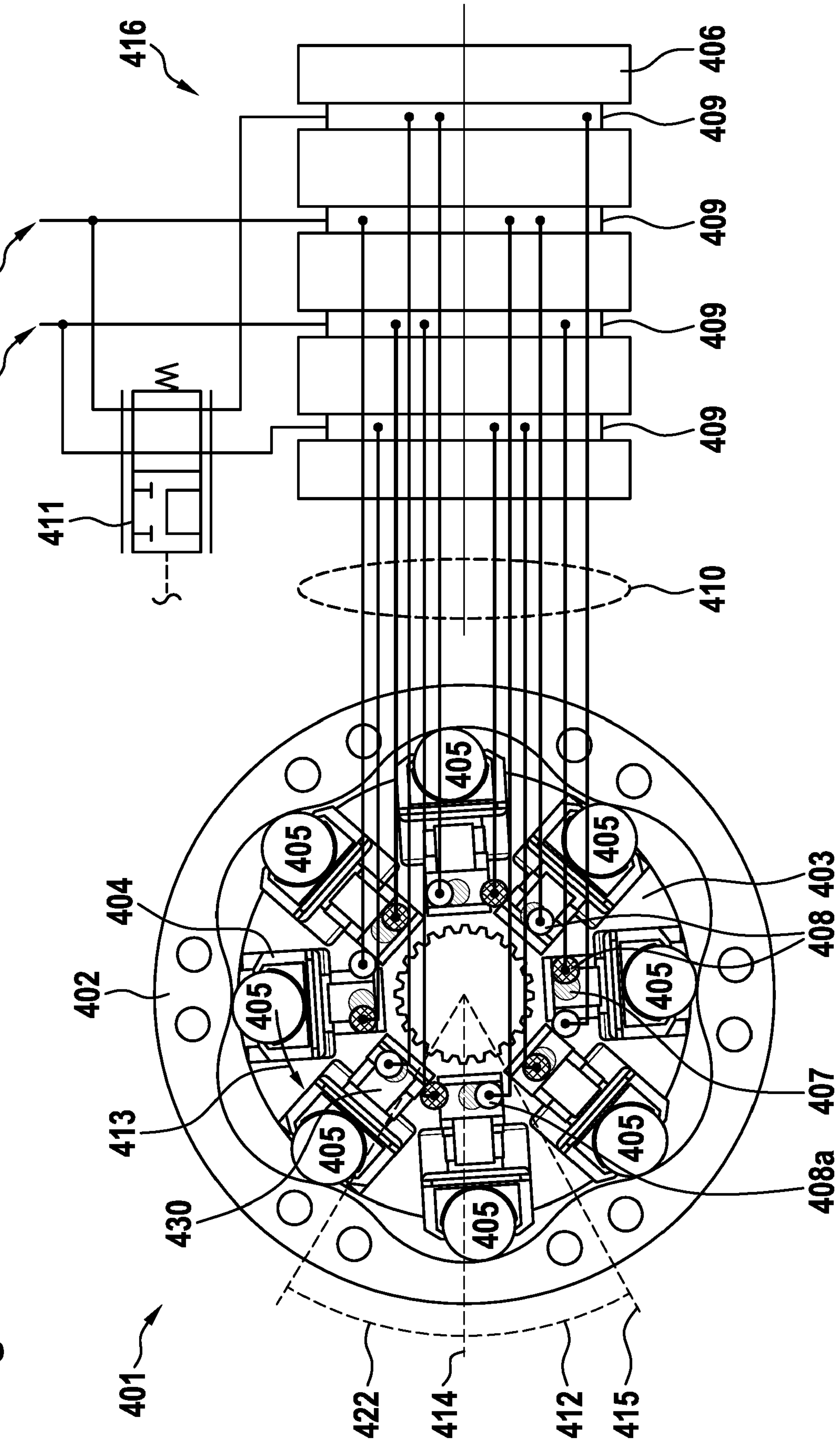

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Fig. 2

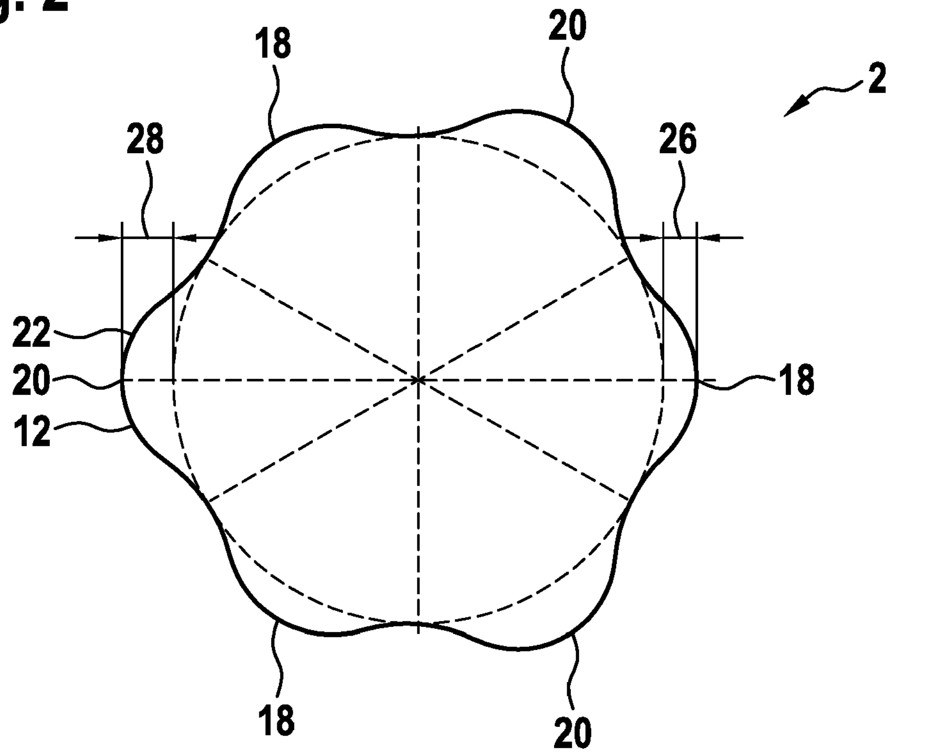
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Fig. 3

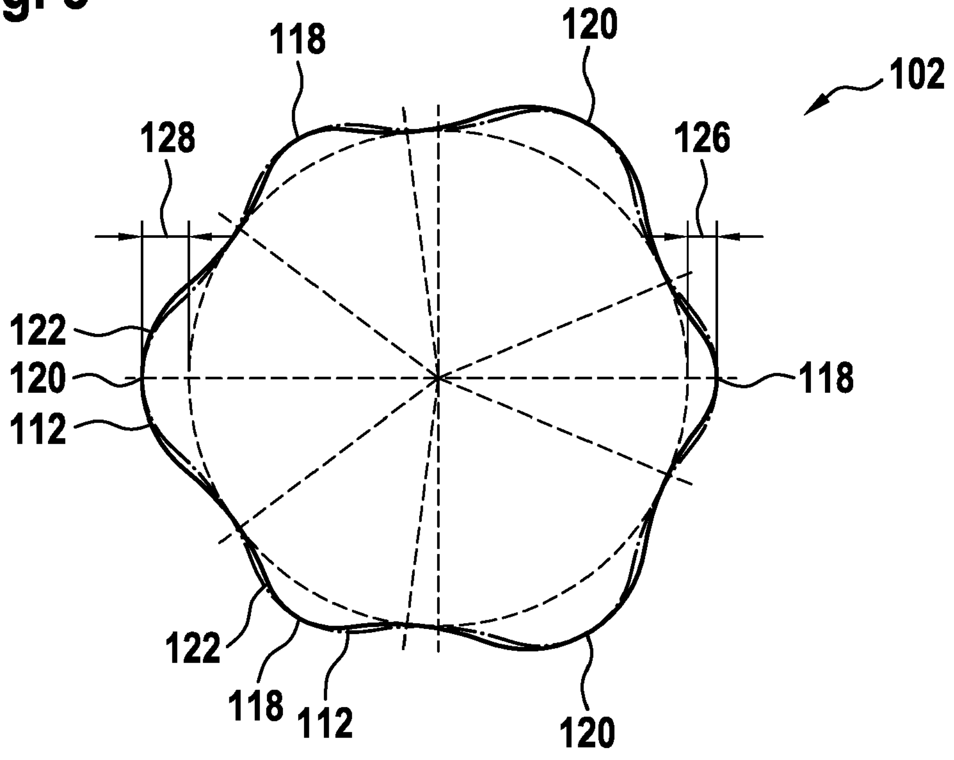
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Fig. 4

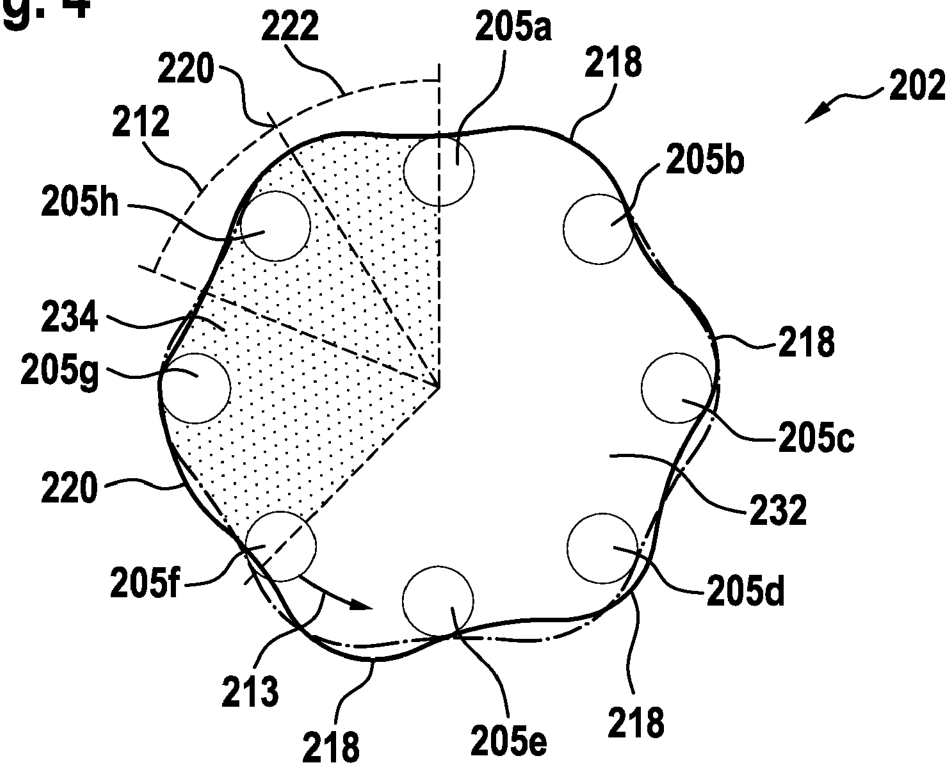
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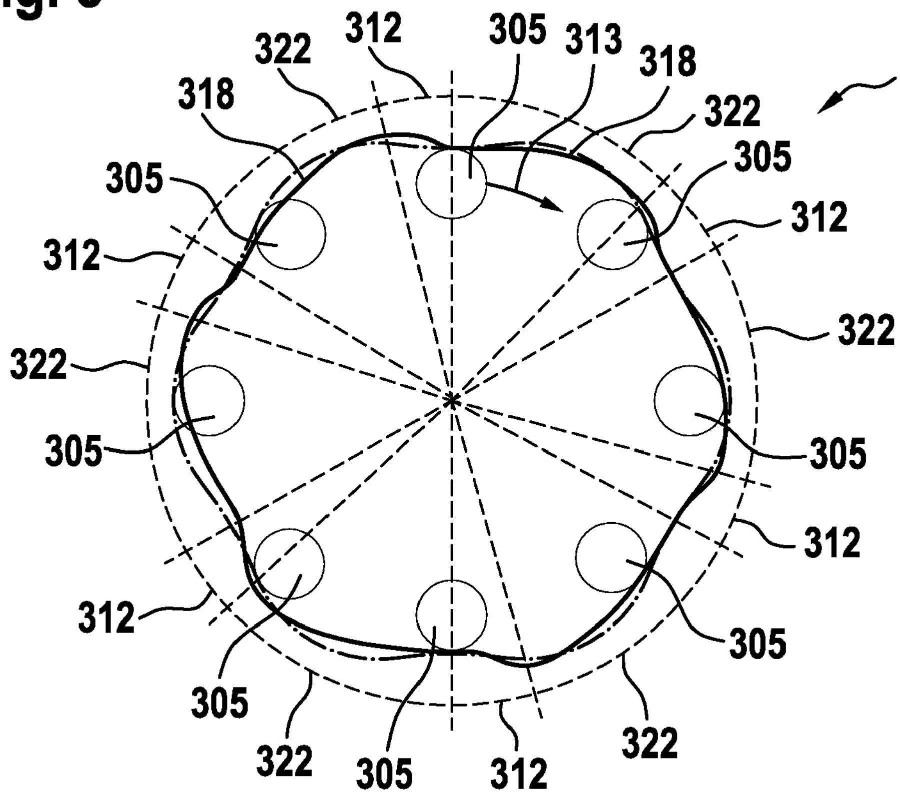
Fig. 5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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 3248

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 6 125 802 A (PEN PAO CHI [US]) 3 October 2000 (2000-10-03) * column 11, line 5 - line 28; figure 20 *	1-9	INV. F04B1/04 F04B1/047 F04B1/053 F04B49/12 F03C1/30 F03C1/047 F03C1/053
X	GB 2 243 881 A (POCLAIN HYDRAULICS SA [FR]) 13 November 1991 (1991-11-13) * page 7 - page 17; figures 2-5 *	1-3,5,6, 8,9	
X	WO 2015/162237 A1 (POCLAIN HYDRAULICS IND [FR]) 29 October 2015 (2015-10-29) * page 3, line 6 - page 7, line 23; figures 1,3-5 *	1-6,8,9	
A	GB 1 404 705 A (RELIANCE ELECTRIC CO) 3 September 1975 (1975-09-03) * column 3, line 55 - line 109; figure 3 *	1-6,8,9	
X	WO 2013/000029 A1 (EXODUS R & D INTERNAT PTE LTD [AU]; FLENCHE GEORGE [AU]) 3 January 2013 (2013-01-03) * page 11, line 1 - line 25; figure 6 *	7	TECHNICAL FIELDS SEARCHED (IPC)
X	US 6 422 196 B1 (PIEN PAO CHI [US]) 23 July 2002 (2002-07-23) * column 6, line 25 - column 7, line 13; figures 3,4,6 *	7	F03C F01B F16C F04B

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	26 March 2019	Jurado Orenes, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

- [ ] Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

- [ ] No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- [x] All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

- [ ] As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

- [ ] Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

- [ ] None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

- [ ] The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 17 20 3248

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-6, 8, 9

   Cam profile for a hydrostatic radial piston machine, comprising lobes arranged in a circumferential direction, each lobe comprising a lobe portion of rising type and a lobe portion of falling type, wherein as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type, and mostly decreases in each portion of falling type, characterized in that the shapes of at least two lobe portions of the same type are different.

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2. claim: 7

   Cam profile for a hydrostatic radial piston machine, comprising lobes arranged in a circumferential direction, each lobe comprising a lobe portion of rising type and a lobe portion of falling type, wherein as the cam profile extends in a circumferential direction, its radial dimension mostly increases in each portion of rising type and mostly decreases in each portion of falling type, characterized in that the angular extents of at least two lobe portions of different type are different.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 20 3248

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-03-2019

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82