HYDRAULIC DEVICE INCLUDING A FACE PLATE

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ABSTRACT

The invention is related to a hydraulic device comprising a housing including pipe ports, a rotor (14) having rotor chambers (9) which are formed by a cylinder (11) and a piston (12) which rotate about a first axis of rotation (m1) and a second axis of rotation (m2). Both axes of rotation extend within a common plane and intersect each other. A face plate (4) including a face plate centre line which coincides with the second axis of rotation (m1) has two or more face plate ports (3) which are each communicating with a pipe port for communicating the pipe port with the rotor chambers (9). An adjustment device adjusts the mutual positions of the face plate (4) and the common plane. Corresponding to the invention a face plate bearing (30, 32) between the face plate (4) and the housing has at least two axes of rotation which intersect the face plate centre line preferably perpendicularly and upon rotating the face plate (4) the common plane rotates with respect to the housing.
HYDRAULIC DEVICE INCLUDING A FACE PLATE

[0001] The invention is related to a device according to the preamble of claim 1. Such devices are known as a pump or hydraulic motor in which rotation of the face plate is used to adjust the swept volume, or as a hydraulic transformer wherein rotation of the face plate is used for adjusting the hydraulic transformer.

[0002] The disadvantage of the known devices is that inter alia upon application in the hydraulic transformer it is necessary to rotate the face plate about a wide angle, which causes problems in respect of the connection of the face plate ports to the pipe ports in the housing. Furthermore, high friction occurs upon rotating the face plate such that driving of the face plate must be sufficiently powerful and which makes accurate and/or quickly adjusting difficult.

[0003] In order to avoid this disadvantage the hydraulic device is according to claim 1. As a consequence, adjusting the face plate quickly and accurately is possible in a simple manner.

[0004] An embodiment of the hydraulic device is according to claim 2. As a consequence, the relative movement between the pistons and cylinders and the face plate remains unchanged upon adjusting the face plate.

[0005] An embodiment of the hydraulic device is according to claim 3. As a consequence, the face plate can be adjusted in a simple manner wherein the face plate port only has a small displacement with respect to the ports in the housing.

[0006] An embodiment of the hydraulic device is according to claim 4. As a consequence, a little force is required to adjust the face plate.

[0007] An embodiment of the hydraulic device is according to claim 5. As a consequence, the angle of stroke can be limited in a simple manner.

[0008] An embodiment of the hydraulic device is according to claim 6. As a consequence, rotation of the face plate about the face plate centre line is limited in a simple manner.

[0009] An embodiment of the hydraulic device is according to claim 7. As a consequence, a force which has risen between the spherical surface of the face plate and the concave surface of the housing and which is directed perpendicular to the face plate centre line, is compensated and reduces friction in the ball bearing.

[0010] An embodiment of the hydraulic device is according to claim 8. As a consequence, the location of the force at the face plate port between the face plate and the concave surface is determined accurately, such that accurate compensation of this force is possible.

[0011] An embodiment of the hydraulic device is according to claim 9. As a consequence, the direction of the force exerted by the support cylinder onto the face plate is always perpendicular to the face plate centre line and directed to the same location on the face plate, independent from the rotational position of the face plate.

[0012] An embodiment of the hydraulic device is according to claim 10. As a consequence, the face plate is balanced in relation to the forces that are caused by oil pressure such that the face plate can be moved easily.

[0013] An embodiment of the hydraulic device is according to claim 11. As a consequence, deformations of the face plate caused by oil pressure in the channels through the face plate are avoided as much as possible, such that leakages along sealing surfaces will be minimized.

[0014] The invention will be elucidated hereinafter by means of some embodiments by means of a drawing. The drawing includes a number of figures, in which similar components in the different figures have the same reference signs.

[0015] FIGS. 1 and 2 show parts of a known hydraulic device.

[0016] FIG. 3 shows a manner of adjusting a hydraulic device according to the invention.

[0017] FIG. 4 shows a first embodiment of the manner of adjustment as shown in FIG. 3.

[0018] FIG. 5 shows a second embodiment of the manner of adjustment as shown in FIG. 3.

[0019] FIG. 6 shows a perspective view of the face plate of FIG. 5.

[0020] FIG. 7 shows schematically the forces on the face plate of FIG. 5.

[0021] FIG. 8 shows an arrangement of compensation cylinders in combination with the face plate of FIG. 5.

[0022] FIG. 9 shows a third embodiment of the manner of adjustment as shown in FIG. 3.

[0023] FIG. 10 shows a perspective exploded view of a face plate and a part of the housing according to the embodiment of FIG. 9, and

[0024] FIG. 11 shows a perspective view of the face plate according to FIG. 10 as seen from the opposite direction.

[0025] The parts as shown in FIGS. 1 and 2 are parts that are mounted in a housing (not shown) of a hydraulic transformer. Such a hydraulic transformer is described, for example, in the publications of the patent applications WO 9731183 and WO 9940318, which content is assumed to be known. Rotor bearings are mounted in a known manner. In the housing in which a rotor shaft 2 having a rotor centre line 1 can rotate, a rotor 14 including rotor holes 15 is mounted on the rotor shaft 2. Bar-shaped parts are mounted in the rotor holes 15 and form pistons 12 at both sides of the rotor 14. The pistons 12 are provided with piston rings 10, wherein the outer surface of the piston rings 10 have a spherical shape and the centre of these spheres of all pistons lie within one plane at a side of the rotor 14. The left side and the right side of the rotor 14 are symmetrical with respect to the centre of the rotor 14. Each side of the rotor 14 cooperates with a drum plate 7 including drum bushes 11 which rotate about a drum plate centre line m₀ and drum plate centre line m₀₂, wherein the rotor centre line 1 and drum plate centre line m₀, and rotor centre line 1 and drum plate centre line m₀₂ respectively, intersect each other by an angle of stroke α in a point of intersection M which lies in the plane extending perpendicular to the rotor centre line 1 and in which the centre points of the spherical outer surfaces of the piston rings 10 of the pistons 12 are located at that side. In the embodiment as shown the angle of stroke α is about 8°.

[0026] A centring surface 22 about which the drum plate 7 can swivel is formed on the rotor shaft 2. The centring surface 22 is spherical and the intersection M forms the centre of the sphere. The rotation of the drum plate 7 is coupled to a rotation of the rotor shaft 2 by means of a key 16 which engages in a key path. The key 16 has a radius of curvature in the plane of the surface of the shaft which is smaller than the radius of the centring surface 22, such that the key 16 does not clamp in the key path upon rotation of the drum plate 7. Possibly more than one key 16 is present. It is also possible that the key 16 is mounted in the rotor shaft 2 and the key path is provided in the drum plate 7.

[0027] The drum plate 7 is provided with drum bushes 11 at the side which is directed to the pistons 12, which drum
bushes 11 are clamped against the drum plate 7 by a bush holder 18. The drum bush 11 has a cylindrical wall 23 at its inner side. Each piston 12 is enveloped by a drum bush 11 wherein the piston ring 10 can move along the cylindrical wall 23 in a seaming manner. The piston 12 and the cylindrical bush 11 thus form a chamber 9 of which the volume changes upon rotation of the rotor shaft 2. As a consequence of the volume change, oil flows into and out of the chamber 9 via a drum bush opening 24, a drum port 6, wherein each chamber 9 has its own drum bush opening 24 and drum port 6. The drum plate 7 including the drum ports 6 rotates along a face plate 4 which is at a stand still in the housing and the oil flows through the drum port 6 via one of the kidney-shaped face plate ports 3 to a pipe connection (not shown) in the housing. The face plate 4 has three kidney-shaped face plate ports 3 which together form a ring which is discontinuous between the different face plate ports 3. For other applications such face plate 4 may have two or four face plate ports 3. Each face plate port 3 has its own pipe connection wherein corresponding face plate ports 3 at both sides of the rotor 14 are connected to the same pipe connection, for example due to the fact that they are coupled to each other in the housing.

[0028] Since the shafts of rotations of the rotor 14 and the drum plate 7 are angled by an angle of stroke α, the pistons follow an elliptical path in the plane of the drum plate 7 and the drum bush 11 will slide over a contact surface 8 of the drum plate 7. The holder 18 is provided with openings which allow this sliding and serves to limit the gap between the drum plate 7 and drum bush 11 such that a pressure can arise in the chamber 9 upon starting.

[0029] The face plate port 3 is a kidney-shaped opening in the face plate 4 which is supported by a surface of the housing. This surface does not extend perpendicular to the rotor centre line 1 but is angled to that rotor centre line and hence defines the direction of the drum plate centre line m₁ or m₂, and also the rotational position where the volume in the chamber 9 is minimal or maximal. In the known hydraulic transformer as shown in FIGS. 1 and 2 the face plate 4 is rotatably mounted in the housing and rotatable about the drum plate centre line m₁ or m₂. In order to be able to rotate the face plate 4 about the drum plate centre line m₁ or m₂, the face plate 4 is provided with a tooth profile 5 on a part of its circumference which tooth profile meshes with a gear wheel which is driven by a driving means.

[0030] In the position of the drum plate 7 with respect to the rotor shaft 2 as shown in FIGS. 1 and 2 the volume of the upper chamber 9 is the smallest and the volume of the lower chamber 9 is the largest. In other words analogous to a piston and crank-connecting rod mechanism in this embodiment the upper chamber 9 can be designated as the top dead centre BDP.

[0031] Upon rotating the face plate 4 the settings of the hydraulic transformer changes as described in the above identified patent applications. The rotation of the face plate 4 is limited since each face plate port 3 communicates with a port in the housing which communicates with a pipe connection and upon rotating the face plate 4 about a too large angle a face plate port 3 would possibly communicate with a different pipe connection. As a consequence, not all of the setting possibilities of the hydraulic transformer are applied.

[0032] FIG. 3 shows schematically a different method for changing the settings of the hydraulic transformer wherein a face plate 25 which is similar to the face plate 4 as described hereinafter, is not rotated only in its own plane about the drum plate centre line m₁, m₂. The rotor centre line 1 intersects the drum plate centre line m₁ in M. The face plate 25 has a centre line which coincides with the drum plate centre line m₁. The face plate 25 comprises two and in case of a hydraulic transformer three face plate openings and one thereof has a central face plate opening 26 and an axis of symmetry s, the face plate openings 26 are similar to the face plate ports 3 as described hereinafter. The drum plate centre line m₁ and the axis of symmetry s intersect in a centre C. The rotor centre line 1 and the drum plate centre line m₁ lie in a plane that intersects the face plate 25 in a plane V. The plane V is angled with respect to the axis of symmetry s by a setting angle δ. As described hereinafter the setting angle δ of the device according to FIGS. 1 and 2 is adjusted by rotating the face plate 4 or the corresponding face plate 25 about an axis of rotation Rev₁, which coincides with the drum plate centre line m₁.

[0033] In the embodiment of FIG. 3 the face plate 25 is adjusted by rotating the face plate 25 about a second axis of rotation Rev₂ and a third axis of rotation Rev₃, which axes of rotation extend perpendicular to the first axis of rotation Rev₁. The face plate 25 is not rotated about the axis of rotation Rev₁, this rotation can be obstructed. The centre C of the face plate 25 follows a path to a position C₁ and the new position of the drum plate centre line m₁ is drawn as m₁'. The plane through the drum plate centre line m₁' and the rotor shaft 1 intersects the adjusted face plate 25 in a plane V'. The plane V' is angled with respect to the axis of symmetry s by a setting angle δ'. As can be seen in FIG. 3 the setting angle δ has been changed due to the fact that the plane in which the rotor shaft 1 and the drum plate centre line m₁ lie, rotates with respect to the face plate 25 whereas the face plate 25 itself does not rotate about the drum plate centre line m₁. In the embodiment as shown in FIG. 3 the first axis of rotation Rev₁, the second axis of rotation Rev₂, and the third axis of rotation Rev₃ intersect each other in the intersection M, in an alternative embodiment this may be at a different location such as the centre C. However, this will influence the relative movement of the pistons 12 with respect to the drum bush 11. The rotation about the second axis of rotation Rev₂ and the third axis of rotation Rev₃ are limited and coupled such that the angle of stroke α has a constant or adjustable value.

[0034] FIG. 3 illustrates on the face plate 25 that upon adjustment, the top dead centre BDP in the plane V in the new position BDP' in the plane V' has a different angle with respect to the face plate opening 26. As described hereinafter this is different in the know device according to FIGS. 1 and 2, in which the top dead centre BDP remains at the same position with respect to the housing and the face plate 4 is turned with respect to the housing about the drum plate centre line m₁. In the embodiment according to FIG. 3 the face plate 25 is turned to a new tilting position such that the BDP replaces with respect to the housing. The adjustment according to FIG. 3 does not mean that only the face plate 25 is tilted, but that the drum plate 7 moves together with it. In fact the adjustment according to FIG. 3 has the same effect as virtually rotating the face plate 25 and the drum plate 7 in the housing in a fixed position with respect to the rotor shaft 2 by an angle about the rotor centre line 1, such that the top dead centre BDP turns about this angle, after which the face plate 4 is rotated back with respect to the drum plate in the housing about the same angle, but in that case about the drum plate centre line m₁. The movement as described hereinafter about the different axes is comparable to the combined swiveling movement as illus-
trated in FIG. 3. In terms of FIG. 3 the plane of symmetry V is turned to the left about the rotor centre line 1 and the face plate 29 is rotated to the right about the line m
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[0035] FIG. 4 shows the hydraulic device as shown in FIGS. 1 and 2 including a face plate 29 which is adjusted in the manner as described in FIG. 3. The face plate 29 has an opening through which the rotor shaft extends and the rotor bearing 1 is located at the side of the face plate 29 which is facing away from the drum plate 6. The device which adjusts the face plate 29 is not shown. The face plate 29 is rotatably mounted in a cardan ring 27 and is rotatable about a first cardan shaft 31. A second bearing and a second cardan shaft (not shown) are located between the cardan ring 27 and the housing. The first cardan shaft 31 and the second cardan shaft intersect the rotor shaft 1 in the intersection M. The face plate 29 has face plate ports 3 which communicate with the pipe connections in the housing through connecting ports 28. The face plate ports 3 are similar to the face plate openings 26 as shown in FIG. 3. A flexible connection is present between the housing and face plate 29, e.g. a flexible line or a tube. In the embodiment as shown the cardan ring 27 is formed with cylindrical bearings, but other bearings are also possible, for example because of the occurrence of a small rotation cross spring pivots or knife bearings can be applied. In order to limit the angle of stroke \( \alpha \) an edge for limiting the tilting angle of the face plate 25 is present in the housing. This edge may form a flat plane and in that case the angle of stroke \( \alpha \) is constant at each setting angle \( \delta \). In an alternative embodiment the edge is corrugated such that the angle of stroke \( \alpha \) is dependent on the setting angle \( \delta \).

[0036] FIG. 5 shows a hydraulic device as shown in FIGS. 1 and 2 including a face plate 34 which is adjusted in the manner as described in FIG. 3. The face plate 29 has an opening through which the rotor shaft 2 extends and the rotor bearing 1 is located at the side of the face plate 29 which is facing away from the drum plate 6. The device through which the face plate 34 can be adjusted is not shown. The side of the face plate 34 which faces away from the pistons 12 is provided with a spherical surface having a radius, which spherical surfaces forms a ball pivot 32 including a concave surface having the same radius in the housing (not shown). The centre of the concave surface in the housing is located on the rotor axis 1 in the intersection M and the centre of the ball is located on the drum plate centre line m
. As a consequence the intersection M forms the centre of the ball pivot 32 and the face plate 34 could rotate about this point in three directions. In order to limit the rotation of the face plate 23 to two axes of rotation, the face plate 34 is provided with teeth 35 which mesh with teeth 37 in the housing (see FIG. 6). Possibly the teeth 37 are in the plane that extends perpendicular to the axis of rotation 1 through the centre point M. In that case the teeth 35 and 37 have the same number of teeth.

[0037] In an alternative embodiment (not shown) in the ball pivot on the spherical surface of the face plate 34 a pin is provided and in the opposite concave surface of the housing a slit is provided in a plane through the rotor centre line 1. In this way the pin limits one of the possible rotations of the face plate 34 whereas the pin in the split can move and a rotation about the axis of the pin in the slit is possible such that the face plate 34 can rotate about two remaining axes of rotation. The face plate ports 3 communicate with openings in the housing via connection openings 33.

[0038] FIG. 6 shows the face plate 34 in a perspective view wherein the face plate 34 is supported by an edge of the housing including teeth 37 which mesh with teeth 35 of the face plate 34. The face plate 34 is drawn in three positions, the first position is indicated by continuous lines and shows the position in which the face plate 34 is supported by the housing 36 in location A. In location A the teeth 35 and 37 contact each other and the top dead centre BDP is located at location A. The second position is indicated by dash-dotted lines wherein the face plate 34 is supported by the housing 36 in location B. The top dead centre BDP is then located at location B. The third position is indicated by broken lines wherein the face plate 34 is supported by the housing 36 in location C. The locations A, B and C follow an arc of more than 180°, such that the hydraulic device has a wide adjusting range and the setting angle \( \delta \) can be more than 90°. It appears from the figure that the connection openings 33 have only small displacements with respect to the housing, such that the ports in the housing (not shown) can be small whereas the setting angle \( \delta \) is large. In the embodiment according to FIG. 6 a circular edge of the face plate 34 is rolled on a circular edge of the housing and this edge limits the angle of stroke \( \alpha \).

[0039] In the face plate port 3 and the associated connection opening 33 the oil pressure is the same for each face plate port 3, and this oil pressure will be different for the different face plate ports 3. In the area where oil pressure is present around the connection opening 33 between the housing and the face plate 34 the oil pressure exerts a port force 38 on the face plate 34 which is directed to the intersection M, see FIG. 7. In the area where oil pressure is present around the face plate port 3 between the face plate 34 and the drum plate 7 the oil pressure exerts a port force 41 in the direction of the drum plate centre line m
. The port force 38 and the port force 41 are proportional to the hydraulic pressure and proportional to the surface of the corresponding port. The value of these port forces 38, 41 are selected by dimensioning the surface of the connection port 33 carefully such that a port force component 39 of the port force 38 in the direction of the drum plate centre line m
, is the same as and directed opposite to the port force 41. This results in that the port force 38 results in a port force component 40 which is directed perpendicular to the direction of the drum plate centre line m
, and this could lead to high forces in the ball pivot 32 which could lead to a too high friction during adjusting. In order to compensate the port force component 40 a piston 44 is mounted to the face plate 34 having a centre line in the direction of the port force component 40. The piston 44 can move within a bush 45 which is supported by a surface 45 in the housing. The chamber between the piston 44 and the bush 44 communicates with the face plate port 3 such that a force 42 on the piston is proportional to the oil pressure in the face plate port 3 and the dimensions are such that the force 42 equals the port force component 40. Possibly two pistons 44 are provided in the face plate 34, such as in case the face plate 34 includes an opening for a shaft, see FIG. 8. In FIG. 8 the centre lines of the two cooperating pistons 44 are parallel, but it is also possible that the centre lines are directed radially.

[0040] The adjustment device of the face plates 25, 34 of FIGS. 4, 5 may comprise two hydraulic cylinders which are located diagonally with respect to the rotor shaft 1, which cylinders are controllable like adjustment devices or actuators, and which exert a force on the face plate 24, 34 in a direction of the rotor shaft 1 or parallel thereto. As a consequence the face plate can be adjusted to the desired tilting position.
FIGS. 9-11 show an illustration of a second embodiment of a face plate which is supported by a ball pivot, wherein hydraulic support cylinders are present for compensating hydrostatic pressure between the face plate 50 and the drum plate 7 at the face plate port 3 and between the face plate 50 and a cover 51 of the housing at the connection opening 33. In this second embodiment a rotor shaft 46A, 46B includes two rotor flanges in which pistons 12 (not shown) having centre lines 49 are mounted. Bearings 47 are mounted between the rotor shaft 46A, 46B which is made of two parts, such that a face plate 50 is not provided as a ring but without central opening. This means that the face plate 50 is more rigid and deforms less under load.

The bearings 47 are mounted in a central housing 48 and the covers 51 are mounted at the ends of the central housing 48. The inner side of the cover 51 forms a concave surface 53 along which the face plate 50 can move in the way as described in relation to FIG. 5. At the other side of the face plate 50 a drum plate and the pistons and drum bushes (not shown) are mounted in the way as described hereinafter and/or mounted in a known manner. At the face plate port 3 the port force 41 arises, which force is compensated by the port force 38 at the connection opening 33. In order to determine the level and location of the port force 38 which is directed to the centre of the concave surface 53 and the corresponding opening in the cover 51 which communicates with the connection opening 33 and the line connection (not shown).

FIG. 9 shows schematically a piston 58 including a bush 56 which is supported by a supporting plate 54. The support cylinder force 42 which exerts a force on the piston 58 is aligned with and directed opposite to the port force 40, which is the component of the port force 38 which extends perpendicular to the centre line m, m of the face plate 50. The piston 58 is sealed in the bush 56 by a spherical surface and the bush 56 is supported in a sealing manner by a cylindrical support surface 52, and the bush 56 has an opening 55 through which the contact between the bush 56 is lubricated by oil and the bush 56 can slide along the support surface 52. The support surface 52 is part of the support plate 54 which is disposed in the cover 51. The support surface 52 is cylindrical and has a radius 60 having a centre line which intersects the rotor centre line 1 in 1. A portion of the bush 56 which is supported by the support surface 52 has a radius which corresponds with the radius 60. The face plate port 3 communicates with the connection opening 33 via a channel 63. The channel 63 communicates with a chamber 57 via a channel 61 and a channel 59 through the piston 58, such that the port force 41, the port force 38 and the support cylinder force 42, which are generated by the same hydraulic pressure, are directed through a common intersection and hence neutralize each other.

FIG. 10 shows a portion of the cover 51 including the concave inner surface 53 in which the spherical side of the face plate 50 is supported. The inner surface 53 is provided with openings (not shown) which are located at the connection opening 33 in order to release oil through channels in the cover 51 to the line connection. Three pistons 58 are mounted to the face plate 50, which is shown in a position above its mounted position for clarity reasons, which pistons are placed diametrically opposite to a face plate port 3. In the mounted condition the pistons 58 including the bushes 56 which are mounted thereon extend through the openings in the concave inner surface 53 and the support plates 54 which are shown separately are mounted to the cover 51 such that each of the bushes 56 is supported by a cylindrical support surface 52.

FIGS. 10 and 11 show that each of the three face plate ports 3 are provided with three channels 63. The three channels 63 communicate with the connection port 33 located at the opposite side of the face plate 50 through inner channels in the face plate 50. The channels 63 are separated by ridges 64 which connect the outer ring of the face plate with the centre portion such that deformation under influence of hydraulic pressure in the channels 63 is prevented or limited. The ridges 64 extend up to a small distance below the flat upper surface of the face plate 50 such that anywhere in the face plate port 3 the same pressure may be present. The ridges 64 are provided such that the largest dimension of the channels 63 is smaller than three times the width of the face plate port 3. Through the application of the ridges 64 the sealing surface of the face plate 50 against the drum plate 4 and the sealing ridges 62 keep their shape better and leakage is prevented or limited. Additionally at the spherical side of the face plate 50 the ridges 64 extend up to a small distance below the spherical surface of the sealing ridges 62 such that in the connection port 33 from all channels 63 oil can flow to the opening in the concave inner surface 62 without obstruction.

As described earlier, a pin which is mounted to the face plate 50 and moves within a slit, wherein the face plate 50 can rotate about the rotation shaft of the pin, can serve to limit the rotation of the face plate 50 in one axis of rotation. This means that the exact position of the face plate in respect of the angle of stroke α and setting angle δ can be set by means of two actuators. It is possible for example to guide one of the pistons 58 in a slit 65 in the concave inner surface 53 of the face plate 50. Possibly the slit 65 can be oval and in that case the rotation is limited by guiding two pistons 58 within a slit 65. If the slit 65 lies in a plane in which the rotor shaft 1 lies, the face plate 50 will not rotate about the rotor shaft 1.

The embodiments as described hereinafter describe the adjustment of the face plate of a hydraulic transformer. The face plate of a pump of a hydraulic motor can be adjusted in a comparable manner, such that this obtains an adjustable swept volume in a simple way.

The invention is described by means of a hydraulic device wherein the pistons move within bushes which are supported by a drum plate and wherein the drum plate rotates along the face plate. It may be clear that the invention can also be applied in hydraulic devices which do not have separate bushes but wherein a rotor in which pistons move rotates against the face plate or wherein the chambers that have varying volumes are formed with other components in another way.

1. A hydraulic device comprising:
   a housing,
   two or more pipe ports in the housing,
   a rotor including a plurality of rotor chambers which are each formed by a cylinder and a piston which rotate about a first axis of rotation and a second axis of rotation, respectively, wherein both axes of rotation extend in a common plane and intersect each other by an acute angle such that upon rotating the rotor the volume of the rotor chambers changes,
   a face plate including a face plate centre line which coincides with the second axis of rotation, wherein the face plate comprises two or more face plate ports which each
connect with a pipe port in the housing for connecting the pipe port with the rotor chambers, an adjustment device for adjusting the mutual positions of the face plate and the common plane, and wherein a face plate bearing, between the face plate and the housing, has at least two axes of rotation which intersect the face plate centre line, and wherein upon rotating the face plate the common plane rotates with respect to the housing.

2. The hydraulic device according to claim 1, wherein two axes of rotation of the face plate bearing intersect the face plate centre line in the intersection point of the first axis of rotation and the second axis of rotation.

3. The hydraulic device according to claim 1, wherein the face plate bearing comprises a spherical surface of the face plate and a concave surface of the housing, in which the spherical surface can rotate.

4. The hydraulic device according to claim 1, wherein the face plate bearing comprises cylindrical bearings having non-parallel axes of rotation.

5. The hydraulic device according to claim 1, wherein the housing is provided with a limiting edge which limits rotation of the face plate with respect to the housing.

6. The hydraulic device according to claim 3, wherein the face plate and the housing are provided with meshing teeth.

7. The hydraulic device according to claim 3, wherein support cylinders are provided between the housing and the face plate and wherein via a channel the support cylinder(s) communicates with the face plate port which is located diametrically opposite to the support cylinder(s).

8. The hydraulic device according to claim 7, wherein the face plate port has a connection opening at the side of the spherical surface and wherein the face plate around the connection opening has a sealing ridge which seals against the concave surface of the housing.

9. The hydraulic device according to claim 7, wherein each support cylinder is supported by a support surface of the housing wherein the support surface forms a part of a cylinder of which the centre line intersects the axis of rotation perpendicularly.

10. The hydraulic device according to claim 8, wherein the projection of the connection opening on a plane perpendicular to the face plate centre line has the same surface area and centre of gravity at the same location as the projection of the face plate port on the plane perpendicular to the face plate centre line and wherein the projection of the connection opening on a plane through the face plate centre line and extending perpendicular to a line through the centre of gravity of the surface of the connection opening and the face plate centre line has the same surface area and centre of gravity in the same location as the projection of the contact surfaces of the support cylinder(s) with the housing on the plane.

11. The hydraulic device according to claim 3, wherein the face plate port is provided with ridges such that the largest dimension of a channel through the face plate is smaller than three times the width of the face plate port.

12. The hydraulic device according to claim 1, wherein the at least two axes of rotation of the face plate bearing intersect the face plate centre line perpendicularly.

13. The hydraulic device according to claim 2, wherein the face plate bearing comprises a spherical surface of the face plate and a concave surface of the housing, in which the spherical surface can rotate.

14. The hydraulic device according to claim 2, wherein the face plate bearing comprises cylindrical bearings having non-parallel axes of rotation.

15. The hydraulic device according to claim 8, wherein each support cylinder is supported by a support surface of the housing wherein the support surface forms a part of a cylinder of which the centre line intersects the axis of rotation perpendicularly.

16. The hydraulic device according to claim 9, wherein the projection of the connection opening on a plane perpendicular to the face plate centre line has the same surface area and centre of gravity at the same location as the projection of the face plate port on the plane perpendicular to the face plate centre line and wherein the projection of the connection opening on a plane through the face plate centre line and extending perpendicular to a line through the centre of gravity of the surface of the connection opening and the face plate centre line has the same surface area and centre of gravity in the same location as the projection of the contact surfaces of the support cylinder(s) with the housing on the plane.

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