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(54) **Hydraulic machine, in particular hydraulic pressure exchanger**

(57) A hydraulic machine, in particular hydraulic pressure exchanger, is provided comprising a drum rotatable about a rotational axis, a first front plate arrangement at a first front face of said drum, a second front plate arrangement at a second front face of said drum, said drum comprising a plurality of cylinders, said first front plate arrangement comprising a first front plate and a pressure shoe (8), said first front plate comprising at least a high pressure supply port.

Such a pressure exchanger should have a simple construction.

To this end the pressure shoe (8) comprises at least a pressure cylinder (14), said pressure cylinder (14) opening to said first front plate, a piston (17) being arranged in said pressure cylinder (14), said pressure cylinder (14) being in fluid contact with said high pressure supply port.

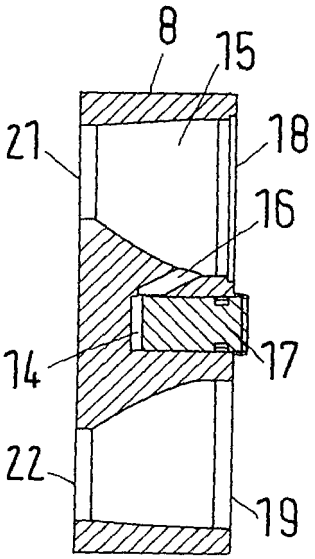

Fig.3

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Description

[0001] The present invention relates to a hydraulic machine, in particular hydraulic pressure exchanger, comprising a drum rotatable about a rotational axis, a first front plate arrangement at a first front face of said drum, a second front plate arrangement at a second front face of said drum, said drum comprising a plurality of working cylinders, said first front plate arrangement comprising a first front plate and a pressure shoe, said first front plate comprising at least a supply port.

[0002] Such a hydraulic pressure exchanger is known from EP 1 508 361 A1. A pressure exchanger of this kind can be used for example in a reverse osmosis system in which a liquid is pumped through a membrane under a rather high pressure. The liquid not passing the membrane is supplied to the supply port of the pressure exchanger. The high pressure of this liquid is transferred to a fluid being supplied to the second front face of the drum. A piston in each working cylinder is used to effect the pressure transfer. When a working cylinder is in fluid connection with the supply port high pressure fluid enters, shifting the piston to the other side thereby transferring the high pressure to the liquid on the other side. The drum rotates. After a predetermined rotational angle this working cylinder comes in contact to a low pressure supply port in which fresh liquid under a lower pressure fills the working cylinder shifting the piston back to the first front face.

[0003] The path between the high pressure supply port (and all other ports as well) and the working cylinder must be as tight as possible to avoid leakage. In the known case each working cylinder is provided with a bushing at each end. This bushing is pressed axially outwardly to contact the pressure shoe with a force being high enough to establish the necessary tightness. This force is also used to press the pressure shoe at each front face axially outwardly so that the pressure shoe rests against the front plates at each front face of said drum.

[0004] The object underlying the invention is to have a simple construction of a hydraulic machine.

[0005] This object is solved in that the pressure shoe comprises at least a pressure cylinder, said pressure cylinder opening to said first front plate, a piston being arranged in said pressure cylinder, said pressure cylinder being in fluid contact with said high pressure supply port.

[0006] With this solution it is possible to keep the pressure shoe unrotatable relative to the first front plate. The pressure shoe is pressed against the front face of the drum. The force pressing the pressure shoe against the front face of the drum is at least partly generated by the piston in the pressure cylinder. This piston is loaded by the pressure in the port which is preferably the highest pressure in the pressure exchanger. In this case the port is a high pressure supply port. This pressure presses the piston in the pressure cylinder in a direction towards the first front plate. This force creates a counter force pressing the pressure shoe against the drum. The pressure pressing the pressure shoe against the drum should be high enough to achieve the desired tightness. However, it should be not too high in order to avoid excessive wear. The resulting force can be determined rather exactly by the dimension of the piston in the pressure cylinder. The term "cylinder" is used to facilitate the explanation. Such a cylinder can have a circular cross section although other forms are possible. The working cylinders can simply be considered as channels, such channels may be straight or curved.

[0007] Preferably said pressure cylinder is arranged in an area which is closer to said rotational axis than to a circumference of said drum. In this case, the force pressing the pressure shoe towards the front face of the drum acts in a region near the center of the pressure shoe and of the center of the drum. This allows a rather equal distribution of forces over the entire area of the pressure shoe.

[0008] Preferably at least two pressure cylinders are arranged in said pressure shoe. In this case the force pressing the pressure shoe against the front face of the drum can be doubled so that each pressure cylinder can be kept small. Furthermore, such a construction has the advantage that the forces act at different positions on the pressure shoe.

[0009] In a preferred embodiment said pressure cylinders have the same cross section area. In this way, the forces generated by the pistons in each cylinder are equal since the pressure cylinders are loaded with the same pressure. This makes it easier to distribute the forces in the desired manner. Preferably said pressure shoe comprises two ports on a side facing said front plate, said ports having a minimum distance along a straight line, said pressure cylinder being offset to said straight line by a predetermined displacement. In many cases, the pressure shoe comprises a first port connected to a high pressure supply port and a second port connected to a low pressure return port. When these two ports are arranged on a vertical line, the pressure cylinder is offset to this vertical line in horizontal direction. The same relation is true when the two ports are arranged in another spatial direction. When the pressure cylinder is offset to the straight line between the two ports, there is sufficient space available so that the pressure cylinder can have a sufficiently large diameter.

[0010] In a preferred embodiment said pressure cylinder is arranged between said ports. Seen parallel to the above mentioned straight line, said pressure cylinder and said ports overlap each other. This makes it possible to position the pressure cylinder in an area near the center of the pressure shoe.

[0011] Preferably said pressure shoe comprises at least a high pressure channel connected to said port and an outer pressure area loaded by a pressure in said port in a direction towards said drum, said outer pressure area being larger than an inner pressure area on a side of said pressure shoe facing such drum. In this way an additional force is generated pressing the pressure shoe against

the front face of the drum. This additional force is based on the difference between the outer pressure area and the inner pressure area.

[0012] Preferably said outer pressure area is arranged within said channel. No other areas are necessary. The liquid entering the channel acts automatically on the outer pressure area.

[0013] In a preferred embodiment said pressure shoe rests against said drum in a contact area, two different materials contacting each other in said contact area, one material being steel and the other material being a plastic material sliding with slow friction on steel, in particular a high-resistant thermoplastic plastic material on the basis of polyaryl etherketones, particularly polyetheretherketones (PEEK), polyamides, polyacetals, polyarylethers, polyethylene terephthalates, polyphenylene sulfides, polysulphones, polyether sulphones, polyether imides, polyamide imides, polyacrylates, phenol resins, like novolacquer resins or the like, preferably provided with a filling of glass, graphite, polytetraflourethylene or carbon, the fillings being particularly useful as fibres. In this case, the pressure exchanger and advantages be used as a water hydraulic device.

[0014] A preferred example of the invention will now be described in more detail with reference to the drawing, wherein:

Fig. 1 is a schematic longitudinal section of a hydraulic machine,

Fig. 2 is a view of a pressure shoe seen from a front plate and

Fig. 3 is a section III-III of Fig. 2.

[0015] Fig. 1 shows a hydraulic machine in the form of a hydraulic pressure exchanger 1 in a schematically longitudinal section.

[0016] The pressure exchanger 1 comprises a drum 2 rotatable about an axis 3. The term "drum" is used to facilitate the explanation. It is not necessary that this drum 2 is of cylindrical form. The main purpose of the drum 2 is to form a basis for working cylinders 4. The drum 2 comprises a plurality of working cylinders 4, two working cylinders 4 being shown in Fig. 1. The drum 2 can also be termed as "cylinder carrier". The term "working cylinder" is used to simplify the description. The working cylinder can be regarded as channel. It is not necessary that the working cylinder has circular cross section nor is it necessary that it is straight. It can be curved as well.

[0017] A first front plate arrangement 5 is arranged at a first axial end or front face of the drum 2. A second front plate arrangement 6 is arranged at a second axial end or front face of the drum 2 which is opposite of the first axial end of the drum 2.

[0018] The first front plate arrangement 5 comprises a first front plate 7 and a pressure shoe 8. The pressure shoe 8 rests against the drum 2. The pressure shoe 8 is loaded in a direction towards the drum 2 by means explained below. A sleeve 9 is fixedly inserted into the pressure shoe 8 and slidingly arranged in the first front plate 7.

[0019] The first front plate 7 comprises a port 10 and a second port 11. The sleeve 9 is inserted into an opening of the first front plate 7 connected to the first port 10. The first port 10 can be used to supply high pressure and the second port can be used to return hydraulic liquid. However, this is just an example and other pressure relations are possible in principle.

[0020] The first front plate 7 is connected to a housing 12. The housing 12 is connected to a second front plate 13 which is arranged on the opposite side of the housing 12 relative to the first front plate 7. The second front plate 13 is part of the second front plate arrangement 6.

[0021] Means for rotatably supporting and driving the drum 2 are not shown in order to keep the illustration simple. However, the drum 2 can be rotatable supported within the housing 12. A driving shaft can be passed through the second front plate 13.

[0022] The pressure shoe 8 is supported unrotatably in the housing 12, so that it remains stationary in rotating direction relative to the first front plate 7. However, a small movement in a direction towards the drum 2 is possible.

[0023] As can be seen in Fig. 2 and 3, the pressure shoe 8 comprises two pressure cylinders 14 which are connected to a high pressure channel 15, said high pressure channel 15 being in fluid connection with the first port 10. A short supply channel 16 establishes a connection between the cylinder 14 and the high pressure channel 15. The pressure cylinder 14 has a circular cross section although other forms are possible.

[0024] A piston 17 is arranged in each pressure cylinder 14. In Fig. 3 it is shown that the piston 17 protrudes out of the pressure shoe 8. The length of the piston 17 protruding out of the pressure shoe 8 is larger than it is in reality in order to facilitate the explanation. The piston 17 could have different diameters in order to achieve an amplification.

[0025] The pressure shoe comprises two ports 18, 19, i.e. a first port 18 which is connected to the high pressure channel 15 and which overlaps the first port 10 in the first front plate 7, and a second port 19 which is connected to a low pressure channel 20 in the pressure shoe 8 and overlaps the second port 11 in the first front plate 7.

[0026] The two ports 18, 19 have a minimum distance along a straight line, said straight line running through the axis 3. The two pressure cylinders 14 are offset to this minimum distance line, i.e. offset to the axis 3 in radial direction.

[0027] Furthermore, the pressure cylinders 14 are nevertheless arranged between said two ports 18, 19, i.e. seen in a direction parallel to the above mentioned straight line the ports 18, 19 and the pressure cylinders 14 overlap each other at least partially.

[0028] During operation, the pressure cylinder 14 is loaded by the pressure in the high pressure supply port 10. This pressure presses the piston 17 against the first

front plate 7 generating a counter force pressing the pressure shoe against the drum 2. In this way, a fluid tight or almost fluid tight connection can be established between the first port 10 and the working cylinders 4.

[0029] The force with which the pressure shoe 8 is pressed against the front face of the drum 2 should be sufficient to create a tight fluid path between the first port 10 and the working cylinders 4. However, it should not be too large in order to avoid wear and abrasion. The force can be determined with high accuracy by dimensioning the pressure cylinder 14 and the piston 17 in an appropriate manner.

[0030] At the side facing the drum 2, the pressure shoe 8 comprises two arc-shaped or kidney-shaped openings 21, 22. The area of the first port 18 is larger than the area of the high pressure kidney-shaped opening 21 and the area of the second port 19 is larger than the area of the low pressure kidney-shaped opening 22. In this way, additional forces are provided pressing the pressure shoe 8 against the drum 2. According to this dimensioning, in the high pressure channel 15 an outer pressure area is provided on which the pressure in the high pressure supply port 18 can act. This outer pressure area is larger than an inner pressure area on which hydraulic pressure can act in the opposite direction.

[0031] When the hydraulic pressure exchanger 1 is used as a water hydraulic machine, the pressure shoe 8 and the drum 2 rest against each other in a contact area. In this contact area at least the surfaces of the drum 2 and the pressure shoe 8, respectably, have different materials, one material being steel and the other material being a plastic material sliding with slow friction on steel, in particular a high-resistant thermoplastic plastic material on the basis of polyaryl etherketones, particularly polyetheretherketones (PEEK), polyamides, polyacetals, polyarylethers, polyethylene terephthalates, polyphenylene sulfides, polysulphones, polyether sulphones, polyether imides, polyamide imides, polyacrylates, phenol resins, like novolacquer resins or the like, preferably provided with a filling of glass, graphite, polytetraflourethylene or carbon, the fillings being particularly useful as fibers. Such a combination of materials guarantee a long lifetime duration even in the case water is used as hydraulic fluid instead of an lubricating oil.

Claims

1. A hydraulic machine, in particular hydraulic pressure exchanger (1) comprising a drum (2) rotatable about a rotational axis (3), a first front plate arrangement (5) at a first front face of said drum (2), a second front plate (6) arrangement at a second front face of said drum (2), said drum (2) comprising a plurality of working cylinders (4), said first front plate arrangement (5) comprising a first front plate (7) and a pressure shoe (8), said first front plate (7) comprising at least a port (10), **characterized in that** the pressure shoe (8) comprises at least a pressure cylinder (14), said pressure cylinder (14) opening to said first front plate (7), a piston (17) being arranged in said pressure cylinder (14), said pressure cylinder (14) being in fluid contact with said port (10).

2. The hydraulic machine according to claim 1, **characterized in that** said pressure cylinder (14) is arranged in an area which is closer to said rotational axis (3) than to a circumference of said drum (2).

3. The hydraulic machine according to claim 1 or 2, **characterized in that** at least two pressure cylinders (14) are arranged in said pressure shoe (8).

4. The hydraulic machine according to claim 3, **characterized in that** said pressure cylinders (14) have the same cross section area.

5. The hydraulic machine according to any of claims 1 to 4, **characterized in that** said pressure shoe (8) comprises two ports (18, 19) on a side facing said first front plate (7), said ports (18, 19) having a minimum distance along a straight line, said pressure cylinder (14) being offset to said straight line by a predetermined displacement.

6. The hydraulic machine according to claim 5, **characterized in that** said pressure cylinder (14) is arranged between said ports (18, 19).

7. The hydraulic machine according to any of claims 1 to 6, **characterized in that** said pressure shoe (8) comprises at least a high pressure channel (15) connected to said port (10) and an outer pressure area loaded by a pressure in said port (10) in a direction towards said drum (2), said outer pressure area being larger than an inner pressure area on a side of said pressure shoe facing said drum (2).

8. The hydraulic machine according to claim 7, **characterized in that** said outer pressure area is arranged within said channel (15).

9. The hydraulic machine according to any of claims 1 to 8, **characterized in that** said pressure shoe (8) rests against said drum (2) in a contact area, two different materials contacting each other in said contact area, one material being steel and the other material being a plastic material sliding with slow friction on steel, in particular a high-resistant thermoplastic plastic material on the basis of polyaryl etherketones, particularly polyetheretherketones (PEEK), polyamides, polyacetals, polyarylethers, polyethylene terephthalates, polyphenylene sulfides, polysulphones, polyether sulphones, polyether imides, polyamide imides, polyacrylates, phenol resins, like novolacquer resins or the like, preferably provided

with a filling of glass, graphite, polytetraflourethylene or carbon, the fillings being particularly useful as fibres.

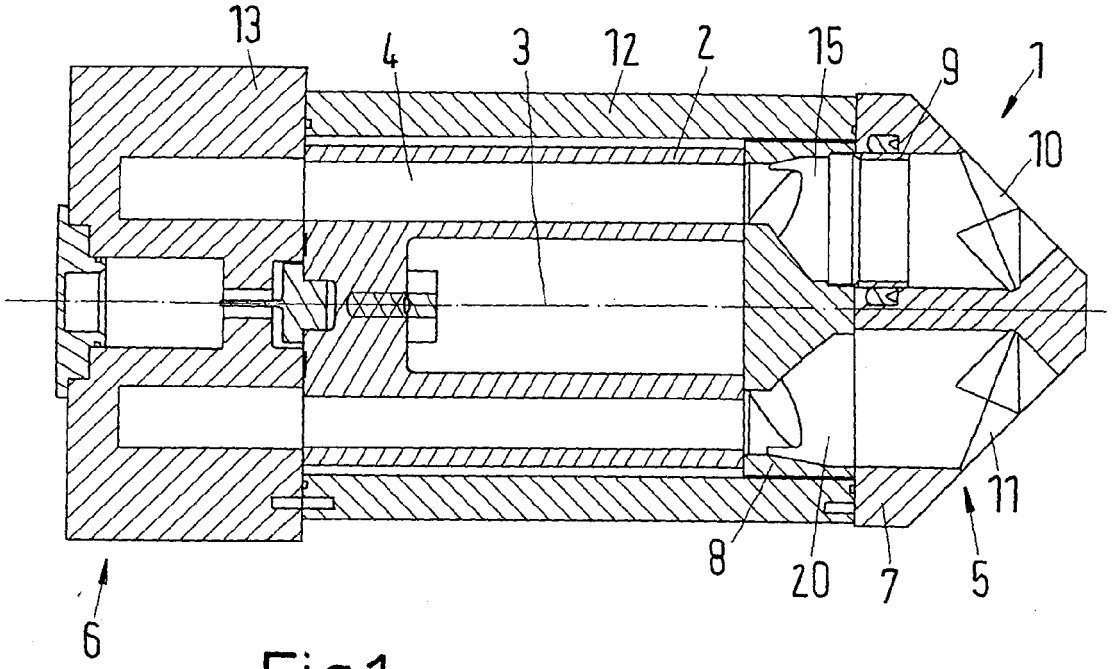

Fig.1

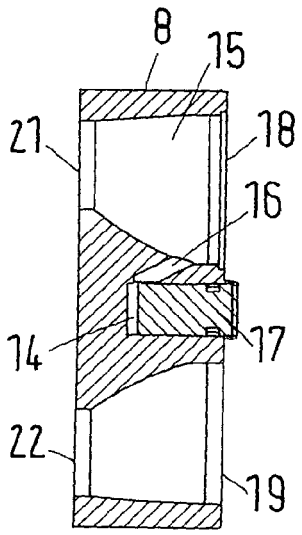

Fig.3

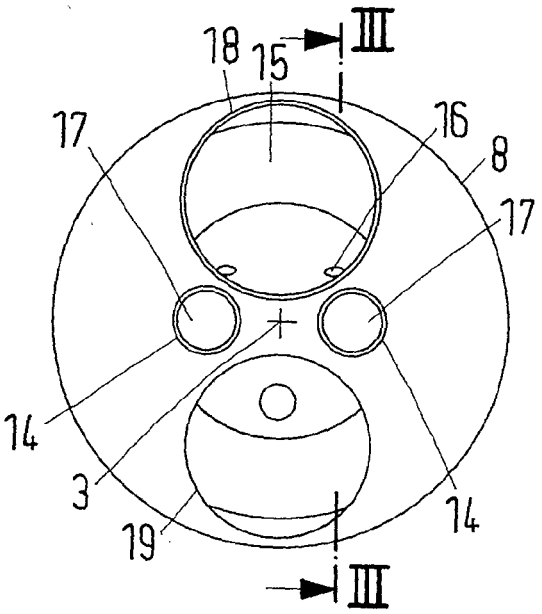

Fig.2

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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 0511

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 January 2014	Fistas, Nikolaos

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 18 0511

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REFERENCES CITED IN THE DESCRIPTION

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