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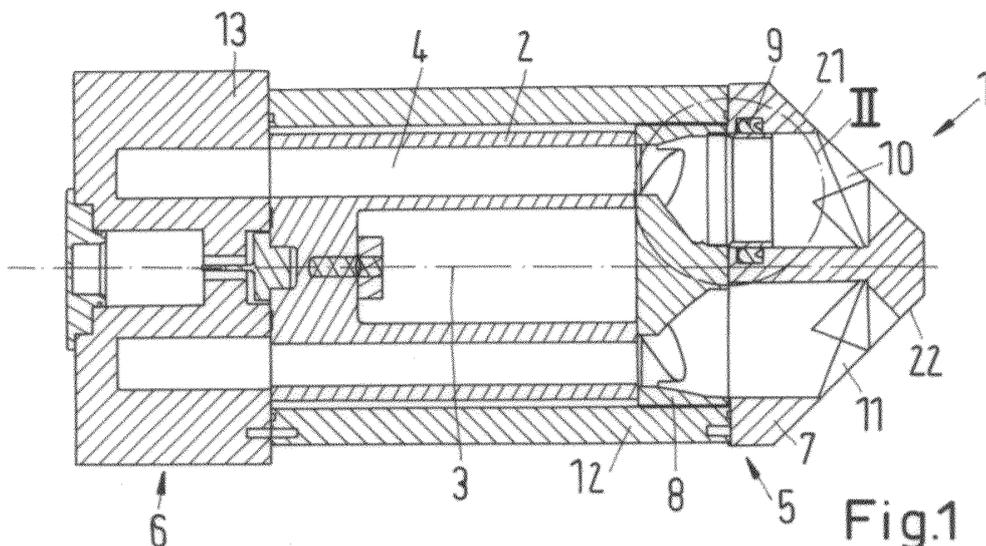
Remarks:
 Amended claims in accordance with Rule 137(2) EPC.

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

(57) A hydraulic machine (1) comprising a drum (2) rotatable around a rotational axis (3), a motor connection for driving said drum (2), a first front plate arrangement (5) at a first front face of said drum (2), a second front plate arrangement (5) at a second front face of said drum (2), said drum (2) comprising a plurality of cylinders (4), said first front plate arrangement (5) comprising a first front plate (7), a pressure shoe (8), and first sealing means (9), said first front plate (7) comprising at least a high pressure supply port (10).

Such a pressure exchanger should have a simple construction.

To this end, said pressure shoe (8) comprises at least a high pressure channel (17) connected to said high pressure supply port (10) and an outer pressure area (18) loaded by a pressure in said high pressure supply port (10) in a direction towards said drum (2), said outer pressure area (18) being larger than an inner pressure area (19) on a side of said pressure shoe (8) facing said drum (2).



Description

[0001] The invention relates to a hydraulic machine comprising a drum rotatable about a rotational axis, a motor connection for driving said drum, a first front plate arrangement at a first front face of said drum, a second front plate arrangement at a second 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, said first front plate comprising at least a port.

[0002] Such a hydraulic machine in the form of a hydraulic pressure exchanger is known from EP 1 508 361 A 1. A pressure exchanger of this kind can be used for example in a reverse osmosis system in which the liquid is pumped through a membrane under a rather high pressure. The liquid not passing the membrane is supplied to the high pressure supply port of the pressure exchanger. This high pressure is transferred to a fluid being supplied to the second front face of the drum. A piston in each cylinder is used to affect the pressure transfer. When a cylinder is in fluid connection with the high pressure supply port high pressure fluid enters this cylinder and shifts 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 cylinder comes in contact to a low pressure supply port in which fresh liquid under a lower pressure fills the cylinder shifting the piston back again.

[0003] The path between the high pressure supply port (and all other ports as well) and the cylinder must be as tight as possible to avoid leakage. In the known case each 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 shoes 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 by a hydraulic machine as mentioned above in that said pressure shoe is movable relative to the drum in a direction of said rotational axis and 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 said drum.

[0006] The term "drum" is used for the purpose of explanation only. It is not necessary that the "drum" is cylindrical body. The term "drum" just means a carrier of the cylinders mentioned above which is rotatable about the rotational axis. Furthermore, the cylinders can have a cross section which may be circular or may have any other form. Furthermore, the cylinders may be straight or curved in longitudinal direction. The pressure shoe is

pressed against the front face of the drum by means of the pressure at the high pressure supply port. A pressure shoe is necessary only on one side. The other side of the drum rests against the second front plate arrangement. In this way equal pressures on both front faces of the drum can be realised. This leads automatically to an equilibrium of forces over the drum (independent of pressure).

[0007] Preferably said pressure shoe is held unrotatable. In this way the first front face of the drum rests against the pressure shoe and friction is generated between this front face and the pressure shoe only. This reduces wear. Since the pressure shoe is not rotating, the number of bushings needed is dramatically reduced. Only one bushing is necessary for the high pressure port connecting said first front plate and said pressure shoe. A second bushing may be necessary between the first front plate and the pressure shoe in a region of another port. The pressure shoe can be moved in the direction of the rotational axis only, wherein such movement is very small.

[0008] 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.

[0009] Preferably said channel comprises a section area decreasing in a direction towards said drum. The decreasing section area automatically provides the outer pressure area on which the pressure acts at the high pressure supply port.

[0010] In a preferred embodiment said high pressure channel comprises a circle-shaped inlet on a side facing said first front plate and a kidney-shaped outlet on a side facing said drum. The circle-shaped inlet comprises an area which is larger than the kidney-shaped outlet. The difference between the area of the circle-shaped inlet and the kidney-shaped outlet is the area on which the pressure at the high pressure supply port acts in a direction towards the drum.

[0011] Preferably a sleeve is inserted in said high pressure channel in said pressure shoe and in said port in said first front plate. This sleeve makes a fluid tight path between the first front plate and the pressure shoe. When a circle-shaped inlet is used it is rather simple to use a cylindrical sleeve.

[0012] In a preferred embodiment said sleeve is fixed in said pressure shoe and movable and sealed in said first front plate. The movement is restricted to the axial direction and allows to establish sufficient pressure contact between the pressure shoe and the front face of the drum.

[0013] Preferably said first front plate comprises two ports the centres of which are arranged on a first straight line and said second front plate arrangement comprises a second front plate with two ports the centres of which are arranged on a second straight line, said first straight line and said second straight line being angularly offset to each other. In this way it is possible to have connecting

lines on one side extending in a first direction and connection lines at the other side extending in a second direction which is angularly offset to the first direction. This gives a greater freedom in the arrangement of connecting lines.

[0014] Preferably one of said front plates comprises a connecting geometry having at least a first mounting surface in which one of the ports is arranged, said first mounting surface being arranged under a predetermined angle relative to the rotational axis of said drum, said angle being in the range of 10° to 80°, in particular in the range of 30° to 60°, and preferably in the range of 40° of 50°. When the mounting surface is arranged under an angle relative to the rotational axis and relative to a plane which is perpendicular to the rotational axis there is a larger area available for connecting a line to the mounting surface.

[0015] 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, polytetrafluorethylene or carbon, the fillings being particularly useful as fibres. In this case, the hydraulic machine and advantages be used as a water hydraulic device.

[0016] 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 an enlarged detail II of Fig. 1,

Fig. 3 is a perspective view of the hydraulic machine,

Fig. 4 is a view of a pressure shoe seen from the inside,

Fig. 5 is a section V-V according to Fig. 6,

Fig. 6 is a view of a pressure shoe seen from the outside and

Fig. 7 is a perspective view of the pressure shoe.

[0017] Fig. 1 shows a hydraulic machine 1 in form of a hydraulic pressure exchanger in a schematically longitudinal section. However, hydraulic machine can also be, for example, a pump, a motor, an energy converter,

an amplifier etc.

[0018] The hydraulic machine 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 cylinders 4. The cylinders 4 can be considered as channels. It is not necessary that they are of circular cross section.

[0019] A first front plate arrangement 5 is arranged at a first front face of the drum 2. A second front plate arrangement 6 is arranged at a second front face of the drum 2 which is opposite of the first front face of the drum 2. The first front plate arrangement 5 comprises a first front plate 7 and a pressure shoe 8. Further more, sealing means 9 are provided at the first front plate arrangement 5.

[0020] The first front plate 7 comprises a first port 10 and a second port 11. The first port 10 may be a high pressure supply port and the second port 11 may be a low pressure return port. However, other pressures and other flow directions may be possible.

[0021] 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.

[0022] 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 rotatably supported within the housing 12. A driving shaft can be passed through the second front plate 13 and be connected to a motor (not shown).

[0023] 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. A bushing or sleeve 14 is inserted into an inlet 15 (Fig. 2) of the pressure shoe 8. This inlet 15 has the form of a circle, so that the sleeve 14 can be made as a hollow cylinder. The sleeve 14 is inserted as well in the first port 10. Here, the sealing means 19 are used to form a fluid tight connection between the first port 10 and the inlet 15 of the pressure shoe 8.

[0024] As can be seen in Fig. 4 the pressure shoe 8 shows at the side opposite to the inlet 15 an outlet 16 having the form of a kidney. The side of the pressure shoe 8 in which the kidney-shaped outlet 16 is arranged faces the drum 2. The kidney-shaped outlet 16 is arranged on the same radius as the cylinders 4. Therefore, the openings of the cylinders 4 come in overlapping relation with the kidney-shaped outlet 16 during a rotation of the drum. As can be seen in Fig. 4-6, the pressure shoe 8 comprises a high pressure channel 17 between the first port 10 and the drum 2.

[0025] A pressure area 18, which is termed "outer pressure area", is arranged in this channel 17. The outer pressure area is larger than an inner pressure area 19 on a side of said pressure shoe 8 facing said drum 2.

[0026] Due to this construction the force on the pres-

sure shoe 8 acting in a direction towards the drum 2 is larger than the force acting in the opposite direction so that the pressure shoe 8 is firmly pressed against the drum 2. The effect is that a pressure tight connection is formed between the high pressure channel 17 and the cylinders 4 overlapping the kidney-shaped outlet 16. The force acting in direction towards the drum 2 is a product of the pressure in the first port 10 and the outer pressure area 18. The force acting in the opposite direction is the product of the same pressure and the slightly smaller inner pressure area 19.

[0027] Due to this construction only one pressure shoe on the first front face of the drum 2 is necessary. The force pressing the pressure shoe 8 against the drum 2 also presses the drum 2 against the second front plate 13 so that a liquid tight seal is formed between the drum 2 and the second front plate 13 as well.

[0028] In this way an equilibrium of forces is formed over the drum 2 (independent of pressure). By adjusting the sizes of the outer pressure area 18 and the inner pressure area 19 the forces acting between the pressure shoe 8 and the drum 2 or the drum 2 and the second front plate 13 can be adjusted very accurately.

[0029] Due to the sleeve 14, the pressure shoe 8 can be moved in axial direction, i.e. parallel to the axis 3. Such a movement is necessary only to press the pressure shoe 8 against the drum 2. Therefore, such a movement can be kept very small.

[0030] As can be seen in Fig. 3, the first front plate 7 comprises two ports (only the second port 11 is visible). These ports are arranged on a first straight line.

[0031] The second front plate 13 comprises two ports as well, i.e. a first port 20 and a second port (not visible). The last two ports are arranged on a straight line as well. As can be seen in Fig. 3, these two straight lines are angularly offset to each other. In the embodiment shown in Fig. 3, the first straight line is arranged vertically and the second straight line is arranged on the angle of 45° relative to the vertical direction.

[0032] As can be seen in Figs. 1 and 3, the first front plate 7 comprises a connecting geometry having at least a mounting surface 21, 22. The mounting surfaces 21, 22 are arranged under a predetermined angle relative to the rotational axis 3 of the drum 2. In the present case, this angle is approximately 45°. However, it can be in the range of 10° to 80°, and particular in the range of 30° to 60° and preferably in the range of 40° to 50°.

[0033] When the hydraulic machine 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, respectively, have different materials, one material is steel and the other material is a plastic material, said plastic material having a low friction coefficient on steel. This plastic material is in particular a high-resistant thermoplastic plastic material on the basis of polyaryl etherketones, particularly polyetheretherketones (PEEK), polyamides, polyacetals, polyarylethers, poly-

ethylene 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, polytetrafluorethylene or carbon, the fillings being particularly useful as fibres. 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 (1) comprising a drum (2) rotatable around a rotational axis (3), a motor connection for driving said drum (2), a first front plate arrangement (5) at a first front face of said drum (2), a second front plate arrangement (6) at a second front face of said drum (2), said drum (2) comprising a plurality of 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** said pressure shoe (8) is movable relative to the drum (2) in a direction of said rotational axis (3) and comprises at least a high pressure channel (17) connected to said port (10) and an outer pressure area (18) loaded by a pressure in said port (10) in a direction towards said drum (2), said outer pressure area (18) being larger than an inner pressure area (19) on a side of said pressure shoe (8) facing said drum (2).
2. The pressure exchanger according to claim 1, **characterized in that** said pressure shoe (8) is held unrotatable.
3. The pressure exchanger according to claim 1 or 2, **characterized in that** said outer pressure area (18) is arranged within said channel (17).
4. The pressure exchanger according to claim 3, **characterized in that** said channel (17) comprises a section area decreasing in a direction towards said drum (2).
5. The pressure exchanger according to claim 4, **characterized in that** said high pressure channel (17) comprises a circle-shaped inlet (15) on a side facing said first front plate (7) and a kidney-shaped outlet (16) on a side facing said drum (2).
6. The pressure exchanger according to any of claims 1 to 5, **characterized in that** a sleeve (14) is inserted in said high pressure channel (17) in said pressure shoe (8) and in said high pressure supply port (10) in said first front plate (7).
7. The pressure exchanger according to claim 6, **char-**

acterized in that said sleeve (14) is fixed in said pressure shoe (8) and movable and sealed in said first front plate (7).

8. The pressure exchanger according to any of claims 1 to 7, **characterized in that** said first front plate (7) comprises two ports (10, 11) the centers of which are arranged on a first straight line and said second front plate arrangement (6) comprises a second front plate with two ports (20) the centers of which are arranged on a second straight line, said first straight line and said second straight line being angularly offset to each other.
9. The pressure exchanger according to claim 8, **characterized in that** at least one of said front plates (7, 13) comprises a connecting geometry having at least a first mounting surface (21, 22) in which one of the ports (10, 11) is arranged, said first mounting surface (21, 22) being arranged under a predetermined angle relative to the rotational axis (3) of said drum (2), said angle being in the range of 10° to 80°, in particular in the range of 30° to 60° and preferably in the range of 40° to 50°.
10. The pressure exchanger according to any of claims 1 to 9, **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, polytetrafluorethylene or carbon, the fillings being particularly useful as fibres.

Amended claims in accordance with Rule 137(2) EPC.

1. A pressure exchanger (1) comprising a drum (2) rotatable around a rotational axis (3), a motor connection for driving said drum (2), a first front plate arrangement (5) at a first front face of said drum (2), a second front plate arrangement (6) at a second front face of said drum (2), said drum (2) comprising a plurality of 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** said pressure shoe (8) is movable relative to the drum (2) in a di-

rection of said rotational axis (3) and comprises at least a high pressure channel (17) connected to said port (10) and an outer pressure area (18) loaded by a pressure in said port (10) in a direction towards said drum (2), said outer pressure area (18) being larger than an inner pressure area (19) on a side of said pressure shoe (8) facing said drum (2), whereby the force on the pressure shoe (8) acting in a direction towards the drum (2) is larger than the force acting in the opposite direction so that the pressure shoe (8) is firmly pressed against the drum (2).

2. The pressure exchanger according to claim 1, **characterized in that** said pressure shoe (8) is held unrotatable.
3. The pressure exchanger according to claim 1 or 2, **characterized in that** said outer pressure area (18) is arranged within said channel (17).
4. The pressure exchanger according to claim 3, **characterized in that** said channel (17) comprises a section area decreasing in a direction towards said drum (2).
5. The pressure exchanger according to claim 4, **characterized in that** said high pressure channel (17) comprises a circle-shaped inlet (15) on a side facing said first front plate (7) and a kidney-shaped outlet (16) on a side facing said drum (2).
6. The pressure exchanger according to any of claims 1 to 5, **characterized in that** a sleeve (14) is inserted in said high pressure channel (17) in said pressure shoe (8) and in said high pressure supply port (10) in said first front plate (7).
7. The pressure exchanger according to claim 6, **characterized in that** said sleeve (14) is fixed in said pressure shoe (8) and movable and sealed in said first front plate (7).
8. The pressure exchanger according to any of claims 1 to 7, **characterized in that** said first front plate (7) comprises two ports (10, 11) the centers of which are arranged on a first straight line and said second front plate arrangement (6) comprises a second front plate with two ports (20) the centers of which are arranged on a second straight line, said first straight line and said second straight line being angularly offset to each other.
9. The pressure exchanger according to claim 8, **characterized in that** at least one of said front plates (7, 13) comprises a connecting geometry having at least a first mounting surface (21, 22) in which one of the ports (10, 11) is arranged, said first mounting surface (21, 22) being arranged under a predetermined an-

gle relative to the rotational axis (3) of said drum (2), said angle being in the range of 10° to 80°, in particular in the range of 30° to 60° and preferably in the range of 40° to 50°.

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10. The pressure exchanger according to any of claims 1 to 9, **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, polytetrafluorethylene or carbon, the fillings being particularly useful as fibres.

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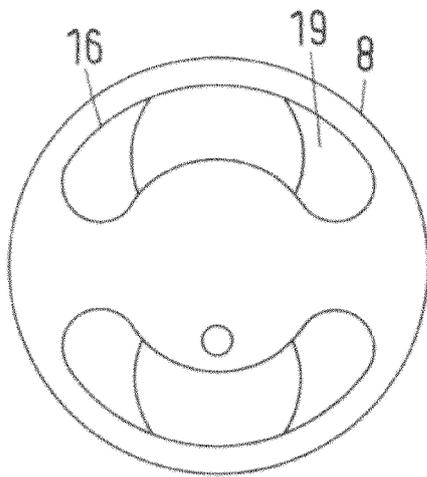


Fig.4

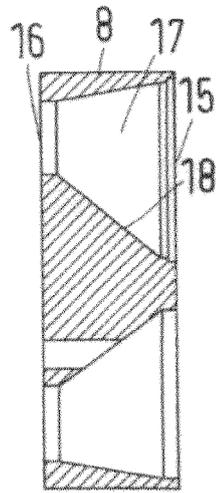


Fig.5

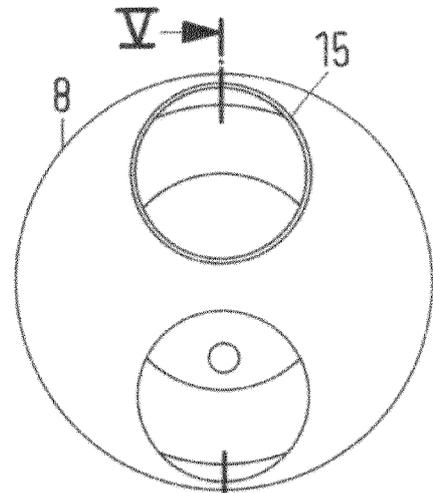


Fig.6

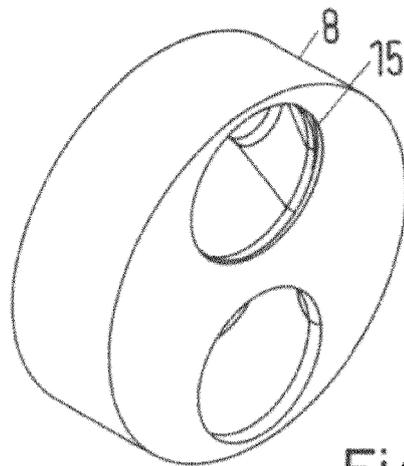


Fig.7



EUROPEAN SEARCH REPORT

Application Number
EP 13 18 0505

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
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Place of search		Date of completion of the search	Examiner
Munich		11 November 2013	Fistas, Nikolaos
CATEGORY OF CITED DOCUMENTS		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	
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		& : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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11-11-2013

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

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