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(54) High-pressure piston pump for feeding fuel to an internal combustion engine

(57) A high-pressure piston pump for feeding fuel to an internal combustion engine, in particular a diesel engine, is provided with a pump housing (2); at least a piston (6) reciprocated in a cylinder (3); a roller (12) for reciprocating the piston (6); and a fuel suction valve (7) to selectively let in low-pressure fuel from a fuel feeding duct (4) in the cylinder (3) and isolate the cylinder (3) from the fuel feeding duct (4) when the piston (6) is in the compression stage; the suction valve (7) having a valve plate (21) and a valve shutter (22), which cyclically impacts on the valve plate (21) and is made of a material selected in the group of the cemented carbides.

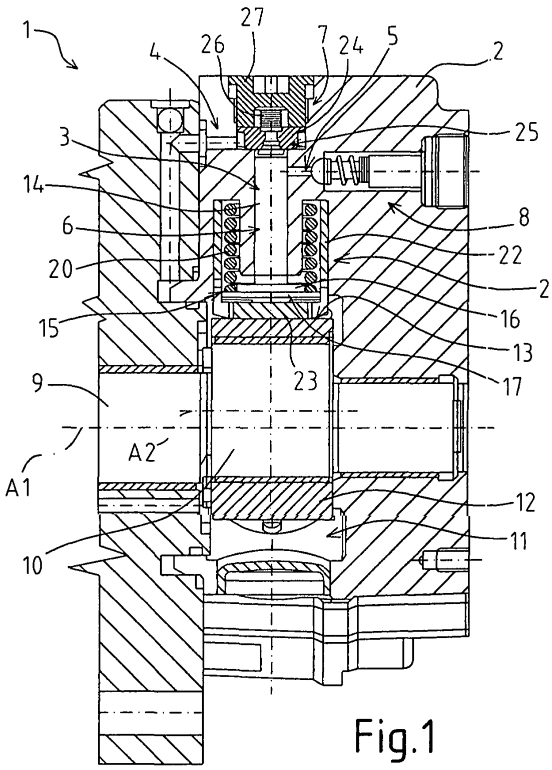

Fig.1

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Description

[0001] The present invention relates to a high-pressure piston pump for feeding fuel to an internal combustion engine.

[0002] In particular, the present invention relates to a high-pressure piston pump for feeding fuel to a common rail of an internal combustion diesel engine.

[0003] The above-identified type of high-pressure piston pumps generally comprises a pump housing; at least a piston reciprocated in a cylinder; a roller for reciprocating the piston; and a fuel suction valve to selectively let in low-pressure fuel from a fuel feeding duct in the cylinder when the piston is in the suction stage, and isolate the cylinder from the fuel feeding duct when the piston is the compression stage; the suction valve comprising a valve plate and a valve shutter cyclically impacting on the valve plate.

[0004] In other words, the high-pressure piston pump is made of a high number of components such as the piston, the suction valve shutter and a roller acting as a cam, which undergo high cyclic loads that may be either impacts or sliding frictions when they carry out their proper functions.

[0005] The pressure generated by the high-pressure piston pump reaches nowadays up to 2000 bar and it is foreseen for the next future a further increase of the fuel pressure in order to fulfil the new environmental legislation concerning the emissions of exhaust gases. Therefore, the above-mentioned cyclic loads are foreseen to stress even more severely the components of the high-pressure piston pump. It follows that the mentioned components can be rapidly worn out.

[0006] Moreover, the diffusion of the common rail system also in region where poor-lubricant fuels are used, leads to worsening of the wear drawbacks. When high-pressure piston pump is running with poor-lubricant fuel, the piston, the roller and the suction valve shutter are affected by an abnormal wear that can rapidly lead to the pump failure.

[0007] Generally, the above-mentioned components are made of steels, which are thermally treated so as to improve the desired properties in terms of stress and wear resistance.

[0008] However, in case of poor-lubricant fuel, a wear-resistant coating is applied to the surfaces of the piston, of the roller, and of the suction valve shutter. The wear-resistant coating is applied only to those portions of the surfaces that are subjected to intense wear. However, the application of the wear-resistant coating is still an expensive process that determines a high cost for the entire pump. Furthermore the shallow wear-resistant coating layer might delaminate, when impact loads occur.

[0009] In order to overcome the above-identified drawbacks, in patent applications WO 2004/111450 and WO 2004/111449 it has been suggested to insert plates of wear-resistant material into the pistons and into the roller. The inserts are made of ceramic material and can solve the problem of the wear determined by abrasion (friction), but they are not adapted for those components that are subject to impacts.

[0010] Therefore, the use of such inserts does not completely solve the problem, and the assembling of the inserts on the pistons and on the rollers still involves additional costs.

[0011] It is an object of the present invention to make a high-pressure piston fuel pump for feeding fuel to an internal combustion engine, which is free from the drawbacks of the known art, in particular, is made of components that are wear and impact resistant, and thus cost competitive.

[0012] According to the present invention, there is provided a high-pressure piston pump for feeding fuel to an internal combustion engine, in particular a diesel engine; the pump comprising a pump housing; at least a piston reciprocated in a cylinder; a roller for reciprocating the piston; and a fuel suction valve to selectively let in low-pressure fuel from a fuel feeding duct in the cylinder when the piston is in the suction stage, and isolate the cylinder from the fuel feeding duct when the piston is in the compression stage; the suction valve comprising a valve plate and a valve shutter cyclically impacting on the valve plate; the pump being characterized in that the valve shutter is made of a material selected in the group of the cemented carbides.

[0013] According to the present invention and to the tests carried out by the applicant, cemented carbides, further to the known property of being wear-resistant to frictions, have proven to be resistant even to impacts.

[0014] According to a preferred embodiment of the present invention the valve shutter comprises and shutting body impacting on the valve plate and a shank sliding inside the valve plate; the valve shutter being made as a single body of said material.

[0015] In accordance with the above-identified preferred embodiment, there is no need of assembling inserts on the suction valve shutter.

[0016] For a better understanding of the present invention, a preferred embodiment thereof will now be described only by way of a non-limitative example, and with reference to the accompanying drawings, in which:

Figure 1 is a side section view, with parts removed for clarity, of a high-pressure piston pump in accordance to the present invention;

Figure 2 is a front section view, with parts removed for clarity, of the high-pressure piston pump of figure 1;

Figure 3 is an enlarged section view, with parts removed for clarity, of a detail of the high-pressure piston pump of figure 1;

Figure 4 is a side view of a piston of the high-pressure piston pump of figure 1; and

Figure 5 is an enlarged section view of a variation of the detail shown in figure 3.

[0017] With reference to figures 1 and 2, reference numeral 1 indicates as a whole a high-pressure radial piston pump suitable for receiving fuel from a low-pressure pump (not shown) and for compressing the fuel to pressures higher than 2200 bars for feeding the fuel to a common rail of an internal combustion Diesel-engine (not shown in the enclosed figures).

[0018] Even though in the annexed figures specific reference is made to a high-pressure radial piston pump, it is intended that the present invention refers also to a high-pressure linear piston pump.

[0019] Pump 1 comprises a pump housing 2 essentially made of a block of metallic material, in which three cylinders 3 (only one shown in figure 1), three fuel feeding duct 4, and three fuel delivery ducts 5 are machined. Pump 1 comprises for each cylinder 3 a piston 6; a suction valve 7 arranged along the feeding duct 4; and a delivery valve 8 arranged along the delivery duct 5.

[0020] The pump 1 comprises a camshaft 9, which has a cylindrical cam 10, and rotates about a longitudinal axis A1 perpendicular to the cylinders 3; a cylindrical chamber 11 for housing cam 10; a roller 12, which is coupled to cam 10 and is revolved along a circular path about longitudinal axis A1 by cam 10. In other words cam 10 has an axis A2, which is parallel to axis A1 and axially offset with respect to A1.

[0021] Roller 12 is fitted to cam 10 that has a cylindrical portion; and comprises an outer face having three flat surfaces 13, each of which faces a corresponding piston 6, and an inner cylindrical face in direct contact with a cylindrical outer face of the cylindrical portion of the cam 10. In other words, the rotation of the camshaft 9 about longitudinal axis A1 determines the revolution of the roller 12 about longitudinal axis A1 and the rotation of the roller 12 about axis A2 of cam 10. Roller 12 during revolution along the circular path keeps parallel to itself and determines the strokes of the pistons 6.

[0022] With reference to figure 4, each piston 6 extends along an axis A3 and is made as a single body. Each piston 6 comprises a cylindrical body 14 and a foot 15, which has substantially a shape of two superimposed discs 16 and 17 larger than the cylindrical body 14 and an end protrusion 18 defining a surface 19.

[0023] With reference to figure 1, superimposed discs 16 and 17 define the seat for an end of a helical spring 20 for biasing the piston 6 towards roller 12. The helical spring 20 is housed inside an annular seat machined in the pump housing 2 and determines the back stroke of the piston 6.

[0024] Pump 1 further comprises for each piston 6 a bucket tappet 21 that comprises a cylindrical wall 22 arranged about the helical spring 20 and a base wall 23 arranged between the piston 6 and the roller 12. In other words, the lateral wall 22 is reciprocated in a seat machined in the pump housing 2, whereas the base wall 23 slides along the flat surface 13 of the roller 12.

[0025] Each suction valve 7 comprises a valve plate 24; a shutter 25; a helical spring 26 for biasing the shutter 25 against the valve plate 24 and a screw plug 27 for fastening the valve plate 24 in a seat machined in the pump housing 2. With reference to figure 3, the suction valve 7 comprises a ring 28 pressed in and welded to the shutter 25. The valve plate 24 is ringshaped and has a portion 29 of the fuel feeding duct 4 machined in it and a truncated cone-shaped surface 30 defining a resting seat for the shutter 25.

[0026] The shutter 25 has a shutting body 31 and a shank 32, which is guided by a seat matching with the shank 29 and machined in the valve plate 24; and is pressed into and welded to the ring 28. Helical spring 26 is compressed between the valve plate 24 and the ring 28 so as to bias the shutting body 31 against the valve plate 24. The shutting body 31 is provided with a truncated cone-shaped surface 33 matching with the truncated cone-shaped surface 30 of the valve plate 24 so as to close (when in closed position) the suction valve 7 in fluid-tight manner.

[0027] In use, the rotation of the camshaft 9 determines the revolution along a circular path of the roller 12 that, in turn, imparts a reciprocated movement to the pistons 6. The protrusion 18 of each piston 6 is in contact with the base wall 23 of the bucket tapped 21 that slides along the flat surface 13 of the roller 12, whereas the cylindrical body 14 of each piston 6 slides along the corresponding cylinder 3. During the suction stage each suction valve 7 opens to let in low-pressure fuel in the cylinder 3 from fuel delivery duct 4, and successively closes to isolate the cylinder 3 from the fuel feeding duct 4 and to compress the fuel by the piston 6. Each time the suction valve 7 closes, the shutter 25 impacts against the valve plate 24 and is further pressed by the fuel compressed in the cylinder 3 against the valve plate 24.

[0028] According to the variation of figure 5, the ring 28 is omitted and the helical spring 26 is compressed between the piston 6 and the shutting body 31.

[0029] The suction valve shutter 25, it being made either according to the embodiment shown in figure 3 or according to the variation of figure 5, is made as a single body of a material selected in the group of the cemented carbides. In accordance to the tests carried out by the applicant, cemented carbides have proven to be resistant to impacts. In particular, the suction valve shutter 25 is made of sintered cemented carbides.

[0030] The material performing particularly well comprises a metallic binder in the range of 5 to 30 % in weight and carbides to the balance to 100 %.

[0031] According to above-mentioned tests, it comes out that the preferred materials have the following features:

- The carbides are selected from the tungsten carbide and the titanium carbide;
- The metallic binder is selected from a NiMo alloy and a NiMoCrC alloy;
- The material has a hardness comprised in the range of 900 and 1.600 in accordance to the scale HV30;

- The material has a density higher than 10 g/cm^3.

[0032] The tested materials have proven to be particularly advantageous because they are wear-resistant in particular to frictions and impacts and then suitable for producing the shutter 25.

[0033] Furthermore, the selected materials can be welded. Moreover, cemented carbides are known as being wear resistant to abrasion and friction and can be conveniently be used in producing the roller 12 and the piston 6.

[0034] The piston 6 is made as single body of cemented carbides. The same applies to roller 12. The selected materials have proven to be suitable to make an entire component of the pump 1 even with a complex shape. Since roller 12 is made of cemented carbides and highly wear-resistant to friction, the roller 12 can be coupled to cam 10 without bearing.

[0035] The sintered cemented carbides have proven to be compatible with the material of the pump housing that is selected among the alloys 20MnCrS5, 23MnCrMo5 and 100Cr 6. The radial clearance between the cylindrical body 14 of the piston 6 and the cylindrical surface of the cylinder 3 is comprised in the range of 1.5 and 7.7 μm.

[0036] According to a not shown embodiment the piton can be made in two piece: the cylindrical sliding body can be made of cemented carbides, whereas the foot can be made of steel.

Claims

1. A high-pressure piston pump (1) for feeding fuel to an internal combustion engine, in particular a diesel engine; the pump (1) comprising a pump housing (2); at least a cylinder (3); at least a piston (6) reciprocated in the cylinder (3); a roller (12) for reciprocating the piston (6); and a fuel suction valve (7) to selectively let in low-pressure fuel from a fuel feeding duct (4) in the cylinder (3) and isolate the cylinder (3) from the fuel feeding duct (4) when the piston (6) is in the compression stage; the suction valve (7) comprising a valve plate (21) and a valve shutter (22) cyclically impacting on the valve plate (21); the pump (1) being **characterized in that** the valve shutter (22) is made of a material selected in the group consisting of the cemented carbides.

2. Pump according to claim 1, **characterized in that** said material is selected in the group consisting of the sintered cemented carbides.

3. Pump according to claim 1 or 2, **characterized in that** said material comprises carbides in a metallic binder; the metallic binder being comprised in the range 5 to 30 % in weight; the balance to 100 % being made of carbides.

4. Pump according to claim 3, **characterized in that** the carbides are selected in the group consisting of tungsten carbide, titanium carbide.

5. Pump according to claim 3 or 4, the metallic binder is a NiMo alloy and/or a NiMoCrC alloy.

6. Pump according to any one of the foregoing claims, **characterised in that** said material has a hardness comprised in the range of 900 and 1.600 according to the scale HV30.

7. Pump according to any one of the foregoing claims, **characterised in that** said material has a density higher than 10 g/cm^3.

8. Pump according to any one of the foregoing claims, **characterised in that** the valve shutter (25) comprises a shutting body (31) impacting on said valve plate (24) and a shank (32) sliding inside the valve plate (24); the valve shutter (25) being made as a single body of said material.

9. Pump according to any one of the foregoing claims, **characterised in that** the piston (6) is made of said material.

10. Pump according to claim 9, **characterized in that** said piston (6) comprising a cylindrical body (14) sliding in the cylinder (3) and a foot (15); the piston (6) being made as single body of said material.

11. Pump according to any one of the foregoing claims, **characterized in that** the roller (12) is made of said material.

12. Pump according to claim 11, **characterized by** comprising a camshaft (9) coupled to said roller (12); said roller (12) sliding against said camshaft (9) without any intermediate bearing.

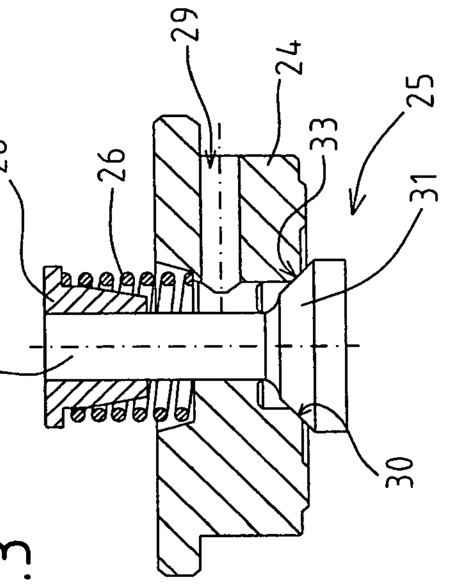

Fig.3

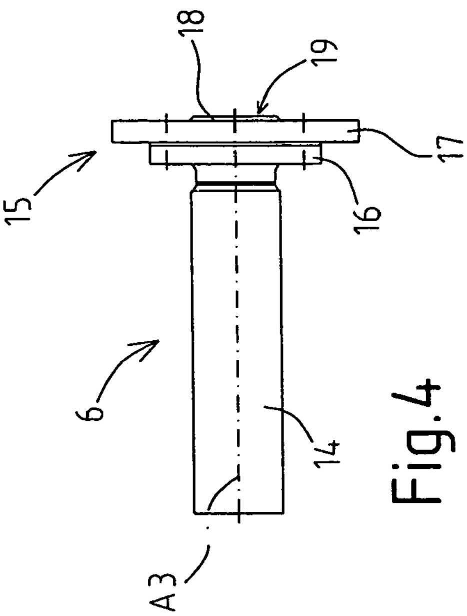

Fig.4

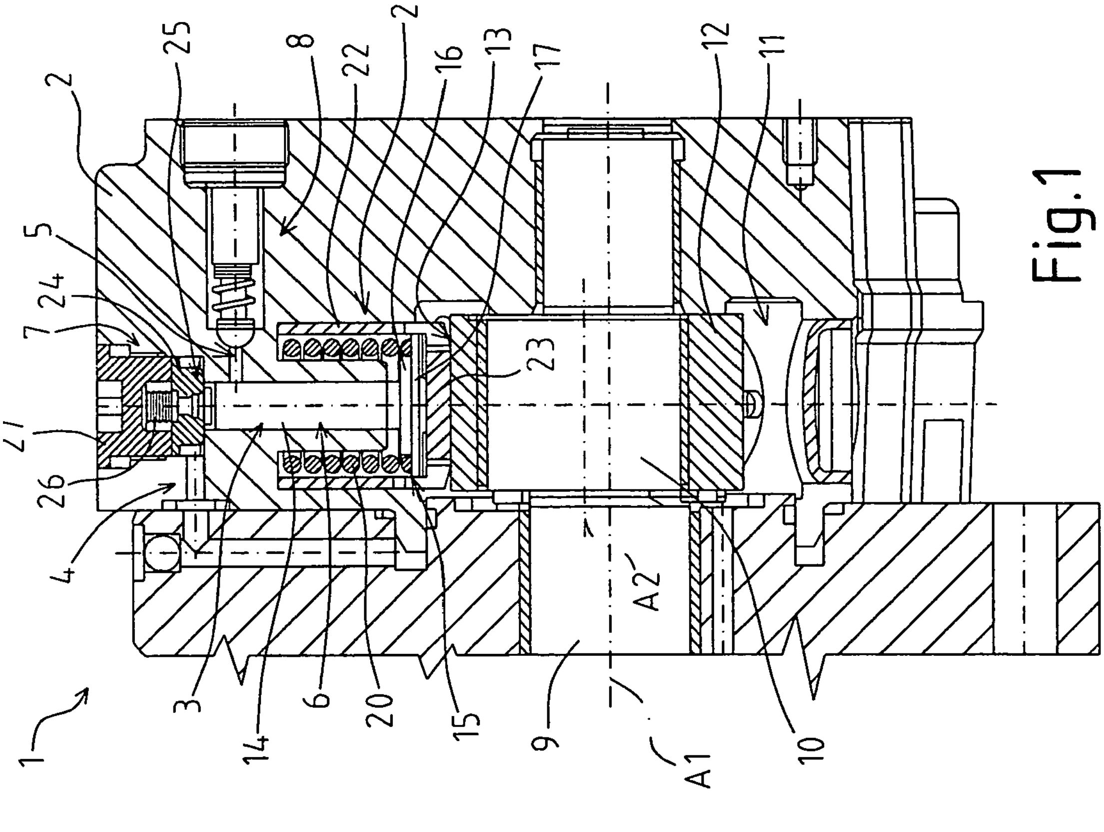

Fig.1

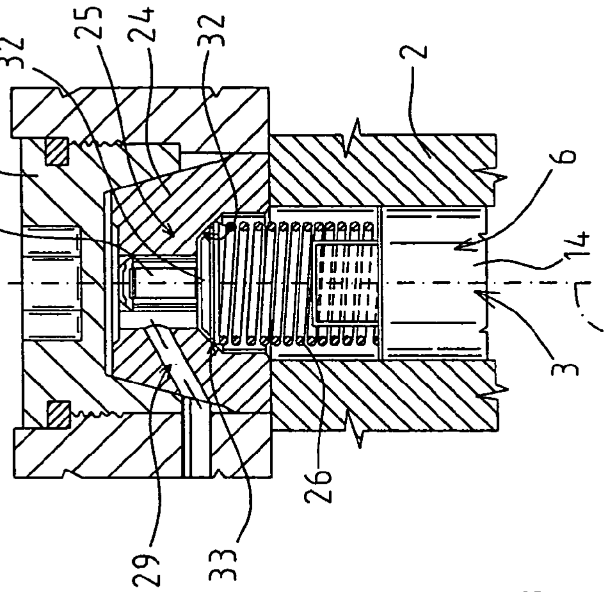
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Fig.5

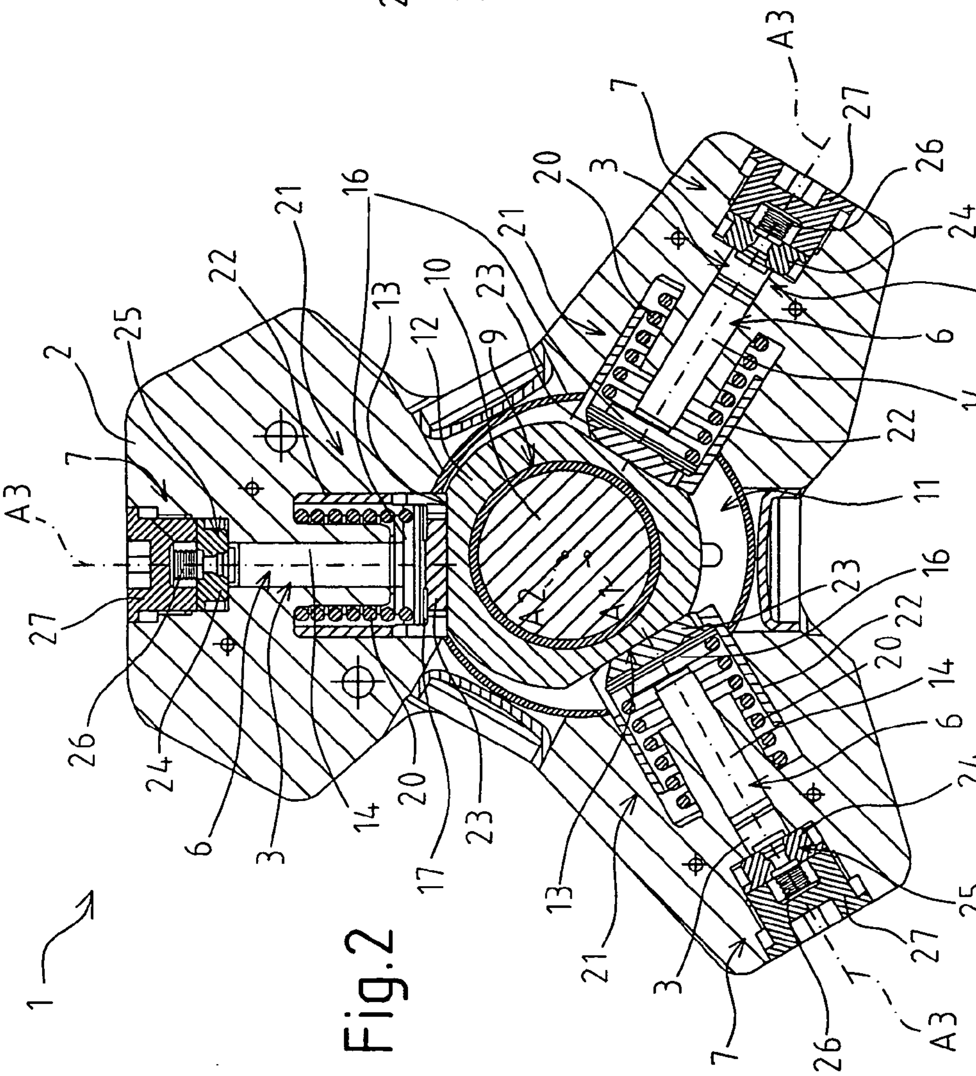
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Fig.2

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Application Number
EP 06 42 5486

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	20 December 2006	Gnüchtel, Frank

CATEGORY OF CITED DOCUMENTS

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