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ing. A corresponding airfoil arrangement (100) and a method for manufacturing such an arrangement are also provided.

FIG. 1 is a cross-sectional view of a mechanical assembly 100. The assembly includes a central core 101 with a diagonal hatching pattern, flanked by side walls 102 and 103. A top flange 120 is connected to the core via a top joint 106' and a top cap 106''. A bottom flange 110 is connected to the core via a bottom joint 106. A force F is applied horizontally to the left side of the core. Dimensions x1 and x2 are indicated. Section line II-II is shown.

Description

Field of invention

[0001] The present invention relates to an airfoil with a MCrAlY coating and preferably an Aluminide coating, an airfoil arrangement for a gas turbine and to a method for manufacturing an airfoil for a gas turbine.

Art Background

[0002] The stator vanes and the rotor blades in a gas turbine are exposed to the high temperature of the working fluid passing the vanes and the blades. Due to the high temperature a significant oxidation of the base alloy can occur at the leading edge of an airfoil of the stator vane or, the rotor blade. Furthermore, oxidation at the inner platform of the inner shroud and/or outer shroud of the stator vane or the rotor blade can also occur. Such degradation is currently the life limiting mechanism on this component.

Summary of the Invention

[0003] It may be an object of the present invention to provide a more robust airfoil for a gas turbine.

[0004] The subject may be solved by an airfoil for a gas turbine, an airfoil arrangement and by a method for manufacturing an airfoil for a gas turbine.

[0005] According to a first aspect of the present invention, an airfoil, such as a stator vane or a rotor blade, for a gas turbine is presented. The airfoil comprises a coated surface section (e.g. a coated "patch") which is coated with a MCrAlY coating and which represents at least a part of the total surface of the airfoil.

[0006] According to a further aspect of the present invention a method for manufacturing an airfoil arrangement for a gas turbine is presented. The airfoil arrangement comprises an airfoil. According to the method, the airfoil is coated with a coated surface section comprising a MCrAlY coating, wherein the surface section represents at least a part of the total surface of the airfoil.

[0007] The airfoil arrangement may describe a rotor blade arrangement or a stator vane arrangement. In a stator vane arrangement, the airfoil as described above is e.g. a vane, wherein the stator vane arrangement is fixed to a casing of the gas turbine.

[0008] A rotor blade arrangement is fixed to a rotary shaft of the gas turbine and rotates with respect to the stator vane device. The airfoil of a rotor blade arrangement is a blade which is driven by the working fluid of the gas turbine.

[0009] The airfoil comprises a leading edge and a trailing edge. At the leading edge, the airfoil has a maximum curvature, for example. Generally, the fluid which flows against the airfoil contacts firstly the leading edge and the fluid is divided into a first part which flows along a suction side of the airfoil and in a second part which flows

along a pressure side of the airfoil. The suction side is generally associated with higher velocity and thus lower static pressure. The pressure side has a comparatively higher static pressure than the suction side.

[0010] The trailing edge defines the edge of the airfoil where the fluid flowing along the suction surface and the fluid flowing along the pressure surface is again merged to one flow stream.

[0011] The airfoil arrangement may comprise one airfoil or a plurality of further airfoils which are spaced apart from each other along a circumferential direction with respect to a rotary axis of the gas turbine.

[0012] The airfoil arrangement further comprises an inner shroud and an outer shroud. The airfoil is arranged between the inner shroud and the outer shroud. In particular, the leading edge and the trailing edge extend between the inner shroud and the outer shroud.

[0013] The inner shroud is located closer to the rotary axis of the gas turbine than the outer shroud. The inner shroud comprises a first inner platform and the outer shroud comprises a second inner platform, wherein respective inner surfaces of the first and second inner platforms face the inner volume of the gas turbine through which inner volume the hot working gas streams. Hence, the respective inner surfaces of the first and second inner platforms are gas-washed by the hot working gas of the gas turbine.

[0014] The hot working gas contacts first of all the leading edge section of the airfoil before flowing along the suction side and the pressure side to the trailing edge section. For this reason, the leading edge section is more affected by the working fluid than the trailing edge section.

[0015] Hence, greater oxidation of a base alloy at the leading edge section may be caused. According to the present approach, the airfoil and specifically a section around the leading edge comprise a coated surface section which is coated with a MCrAlY coating in order to reduce the oxidation in this most critical section of the airfoil, namely the leading edge section.

[0016] The coated surface section may be defined as the section of the airfoil which has a predefined width in the direction from the leading edge to the trailing edge along the suction side and/or the pressure side of the airfoil. The width may be of (approximately) 5% to 100%, preferably (approximately) 5% to (approximately) 25% of a total width (100%) of a line between the leading edge to the trailing edge along the suction side and/or the pressure side. In particular, the airfoil comprises a cross-section, which is located within a cross-sectional plane. The width of the coated surface section may be defined by the width measured along a line connecting running within the cross-sectional plane along the suction or pressure side of the airfoil and connecting the leading edge and the trailing edge.

[0017] By providing only a leading edge section of the overall airfoil surface with the coated surface section, an efficient protection against oxidation is achieved. Hence,

because only the sections of the airfoil which are significantly exposed to oxidation are coated with a MCrAlY coating, a cost-efficient and likewise airfoil arrangement can be provided.

[0018] Alternatively, the complete surface of the airfoil may be covered by the coated surface section and hence may be coated with MCrAlY.

[0019] The MCrAlY composition comprises indicated by the "M" in particular Nickel (Ni), Cobalt (Co) or a mixture of both. The MCrAlY coating may be coated onto the coated surface section by application methods such as electro-plating, thermal spray techniques or Electron Beam Vapour Deposition (EPPVD). However, these are example application methods and other processes could be used.

[0020] Furthermore, in order to provide the proper oxidation protection, the thickness of the MCrAlY coating may be between (approximately) 0,025 mm to (approximately) 0,3 mm, in particular between (approximately) 0,05 mm to (approximately) 0,25 mm.

[0021] In particular, according to a further exemplary embodiment of the present invention, the coated surface section is spaced from the inner shroud and/or the outer shroud with a first distance. The first distance, at either extremity of the coated patch, may be between (approximately) 2.5% and (approximately) 45%, in particular between (approximately) 5% and (approximately) 25% of a total length (100%) of the airfoil between the inner shroud and the outer shroud. A coating thinning out section may be still located between the coated surface section and the inner shroud or the outer shroud. In the thinning out section the thickness of the coating is constantly reduced along a run to the inner or outer shroud until no coating is left at the inner or outer shroud.

[0022] In a further exemplary embodiment, the airfoil further comprises a further coated surface section (e.g. a further coated "patch") which e.g. surrounds, overlaps or covers the coated surface section. The further coated surface section comprises an aluminide anti-corrosive and oxidative coating, such as a pack cementation or Vapour Phase Aluminide (VPA) coating but is not limited to these processes.

[0023] At the interface section between the coated surface section and the further coated surface section, a smooth transition may be formed in order to not affect the flow of the working fluid along the airfoil. Hence, a so-called MCrAlY patch may have feathered edges and thus allows some overspray beyond the edges of the coated surface section.

[0024] According to a further exemplary embodiment, the aluminide coating on the further coated section covers at least partially or fully the MCrAlY anti-oxidative coating of the coated surface section. e.g. additionally the MCrAlY coated surface section may be over-aluminised by using e.g. a VPA coating.

[0025] According to a further exemplary embodiment, the (e.g. complete) airfoil and in an exemplary embodiment also the inner surface of the inner platform of the

inner shroud and the inner surface of the inner platform of the outer shroud may be coated by using an aluminide coating. Additionally there may be an internal coating of the aerofoil to provide oxidation and corrosion protection.

[0026] Summarizing, the above described exemplary embodiment improves the design life of the airfoil arrangement by providing a MCrAlY coating at the coated surface section and additionally by providing a further coated surface section, such as the above described aluminide coating to form e.g. aluminium oxide scales onto the airfoil. In particular, the additional aluminium from the MCrAlY coating enables a stable aluminium scale to increase oxidation and corrosion life.

[0027] During or after coating of the airfoil at the coated surface section and the further coated surface section, the airfoil may be exposed to a heat treatment, so that a diffusion between the coated layers in particular of aluminium occurs. Additional, a final ageing heat treatment may be applied for the component substrate material.

[0028] During or after coating, if required, a surface finish may be applied to the coated surface section and/or the further coated surface section in order to achieve a roughness of approximately Ra=1,0 Micrometer to Ra=8 Micrometer for the coating.

[0029] It has to be noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to apparatus type claims whereas other embodiments have been described with reference to method type claims. However, a person skilled in the art will gather from the above and the following description that, unless otherwise notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters, in particular between features of the apparatus type claims and features of the method type claims is considered as to be disclosed with this application.

Brief Description of the Drawings

[0030] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 shows schematically an airfoil arrangement according to an exemplary embodiment of the present invention;

Fig. 2 shows a cross-section of an airfoil according to an exemplary embodiment of the present invention; and

Fig. 3 shows a perspective view of an airfoil arrange-

ment according to an exemplary embodiment of the present invention.

Detailed Description

[0031] The illustrations in the drawings are schematic. It is noted that in different figures, similar or identical elements are provided with the same reference signs.

[0032] Fig. 1 shows an airfoil arrangement 100, in particular a stator vane arrangement, for a gas turbine. The airfoil arrangement 100 comprises an airfoil 101 (e.g. a vane) with a leading edge 102 and a trailing edge 103. The leading edge 102 is covered by a coated surface section 104 (also called patch) which comprises a MCrAlY coating.

[0033] Furthermore, according to Fig. 1, the airfoil 101 is arranged between an inner shroud 110 and an outer shroud 120. The leading edge 102 and the trailing edge 103 extend between the inner shroud 110 and the outer shroud 120.

[0034] Fig. 1 further shows a flow direction F of a working fluid of the gas turbine. The working fluid flows against the leading edge 102. The working fluid streams along the surfaces of the airfoil 101, i.e. the pressure side 202 and the suction side 201 (see Fig. 2), and leave the airfoil 101 at the trailing edge 103.

[0035] In Fig. 1, the coated surface section 104 is shown which comprises a MCrAlY coating. The coated surface section 104 comprises a width x1, wherein the width x1 may be defined by a distance between the leading edge 102 and the trailing edge 103.

[0036] As shown in Fig. 1, the coated surface section 104 may be spaced apart from the respective inner shroud 110 or the outer shroud 120. Between the coated surface section 104 and the respective inner shroud 110 or the outer shroud 120 a transition section may be formed. The coated surface section 104 is spaced from the inner shroud 110 and/or the outer shroud 120 with a distance x2. The distance x2 is measured e.g. by a length along a normal of a plane in which the inner surface 302 (see Fig. 3) of the inner shroud 110 or the inner surface of the outer shroud 120 is located. The distance x2 to the inner shroud 110 may be the same or different than the distance x2 to the outer shroud 120.

[0037] The coated surface section 104 may be surrounded by a further coated surface section 105 which comprises for example a MCrAlY coating or a VPA coating. In particular, the further coated surface section 105 is an anti-oxidative and anti-corrosive coating. In a further exemplary embodiment, the coating of the further coated surface section 105 may have a different thickness than the thickness of the MCrAlY coating of the coated surface section 104.

[0038] Furthermore, guiding rails located at the inner shroud 110 and/or at the outer shroud 120. The guiding rails are needed for a fixation of the airfoil arrangement 100 to a respective housing of the turbine or for guiding cooling fluid. At selective sections of the inner shroud

110 and the outer shroud 120 further surface sections 106, 106', 106" may be coated for example with an anti-oxidation coating, such as a VPA coating.

[0039] Fig. 2 shows a sketch II-II which is indicated in Fig. 1. The sketch II-II shows a cross-section of the airfoil 101 within a cross-sectional plane.

[0040] It can be taken from Fig. 2 that the airfoil 101 comprises the leading edge 102 on which the working fluid impinges. The flow direction of the working fluid is indicated by the arrow F. Furthermore, the trailing edge 103 is shown. From the leading edge 102, a part of the working fluid flows along a suction side (surface) 201 and another part flows along a pressure side (surface) 202 to the trailing edge 103.

[0041] In Fig. 2, the width x1 of the coated surface section 104 is shown. The width x1 is defined by a width starting from the leading edge 102 and running from the leading edge 102 along the suction side 201 and/or the pressure side 202 within the cross-sectional plane until the coated surface section 104 ends. After the end of the coated surface section 104, the further coated surface section 105, which may be an anti-oxidation and/or anti-corrosion coating, covers the airfoil 101.

[0042] Fig. 3 shows an exemplary embodiment of an airfoil arrangement 100 which comprises the airfoil 101 and further airfoils 301, 301', 301". The airfoils 101, 301, 301', 301" are arranged between the inner shroud 110 and the outer shroud 120. Furthermore, in Fig. 3 an inner surface 302 of the inner shroud 110 is shown. The inner surface 302 of the inner shroud faces the inner volume of the gas turbine through which the hot working fluid flows. Hence, the inner surface 302 is washed by the hot working fluid.

[0043] Specifically, the inner surface 302 of the inner shroud 110 and/or the inner surface of the outer shrouds 120 may be coated with an anti-oxidative coating in order to reduce oxidation.

[0044] Seal slots, such as scallop seal slots, and machined surfaces of the airfoil arrangement 100 may be kept free from any coating in order to maintain the original dimensions.

[0045] To summarize, the airfoil is coated with a MCrAlY coating which represents at least a part of the total surface of the airfoil 101 and particularly the MCrAlY coating may be limited to a leading edge section of the airfoil. Particularly the MCrAlY coating may be applied to a pressure and a suction side of the airfoil. Furthermore the MCrAlY coating may not extend over the full airfoil height. In respect of the height of the airfoil, the MCrAlY coating may be limited to a middle section of the airfoil. Particularly the MCrAlY coating may be limited to a straight section of the leading edge of the airfoil. It may not be applied to airfoil section converging to the inner and/or outer shroud. The MCrAlY coating may be applied as an additional patch on top of a previously applied further coating. Or the MCrAlY coating may be applied as an additional patch underneath of a later applied further coating.

[0046] It should be noted that the term "comprising"

does not exclude other elements or steps and "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

Claims

1. Airfoil for a gas turbine, the airfoil (101) comprising a coated surface section (104) which is coated with a MCrAlY coating and which represents at least a part of the total surface of the airfoil (101). 5
2. Airfoil (101) according to claim 1, further comprising a leading edge (102) and a trailing edge (103), and a suction side (201) and a pressure side (202), wherein the coated surface section has a width (x1) in a direction from the leading edge (102) to the trailing edge (103) along the suction side (201) and/or along the pressure side, wherein the width (x1) is of 5% to 100%, preferably 5% to 25%, of a total width of a line between the leading edge (102) to the trailing edge (103) along the suction side (202) and/or the pressure side (203). 10 15 20 25
3. Airfoil (101) according to claim 1 or 2, wherein the MCrAlY coating has a thickness between 0,025 mm to 0,3 mm, in particular between 0,05 mm to 0,25 mm. 30
4. Airfoil (101) according to one of the claims 1 to 3, wherein the airfoil (101) further comprises a further coated surface section (105) which comprises an anti-oxidative and/or anti-corrosive coating. 35
5. Airfoil (101) according to claim 4, wherein the anti-oxidative coating comprises a further MCrAlY coating and/or an aluminide coating, in particular a VPA coating. 40
6. Airfoil (101) according to one of the claims 1 to 5, wherein the airfoil is a stator vane or a rotor blade. 45
7. Airfoil arrangement (100) comprising an airfoil (101) according to one of the claims 1 to 6 an inner shroud (110) and an outer shroud (120), wherein the airfoil (101) is arranged between the inner shroud (110) and the outer shroud (120). 50
8. Airfoil arrangement (100) according to claim 7, wherein the coated surface section (104) is spaced from the inner shroud (110) and/or the outer shroud (120) with a distance (x2). 55
9. Airfoil arrangement (100) according to claim 8,

wherein the distance (x2) on either side of the MCrAlY patch is between 2.5% and 25%, in particular between 5% and 25%, of a total length of the airfoil (101) between the inner shroud (110) and the outer shroud (120).

10. Method for manufacturing an airfoil arrangement (100) for a gas turbine, wherein the airfoil arrangement (100) comprises an airfoil (101), the method comprising coating a surface section (104) of the airfoil (101) with a MCrAlY coating, wherein the surface section (104) represents at least a part of the total surface of the airfoil (101).

FIG 1

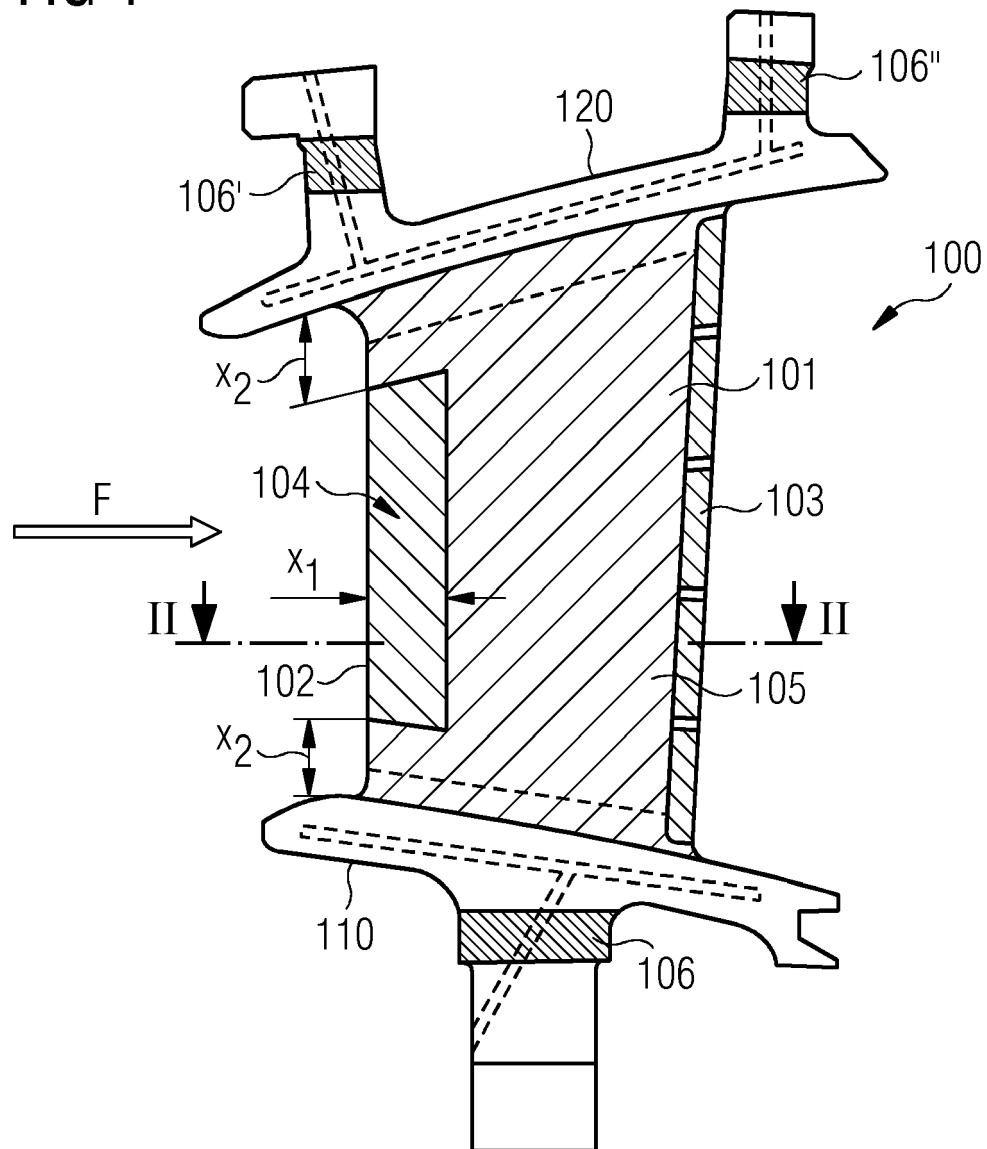


FIG 2

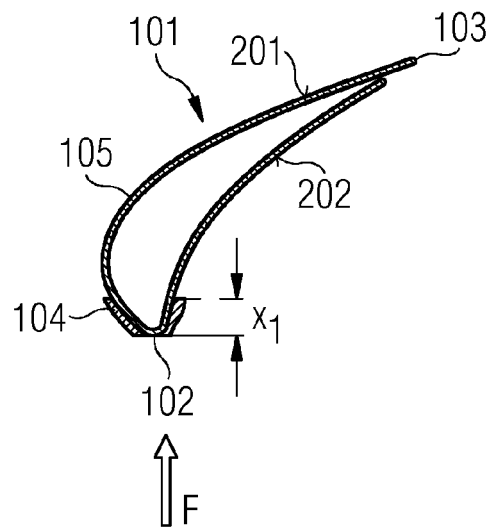
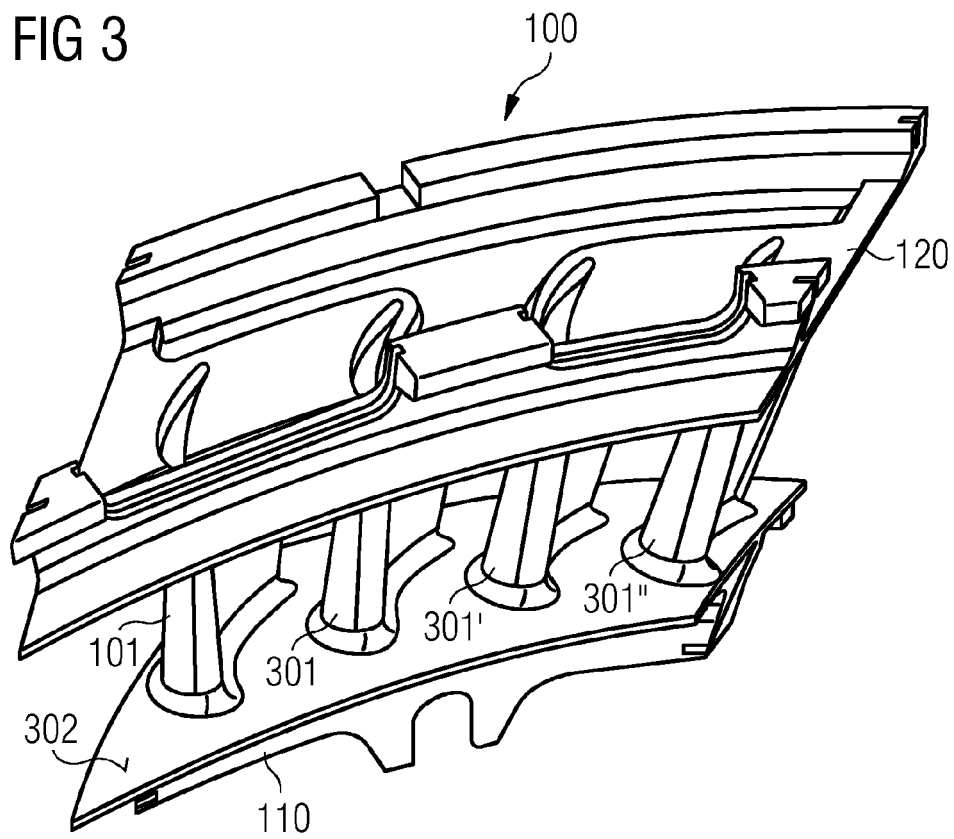


FIG 3





EUROPEAN SEARCH REPORT

Application Number
EP 12 16 7244

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 844 368 A2 (UNITED TECHNOLOGIES CORP [US]) 27 May 1998 (1998-05-27)	1-7,10	INV. F01D5/28 F01D9/04
Y	* the whole document *	8,9	
X	US 7 491 033 B2 (TRISHKIN ALEXANDER [RU] ET AL) 17 February 2009 (2009-02-17)	1-10	
Y	* figures *	8,9	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F01D
Place of search		Date of completion of the search	Examiner
Munich		11 July 2012	Raspo, Fabrice
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 (03.02 (P04C01))

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

EP 12 16 7244

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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11-07-2012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0844368	A2	27-05-1998	DE 69732404 D1	10-03-2005
			DE 69732404 T2	06-04-2006
			EP 0844368 A2	27-05-1998
			JP 4084452 B2	30-04-2008
			JP 10159502 A	16-06-1998
			US 6095755 A	01-08-2000

US 7491033	B2	17-02-2009	CA 2565266 A1	17-11-2005
			DE 102004023623 A1	01-12-2005
			EP 1745195 A1	24-01-2007
			US 2007148003 A1	28-06-2007
			WO 2005108746 A1	17-11-2005
