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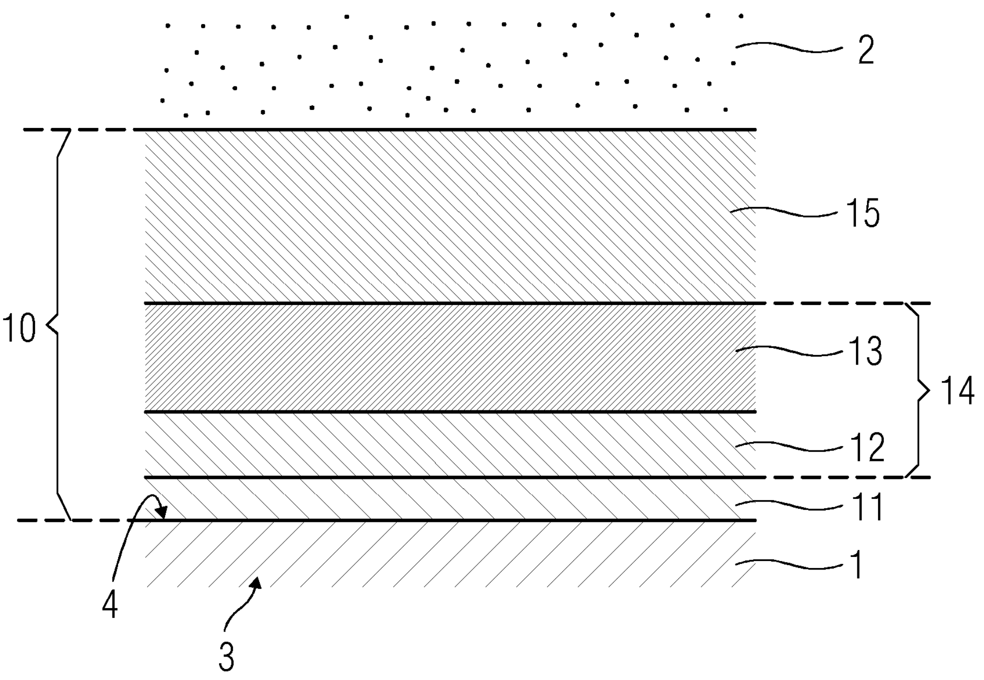
(54) A coating system for a component of a turbomachine and a method for generating a coating system

(57) A turbo machine coating system for coating a portion of a component of a turbo machine, comprises, in addition to the standard bond coat layer to be arranged on the portion of the component, a first ceramic coating layer to be arranged over the portion to be coated and on the bond coat layer and an abradable, second ceramic coating layer, wherein the second ceramic coating layer is arranged on the first ceramic coating layer. Therein, the abradable, second ceramic coating layer is a porous coating layer comprising full-stabilized Yttrium Zirconium oxide. Thus, the second ceramic coating layer comprises the attributes of an abrasion layer. I.e. the second ceramic coating layer is supposed to wear, for example during operation of the turbomachine.

FIG 1



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Description

[0001] The present invention relates to the field of turbomachines, such as gas turbines and steam turbines. Especially, the invention relates to coating systems for components of such turbomachines.

[0002] A turbomachine, for example a gas turbine or a steam turbine, is widely used in the field of power generation. During the course of power generation, a fuel in the turbomachine undergoes combustion, during which the chemical energy contained in the fuel is converted into mechanical energy, which is thereafter converted into electrical energy. The combustion of the fuel inside the turbomachine is a highly exothermic reaction, whereby a tremendous amount of heat is generated. Thus, the turbomachine and certain components thereof are required to operate at high temperatures. Such components might be, for example, blades and/or vanes of the turbomachine.

[0003] Therein, it has to be considered that the turbomachine efficiency will generally increase with increasing temperatures. However, as the operating temperatures increase, the aforementioned components of the turbomachine face higher thermal loading, either in the form of static temperatures or in the form of temperature gradients. High thermal loading will effect damages of the component. In order to overcome the damaging effects of high thermal loading, the temperature durability of the turbomachine components has to be improved, correspondingly.

[0004] Currently, a protective coating system is applied on the component's base material at least on portions of the component which are exposed to high temperature gases during operation of the turbomachine. The coating system might be a multi-layer system comprising several layers of certain materials which will protect the underlying component against heat.

[0005] Besides the dependency of the turbomachine efficiency on the operating temperature, also the clearances between different components of the turbomachine which are movable relative to each other will have an effect on the efficiency. For example, a minimized gap between the stator, especially the ring-segment or the vane platform, and the rotator, especially the blades and the tips of the blades, respectively, would result in a maximized efficiency.

[0006] However, it has to be considered that the dimensions of the components will vary between the operating state of the turbomachine with high temperatures and a standstill state with low temperatures, like during commissioning, maintenance or repair. For example, the length of a blade during operation of the turbomachine will differ significantly from the length during standstill due to the extreme temperature differences, resulting in different clearings between the blade tip and the inner surface of the stator ring.

[0007] Therefore, some components are coated with a special, abradable coating system. Such a coating must have appropriated themo-mechanical capabilities which should fulfill wear behavior with no damage of the counterpart, while remain stable and attached to the underlying coating layer at the operating temperatures. For example, it is known to use 33YBZO for this purpose. However, this material is known to be expensive due to the concentration of Ytterbium.

[0008] It is therefore an object of the present invention to provide a coating system for a component of a turbomachine.

[0009] The aforementioned object is achieved by a component for a turbomachine according to claim 1, and a method for generating a corresponding coating system according to claim 11.

[0010] A turbo machine coating system for coating a portion of a component of a turbo machine, comprises, in addition to the standard bond coat layer to be arranged on the portion of the component,

- a first ceramic coating layer to be arranged over the portion to be coated and on the bond coat layer,
- an abradable, second ceramic coating layer, wherein the second ceramic coating layer is arranged on the first ceramic coating layer, such that the first ceramic coating layer is located between the bond coat layer and the component, respectively, and the second ceramic coating layer.

[0011] Therein, the abradable, second ceramic coating layer is a porous coating layer comprising full-stabilized Yttrium Zirconium oxide.

[0012] Thus, the porous, second ceramic coating layer comprises the attributes of an abrasion layer. I.e. the second ceramic coating layer is supposed to wear, for example during operation of the turbomachine.

[0013] The porosity of the abradable, second ceramic coating layer is between 25% and 35%. Preferably, the porosity of the abradable, second ceramic coating layer is 30%.

[0014] In one embodiment, the first ceramic coating layer is a Taylon type layer.

[0015] The Taylon type layer is a multi-layer system comprising at least a first and a second porous sub-layer, wherein

- the first and the second porous sub-layers are arranged such that the second sub-layer is located between the first sub-layer and the second ceramic coating layer and
- the first and second porous sub-layers have different porosities.

[0016] Therein, the porosity of the first sub-layer is between 8% and 16% and the porosity of the second sub-layer is between 20% and 30%.

[0017] In another embodiment, the first ceramic coating layer is a porous layer.

[0018] Therein, the porosity of the first ceramic coating layer is between 14% and 22%.

[0019] Preferably, the first ceramic coating layer is a High Homogeneous Porosity TBC layer.

[0020] In a preferred embodiment, not only the second ceramic coating layer, but also the first ceramic coating layer is an abradable layer.

[0021] A method for generating a coating system according to the invention and as summarized above, comprises

- a step of generating the first ceramic coating layer using a Air Plasma Spraying technique and
- a step of overlaying the first ceramic coating layer with the abradable, second ceramic coating layer.

[0022] The use of full-stabilized Yttrium Zirconium Oxide (FYSZ) as abradable porous overlayer coating reduces the price of the processing of the coated components, which can be ring-segments or vane-platforms or other components of the turbomachine. FYSZ has low fracture toughness. For example, the fracture toughness is significantly lower than for partly-stabilized Yttrium Zirconium Oxide (PYSZ) which is known to be used as standard thermal barrier coating (TBC). Moreover, the full stabilized ceramic material possesses a higher temperature stability, namely up to the melting point of the material, and lower thermal conductivity than the partly stabilized material. This achieves in a better thermal isolation. The deposition of this coating with a specific porosity, which is high enough to further enhance its wear behaviour, improves its capability to be used as an abradable coating. Preferably, the specific porosity is 25%. Additionally, the adhesion of this porous FYSZ on top of a PYSZ layer is advantageous as compared to 33YBZO.

[0023] Moreover, the use of a full-stabilized material in the outer coating layer allows to use the coated component in the presence of higher operating temperatures, since the C phase in such a system is stable over a broader temperature range. Therewith, no phase shifts will occur.

[0024] The aforementioned and other embodiments of the present invention related to a coating system for a component of a turbomachine and to a method for generating such a coating system will now be addressed with reference to the accompanying drawings of the present invention. The illustrated embodiments are intended to illustrate, but not to limit the invention. The accompanying drawings herewith contain the following figures, in which like numbers refer to like parts, throughout the description and drawings.

[0025] The figures illustrate in a schematic manner further examples of the embodiments of the invention, in which:

FIG 1 depicts a cross section of a first embodiment of the coating system,

FIG 2 depicts a cross section of a second embodiment of the coating system.

[0026] Embodiments of the present invention described below relate to a coating system comprising a plurality of coating layers to be applied on a blade component in a turbomachine. However, the details of the embodiments described in the following can be transferred to a coating system which is placed on any suitable component of the turbomachine, like a vane, a stator ring surface etc. The turbomachine may include a gas turbine, a steam turbine, a turbofan and the like.

[0027] The component to be coated with the coating system 10 has an outer wall 1 which comprises a base metal. In the figures, only a section of the component and its outer wall 1 is shown to illustrate the arrangement of the coating system 10. For example, the component can be an airfoil or a platform of a vane or a blade of the turbomachine. Also, the component might be the ring segment of the rotor-stator section of the turbomachine. Other applications are also possible.

[0028] The component is subjected to extremely high temperatures during the operation of the turbomachine. For example, the temperature might be in the dimension of 1000°C. Furthermore, the component can be subjected to high temperature gradients, i.e. varying temperatures across an extension of the component. Thus, extremely high thermal fatigues are experienced by the component during its operation. Furthermore, the component is subjected to contact with various chemicals and contaminants present in the fuel and/or the working fluid, which can cause mechanical abrasions, corrosions, et cetera, thereby resulting in surface damages, wear and tear of the component, et cetera. Therewith, a reduction in the operational life of the component is experienced. The manner in which the operational life of the can be enhanced in accordance with the teachings of the present invention is elucidated in the subsequent paragraphs.

[0029] To protect the component against the above mentioned damages and fatigues, a coating system is applied at least on a portion 3 on the outer surface 4 of the component, i.e. on the outer surface 4 of the outer wall 1. Therein, the outer surface 4 is that surface which would be exposed to the high temperatures during operation of the turbomachine without the presence of the coating system 10.

[0030] FIG 1 shows a cross-section of a coating system 10 wherein the cross-section shows the order of coating layers 11, 14, 15 of the coating system 10 to be applied on the portion 3 of the outer wall 1.

[0031] The coating system 10 essentially comprises a first ceramic coating layer 14, and a second ceramic coating layer 15. Additionally, the coating system 10 has a bond coat 11, which is used to facilitate the fixing of the first ceramic coating layer 14 to the outer wall 1 of the component. Therefore, the bond coat 11 is applied on the portion 3 of the outer wall 1. The first coating layer 14 is arranged between the bond coat 11 and the second coating layer 15 such that it is located over the portion 3 to be coated by the coating system 10.

[0032] In the embodiment shown in FIG 1, the first ceramic coating layer 14 is a Taylon type coating layer which is a multi-layer system with a first sub-layer 12 and a second sub-layer 13. The sub-layers 12, 13 are arranged such that the first sub-layer 12 is located between the bond coat 11 and the second sub-layer 13.

[0033] Both the first sub-layer 12 and the second sub-layer 13 are porous layers. Preferably, the sub-layers 12, 13 have different porosities, wherein the porosity of the first sub-layer 12 is between 8% and 16% and the porosity of the second sub-layer 13 is between 20% and 30%. In a preferred embodiment, the porosity of the first sub-layer 12 is 12% and the porosity of the second sub-layer 13 is 25%.

[0034] The second ceramic coating layer 15 is an abradable, porous coating layer which is arranged on the first ceramic coating layer 14 and on the second sub-layer 13, respectively, and over the portion 3 to be coated. Thus, the second coating layer 15 is arranged such that the first ceramic coating layer 14 is located between the bond coat 11 and the second ceramic coating layer 15. The second ceramic coating layer 15 is the outer layer of the coating system 10, i.e. the second ceramic coating layer 15 is exposed to hot gases 2 etc. during operation of the turbomachine. The porosity of the second ceramic coating layer is between 25% and 35%. Preferably, the porosity of the second ceramic coating layer is 30%.

[0035] Moreover, with the second ceramic coating layer 15 being the outermost layer of the coating system 10, the layer 15 is lo-cated directly opposite to another, corresponding component of the turbemachine with only an airgap separating the outermost layer 15 and the opposing component.

[0036] For example, in case the component is a blade of a rotor of the turbomachine, especially the tip of the blade, the opposing component might be the inner wall section of a surrounding stator ring. Only the airgap is separating the tip and the inner wall of the stator, wherein the extension of the airgap has to be minimized to assure optimal operation efficiency of the turbomachine. The same approach of minimizing the airgap is applicable for respective pairs of corresponding, opposing components of the turbomachine, which are separated by an airgap to be minimized. Therefore, at least one component of such a pair of components is coated with a coating system 10 as disclosed herein.

[0037] However, the extension of the component would change during operation of the turbomachine due to the extreme temperature differences between operation and standstill. This effect has to be considered in the dimensioning of the component. The presence of a layer 15 which is abradable, in the following referred to as an "abrasion layer", allows an extreme dimensioning of the component including the coating system 10 such that the airgap is minimized. During commissioning of the turbomachine, the temperature and with it the extension of the component will increase. Correspondingly, the component and the outermost layer 15 of the coating system 10 might get in contact with the opposing component. However, damages of the component and/or of the opposing component will be avoided since at least a part of the abrasion layer 15 will be abraded.

[0038] In a preferred embodiment, the abrasion layer 15 and the second ceramic coating layer 15, respectively, is a porous coating layer comprising full-stabilized Yttrium Zirconium (FYSZ) oxide. Preferably, the FYSZ comprises 20% Yttrium oxide to achieve full-stability. This guarantees a better resistivity against high temperatures.

[0039] In a further embodiment, not only the second ceramic coating layer 15 is an abradable layer, but also the first ceramic coating layer 14 has properties of an abrasion layer, i.e. it is at least partially abradable. This can be achieved by selecting a material with a suitable porosity, without endangering a cohesion of the coating. In the embodiment shown in FIG 1, the second sub-layer 13 of the first ceramic coating layer 14 has a porosity between 20% and 30%. This qualifies the second sub-layer 13 to be an abrasion layer.

[0040] For example, the first embodiment of the coating system 10 as shown FIG 1 is advantageous for coating stator ring segments and/or vane platforms.

[0041] FIG 2 shows a cross-section of a second embodiment of the coating system 10. The coating system 10 of FIG 2 again essentially comprises a first ceramic coating layer 16 and a second ceramic coating layer 15. Additionally, the coating system 10 has a bond coat 11, which is used to facilitate the fixing of the first ceramic coating layer 16 to the outer wall 1 of the component. Therefore, the bond coat 11 is applied on the portion 3 of the outer wall 1. The first coating layer 16 is arranged between the bond coat 11 and the second coating layer 15 such that it is located over the portion 3 to be coated by the coating system 10.

[0042] The coating system 10 in the second embodiment differs from the coating system 10 of the first embodiment as shown in FIG 1 in the first ceramic coating layer 16. The remaining layers, i.e. the bond coat 11 and the second ceramic coating layer 15, are the same as in FIG 1. Thus, the explanations and details given for the second ceramic coating layer 15 with reference to FIG 1 are also applicable for the second ceramic coating layer 15 of the second embodiment as shown in FIG 2. Especially, the second ceramic coating layer 15 again comprises the properties of an abrasion layer.

[0043] The first ceramic coating layer 16 of the second embodiment is a High Homogeneous Porosity (HHP) TBC layer. Preferably, the first ceramic coating layer 16 is applied onto the bond coat 11 using an Air Plasma Spraying (APS) technique. Correspondingly, the first ceramic coating layer 16 can be referred to as HHP APS TBC 16. Preferably, the HHP APS TBC 16 is also a porous layer, wherein the porosity is between 14% and 22%.

[0044] For example, the second embodiment of the coating system 10 as shown in FIG 2 is advantageous for coating vane platforms.

[0045] The overlaying of the first ceramic coating layer 14, 16 on the bond coat 11 can be achieved using any of the well-known processes such as Air Plasma Spraying, Electron Beam Physical Vapor Deposition, High Velocity Oxygen Fuel, Electrostatic Spray Assisted Vapour Deposition, Direct Vapour Deposition, etcetera. The same is applicable for overlaying the second ceramic coating layer 15 on the first ceramic coating layer 14, 16. The aforementioned techniques for applying a coating layer are well-known in the art, and the same is not elucidated herein for the purpose of brevity.

[0046] The component introduced above which is to be coated with the coating system according to one of the embodiments can be, for example, a ring segment of the stator ring of the turbomachine. Therein, the portion of the component to be coated would be the inner surface of the stator ring which is facing the rotor and the corresponding blades or vanes. In addition or as an alternative to this, the tips of the blades of the rotor can be coated with the coating system as well. Thus, the tips would represent the portion of the component and the component would be the blade.

[0047] In general, the coating system according to the invention is suitable for any component of the turbomachine which moves relative to a neighboring or opposite component of the turbomachine during operation of the turbomachine. This is especially applicable for components or pairs of components of the turbomachine, which are movable relative to each other and which are separated by an airgap, which has to be minimized to achieve optimum efficiency.

[0048] Though the invention has been described herein with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various examples of the disclosed embodiments, as well as alternate embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. It is therefore contemplated that such modifications can be made without departing from the embodiments of the present invention as defined.

Claims

1. A turbo machine coating system (10) for coating a portion (3) of a component of a turbo machine, comprising

    - a first ceramic coating layer (14, 16) to be arranged over the portion (3) to be coated,
    - an abradable, second ceramic coating layer (15), wherein the second ceramic coating layer (15) is arranged on the first ceramic coating layer (14, 16),

    wherein
    - the abradable, second ceramic coating layer (15) is a porous coating layer comprising full-stabilized Yttrium Zirconium oxide.

2. Coating system according to claim 1, wherein the porosity of the abradable, second ceramic coating layer (15) is between 25% and 35%.

3. Coating system according to claim 2, wherein the porosity of the abradable, second ceramic coating layer (15) is 30%.

4. Coating system according to any one of the claims 1 to 3, wherein the first ceramic coating layer (14) is a Taylon type layer (14).

5. Coating system according to claim 4, wherein the Taylon type layer (14) is a multi-layer system comprising at least a first (12) and a second (13) porous sub-layer, wherein

    - the first and the second porous sub-layers (12, 13) are arranged such that the second sub-layer (13) is located between the first sub-layer (12) and the second ceramic coating layer (15) and
    - the first and second porous sub-layers (12, 13) have different porosities.

6. Coating system according to claim 5, wherein the porosity of the first sub-layer (12) is between 8% and 16% and the porosity of the second sub-layer (13) is between 20% and 30%.

7. Coating system according to any one of the claims 1 to 3, wherein the first ceramic coating layer (16) is a porous layer.

8. Coating system according to claim 7, wherein the porosity of the first ceramic coating layer (16) is between 14% and 22%.

9. Coating system according to claim 7 or 8, wherein the first ceramic coating layer (16) is a High Homogeneous Porosity TBC layer.

10. Coating system according to any one of claims 1 to 9, wherein the first ceramic coating layer (14, 16) is an abradable layer.

11. A method for generating a coating system (10) according to any one of the claims 1 to 10, comprising

    - a step of generating the first ceramic coating layer (14, 16) using a Air Plasma Spraying technique,
    - a step of overlaying the first ceramic coating layer (14, 16) with the abradable, second ceram-

ic coating layer.

FIG 1

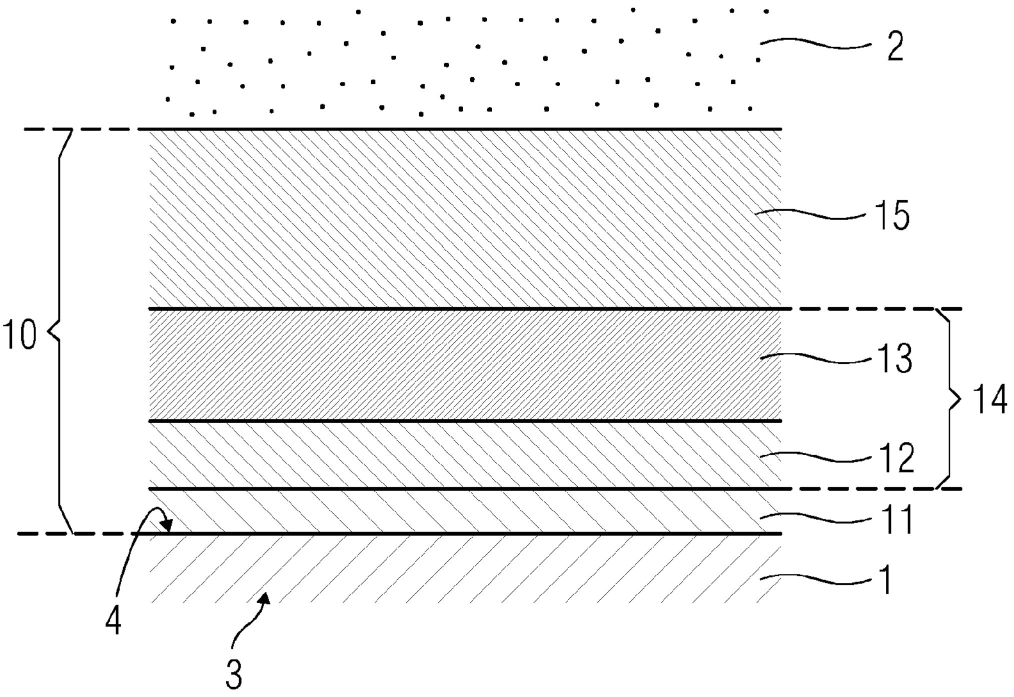
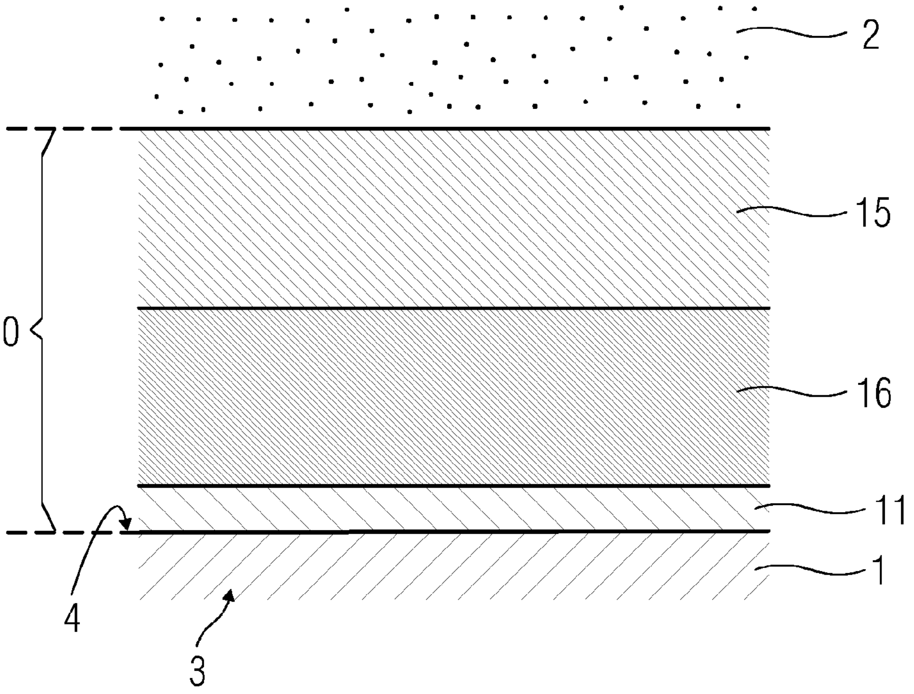


FIG 2



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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 6057

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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	28 April 2014	Tsipouridis, P

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 19 6057

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