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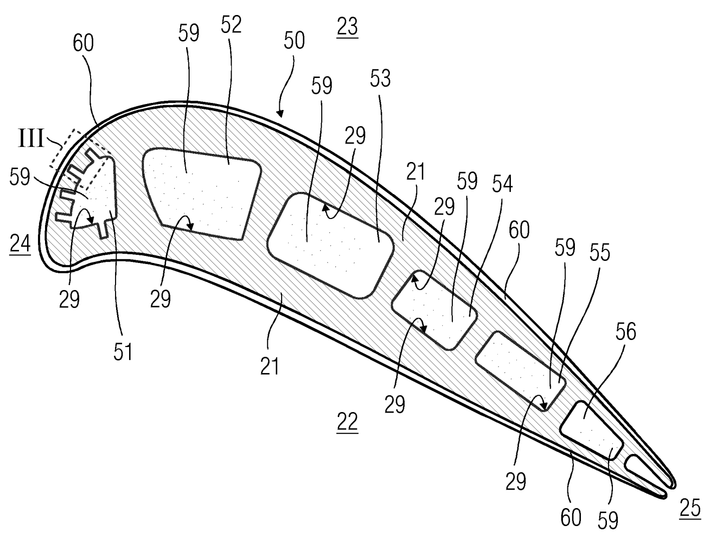
## (54) Enhanced cooling arrangement for a turbomachine component

(57) The invention addresses the issue of local over temperature of a turbomachine blade due to loss of protective thermal barrier coating (TBC). In predefined areas of the blade's (1) outer wall (21) recesses (73) are placed. The outer wall's thickness at the locations (72, d2) of the recesses is less than in regions (71, d1) surrounding the recess. In case of an over temperature due to a TBC loss, the thinner walls (d2) of the recess at the location of the TBC loss will melt away faster than the material of the thicker walls (d1) surrounding the recess. This will open up a hole (74) in the outer wall such that cooling fluid from the underlying core passage way can exit the blade, resulting in a film cooling effect. This cooling will protect the blade at least temporarily and guarantee a proper functioning until the next inspection.

FIG 2

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## Description

**[0001]** The present invention relates to a blade or a vane for a turbomachine and more particularly to an arrangement for achieving continuous cooling of the blade or vane in case of a damage of a protecting coating of the blade or vane.

**[0002]** In the present application, for the sake of brevity only the term "blade" will be used, but the specifications and features can be transferred to a vane without further modifications. It might be mentioned that the basic idea of the invention is also applicable for a platform of a blade or a vane.

**[0003]** In modern day turbomachines various components of the turbomachine operate at very high temperatures. Especially, turbine blades of the first stages of the turbomachine are thermally high loaded due to hot gas temperatures and high heat transfer coefficients caused by flow stagnation at the leading edges as well as high gas velocities.

**[0004]** The high temperatures during operation of the turbomachine may damage the blades. Therefore, the blades are coated with a ceramic thermal barrier coating (TBC) to reduce heat flux from the hot gas to the blade's base material which is typically a metal. This results in lower metal temperatures than without the TBC.

**[0005]** Furthermore, various methods of cooling of the blades are applied to achieve moderate temperatures during operation of the turbomachine.

**[0006]** For example, internal cooling is generally achieved by passing a cooling fluid through a core passage way cast into the blade component and into the airfoil of the blade, respectively. The airfoil portion of the blade is cooled by directing the cooling fluid to flow through multiple flow paths of the core passage way that are designed to maintain all aspects of the turbine blade at a relatively uniform temperature. Therewith, the cooling fluid is directed over the internal surfaces of the airfoils to achieve a cooling effect.

**[0007]** In addition to the internal cooling, film cooling holes are available through which the cooling fluid can exit the blade to create a separation in the form of a film of cold air between the hot gas flow and the blade surface. This results in external cooling of the blade. The film cooling holes are especially located at thermally high loaded areas of the blade and the airfoil such as the leading edge. The cooling fluid can be fed to the film cooling holes by the core passage way.

**[0008]** However, with the need for increasing gas turbine efficiency, not only the temperatures of the hot gases are increased, but also the cooling fluid mass flow is decreased. This necessitates thicker TBC layers to ensure that the base metal temperatures during operation remain at levels which can still guarantee the structural integrity of the base material of the blade. Yet, a strong reliance on the TBC could lead to fatal failures of the blade in case the TBC cracks and gets lost so that the underlying bond coat or metal surface would be exposed. In that scenario and under the precondition of less cooling fluid mass flow, local temperatures higher than the melting point of the metal can be reached. Such temperatures would compromise the mechanical integrity of the blade and lead to fatal failures within a time span which can be shorter than the typical inspection interval.

**[0009]** It is an object of the present invention to achieve a longer life time of a damaged turbomachine component. It has to be achieved that the functionality of the damaged component can be maintained until the next inspection.

**[0010]** The object is achieved by providing a component for a turbomachine according to claim 1.

**[0011]** The approach of the invention is to address the issue of local over temperature by implementing blind holes in predefined areas of certain regions of the component. For example, the certain regions can be located at an airfoil wall of a blade of the turbomachine. The blind holes can be realized as predetermined breaking points of the blade walls by varying the thickness of the blade wall such that the wall comprises regions with less wall thickness. In case of an over temperature due to a TBC loss, the thinner walls of the blind holes will melt away faster than the material of the thicker walls surrounding the blind holes. This will open up the blind hole such that cooling fluid from the underlying core passage way can exit the airfoil, resulting in a film cooling effect. This cooling will protect the blade at least temporarily and guarantee a proper functioning until the next inspection. This helps in preventing a damaged part from complete failure at least until the next inspection of the part. In other words, the hole resulting from the molten material of the blind hole will act as a cooling opening, without affecting the structural integrity of the blade.

**[0012]** According to the invention, a component for a turbomachine is provided. The component comprises an outer wall having an inner surface and having a plurality of wall thicknesses, wherein the outer wall surrounds a volume. The volume contains at least a section of a cooling arrangement, e.g. one of a plurality of cooling channels of the cooling arrangement which are used for guiding a cooling fluid. The outer wall comprises first regions with at least one first wall thickness and second regions at defined locations of the outer wall with at least one second wall thickness. Each second region is surrounded by at least one of the first regions and the second wall thickness is less than the first wall thickness. Thus, in case the outer wall is exposed to the hot gas in the environment of the component during operation of the turbomachine due to a loss of TBC, the outer wall will melt first at the second region only to generate a hole in the outer wall. Therein, the term "surrounded" includes an arrangement in which the second region is arranged in between two first regions, i.e. those first regions are arranged on either side of the particular second region. For example, this scenario might occur in case the second region comprises a lengthy slot, as will be described later, and the two first regions are located on both sides of the lengthy slot. Moreover, the inner surface of the outer wall is fluidly connected to the cooling path at least at the locations of the second regions, such that, in case the outer wall comprises the hole as described above at the location of the second region, the cooling fluid can stream through the hole to achieve a film cooling effect in the region surrounding the hole. This film cooling effect protects the component against further melting such that a longer life time is achieved despite the loss of TBC.

**[0013]** At least one of the second regions comprises a recess with a three dimensional shape. Such a recess can be manufactured easily and it results in the reduced wall thickness in the second regions.

**[0014]** Therein, the three dimensional shape of the recess is such that a diameter of the recess increases with a decreasing thickness of the outer wall which might occur due to erosion and melting. Thus, a reduced wall thickness results in a hole with a bigger diameter, allowing a stronger flow of cooling fluid through the hole. This measure achieves in an increased cooling effect.

**[0015]** In one embodiment, the recess has a star-shaped cross section in a direction of viewing perpendicular to the outer wall. This increases the wetted surface in the recess and the hole, respectively, to that a stronger heat transfer can be achieved.

**[0016]** In another embodiment, the three dimensional shape is a lengthy slot with an extension in a first direction along the outer wall being significantly larger than the extensions in the other directions. Therein, the term "significantly" refers to dimensions of the extension in the first direction which are larger than the other two dimensions by a factor of 3 or more. The extension in the first direction might be such that the lengthy slot forms a closed loop around the circumference of the component. With this approach, large parts of the component span or chord can be covered and the probability that TBC is lost in an area without a second region is reduced significantly.

**[0017]** In a further embodiment, the three dimensional shape is a conic shape, a pyramidal shape, or a half dome shape. Therein, the corresponding recesses are arranged such that the axis of symmetry of these shapes is perpendicular to the outer wall. Such shapes can be manufactured easily and they achieve that the diameter of the recess increases with a decreasing thickness of the outer wall, resulting in a increased cooling effect with decreasing wall thickness.

**[0018]** Therein, the three dimensional shape is a truncated shape with a first flat surface A at a base of the shape and a second flat surface B at a top of the shape, wherein an area of the second surface B at the top of the shape is larger than an area of the first surface A at the base of the shape. Again, such shapes can be manufactured easily and they achieve that the diameter of the recess increases with a decreasing thickness of the outer wall, resulting in a increased cooling effect with decreasing wall thickness.

**[0019]** In another embodiment, the three dimensional shape is cylinder or a box with at least two parallel surfaces A, B, wherein the three dimensional shape comprises a first flat surface A at a base of the shape and a second flat surface B at a top of the shape. The corresponding recess would again be arranged such that the axis of symmetry of the cylinder is perpendicular to the outer wall at the location of the recess. The recess is oriented such that the first surface A of the shape is facing to the inner surface of the outer wall and the second surface B is facing to an outer surface of the outer wall, wherein both the first surface A and the second surface B are essentially parallel to the outer wall. With the above explained features of the surfaces A, B, an improved cooling effect is achieved with decreasing wall thickness.

**[0020]** During operation of the turbomachine, the component typically comprises zones with different thermal loads, i.e. at least a zone with highest thermal load, a zone with medium thermal load, and a zone with lowest thermal load. The second regions are located in the zone with highest thermal load. In that zone, the probability of damages is highest, so that the arrangement of the second regions in that zone guarantees the best protection with least efforts.

**[0021]** The component comprises a leading edge zone and a trailing edge zone, and the second regions are located in the leading edge zone.

**[0022]** In one embodiment, the second wall thickness of one particular region of the second regions and the first wall thickness of the at least one first region surrounding the particular second region are dimensioned such that, upon unprotected exposure of the particular second region and the surrounding first region to a hot gas during operation of the turbomachine, the outer wall melts at the location of the particular second region to form a hole in the particular second region, such that a cooling fluid can leak out of the component to achieve the film cooing effect. In other words, the wall thickness in that particular second region is such that the wall in that second region melts so much faster than the wall in the first region surrounding that only a hole is formed upon exposure of the outer wall to the hot gases. This would occur as soon as TBC is lost at the corresponding location. The above explained film cooling effect would then be achieved by cooling fluid leaking out of the hole.

**[0023]** The component can be an airfoil of a blade or a vane.

**[0024]** Each of the second regions may comprise a depression on the inner surface of the outer wall. Thus, the outer surface of the outer wall can be even and the coating comprising a bond coat and the TBC can be applied easily.

**[0025]** A preferred method for manufacturing a component for a turbomachine according to the invention, comprises

- a step of providing a casting mold, at least comprising protrusions corresponding to the depressions to be generated on the inner surface of the outer wall, and

- a step of casting the component using the casting mold.

**[0026]** The above-mentioned and other features of the invention will now be addressed with reference to the accompanying drawings of the present invention. The illustrated embodiments are intended to illustrate, but not limit the invention. The drawings contain the following figures, in which like numbers refer to like parts, throughout the description and drawings.

FIG. 1 is a perspective view of a blade of a turbomachine,

FIG. 2 shows a cross-sectional view of an airfoil of the blade,

FIG. 3 shows an enlarged view on the section III of FIG 2, with recesses on an inner outer surface of an outer wall of the airfoil,

FIG. 4 again shows an enlarged view on the section III with a damaged coating,

FIG. 5 shows the shape of a cylindrical recess,

FIG. 6 shows the shape of a conic recess,

FIG. 7 shows the shape of a pyramidal recess,

FIG. 8 shows the shape of a cubic recess,

FIG. 9 shows the shape of a recess in the form of a lengthy slot,

FIG. 10 shows the shape of a half-dome recess,

FIG. 11 shows a star-like cross section of a recess,

FIG. 12 shows a hexagonal distribution of recesses,

FIG. 13 shows a triangular distribution of recesses,

FIG. 14 shows a quadratic distribution of recesses,

FIG. 15 shows an enlarged view on the section III of FIG 2, with recesses on an outer surface of the outer wall,

FIG. 16 shows an enlarged view on the section III of FIG 2, with recesses on both the outer and the inner surface of the outer wall.

**[0027]** Embodiments of the present invention described below relate to a blade component in a turbomachine. However, the details of the embodiments described in the following can be transferred to a vane component without modifications, that is the terms "blade" or "vane" can be used in conjunction, since they both have the shape of an airfoil with an integrated cooling arrangement in the form of a core passage way comprising one or multiple flow paths through which a cooling fluid is directed. The turbomachine may include a gas turbine, a steam turbine, a turbofan and the like.

**[0028]** The present invention relates to a component of a turbomachine, especially to a blade. The blade is connected to a rotor of said turbomachine, wherein the rotor with the blade is rotatable around an axis of rotation. Herein, any term describing a direction like "radial" or "axial" is with reference to the axis of rotation of the rotor, i.e. a radial direction means a direction perpendicular to the axis of rotation of the rotor and an axial direction is in parallel to the axis of rotation.

**[0029]** FIG 1 shows a schematic diagram of an exemplary blade 1 of a rotor (not shown) of a turbomachine, such as a gas turbine. The blade 1 includes an airfoil portion 20, a root portion 30, and a platform portion 40. The airfoil portion 20 projects from the root portion 30 in a radial direction and the platform portion 40 is located between the airfoil portion 20 and the root portion 30. Thus, the airfoil portion 20 extends radially along a longitudinal direction of the blade 1.

**[0030]** The blade 1 is attached to a body of the rotor (not shown), in such a way that the root portion 30 is attached to the body of the rotor whereas the airfoil portion 20 is located at a radially outermost position. The platform portion 40 is attached to the radial outer surface of the rotor. Platform portions of neighbouring blades form an essentially cylindric surface.

**[0031]** Moreover, the blade 1 and the airfoil portion 20 comprises a cooling arrangement 50 (not visible in FIG 1), typically with a plurality of cooling paths and cooling cavities. During operation of the turbomachine, a cooling fluid 59 is directed through the cooling arrangement 50 to maintain a suitable temperature of the blade 1 and the airfoil 20, respectively.

**[0032]** FIG 2 shows a cross-sectional view of the airfoil 20 in a radial direction, including a simplified version of the cooling arrangement 50 with a plurality of channels 51-56.

**[0033]** The airfoil portion 20 has a pressure side 22 and a suction side 23. The pressure side 22 and the suction side 23 are joined together along a leading edge 24 and a trailing edge 25. The leading edge 24 and the trailing edge 25 extend along the radial direction.

**[0034]** The airfoil 20 comprises an outer wall 21 with at least one inner surface 29. The outer wall 21 surrounds a volume in which the cooling arrangement 50 is arranged. Moreover, the volume contains ribs 28, which are arranged to divide the cooling channels 51-56 inside the airfoil 20, wherein the ribs 28 are usually only slightly thicker than the outer wall 21. The channels 51-56 of the cooling arrangement 50 might be interconnected in a serpentine manner or they are connected to a separating cavity via which the cooling fluid 59 would be provided. For the sake of brevity, the cooling arrangement 50 itself will not be described in more detail since its design is not an essential part of the invention. It is sufficient to mention that the cooling arrangement 50 has a cooling path along which the cooling fluid 59 is directed. The cooling path extends along the channels 51.

**[0035]** The cooling path and the channels 51, respectively, is fluidly connected with an inner surface 29 of the outer wall 21 of the airfoil 20, such that during operation of the turbomachine, when the cooling fluid 59 is streaming through the cooling arrangement 50 and through the channels 51 along the cooling path, the cooling fluid 59 is in connection with the inner surface 29 of the outer wall 21, so that a heat transfer from the inner surface 29 to the cooling fluid 59 is achieved. It might only be mentioned, that in cases in which the cooling arrangement is more complicated than the arrangement shown in FIG 2, one or more cooling channels might be arranged such that they are not fluidly connected to the inner surface 29 of the outer wall 21. However, in the embodiment shown in FIG 2 all channels 51 of the cooling arrangement 50 are fluidly connected to a section of the inner surface 29 of the outer wall 21.

**[0036]** The outer wall 21 comprises first regions 71 in which the outer wall 21 has a first wall thickness d1. Moreover, the outer wall 21 comprises second regions 72 at defined locations on the outer wall 21. In the second regions 72 the outer wall 21 has a wall thickness d2 which is less than the first wall thickness d1, i.e. d2<d1. Thus, the outer wall 21 comprises a discontinuous wall thickness. In both cases, the wall thicknesses d1, d2 are measures for the extension of the outer wall 21 in a direction perpendicular to the outer wall 21.

**[0037]** For example, the outer wall 21 may comprise recesses 73 of a certain three dimensional (3D) shape in the second regions 72. At the location of a recess 73, the thickness d2 of the outer wall 21 is less than the wall thickness d1 in regions surrounding the recess 73. Therein, the region surrounding the recess 73 in the second region 72 is the first region 71.

**[0038]** At least at the locations of the second regions 72, the inner surface 29 of the outer wall 21 is fluidly connected with the cooling arrangement 50 and the cooling channels 51-56, respectively. Thus, in case a cooling fluid 59 is directed through the cooling channels 51-56 of the cooling arrangement 50, the cooling fluid 59 gets in contact with the second regions 72.

**[0039]** Preferably, as shown in the example of FIG 2, the second regions 72 with the recesses 73 are located in a zone of the airfoil 20 which has the highest thermal load during operation of the turbomachine. Such a zone would be located at the leading edge 24. Thus, the second regions 72 with reduced thickness d2 are preferably located at least at the inner surface 29 of the outer wall 21 at the particular cooling channel 51 which is located at the leading edge 24.

**[0040]** FIG 2 also shows that the outer wall 21 of the airfoil 20 is covered by a coating 60 which can comprise a bond coat 61 and a thermal barrier coating (TBC) 62. This is shown in detail in FIG 3. The bond coat 61 is applied on the outer surface 27 of the outer wall 21 and the TBC 62 is applied on the bond coat 61, i.e. the bond coat 61 is arranged between the outer wall 21 and the TBC layer 62. For example, the material of the outer wall 21 may comprise one or more metals. In general, the material of the outer wall 21 would melt if it is exposed to the hot gases in the environment of the blade during operation of the turbomachine. Therein, the melting time necessary until a hole in the wall occurs depends on the thickness of the unprotected outer wall 21 at the location of exposure to the hot gas. Such an exposure would occur when the coating 60, especially the TBC 61, is damaged.

**[0041]** FIG 3 shows an rotated, enlarged view on the section III marked in FIG 2 with the outer wall 21, the coating 60 with bond coat 61 and TBC 62, hot gas 80, first and second regions 71, 72, recesses 73, and with the particular cooling channel 51.

**[0042]** FIG 4 depicts the situation in which the coating 60 is damaged and a part of the coating 60 has been lost. In the shown example, both a part of the bond coat 61 and of the TBC 62 have been lost. Therewith, the material of the outer wall 21 at the location of the damage is exposed to hot gas 80 in the environment of the blade.

**[0043]** Due to the presence of hot gas 80, the material of the outer wall 21 at the location of the damage will start melting. However, since the wall thickness d2 in the second region 72 at the location of the recess 73 is less that the wall thickness d1 in the first region 71, i.e. in the region surrounding the recess 73, the wall material in the second region 72 will be molten away faster than the material in the surrounding region 71.

**[0044]** This results in a hole 74 in the outer wall 21, as depicted in FIG 4. Since the particular cooling channel 51 is fluidly connected with the second regions 72 and the recesses 73, respectively, the cooling fluid 59 streaming through the cooling arrangement 50 will pass the hole 74 and parts of the cooling fluid 59 will leave the blade through the hole 74. This results in a protective film 75 of cooling fluid and a film cooling effect at the location of the damage so that further melting of the material of the outer wall 21 and further damages of the blade are avoided.

**[0045]** The damage would be detected with the next inspection interval and the blade would be repaired. However, it can be assured that the blade can be used for normal operation in spite of the local damage.

**[0046]** As mentioned earlier, the airfoil 20 typically comprises zones with different thermal loads during operation of the turbomachine. The thermal load will be highest in a zone around the leading edge 24 and lowest in a zone around the trailing edge 25. In an intermediate zone between the leading edge 24 and the trailing edge 25, thermal load will be medium. Preferably, the second regions 72 are located only in the zone with highest thermal load, i.e. in the zone around the leading edge 24. Additionally, second regions 72 might be located in the intermediate zone.

**[0047]** For example, in areas prone to TBC loss the distance between neighbouring second regions 72 should be less than 10mm in all directions along the outer wall 21. This is especially applicable in the leading edge zone.

**[0048]** As mentioned above and as illustrated in FIG 5, the recesses 73 have a certain three dimensional (3D) shape. For example, a recess 73 can be cylindric, wherein the recess 73 would be arranged such that the axis of symmetry of the cylinder is perpendicular to the outer wall 21 at the location of the recess.

**[0049]** Alternatively, the recess 73 can be conical. Preferably, the conical shape is only a section of a full cone, i.e. a truncated cone or a conic section, as shown FIG 6. The shape has a first flat surface A at the base and a second flat surface B at the top. The cross-sections of those surfaces A, B can be round or oval. The area of the surface B at the top is less than the area of the surface A at the base of the conic section.

**[0050]** In another alternative, the recess 73 has a pyramidal shape. Preferably, the pyramidal shape is only a section of a full pyramid, i.e. a truncated pyramid or a pyramidal section, as shown FIG 7. The shape has a first flat surface A at the base and a second flat surface B at the top. The cross-sections of those surfaces A, B can be rectangular, especially square. The area of the surface B at the top is less than the area of the surface A at the base of the pyramidal section.

**[0051]** In another alternative, the recess 73 is box shaped. Therein, the box might be cubic, cuboid, or rectangular cuboid, as shown FIG 8.

**[0052]** In a special embodiment, the extension of the boxed shaped recess 73 in one particular direction parallel to the outer wall 21, i.e. to the inner surface 29 or the outer surface 27 of the outer wall 21, is substantially larger than the extensions in the other two directions, as shown in FIG 9. Thus, the recess 73 has the shape of a lengthy slot. The extension in the particular direction might be such that the lengthy slot forms a closed loop around the circumference of the airfoil 20. With this approach, large parts of the airfoil span or chord can be covered and the probability that TBC 62 is lost in an area without a second region 72 is reduced significantly.

**[0053]** In another alternative, the recess 73 has the shape of a half dome. Preferably, the domed shape is only a section of a full half dome, i.e. a truncated half dome, as shown FIG 10. The shape has a first flat surface A at the base and a second flat surface B at the top. The cross-sections of those surfaces A, B can be round or oval. The area of the surface B at the top is less than the area of the surface A at the base of the conic section.

**[0054]** In case of the conic shape, the pyramidal shape, and the half dome shape, the recess is oriented such that the larger base surface A of the shape is facing to the inner surface 29 of the outer wall 21 and the smaller top surface B is facing at the outer surface 27 of the outer wall 21. Both the top surface B and the base surface A are essentially parallel to the outer wall 21. In general, the shape of the recess increases in diameter with a decreasing thickness of the outer wall 21 due to erosion and melting to increase cooling flow and thereby increase cooling.

**[0055]** For example, the equivalent diameter of the cross-section area of the recess 73 can be between 0.0 and 0.7mm at the top and between 0.2 and 1.5mm at the base.

**[0056]** As an additional measure to increase heat transfer of an opened up hole 74, the whole cross-section of the recess 73 in a direction of viewing perpendicular to the outer wall 21 at the location of the recess 73 can be shaped like a star instead of a circle or a rectangle etc., as shown in FIG 11 in a direction of viewing perpendicular to the outer wall 21. This measure increases the so called wetted surface, i.e. the surface of the film on the surface of the outer wall 21 at the location of the hole 74 and its surroundings, and, therewith, the heat transfer to the cooling fluid 59.

**[0057]** In one embodiment, the first regions 71 are interconnected with each other, i.e. practically the first regions 71 form an uniform, extended surface and the second regions 72 with the recesses 73 are depressions in the uniform, extended surface 71. Thus, the recesses 73 and the second regions 72, respectively, are not interconnected. The second regions 72 can be distributed in the extended surface 71 according to a certain pattern. For example, the pattern can be a hexagonal pattern with the second regions 72 and the recesses 73 located on the corners of the hexagons of the pattern, as shown in FIG 12. Alternatively, the pattern might be a triangular (FIG 13) or a quadratic pattern (FIG 14) consisting of a plurality of regular triangles or squares, respectively, with the second regions 72 located at the corners of the triangles or squares. In FIGs 12, 13, and 14, only few of the second regions 72 have been marked with reference signs.

**[0058]** Preferably, the recesses 73 are located on the inner surface 29 of the outer wall 21, as shown in FIG 3 and 4. In this embodiment, the outer surface 27 of the outer wall 21 is even.

**[0059]** However, in an alternative embodiment the recesses 73 can be located on the outer surface 27 of the outer wall 21, as shown in FIG 15. In this embodiment, the inner surface 29 of the outer wall 21 is even.

**[0060]** In a further alternative embodiment, shown in FIG 16, recesses 73 are located both on the outer surface 27 of the outer wall 21 and on the inner surface 29 of the outer wall 21, i.e. a recess 73 would have the form of a double-recess. Therein, a recess 73-1 on the outer surface 27, i.e. an outer recess 73-1, opposes a recess on the inner surface, i.e. an inner recess 73-2, in a direction perpendicular to the outer wall 21 at the location of the recess. Therewith, the recesses 73-1, 73-2 are located such that a pair of recesses comprising an outer recess 73-1 and a corresponding inner recess 73-2 is located in one second region 72. Again, the thickness d2 of the outer wall 21 at the location of the double-recess 73 is less than the first wall thickness d1 in the first regions 71 of the outer wall 21.

**[0061]** For example, the surface 27, 29 of the outer wall 21 comprising the recesses 73 might be compared with the surface of a golf ball.

**[0062]** The airfoil 20 with the outer wall 21 and the discontinuities 73 can be manufactured by either conventional casting using a specially modified mold or by creating the part not by casting but by a selective laser melting (SLM) process. In case the part is casted, the mold can be manufactured either in a conventional way in one or more steps and pieces or the SLM process can be used to add certain features to the mold surface.

**[0063]** It might be specified that the formulation "perpendicular to the outer wall 21" is to be understood as "perpendicular to the outer surface 27 of the outer wall 21". Since the inner surface 29 and the outer surface 27 of the outer wall 21 are essentially parallel, the formulation can also be understood as "perpendicular to the inner surface 29 of the outer wall 21".

**[0064]** Although the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various modifications 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 component (1) of a turbomachine, comprising

- an outer wall (21) having an inner surface (29) and having a plurality of wall thicknesses (d1, d2), wherein the outer wall (21) surrounds a volume,
- a cooling arrangement (50) with at least one cooling channel (51-56) for guiding a cooling fluid (59), wherein at least a section (51) of the cooling arrangement (50) is located in the volume,

wherein the outer wall (21) comprises

- first regions (71) with at least one first wall thickness (d1),
- second regions (72) at defined locations of the outer wall (21) with at least one second wall thickness (d2), wherein each second region (72) is surrounded by at least one of the first regions (71) and wherein the second wall thickness (d2) is less than the first wall thickness (d1),

and wherein

- the inner surface (29) of the outer wall (21) is fluidly connected to the cooling arrangement (50) at least at the locations of the second regions (72).

**2.** The component according to claim 1, wherein at least one of the second regions (72) comprises a recess (73) with a three dimensional shape.

**3.** The component according to claim 2, wherein the three dimensional shape of the recess (73) is such that a diameter of the recess (73) increases with a decreasing thickness (d2) of the outer wall (21).

**4.** The component according to claim 2 or 3, wherein the recess (73) has a star-shaped cross section in a direction of viewing perpendicular to the outer wall (21).

**5.** The component according to claim 2 or 3, wherein the three dimensional shape is a lengthy slot with an extension in a first direction along the outer wall (21) being significantly larger than the extensions in the other directions.

**6.** The component according to claim 2 or 3, wherein the three dimensional shape is a conic shape, a pyramidal shape, or a half dome shape.

**7.** The component according to claim 6, wherein the three dimensional shape is a truncated shape with a first flat surface (A) at a base of the shape and a second flat surface (B) at a top of the shape, wherein an area of the second surface (B) at the top of the shape is larger than an area of the first surface (A) at the base of the shape.

**8.** The component according to claim 2 or 3, wherein the three dimensional shape is cylinder or a box with at least two parallel surfaces (A, B), wherein the three dimensional shape comprises a first flat surface (A) at a base of the shape and a second flat surface (B) at a top of the shape.

**9.** The component according to claim 7 or 8, wherein the recess (73) is oriented such that the first surface (A) of the shape is facing to the inner surface (29) of the outer wall (21) and the second surface (B) is facing to an outer surface (27) of the outer wall (21), wherein both the first surface (A) and the second surface (B) are essentially parallel to the outer wall (21).

**10.** The component according to any one of the preceding claims, wherein the component (1) comprises zones with different thermal loads during operation of the turbomachine, wherein the second regions are located in the zone with highest thermal load.

**11.** The component according to any one of the preceding claims, wherein the component (1) comprises a leading edge (24) zone and a trailing edge (25) zone, wherein the second regions are located in the leading edge (24) zone.

**12.** The component according to any one of the preceding claims,
wherein the second wall thickness (d2) of one particular of the second regions (72) and the first wall thickness (d1) of the at least one first region (71) surrounding the particular second region (72) are dimensioned such that, upon exposure of the particular second region (72) and the surrounding first region (71) to a hot gas (80) during operation of the turbomachine, the outer wall (21) melts at the location of the particular second region (72) to form a hole (74) in the particular second region (72).

**13.** The component according to any one of the preceding claims,
wherein the component (1) is an airfoil (20) of a blade or a vane.

**14.** The component according to any one of claims 2 to 9, wherein each of the second regions (72) comprises a depression (73) on the inner surface (29) of the outer wall (21).

**15.** A method for manufacturing a component for a turbomachine according to claim 14, comprising

- a step of providing a casting mold, at least comprising protrusions corresponding to the depressions to be generated on the inner surface of the outer wall,
- a step of casting the component using the casting mold.

FIG 1

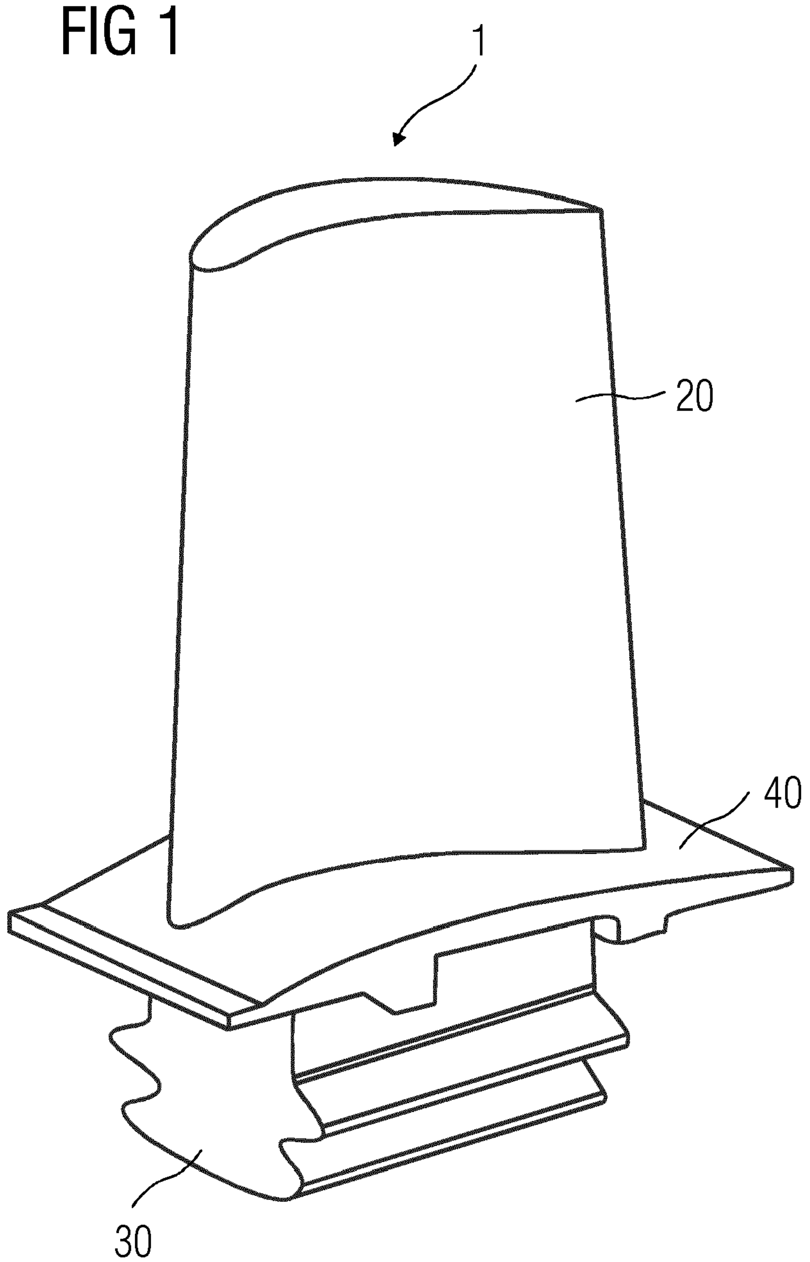

FIG 2

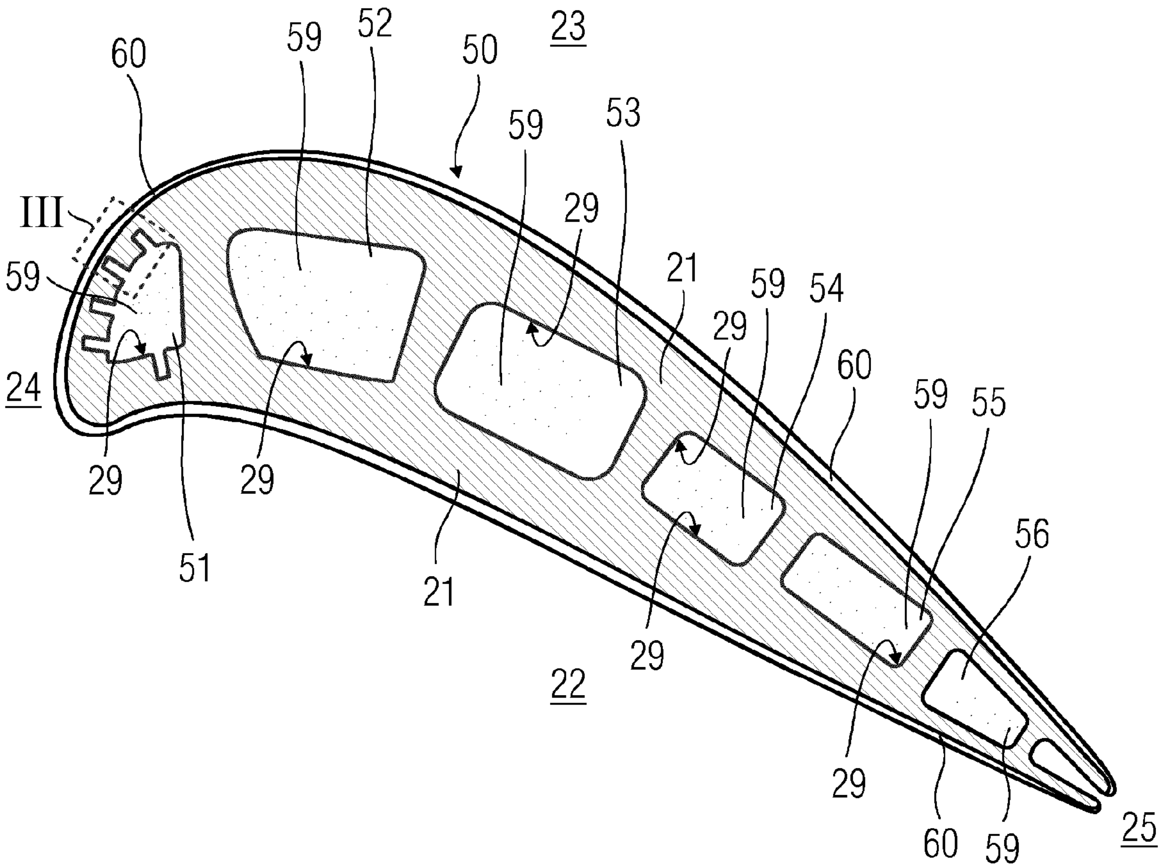
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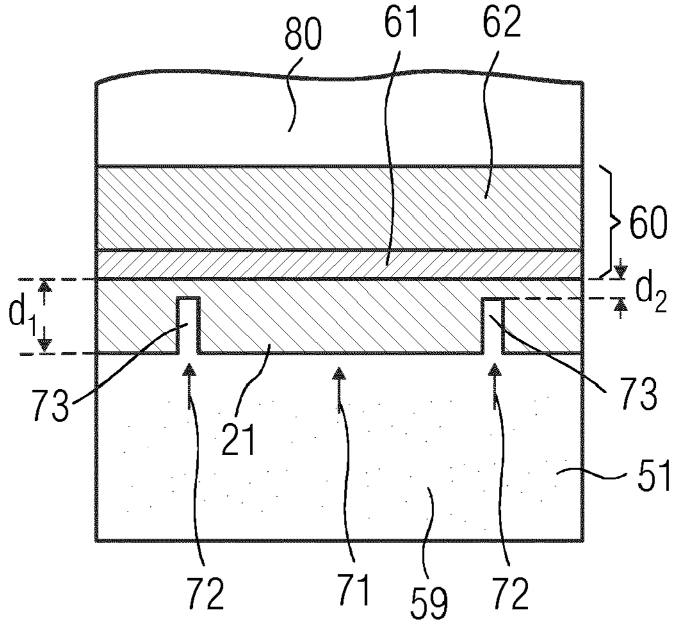
FIG 3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d1
d2
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71
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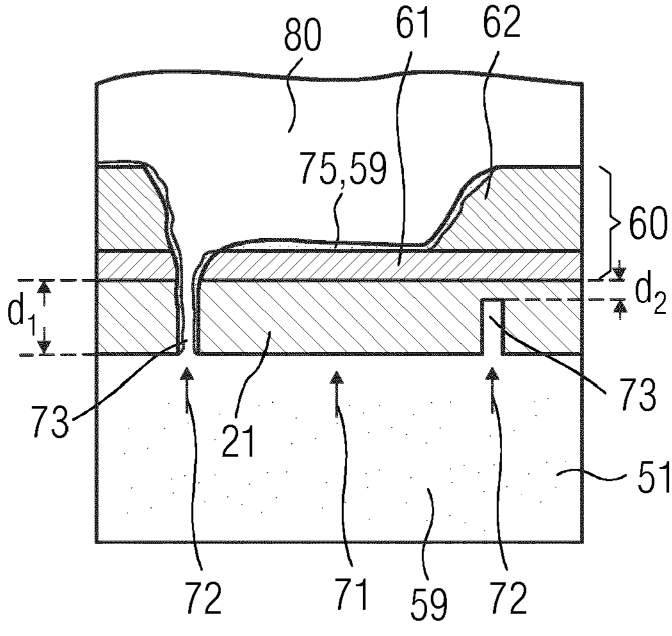
72

FIG 4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75,59
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d1
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FIG 5

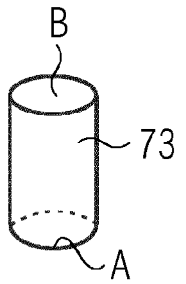



FIG 6

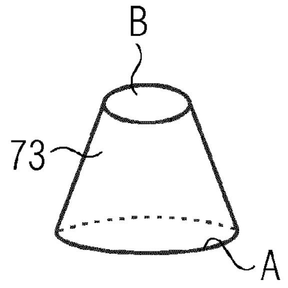



FIG 7

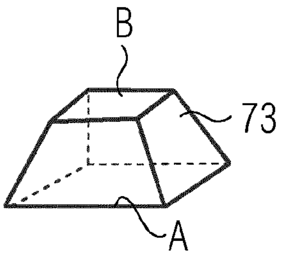



FIG 8

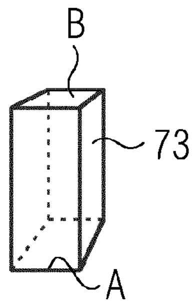



FIG 9

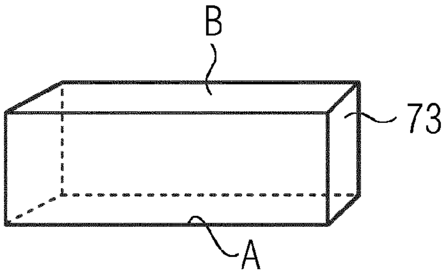



FIG 10

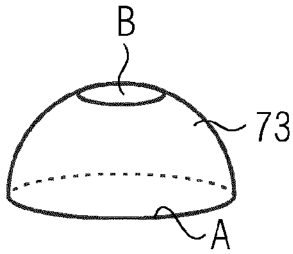



FIG 11

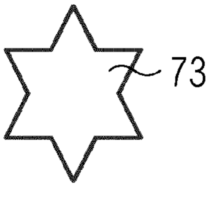


FIG 12

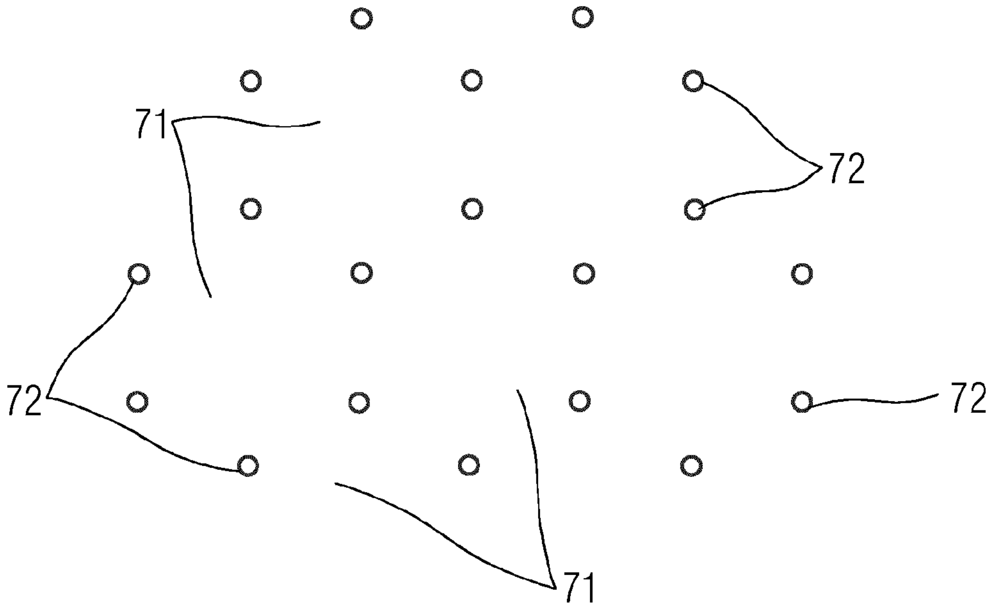



FIG 13

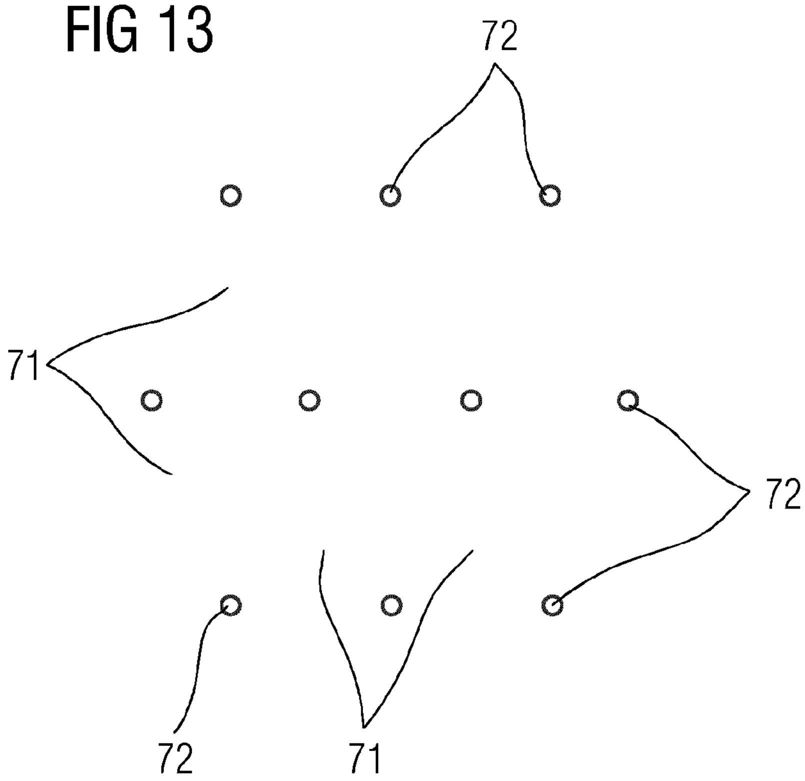


FIG 14

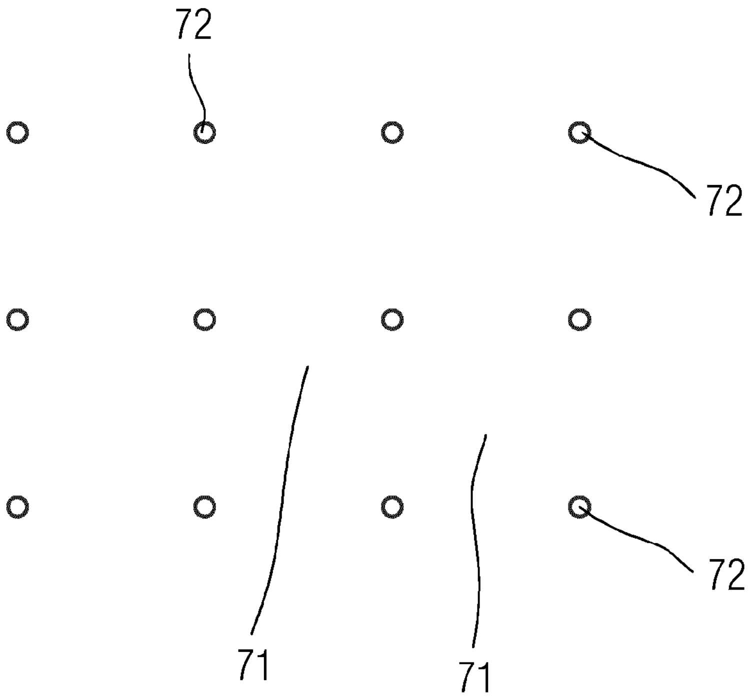



FIG 15

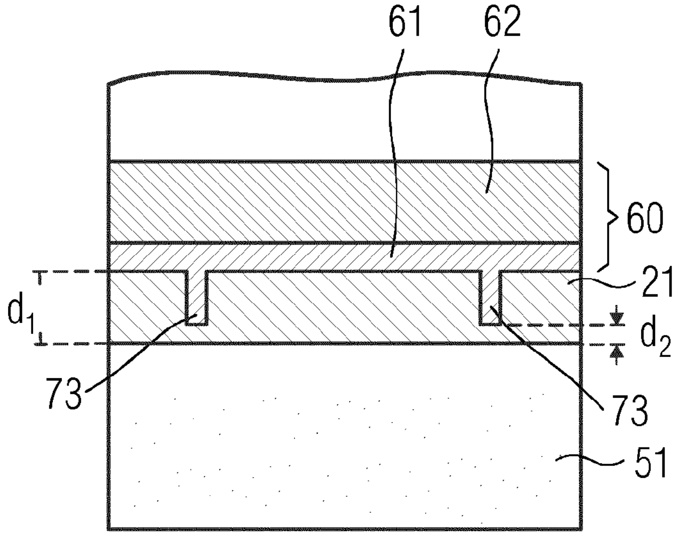
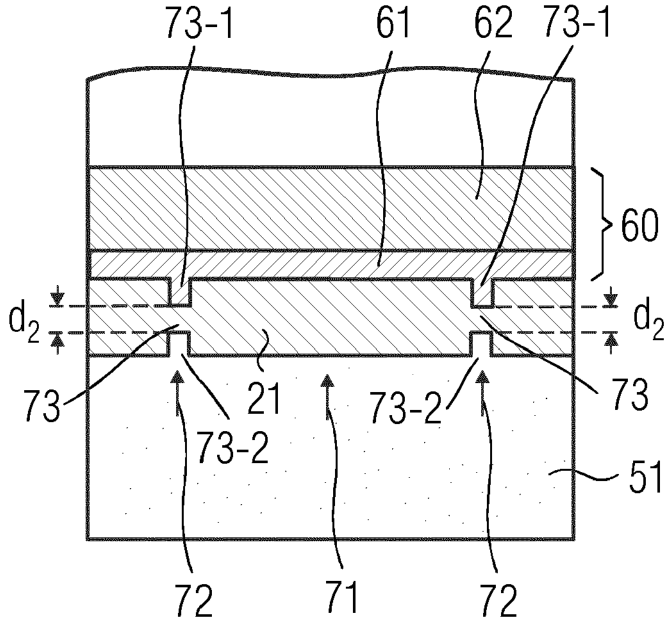


FIG 16



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Application Number
EP 13 18 6903

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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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 |
|---|---|---|
| Munich | 20 February 2014 | Koch, Rafael |

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EPO FORM 1503 03.82 (P04C01)

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