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(54) **COMPONENT AND CORRESPONDING METHOD OF MANUCFACTURING**

(57) A component (100) for a turbo machine. The component (100) comprises : a main body (104) having a fluid inlet (103) and fluid outlet (200) and a cooling passage (204) extending between the fluid inlet (103) and the fluid outlet (200). The cooling passage (204) is divided into a first section (204A) and a second section (204B) which extends between the fluid inlet (103) and fluid outlet (200). At least part of the first section (204A) and second section (204B) comprise a surface roughness (Ra) no less than about 7μm but no more than about 15 μm.

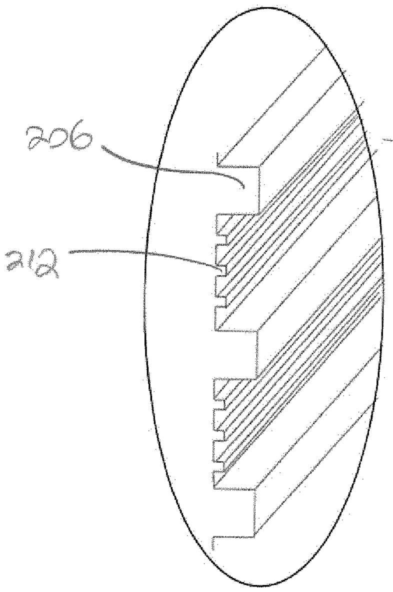

Figure 5

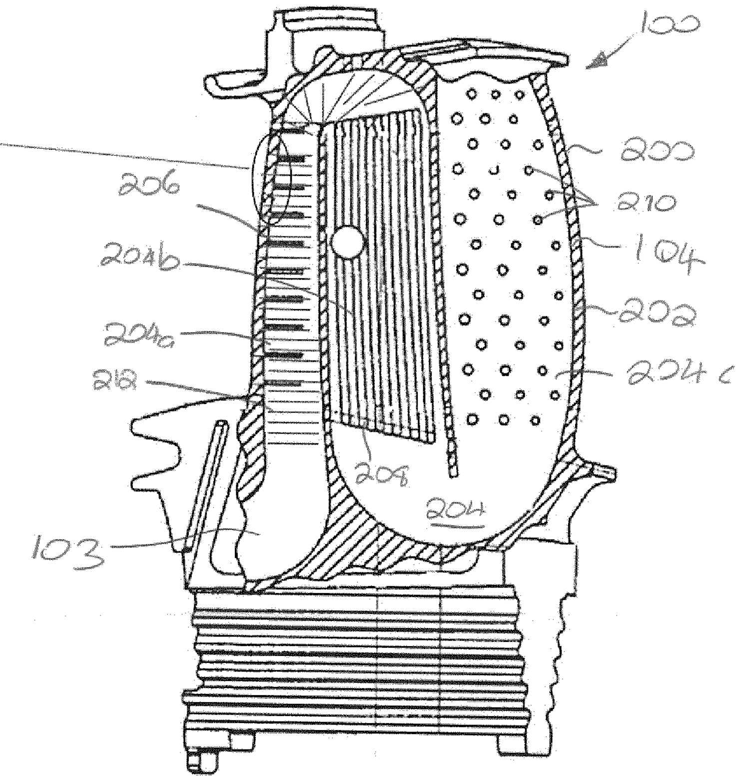

Figure 4

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Description

[0001] The present disclosure relates to a component for a turbo machine, and a method of manufacturing a component for a turbo machine.

Background

[0002] Gas turbines generally include a rotor with a number of rows of rotating rotor blades which are fixed to a rotor shaft and rows of stationary vanes between the rows of rotor blades which are fixed to the casing of the gas turbine. When a hot and pressurized working fluid flows through the rows of vanes and blades it transfers momentum to the rotor blades and thus imparts a rotary motion to the rotor while expanding and cooling. The vanes are used to control the flow of the working medium so as to optimize momentum transfer to the rotor blades.

[0003] A typical gas turbine rotor blade comprises a root portion by which it is fixed to the rotor shaft, and an aerodynamically formed aerofoil portion which allows a transfer of momentum when the hot and pressurized working fluid flows along the aerofoil section.

[0004] Rotor blades tend to be hollow, for example comprising a plenum through which cooling air is forced. The plenum may be divided by internal walls which are formed integrally with the aerofoil structure.

[0005] As the components are usually made by the 'lost wax' casting method the surface finish of the internal passages which is smooth enough to have a negligible effect on the surface heat transfer. Typical cooling designs for nozzle guide vanes and turbine blades use turbulators (e.g. ribs, pins or pedestals) or impingement jets in various combinations to generate the necessary internal heat transfer.

[0006] However, such an arrangement may not provide a suitable level of cooling at all engine conditions, and hence may limit the maximum working temperature of the engine.

[0007] Hence a cooling arrangement for a component which provides a greater degree of cooling is highly desirable.

Summary

[0008] According to the present disclosure there is provided an apparatus and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

[0009] Accordingly there may be provided a component (100) for a turbo machine, the component (100) comprising : a main body (104) having a fluid inlet (103) and fluid outlet (200); a cooling passage (204) extending between the fluid inlet (103) and the fluid outlet (200); the cooling passage (204) divided into a first section (204A) and a second section (204B) which extend between the fluid inlet (103) and fluid outlet (200); and at least part of the first section (204A) and/or second section (204B) comprise a surface roughness (Ra) no less than about 7μm but no more than about 15 μm.

[0010] The surface roughness of the first section (204A) and second section (204B) may be different to one another.

[0011] The surface roughness of the remaining areas of the cooling passage (204) may be no less than about 1.5μm but no more than about 3.5 μm.

[0012] The surface roughness of the first section (204A) and second section (204B) may be the same as one another.

[0013] The surface roughness may be defined by a plurality of spaced apart micro ribs (212) which extend at least part of the way across the cooling passage (204). The micro ribs (212) may have a height and width of no less than 0.025mm and no greater than 0.1 mm.

[0014] The micro ribs (212) may be polygonal in cross section.

[0015] One of the cooling passage (204) sections may be further provided with macro ribs (206) which extend across the cooling passage (204). The macro ribs (206) may have a height and width of no less than 0.5mm and no greater than 5.0mm. At least one micro rib (212) may be provided between adjacent macro ribs (206).

[0016] The macro ribs (206) may be polygonal in cross section.

[0017] The macro ribs (206) and micro ribs (212) may be are parallel with one another.

[0018] The macro ribs (206) and micro ribs (212) may be at an angle to one another.

[0019] The macro ribs (206) may be parallel to one another.

[0020] The micro ribs (212) may be parallel to one another.

[0021] The component (100) may be one of : a rotor blade, stator vane or rotor disc.

[0022] There may also be provided a method of manufacturing a component (100) for a turbo machine, the method comprising : providing a ceramic core element (300) for forming internal fluid flow passages of the component (100) by casting the component (100) around the ceramic core; wherein the walls of the ceramic core (300) which define a surface of the flow passages comprise a region having a predetermined surface roughness of no less than about 7μm but no more than about 15μm.

[0023] The surface roughness may be defined by micro grooves (312) provided in the surface of the ceramic core (300).

[0024] Hence there is provided a component for a turbo machine, for example a gas turbine engine, configured to have a cooling passage with a predetermined surface roughness which increases heat transfer between the material of the component and fluid/air passing through the component. There is also provided a method of making the component with the required pattern of surface roughness.

Brief Description of the Drawings

[0025] Examples of the present disclosure will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a schematic representation of an example of a turbo machine;

Figure 2 shows an enlarged region of a section of a turbine of the turbo machine shown in Figure 1;

Figure 3 shows an end view of the rotor blades shown in Figures 1, 2;

Figure 4 shows a part sectional view of a rotor blade according to the present disclosure;

Figure 5 shows an enlarged region of the rotor blade of Figure 5;

Figures 6 to 10 show pictorial representations of different examples of rotor blade cooling passages configured according to the present disclosure;

Figure 11 shows a ceramic core used for the manufacture of a rotor blade; and

Figure 12 shows a region of a rotor blade corresponding to the core of Figure 11.

Detailed Description

[0026] The present invention relates to a method of manufacture of a component for a turbo machine, and the component. The turbo machine may be a gas turbine engine, and the component may be a rotor blade, stator vane or rotor disc.

[0027] By way of context, Figure 1 shows an example of a gas turbine engine 60 in a sectional view, which illustrates the nature of components according to the present disclosure (for example rotor blades) and the environment in which they operate. The gas turbine engine 60 comprises, in flow series, an inlet 62, a compressor section 64, a combustion section 66 and a turbine section 68, which are generally arranged in flow series and generally in the direction of a longitudinal or rotational axis 70. The gas turbine engine 60 further comprises a shaft 72 which is rotatable about the rotational axis 70 and which extends longitudinally through the gas turbine engine 60. The rotational axis 70 is normally the rotational axis of an associated gas turbine engine. Hence any reference to "axial", "radial" and "circumferential" directions are with respect to the rotational axis 70.

[0028] The shaft 72 drivingly connects the turbine section 68 to the compressor section 64. In operation of the gas turbine engine 60, air 74, which is taken in through the air inlet 62 is compressed by the compressor section 64 and delivered to the combustion section or burner section 66. The burner section 66 comprises a burner plenum 76, one or more combustion chambers 78 defined by a double wall can 80 and at least one burner 82 fixed to each combustion chamber 78. The combustion chambers 78 and the burners 82 are located inside the burner plenum 76. The compressed air passing through the compressor section 64 enters a diffuser 84 and is discharged from the diffuser 84 into the burner plenum 76 from where a portion of the air enters the burner 82 and is mixed with a gaseous or liquid fuel. The air/fuel mixture is then burned and the combustion gas 86 or working gas from the combustion is channelled via a transition duct 88 to the turbine section 68.

[0029] The turbine section 68 may comprise a number of blade carrying discs 90 or turbine wheels attached to the shaft 72. In the example shown, the turbine section 68 comprises two discs 90 which each carry an annular array of turbine assemblies 12, which each comprises an aerofoil 14 embodied as a turbine blade 100. Turbine cascades 92 are disposed between the turbine blades 100. Each turbine cascade 92 carries an annular array of turbine assemblies 12, which each comprises an aerofoil 14 in the form of guiding vanes (i.e. stator vanes 96), which are fixed to a stator 94 of the gas turbine engine 60.

[0030] Figure 2 shows an enlarged view of a stator vane 96 and rotor blade 100. Arrows "A" indicate the direction of flow of combustion gas 86 past the aerofoils 96,100. Arrows "B" show air flow passages provided for sealing, and arrows "C" indicate cooling air flow paths for passing through the stator vanes 96. Cooling flow passages 101 may be provided in the rotor disc 90 which extend radially outwards to feed an air flow passage 103 in the rotor blade 100.

[0031] The combustion gas 86 from the combustion chamber 78 enters the turbine section 58 and drives the turbine blades 100 which in turn rotate the shaft 72 to drive the compressor. The guiding vanes 96 serve to optimise the angle of the combustion or working gas 86 on to the turbine blades.

[0032] Figure 3 shows a view of the rotor blades 100 looking upstream facing the flow "A" shown in Figure 2.

[0033] Each rotor blade 100 comprises an aerofoil portion 104, a root portion 106 and a platform 108 from which the aerofoil extends.

[0034] The rotor blades 100 are fixed to the rotor disc 102 by means of their root portions 106, through which the flow passage 101 may extend. The root portions 106 have a shape that corresponds to notches (or grooves) 109 in the rotor disc 90, and are configured to prevent the rotor blade 100 from detaching from the rotor disc 102 in a radial direction as the rotor disc 102 spins.

[0035] Figure 4 shows a part sectional view of a component according to the present disclosure. In this example the component is a rotor blade 100 as described above. The component 100 comprises a main body 104, provided in this example as the aerofoil portion 104. The main body 104 has a fluid inlet 103 which, as described above, in situ will be in flow communication with a cooling passage 101 or other fluid source.

[0036] Although the present example relates to a rotor blade, the component may be another fluid/air cooled component for a gas turbine engine. For example a nozzle guide vane or a turbine rotor in which the rotor blades are provided integrally with a rotor disc 90.

[0037] The inlet 103 may be provided as a single passage, or a plurality of passages. The component 104 further comprises a fluid outlet, or a plurality of fluid outlets 200. A cooling passage 204 extends between the fluid inlet 103 and fluid outlet 200.

[0038] In the present example the fluid outlet is provided along a trailing edge 202 of the aerofoil, for example as an elongate slit or plurality of openings. The fluid outlet may also be through a hole in the blade tip section.

[0039] Where the term fluid inlet and fluid outlet are used, this may be taken to mean a single inlet and/or outlet, or a plurality of inlets and/or a plurality of outlets. Hence a subdivided inlet may feed the cooling passage 204 and/or a sub divided outlet may provide an exhaust path from the cooling passage 204.

[0040] In the example shown in Figure 4 the cooling passage 204 is divided into a first section 204A and a second section 204B. The first section 204A and second section 204B extend between the fluid inlet 103 and fluid outlet 200. In the example shown the first section 204A and second section 204B are in series with each other between the fluid inlet 103 and fluid outlet 200. In the present example there is also provided a third section 204C. In the example shown the third section is in series with the first section and second section. Hence fluid (i.e. air) entering the flow passage 204 through the fluid inlet 103 will pass through the first section 204A, then the second section 204B and then the third section 204C before exiting the fluid outlet 200.

[0041] The terms "first section", "second section" and "third section" are intended to mean "different sections". In some of the examples shown the third section is located downstream of the second section, and the second section is located downstream of the first section in the cooling passage, in terms of direction of flow of cooling flow. However, in other examples the first, second and third sections may be arranged differently. For example, the first section may be downstream of the second section, and/or the third section may be immediately downstream of the first section.

[0042] In the example shown in Figure 4, different macro cooling features (i.e. turbulators) are provided in each of the sections. The first section 204A comprises turbulators 206 which extend from a wall of the rotor blade, providing a flow restriction and increased surface area in the flow path. The second section 204B comprises a plurality of dividing walls 208 with spaces therebetween, which define flow passages and provide an increased surface area. The third section 204C comprises pedestals 210 to provide an increased surface area. Each of these macro cooling features are configured to increase surface area and promote turbulence and hence increase the amount of heat that will be transferred from the material of the rotor blade to the air passing therethrough.

[0043] In other examples different macro cooling features, or a different combination of the above described macro features may be provided. In other examples cooling passage may not comprise any macro cooling features.

[0044] The surface roughness (Ra) of at least one of the first section and second section is configured to be no less than about 7μm but no more than about 15 μm. That is to say, at least part of the first section and/or second section comprise a surface roughness (Ra) no less than about 7μm but no more than about 15 μm. Put another way, the surface roughness (Ra) of at least one region of at least one section of the cooling passage 204 is configured to be no less than about 7 μm but no more than about 15 μm. That is to say at least one region of at least one section of the cooling passage 204 is configured to have a predetermined surface roughness (Ra) no less than about 7 μm but no more than about 15 μm. Alternatively the predetermined surface roughness (Ra) may be no less than about 8 μm but no more than about 11 μm.

[0045] The surface roughness of the remaining areas of the cooling passage 204 may be no less than about 1.5 μm but no more than about 3.5 μm.

[0046] Hence the surface roughness of the second section may be no less than about 1.5 μm but no more than about 3.5 μm.

[0047] In other examples, the surface roughness of the first section and second section may be the same as one another.

[0048] Although in the present example the first section is provided immediately downstream of the fluid inlet 103, the first section of the cooling passage may be located further downstream the cooling passage. The predetermined surface roughness (i.e. in the desired range) may be provided over the entire cooling passage 204 or to selected regions of the cooling passage 204. The predetermined surface roughness (i.e. in the desired range) may be provided on all of a cooling passage section, as shown in the Figure 4, or a subset (i.e. region) of a section of the flow passage. Hence for example the second section may be provided with the predetermined surface roughness in the desired range, and the first section and third section may have a different surface roughness to the second section. The surface roughness of the first section and second section may be different to one another.

[0049] Although different means of achieving the surface roughness may be provided, in the present example the surface roughness is defined by a plurality of spaced apart micro ribs 212 which extend at least part of the way across the cooling passage 204, and in particular across the first section 204A of the cooling passage 204. The micro ribs may have a height and width of no less than

0.025mm and no greater than 0.05mm. Alternatively the micro ribs may have a height and width of no less than 0.025mm and no greater than 0.1 mm. This is sufficient to create the surface roughness (Ra) of no less than about 7 μm but no more than about 15 μm.

[0050] The micro ribs 212 may be polygonal in cross section. The micro ribs 212 may be square in cross section.

[0051] Alternatively, or additionally, the macro ribs (turbulators) 206 may be polygonal in cross section, for example square.

[0052] The macro ribs may have a height and width of no less than 0.5mm and no greater than 5mm.

[0053] At least one micro rib may be provided between adjacent macro ribs.

[0054] The macro ribs 206 may be parallel with the micro ribs 212. The macro ribs may be parallel to one another. The micro ribs may be parallel to one another. At least one of the micro ribs may be angled relative to another one of the micro ribs. For example, the micro ribs may be provided 20° to 70° to the flow direction. The macro ribs and micro ribs may be provided at an angle to one another. That is to say the macro ribs may be provided at an angle to the micro ribs.

[0055] Figures 6 to 10 show different arrangements according to the present disclosure. It will be appreciated that cooling passages through turbine blades may be provided in a great number of different ways, and that the provision of a predetermined surface roughness in the cooling passage may be applied regardless of the geometry of the cooling passage.

[0056] Figures 6 to 9 show variations on the arrangements shown in Figure 4, with Figure 6 showing the first section 204A having the predetermined surface roughness (i.e. Ra provided as no less than about 7 μm but no more than about 15 μm). In the examples shown the surface roughness of the remaining sections of the cooling passage have a different surface roughness to that of the first section 204A. In Figure 6 the surface roughness is provided by micro ribs which are perpendicular to the direction of flow through the first section 204A. In Figure 7 micro ribs are provided an angle to the direction of flow in the first section 204A.

[0057] It may be advantageous to provide the predetermined surface roughness in the first section of the cooling passage 204, and to have the surface roughness in the remaining parts of the cooling passage to be configured with a lower surface roughness than in the first section.

[0058] The predetermined surface roughness may be provided in a region of the cooling passage 204 which extends through a region of the component which will, in use, require most cooling (for example, the leading edge region, as shown in Figures 4 to 10), with the surface roughness in the remainder of the cooling passage being provided with a surface roughness less than that having the predetermined surface roughness.

[0059] With such a configuration, in use, the majority of the cooling effect will be in the region having the predetermined surface roughness.

[0060] Thus when the component is a rotor blade, and hence the leading edge of the rotor blade will be the region requiring most cooling, it may be advantageous to provide the section of the cooling passage passing through the leading edge region with the predetermined surface roughness, as shown in Figures 4 to 10.

[0061] In Figure 8 the first section 204A and second section 204B of the cooling passage are provided with micro ribs which extend perpendicular to the flow of air through them. Alternatively, or additionally, the micro ribs may be provided at an angle to the direction of flow. The surface roughness may be different in different sections or sub sections of the cooling passage 204. Hence in one section of the cooling flow passage the surface roughness may be configured to be no less than about 7 μm but no more than about 15 μm, and in another section the surface roughness has a different value (for example less than 7 μm or greater than 15 μm), and in the third section the surface roughness is less than in either of the other sections.

[0062] In the example of Figure 8 the surface roughness of two sections (first section 204A and the second section 204B) are provided with micro ribs to define the surface roughness, whereas the third section 204C is not provided with micro ribs, although is provided with pedestals 210 as taught in the example of Figure 4. Conversely, in the example of Figure 9 the predetermined surface roughness is different in all three of the sections 204A, 204B, 204C with a different pattern of micro ribs in each section. For example in the first section the micro ribs are an angle to the direction flow, in the second section the micro ribs are provided in a crosshatch form (i.e. some of the micro ribs being at an angle to some of the other micro ribs) and in the third section the micro ribs are provided in a zig zag form. Hence the micro ribs or surface finish may be provided in many ways to provide a predetermined surface roughness.

[0063] Figure 10 shows a further arrangement in which the cooling passage is divided into three sections, with a first section 204A being immediately downstream of a fluid inlet 103 and the flow being divided between a second section 204B and a third section 204C, where the flow passage through the second section 204B and third section 204C are arranged in parallel to the flow passage in the first section 204A. Hence the second section 204B is adjacent the trailing edge of the rotor blade, and the third section 204C is adjacent the leading edge of the rotor blade.

[0064] The second section 204B has a fluid outlet 200 as well as being provided with micro ribs to define a predetermined surface roughness, for example no less than about 7 μm but no more than about 15 μm, with the micro ribs being provided at an angle to the longitudinal direction of the second section 204A. The third section 204C has a first sub section 204C1 in flow communication with a second sub section 204C2 to form a "U" shape, the third section 204C being between the first section 204A and a leading edge of the rotor blade. The second sub section 204C2 is provided with the predetermined surface roughness whereas the first sub section 204C1 is relatively smooth compared to the second sub section.

[0065] The provision of a region of predetermined surface roughness (e.g. with a value of Ra in the range 7μm to 15 μm, or in the range of in the range 8μm to 11 μm) enhances the heat transfer from that region on which is it provided. The rough surface can be used in isolation or in combination with conventional cooling methods to further enhance the heat transfer. That is to say, the predetermined surface roughness may be provided instead of macro cooling features, or in addition to macro cooling features.

[0066] The range of 7μm to 15 μm has been determined to provide a surprising effect. Below this range there is no appreciable enhanced heat transfer coefficient (i.e. cooling effect), and above this range there is no appreciable change in heat transfer coefficient of the material, although pressure losses above this range become significant, which impedes flow.

[0067] Conventionally surface roughness of cooling passages is provided in the range of 1.5 μm to no more than about 3.5 μm.

[0068] As is understood in the art, the component may be cast by casting the component around a ceramic core. The method of manufacturing a component for a turbo machine, for example a gas turbine engine as hereinbefore disclosed, may comprise the step of providing a ceramic core element 300, more than one element per rotor blade, for forming internal flow passages for example as shown in Figures 4 to 10.

[0069] Figure 11 shows an example of a ceramic core 300 that may be used in the manufacture of a rotor blade according to the present disclosure. Figure 12 shows an enlarged region of the features created in a cooling passage of the component by the features of the ceramic core 300 shown in Figure 11.

[0070] In order to achieve a rough surface to the internal walls which define the cooling passages of the final component, the outer surfaces of the ceramic core 300 are provided with the predetermined surface roughness, which may be achieved in a variety of ways.

[0071] Put another way, the walls of the ceramic core which define a surface of the flow passages may comprise a region or regions having a predetermined surface roughness of no less than about 7μm but no more than about 15μm.

[0072] The walls which define the ceramic core 300 which define a surface of the cooling passage sections (where the surfaces are indicated as 304A, 304B and 304C to correspond to passage sections 204A, 204B and 204C, and sub sections thereof, respectively) may have a surface roughness of no less than about 7 μm but no more than about 15 μm.

[0073] They may be divided still into sub sections such that a predetermined surface roughness may be provided on one or more of these sections 304A, 304B, 304C or a sub section thereof (for example a sub section of one of the sections, but not the whole section). Hence with a predetermined surface roughness applied to the surface of the core, when cast, the surface roughness will be reflected in the resultant cooling passage of the component.

[0074] The surface roughness may be defined by micro grooves 312 provided in the surface of the ceramic to produce a pattern as shown in the enlarged region in Figure 13. Other features of the core (for example macro grooves 306) may also be provided to provide any required features of the resultant cooling passages, for example any required pattern to produce features such as the macro cooling feature 206 which interrupt the flow through the remainder of the cooling passage.

[0075] In examples where micro grooves 312 are provided, the micro grooves may be formed by machining the surface of the ceramic core. Alternatively the micro grooves may be formed by laser ablating the surface of the ceramic core. The surface of the ceramic core may be laser ablated to remove small amounts of the ceramic, thereby forming a uniformly rough surface, i.e. a homogeneous region of surface treatment. Alternatively the surface roughness may be provided by applying a coarse coating to the ceramic core, where the coarse coating provides the desired predetermined surface roughness.

[0076] Where micro grooves are provided, they may be provided in a variety of patterns corresponding to the desired pattern of micro-ribs, as previously described. That is to say, the width, depth and orientation of the grooves should be provided such that a surface roughness (Ra) greater than 7 μm but no more 15 μm is achieved on the resultant component.

[0077] Hence there is provided a component for a turbo machine which may be provided as a rotor blade, with a cooling passage, a region of the cooling passage having a predetermined surface roughness in the range of about 7 μm but no more than about 12 μm to thereby enhance surface cooling in that region. There is also provided a method of manufacturing such a component.

[0078] The regions of predetermined surface roughness provide enhanced internal cooling to ensure that the metal temperatures are low enough to prevent excessive oxidation, and provide an adequate creep life. By having a rough surface to the internal cooling passages the heat transfer can be significantly enhanced thus allowing greater engine efficiency, or a longer service life.

[0079] Provision of predetermined roughness according to the present disclosure is also advantageous as it can be use in addition with conventional turbulators (macro ribs) or impingement jets to further enhance the heat transfer. Thus the internal cooling systems of gas turbine components can be increased without change to the amount of air used for cooling.

[0080] The increase of internal heat transfer to cooled gas turbine components results in cooler component operating temperatures allowing greater service life. It may also result in less cooling air being used for the same component temperatures giving greater engine power for the same fuel consumption. It may also result in higher engine operating temperatures for the same cooling flow leading to higher engine efficiency.

[0081] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0082] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0083] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0084] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A component (100) for a turbo machine, the component (100) comprising :

a main body (104) having a fluid inlet (103) and fluid outlet (200);
a cooling passage (204) extending between the fluid inlet (103) and the fluid outlet (200);
the cooling passage (204) divided into a first section (204A) and a second section (204B) which extend between the fluid inlet (103) and fluid outlet (200); and
at least part of the first section (204A) and/or second section (204B) comprise a surface roughness (Ra) no less than about 7μm but no more than about 15 μm.

2. A component (100) for a turbo machine as claimed in claim 1, wherein :

the surface roughness of the first section (204A) and second section (204B) are different to one another.

3. A component (100) for a turbo machine as claimed in claim 1, wherein :

the surface roughness of the remaining areas of the cooling passage (204) is no less than about 1.5μm but no more than about 3.5 μm.

4. A component (100) for a turbo machine as claimed in claim 1, wherein :

the surface roughness of the first section (204A) and second section (204B) are the same as one another.

5. A component (100) for a turbo machine as claimed in any one of the preceding claims, wherein :

the surface roughness is defined by a plurality of spaced apart micro ribs (212) which extend at least part of the way across the cooling passage (204),
wherein the micro ribs (212) have a height and width of no less than 0.025mm and no greater than 0.1 mm.

6. A component (100) for a turbo machine as claimed in claim 5, wherein :

the micro ribs (212) are polygonal in cross section.

7. A component (100) for a turbo machine as claimed in claim 5 or claim 6, wherein :

one of the cooling passage (204) sections is further provided with macro ribs (206) which extend across the cooling passage (204),
wherein the macro ribs (206) have a height and width of no less than 0.5mm and no greater than 5.0mm,
at least one micro rib (212) being provided between adjacent macro ribs (206).

8. A component (100) for a turbo machine as claimed in claim 7, wherein :

the macro ribs (206) are polygonal in cross section.

9. A component (100) for a turbo machine as claimed in claim 7 or claim 8, wherein :

the macro ribs (206) and micro ribs (212) are parallel with one another.

10. A component (100) for a turbo machine as claimed in claim 7 or claim 8, wherein :

the macro ribs (206) and micro ribs (212) are at an angle to one another.

11. A component (100) for a turbo machine as claimed in claims 7 to 10, wherein :

the macro ribs (206) are parallel to one another.

12. A component (100) for a turbo machine as claimed in claim 5 to 11, wherein :

the micro ribs (212) are parallel to one another.

13. A component (100) for a turbo machine as claimed in any one of the preceding claims, wherein :

the component (100) is one of:

a rotor blade, stator vane or rotor disc.

14. A method of manufacturing a component (100) for a turbo machine, the method comprising :

providing a ceramic core element (300) for forming internal fluid flow passages of the component (100) by casting the component (100) around the ceramic core;
wherein the walls of the ceramic core (300) which define a surface of the flow passages comprise a region having a predetermined surface roughness of no less than about 7μm but no more than about 15μm.

15. A method of manufacturing a component (100) as claimed in claim 14 wherein:

the surface roughness is defined by micro grooves (312) provided in the surface of the ceramic core (300).

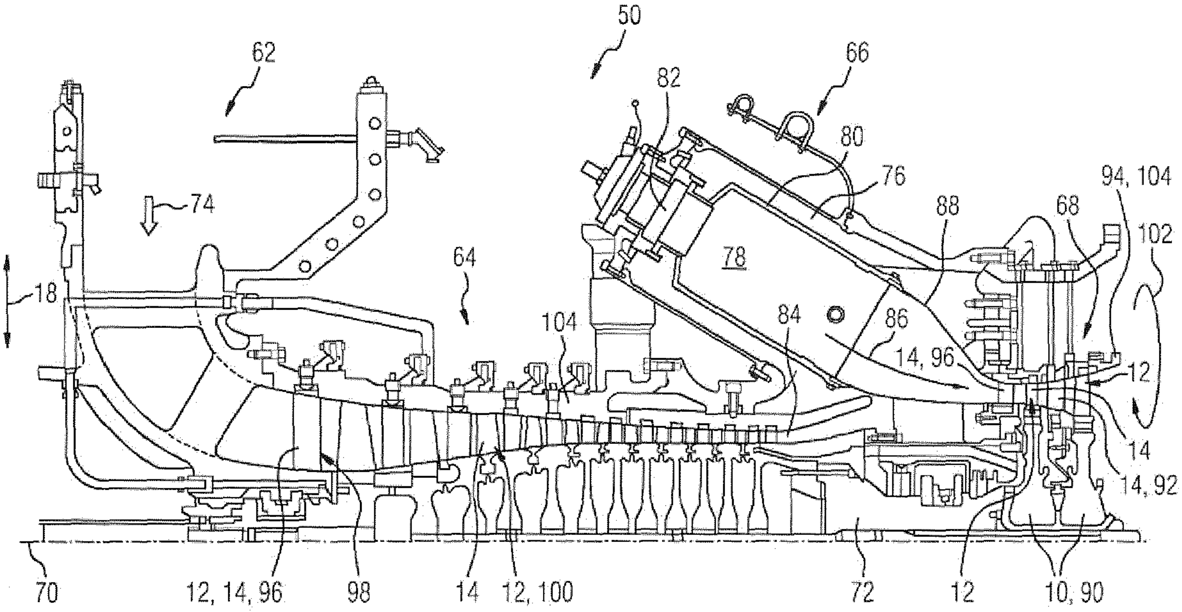
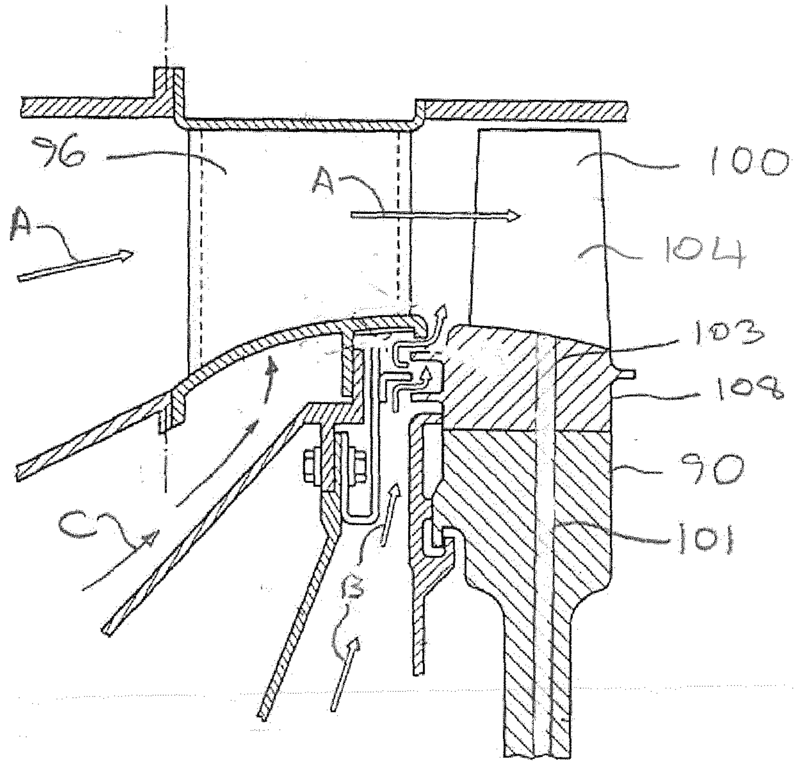


Figure 1



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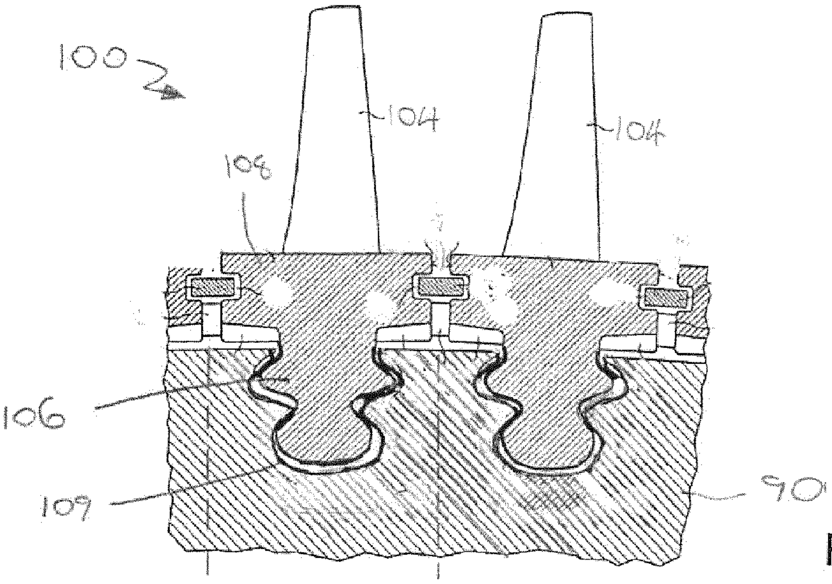

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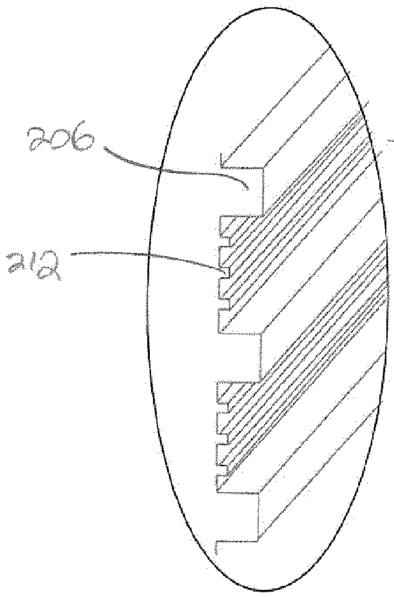

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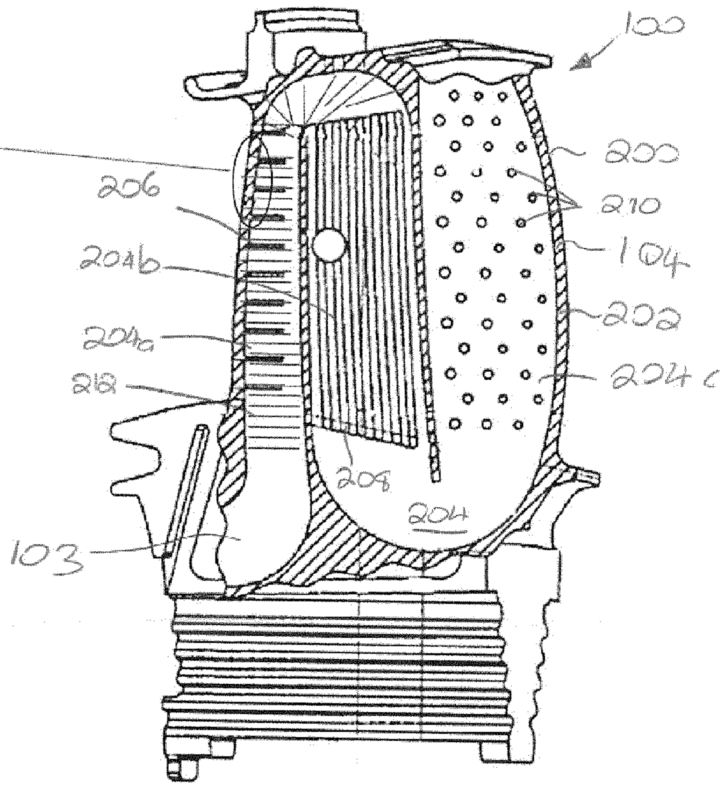

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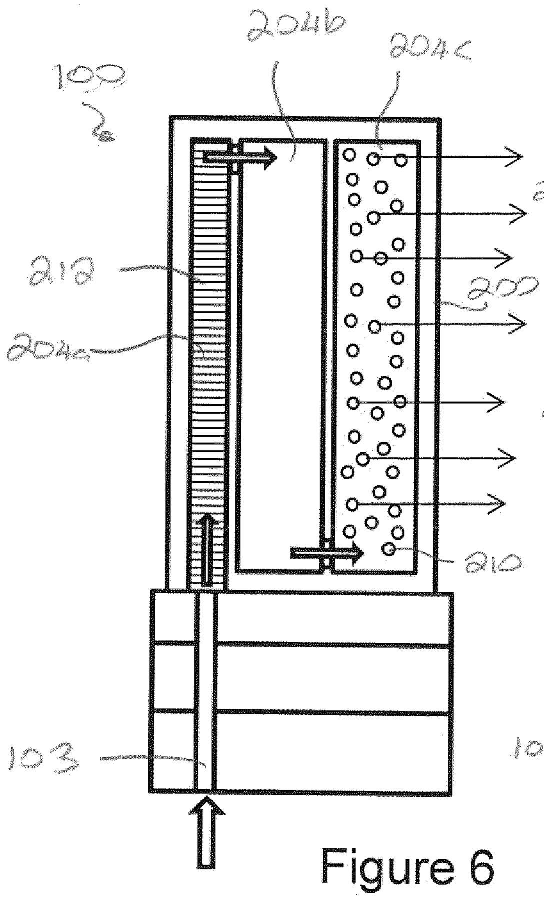

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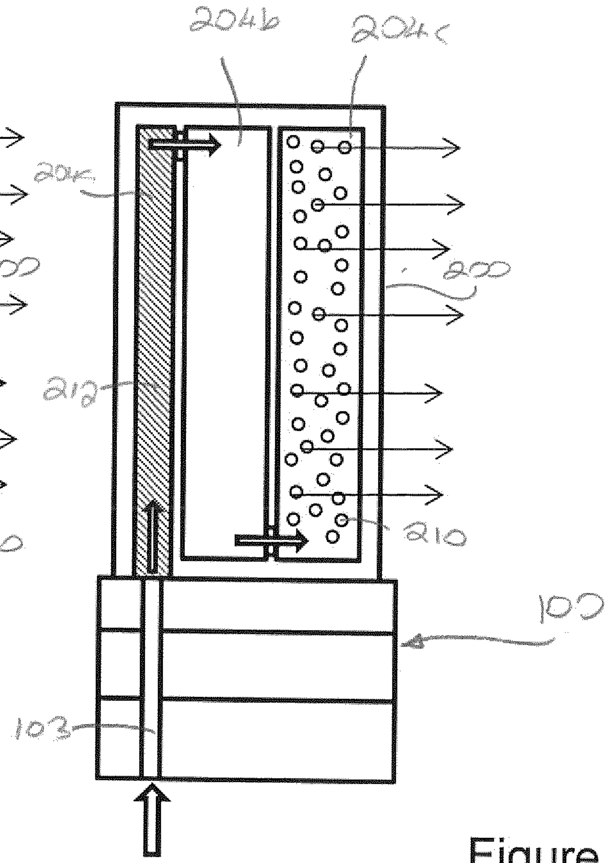

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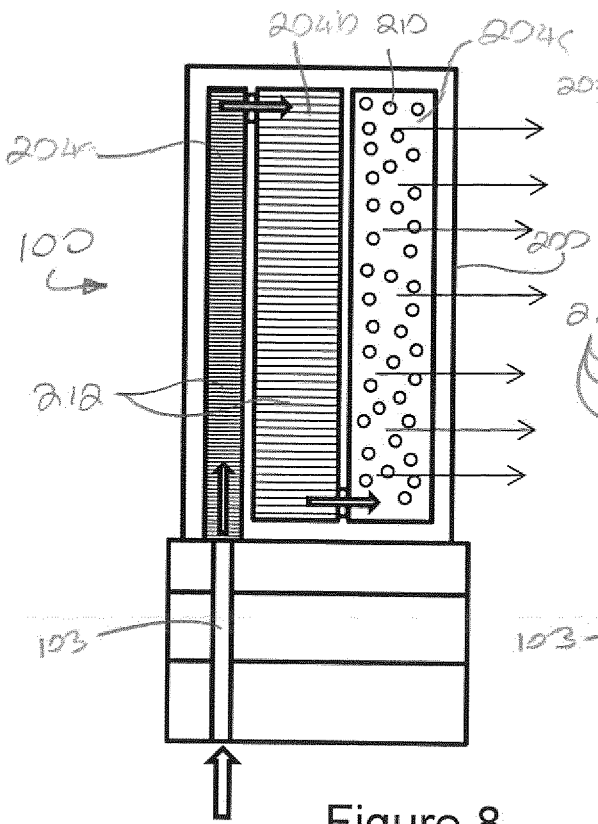

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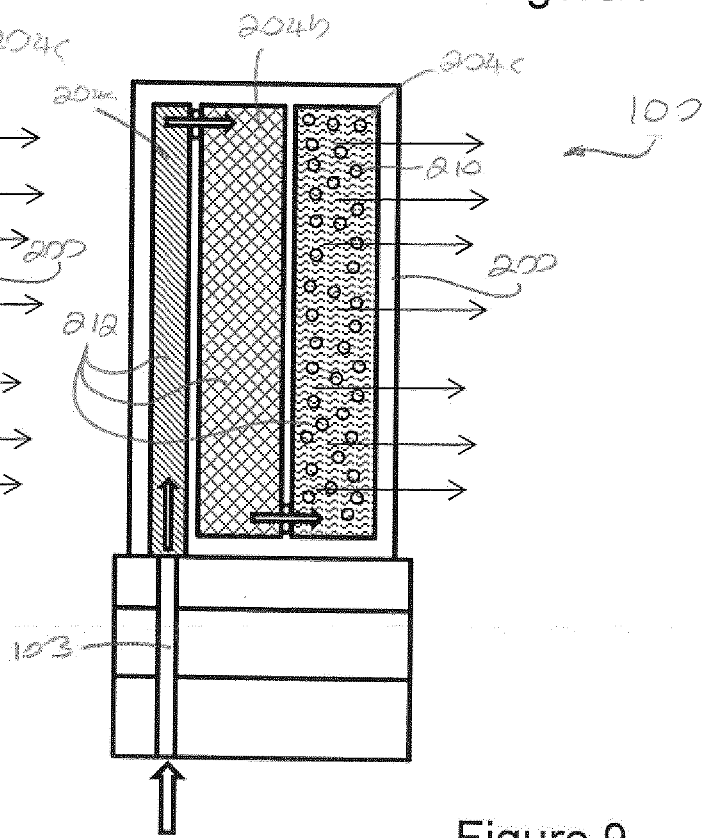

Figure 9

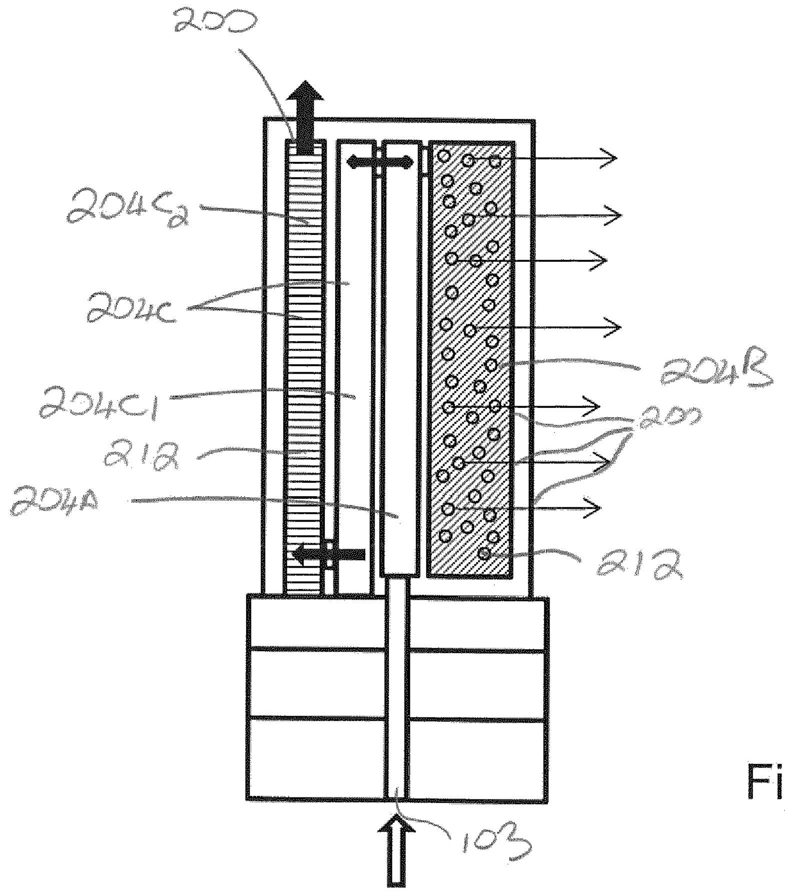

Figure 10

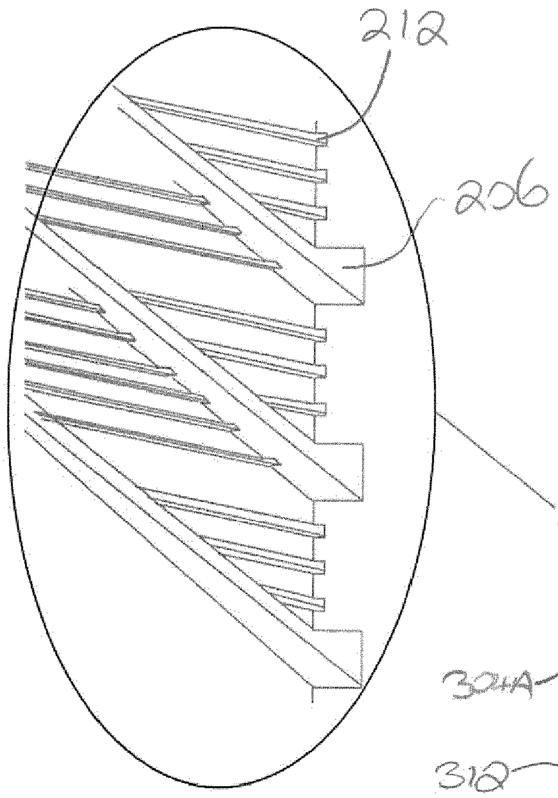

Figure 12

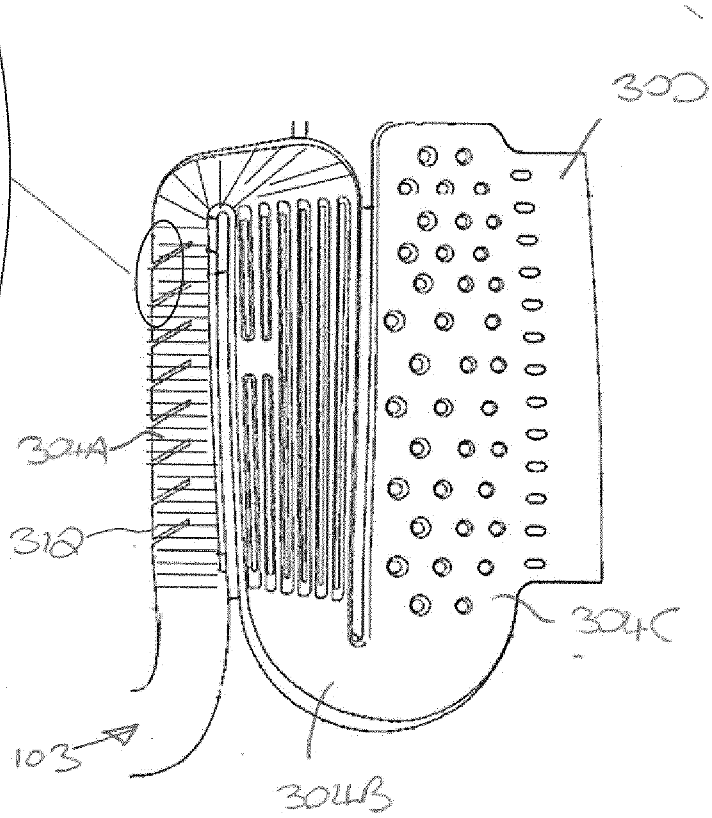

Figure 11

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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 9178

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The present search report has been drawn up for all claims

4

Place of search	Date of completion of the search	Examiner
Munich	14 March 2018	Ketelheun, Anja

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