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(54) **COOLED STATOR HEAT SHIELD**

(57) The present invention provides a stator heat shield (10) for a gas turbine, the gas turbine having a rotor defining an axis of rotation, the stator heat shield comprising a plurality of cooling units (20) disposed in array along the axis of rotation, each of the cooling units comprises an outside part (21) facing hot gas path of the gas turbine, and an inside plate (22) positioned on the outside part and exposed to cooling air, wherein the inside plate comprises a plurality of inlet openings (23)

formed through the inside plate to introduce the cooling air into the outside part and thereby impingement cooling of the hot gas washed wall of the outside part, the outside part comprises a cooling air channel (24) formed therein with a first central portion (25) to receive the cooling air, and a second spiral portion (26) around the first central portion to convey the cooling air outward to a cooling air outlet of the second spiral portion.

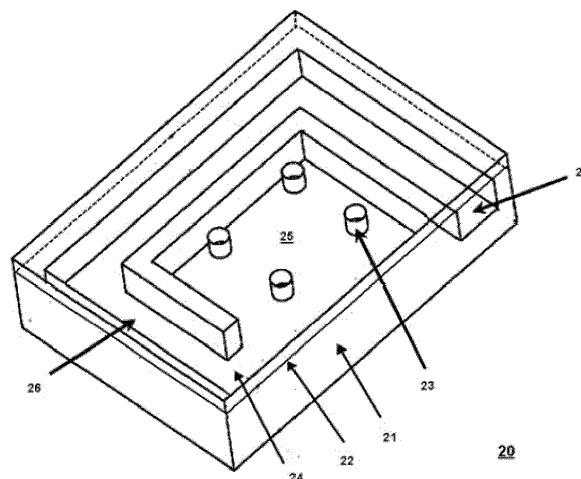


Fig.2

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Description

Technical Field

[0001] The invention relates to a cooled stator heat shield for a gas turbine and a gas turbine equipped with such a cooled stator heat shield.

Background of the Invention

[0002] In the installed state, stator heat shields are situated on a stator and/or on a housing of a gas turbine. They are usually mounted on a guide vane carrier and form a radial border for a hot gas path of the gas turbine in the area of the rotor blades of a rotor of the gas turbine. As a rule, a plurality of such stator heat shields are arranged adjacent to one another in the circumferential direction with regard to an axis of rotation of the rotor, thereby forming a closed ring of individual stator heat shields. The individual stator heat shields here form ring segments. The stator heat shields protect the housing and/or the guide vane carriers from exposure to the hot gas of the gas turbine. The outside of the stator heat shields is exposed to the hot gas, while the inside of the respective stator heat shield facing away from the hot gas path is exposed to a suitable cooling air to cool the respective stator heat shield. Due to this cooling, the lifetime of the stator heat shields can be increased. Fundamentally, however, there is a need for increasing the lifetime of such stator heat shields further.

[0003] Cooling of stator heat shields, particularly of first stage is a very challenge task. Cooling effectiveness is limited to convective cooling scheme, since film cooling of hot gas exposed surface is not applicable at area where the rotating blade passes the stator heat shields. This is for two reasons. Firstly, the complex flow field in the gap between stator heat shields and blade tip does not allow for cooling film development and resulted film effectiveness is very low and extremely hard to predict and measure. Secondly, in case of rubbing events cooling openings are often closed by this event, thus preventing required cooling air outflow that would have detrimental effect on the whole cooling system and significantly reduce lifetime.

[0004] The common practice for stator heat shield cooling is to use extensive impingement cooling with cooling air discharged from side faces. For example, a component of a gas turbine engine, i.e. the heat shield, is disclosed in US20120251295 A1. The component includes an external wall which, in use, is exposed on one surface thereof to working gas flowing through the engine. The component further includes effusion cooling holes formed in the external wall. In use, cooling air blows through the cooling holes to form a cooling film on the surface of the external wall exposed to the working gas. The component further includes an air inlet arrangement which receives the cooling air for distribution to the cooling holes. The component further includes a plurality of

metering feeds and a plurality of supply plena. The metering feeds meter the cooling air from the air inlet arrangement to respective of the supply plena, which in turn supply the metered cooling air to respective portions of the cooling holes. The cooling scheme of US20120251295 A1 is well robust but due to limitation of the impingement system for cooling of large areas, low coolant consumption is not achievable.

[0005] US6354795 B1 proposes impingement cooled stator heat shields with cooling air ejection at hot gas exposed surface in one possible arrangement. However, this disclosure does not propose high heat transfer utilization rates, since cooling air is discharged to the flow path right after the impingement without passing through any additional channels to cover higher cooled area. Thus this scheme has high coolant mass flow rate per square unit and does not support significant saving of cooling air.

[0006] With further development of gas turbines, it is focused on the raise of cyclic parameters (pressure ratio and hot gas temperature), that would lead to increase of hot gas thermal exposure of all cooled parts with highest impact on heat shields, since they are only convectively cooled. To turn the lifetime of stator heat shield back to the acceptable level, that would require to increase cooling flow rates by opening discharge areas, or increase air to hot gas pressure ratio by using air from higher compressor stages. Both these actions would lead to detrimental impact on turbine and engine efficiency. Under such situation, it is required to provide improved stator heat shields which could enhance the cooling effect to a higher level while achieve substantial coolant savings.

[0007] A turbine shroud cooling assembly for gas turbines is described in document EP 2 57451 A2, where a typical impingement cooling features is combined with cooling micro channels. Because the impingement is not exposed to the hot gas washed surface there is only a low cooling efficiency. Furthermore, the arranged micro channels do weaken the hot gas washed wall, which is not robust due to high possibility of internal leakages. US 8,449,246 B1 describes an impingement cooling exposed to "cold" walls and therefore providing very minor effect on overall metal temperature reduction. US2006/210390 A1 suggests a pure serpentine channel cooling system with very smooth channels which cannot result in an achievement of high cooling effectiveness with low coolant consumption rates. The cooling scheme using serpentine channels with heat transfer enhancing elements which is disclosed in US2010/183428 A1 implies lots of pressure loss generators, especially bends. Thus this cooling scheme requires excessive coolant to hot gas pressure ration and cannot be implemented for the leading edge regions of heat shields.

Summary of the Invention

[0008] It is therefore an object of the present invention to solve the aforementioned problems in the common

practice for stator heat shield cooling.

[0009] The invention provides a cooled stator heat shield for a gas turbine, the gas turbine having a rotor defining an axis of rotation, the stator heat shield comprising a plurality of cooling units disposed in array substantially along the axis of rotation and covering the whole hot gas exposed surface of the heat shield, each of the cooling units comprises an outside part facing hot gas path of the gas turbine, and an inside plate positioned on the outside part and exposed to cooling air, wherein the inside plate comprises a plurality of inlet openings formed through the inside plate to introduce the cooling air into the outside part, thereby impingement cooling of the outside part,

the outside part comprises a cooling air channel formed therein with a first central portion to receive the cooling air, and a second spiral portion around the first central portion to convey the cooling air outward to a cooling air outlet of the second spiral portion.

[0010] The core of the invention is to combine impingement cooling with ribbed serpentine channels with the target to find a balance between maximum high heat utilization rates (thus minimum coolant consumption) together with high cooling effectiveness. Impingement provides best cooling effectiveness with small pressure drop, but is not suitable for large cooled areas, while the use of the disclosed serpentine channels allows to increase the cooled area with a certain amount of coolant, but provides excessive pressure drops. The cooling units are small-scale cellular (snail-like) cells, covering the whole hot gas exposed surface of the heat shield. Each individual cooling unit comprises impingement cooling features followed by a spiral (270 degrees) serpentine multipass. Both cooling features are directly faced hot gas washed wall.

[0011] According to one example embodiment of the present invention, in the cooling units positioned near the leading edge and trailing edge regions of the stator heat shield, the cooling air outlet is formed as a plurality of discharge holes through the undersurface of the outside part to feed the cooling air into the hot gas path.

[0012] According to one example embodiment of the present invention, in the cooling units positioned near the leading edge and trailing edge regions of the stator heat shield, the cooling air outlet is formed as a plurality of film cooling holes through the undersurface of the outside part.

[0013] According to one example embodiment of the present invention, a plurality of flow barrier elements are disposed inside the cooling air channel.

[0014] According to one example embodiment of the present invention, the flow barrier elements are selected from the group consisting of plain ribs, V shaped ribs, W shaped ribs, pins, vortex generators and dimples.

[0015] According to one example embodiment of the present invention, the stator heat shield is manufactured by casting or additive manufacturing method.

[0016] According to one example embodiment of the

present invention, the additive manufacturing method includes selective laser melting.

[0017] The present invention also relates to a gas turbine comprising the stator heat shield of above.

[0018] The configuration of the stator heat shield in the present invention is able to optimize the thermal performance of every single cooling unit to collect required heat flux under the hot gas thermal conditions, resulting in maximum uniformity of metal temperatures and stresses in all locations, eliminating all critical zones and thus providing maximum lifetime of the stator heat shield while achieving the coolant savings. Further, the arrangement of the cooling units in the present invention allows to discharge the cooling air into the hot gas flow path at the leading edge and trailing edge regions of the stator heat shield. This would allow to keep the maximum operation pressure ratio and in consequence coolant flow velocities and heat transfer rates for highest cooling effectiveness. Initial investigation of the proposed cooling scheme in the present invention shows that the cooling air saving of 40% is expected compared to the common design.

Brief Description of the Drawings

[0019] The objects, advantages and other features of the present invention will become more apparent upon reading of the following non-restrictive description of preferred embodiments thereof, given for the purpose of exemplification only, with reference to the accompany drawing, through which similar reference numerals may be used to refer to similar elements, and in which:

- | | |
|------------|---|
| Fig. 1 | shows a partial schematic view of a gas turbine with a stator heat shield; |
| Fig. 2 | shows a perspective view of the cooling unit in the first embodiment of the invention; |
| Fig. 3 | shows a perspective view of the cooling unit in the second embodiment of the invention; |
| Fig. 4a-4f | show alternative structures for the flow barrier element in the invention; |
| Fig. 5 | shows a perspective view of the cooling unit in the third embodiment of the invention; |
| Fig. 6 | shows a perspective view of the cooling unit in the fourth embodiment of the invention; |
| Fig. 7 | shows a schematic view of the stator heat shield with cooling air flow and |
| Fig. 8 | shows a stator heat shield with a plurality of cellular cooling units according to present invention. |

Detailed Description of Different Embodiments of the Invention

[0020] According to FIG. 1, a gas turbine 1, only a small detail of which is shown here, has a stator 2 and a rotor 3, each of which is also shown only in part. Of the stator 2, guide vanes 4 are partially discernible as well as a section of a guide vane carrier 5. The guide vanes 4 are attached to the guide vane carrier 5. A stator heat shield 10 is mounted on the guide vane carrier 5. Of the rotor 3, only one turbine blade 6 is discernible here, this blade being arranged between the two guide vanes 4. An axis of rotation 9 about which the rotor 3 rotates during operation of the gas turbine 1 and which defines the axial direction of the gas turbine 1 is indicated here with a dash-dot line. Axial in the present context thus means parallel to the axis of rotation 9, whereas a radial direction is perpendicular to the axis of rotation 9 and the circumferential direction is oriented along a circular path about the axis of rotation 9. Accordingly, the rotor blade 6 is arranged axially between the two guide vanes 4. The stator heat shield 10 is arranged radially opposite the rotor blade 6 and is positioned axially between the two guide vanes 4. A plurality of the stator heat shields 10 form segments which are arranged adjacent to one another in the circumferential direction and form a closed circular ring surrounding a rotor blade row formed by rotor blades 6 adjacent to one another in the circumferential direction. The respective stator heat shield 10 as shown in FIG. 1 separates a hot gas path 8 of the gas turbine 1, which is indicated by an arrow, from a cooling gas air 7, which is also indicated by an arrow and runs essentially in the stator 2. As the arrangement of the stator heat shield 10 is well known in the art, it is just schematically shown in FIG. 1.

[0021] According to the present invention, the stator heat shield 10 comprises a plurality of cooling units 20 disposed in array substantially along the axis of rotation 9. As shown in FIG. 1, the stator heat shield 10 includes four cooling units 20, but the number of the cooling units is not limited to four.

[0022] FIG. 2 shows a perspective view of one cooling unit 20 according to the first embodiment of the invention. The cooling unit 20 comprise an outside part 21 facing the hot gas path 8 of the gas turbine, and an inside plate 22 positioned on the outside part 21 and exposed to the cooling air 7. The inside plate 22 comprises a plurality of inlet openings 23 formed through the inside plate 22 to introduce the cooling air 7 into the outside part 21. As shown in FIG. 2, there are four inlet openings 23 formed in the substantial central region of the inside plate 22. It should be noted that the number of the inlet openings is not limited to four. The outside part 21 comprises a cooling air channel 24 formed therein. The cooling air channel 24 includes a first central portion 25 and a second spiral portion 26. The first central portion 25 is arranged at the substantial central region of the outside part 21 as a recessed chamber to receive the cooling air 7 flowing

through the inlet openings 23 of the inside plate 22. The second spiral portion 26 is formed as a U-shape groove and spiraled outward around the first central portion 25, and comprises a cooling air outlet 27. The second spiral portion 26 is communicated with the first central portion 25 to convey the cooling air 7 from the inlet openings 23 to the cooling air outlet 27. The cooling air flow is schematically shown by the arrows in FIG. 3. This configuration of the cooling air channel 24 is able to optimize the thermal performance of every single cooling unit 20 to collect required heat flux under the hot gas thermal conditions, resulting in maximum uniformity of metal temperatures and stresses in all locations, eliminating all critical zones and thus providing maximum lifetime of the stator heat shield while achieving the coolant savings.

[0023] FIG. 3 shows the perspective view of the cooling unit 20 according to a second embodiment of the present invention. The basic structure of the cooling unit is same as that in FIG. 2. As shown in FIG. 3, a plurality of flow barrier elements 28 such as plain ribs are disposed inside the second spiral portion 26 of the cooling air channel 24 in order to enhance heat transfer rates. The plain rib is angled to a wall of the second spiral portion 26.

[0024] FIG. 4a-4f show alternative structures for the flow barrier element 28, where the flow barrier element 28 may be configured to be V shaped ribs, W shaped ribs, pins, vortex generators and dimples as shown by FIG. 4b to 4f respectively. FIG. 4b shows the flow barrier element is configured to be V shaped ribs, FIG. 4c shows the flow barrier element is configured to be W shaped ribs, FIG. 4d shows the flow barrier element is configured to be pins, which are disposed in middle of the second spiral portion and/or attached to the wall of second spiral portion, FIG. 4e shows the flow barrier element is configured to be vortex generators, which are disposed in middle of the second spiral portion and/or attached to the wall of second spiral portion, FIG. 4f shows the flow barrier element is configured to be dimples, which are disposed in middle of the second spiral portion and/or attached to the wall of second spiral portion. These flow barrier elements are provided to increase the cooling effectiveness and ensure maximum heat utilization with minimum coolant consumption.

[0025] FIG. 5 shows a perspective view of a cooling unit 20 according to third embodiment of the invention. The basic structure of the cooling unit 20 is same as that in FIG. 2. The cooling air channel 24 includes a first central portion 25 and a second spiral portion 26. A plurality of flow barrier elements are disposed inside the second spiral portion 26 of the cooling air channel 24. The cooling air outlet 27 of the second spiral portion 26 is formed as a plurality of discharge holes 29 in a line through the undersurface of the outside part 21. As shown by the arrows in FIG. 5, the cooling air enters the inlet openings 23, travels through the cooling air channel 24 and goes through the discharge holes 29 into the hot gas path. FIG. 6 shows a cooling unit 20 according to fourth embodiment of the invention. In this embodiment, the dis-

charge holes 29 are replaced by the film cooling holes 30. The flow path of the cooling air is shown in FIG. 6, which is same as that in FIG. 5.

[0026] FIG. 7 shows a schematic view of the arrangement of the cooling units 20 in the stator heat shield 10 according to another embodiment of the invention. The stator heat shield 10 comprises a plurality of cooling units 20 disposed in array. In this case the number of the cooling units is four. Of this stator heat shield 10, the cooling units 20 with discharge holes or film cooling holes as described above in third and fourth embodiment are arranged near the leading edge 12 and trailing edge 11 regions of the stator heat shield, which are positioned out of the rotation blade 6. The four arrows above the stator heat shield 10 as shown in FIG. 7 refer to the cooling air to be fed into the cooling units 20. The two arrows below the stator heat shield 10 refer to the cooling air fed into the hot gas path after passing through the cooling units. Normally the leading edge and trailing edge regions of the stator heat shield are subject to the highest coolant temperature and thus lower cooling effectiveness. With such arrangement where the cooling units are positioned out of the rotation blade 6, no rubbing risk, i.e., discharge hole smearing by the blade, is expected and the cooling air discharge to the hot gas flow path or film cooling is possible. It therefore would allow to keep the maximum operation pressure ratio and in consequence coolant flow velocities and heat transfer rates for highest cooling effectiveness.

[0027] It should be noted that the stator heat shield comprising a plurality of cooling units can be manufactured by casting or additive manufacturing method such as selective laser melting or any other appropriate means.

[0028] While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description, but is only limited by the scope of the appended claims.

List of Reference Numerals

[0029]

- 1 gas turbine
- 2 stator
- 3 rotor
- 4 guide vane
- 5 guide vane carrier

- 6 turbine blade
- 7 cooling air
- 8 hot gas path
- 9 axis of rotation
- 10 stator heat shield
- 11 trailing edge of the stator heat shield
- 12 leading edge of the stator heat shield
- 20 cooling unit
- 21 outside part
- 22 inside plate
- 23 inlet opening
- 24 cooling air channel
- 25 first central portion
- 26 second spiral portion
- 27 cooling air outlet
- 28 flow barrier elements
- 29 discharge hole
- 30 film cooling hole

Claims

1. A cooled stator heat shield for a gas turbine, the gas turbine having a rotor defining an axis of rotation, the stator heat shield comprising a plurality of cooling units disposed in array substantially along the axis of rotation and covering the whole hot gas exposed surface of the heat shield, **characterized in that**, each of the cooling units comprises an outside part facing hot gas path of the gas turbine, and an inside plate positioned on the outside part and exposed to cooling air, wherein the inside plate comprises a plurality of inlet openings formed through the inside plate to introduce the cooling air into the outside part, thereby impingement cooling of the outside part, the outside part comprises a cooling air channel formed therein with a first central portion to receive the cooling air and a second spiral portion around the first central portion to convey the cooling air outward to a cooling air outlet of the second spiral portion.
2. The stator heat shield according to claim 1, **characterized in that**, in the cooling units positioned near the leading edge and trailing edge regions of the stator heat shield, the cooling air outlet is formed as a plurality of discharge holes through the undersurface of the outside part to feed the cooling air into the hot gas path.
3. The stator heat shield according to claim 1, **characterized in that**, in the cooling units positioned near the leading edge and trailing edge regions of the stator heat shield, the cooling air outlet is formed as a plurality of film cooling holes through the undersurface of the outside part.

4. The stator heat shield according to any of claim 1 to 3, **characterized in that**, a plurality of flow barrier elements are disposed inside the cooling air channel.
5. The stator heat shield segment according to claim 4, **characterized in that**, the flow barrier elements are selected from the group consisting of plain ribs, V shaped ribs, W shaped ribs, pins, vortex generators and dimples.
6. The stator heat shield according to any of claim 1 to 5, **characterized in that**, the stator heat shield is manufactured by casting or additive manufacturing method.
7. The stator heat shield segment according to claim 6, **characterized in that**, the additive manufacturing method includes selective laser melting.
8. A gas turbine comprising the stator heat shield according to any of claim 1 to 7.

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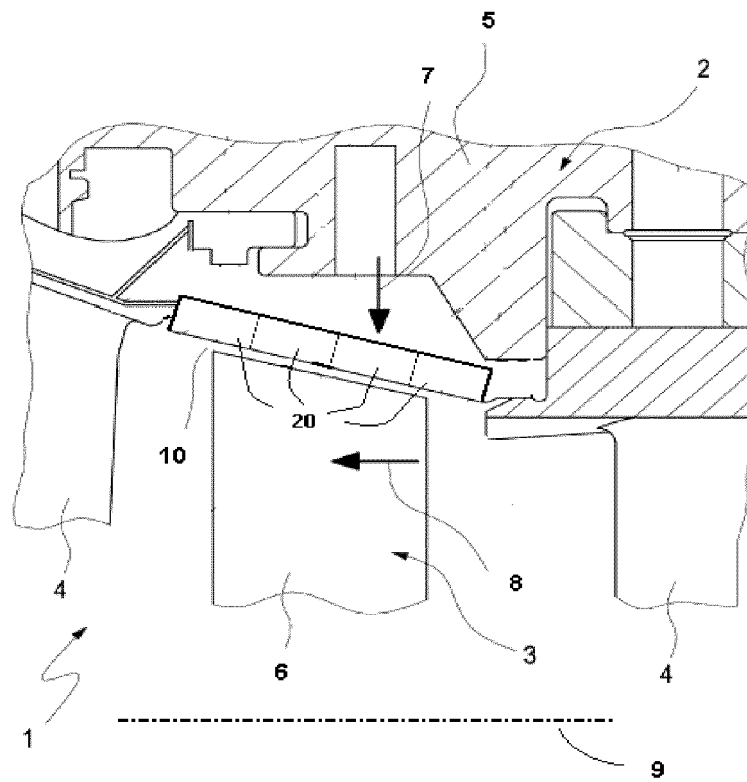


Fig.1

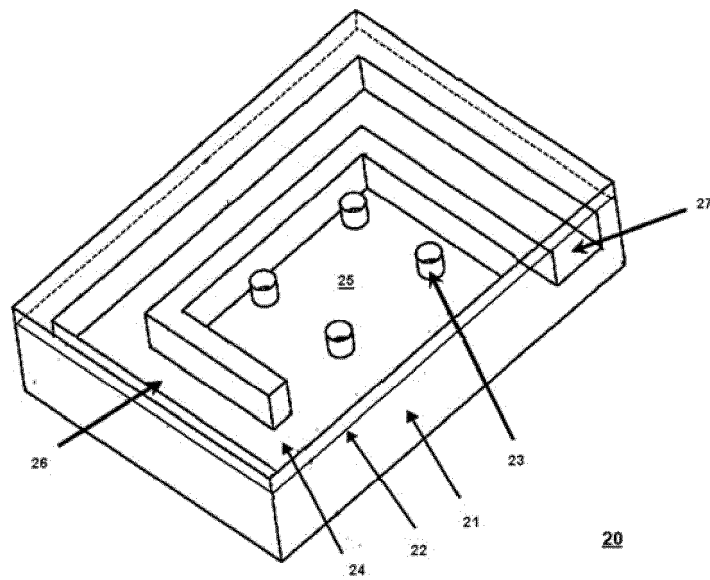


Fig.2

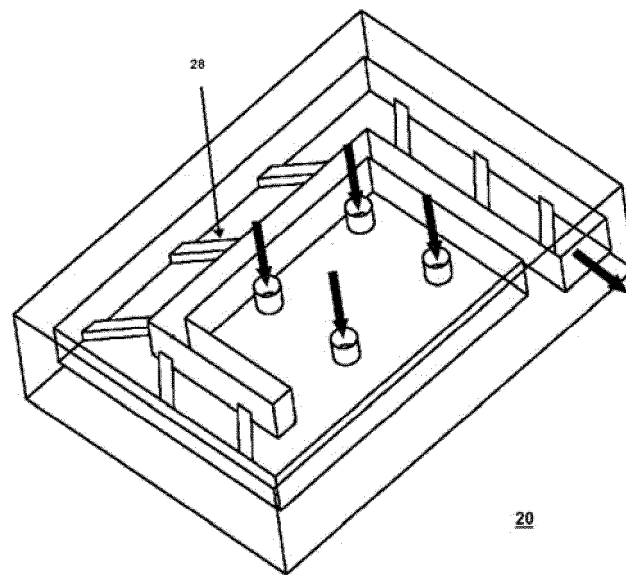


Fig.3

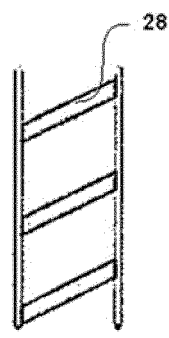


Fig.4a

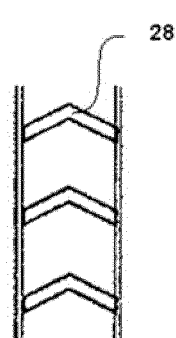


Fig.4b

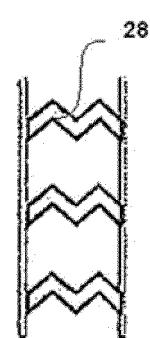


Fig.4c

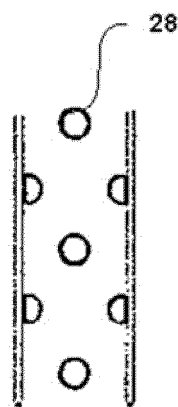


Fig.4d

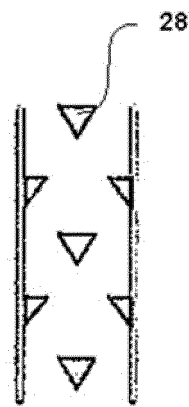


Fig.4e

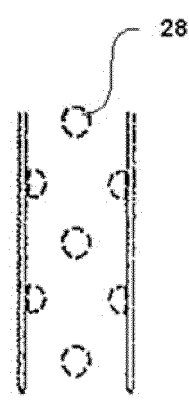


Fig.4f

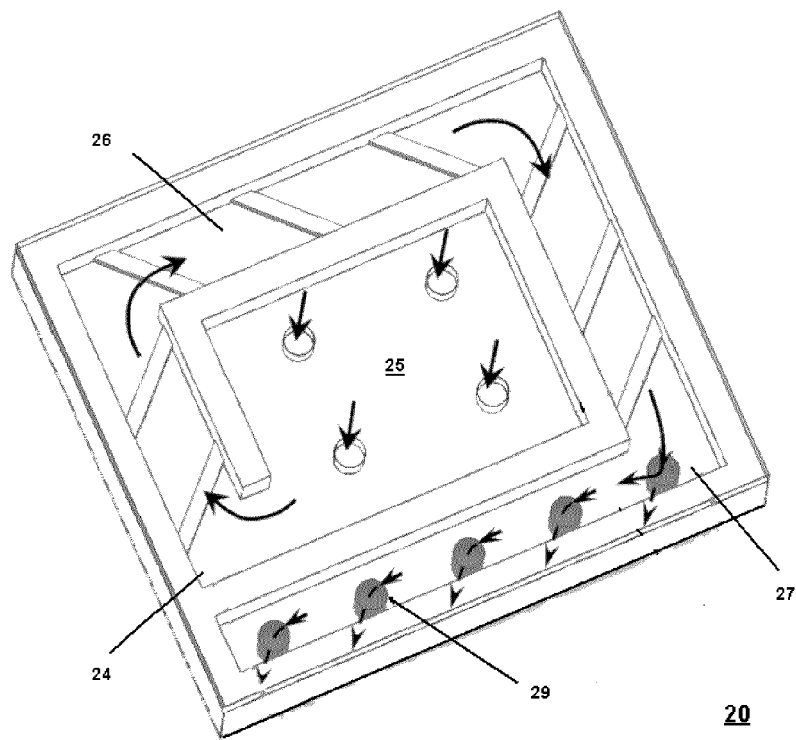


Fig. 5

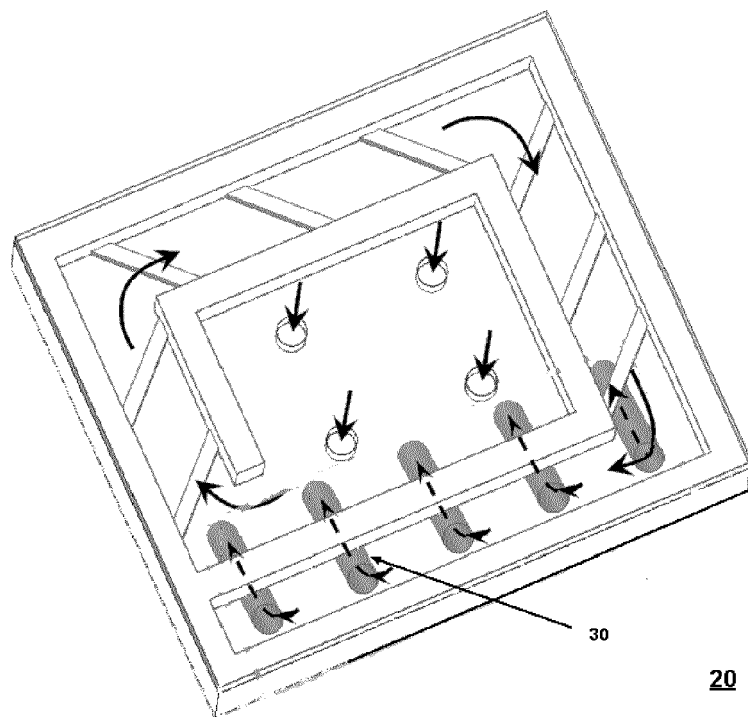


Fig. 6

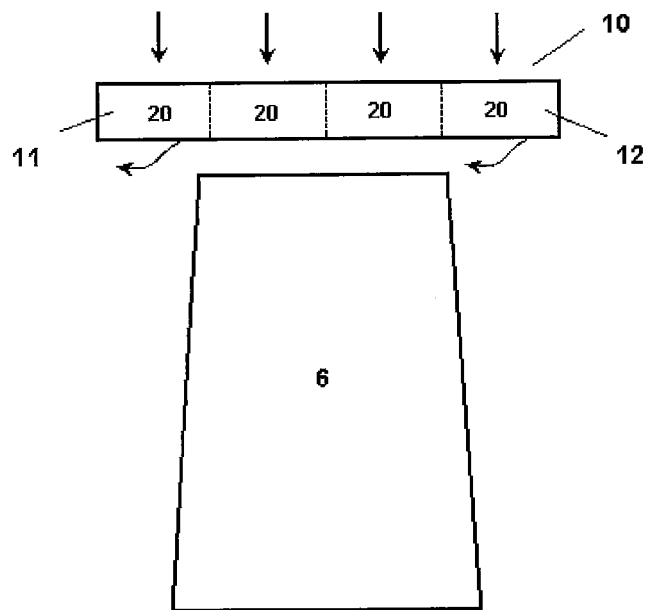


Fig. 7

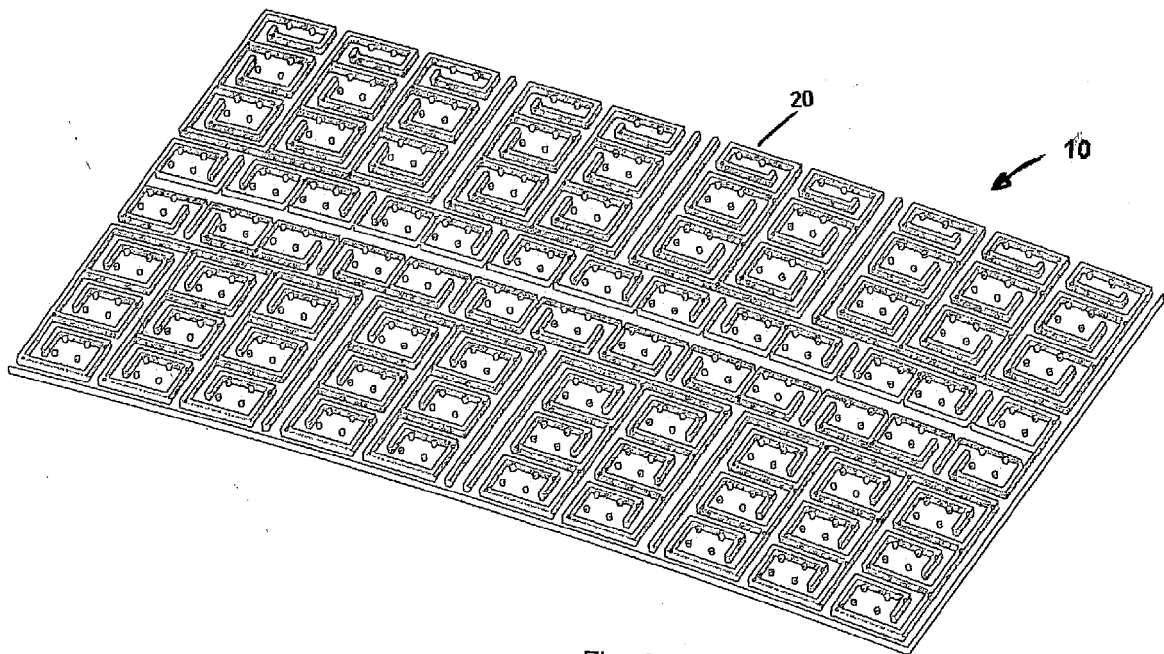


Fig. 8



EUROPEAN SEARCH REPORT

Application Number
EP 15 15 0590

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,D	US 2010/183428 A1 (LIANG GEORGE [US]) 22 July 2010 (2010-07-22) * paragraphs [0038], [0029], [0036]; figures 1,2 * -----	1-8	INV. F01D11/24
			TECHNICAL FIELDS SEARCHED (IPC)
			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 May 2015	Examiner Rolé, Florian
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