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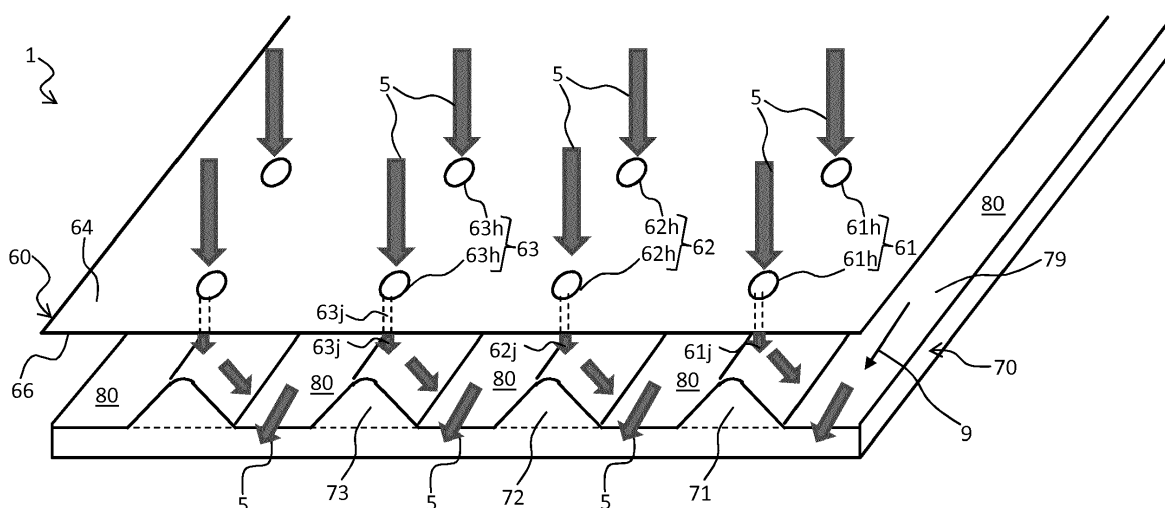
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(54) **IMPINGEMENT COOLING ARRANGEMENT WITH GUIDED COOLING AIR FLOW FOR CROSS-FLOW REDUCTION IN A GAS TURBINE**

(57) An impingement cooling arrangement (1) for cooling a target surface in a gas turbine (10), the arrangement includes an impingement component (60) and a target component (70) having the target surface. The impingement component includes pluralities of linearly arranged impingement holes (61h, 62h, 63h) through which impingement jets of cooling air are ejected towards the target surface. The target component includes a target region (71, 72, 73) corresponding to each plurality that extends from the target surface towards the impingement

component and on the target surface linearly corresponding to the linear arrangement of the impingement holes of the corresponding plurality. At least one trench (80) is present on the target surface adjacent to each target region and extends linearly corresponding to the target region. Each target region is arranged such that the impingement jets from the corresponding plurality are received on the target region and guided by the target region into the trench formed adjacent to the target region.

FIG 4



Description

[0001] The present invention relates to cooling of gas turbine components, and more particularly impingement cooling of gas turbine components.

[0002] To effectively use cooling air for cooling of gas turbine components is a constant challenge and an important area of interest in gas turbine engine designs. For example, cooling various turbomachine components such as turbomachine components having an aerofoil, such as a vane or a blade, or for combustor liner cooling, conventional design uses many impingement holes spread in a large area of a cooling air channel wall or plate, also called as impingement plate, from where impingement jets are ejected directed to the target surface to be cooled, i.e. towards in inner wall of the aerofoil for cooling the aerofoil, or towards an inner wall of a platform of blade/vane for cooling the platform, or towards an outer surface of the combustor liner, etc. The cooling air emerging from the impingement holes in form of impingement jets flows towards the target surface, which is to be cooled in order to impact the target surface generally normal to the surface. It is important to have an adequate velocity in the impingement jets in order for the cooling air to reach the target surface and thus to cool the target surface. Therefore to achieve adequately high velocity in the impingement jets, size of the impingement holes is required to be small but concentration of impingement holes in a given area is high to ensure adequate volume of the cooling air is available to the target surface. However, since most of the target surfaces, such as inner surface of aerofoil, or inner surface of platform of a blade/vane, or outer surface of a combustor liner, are longitudinally extended, the impingement jets delivering the cooling air to downstream sections of the target surface are subjected to strong cross flow resulting from the cooling air that has entered through the impingement jets delivering the cooling air to upstream sections of the target surface and then flowing across the longitudinally extended target surface from the upstream section to the downstream section of the longitudinally extended target surface.

[0003] The cross-flow affects the impingement jets delivering cooling air to the downstream sections of the combustion liner surface. The flow of cooling air in the impingement jets substantially normal to the target surface is disturbed by the cross flowing cooling air which flows substantially parallel to the target surface and as a result the impingement jets delivering cooling air to the downstream sections of the target surface may not impinge on the target surface especially in the downstream sections of the longitudinally extended target surface. The disturbance to the impingement jets as a result of the cross flow is increased as the cross flow gains more and more volume from the impingement jets received by the cross flow as the cross flow travels from the upstream section of the target surface to the downstream section of the target surface. Therefore, an improvement in cooling air flow in an impingement cooling arrangement for

a gas turbine engine is desired.

[0004] Thus the object of the present disclosure is to provide a impingement cooling arrangement for target surface cooling in a gas turbine engine such that the impingement cooling arrangement minimizes the disturbances due to the cross flow of the cooling air over longitudinally extended target surfaces that are to be cooled by impingement jets.

[0005] The above objects are achieved by an impingement cooling arrangement according to claim 1 of the present technique. Advantageous embodiments of the present technique are provided in dependent claims. Features of claim 1 can be combined with features of dependent claims, and features of dependent claims can be combined together.

[0006] An impingement cooling arrangement for target surface cooling in a gas turbine engine is presented. The impingement cooling arrangement includes an impingement component and a target component. The target component includes a target surface that is desired to be cooled. The target component may be, but not limited to, an aerofoil of a turbine blade/vane, a platform of a turbine blade/vane, a combustor liner for a combustor assembly for a gas turbine engine, whereas the target surface may be, but not limited to an internal surface of the aerofoil, an internal surface of the platform, of an external surface of the combustor liner, respectively.

[0007] The impingement component includes one or more pluralities of impingement holes. Each plurality is linearly arranged i.e. the impingement holes of each plurality are positioned in a linear arrangement on the impingement component. Cooling air is received at the impingement component on a face of the impingement component facing away from the target component. The cooling air goes through the impingement holes that are configured to eject cooling air towards the target surface in form of impingement jets of cooling air.

[0008] The target component includes a target region corresponding to each plurality. The target region, for example a ridge shaped structure, extends outwards from the target surface towards the impingement component. Each target region extends on the target surface linearly corresponding to the linear arrangement of the impingement holes of the corresponding plurality. At least one trench is present on the target surface adjacent to each target region. The trench extends linearly corresponding to the linearly extending target region.

[0009] Each target region is arranged on the target surface such that the cooling air of the impingement jets ejected from the corresponding plurality are received on the target region and guided by the target region into the trench formed adjacent to the target region.

[0010] As a result of guiding of the cooling air into the trenches, the cross-flow of cooling air is kept away from the impingement jets, therefore the cross-flow effects are reduced or eliminated and the efficiency of the impingement jets and resultant cooling is sustained throughout the target surface.

[0011] In one embodiment of the impingement cooling arrangement, each target region is arranged on the target surface such that the cooling air of the impingement jets ejected from the corresponding plurality are received on a top part of the target region. The cooling air is thereafter guided by a side surface of the target region into the trench formed adjacent to the target region. The top part of the target region may be crest-shaped i.e. having an edge as the top most part of the target region or may be plateau-shaped i.e. having a flat albeit narrow surface as the top most part of the target region. Preferably, the cooling air after impinging on the crest-shaped or plateau shaped top part of the target region is distributed along two sides of the target region and flows into the adjacent trenches. Alternatively, the impingement jets of cooling air are directed to a side surface of the target region. The side surface of the target region is a slanting surface. The cooling air after impinging on the side surface of the target region flows into the adjacent trench guided by the side surface of the target region.

[0012] In another embodiment of the impingement cooling arrangement, the linear arrangements of the pluralities of the impingement holes are parallel to each other. Thus several linearly arranged pluralities of the impingement holes and their corresponding target region can be efficiently arranged without aggravating cross-flow effect in the impingement cooling arrangement.

[0013] In another embodiment of the impingement cooling arrangement, the target regions and the trenches are alternatively arranged on the target surface. Thus cooling air from the impingement jets may be directed by the surface of the target region in one or both of adjacently located trenches. Furthermore, this arrangement ensures that the target regions and the trenches are arranged efficiently for reduced cross flow effects and effective cooling.

[0014] In another embodiment of the impingement cooling arrangement, a base of the trench comprises a plurality of turbulators that create turbulence in the cooling air flowing within the trench. The cooling air after being directed into the trench flows along the base of the trench and the turbulators positioned on the base increase efficiency of cooling of the base which being a part of the target surface increases cooling efficiency for the target component. The turbulators may have varied shapes and sizes, for example the turbulators may be pin-fins, ribs, dimples, etc.

[0015] In another embodiment of the impingement cooling arrangement, either a width of the trench, or a depth of the trench, or both the width and the depth of the trench increases, preferably gradually, in a direction of flow of cooling air within the trench. The depth of the trench at any given location of the trench may be understood as the shortest distance of the lowest point on the base of the trench from a surface of the impingement component positioned directly above the base. When the depth is uniform the volume of the trench remains uniform, however when the depth of the trench increases in

the direction of flow of cooling air within the trench, the volume of the trench also increases in the direction of flow of cooling air within the trench, thus downstream sections of the trench are capable of accommodating more cooling air flow than upstream sections of the trench. The width of the trench at any given location of the trench may be understood as the linear expanse of the base of the trench at the given location in a direction perpendicular to flow direction of the cooling air. When the width is uniform the volume of the trench remains uniform, however when the width of the trench increases in the direction of flow of cooling air within the trench, the volume of the trench also increases in the direction of flow of cooling air within the trench, thus downstream sections of the trench are capable of accommodating more cooling air flow than upstream sections of the trench.

[0016] The above mentioned attributes and other features and advantages of the present technique and the manner of attaining them will become more apparent and the present technique itself will be better understood by reference to the following description of embodiments of the present technique taken in conjunction with the accompanying drawings, wherein:

FIG 1 shows part of a turbine engine in a sectional view and in which an impingement cooling arrangement of the present technique is incorporated;

FIG 2 schematically illustrates a perspective view of an exemplary embodiment of the turbomachine component with an aerofoil wherein the impingement cooling arrangement of the present technique is incorporated in a platform of the turbomachine component;

FIG 3 schematically illustrates cross-sectional view of an exemplary embodiment of an aerofoil of the turbomachine component the impingement cooling arrangement of the present technique is incorporated;

FIG 4 schematically illustrates a perspective view an exemplary embodiment of the impingement cooling arrangement of the present technique that is incorporated in FIGs 1, 2 and 3 and having a impingement component and a target component;

FIG 5 schematically illustrates a perspective view the impingement cooling arrangement of FIG 4 with the impingement component removed and depicting target regions;

FIG 6 schematically illustrates an exemplary embodiment a target region;

- FIG 7 schematically illustrates another exemplary embodiment the target region;
- FIG 8 schematically illustrates yet another exemplary embodiment the target region;
- FIG 9 schematically illustrates an exemplary scheme of working of the impingement cooling arrangement of the present technique;
- FIG 10 schematically illustrates another exemplary scheme of working of the impingement cooling arrangement of the present technique;
- FIG 11 schematically illustrates a part of the cross-section of the aerofoil shown in FIG 4 and depicts an exemplary positioning of the first pins and the second pins arranged in the cooling channel;
- FIG 9 schematically illustrates the part of FIG 8 and depicts another exemplary positioning of the first pins and the second pins arranged in the cooling channel;
- FIG 10 schematically illustrates the part of FIG 8 and depicts yet another exemplary positioning of the first pins and the second pins arranged in the cooling channel;
- FIG 11 schematically illustrates an exemplary embodiment a trench having variable width in the impingement cooling arrangement;
- FIG 12 schematically illustrates an exemplary embodiment the trench having variable depth in the impingement cooling arrangement; and
- FIG 13 schematically illustrates another exemplary embodiment the trench having variable depth in the impingement cooling arrangement; in accordance with the present technique.

[0017] Hereinafter, above-mentioned and other features of the present technique are described in details. Various embodiments are described with reference to the drawing, wherein like reference numerals are used to refer to like elements throughout. In the following description, for the purpose of explanation, numerous specific details are set forth in order to provide a thorough understanding of one or more embodiments. It may be noted that the illustrated embodiments are intended to explain, and not to limit the invention. It may be evident that such embodiments may be practiced without these specific details.

[0018] It may be noted that in the present disclosure, the terms "first", "second", "third" etc. are used herein only to facilitate discussion, and carry no particular tem-

poral or chronological significance unless otherwise indicated.

[0019] FIG. 1 shows an example of a gas turbine or a gas turbine engine 10 in a sectional view. The gas turbine engine 10 comprises, in flow series, an inlet 12, a compressor or compressor section 14, a combustor section 16 and a turbine section 18 which are generally arranged in flow series and generally about and in the direction of a longitudinal or rotational axis 20. The gas turbine engine 10 further comprises a shaft 22 which is rotatable about the rotational axis 20 and which extends longitudinally through the gas turbine engine 10. The shaft 22 drivingly connects the turbine section 18 to the compressor section 14.

[0020] In operation of the gas turbine engine 10, air 24, which is taken in through the air inlet 12 is compressed by the compressor section 14 and delivered to the combustion section or burner section 16. The burner section 16 comprises a longitudinal axis 35 of the burner, a burner plenum 26, one or more combustion chambers 28 and at least one burner 30 fixed to each combustion chamber 28. Each combustor chamber 28 is defined by or located inside a combustor liner 110. The combustor liner 111 has an external surface 111 facing away from the combustor chamber 28. The combustion chambers 28 and the burners 30 are located inside the burner plenum 26. The compressed air passing through the compressor 14 enters a diffuser 32 and is discharged from the diffuser 32 into the burner plenum 26 from where a portion of the air enters the burner 30 and is mixed with a gaseous or liquid fuel. The air/fuel mixture is then burned and the combustion gas 34 or working gas from the combustion is channelled through the combustion chamber 28 to the turbine section 18 via a transition duct 17.

[0021] This exemplary gas turbine engine 10 has a cannular combustor section arrangement 16, which is constituted by an annular array of combustor cans 19 each having the burner 30 and the combustion chamber 28, the transition duct 17 has a generally circular inlet that interfaces with the combustor chamber 28 and an outlet in the form of an annular segment. Each such combustor can 19 along with the burner 30 and the combustion chamber 28 forms a combustor assembly 25. An annular array of transition duct outlets form an annulus for channelling the combustion gases to the turbine 18.

[0022] The turbine section 18 comprises a number of blade carrying discs 36 attached to the shaft 22. In the present example, two discs 36 each carry an annular array of turbine blades 38. However, the number of blade carrying discs could be different, i.e. only one disc or more than two discs. In addition, guiding vanes 40, which are fixed to a stator 42 of the gas turbine engine 10, are disposed between the stages of annular arrays of turbine blades 38. Between the exit of the combustion chamber 28 and the leading turbine blades 38 inlet guiding vanes 44 are provided and turn the flow of working gas onto the turbine blades 38.

[0023] The combustion gas from the combustion

chamber 28 enters the turbine section 18 and drives the turbine blades 38 which in turn rotates the shaft 22. The guiding vanes 40, 44 serve to optimise the angle of the combustion or working gas on the turbine blades 38.

[0024] The turbine section 18 drives the compressor section 14. The compressor section 14 comprises an axial series of vane stages 46 and rotor blade stages 48. The rotor blade stages 48 comprise a rotor disc supporting an annular array of blades. The compressor section 14 also comprises a casing 50 that surrounds the rotor stages and supports the vane stages 48. The guide vane stages include an annular array of radially extending vanes that are mounted to the casing 50. The vanes are provided to present gas flow at an optimal angle for the blades at a given engine operational point. Some of the guide vane stages have variable vanes, where the angle of the vanes, about their own longitudinal axis, can be adjusted for angle according to air flow characteristics that can occur at different engine operational conditions.

[0025] The casing 50 defines a radially outer surface 52 of the passage 56 of the compressor 14. A radially inner surface 54 of the passage 56 is at least partly defined by a rotor drum 53 of the rotor which is partly defined by the annular array of blades 48.

[0026] The present technique is described with reference to the above exemplary turbine engine having a single shaft or spool connecting a single, multi-stage compressor and a single, one or more stage turbine. However, it should be appreciated that the present technique is equally applicable to two or three shaft engines and which can be used for industrial, aero or marine applications. Furthermore, the cannular combustor section arrangement 16 is also used for exemplary purposes and it should be appreciated that the present technique is equally applicable to annular type and can type combustion chambers.

[0027] The terms axial, radial and circumferential are made with reference to the rotational axis 20 of the engine, unless otherwise stated.

[0028] It may be noted that the present technique has been explained in details with respect to an exemplary embodiment of a turbine blade/vane 38,40,44, and with respect to an exemplary embodiment of a combustor liner 110, however, it must be appreciated that the present technique is equally applicable and implemented similarly with respect any other turbomachine component being cooled by impingement cooling. The present technique provides an impingement cooling arrangement 1. The impingement cooling arrangement 1 is incorporated for impingement cooling of the combustor liner 110 as shown in FIG 1, and/or for impingement cooling of the turbine blade/vane 38,40,44 as shown in FIG 1.

[0029] FIG 2 schematically depict an exemplary embodiments of the turbine blade/vane 38,40,44 wherein the impingement cooling arrangement 1 has been incorporated, for example the impingement cooling arrangement 1 may be incorporated in a platform 100 of the turbine blade/vane 38,40,44, and/or may be incorporated

in an aerofoil 90 that extends from the platform 100 of the turbine blade/vane 38,40,44 and that has been depicted in further details in FIG 3. A root (not shown) may also extend from the platform 100 in a direction opposite to that of the aerofoil 90.

[0030] The platform 100 has a surface 102 from which the aerofoil 90 extends radially. The surface 102 is a gas washed surface of the platform 100 i.e. the surface 102 is located in a path of gas flow through the gas turbine 10. The platform 100 may include internal cavities 105 or cavities that fluidly connect to an aerofoil cavity 93 as shown in FIG 3. As internal surface 101 of the platform 110 i.e. a wall of the platform cavity 105 may be cooled by the impingement cooling arrangement 1 of the present technique.

[0031] The aerofoil 90 includes an external wall 92 having an outer surface or external surface 96 and an inner surface or internal surface 91. The aerofoil cavity 93 is enclosed with the aerofoil wall 92. The aerofoil 90 generally has a suction side (not shown) and a pressure side (not shown) that together form or meet at a trailing edge (not shown) on one end and a leading edge (not shown) on another end. From the inner surface 91 of the aerofoil wall 92 may arise different other structural features of the aerofoil 90 for example ribs 95.

[0032] The platform 100 and/or the aerofoil 90 include one or more cooling passages (not shown) defined therein. The cooling passages may include one or more cooling passages or channels that may be fluidly distinct from each other or connected to each other. The cooling passages provide a flow path for cooling air 5 to flow through the aerofoil 90. The cooling air 5 impinges, as explained later with respect to FIGs 4 to 13 in further details, on the internal surface 91 of the aerofoil 90 and/or the internal surface 101 of the platform 100, as shown in FIGs 3 and 2.

[0033] In the aerofoil 90, a plurality of film cooling holes 94 are formed through the aerofoil wall 92. The film cooling holes 94 are present spaced apart over at least a part of the aerofoil wall 92 as shown in FIG 3. The cooling air 5 after impinging on the inner surface 91 of the aerofoil 90 generally exits the aerofoil 90 through the film cooling holes 94 or through other internal passages (not shown) into the hot gas flow.

[0034] The impingement cooling arrangement 1 of the present technique has been explained in further details hereinafter with respect to FIGs 4 to 13. References have been made to FIGs 1 to 3 to further explain the cooling arrangement 1 as incorporated in the aerofoil 90 and/or the platform 100 and/or the combustor assembly 25 of the gas turbine engine 10.

[0035] As schematically shown in FIG 4, the impingement cooling arrangement 1 of the present technique cools, by impingement cooling, a target surface 79 in the gas turbine engine 10. The impingement cooling arrangement 1 includes an impingement component 60 and a target component 70. The target component 70 includes the target surface 79 that is desired to be cooled. The target component 70 may be, but not limited to, the aer-

ofoil 90 (shown in FIGs 2 and 3) of the turbine blade/vane 38,40,44, the platform 100 (shown in FIG 2) of the turbine blade/vane 38,40,44 and/or the combustor liner 110 (shown in FIG 1) for the combustor assembly 25 in the gas turbine engine 10, whereas the target surface 79 may be, but not limited to the internal surface 91 of the aerofoil 90, the internal surface 101 of the platform 100, and/or the external surface 111 of the combustor liner 110, respectively.

[0036] The impingement component 60 has two opposite faces, namely a first face 64 and a second face 66, and impingement holes 61h,62h,63h that run through the impingement component 60 and open at the faces 64,66. The impingement holes 61h,62h,63h form pluralities 61,62,63. Each plurality 61,62,63 may be linearly arranged i.e. the impingement holes 61h,62h,63h of each plurality 61,62,63 may be positioned in a linear arrangement on the impingement component 60 as shown in FIG 4. For example the plurality 61, say a first plurality 61, includes multiple impingement holes 61h arranged linearly. Similarly, the plurality 62, say a second plurality 62, includes multiple impingement holes 62h arranged linearly and the plurality 63, say a third plurality 63, includes multiple impingement holes 63h arranged linearly. The number of pluralities 61,62,63 and the number of impingement holes 61h,62h,63h in each plurality 61,62,63 depicted in FIG 4 are for exemplary purposes only and do not present a limitation on the present technique. In one embodiment of the impingement cooling arrangement 1 and as depicted in FIG 4, the linear arrangements of the pluralities 61,62,63 of the impingement holes 61h,62h,63h are parallel to each other.

[0037] The cooling air 5 is received at the impingement component 60 on the first face 64 of the impingement component 60 that is on the side opposite to the second face 66 that faces the target component 70, particularly the target surface 79. For example as shown in FIG 3 the cooling air 5 may come from the aerofoil cavity 93 and onto the impingement component 60. Thereafter, the cooling air 5 goes through the impingement holes 61h,62h,63h and gets ejected towards the target surface 79 in form of impingement jets 61j,62j,63j of the cooling air 5 as shown in FIG 4. The impingement jets ejected from the impingement holes 61h of the plurality 61 are referenced in FIG 4 as 61j. Similarly, the impingement jets ejected from the impingement holes 62h and the impingement holes 63h of the plurality 62 and the plurality 63 are referenced in FIG 4 as 62j and 63j, respectively.

[0038] The target component 70 includes a target region 71,72,73 corresponding to each plurality 61,62,63. The target regions 71,72,73 for example ridge shaped structures 71,72,73 as shown in FIG 4, extend outwards from the target surface 79 towards the impingement component 60. An exemplary embodiment of a part of the target component 70 along with the target regions 71,72,73 are depicted in FIG 5 with the impingement component 60 removed for schematically depicting further details of the arrangement and structure of the target

regions 71,72,73.

[0039] As shown in FIGs 4 and 5, each target region 71,72,73 extends on the target surface 79 linearly corresponding to the linear arrangement of the impingement holes 61h,62h,63h of the corresponding plurality 61,62,63. In other words, each target region 71,72,73 extends on the target surface 79 such that the impingement holes 61h,62h,63h of the corresponding pluralities 61,62,63 may be superimposed on the target region 71,72,73. For example the impingement holes 61h of the first plurality 61 may be superimposed on the target region 71, say the first target region 71, the impingement holes 62h of the second plurality 62 may be superimposed on the target region 72, say the second target region 72, and the impingement holes 63h of the third plurality 63 may be superimposed on the target region 73, say the third target region 73, as depicted in FIG 4 in combination with FIG 5. The target regions 71,72 are shown in FIG 5 as linearly extending by extending along an axis 77.

[0040] In the impingement cooling arrangement 1, at least one trench 80 is present on the target surface 79 adjacent to each target region 71,72,73. The trench 80 extends linearly corresponding to the linearly extending target region 71, 72, 73. In FIG 4, five such trenches 80 are schematically depicted whereas in FIG 5 three such trenches 80 are schematically depicted, for exemplary purposes. The trench 80 may be formed between two adjacent target regions 71,72,73 or between one target region 71,72,73 and another structure for example an adjacent wall (not shown) extending outwardly from the target surface 79. In a preferable embodiment of the impingement cooling arrangement 1, the target regions 71,72,73 and the trenches 80 are alternatively arranged on the target surface 79.

[0041] As shown in FIG 4, each target region 71,72,73 is arranged on the target surface 79 such that the cooling air 5 of the impingement jets 61j,62j,63j ejected from the corresponding plurality 61,62,63 are received on the corresponding target region 71,72,73 and guided, as shown in FIG 4, by the target region 71,72,73 into the trench 80 formed adjacent to the target region 71,72,73.

[0042] As a result of guiding of the cooling air 5 into the trenches 80, the cross-flow of cooling air is kept away from the impingement jets 61j,62j,63j, therefore the cross-flow effects are reduced or eliminated and the efficiency of the impingement jets 61j,62j,63j and resultant cooling is sustained throughout the target surface 79.

[0043] FIGs 6, 7 and 8 schematically present further details of the structure of one of the target regions 71,72,73. The other target regions 72,73 may be understood to have similar structures. As shown in FIGs 6 to 8, the target region 71 has a ridge shaped structure i.e. the target region 71 has a raised structure, as compared to the target surface 79, and has two sloping sides 75, 76, namely a first side surface 75 and a second side surface 76, that meet at a top part 74. The top part 74 may be crest shaped as shown in FIGs 6 and 8. The two

side surfaces 75,76 may meet at the crest shaped top part 74 at a sharp edge as shown in FIG 6, or may meet at the crest shaped top part 74 at a rounded edge as shown in FIG 8. Alternatively, the top part 74 may be plateau-shaped as shown in FIG 7. The two side surfaces 75,76 meet a flat albeit narrow surface forming the top part 74. The side surfaces 75,76 slope into the trenches 80 as shown in FIGs 6 to 8.

[0044] FIG 9 presents an exemplary embodiment of the arrangement of the target region 71 on the target surface 79, and schematically depicts an exemplary working of the impingement cooling arrangement 1. The other target regions 72,73 may be understood to have similar arrangement and to work similarly. In one embodiment of the impingement cooling arrangement 1, each target region 71,72,73 is arranged on the target surface 79 such that the cooling air 5 of the impingement jets 61j,62j,63j ejected from the corresponding plurality 61,62,63 are received on the top part 74 of the target regions 71,72,73, for example as shown in FIG 9 the impingement jet 61j from the impingement holes 61h of the first plurality 61 fall on or impinge on the top part 74 of the target region 71. It may be noted that although in FIG 9 only one impingement jet 61j is shown, according to the present technique the target region 71 is arranged on the target surface 79 such that all the impingement jets 61j from the impingement holes 61h of the plurality 61 impinge on the top part 74 of the target region 71. Similarly, the target regions 72,72 (not shown in FIG 9) are arranged on the target surface 79 such that all the impingement jets 62j,63j from the impingement holes 62h,63h of the pluralities 62,63, respectively impinge on the top parts 74 of the target regions 72,73.

[0045] The cooling air 5 is thereafter guided by the side surface 75,76 of the target region 71 into the trench 80 formed adjacent to the target region 71. Preferably, the cooling air 5 after impinging on the crest-shaped or plateau-shaped top part 74, as shown in FIGs 6 to 8, of the target region 71 is distributed along two sides 75,76 of the target region 71 and flows into the adjacent trenches 80. The cooling air 5 thereafter flows in the trench 80 along a direction 9 shown in FIGs 4 and 5. It may be noted that the flow direction 9 depends on an exit of the cooling air 5 designed for the trench 80, for example as shown in FIG 3 the cooling air 5 flows in the directions 9 depending on the placement of the film cooling holes 94 on the aerofoil wall 92. In the impingement cooling arrangement 1, the linear arrangement of the impingement holes 61h,62h,63h in their corresponding pluralities 61,62,63 and the linear extension of the corresponding target regions 71,72,73 and the adjacent trenches 80 are in the flow direction 9 of the cooling air 5 when flowing over the target surface 79 after being impinged on the target surface 79 in form of impingement jets 61j,62j,63j ejected from the impingement holes 61h,62h,63h.

[0046] FIG 10 presents another exemplary embodiment of the arrangement of the target region 71 on the target surface 79, and schematically depicts another ex-

emplary working of the impingement cooling arrangement 1. The other target regions 72,73 may be understood to have similar arrangement and to work similarly. In this embodiment of the impingement cooling arrangement 1, each target region 71,72,73 is arranged on the target surface 79 such that the cooling air 5 of the impingement jets 61j,62j,63j ejected from the corresponding plurality 61,62,63 are received on one of the side surfaces 75,76 or such that two impingement jets 61j,62j from two adjacent pluralities 61,62 are received on the side surfaces 75,76, of the same target region 71 as shown in FIG 10, one on each side surface 75,76 of the target region 71. The cooling air 5 is thereafter guided by the side surface 75,76 of the target region 71 into the trench 80 formed adjacent to the target region 71.

[0047] The trenches 80 have been explained herein-after in further details with respect to FIGs 11 to 13, in combination with FIG 5. Each trench 80 is formed generally between two opposing side surfaces 75,76 of two adjacent target regions 71,72, or may alternatively be formed between one of the side surfaces 75,76 of one of the target regions 71,72,73 and another structure. Furthermore each trench 80 has a base 81 i.e. a part of the target surface 79 between the two opposing side surfaces 75,76 of the two adjacent target regions 71,72. The base 81 meets the side surfaces 75,76 at two edges, namely a first edge 82 and a second edge 83 as shown in FIG 11.

[0048] As shown in FIG 5, in an embodiment of the impingement cooling arrangement 1, the base 81 of the trench 80 includes a plurality of turbulators 88 that create turbulence in the cooling air 5 flowing within the trench 8 in the flow direction 9. The cooling air 5 after being directed into the trench 80 by the target region 70 flows along the base 81 of the trench 80 and the turbulators 88 are positioned on the base 81 along the flow direction 9 of the cooling air 5. The turbulators 88 may have varied shapes and sizes, for example the turbulators 88 may be pin-fins, ribs, dimples, etc.

[0049] In an exemplary embodiment of the impingement cooling arrangement 1, the trench 80 is formed or structured such that a width 84,84' of the trench 80, and a depth 85,85' of the trench 80, is uniform in the direction 9 of flow of cooling air 5 within the trench 80. Alternatively, in another embodiment of the impingement cooling arrangement 1, the trench 80 is formed or structured such that either the width 84,84' of the trench 80, or the depth 85,85' of the trench 80, or both the width 84,84' and the depth 85,85' of the trench 80 increases, preferably gradually, in the direction 9 of flow of cooling air 5 within the trench 80.

[0050] FIG 11 schematically represents one such trench 80 which is formed such that the width 84,84' of the trench 80 increases gradually along the flow direction 9. The width 84,84' of the trench 80 at any given location of the trench 80 may be understood as the linear expanse of the base 81 of the trench 80 at the given location in a direction perpendicular to flow direction 9 of the cooling

air 5 i.e. the width 84,84' of the trench 80 at any given location of the trench 80 is the distance between the edges 82,83 of the trench 80 at that location in the direction perpendicular to flow direction 9. As depicted in FIG 11, the width 84' of the trench 80 at a downstream location is greater than the width 84 of the trench 80 at a relatively upstream location of the trench 80.

[0051] FIGs 12 and 13 schematically represents exemplary embodiments of the trench 80 which is formed such that the depth 85,85' of the trench 80 increases gradually along the flow direction 9. The depth 85,85' of the trench 80 at any given location of the trench 80 may be understood as the shortest distance of the base 81 of the trench 80 from the second face 66 of the impingement component 60 at that location positioned directly above the base 81, as shown in FIG 13. The base 81 slants downwards along the direction 9. As depicted in FIG 13, the depth 85' of the trench 80 at a downstream location is greater than the depth 85 of the trench 80 at a relatively upstream location of the trench 80.

[0052] Alternatively, as schematically depicted in FIG 12, the depth 85,85' of the trench 80 at any given location of the trench 80 may be understood as the shortest distance of the base 81 of the trench 80 from the top part 74 of the target region 71,72,73 at that location positioned directly adjacent to the base 81 at that location, as shown in FIG 12. The target region 71,72,73 in this embodiment slants upwards along the direction 9. As depicted in FIG 13, the depth 85' of the trench 80 at a downstream location is greater than the depth 85 of the trench 80 at a relatively upstream location of the trench 80.

[0053] While the present technique has been described in detail with reference to certain embodiments, it should be appreciated that the present technique is not limited to those precise embodiments. Rather, in view of the present disclosure which describes exemplary modes for practicing the invention, many modifications and variations would present themselves, to those skilled in the art without departing from the scope and spirit of this invention. The scope of the invention is, therefore, indicated by the following claims rather than by the foregoing description. All changes, modifications, and variations coming within the meaning and range of equivalency of the claims are to be considered within their scope.

Claims

1. An impingement cooling arrangement (1) for target surface cooling in a gas turbine engine (10), the impingement cooling arrangement (1) comprising:
 - an impingement component (60) having one or more pluralities (61,62,63) of impingement holes (61h,62h,63h), wherein the impingement holes (61h,62h,63h) of each plurality (61,62,63) are positioned in a linear arrangement on the impingement component (60) and are config-

ured to eject cooling air (5) outward from the impingement component (60) in form of impingement jets (61j,62j,63j) of the cooling air (5); and

- a target component (70) having a target surface (79) and comprising:

- a target region (71,72,73) corresponding to each plurality (61,62,63) and extending outwards from the target surface (79) towards the impingement component (60), wherein each target region (71,72,73) extends on the target surface (79) linearly corresponding to the linear arrangement of the impingement holes (61h,62h,63h) of the corresponding plurality (61,62,63), and
- at least one trench (80) formed on the target surface (79) adjacent to each target region (71,72,73), wherein the trench (80) extends linearly corresponding to the linearly extending target region (71,72,73);

- wherein each target region (71,72,73) is arranged on the target surface (79) such that the cooling air (5) of the impingement jets (61j,62j,63j) ejected from the corresponding plurality (61,62,63) are received on the target region (71,72,73) and guided by the target region (71,72,73) into the trench (80) formed adjacent to the target region (71, 72, 73) .

2. The impingement cooling arrangement (1) according to claim 1, wherein the target region (71,72,73) is ridge shaped.
3. The impingement cooling arrangement (1) according to claim 1 or 2, wherein each target region (71,72,73) is arranged on the target surface (79) such that the cooling air (5) of the impingement jets (61j,62j,63j) ejected from the corresponding plurality (61,62,63) are received on a top part (74) of the target region (71,72,73) and guided by a side surface (75,76) of the target region (71,72,73) into the trench (80) formed adjacent to the target region (71,72,73).
4. The impingement cooling arrangement (1) according to claim 3, wherein the top part (74) of the target region (71,72,73) is crest-shaped.
5. The impingement cooling arrangement (1) according to claim 3, wherein the top part (74) of the target region (71,72,73) is plateau-shaped.
6. The impingement cooling arrangement (1) according to claim 1 or 2, wherein each target region (71,72,73) is arranged on the target surface (79) such that the cooling air (5) of the impingement jets (61j,62j,63j) ejected from the corresponding plurality (61,62,63)

are received on a side surface (75,76) of the target region (71,72,73) and guided by the side surface ((75,76) of the target region (71,72,73) into the trench (80) formed adjacent to the target region (71,72,73).

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7. The impingement cooling arrangement (1) according to any of claims 1 to 6, wherein the linear arrangements of the pluralities (61,62,63) of the impingement holes (61h,62h,63h) are parallel to each other.

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8. The impingement cooling arrangement (1) according to any of claims 1 to 7, wherein the target regions (71,72,73) and the trenches (80) are alternatively arranged on the target surface (79).

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9. The impingement cooling arrangement (1) according to any of claims 1 to 8, wherein a base (81) of the trench (80) comprises a plurality of turbulators (88).

10. The impingement cooling arrangement (1) according to any of claims 1 to 9, wherein at least one of a width (84,84') of the trench (80) and a depth (85,85') of the trench (80) increases in a direction (9) of flow of cooling air (5) within the trench (80).

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11. The impingement cooling arrangement (1) according to any of claims 1 to 10, wherein the target component (70) is an aerofoil (90) of a turbine blade/vane (38,40,44) and wherein the target surface (79) is a part of an internal surface (91) of the aerofoil (90).

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12. The impingement cooling arrangement (1) according to any of claims 1 to 10, wherein the target component (70) is a platform (100) of a turbine blade/vane (38,40,44) and wherein the target surface (79) is a part of an internal surface (101) of the platform (100).

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13. The impingement cooling arrangement (1) according to any of claims 1 to 10, wherein the target component (70) is a combustor liner (110) for a combustor assembly (25) and wherein the target surface (79) is a part of an external surface (111) of the combustor liner (110).

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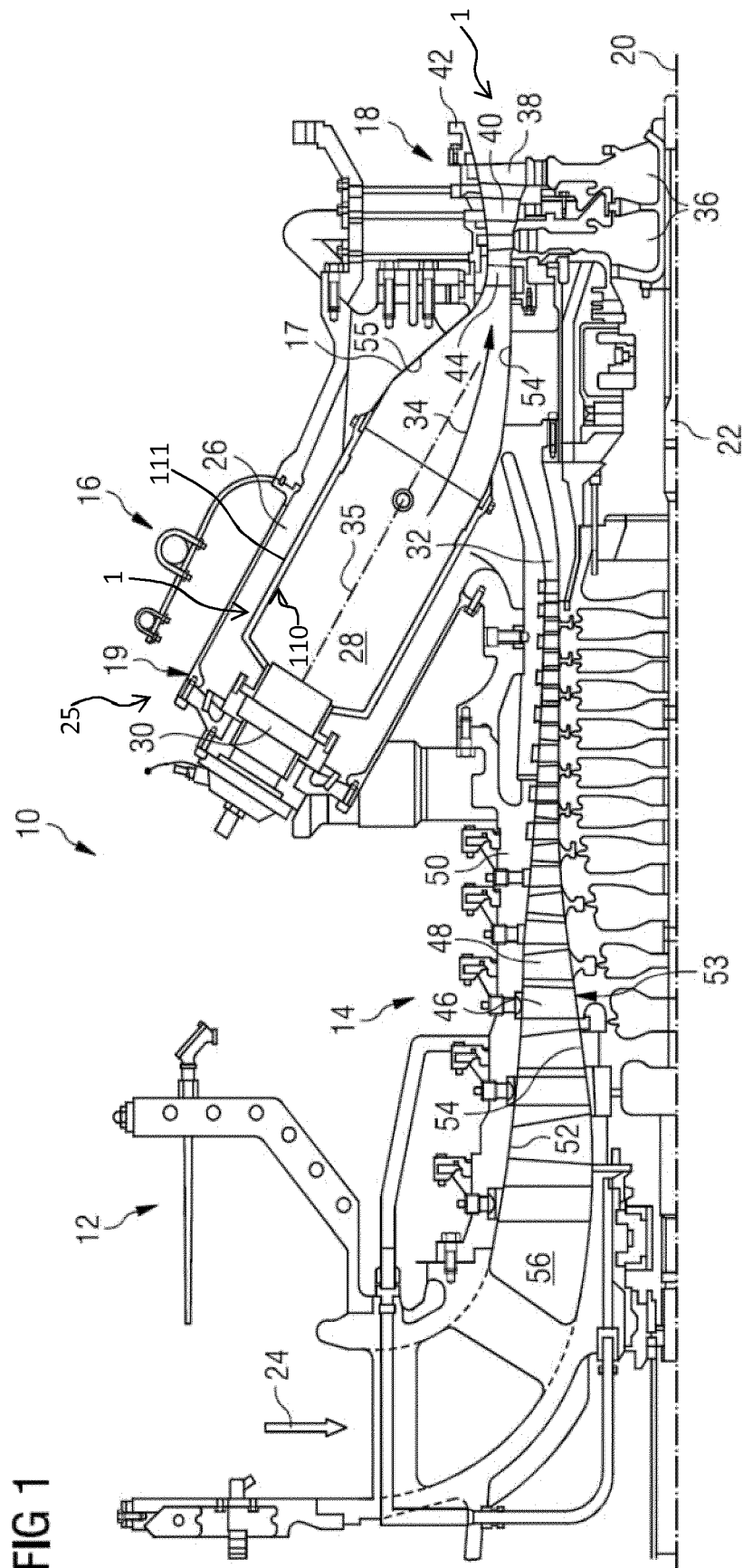


FIG 1

FIG 2

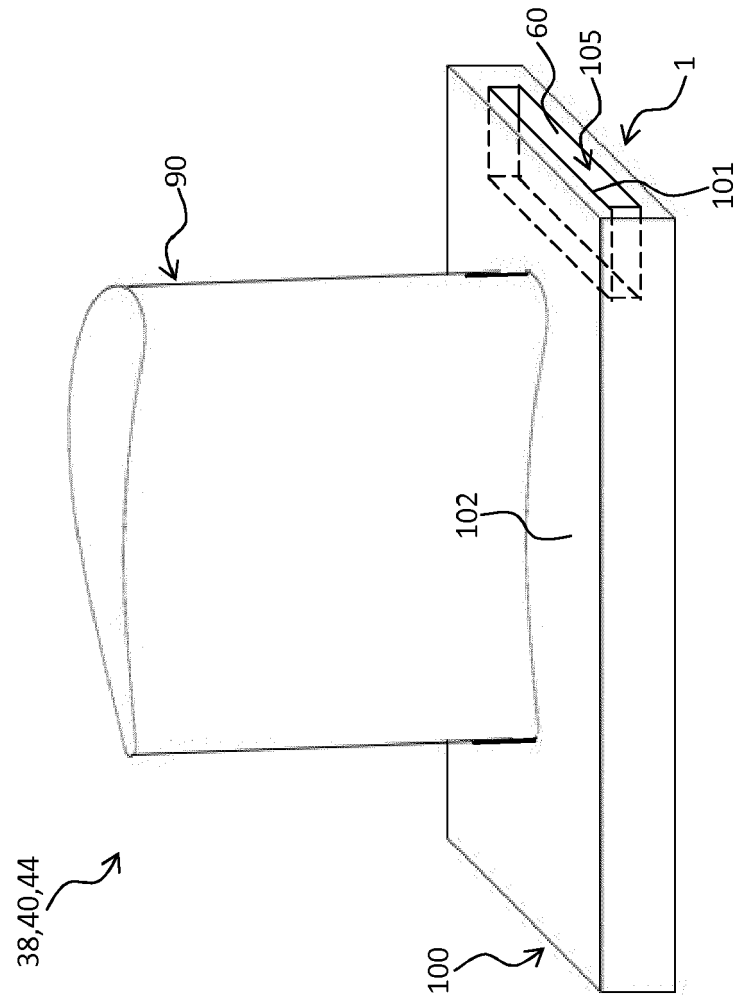


FIG 3

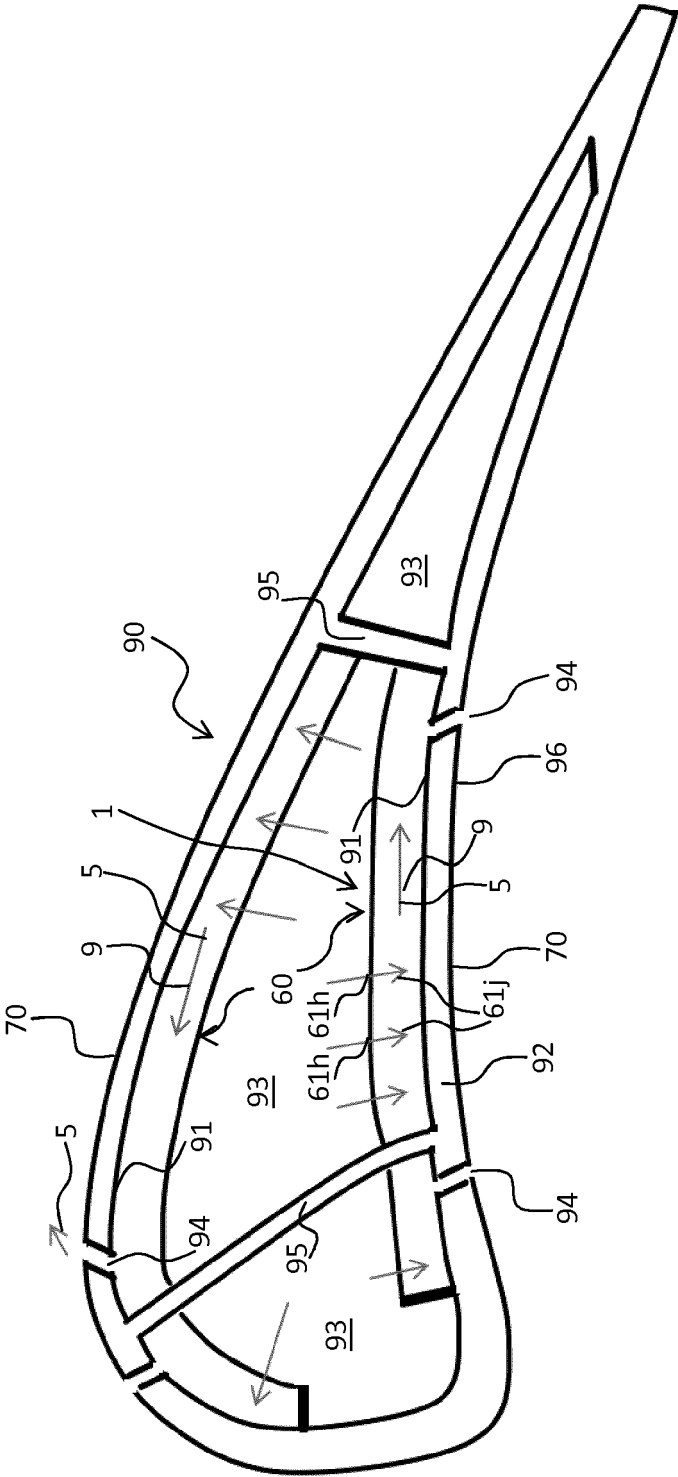


FIG 4

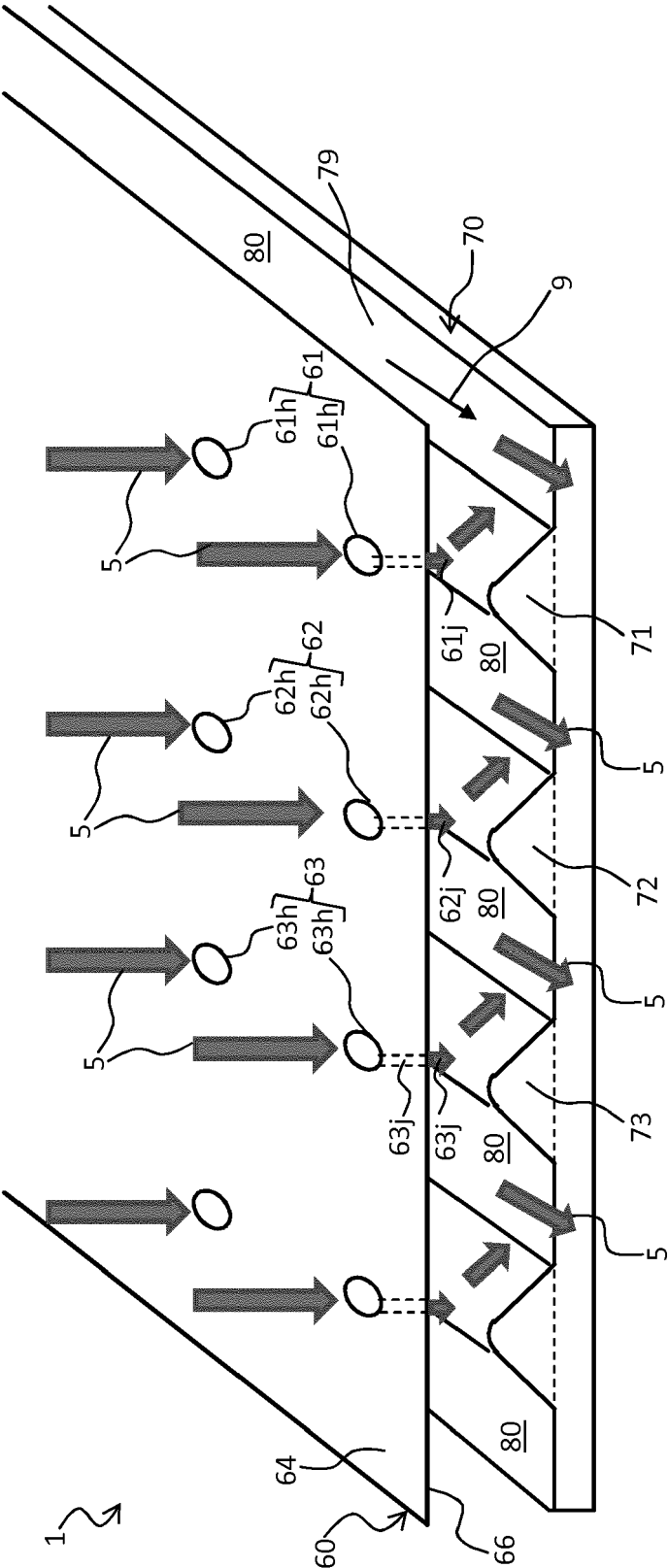


FIG 6

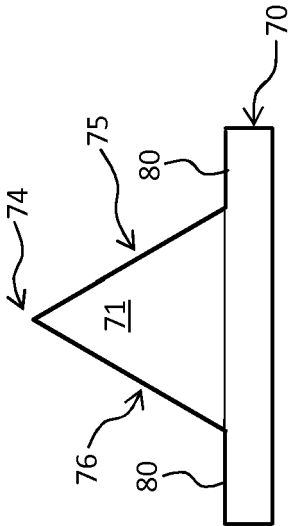


FIG 7

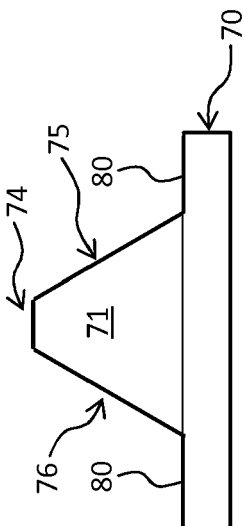


FIG 8

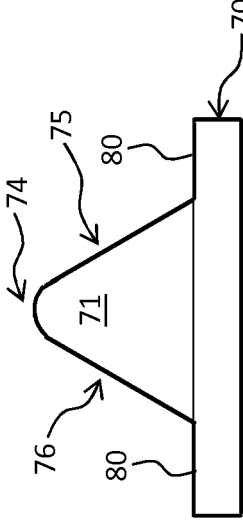


FIG 5

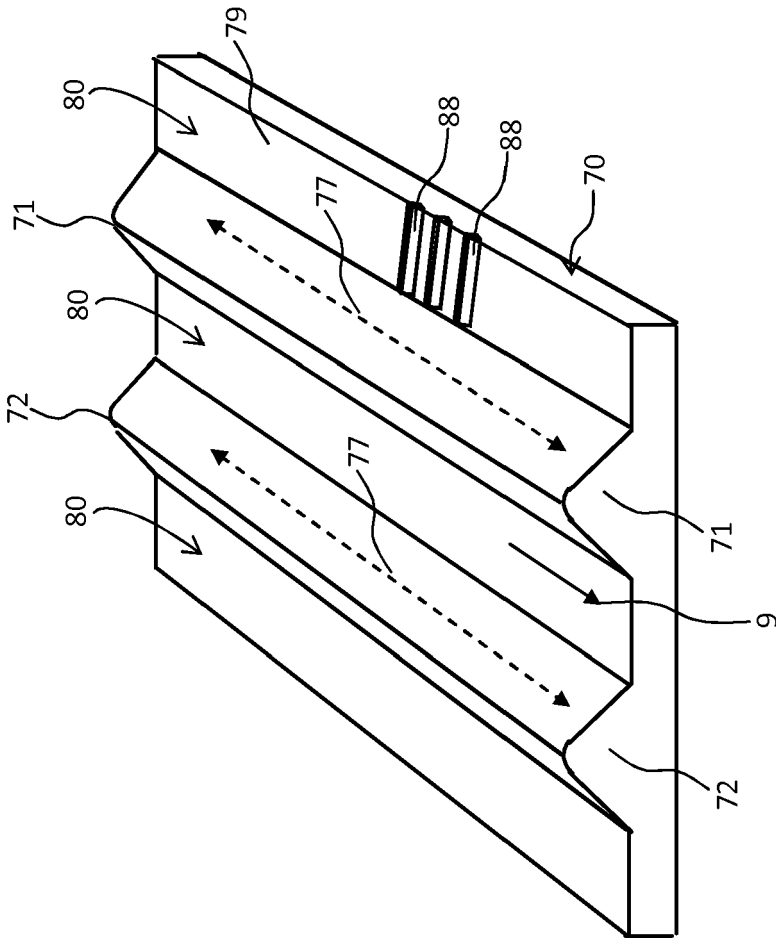


FIG 10

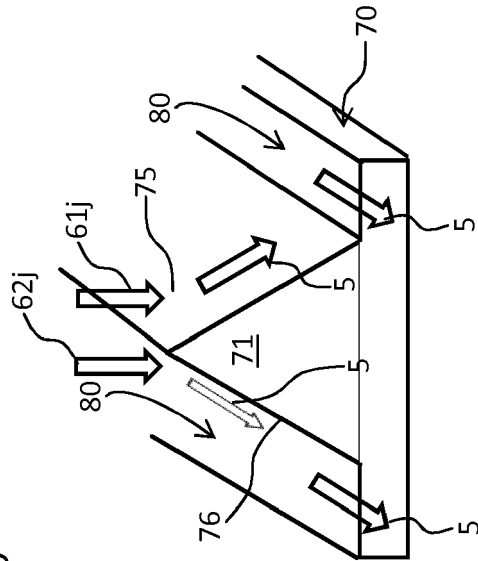


FIG 9

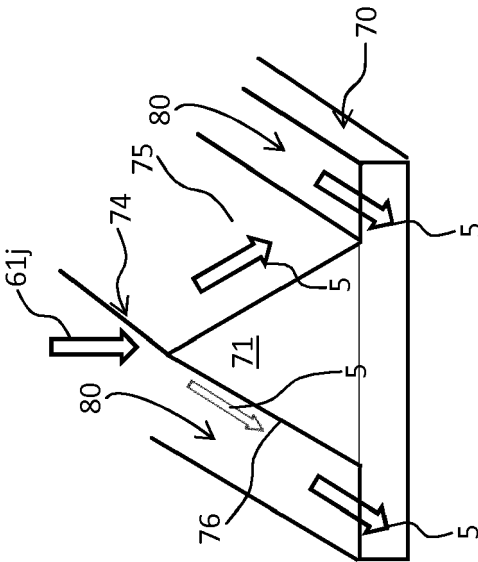


FIG 11

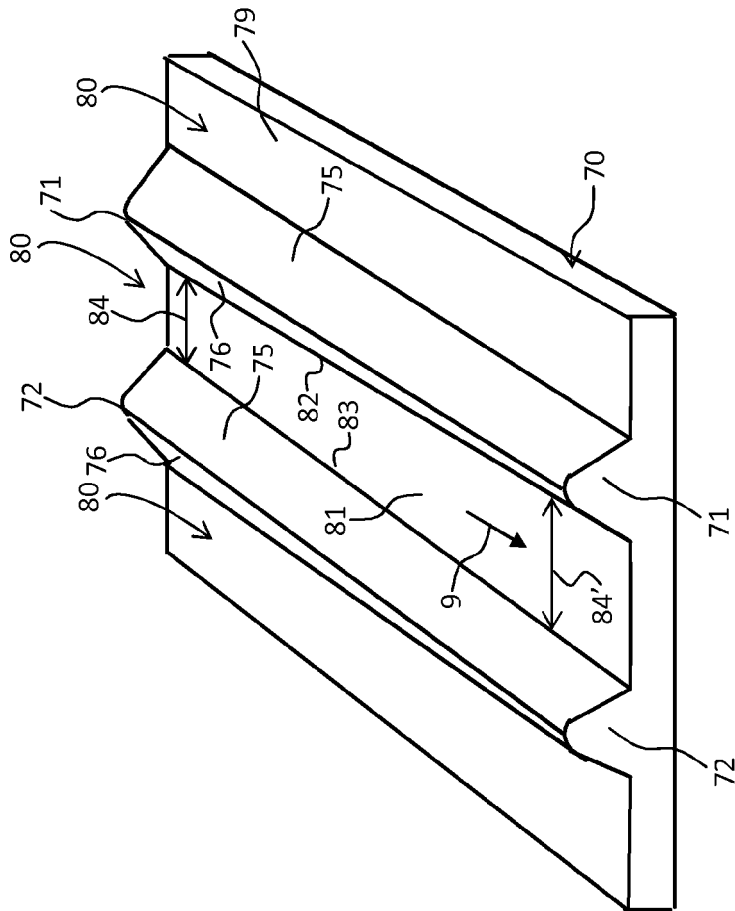


FIG 12

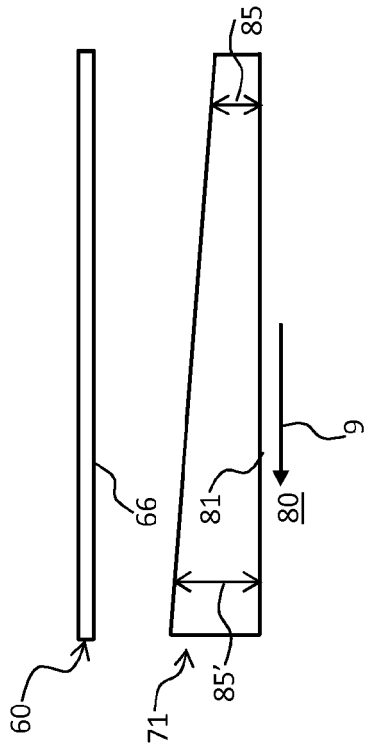
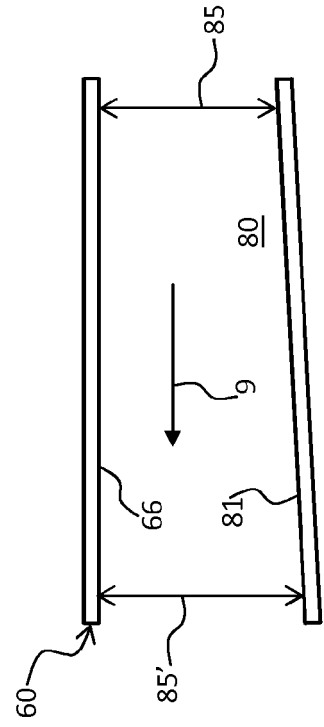


FIG 13





EUROPEAN SEARCH REPORT

Application Number
EP 17 17 9339

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A	----- US 2003/140632 A1 (DAILEY GEOFFREY M [GB] ET AL) 31 July 2003 (2003-07-31) * figures 3, 5 *	1-13	

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			F01D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 5 December 2017	Examiner Georgi, Jan
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