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## (54) COOLED GAS TURBINE BLADE

(57) A blade for a gas turbine (5) is provided with an airfoil (18) having a leading edge (27), a trailing edge (28), a pressure side (24) and a suction side (25); the airfoil (18) comprising an outer wall (30) and an inner wall (31) substantially enclosed by the outer wall (30); and with a cooling arrangement (29) which comprises at least one cooling path (31a; 31b; 31c; 31d) between the outer wall (30) and the inner wall (31); the cooling path (31a; 31b; 31c; 31d) having at least one inlet (40; 44; 51; 57) and at least one discharge arrangement (41; 45; 53; 58); wherein the discharge arrangement (41; 45; 53; 58) extends through the outer wall (35) and comprises a plurality of inlet holes (60; 160) and at least one outlet common slot (61; 161).

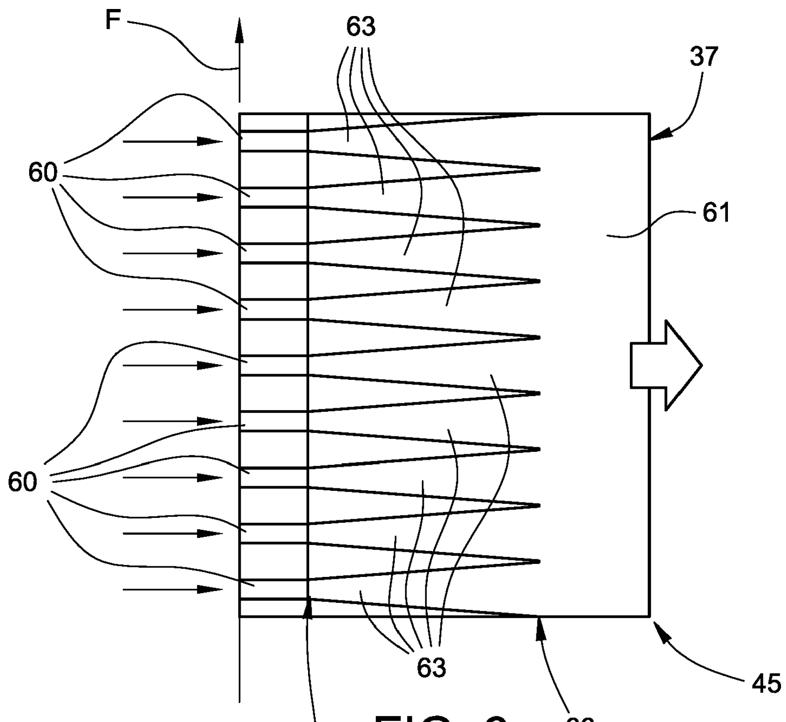

FIG. 6

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## Description

TECHNICAL FIELD

**[0001]** The present invention relates to a blade for a gas turbine and to an electric power production plant comprising said blade. In particular, the present invention relates to an improved cooling of the blades of a gas turbine. Preferably the electric power production plant is connected to an electrical grid.

BACKGROUND

**[0002]** During the operation of the electrical energy production plants, the blades of gas turbines are constantly exposed to a hot gas flow coming from the combustion chamber.

**[0003]** The temperature of the hot gas flowing in the gas turbine affects the performance of the plant. In particular, performances of the plant increase with an increasing temperature of the hot gas flowing inside the turbine.

**[0004]** However, the increase of the temperature of the hot gas flowing in the gas turbine is limited by the thermal resistance of the material constituting the blades.

**[0005]** To overcome this kind of limitation, in recent years, a cooling system for the blades has been adopted. Normally cooling air extracted from the compressor or coming from a dedicated cooling air source is driven through the blades.

**[0006]** Examples of blades provided with a cooling system are disclosed in documents US 8,231,349 or EP 2107215.

**[0007]** However, introducing a large amount of cooling air into the blades of the gas turbine would lead to excessive thermodynamic losses.

SUMMARY

**[0008]** The object of the present invention is therefore to provide a blade having an optimized cooling system, capable of improving the thermal resistance of the blades, allowing a further increase of the temperature of the gases flowing in the gas turbine and reducing the thermodynamic losses thus consequently improving the plant performances.

**[0009]** According to the present invention, there is provided a blade for a gas turbine comprising:

an airfoil having a leading edge, a trailing edge, a pressure side and a suction side; the airfoil comprising an outer wall and an inner wall substantially enclosed by the outer wall; and

a cooling arrangement which comprises at least one cooling path between the outer wall and the inner wall; the cooling path having at least one inlet and at least one discharge arrangement; wherein the discharge arrangement extends through the outer wall and comprises a plurality of inlet holes and at least one outlet common slot.

**[0010]** Thanks to the presence of a plurality of inlet holes having a defined passage area the flow rate of the cooling fluid exiting through the discharge arrangement is properly regulated. While thanks to the fact that the plurality of cooling fluid flows join at the outlet common slot the film cooling efficiency is improved. The external face of the outer wall, in fact, is lapped by a cooling flow which is wide and homogeneous.

**[0011]** As the efficiency of the cooling is increased, a lower cooling fluid flow rate can be drawn for cooling the blades. This lead to a significant increase in the efficiency of the plant as the cooling fluid is normally drawn from the compressor of the plant.

**[0012]** According to a preferred embodiment of the present invention, the discharge arrangement comprises a plurality of connecting channels, each of which is configured to connect a respective hole with the outlet common slot.

**[0013]** According to a preferred embodiment of the present invention, the inlet holes are substantially identical to each other.

**[0014]** According to a preferred embodiment of the present invention, the connecting channels are substantially identical to each other.

**[0015]** According to a preferred embodiment of the present invention, each connecting channel have an inlet section and an outlet section; the inlet section of each connecting channel being in contact with the respective inlet hole and the outlet section of each connecting channel being in contact with the outlet common slot.

**[0016]** According to a preferred embodiment of the present invention, the passage area of each inlet hole is smaller than the passage area of the inlet section of the respective connecting channels.

**[0017]** According to a preferred embodiment of the present invention, the connecting channels are diverging toward the outlet common slot.

**[0018]** According to a preferred embodiment of the present invention, the passage area of the inlet holes is constant.

**[0019]** According to a preferred embodiment of the present invention, the inlet holes are substantially aligned along a direction which is substantially a straight line extending from a base of the airfoil to a tip of the airfoil.

**[0020]** According to a preferred embodiment of the present invention, the inlet holes are arranged equally spaced from each other.

**[0021]** According to a preferred embodiment of the present invention, the discharge arrangement comprises at least two discharge groups; each discharge group comprises the plurality of inlet holes, the outlet common slot and the plurality of connecting channels.

**[0022]** According to a preferred embodiment of the present invention, the inlet holes of each discharge group are equally spaced one from the other.

**[0023]** According to a preferred embodiment of the present invention, the discharge groups are equally spaced one from the other.

**[0024]** It is furthermore another object of the present invention to provide a plant for electric power production having an improved power efficiency.

**[0025]** According to said object the present invention relates to a plant for electric power production comprising at least one gas turbine, which extends along a longitudinal axis and comprises at least one row of blades circumferentially spaced and extending radially outwardly from a respective supporting disc of the gas turbine; at least one of the blades of the row being of the type claimed in anyone of the claims 1-12.

**[0026]** According to a preferred embodiment of the present invention, the plant comprises at least one compressor which is connected to the gas turbine by a suction line configured to draw cooling air from the compressor and supply it to the cooling arrangement of the at least one blade.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0027]** The present invention will now be described with reference to the accompanying drawings, which illustrate some non-limitative embodiment, in which:

- Figure 1 is a schematic lateral representation, with parts removed for clarity and parts in section, of an electric power production plant comprising according to the present invention;
- Figure 2 is a schematic lateral view, with parts removed for clarity and parts in section, of a blade for a gas turbine according to the present invention;
- Figure 3 is a schematic perspective view, with parts removed for clarity and parts in section, of a first detail of the blade of figure 2;
- Figure 4 is a top section view of the first detail of the blade of figure 2;
- Figure 5 is an enlarged schematic section view of a second detail of the blade according to the present invention.
- Figure 6 is a schematic section view of the second detail along plane VI-VI indicated in figure 5;
- Figure 7 is a schematic section view of the second detail along plane VI-VI indicated in figure 5 according to a further embodiment of the present invention.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

**[0028]** In figure 1, reference numeral 1 indicates a gas turbine plant for electrical energy production comprising a compressor 3, a combustor 4, a gas turbine 5 and a generator 7, which transforms the mechanical power supplied by turbine 5 into electrical power to be supplied to an electrical grid 8, connected to the generator 7 via a switch 9.

**[0029]** A variant not shown provides for plant 1 to be of the combined cycle type and including, in addition to the gas turbine 5 and generator 7, also a steam turbine.

**[0030]** The gas turbine 5 extends along a longitudinal axis A and is provided with a shaft 10 (also extending along axis A) to which compressor 3 and generator 7 are also connected.

**[0031]** Gas turbine 5 comprises an expansion channel 12 wherein the hot gas working fluid coming from the combustor 4 flows in a direction D.

**[0032]** The expansion channel 12 has a section which radially increases along the axis A in the direction D.

**[0033]** In the expansion channel 12 a plurality of stages 13 spaced along the longitudinal axis A is arranged. Each stage 13 comprises a row of fixed blades and a row of rotating blades (not illustrated in figure 1). Each row comprises circumferentially spaced blades extending radially outwardly from a respective supporting disc.

**[0034]** In figure 2 a blade 15 of a stage 13 of the gas turbine 5 is represented.

**[0035]** Preferably, blade 15 is a rotating blade, but it is clear that the present invention can also be applied to stator blades.

**[0036]** The blade 15 comprises a root 17, an airfoil 18 and a platform 20.

**[0037]** The root 17 is configured to be coupled to a supporting disc (not illustrated in the accompanying figures) of the gas turbine 5. In particular, the disc has a plurality of axial seats, which are circumferentially spaced and engaged by respective roots 17 of the rotating blades 15.

**[0038]** The airfoil 18 extends from the root 17 and is provided with base 21 coupled to the root 17 and a tip 22 which, in use, is radially opposite to the base 21.

**[0039]** The airfoil 18 is completely housed in the expansion channel 12 and defines the aerodynamic profile of the rotating blade 15.

**[0040]** The airfoil 18 has a concave pressure side 24 (better visible in figures 3 and 4) and a convex suction side 25, which, in use, extend axially between a leading edge 27 and a trailing edge 28 and radially between the base 21 and the tip 22.

**[0041]** The leading edge 27 is arranged upstream of the trailing edge 28 along the direction D of the hot working fluid in the expansion channel 12.

**[0042]** The platform 20 is arranged between the root 17 and the airfoil 18.

**[0043]** Blade 15 is provided with a cooling arrangement 29. The cooling arrangement 29 comprise a plurality of feeding channels 30 made in the root 17 and a plurality of cooling paths 31 (not illustrated in figure 2 and better visible in figures 3 and 4) made in the airfoil 18.

**[0044]** The feeding channels 30 are supplied with a cooling fluid coming from a cooling fluid source 32.

**[0045]** Preferably, the cooling fluid source 32 is a portion of the compressor 3. In figure 1 a suction line 33 dedicated to the suction of cooling air from the compressor 3 and connected to the gas turbine 5 is shown.

**[0046]** Preferably, each feeding channel 30 is coupled to a respective cooling path 31. According to a variant not shown each feeding channels can be coupled to more than one cooling path.

**[0047]** In the non-limiting embodiment here disclosed and illustrated, the feeding channels 30 are four and the cooling paths 31 are four.

**[0048]** With reference to figure 3, the cooling arrangement 29 comprises a suction side cooling path 31a mainly dedicated to the cooling of the suction side 25, a pressure side cooling path 31b mainly dedicated to the cooling of the pressure side 24, a leading edge cooling path 31c mainly dedicated to the cooling of the leading edge 27 and a trailing edge cooling path 31d mainly dedicated to the cooling of the trailing edge 28.

**[0049]** In figure 3 a dashed line is used to schematically indicate the cooling path 31a, a dashed-dotted line is used to schematically indicate the pressure side cooling path 31b, a dotted line is used to schematically indicate the leading edge cooling path 31c, a solid line is used to schematically indicate the trailing edge cooling path 31d.

**[0050]** The airfoil 18 comprises an outer wall 35 and an inner wall 36.

**[0051]** The outer wall 35 defines at least in part the aerodynamic profile of the blade 15 and has an external face 37 which, in use, is arranged in contact with the hot gas working fluid flowing in the expansion channel 12.

**[0052]** The inner wall 36 is enclosed by the outer wall 35 and may have cooling and structural functions.

**[0053]** In particular the inner wall 36 defines an inner central cooling chamber 38, through which, in use, the cooling fluid coming from a respective feeding channel 30 flows as will be detailed in the following.

**[0054]** The suction side cooling path 31a is defined between the inner wall 36 and the outer wall 35 and extends at least partially along the suction side 25.

**[0055]** The suction side cooling path 31a comprises at least one inlet 40 (better visible in figure 2) and at least one discharge arrangement 41.

**[0056]** The inlet 40 being arranged closer to the trailing edge 28 than the discharge arrangement 41.

**[0057]** In the non-limiting embodiment here disclosed and illustrated, the suction side cooling path 31a comprises one inlet 40, which is defined by an aperture located at the base 21 of the airfoil 18 and in fluidic communication with the respective feeding channel 30 of the root 17.

**[0058]** In the non-limiting embodiment here disclosed and illustrated, the suction side cooling path 31a comprises one discharge arrangement 41 which will be described in detail later.

**[0059]** In more detail, the suction side cooling path 31a comprises a plurality of suction side cooling chambers 42 which are in fluidic communication and arranged side by side between the inner wall 36 and the outer wall 35 along the suction side 25.

**[0060]** Each of the suction side cooling chambers 42 extends substantially along a direction going from the base 21 toward the tip 22.

**[0061]** The plurality of suction side cooling chambers 42 comprises a suction side inlet chamber 42a, which is the suction side cooling chamber 42 closest to the trailing edge 28, and a suction side discharge chamber 42b, which is the suction side cooling chamber 42 closest to the leading edge 27.

**[0062]** The suction side inlet chamber 42a comprises the inlet 40 and the suction side discharge chamber 42b comprises the discharge arrangement 41.

**[0063]** In the non-limiting embodiment here disclosed and illustrated, the suction side cooling path 31a comprises three suction side cooling chambers 42. In other words, between the suction side inlet chamber 42a and the suction side discharge chamber 42b only one suction side intermediate chamber 42c is arranged.

**[0064]** In use, the cooling fluid coming from the respective feeding channel 30 of the root 17 flows along the suction side inlet chamber 41a, along the suction side intermediate chamber 42c along the suction side discharge chamber 42b and exits through the discharge arrangement 41 of the suction side discharge chamber 42b.

**[0065]** In other words, the flow of the cooling fluid along the suction side cooling path 31a is a counter-current flow with respect to the flow of the hot gas working fluid in the expansion channel 12 having direction D.

**[0066]** The pressure side cooling path 31b is defined between the inner wall 36 and the outer wall 35 and extends at least partially along the pressure side 24.

**[0067]** The pressure side cooling path 31b comprises at least one inlet 44 (better visible in figure 2) and at least one discharge arrangement 45.

**[0068]** The discharge arrangement 45 being arranged closer to the trailing edge 28 than the inlet 44.

**[0069]** In the non-limiting embodiment here disclosed and illustrated, the pressure side cooling path 31b comprises one inlet 44, which is defined by an aperture located at the base 21 of the airfoil 18 and in fluidic communication with the respective feeding channel 30 of the root 17.

**[0070]** In the non-limiting embodiment here disclosed and illustrated, the pressure side cooling path 31b comprises two discharge arrangements 45, which will be described in detail later.

**[0071]** In more detail, the pressure side cooling path 31b comprises a plurality of pressure side cooling chambers 47 which are in fluidic communication and arranged side by side between the inner wall 36 and the outer wall 35 along the pressure side 24.

**[0072]** Each of the pressure side cooling chambers 47 extends substantially along a direction going from the base 21 toward the tip 22.

**[0073]** The plurality of pressure side cooling chambers 47 comprises a pressure side inlet chamber 47a, which is the pressure side cooling chamber 47 closest to the leading edge 27, and at least one pressure side discharge chamber 47b, which is the pressure side cooling chamber 47 closest to the trailing edge 28.

**[0074]** The pressure side inlet chamber 47a comprises the inlet 44 and the pressure side discharge chamber 47b comprises at least one discharge arrangement 45.

**[0075]** In the non-limiting embodiment here disclosed and illustrated, the pressure side cooling path 31b comprises three pressure side cooling chambers 47: one pressure side inlet chamber 47a and two subsequent discharge chambers 47b, each of which is provided with at least one discharge arrangement 45.

**[0076]** In use, the cooling fluid coming from the respective feeding channel 30 of the root 17 flows along the pressure side inlet chamber 47a, along the pressure side discharge chamber 47b adjacent to the pressure side inlet chamber 47a and along the pressure side discharge chamber 47b closest to the trailing edge 28 and exits through the two discharge arrangements 45 of the pressure side discharge chambers 47b.

**[0077]** In other words, the flow of the cooling fluid along the pressure side cooling path 31b is a co-current flow with respect to the flow of the hot gas working fluid in the expansion channel 12 having direction D.

**[0078]** The leading edge cooling path 31c is defined by the inner central cooling chamber 38 and by a leading edge cooling chamber 49 arranged between the inner wall 36 and the outer wall 35 at the leading edge 27. The inner central cooling chamber 38 being in fluidic communication with the leading edge cooling chamber 49 by at least one connecting aperture 50.

**[0079]** The inner central cooling chamber 38 and the leading edge cooling chamber 49 extend substantially along a direction going from the base 21 toward the tip 22.

**[0080]** The leading edge cooling path 31c comprising at least one inlet 51 (better visible in figure 2) and at least one discharge arrangement 53.

**[0081]** The discharge arrangement 53 being arranged closer to the leading edge 27 than the inlet 51.

**[0082]** In the non-limiting embodiment here disclosed and illustrated, the leading edge cooling path 31c comprises one inlet 51, which is defined by an aperture located at the base 21 of the airfoil 18 and in fluidic communication with the respective feeding channel 30 of the root 17.

**[0083]** In the non-limiting embodiment here disclosed and the leading edge cooling path 31c comprises a plurality of discharge arrangements 53, which will be described in detail later. Preferably the discharge arrangements 53 are at least three: at least one discharge arrangement 53 directed toward the leading edge 27, at least one discharge arrangement 53 directed toward the suction side 25 and at least one discharge arrangement 53 directed toward the pressure side 24.

**[0084]** In more detail, the leading edge cooling chamber 49 comprises the discharge arrangements 53, while the inner central cooling chamber 38 comprises the inlet 51.

**[0085]** In use, the cooling fluid coming from the respective feeding channel 30 of the root 17 flows along the inner central cooling chamber 38, through the connecting aperture 50, along leading edge cooling chamber 49 and exits through the discharge arrangements 53 of the leading edge cooling chamber 49.

**[0086]** In other words, the flow of the cooling fluid along the leading edge cooling path 31c is a co-current flow with respect to the flow of the hot gas working fluid in the expansion channel 12 having direction D.

**[0087]** The trailing edge cooling path 31d is defined by a trailing edge cooling chamber 55 arranged between the inlet 40 of suction side cooling path 31a and the trailing edge 28.

**[0088]** The trailing edge cooling chamber 55 extends substantially along a direction going from the base 21 toward the tip 22.

**[0089]** The trailing edge cooling path 31d comprises at least one inlet 57 (better visible in figure 2) and at least one discharge arrangement 58.

**[0090]** The discharge arrangement 58 being arranged on the pressure side 24 and configured to direct the flow toward the trailing edge 28.

**[0091]** In the non-limiting embodiment here disclosed and illustrated, the trailing edge cooling path 31d comprises one inlet 57, which is defined by an aperture located at the base 21 of the airfoil 18 and in fluidic communication with the respective feeding channel 30 of the root 17.

**[0092]** In the non-limiting embodiment here disclosed and illustrated the trailing edge cooling path 31d comprises one discharge arrangement 58, which will be described in detail later.

**[0093]** In more detail, the trailing edge cooling chamber 55 comprises the discharge arrangements 58 and the inlet 57.

**[0094]** In use, the cooling fluid coming from the respective feeding channel 30 of the root 17 flows along the trailing edge cooling chamber 55 and exits through the discharge arrangement 58 toward the trailing edge 28.

**[0095]** The suction side cooling chambers 42, the pressure side cooling chambers 47, the leading edge cooling chamber 49 and the trailing edge cooling chamber 55 can be optionally provided with at least one turbulator in order to improve the cooling effect.

**[0096]** In particular, the suction side cooling chambers 42, the pressure side cooling chambers 47 and the trailing edge cooling chamber 55 may comprise turbulators defined by ribs which project from at least one internal face of the respective chamber and are angled with respect to the direction of the cooling fluid inside the chamber.

**[0097]** Preferably said turbulators project from three adjacent internal faces of the respective chamber.

**[0098]** The leading edge cooling chamber 49 may comprise a plurality of turbulators defined by ribs projecting from at least one internal face of the leading edge cooling chamber 49. Said ribs have a trapezoidal-shaped section. Preferably said turbulators are arranged staggered with respect to the inlet holes of the cooling arrangements 53 at least on the two internal faces of the leading edge cooling chamber 49 which are respectively closest to the pressure side 24 and to the suction side 25.

**[0099]** In figures 5 and 6 the shape of a discharging arrangement is illustrated.

**[0100]** Preferably, the discharging arrangement 41 of the suction side cooling path 31a, the discharge arrangements 45 of the pressure side cooling path 31b, the discharge arrangements 53 of the leading edge cooling path 31c and the discharge arrangement 58 of the trailing edge cooling path 31d have all the structure illustrated in figures 5 and 6.

**[0101]** According to a variant not illustrated, at least one of the discharge arrangement 41 45 53 58 have the structure illustrated in figures 5 and 6.

**[0102]** In figure 5 and 6 only the discharge arrangement 45 is illustrated. However, as the structure of the remaining discharge arrangements 41 53 58 is substantially identical to the structure of the discharge arrangement 45, the following considerations can be considered valid also for the discharge arrangements 41 53 58.

**[0103]** Discharge arrangement 45 extends through the outer wall 35 from the respective internal face of the pressure side discharge cooling chamber 47b to the external face 37 of the outer wall 35.

**[0104]** With reference to figure 6, the discharge arrangement 45 comprises a plurality of inlet holes 60, an outlet common slot 61 and a plurality of connecting channels 63, each of which is configured to connect a respective hole 60 with the outlet common slot 61.

**[0105]** Preferably the inlet holes 60 are identical to each other.

**[0106]** Preferably the connecting channels 63 are identical to each other.

**[0107]** The connecting channels 63 are diverging toward the outlet common slot 61. In other words, the connecting channels 63 have a passage area which gradually increases toward the outlet common slot 61.

**[0108]** The increase of the passage area starts from an inlet section 65 of the connecting channels 63 and ends at an outlet section 66 of the connecting channels 63. The inlet section 65 of each connecting channel 63 being in contact with the respective inlet hole 60 and the outlet section 66 of each connecting channel 63 being in contact with the outlet common slot 61.

**[0109]** The passage area of the inlet holes 60 is constant.

**[0110]** As better visible in figure 5, the passage area of the inlet hole 60 is smaller than the passage area of the inlet section 65 of the respective connecting channels 63.

**[0111]** In the non-limiting example here disclosed and illustrated the passage area of the inlet section 65 of the respective connecting channels 63 is 10-20% greater than the passage area of the inlet hole 60.

**[0112]** Moreover, in the non-limiting example here disclosed and illustrated, the area ratio between inlet section 65 and outlet section 66 of the connecting channels 63 is comprised between 3,5 to 5.

**[0113]** Preferably, the inlet holes 60 are substantially aligned along a direction F on the respective internal face of the pressure side discharge cooling chamber 47b. Preferably, the inlet holes 60 are arranged equally spaced from each other.

**[0114]** Preferably, the outlet common slot 61 is substantially aligned along a direction parallel to direction F.

**[0115]** Direction F is substantially a straight line extending from the base 21 to tip 22 of the airfoil 18.

**[0116]** With reference to figure 5, the discharge arrangement 45 extends along a main axis G which is inclined with respect to the external face 37 of the outer wall with an angle $\alpha$.

**[0117]** In other words, the inlet holes 60 and the connecting channels 63 and the outlet common slot 61 extends along said main axis G as shown in the cross section of figure 5.

**[0118]** The depth DH of the inlet holes 60 is 10-20% of the total depth Dtot of the outer wall 35; wherein both depth DH and depth Dtot are measured along the main axis G.

**[0119]** The depth DC of the connecting channels 63 is 50%-70% of the total depth Dtot of the outer wall 35; wherein both depth DC and depth Dtot are measured along the main axis G.

**[0120]** Depth DS of the outlet common slot 61 is 20-30% of the total depth Dtot of the outer wall 35; wherein both depth DS and depth Dtot are measured along the main axis G.

**[0121]** Obviously the angle $\alpha$ of inclination and the total depth of the outer wall 35 measured along the main axis G can be different for each one of the discharge arrangements 41 45 53 58.

**[0122]** In the non-limiting example here disclosed and illustrated, the angle $\alpha$ of discharge arrangement 58 is equal or greater than the angle $\alpha$ of discharge arrangement 45.

**[0123]** In use, the cooling fluid coming from the respective pressure side discharge cooling chamber 47b is divided by the plurality of inlet holes 60, flows into the respective connecting channels 63 and joins at the outlet common slot 61. A single wide and homogenous flow of cooling fluid exits from the outlet common slot 61 as indicated also by the arrow in figure 6.

**[0124]** The presence of a plurality of inlet holes 60 having a defined passage area regulates the flow rate of the cooling fluid exiting through the discharge arrangement 45.

**[0125]** The presence of an outlet common slot 61 improves the film cooling efficiency as the external face 37 of the outer wall 35 is lapped by a cooling flow which is wide and homogeneous.

**[0126]** Due to the increased cooling efficiency lower amounts of cooling air is required for the blade. Due to this the overall efficiency of the gas turbine is increased.

**[0127]** In figure 7 a further embodiment of the discharge arrangement 145 is illustrated. The same reference numbers used for the cooling arrangement 45 of figures 5 and 6 are used also in figure 7 for indicating similar or identical parts.

**[0128]** According to said embodiment, the discharge arrangement 145 comprises at least two discharge groups 146

**[0129]** In the non-limiting example here disclosed and illustrated, the discharge arrangement 145 comprises three discharge groups 146.

**[0130]** Each discharge group 146 comprises a plurality of inlet holes 160, an outlet common slot 161 and a plurality of connecting channels 163, each of which is configured to connect a respective hole 160 with the outlet common slot 161.

**[0131]** In particular, each connecting channel 163 have an inlet section 165 and an outlet section 166; the inlet section 165 of each connecting channel 163 being in contact with the respective inlet hole 160 and the outlet section 166 of each connecting channel 163 being in contact with the outlet common slot 161. The passage area of each inlet hole 160 is preferably smaller than the passage area of the inlet section 165 of the respective connecting channels 163 analogously to the embodiment illustrated in figure 6.

**[0132]** In the non-limiting example here disclosed and illustrated, each discharge group 146 comprises a three inlet holes 160, an outlet common slot 161 and three connecting channels 163, each of which is configured to connect a respective hole 160 with the outlet common slot 161.

**[0133]** The inlet holes 160 of each group 146 are equally spaced one from the other.

**[0134]** The discharge groups 146 are spaced one from the other. Preferably the discharge groups 146 are equally spaced one from the other.

**[0135]** In use the cooling fluid coming from the respective pressure side discharge cooling chamber 47b is divided by the plurality of inlet holes 160, flows into the respective connecting channels 163 and joins at the outlet common slots 161. In the non-limiting example here disclosed and illustrated, three homogenous flows of cooling fluid exits from the outlet common slots 161 as indicated also by the arrows in figure 7.

**[0136]** Finally, it is clear that modifications and variants can be made to the blade and the gas turbine described herein without departing from the scope of the present invention, as defined in the appended claims.

## Claims

**1.** Blade for a gas turbine (5) comprising:

an airfoil (18) having a leading edge (27), a trailing edge (28), a pressure side (24) and a suction side (25);
the airfoil (18) comprising an outer wall (30) and an inner wall (31) substantially enclosed by the outer wall (30); and
a cooling arrangement (29) which comprises at least one cooling path (31a; 31b; 31c; 31d) between the outer wall (30) and the inner wall (31);
the cooling path (31a; 31b; 31c; 31d) having at least one inlet (40; 44; 51; 57) and at least one discharge arrangement (41; 45; 53; 58);
wherein the discharge arrangement (41; 45; 53; 58) extends through the outer wall (35) and comprises a plurality of inlet holes (60; 160)and at least one outlet common slot (61; 161).

**2.** Blade according to claim 1, wherein the discharge arrangement comprises a plurality of connecting channels (63; 163), each of which is configured to connect a respective hole (60;160) with the outlet common slot (61; 161).

**3.** Blade according to claim 2, wherein the inlet holes (60; 160) are substantially identical to each other.

**4.** Blade according to claim 2, wherein the connecting channels (63; 163) are substantially identical to each other.

**5.** Blade according to anyone of the claims 2-4, wherein each connecting channel (63; 163) have an inlet section (65; 165) and an outlet section (66; 166); the inlet section (65; 165) of each connecting channel (63; 163) being in contact with the respective inlet hole (60; 160) and the outlet section (66; 166) of each connecting channel (63; 163) being in contact with the outlet common slot (61; 161).

**6.** Blade according to claim 5, wherein the passage area of each inlet hole (60; 160) is smaller than the passage area of the inlet section (65; 165) of the respective connecting channels (63; 163).

**7.** Blade according to anyone of the claims 2-6, wherein the connecting channels (63; 163) are diverging toward the outlet common slot (61; 161).

**8.** Blade according to anyone of the foregoing claims, wherein the passage area of the inlet holes (60; 160) is constant.

**9.** Blade according to anyone of the foregoing claims, wherein the inlet holes (60; 160) are substantially aligned along a direction (F) which is substantially a straight line extending from a base (21) of the airfoil (18) to a tip (22) of the airfoil (18).

**10.** Blade according to claim 9, wherein the inlet holes (60) are arranged equally spaced from each other.

**11.** Blade according to anyone of the claims 2-10, wherein the discharge arrangement (145) comprises at least two discharge groups (146); each discharge group (146) comprises the plurality of inlet holes

(160), the outlet common slot (161) and the plurality of connecting channels (163).

**12.** Blade according to claim 11, wherein the inlet holes (160) of each discharge group (146) are equally spaced one from the other.

**13.** Blade according to claim 11 or 12, wherein the discharge groups (146) are equally spaced one from the other.

**14.** Plant for electric power production comprising at least one gas turbine (5), which extends along a longitudinal axis (A) and comprises at least one row of blades (15) circumferentially spaced and extending radially outwardly from a respective supporting disc of the gas turbine (5); at least one of the blades (15) of the row being of the type claimed in anyone of the foregoing claims.

**15.** Plant according to claim 14, comprising at least one compressor (3) which is connected to the gas turbine (5) by a suction line (33) configured to draw cooling air from the compressor (3) and supply it to the cooling arrangement (29) of the at least one blade (15).

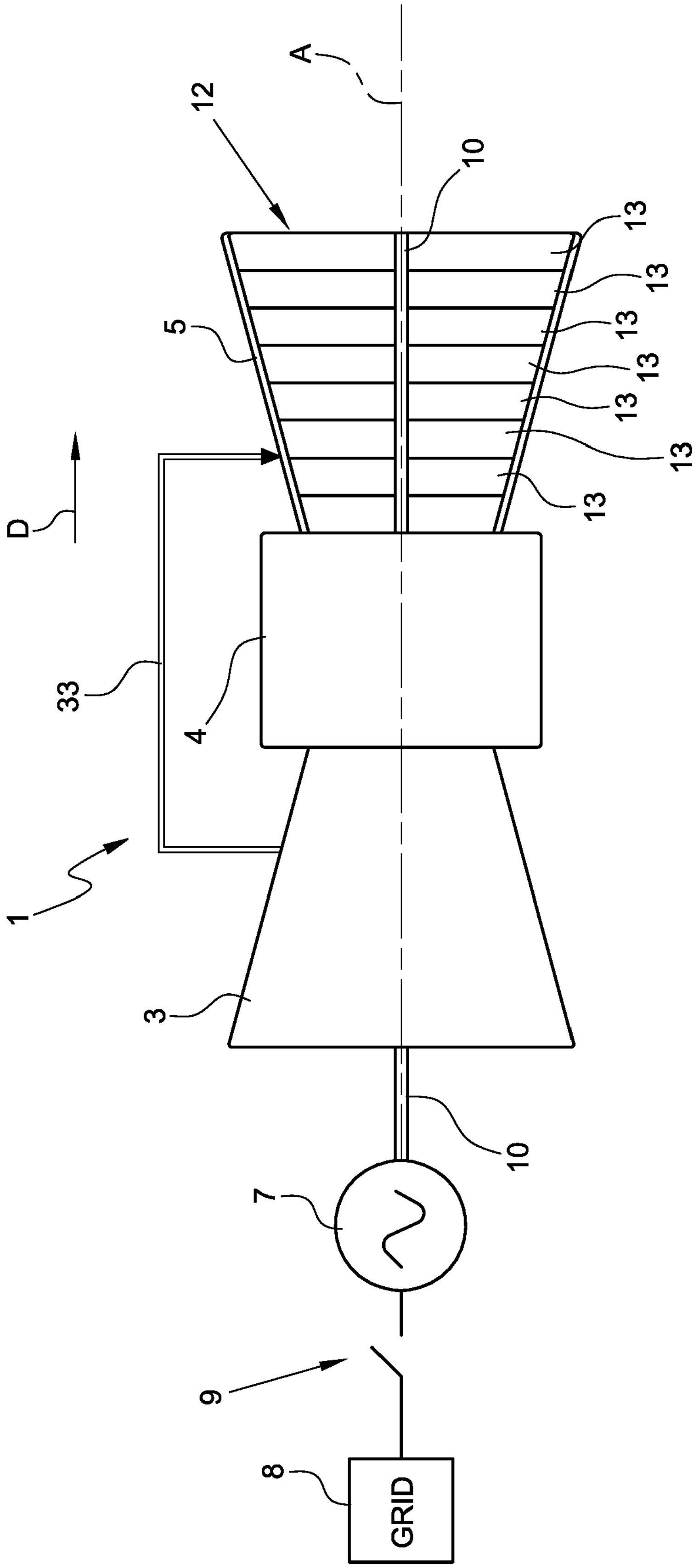
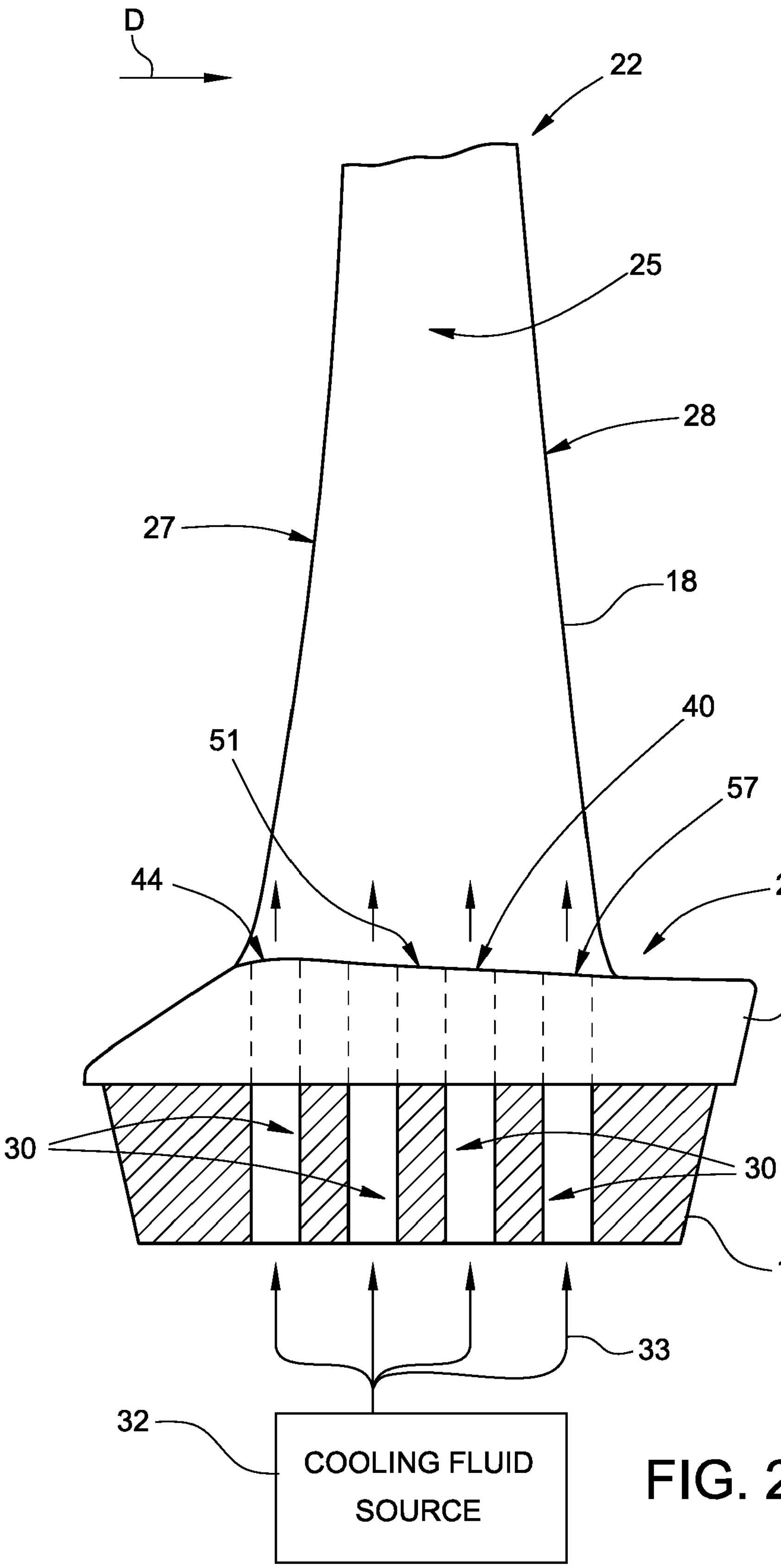



FIG. 1


D
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25
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51
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44
21
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33
32
COOLING FLUID SOURCE

FIG. 2

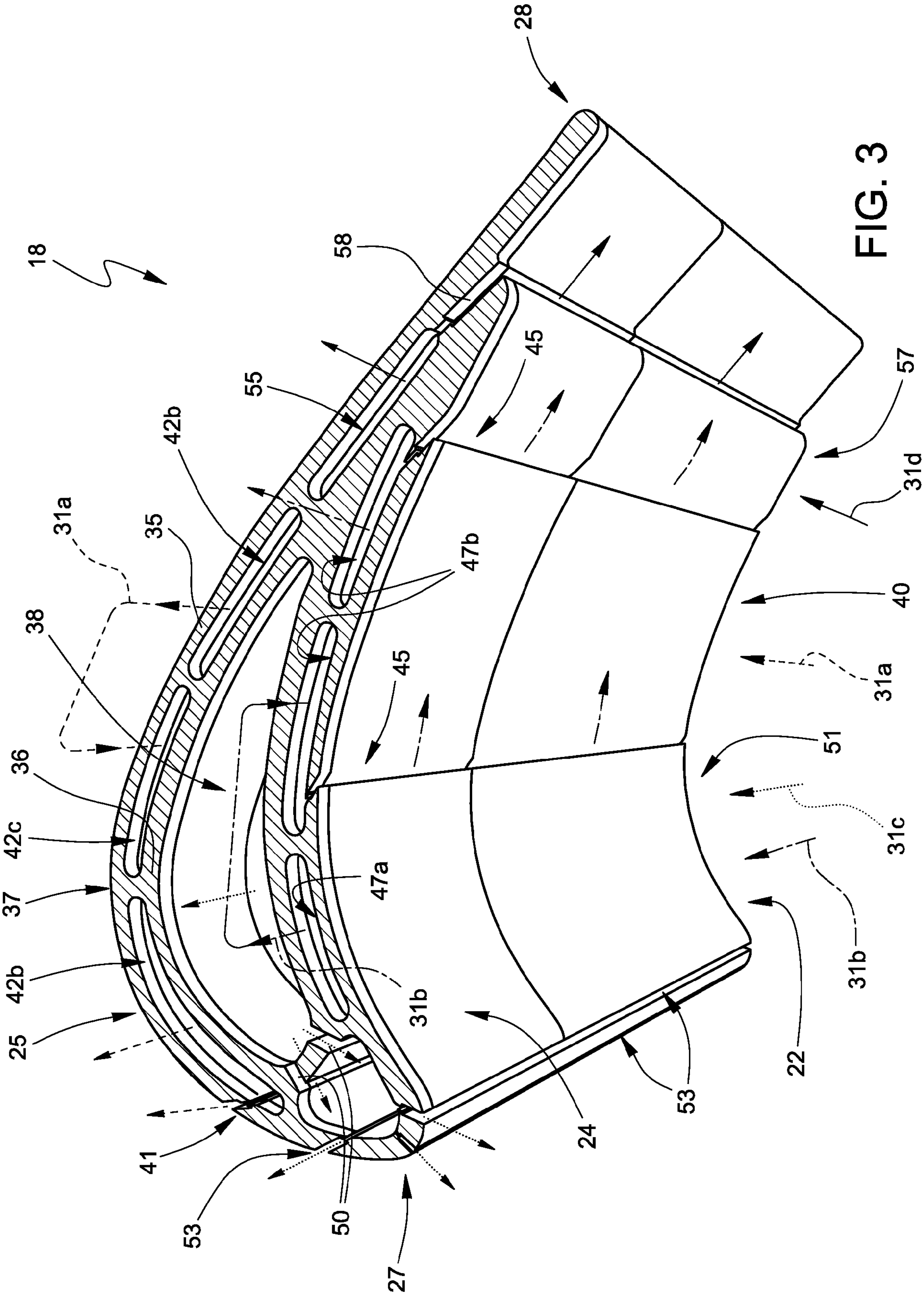
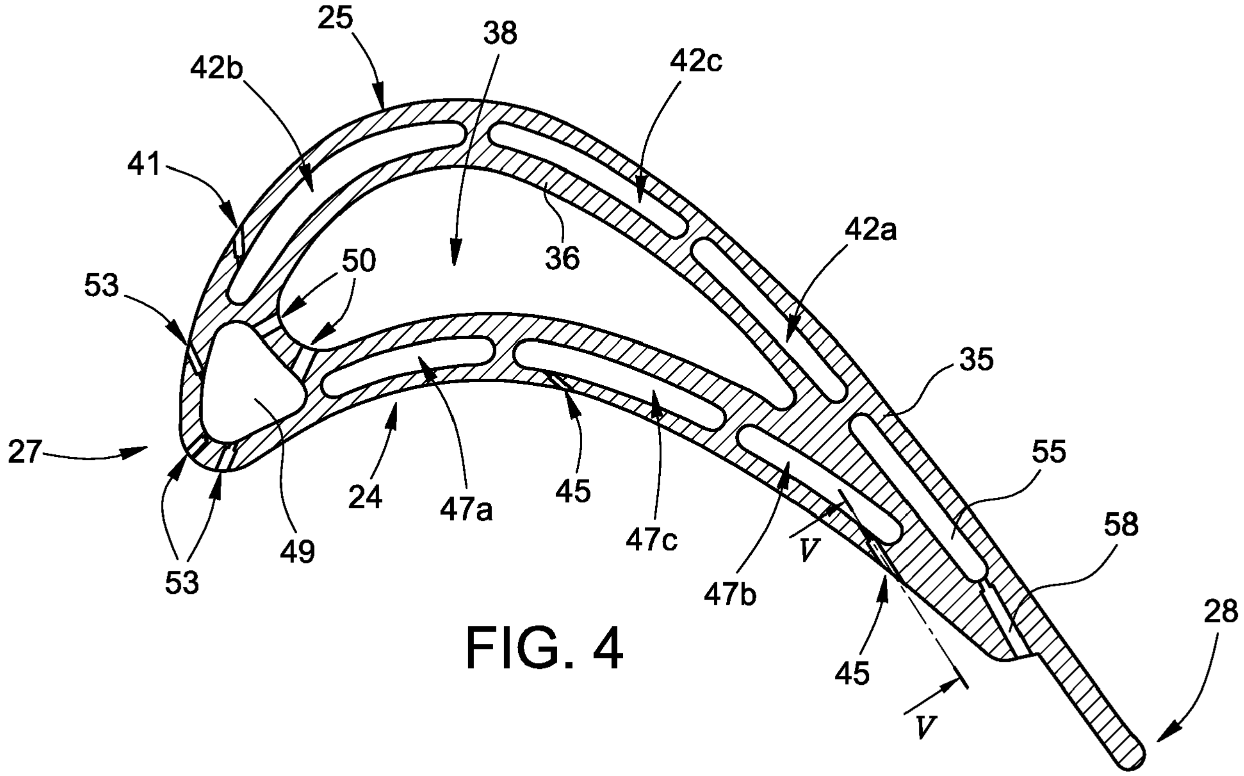

28
18
58
55
45
42b
35
31a
47b
38
36
42c
37
42b
25
41
53
50
27
24
53
22
31b
31c
51
31a
40
31d
57
47a


FIG. 3


25
38
42b
42c
41
42a
36
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35
55
27
24
47a
45
47c
58
V
53
49
47b
28
45
V

FIG. 4

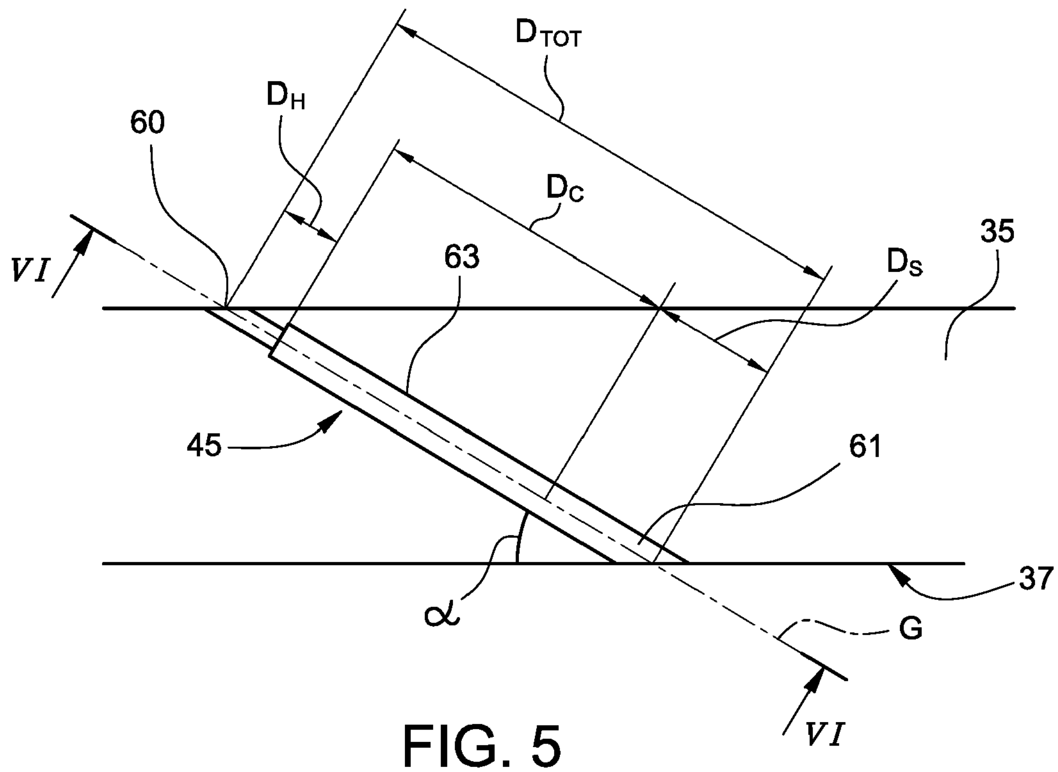
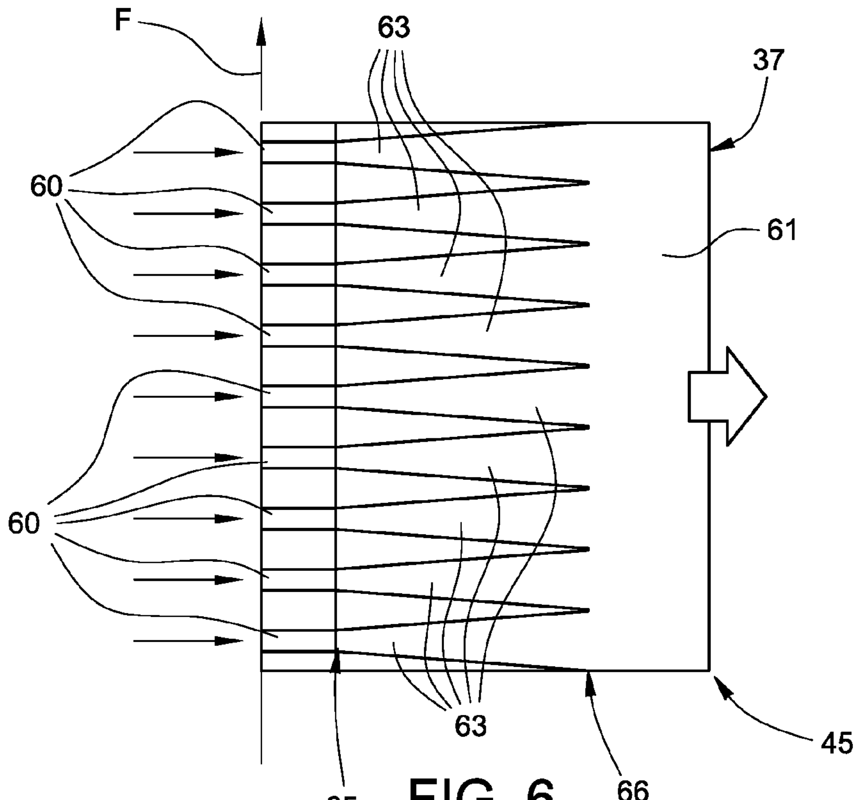

$D_{TOT}$
$D_H$
60
$D_C$
VI
63
35
$D_S$
45
61
$\alpha$
37
G
VI

FIG. 5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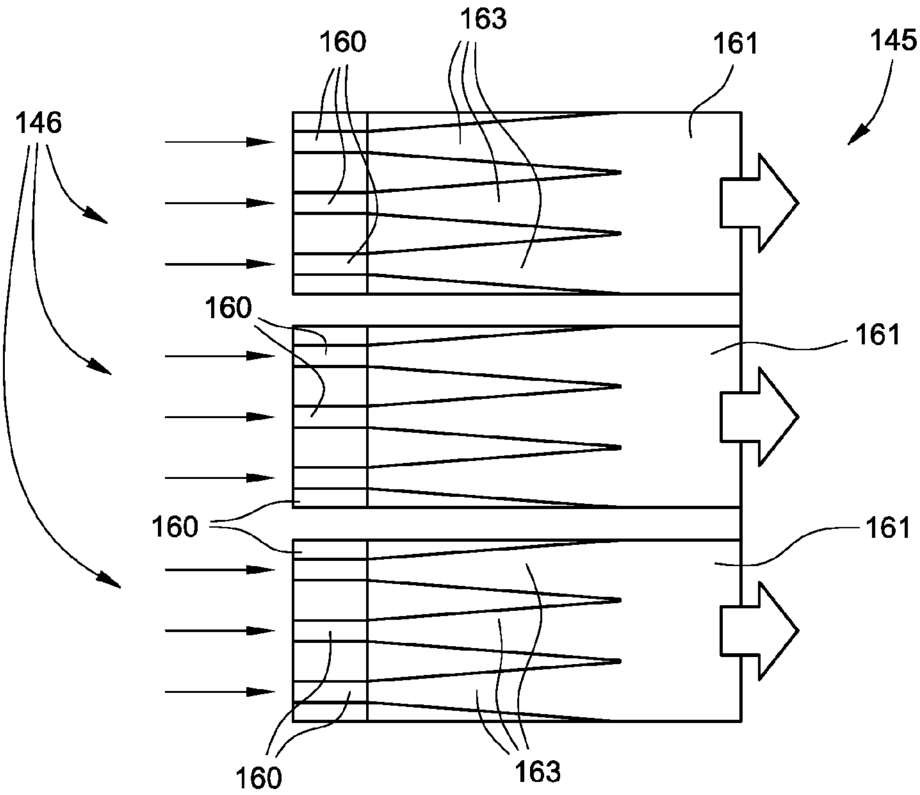
65
66

FIG. 6


163
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163

FIG. 7

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# EUROPEAN SEARCH REPORT

Application Number
EP 17 17 4863

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| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
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F01D

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 28 November 2017 | de la Loma, Andrés |

2

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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28-11-2017

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