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(54) **Method and device for assembling blades into a gas turbine disc by providing heat in order to creat a blade pre-twist**

(57) An assembly method for connecting a plurality of rotor blades (51) to a rotor disc (35) of a rotary turbomachine (10) comprises the steps of:
- providing heat to the pressure side (59) or to the suction side (57) of at least one blade of the plurality of blades for rotating at least a radial section (70) of the blade about a radial direction of the blade, the radial direction extending between a root and a tip of the blade, the radial section (70) being radially distanced from a the root portion (65) or from a tip portion (67) of the blade (51),
- sliding the root portion (65) of the blade (51) inside a respective coupling portion (75) of the rotor disc (35).

A thermal device (100) is also disclosed for providing heat to the rotor blades (51) to a rotor disc (35) of a rotary turbomachine (10), in order to promote the assembly of the rotor blades (51) into the rotor disc (35).

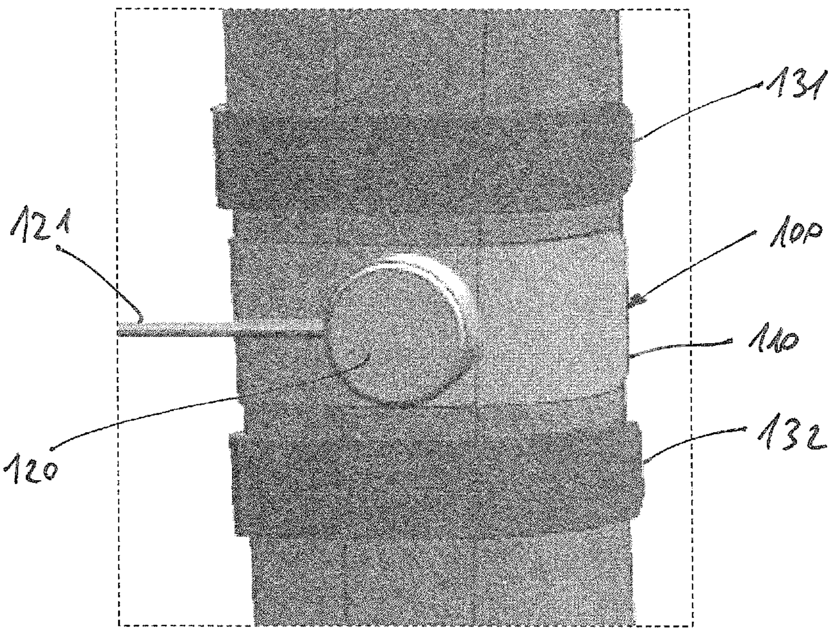


Fig. 7

EP 3 070 267 A1

Description

Field of invention

[0001] The present invention relates to a method for assembling a plurality of blades into a gas turbine disc. Particularly, albeit not exclusively, the method of the present invention can be conveniently used for assembling a plurality including respective shrouded tips. The present invention also relates to a thermal device for promoting the assembly of the plurality of blades.

Art Background

[0002] In the assembly process a set of adjacent blades, each blade extending radially between a fir tree root and a shrouded tip; it is known to start by inserting only by a small amount each of the fir tree roots into the respective fir tree root cavities in the turbine disc. In a subsequent step, the plurality of blades are advanced down the fir tree root by repeated small blows to the blades carried out consecutively to one blade after the other, in a circumferential order. This means that, after the initial step in which all the blades of the set have been partially inserted into the respective fir tree root cavity, a first blade is given a first blow for pushing it along the respective fir tree root cavity, by a further small amount. After the first blow is given to the first blade, also a second blade, adjacent to the first blade is given a first blow for pushing it along the respective fir tree root cavity, by a further small amount. After the second blade, a first blow is then given to a third blade, adjacent to the second blade and so on, up to the last blade of the blade set. The same procedure is then repeated for giving a second blow to all the blades of the set, from the first to the last. After a convenient number of blows, the fir tree roots of all the blades will be completely inserted in the respective fir tree root cavities, i.e. the insertion of the blades will be completed.

[0003] The blows may be, for example, given by means of a hammer operated by an operator.

[0004] This method is suitable for blades with no or limited pre-twist. Depending on the degree of pre-twist there is an attendant risk that, due to the interference between adjacent shrouded tips, the blades are subject to unpredicted forces along the circumferential direction of the turbine disc, i.e. orthogonally to the blades. This may cause the fir tree root surfaces on either the blades or on the rotor disc to be scuffed or damaged, beyond desirable or acceptable limits.

Summary of the Invention

[0005] It is an object of the present invention to provide a method for assembling blades into the disc of a gas turbine, which improves the existing assembly methods of the same type, preventing the fir tree root surfaces from being damaged, in particular when a shrouded blading has to be assembled.

[0006] It is a further object of the present invention to provide a thermal device for manipulating the shape of the blades in order that the assembly into the rotor disc can be performed without damaging the blades or the disc.

[0007] In order to achieve the objects defined above, a method and a device to the independent claim are provided. The dependent claims describe advantageous developments and modifications of the invention.

[0008] According to a first aspect of the present invention, an assembly method for connecting a plurality of rotor blades to a rotor disc of a rotary turbomachine, the method comprising the steps of:

- providing heat to the pressure side or to the suction side of at least one blade of the plurality of blades for rotating at least a radial section of the blade about a radial direction of the blade, the radial direction extending between a root and a tip of the blade, the radial section being radially distanced from a the root portion or from a tip portion of the blade,
- sliding the root portion of the blade inside a respective coupling portion of the rotor disc.

[0009] The method of the present invention is usable for temporarily angularly deforming the blades about a radial direction. This can be used to compensate the negative effects that the blade pre-twist may have during the insertion of the blades into the rotor disc, in particular for blades having a shrouded tip.

[0010] According to a possible embodiment of the present invention, heat is provided to the blade in a span wise direction. Advantageously, this causes the surface to grow in length in a span wise direction causing a rotation about the radial direction and avoiding any leaning of the blade..

[0011] According to another possible embodiment of the present invention, the heat is provided by means of a heat source connected to the radial portion of the blade and one heat sink is provided between the heat source and the tip or the root of the blade.

[0012] According to a further possible embodiment of the present invention, two heat sinks are provided in two respective radial positions of the blade, respectively between the heat source and the tip of the blade and between the heat source and the root of the blade.

[0013] Advantageously, the heat flux from the heating source may be radially contained by the fitting of heat sinks adjacent to the heating device.

[0014] According to another possible embodiment of the present invention, the method comprises the step of sliding the root portions of a plurality of circumferentially adjacent blades inside the respective coupling portions of the rotor disc through a plurality of respective coupling forces applied in series from a first blade to a last blade of the plurality of adjacent blades, the step of sliding being performed after the step of heating. Advantageously, the plurality of thermally deformed blades can then be fitted in parallel, i.e. circumferentially advanced down the fir tree root until the desired axial position is achieved, safely extending to pre-twist blades a procedure which is already known from the prior art for blades having no pre-twist or limited pre-twist. The thermal equipment may be removed after assembly of the blades is completed and temperature be allowed to normalise restoring pre-twist of the aerofoil.

[0015] According to a further possible embodiment of the present invention, the root portions of the blades and the coupling portions of the rotor disc are of the fir tree type. The present invention allows the use of a strong coupling between the blades and the rotor disc, preventing any surface damaging during assembly.

[0016] According to a further aspect of the invention it is provided an heating device for providing heat to the pressure side or of the suction side of a blade of a rotary turbomachine, the heating device comprising an heat source and a connection for connecting the heat source to a radial section of the blade, the heat source and the connection being configured in such a way that when heat is provided from the heat source to the blade the radial section rotate about a radial direction extending between a root and a tip of the blade.

[0017] The thermal device according to the present invention can be effectively used for providing heat to the thermal blades, thus temporarily angularly deforming them about a radial direction. The thermal device can be used to compensate the negative effects that the blade pre-twist may have during the insertion of the blades into the rotor disc, in particular for blades having a shrouded tip.

[0018] According to a possible embodiment of the present invention, the connection includes a conductive band which is subject to contact the pressure side or of the suction side of a blade along a direction orthogonal to the radial direction. Advantageously, this permits to concentrate the thermal deformation in an optimal position, with reference to the desired results of minimising interferences between the blade tips. The applied positioning of the heat source along the blade can be determined analytically via Finite Element Analysis or experimentally in a test rig.

[0019] According to another possible embodiment of the present invention, the connection includes a clamp which is subject to be clamped around the leading or trailing edge of the blade for keeping the heating device connected to the radial section of the blade. Advantageously, the clamping of the source permits to advantageously maintain the heat source in contact with the blade in the desired position, during the heating phase.

[0020] According to a possible embodiment of the present invention, the heat source is of an electrical heat source. Advantageously, the use of a thermal device negates the need to use a mechanical or hydraulic system with attendant complexity. In addition, the parts are not subject to externally applied strain energy and the attendant risk of accidental liberation. The amount of heat input can be determined analytically via Finite Element Analysis or experimentally in a test rig.

[0021] In general, the thermal device according to the present invention permits to reach the same advantages described above with reference to the assembly method.

[0022] It has to be noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to apparatus type claims whereas other embodiments have been described with reference to method type claims. However, a person skilled in the art will gather from the above and the following description that, unless other notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters, in particular between features of the apparatus type claims and features of the method type claims is considered as to be disclosed with this document.

<u>Brief Description of the Drawings</u>

[0023] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of the embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 is a longitudinal sectional view of a gas turbine engine including a rotor disc and a plurality of rotor blades, the blades being attachable to the rotor disc by means of the assembly method and the heating device of the present invention,

Fig. 2 shows a perspective view of a rotor disc and of a plurality of rotor blades attached to the rotor disc,

Fig. 3 shows a top view of the rotor disc and of the plurality of rotor blades of Figure 2,

Fig. 4 shows a view of the pressure surface of a rotor blade attached to a rotor disc and including a heating according to the present invention,

Fig. 5 shows a view of the suction surface of a rotor blade attached to a rotor disc and including a heating device according to the present invention,

Fig. 6 shows a perspective view of a rotor disc and of a plurality of rotor blades, from the suction surface side, attached to the rotor disc, each blade including a respective heating device according to the present invention,

Fig. 7 shows a magnified view of the detail VII of

Figure 5,

Fig. 8 shows a circumferential section, i.e. orthogonal to a radial direction of the rotor disc, of a rotor blade including a heating device according to the present invention.

Detailed Description

[0024] **FIG. 1** shows is a schematic illustration of a general arrangement of a turbine engine 10 having an inlet 12, a compressor 14, a combustor system 16, a turbine system 18, an exhaust duct 20 and a shaft arrangement 22. The turbine engine 10 is generally arranged about a rotational axis X which for rotating components is their rotational axis. The combustion system 16 comprises an annular array of combustor units 37, only one of which is shown. In one example, there are six combustor units evenly spaced about the engine. The turbine system 18 includes a high-pressure turbine 28 drivingly connected to the compressor 14 by a first shaft 22. In the embodiment of FIG. 1 the shaft arrangement 22, 24 is a twin-shaft arrangement including a first shaft 22 and a second shaft 24. The turbine system 18 also includes a low-pressure turbine 30 drivingly connected to a load (not shown) via the second shaft 24. According to other embodiments of the present invention, the turbine engine 10 may have a single-shaft arrangement.

[0025] The compressor 14 comprises an axial series of stator vanes and rotor blades mounted in a conventional manner. The stator or compressor vanes may be fixed or have variable geometry to improve the airflow onto the downstream rotor or compressor blades. Each turbine 28, 30 comprises an axial series of stator vanes 33 and rotor blades 51 mounted via rotor discs 35 arranged and operating in a conventional manner. A rotor assembly 36 comprises an annular array of rotor blades 51 and the rotor disc 35.

[0026] The terms radial, circumferential and axial are with respect to the rotational axis X. Therefore, any radial direction is orthogonal to the rotational axis X, i.e. parallel to the rotor blades 51. The circumferential direction is a curved circular direction, parallel to the rotation of the turbine engine 10 about the rotational axis X. The terms upstream and downstream are with respect to the general direction of gas flow through the engine and as seen in FIG.1 is generally from left to right.

[0027] In operation air 32 is drawn into the engine 10 through the inlet 12 and into the compressor 14 where the successive stages of vanes and blades compress the air before delivering the compressed air into the combustion system 16. In a combustion chamber 37 of the combustion system 16 the mixture of compressed air and fuel is ignited. The resultant hot working gas flow is directed into, expands and drives the high-pressure turbine 28 which in turn drives the compressor 14 via the first shaft 22. After passing through the high-pressure turbine 28, the hot working gas flow is directed into the low-pressure turbine 30 which drives the load via the second shaft 24.

[0028] The low-pressure turbine 30 can also be referred to as a power turbine and the second shaft 24 can also be referred to as a power turbine shaft. The load is typically an electrical machine for generating electricity or a mechanical machine such as a pump or a process compressor. Other known loads may be driven via the low-pressure turbine. The fuel may be in gaseous and/or liquid form.

[0029] The turbine engine 10 shown and described with reference to FIG.1 is just one example of a number of engines or turbomachinery in which this invention can be incorporated. Such engines can be gas turbines or steam turbine and include single, double and triple shaft engines applied in marine, industrial and aerospace sectors.

[0030] **FIGS. 2** to **8** show in more detail the rotor disc 35 and a plurality of rotor blades 51 (six rotor blades 51a-51f) mounted on the rotor disc 35.

[0031] Each blade 51 comprises a blade aerofoil body 52, a leading edge 53 at which the flowing combustion gases arrive at the rotor blades 51 and a trailing edge 55 at which the combustion gases leave the rotor blades 51. The exterior surface of the rotor blades 51 is formed by a convex suction side 57 and a less convex, and typically concave, pressure side 59 which is formed opposite to the suction side 57. Both the suction side 57 and the pressure side 59 extend from the leading edge 53 towards the trailing edge 55.

[0032] According to possible embodiment of the present invention, the blade aerofoil body 52 may be hollow and comprise a plurality of internal passages to allow a cooling fluid, typically bleed air from the discharge of the compressor section 12, to flow therethrough in order to cool the blade aerofoil body 52. According to possible embodiment of the present invention, the blade aerofoil body 52 may be solid, without any internal passages to allow the flowing of a cooling fluid.

[0033] With respect to rotational axis X, both the leading and trailing edges 53, 55 span radially from a platform 66 to a tip 67 of the rotor blade 51. Attached to the platform 66, on opposite side with respect to the blade aerofoil body 52, the rotor blade 51 comprises a root 65, for connecting the rotor blade 51 to a coupling portion of the rotor disc 35. The root 65 of each blade 51 is of the fir tree type for being fixed to a respective fir tree cavity 75 of the rotor disc 35.

[0034] Each blade 51 has an inherent geometrical angular arrangement between the root 65 to the tip 67 that necessitates an angular (with respect to the radial direction) pre-twist during the manufacturing of each blade. In the embodiment of the attached figures (in particular section figure 8) the pre-twist of each blade 51a-51f is a clockwise twist when looking the rotor blade from the tip 67 towards the platform 66.

[0035] In the embodiment of the attached FIGS. 2 to 8 the tip 67 of the rotor blades 51 is a shrouded tip. According to other possible embodiment of the present invention, the tip 67 of the rotor blades 51 is an open tip. The present invention, however, particular adapts to rotor blades 51 with shrouded tips 67, as better explained in the following.

[0036] Each shrouded tip 67 is provided with respective interlock suction and pressure surfaces 68, 69, respectively on the suction and the pressure sides of each blade 51. When the blades are assembled to the rotor disc 35, the suction interlock surface 68 of each shrouded tip 67 is in contact with a pressure interlock surface 69 of the shrouded tip 67 of another adjacent rotor blade 51 and the pressure interlock surface 69 of each shrouded tip 67 is in contact with a suction interlock surface 68 of the shrouded tip 67 of a third adjacent rotor blade 51. For example, for the embodiment of the attached figures, in FIG. 3 it is shown that the pressure interlock surface 69 of a first blade 51a is in contact with the suction interlock surface 68 of a second blade 51b and that the pressure interlock surface 69 of the second rotor blade 51b is in contact with the suction interlock surface 68 of a third blade 51c and so on, up to a fifth blade 51e.

[0037] The pre-twist of the rotor blades 51 and the interference between adjacent interlock suction and pressure surfaces 68, 69 and make it impossible to assemble the rotor blades 51 into the rotor disc 35, one after the other, by simply sliding each fir tree root 65 into the respective fir tree cavity 75 up to a final coupling position.

[0038] The pre-twist of the rotor blades 51 and the interference between adjacent interlock suction and pressure surfaces 68, 69 and make it impossible to assemble a set of rotor blades 51a-51e into the rotor disc 35 in parallel, i.e. disposing them adjacently to one another (like in FIG. 3), inserting only by a small amount each of the fir tree roots 65 into the respective fir tree root cavities 75 in the turbine rotor disc 35 and make them advanced down the fir tree root cavities 75 by repeated sets of small blows 76a-76e, performed by an operator along a direction parallel to the fir tree root cavities 75. For each set of blows 76a-76e, the blows are respectively carried out to the set of blades 51a-51e consecutively one blade after the other, in a circumferential order from the first rotor blade 51a to the last rotor blade 51e. This assembly method is not however enough to prevent that the blades are subject to unpredicted forces along the circumferential. This may cause the fir tree root surfaces on either the blade root 65 or on the root cavity 75 disc to be scuffed or 'picked-up', beyond desirable or acceptable limits.

[0039] The assembly method of the present invention provide additional steps to the method above described and a thermal device from preventing the damages in the contact surfaces along any of the fir tree root couplings.

[0040] According to the present invention and with reference to **FIGS. 4** to **8,** a heating device 100 is provided for transferring heat to the pressure side 59 or of the suction side 57 of the rotor blade 51. According to the embodiment of the attached figures 4 to 8, the heating device 100 is provided for transferring heat to the suction side 57 of the blade 51. According to other embodiments of the present invention (not shown), the heating device 100 is provided for transferring heat to the pressure side 59 of the blade 51.

[0041] The heating device 100 comprises an electrical heat source 120 and a connection 110 for connecting the heat source to a radial section 70 of the rotor blade 51. The electrical heat source 120 comprises a wiring 121 for connection with an external electric source and an impedance (not shown) for transforming current from the wiring 121 into heat. The radial section 70 have a height H, measured along the trailing edge 55, and is positioned at a distance D1, measured along the trailing edge 55, from the platform 66 and at a distance D2, measured along the trailing edge 55, from the shrouded tip 67.

[0042] According to other possible embodiments of the present invention (not shown), a cooling device may be used instead of a heating device. In such embodiments, the heating device comprises a cooling source for transferring heat from the suction side 57 or the pressure side 59 of the blade 51 towards the cooling source.

[0043] The connection 110 comprises a first conductive metallic band 112, having the same height H of the radial section 70 and which in operation is subject to contact the radial section 70 on the suction side 57, along a direction orthogonal to the radial direction. In operation, when the heating device 100 is connected to the blade 51, the first conductive metallic band 112 extends from one to the other of the leading and trailing edges 53, 55. The connection 110 comprises a second conductive metallic band 114, which in operation is subject to contact a portion of the radial section 70 on the pressure side 59, along a direction orthogonal to the radial direction. The second conductive metallic band 114 extends chord wise from the trailing edge 55 towards the leading edge 53, but it is considerably shorter than the first conductive metallic band 112, in such a way that most of the heat from the electrical heat source 120 is transferred asymmetrically, mainly on the suction side 57. The first conductive metallic band 112 and the second conductive metallic band 114 are connected together by a metallic curve 116, which in operation surrounds the portion of the trailing edge 55 at the radial section 70 of the rotor blade which is connected to the heating device 100. The second conductive metallic band 114 and metallic curve 116 together constitutes a clamp for the connection 120, which allows the connection 120 to be clamped around the trailing edge 55 of the rotor blade 51 for keeping the heating device 100 connected to the radial section 70 of the rotor blade 51.

[0044] According to other embodiments of the present invention (not shown), the first conductive metallic band 112 is applied to the pressure side 59 from one to the other of the leading and trailing edges 53, 55 while the second conductive metallic band 114 is applied only along a portion of suction side 57, in such a way that most of the heat from the electrical heat source 120 is transferred mainly on the pressure side 59.

[0045] In any case, the asymmetrical heat input creates a local lengthening of the aerofoil surface leading to a twist rotation about the radial direction of the radial section 70 and consequently of the upper portion (between the radial section 70 and the shroud tip 67) of the blade 51 with respect to the lower portion (between the radial section 70 and the platform 66).

[0046] According to the embodiment of the present invention (FIG. 8), the heating device 100 generates a heat flux which is intended to be limited to a span wise along the suction side 57 and which is schematically represented by the span wise arrows F1, F2, oriented from the electrical heat source 120 towards the leading edge 53 and the trailing 55, respectively. This causes a rotation of the radial section 70 around an anticlockwise rotating direction, when looking the rotor blade 51 from the tip 67 towards the platform 66, i.e. a rotation towards a direction opposite to the pre-twist of the blade 51. With reference to FIG. 8 the radial section 70 rotates up to the final position 71, shown in dashed line.

[0047] According to another embodiment of the present invention (not shown), the heating device 100 may be connected to the pressure side 59 of the blade 51, thus generating a heat flux which is intended to be limited to a span wise along the pressure side 59 and which may cause a clockwise rotation of the radial section 70.

[0048] In all cases, the span wise direction of the heat flux avoids a leaning of the aerofoil in the circumferential sense.

[0049] The heating device 100 further comprises a first heat sink 131 to be connected to the rotor 51 blade between the heat source 120 and the shrouded tip 67 and a second heat sink 132 to be connected to the rotor 51 blade between the heat source 120 and the platform 66. The first and second heat sinks 131, 132 are oriented orthogonally to the radial direction, i.e. parallel to the first and second conductive metallic band 112, 114. The first and second heat sinks 131, 132 are made of thermally conductive material, for example copper or aluminium, having a conductivity which permits to contain the heat flux in radial direction, in order that thermal deformation is only caused on the selected radial section 70 and close to it, where the heating device 100 is installed, i.e. between the first and second heat sinks 131, 132.

[0050] The assembly method according to the present invention comprises in series the following steps (FIG. 6):

- a plurality of heating devices 100 are respectively connected to a plurality of respective rotor blades 51a-51e;
- heat is provided through the heating device 100 to the suction side 57 of the plurality of rotor blades 51a-51e for rotating the respective radial sections 70 about the radial direction. The rotation of the aerofoil body 52 effectively allows for unimpeded insertion of the fir tree roots 65 into the respective fir tree root cavities 75 of the turbine rotor disc 35;
- the rotor blades 51a-51e are inserted in parallel into the rotor disc 35, according to the following sub steps:
    - disposing the rotor blades 51a-51e circumferentially adjacently to one another;
    - inserting only by a small amount each of the fir tree roots 65 into the respective fir tree root cavities 75 in the turbine rotor disc 35,
    - make the rotor blades 51a-51e advance down the fir tree root cavities 75 by repeated sets of small blows 76a-76e or, as an alternative, they may be advanced as a set by mechanical or hydraulic means, performed by an operator along a direction parallel to the fir tree root cavities 75. For each set of blows 76a-76e, the blows are respectively carried out to the set of blades 51a-51e consecutively one blade after the other, in a circumferential order from the first rotor blade 51a to the last rotor blade 51e;
- after the rotor blades 51a-51e have reached the respective final positions in the fir tree root cavities 75, heating devices 100 are removed and temperature in the blades 51a-51e is allowed to normalise restoring pre-twist of the aerofoil.

[0051] Removal of the blade set 51a-51e may achieved by the reversing of the third step of the process above described, i.e., pushing the rotor blades 51a-51e in parallel out from the respective fir tree root cavities 75 after heat has been provided through the heating devices 100.

[0052] The amount of heat input to be provided through the heating device 100 and the applied position (distances D1, D2 from platform 66 and shrouded tip 67) can be determined analytically via Finite Element Analysis or experimentally in a test rig.

[0053] The solution of the present invention gives an effective and safe method of blade insertion into a turbine disc, minimizing assembly time and risk of damage to fir tree root and interlock surfaces.

Claims

1. An assembly method for connecting a plurality of rotor blades (51) to a rotor disc (35) of a rotary turbomachine (10), the method comprising the steps of:

    - providing heat to the pressure side (59) or to the suction side (57) of at least one blade of the plurality of blades for rotating at least a radial section (70) of the blade about a radial direction of the blade, the radial direction extending between a root and a tip of the blade, the radial

section (70) being radially distanced from a the root portion (65) or from a tip portion (67) of the blade (51),
- sliding the root portion (65) of the blade (51) inside a respective coupling portion (75) of the rotor disc (35).

2. The assembly method of claim 1, wherein heat is provided to the blade (51) in a span wise direction.

3. The assembly method of claim 1 or 2, wherein the heat is provided by means of a heat source (120) connected to the radial portion (70) of the blade (51) and one heat sink (131, 132) is provided between the heat source (120) and the tip (67) or the root (65) of the blade (51).

4. The assembly method of claim 3, wherein two heat sinks (131, 132) are provided in two respective radial positions of the blade, respectively between the heat source (120) and the tip (67) of the blade (51) and between the heat source (120) and the root (65) of the blade (51).

5. The assembly method of any of the preceding claim, wherein the method comprises the step of sliding the root portions (65) of a plurality of circumferentially adjacent blades (51a-51e) inside the respective coupling portions (75) of the rotor disc (65) through a plurality of respective coupling forces (76a-76e) applied in series from a first blade (51a) to a last blade (51e) of the plurality of adjacent blades (51a-51e), the step of sliding being performed after the step of heating.

6. The assembly method of claim 5, wherein the root portions (65) of the blades and the coupling portions of the rotor disc are of the fir tree type.

7. The assembly method of claim 5, wherein the step of heating is stopped after a plurality of circumferentially adjacent blades have reached a final positions inside the respective coupling portions (75) of the rotor disc (35).

8. An heating device (100) for providing heat to the pressure side (59) or of the suction side (57) of a blade (51) of a rotary turbomachine (10), the heating device comprising an heat source (120) and a connection (110) for connecting the heat source (120) to a radial section (70) of the blade (51), the heat source (120) and the connection (110) being configured in such a way that when heat is provided from the heat source (120) to the blade (51) the radial section (70) rotate about a radial direction extending between a root (65) and a tip (67) of the blade (51).

9. The heating device (100) of claim 8, wherein the connection (110) includes a conductive band (112, 114) which is subject to contact the pressure side (59) or of the suction side (57) of a blade (51) along a direction orthogonal to the radial direction.

10. The heating device of claim 8 or 9, wherein the connection (110) includes a clamp (114, 116) which is subject to be clamped about the leading (53) or trailing edge (55) of the blade (51) for keeping the heating device connected to the radial section (70) of the blade.

11. The heating device of claim 9 or 10, further comprising a heat sink (131, 132) to be connected to the blade (51) between the heat source (120) and one of the tip (67) or the root (65) of the blade (51).

12. The heating device of claim 11, wherein the heating device comprises a second heat sink (132), the two heat sinks (131, 132) being subject to be connected in two respective radial positions of the blade (51), respectively between the heat source (120) and the tip (67) of the blade and between the heat source and the root of the blade.

13. The heating device of any of the claims 8 to 12, wherein the heat source (120) is of an electrical heat source.

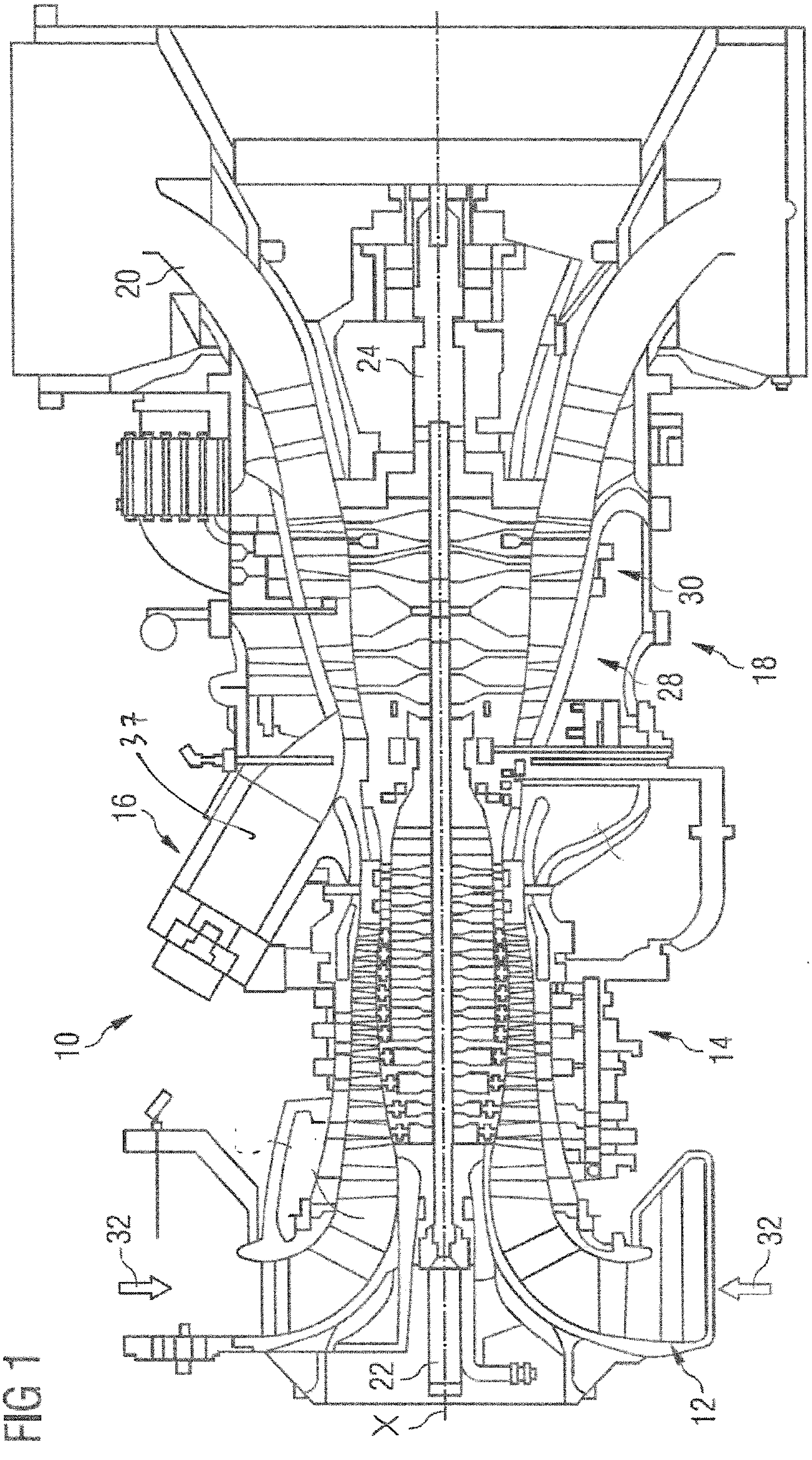
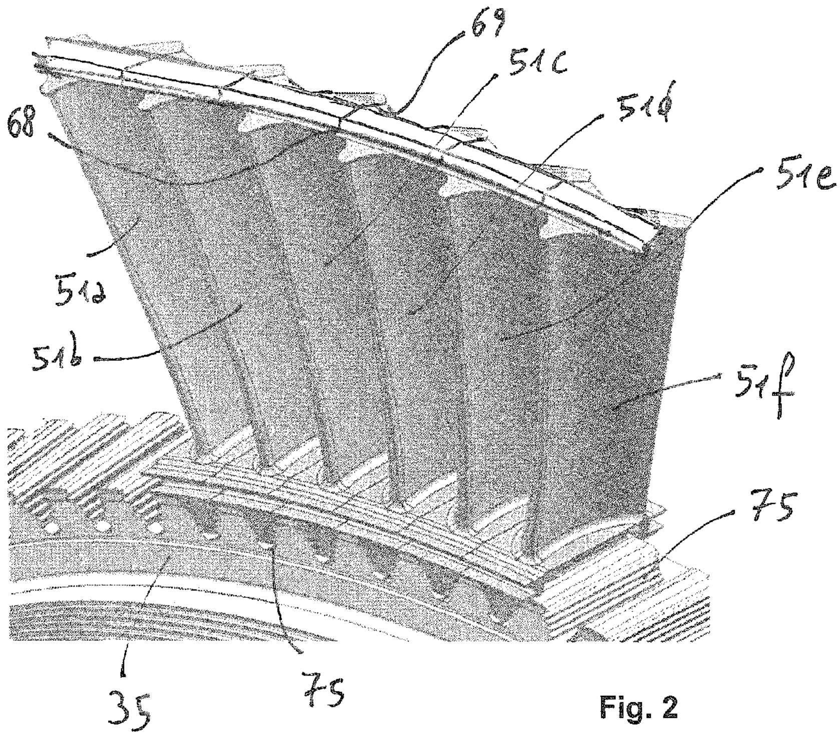


FIG 1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35
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Fig. 2

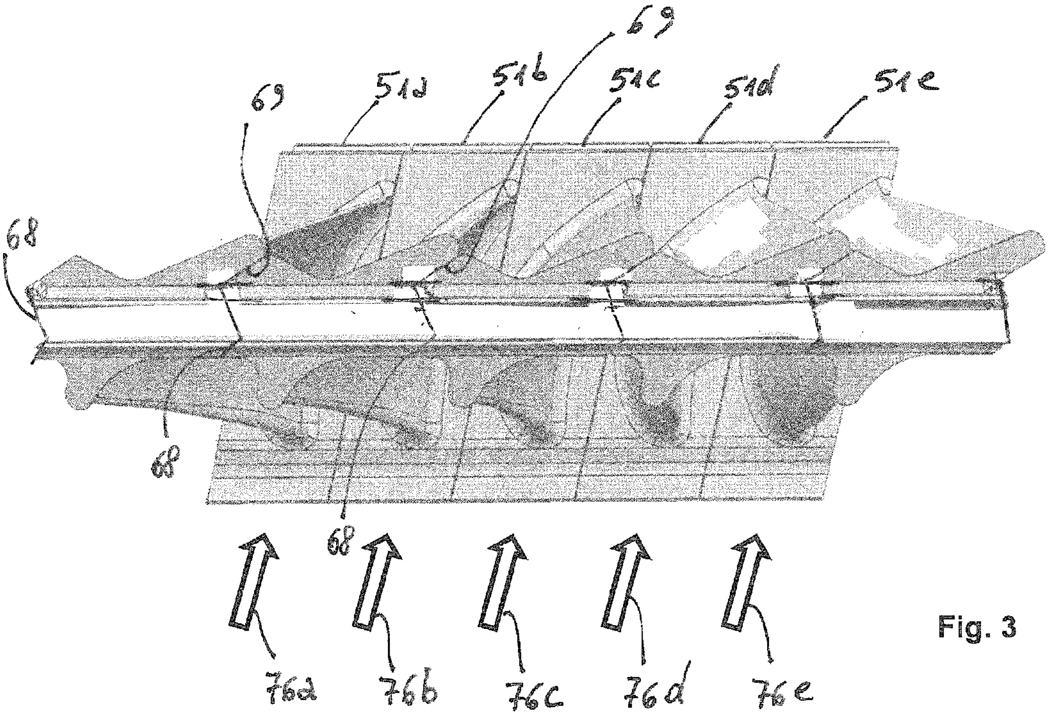
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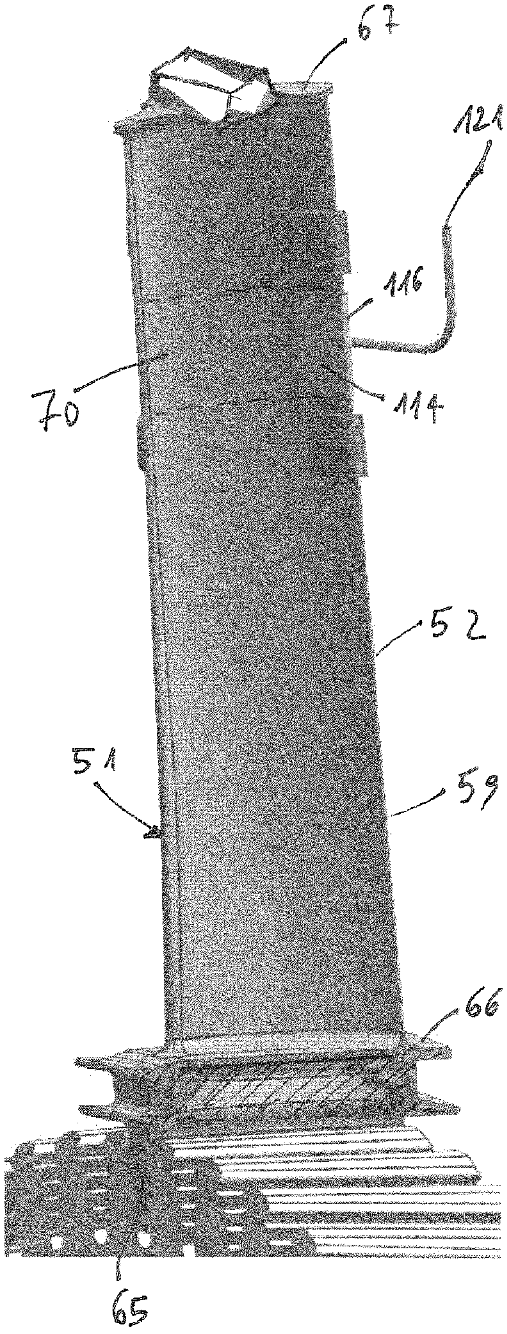
Fig. 3


67
121
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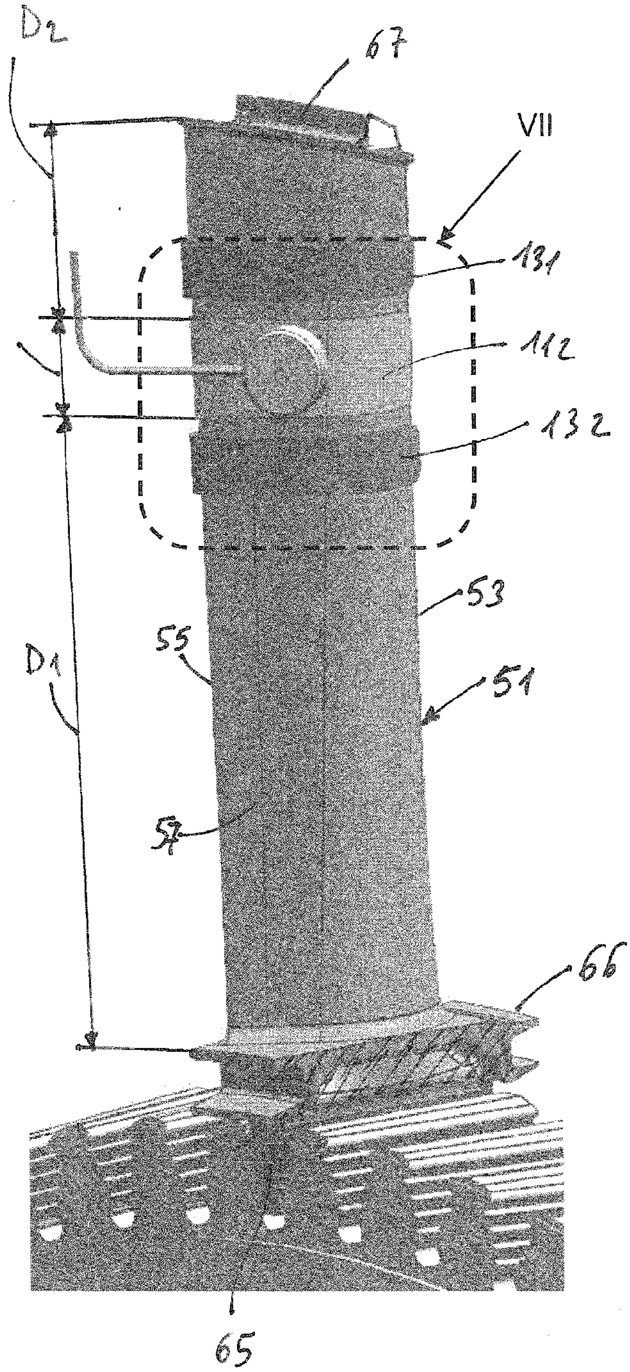
70
114
52
51
59
66
65

Fig. 4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131
H
112
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53
55
D1
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57
66
65

Fig. 5

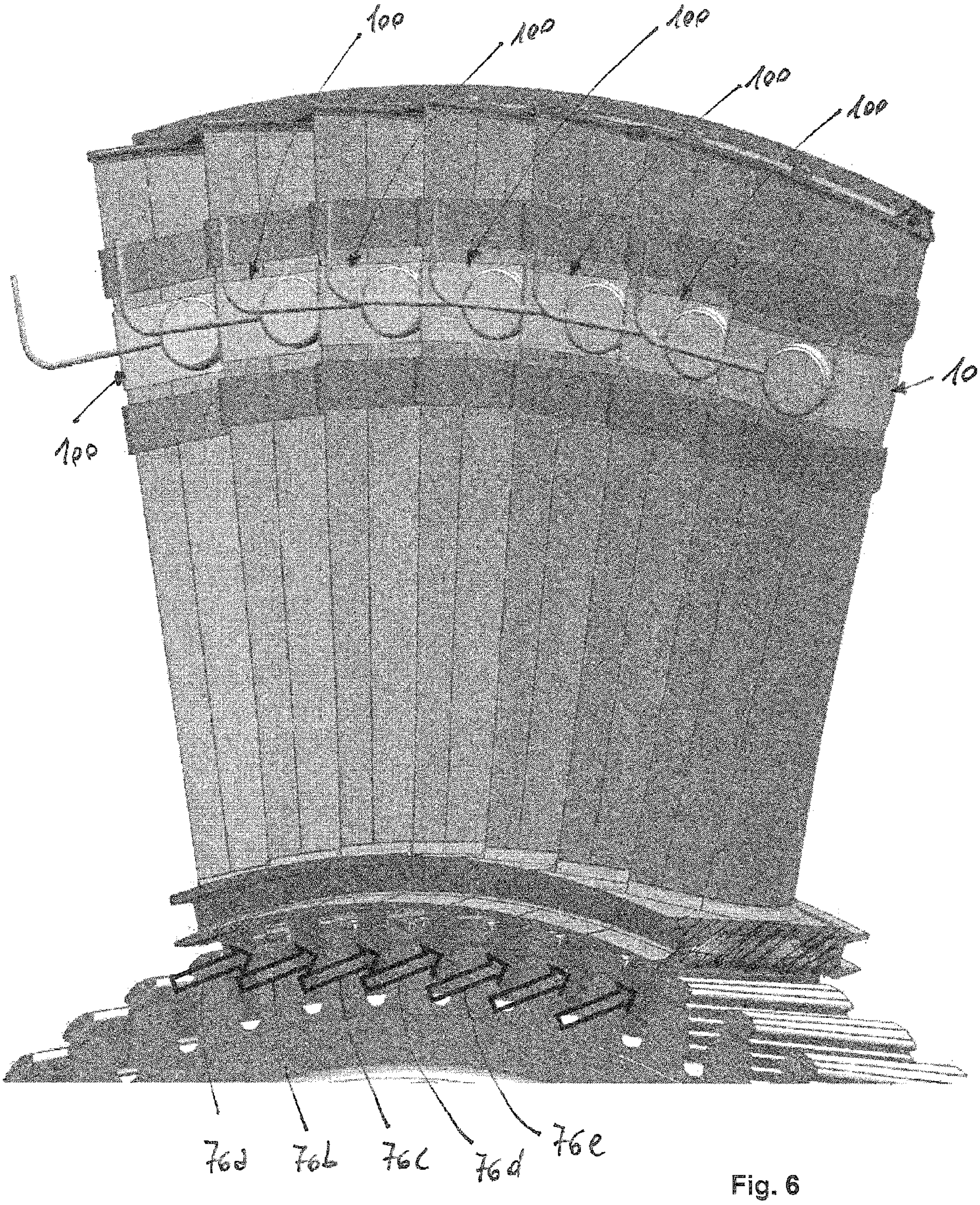

Fig. 6

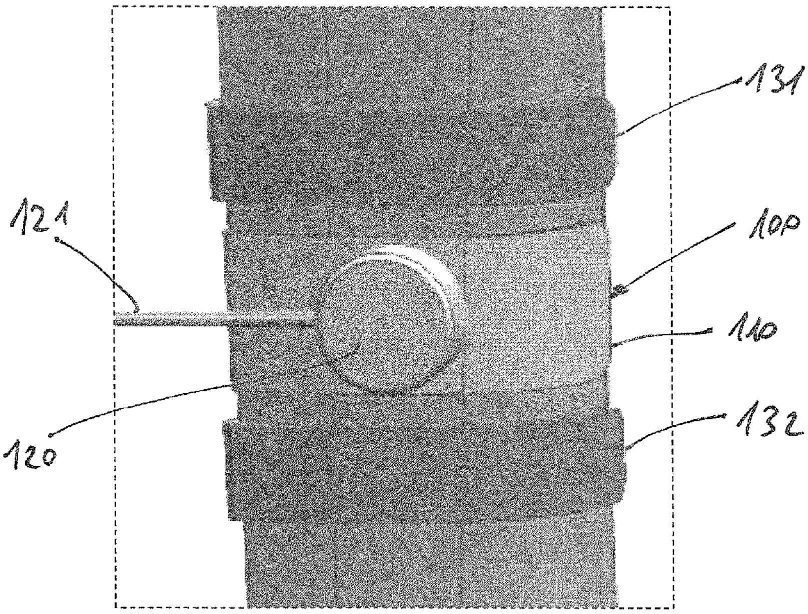

Fig. 7

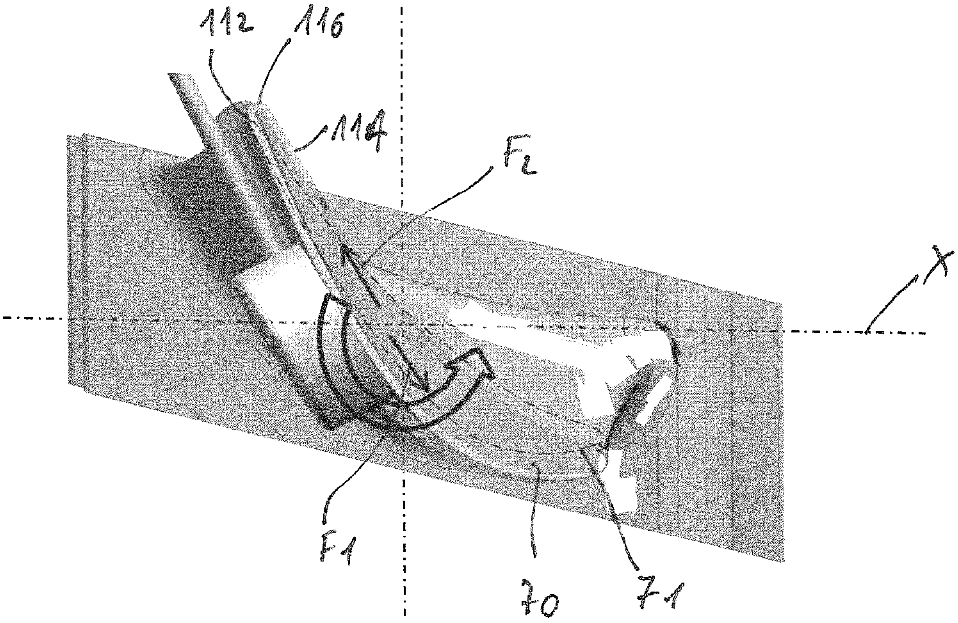

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 0161

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	11 September 2015	Klados, Iason

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