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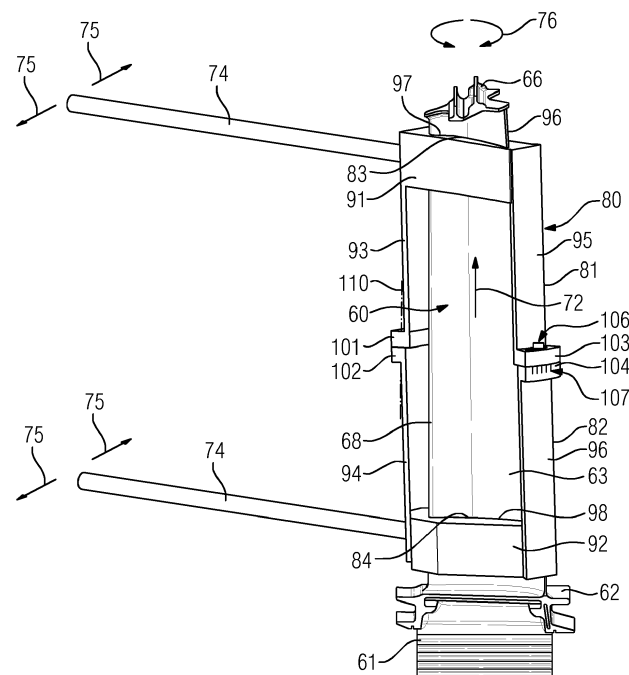
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(54) TURBINE BLADE TORSIONAL CLAMP

(57) A turbine blade torsional clamp (80) for inserting a turbine blade (60) into a turbine disc (70) is provided. The clamp (80) comprises a first element (81) and a second element (82). Each element (81, 82) comprises a main body (91, 92) with a cavity (97, 98) having a surface (83, 84) configured for resting against a surface of an aerofoil (63) of the turbine blade (60). Each element (81, 82) comprises a first frame arm (93, 94) and a second frame arm (95, 96), which protrude from the main body

(91, 92). The first frame arms (93, 94) are configured for connecting to each other by a means allowing the first element and the second element to be pivoted against each other. The second frame arms (95, 96) are configured for connecting to each other by a means (106) for adjusting a torsion angle between the first and the second element and for locking the clamp (80) in a twisted position.

FIG 5

Description

Field of the invention and state of the art

[0001] The present invention relates to a turbine blade torsional clamp, especially for a gas turbine, and to a method of manufacturing a turbine, especially a gas turbine.

[0002] The fitting of Shrouded Interlocked Turbine Blading that has an inherent geometrical angular arrangement between the blade fir tree root and shroud interlock face that necessitates an angular (with respect to the blade radial stacking axis) pre-twist. The present invention enables the collective fitment of an engine set of blading to a circumferential set of fir tree roots located on the periphery of a turbine disc.

[0003] Existing practice is to assemble an entire set of blades by inserting their fir tree roots into the turbine disc by a small amount. This collective set of blades can be advanced down the fir tree root by repeated, small blows to the blade carried out consecutively in a circumferential order. This method is suitable for blades with no or limited pre-twist and is confined to small gas turbines. Depending on the degree of pre-twist there is an attendant risk that the fir tree root surface on either blade of disc may be scuffed or 'picked-up' which may have an undesirable (re-worked) or unacceptable outcome due to being scrapped.

Description of the invention

[0004] It is an objective of the present invention to provide an advantageous turbine blade torsional clamp and an advantageous method of manufacturing gas turbine, which overcome the described difficulties of the existing solutions for inserting turbine blades into a turbine disc.

[0005] The objective is solved by a turbine blade torsional clamp as claimed in claim 1, a turbine blade torsional clamp set as claimed in claim 7 and a method for manufacturing a gas turbine as claimed in claim 8. The depending claims define further developments of the present invention.

[0006] The inventive turbine blade torsional clamp for inserting a turbine blade, preferably for inserting a number of turbine blades, into a turbine disc comprises a first element and a second element. Each element, namely the first element and the second element, comprises a main body with a cavity. The cavity has a surface, which is configured for resting against a surface of an aerofoil of the turbine blade. Moreover, each element comprises a first frame arm and a second frame arm. The frame arms protrude or stick out from the main body. The first frame arms, namely the first frame arm of the first element and the first frame arm of the second element, are configured for connecting to each other by a means allowing the first element and the second element to be pivotable or twistable against each other. The second frame arms, namely the second frame arm of the

first element and the second frame arm of the second element, are configured for connecting to each other by a means for adjusting a torsion angle between the first and the second element and for locking the clamp in a twisted or distorted position.

[0007] This solution gives a device to pre-twist or untwist a blade prior to insertion into a turbine disc and provides an effective and safe blade insertion into a turbine disc. Furthermore, the assembly time and risk of damage to fir tree root and interlock surfaces are minimised. The fitting of one clamp or pre-twisting device per blade allows for a manual operation rather than the use of mechanical or hydraulic assistance.

[0008] The frame arms can be separate components, which are connected to the main body, or the main body and the frame arms can be made as one piece. The first frame arm and the second frame arm of an element may run parallel to each other.

[0009] Advantageously, the first frame arms are configured for connecting to each other by a means allowing the first element and the second element to be pivotable or twistable against each other about a radial axis. The radial axis can be defined as an axis, which runs radial with respect to a disc rotation axis or a turbine rotation axis, when the clamp is connected to a turbine blade mounted to a turbine disc.

[0010] In a preferred variant the first element is configured for assembling or fitting to a portion of an aerofoil close to or adjacent to a blade tip and the second element is configured for assembling or fitting to a portion of an aerofoil close to or adjacent to a blade platform or root.

[0011] The first element and second element are advantageously configured such that when the clamp is fitted to a turbine blade, the first frame arms are positioned close to or adjacent to a leading edge of the blade and the second frame arms are positioned close to a trailing edge of the blade. In this variant the axis of rotation of the clamp is positioned close to the leading edge, which facilitates the twisting of the blade.

[0012] In a further variant at least one of the frame arms comprises a flange for connecting it with another frame arm. For instance the first frame arm of the first element and/or the first frame arm of the second element and/or the second frame arm of the first element and/or the second frame arm of the second element comprise a flange. Preferably each frame arm comprises a flange and is connected to another frame arm, as described, by means of the flange. The flanges provide a robust connection and fixation between the first and the second element.

[0013] Additionally, the first and/or the second element can comprise a means for connecting and/or fixing a lever arm. Advantageously the means for connecting and/or fixing a lever arm is located at the main body. For example, the means comprises a hole for inserting a lever arm or consists of a hole for inserting a lever arm. The means for connecting and/or fixing a lever arm has the advantage, that it allows for temporary connecting and easily removing a lever arm or other mechanical means to the

elements of the clamp to facilitate a twist of the blade.

[0014] The inventive turbine blade torsional clamp set comprises at least two turbine blade torsional clamps as previously described. The turbine blade torsional clamp set has the same properties and advantages as the previously described turbine blade torsional clamp. Preferably, the clamp set comprises a number of clamps, which corresponds to the number of blades per disc.

[0015] The turbine blade torsional clamp set or assembly kit is compact and requires no external power source. The torsional clamping arrangement can be configured to allow multiple blade sizes and profiles to use the same torsional clamp in order to reduce equipment inventory and transport costs.

[0016] The inventive method for manufacturing or assembling a turbine, for example a gas turbine, comprising the following steps: A number of torsional clamps, as previously described, are fitted to a number of blades. Then a predetermined twist or torsional moment is applied to each blade deforming the blades. The torsional clamp is locked in the twisted or deformed position. A root, for example a fir tree profile root, of each blade is partly inserted into a turbine disc. The blade roots are consecutively inserted further into the disc in a circumferential order until a desired axial position is achieved. Then the tension or torsional moment is removed from the blades by relaxing the clamps, for instance by opening or releasing a clamp lock. Finally the clamps are removed from each blade.

[0017] Advantageously a torsional clamp, as previously described, is fitted to each of the blades. The blades may be pre-twisted blades, which are un-twisted by applying the predetermined twist or torsional moment. The predetermined twist or torsional moment is preferably applied to each blade about a longitudinal axis or span axis of the blade.

[0018] The twist or torsional moment can be applied to the blades by mechanical means, for example by temporary fitted levers. The lever arms can be inserted into holes in the frame arms.

[0019] The turbine disc comprises slots or insertions for inserting blade roots. By applying the inventive method the blades are inserted first by a small amount into a turbine disc. Advantageously the blade roots are advanced into the disc by repeated blows to the blades consecutively in a circumferential order until each blade is completely inserted.

[0020] Generally, the turbine can be a gas turbine. The blade or the blades can be Shrouded Interlocked Turbine Blades.

[0021] The present invention provides an effective and safe method of blade insertion into a turbine disc and minimises assembly time and risk of damage to fir tree root and interlock surfaces. The fitting of one clamp or pre-twisting device per blade allows for a manual operation rather than the use of mechanical or hydraulic assistance.

Brief description of the drawings

[0022] The above mentioned attributes and other features and advantages of this invention and the manner of attaining them will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings. The embodiments do not limit the scope of the present invention which is determined by the appended claims. All described features are advantageous as separate features or in any combination with each other.

Fig. 1 schematically shows part of a turbine engine in a sectional view which is assembled by use of the inventive method.

Fig. 2 schematically shows part of a turbine blade interlock arrangement in a perspective view.

Fig. 3 schematically shows part of a turbine blade interlock arrangement in a perspective view.

Fig. 4 schematically shows part of a turbine blade interlock arrangement in a perspective view.

Fig. 5 schematically shows a turbine blade torsional clamp connected to a blade in a perspective view.

Fig. 6 schematically shows the turbine blade torsional clamp connected to a blade in an alternative perspective view.

Fig. 7 schematically shows the fitting of blades to a turbine disc according to the inventive method in a perspective view.

Detailed description of the invention

[0023] Fig. 1 shows an example of a gas turbine engine 10 in a sectional view. The gas turbine engine 10 comprises, in flow series, an inlet 12, a 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.

[0024] 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 burner plenum 26, one or more combustion chambers 28 and at least one burner 30 fixed to each combustion 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.

[0025] 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. An annular array of transition duct outlets form an annulus for channelling the combustion gases to the turbine 18.

[0026] 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.

[0027] The combustion gas from the combustion chamber 28 enters the turbine section 18 and drives the turbine blades 38 which in turn rotate the shaft 22. The guiding vanes 40, 44 serve to optimise the angle of the combustion or working gas on the turbine blades 38.

[0028] 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 operations conditions.

[0029] 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.

[0030] The present invention 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 invention is equally applicable to two or three shaft engines and which can be used for industrial, aero or marine applications.

[0031] The terms upstream and downstream refer to the flow direction of the airflow and/or working gas flow through the engine unless otherwise stated. The terms forward and rearward refer to the general flow of gas through the engine. The terms axial, radial and circumferential are made with reference to the rotational axis 20 of the engine.

[0032] The gas turbine can be assembled or manufactured by use of the inventive torsional clamp, as for example described with reference to figures 2 to 7.

[0033] Fig. 2 to 4 schematically show part of a turbine blade interlock arrangement in perspective views. Fig. 2 is a view in radial direction or onto the tip of the blades and Fig. 4 shows the interlock in an enlarged view.

[0034] The shown turbine blades 60 comprise a blade root 61, in the present example a fir tree root, a platform 62, an aerofoil 63, a tip 64 covered by a shrouding band 65. The shrouding band 65 comprises shroud interlocks 66. Along a radial axis 67 the blade root 61, the platform 62, the aerofoil 63, the tip 64 and the shrouding band 65 are consecutively ordered. The radial direction is indicated by an arrow 72.

[0035] The aerofoil 63 comprises a leading edge 68 and a trailing edge 69.

[0036] The turbine disc 70 comprises a number of slots 71 for axially inserting blade roots 61. The axial direction is indicated by an arrow 73. In the present example the slots 71 have a fir tree profile corresponding to the profile of the blade roots 61.

[0037] Fig. 5 and Fig. 6 schematically show a turbine blade torsional clamp 80 connected to a blade 60 in different perspective views. The clamp 80 comprises a first element 81 and a second element 82. In the present example the first element is configured for positioning close to a blade tip 64 or close to the shrouding band 65 and the second element 82 is configured for positioning close to a blade platform 62 or blade root 61.

[0038] The first element 81 comprises a main body 91, a first frame arm 93 and a second frame arm 95. The main body 91 comprises a cavity 97 with an inner surface for resting on a turbine aerofoil surface. Preferably the inner surface comprises a close fitting soft-faced locator 83.

[0039] The first frame arm 93 and the second frame arm 95 protrude from the main body 91 in radial direction 72. Preferably the first frame arm 93 and the second frame arm 95 run parallel to each other. The first frame arm 93 and the second frame arm 95 each comprise a flange 101 and 103 at their distal or far end, the flanges 101 and 103 being configured for connecting the frame arms 93 and 95 of the first element to frame arms 94 and 96 of the second element 82.

[0040] The second element 82 comprises a main body

92, a first frame arm 94 and a second frame arm 96. The main body 92 comprises a cavity 98 with an inner surface for resting on a turbine aerofoil surface. Preferably the inner surface comprises a close fitting soft-faced locator 84.

[0041] The first frame arm 94 and the second frame arm 96 protrude from the main body 92 in radial direction 72. Preferably the first frame arm 94 and the second frame arm 96 run parallel to each other. The first frame arm 94 and the second frame arm 96 each comprise a flange 102 and 104 at their distal or far end, the flanges 102 and 104 being configured for connecting the frame arms 94 and 96 of the first element to the frame arms 93 and 95 of the first element 81.

[0042] The first frame arms 93 and 94 are connected to each other by means of the flanges 101 and 102 and a means, for example a pin, which allows for pivoting the first element 81 and the second element 82 against each other about an axis 110 which runs parallel to the radial direction 72. In the present example the first frame arms 93 and 94 are positioned close to the leading edge 68 of the blade 60.

[0043] The second frame arms 95 and 96 are connected to each other at the flanges 103 and 104 by a means 106 for adjusting a torsion angle between the first element 81 and the second element 82 and for locking the clamp in a twisted position. Additionally, an angular scale 107 can be provided. The angular scale 107 can be located at the second flange 104 of the second element 82 and/or the second flange 103 of the first element 81. In the shown example the second frame arms 95 and 96 are positioned close to the trailing edge 69 of the blade 60.

[0044] The main body 91 of the first element 81 and the main body 92 of the second element 82 comprise a means 77 for connecting, especially inserting, a lever arm 74. The means 77 may be a hole or drilling. In the present embodiment the means 77 and the lever arms 74 are positioned close to the first frame arms 93 and 94, which can be the leading edge side of the clamp. As an alternative it is possible to position the means 77 and the lever arms 74 close to the second frame arms 95 and 96, which can be the trailing edge side of the clamp. The lever arms 74 are removable. The movement of the lever arms 74 to apply a torsional moment is indicated by arrows 75, causing a twist 76 of the blade 60.

[0045] In the inventive method the described torsional clamp 80 is fitted to each blade 60 within an entire turbine stage i.e. one clamp assembly 80 per blade 60. Externally to the engine a temporary pre-determined torsional untwist is applied to the blade 60 by means of the mechanical advantage generated by the temporary fitted levers 74 and the hitherto loosened clamping arrangement is locked in the deformed position to prevent unwind of the aerofoil 63.

[0046] Fig. 7 schematically shows the fitting of blades 60 to a turbine disc 70 according to the inventive method in a perspective view. The full set is omitted for clarity. Each blade 60 is equipped with a torsional clamp 80, as

described, and the blades 60 are in a twisted or deformed state. The sequential force applied to blading is indicated by arrows 108.

[0047] The collective set of deformed blades with clamps fitted can then be fitted by circumferentially advancing down the fir tree root until the desired axial position is achieved. The torsional clamps 80 are removed at this point in time. Removal of the collective blade set is achieved by the reverse of the process described; this may require higher levels of torque to deform, i.e. untwist, the blade as the blade in the fitted condition is restrained by the interlocks of adjacent blades.

Claims

1. A turbine blade torsional clamp (80) for inserting a turbine blade (60) into a turbine disc (70),
characterized in that
the clamp (80) comprises a first element (81) and a second element (82), wherein each element (81, 82) comprises a main body (91, 92) with a cavity (97, 98) having a surface (83, 84) configured for resting against a surface of an aerofoil (63) of the turbine blade (60),
wherein each element (81, 82) comprises a first frame arm (93, 94) and a second frame arm (95, 96), which protrude from the main body (91, 92),
the first frame arms (93, 94) are configured for connecting to each other by a means allowing the first element and the second element to be pivoted against each other,
the second frame arms (95, 96) are configured for connecting to each other by a means (106) for adjusting a torsion angle between the first and the second element and for locking the clamp (80) in a twisted position.
2. The turbine blade torsional clamp (80), as claimed in claim 1,
characterized in that
the first element (81) is configured for fitting to a portion of an aerofoil (63) close to a blade tip (64) and the second element (82) is configured for fitting to a portion of an aerofoil (63) close to a blade platform (62) or root (61).
3. The turbine blade torsional clamp (80), as claimed in claim 1 or 2,
characterized in that
the first element (81) and second element (82) are configured such that when the clamp (80) is fitted to a turbine blade (60), the first frame arms (93, 94) are positioned close to a leading edge (68) of the blade (60) and the second frame (95, 96) arms are positioned close to a trailing edge (69) of the blade (60).
4. The turbine blade torsional clamp (80), as claimed

- in any of the claims 1 to 3,
characterized in that
 at least one of the frame arms (93, 94, 95, 96) comprises a flange (101, 102, 103, 104) for connecting it with another frame arm (93, 94, 95, 96). 5
5. The turbine blade torsional clamp (80), as claimed in any of the claims 1 to 4,
characterized in that
 the first element (81) and/or the second element (82) 10
 comprises a means (77) for connecting and/or fixing a lever arm (74).
6. The turbine blade torsional clamp (80), as claimed in claim 5, 15
characterized in that
 means (77) for connecting and/or fixing a lever arm (74) comprises a hole for inserting a lever arm (74).
7. A Turbine blade torsional clamp set, comprising at 20
 least two turbine blade torsional clamps (80) as claimed in any of the preceding claims.
8. A method for manufacturing a turbine (10) comprising the steps of: 25
- fitting a number of torsional clamps (80) as claimed in any of the preceding claims to a number of blades (60),
 - applying a predetermined torsional moment to 30
 each blade (60) to deform the blade (60),
 - locking the clamp (80) in the deformed position,
 - inserting a root (61) of each blade (60) partly into a turbine disc (70),
 - consecutively inserting the blade roots (61) further 35
 into the disc (70) in a circumferential order until a desired axial position is achieved,
 - remove the torsional moment from the blades (60) by relaxing the clamps (80) and
 - removing the clamps (80) from each blade (60). 40
9. The method as claimed in claim 8,
characterized in
 applying the torsional moment to the blades (60) by 45
 mechanical means.
10. The method as claimed in claim 8 or claim 9,
characterized in
 advancing the blade roots (61) into the disc (70) by 50
 repeated blows to the blades (60) consecutively in a circumferential order.
11. The turbine blade torsional clamp (80) or the turbine blade torsional clamp set or the method as claimed in any of the preceding claims, 55
characterized in that
 the turbine is a gas turbine (10).
12. The turbine blade torsional clamp (80) or the turbine blade torsional clamp set or the method as claimed in any of the preceding claims,
characterized in that
 the blade (60) is or the blades are Shrouded Inter-locked Turbine Blades.

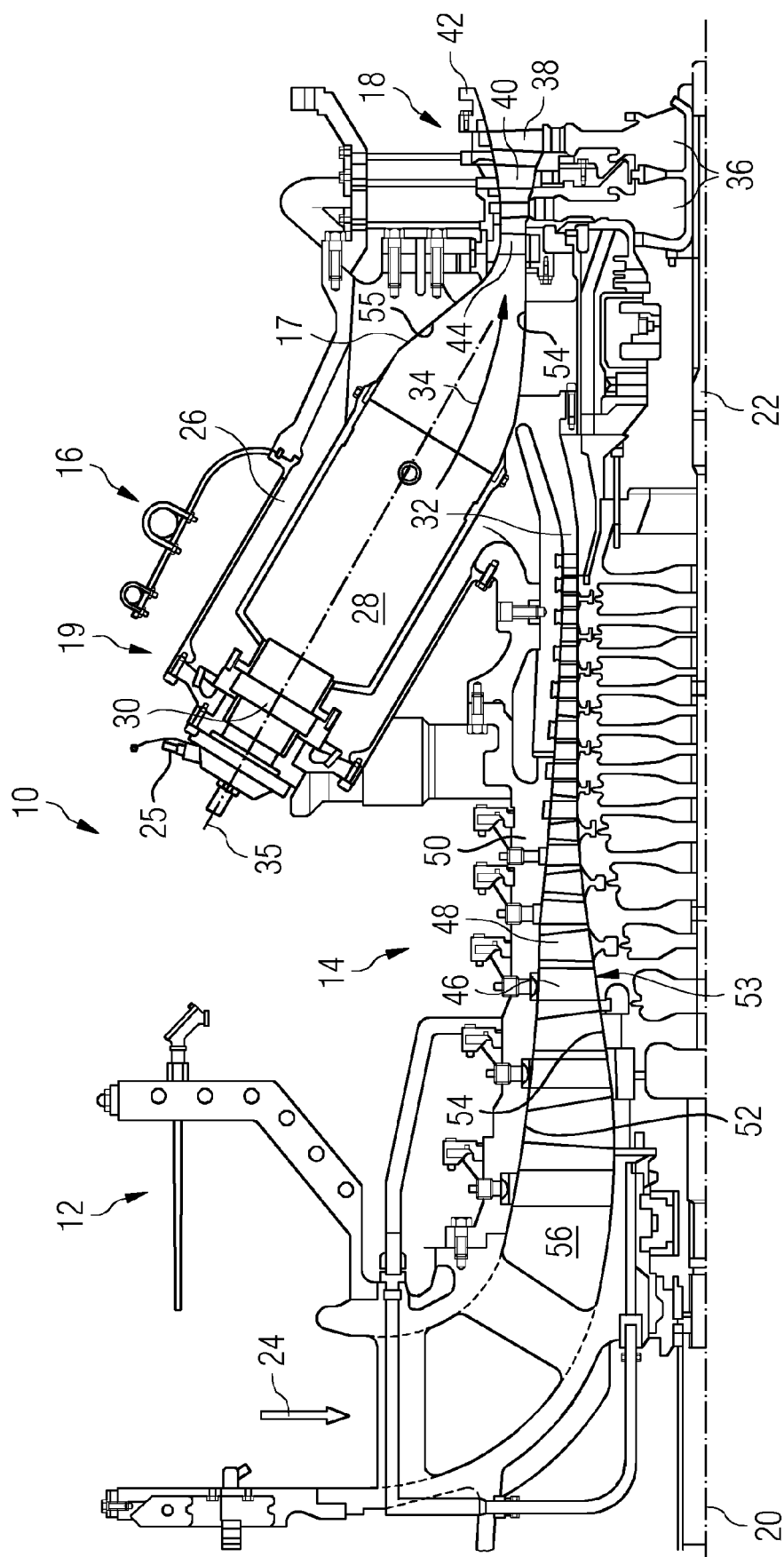


FIG 1

FIG 2

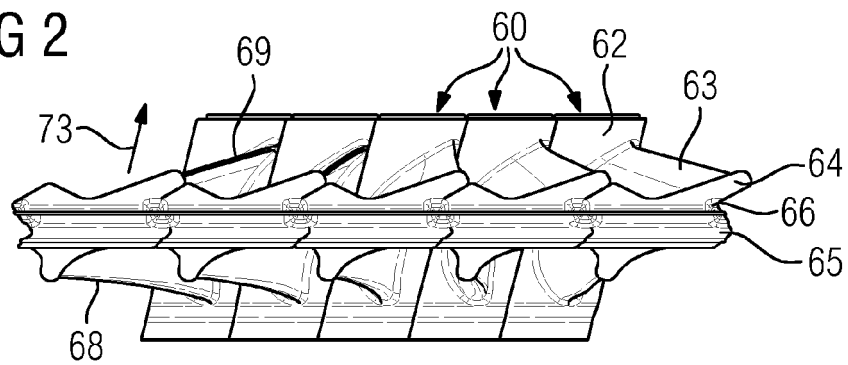


FIG 3

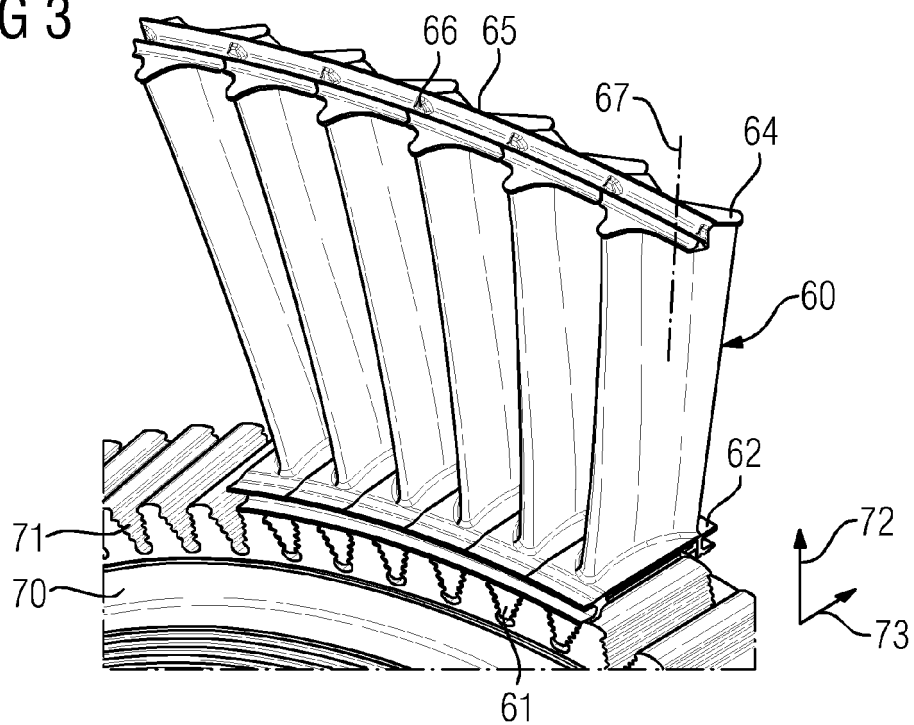


FIG 4

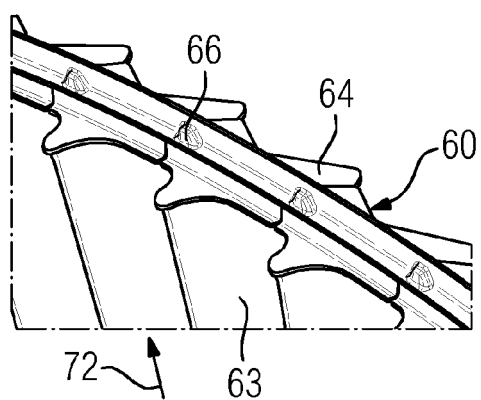


FIG 5

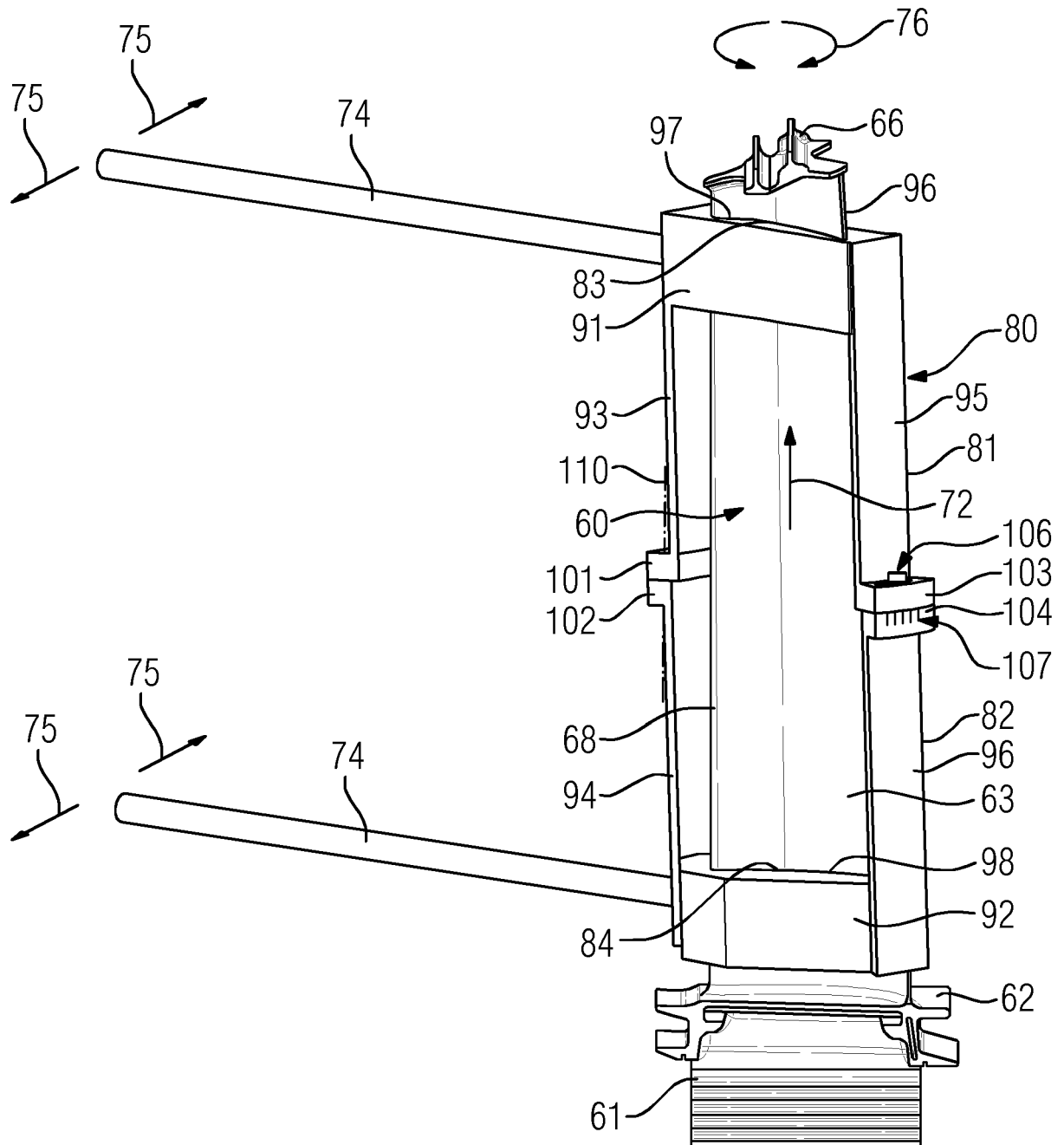


FIG 6

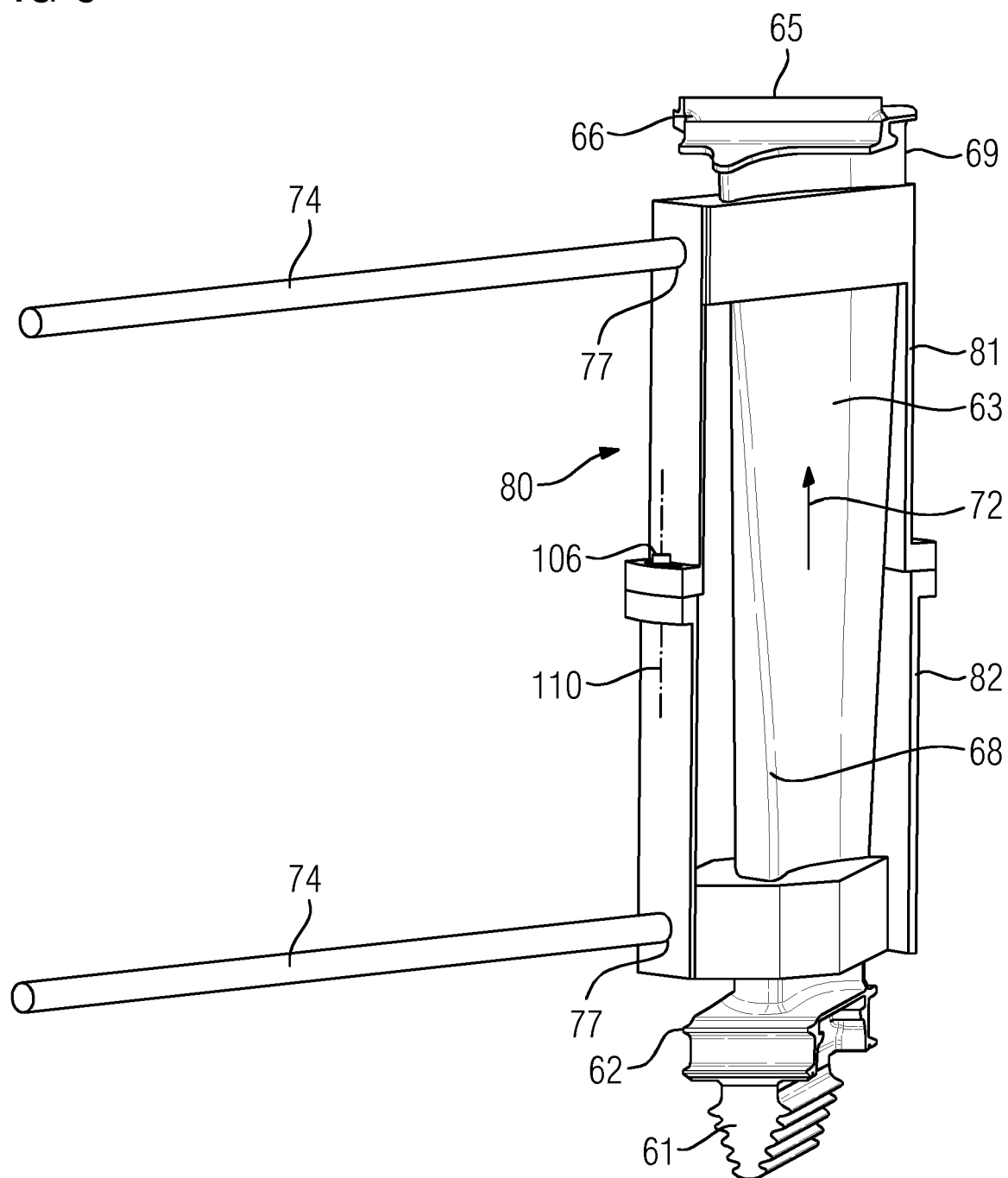
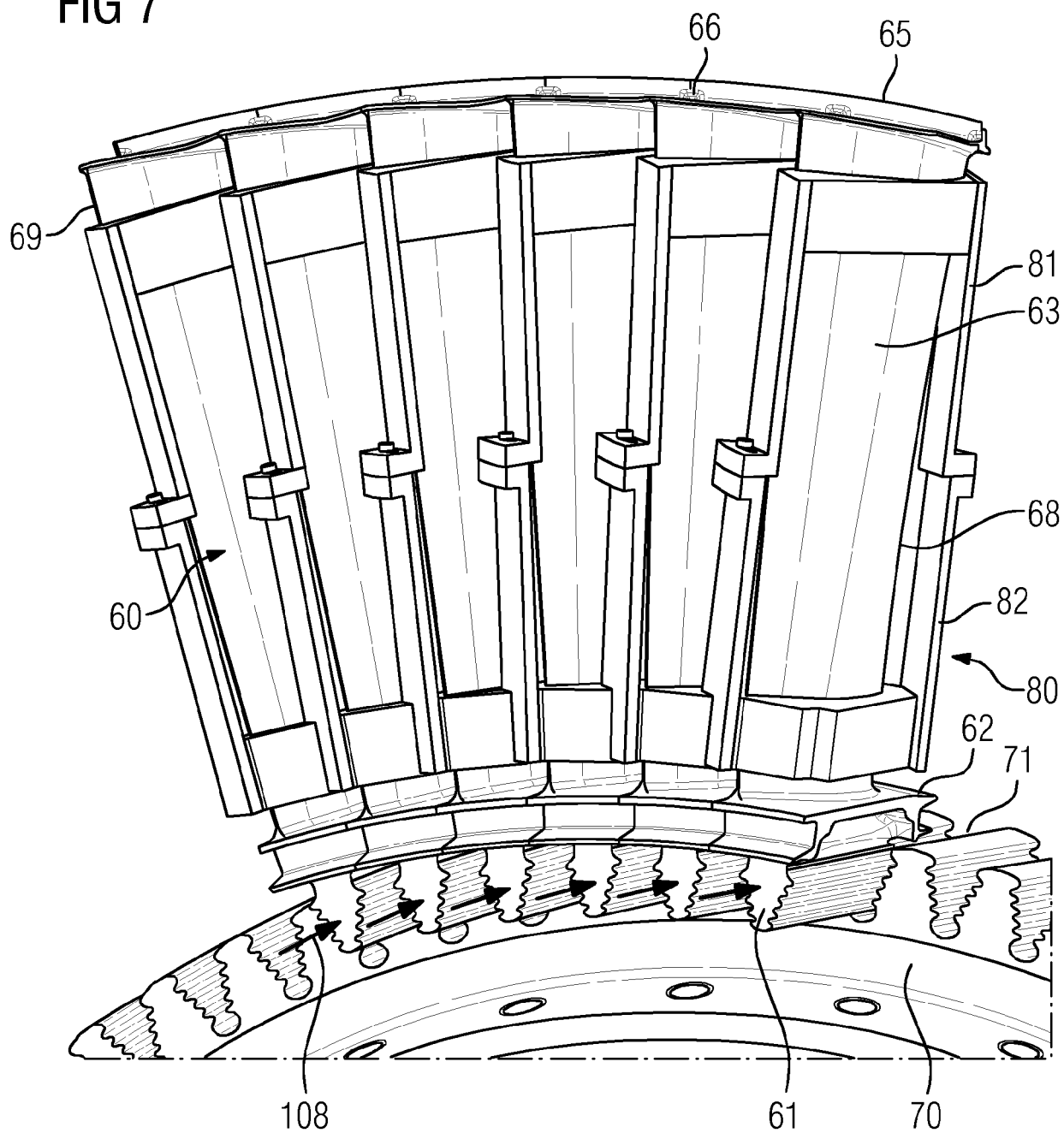


FIG 6

FIG 7





EUROPEAN SEARCH REPORT

Application Number
EP 16 15 5425

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 June 2016	Examiner Hartnack, Kai
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EP 16 15 5425

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