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(54) **MULTI-AIRFOIL GUIDE VANE UNIT**

(57) A multi-airfoil guide vane unit (1) comprises a first platform member (14), a second platform member (15), and at least two airfoil members (11, 12, 13), the airfoil members having a longitudinal extent along an airfoil span width and two longitudinal ends, wherein all airfoil members are rigidly affixed to a platform member at a first longitudinal end and at least one airfoil member (11, 13) is rigidly affixed to both platform members at both longitudinal ends. At least one of the airfoil members (12) is floatingly connected to one of the platform members (14) at a second longitudinal end (121). A longitudinally floating joint arrangement is thus provided between the second longitudinal end (121) of the airfoil member 812) and the platform member, such as to allow displacement of the airfoil member (12) relative to said platform member (14) along the longitudinal extent (2) of said airfoil member (12). In particular, the floating joint arrangement comprises a male joint feature (123) provided at one of the second longitudinal end (121) of the airfoil member and the platform member (14) and a female joint feature (141) provided at the other one of the second longitudinal end of the airfoil member and the platform member, the male feature being received within said female feature.

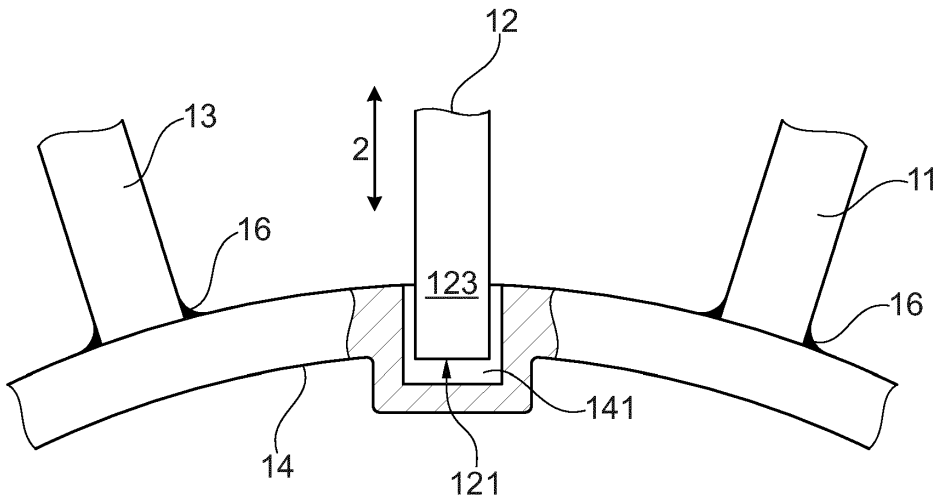

Fig. 2

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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a multi-airfoil guide vane unit as described in claim 1. It further relates to an airfoil member and a platform member for a guide vane unit of the described type.

BACKGROUND OF THE DISCLOSURE

[0002] In turbo engines, such as for instance gas turbines or steam turbines, vane twins, triplets or any multiples are required as they provide several benefits, such as, for instance, increased stiffness and lower platform leakage. Commonly, the multiples are cast in one piece. However, this requires complex tooling to enable precision cast and turns manufacturing expensive. Moreover, the cast yield rate of such multiples can be quite low for the big sizes required in stationary power generation turbines. Moreover, service deterioration of one single airfoil may require replacement and scrapping of an entire multi airfoil unit.

[0003] EP 1 176 284 A2 proposes a built multi-airfoil guide vane unit and to separately manufacture airfoil and platform members, and to join them by brazing. Separation after service for reconditioning purposes is difficult and expensive. Just like in one-piece casts, the whole arrangement is rigid and over-constrained, such that differential thermal expansion results in high thermal mismatch stresses, in turn limiting the service lifetime of the multi-vane unit.

[0004] Document US 5,797,725 discloses to receive an airfoil member in a platform or shroud in a floating manner such as to allow movement in response to thermal conditions.

OUTLINE OF THE SUBJECT MATTER OF THE DISCLOSURE

[0005] It is an object of the present disclosure to provide a multi-airfoil guide vane unit. It is an object of the present disclosure to provide a multi-airfoil guide vane unit which is simple to manufacture. It is a further object of the present disclosure to provide a multi-airfoil guide vane unit which facilitates replacement of single worn members of the unit. It is still a further object of the present disclosure to provide a multi-airfoil guide vane unit in which thermal mismatch stresses are reduced, if not avoided.

[0006] This is achieved by the subject matter of claim 1.

[0007] Further beneficial effects of the herein described subject matter, whether explicitly mentioned or not, will become apparent to the skilled person by virtue of the detailed description in this disclosure.

[0008] Accordingly, disclosed is a multi-airfoil guide vane unit, comprising a first platform member, a second platform member, and at least two airfoil members. The airfoil members have a longitudinal extent along an airfoil span width and two longitudinal ends. All airfoil members are rigidly affixed to a platform member at a first longitudinal end and at least one airfoil member is rigidly affixed to both platform members at both longitudinal ends. At least one of the airfoil members is floatingly connected to one of the platform members at a second longitudinal end, and a longitudinally floating joint arrangement is provided between the second longitudinal end of the airfoil member and the platform member, such as to allow displacement of the airfoil member relative to said platform member along the longitudinal extent of said airfoil member.

[0009] It is understood that the airfoil longitudinal direction may in particular be identical with a radial direction for the intended mounted state of the guide vane unit in a turbo-engine in case of an axial flow stage.

[0010] Due to an airfoil member being displaceable along its longitudinal, that is, span width direction, the multi-airfoil unit is less rigid and allows for relative movement between the members of the unit to account for differential thermal expansion.

[0011] According to an aspect of the multi-airfoil guide vane unit according to the present disclosure, the floating joint arrangement comprises a male joint feature provided at one of the second longitudinal end of the airfoil member and the platform member, and a female joint feature provided at the other one of the second longitudinal end of the airfoil member and the platform member, the male feature being received within said female feature. In that manner, the floating joint arrangement may particularly easy be provided. The floating joint arrangement is intended for a defined displacement range, and the male member and female member are dimensioned such that the male member is at least with a part of its longitudinal extent received within the female member in a nominal built state as well as in all intended displaced positions.

[0012] In a more particular aspect the male joint feature is provided as a peg section at the second longitudinal end of the airfoil member and the female feature is a pocket provided in the platform member. As will be appreciated, generally the male joint feature and in more specific embodiments a peg or the peg section may be particularly easy provided on the airfoil member, as the airfoil member is generally bar-shaped anyway.

[0013] More in particular, the male feature outer surface is a ruled surface spanned by straight parallel lines. This will maintain a gap formed between the peg section and the lateral walls of the pocket constant along in all intended displacement positions. In a further more specific aspect, a peg section provided at a longitudinal end of an airfoil member exhibits an airfoil-shaped cross section. This enables to avoid cross sectional jumps and other geometric discontinuities along the airfoil member longitudinal extent.

[0014] In certain embodiments the male feature and the female feature are arranged and configured to form

a running fit. That is, a narrow gap is provided between an outer boundary of the male feature and an inner boundary of the female feature. It will be appreciated, that the presence of the gap enables a free movement between the male feature and the female feature and thus the unconstrained displacement between the airfoil member and the platform member in one direction at the floating joint arrangement. Further, the narrower the gap is, the more constrained the airfoil member will be in all other directions. This constraint of movement in all other directions but the airfoil longitudinal direction may be found desirable in order to avoid oscillation modes incorporating an airfoil member end. Oscillation frequencies of the airfoil member are thus at least essentially maintained identical to those of a fully constrained airfoil member.

[0015] The running fit may be provided by a fitting member arranged within the female joint feature, wherein the fitting member is in particular provided as one of a bi-cast and an injection molding member. Said arrangement may serve to facilitate manufacturing. The inner dimension of the female feature as such may be provided such as to provide a large clearance with the received male feature. This, in turn, means the female feature may be manufactured with a low demand as to accuracy. No high precision machining or manufacturing is required. Thus, providing the female feature as such is largely facilitated and is thus inexpensive. In applying a process such as bi-cast, metal injection molding, or any other suitable technique which allows to fill the gap between the female and the male feature without creating metallurgical bonding, the residual play is subsequently reduced to achieve the running fit, and a fitting member is produced within the female joint feature and embracing the male joint feature. In certain embodiments a concave form locking feature, for instance a flute, is provided on inner walls of the female joint feature such that, when the fitting member is produced, the added material fills the gap between the female and the male joint features on the one hand, and at the same time creates a form lock with the walls of the female joint feature. Thus, the fitting member is secured within the female joint feature. Other appropriate concave and/or convex form-lock features in order to secure the fitting member may be provided inside the female joint feature.

[0016] According to another aspect of the present disclosure, the multi-airfoil guide vane unit is characterized in that a depth of the female joint feature is larger than a received length of the male joint feature such that a gap is provided between the bottom of the female joint feature and a tip of the male joint feature. Said feature enables improved longitudinal displacement capability, such that the male joint feature may displace deeper into the female feature if needed.

[0017] In specific embodiments, the multi-airfoil guide vane unit comprises three airfoils. In a more specific embodiment, two outer airfoils are rigidly affixed to a platform member at both longitudinal ends and a middle airfoil member is rigidly affixed to a first platform member at one airfoil member end and is floatingly connected to the second platform member at the other airfoil member end. In another more specific embodiment, the middle airfoil member is rigidly affixed to a platform member at both longitudinal ends, and each of two outer airfoil members is rigidly affixed to a platform member at its first end and is floatingly connected to a platform member at its second end. Even more specifically, both outer airfoil members may be rigidly affixed to the first platform member and floatingly connected to the second platform member, or a first outer airfoil member is rigidly affixed to the first platform member and is floatingly connected to the second platform member, and a second outer airfoil member is rigidly affixed to the second platform member and is floatingly connected to the first platform member.

[0018] Disclosed is an airfoil member wherein the male joint feature is provided in that a longitudinal end section of the airfoil member is provided with constant cross sections thus forming a generally cylindrical peg section.

[0019] A platform member is disclosed wherein a female joint feature is provided in that the platform member comprises at least one pocket adapted and configured for receiving an airfoil member end section. In particular, at least one concave form lock feature is provided on the side wall of the pocket, and is in particular provided as a circumferential groove, thus providing a form-lock feature for a fitting member, which fitting member serves to reduce play between the female joint feature and the male joint feature in the directions in which displacement is not desired.

[0020] It is understood that the features and embodiments disclosed above may be combined with each other. It will further be appreciated that further embodiments are conceivable within the scope of the present disclosure and the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The subject matter of the present disclosure is now to be explained in more detail by means of selected exemplary embodiments shown in the accompanying drawings. The figures show

- Fig. 1 a multi-airfoil guide vane unit;
- Fig. 2 a first exemplary floating joint arrangement between an airfoil member end and a platform member;
- Fig. 3 a more detailed view of the floating joint arrangement of figure 2; and
- Fig.4 a second exemplary floating joint arrangement between an airfoil member end and a platform member.

[0022] It is understood that the drawings are highly schematic, and details not required for instruction may have been omitted for the ease of understanding and depiction. It is further understood that the drawings show

only selected, illustrative embodiments, and embodiments not shown may still be well within the scope of the herein claimed subject matter.

EXEMPLARY MODES OF CARRYING OUT THE TEACHING OF THE PRESENT DISCLOSURE

[0023] Figure 1 depicts a guide vane triplet 1. The guide vane triplet comprises a radially inner platform member 14, a radially outer platform member 15, and three airfoil members 11, 12, and 13. The airfoil members extend with their span width or longitudinal extent between the platform members. Two outer airfoil members 11 and 13 are rigidly affixed to both platform members 14 and 15. Visible are braze or weld seams 16 at which airfoil members 11 and 13 are rigidly connected to the radially inner platform 14. Airfoil members 11 and 13 are also rigidly connected to the radially outer platform 15, however, this is not visible in the present depiction. Airfoil members 11 and 13 are thus rigidly connected to a platform member on both respective longitudinal ends. The middle airfoil member 12 is also at one longitudinal end rigidly connected to the radially outer platform member 15. Airfoil member 12 is at its second end 121 floatingly connected to the radially inner platform member 14, in that the second end 121 is for instance received in a pocket 141 provided in the inner platform member 14. This allows displacement of the airfoil member 12 relative to the inner platform member 14 along the longitudinal extend of airfoil member 12.

[0024] With reference to figure 2, the longitudinally floating joint arrangement is shown in more detail. A pocket 141 is provided as a female joint feature in the platform member 14. The airfoil member 12 is at its longitudinal end 121 provided as a peg section 123, constituting a male joint feature. The peg section is provided as a general cylinder, that is to say, the outer surface of the peg section is a ruled surface spanned by straight parallel lines. Peg section 123 of airfoil member 12 is received in the pocket 141, with a gap provided between an inner surface of the pocket 141 and an outer surface of the peg section 123. Due to the general cylindrical shape of the peg section 123, the airfoil member 12 may displace relative to the platform member 14 along the longitudinal direction indicated at 2 without changing the width of the gap between the peg section and the pocket. Peg section 123 may exhibit an airfoil-shaped cross section, and thus constitute a continuation of the cross-sectional geometry of airfoil member 12, thus enabling to provide airfoil member 12 without cross sectional jumps or geometric discontinuities.

[0025] With reference to figure 3, a more detailed view of peg section 123 provided on an airfoil member end 121 and received in a pocket 141 of platform member 14 is shown. An inner wall of the pocket is provided with a flute or other concave form locking feature 18, said flute in particular running around the circumference of the pocket. A fitting member 17 is provided between the inner wall of the pocket 141 and an outer surface of the peg section 123, wherein said fitting member is arranged and configured to minimize lateral play of the peg section within the pocket. Fitting member 17 is in a form-locked manner secured by concave form locking feature or flute 18 provided at the inner wall of pocket 141. Said fitting member 17 and the peg-shaped end section 123 of the airfoil member 12 form a running fit with each other. A minimum gap is still provided between the fitting member 17 and the peg -shaped end section of the airfoil 12, such as to allow a displacement of the airfoil member 12 relative to the platform member 14 along the longitudinal direction 2. However, maintaining said gap very narrow, that is, for instance, less than one millimeter, longitudinal displacement is enabled while constraining movement of the airfoil end section 121 with respect to the platform member in any other direction, that is to say, in axial or circumferential direction of the platform member, or, of the multi-airfoil guide vane unit, with the axial and circumferential directions being defined by the intended arrangement of the platform or the guide vane unit in a turbo engine. The fitting member 17 may in particular be manufactured for instance by bi-cast, as described for instance in US 5,797,725, or metal injection molding, as described for instance in US 8,257,038. It is for instance manufactured in that the peg-shaped end section 123 of the airfoil member 12 is inserted into the pocket 141, and subsequently material is introduced into the gap between the peg section outer surface and the pocket inner wall. Both processes mentioned above are known to create no metallurgical bonding between the bodies. Thus, the gap may be filled and the fitting member 17 may be produced which allows displacement of the airfoil member 12 inside the pocket 141 along the airfoil member longitudinal direction 2.

[0026] Turning now to figure 4, an alternative arrangement is shown, wherein the male joint feature 142 is arranged on the platform member 14 and received within the female joint feature 122 provided at an end 121 of the airfoil member 12.

[0027] While the longitudinally floating joint arrangement has been shown in the foregoing examples to be arranged on a radially inner side of the multi-airfoil guide vane unit, it is apparent that the floating joined arrangement may also be provided at the radially outer platform. Moreover, embodiments are conceivable comprising two or more airfoil members which are floatingly connected to a platform member. In that case, embodiments are conceivable in which the floating connection is provided on the same, that is radially inner or outer, end of the airfoil members, but may also be provided on the radially inner end for some of the airfoil members and on the outer end for others.

[0028] While the subject matter of the disclosure has been explained by means of exemplary embodiments, it is understood that these are in no way intended to limit the scope of the claims. It will be appreciated that the claims cover embodiments not explicitly shown or dis-

closed herein, and embodiments deviating from those disclosed in the exemplary modes of carrying out the teaching of the present disclosure will still be covered by the claims.

LIST OF REFERENCE NUMERALS

[0029]

1	multi-airfoil guide vane unit
2	longitudinal direction of airfoil member, displacement direction
11	airfoil member
12	airfoil member
13	airfoil member
14	platform member
15	platform member
16	seam
17	fitting member
18	concave form lock feature
121	airfoil member longitudinal end
122	female joint feature; pocket
123	male joint feature; peg section
141	female joint feature; pocket
142	male joint feature; peg

Claims

1. A multi-airfoil guide vane unit (1), comprising a first platform member (14), a second platform member (15), and at least two airfoil members (11, 12, 13), the airfoil members having a longitudinal extent (2) along an airfoil span width and two longitudinal ends, wherein all airfoil members are rigidly affixed to a platform member at a first longitudinal end and at least one airfoil member (11, 13) is rigidly affixed to both platform members at both longitudinal ends, **characterized in that** at least one of the airfoil members (12) is floatingly connected to one of the platform members (14) at a second longitudinal end (121) and a longitudinally floating joint arrangement is provided between the second longitudinal end (121) of the airfoil member (12) and the platform member (14), such as to allow displacement of the airfoil member (12) relative to said platform member (14) along the longitudinal extent (2) of said airfoil member (12).

2. The multi-airfoil guide vane unit according to claim 1, **characterized in that** the floating joint arrangement comprises a male joint feature (123, 142) provided at one of the second longitudinal end (121) of the airfoil member and the platform member (14) and a female joint feature (141, 122) provided at the other one of the second longitudinal end (121) of the airfoil member and the platform member, the male feature being received within said female feature.

3. The multi-airfoil guide vane unit according to claim 2, **characterized in that** the male joint feature is provided as a peg section (123) at the second longitudinal end (121) of the airfoil member (12) and the female feature is a pocket (141) provided in the platform member (14).

4. The multi-airfoil guide vane unit according to any of claims 2 or 3, **characterized in that** the male joint feature (123, 142) outer surface is a ruled surface spanned by straight parallel lines.

5. The multi-airfoil guide vane unit according to any of claims 3 or 4, **characterized in that** the peg section (123) has an airfoil-shaped cross section.

6. The multi-airfoil guide vane unit according to any of claims 2 through 5, **characterized in that** the male joint feature (123, 142) and the female joint feature (122, 141) are arranged and configured to form a running fit.

7. The multi-airfoil guide vane unit according to claim 6, **characterized in that** the running fit is provided by a fitting member (17) arranged within the female member, wherein the fitting member is in particular provided as one of a bi-cast or an injection molding member.

8. The multi-airfoil guide vane unit according to any of claims 2 through 7, **characterized in that** a depth of the female joint feature (122, 141) is larger than a received length of the male joint feature (123, 142) such that a gap is provided between the bottom of the female joint feature and a tip of the male joint feature.

9. The multi-airfoil guide vane unit according to any of the preceding claims, the guide vane unit comprising three airfoil members (11, 12, 13), **characterized in that** two outer airfoil members (11, 13) are rigidly affixed to a platform member (14, 15) at both longitudinal ends and a middle airfoil member (12) is rigidly affixed to a first platform member (15) and is floatingly connected to the second platform member (14).

10. The multi-airfoil guide vane unit according to any of the preceding claims, the guide vane unit comprising three airfoils, **characterized in that** a middle airfoil is rigidly affixed to a platform member at both longitudinal ends and each of two outer airfoil members is rigidly affixed to a platform member at its first end and is floatingly connected to a platform member at its second end.

11. The multi-airfoil guide vane unit according to claim 10, **characterized in that** both outer airfoil members

are rigidly affixed to the first platform member and are floatingly connected to the second platform member.

12. The multi-airfoil guide vane unit according to claim 10, **characterized in that** a first outer airfoil member is rigidly affixed to the first platform member and is floatingly connected to the second platform member, and a second outer airfoil member is rigidly affixed to the second platform member and is floatingly connected to the first platform member.

13. An airfoil member (12) for the multi-airfoil guide vane unit according to any of the preceding claims, **characterized in that** a longitudinal end section (121) of the airfoil member is provided with constant cross sections thus forming a generally cylindrical peg section (123).

14. A platform member (14) for the multi-airfoil guide vane unit according to any of claims 1 through 12, **characterized in that** it comprises at least one pocket (141) adapted and configured for receiving an airfoil member end section.

15. The platform member according to claim 14 **characterized in that** at least one concave form-lock feature is provided on the side wall of the pocket and is in particular provided as a circumferential groove.

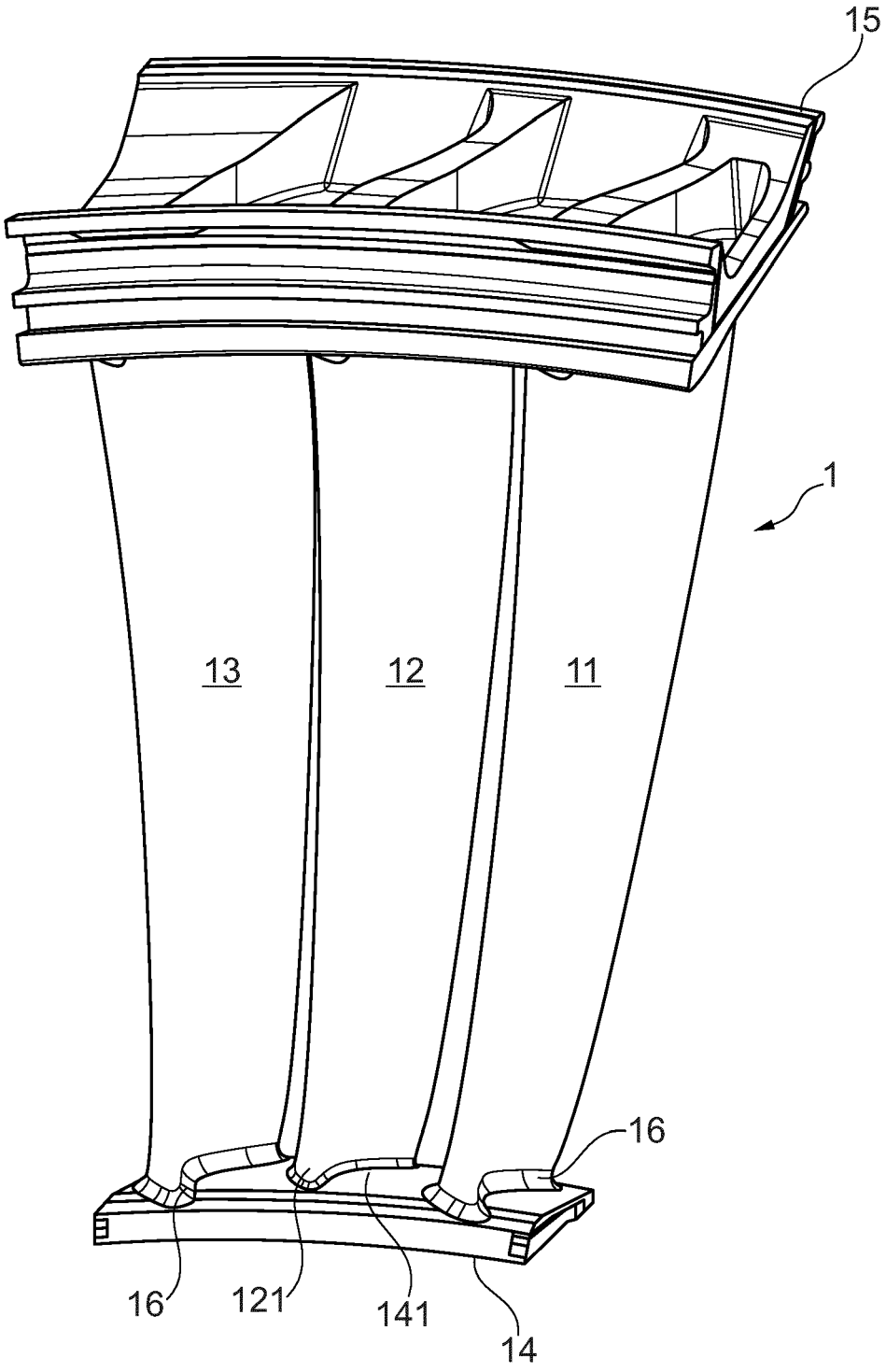

Fig. 1

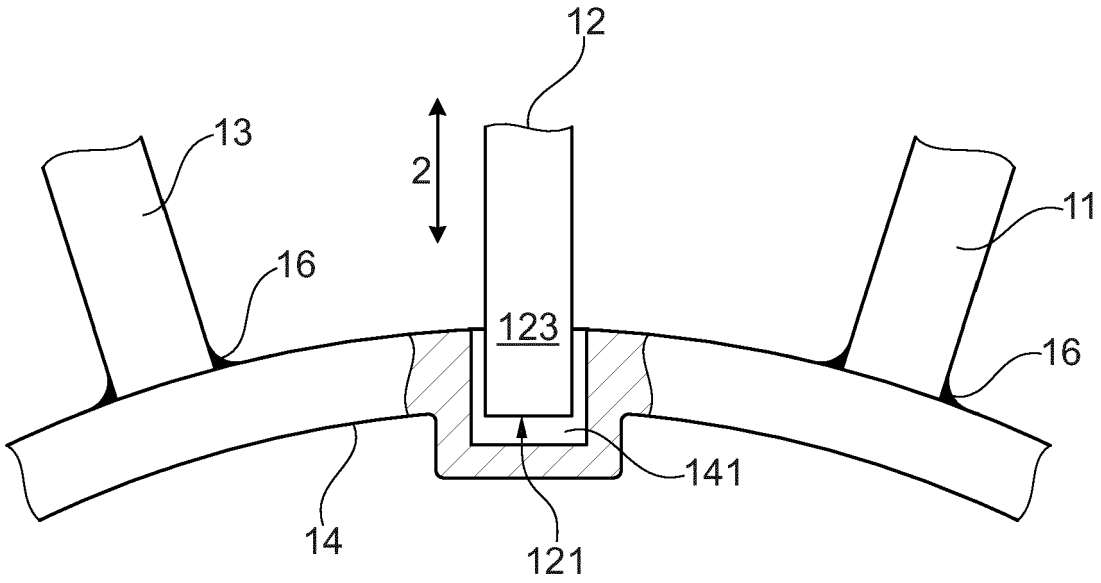

Fig. 2

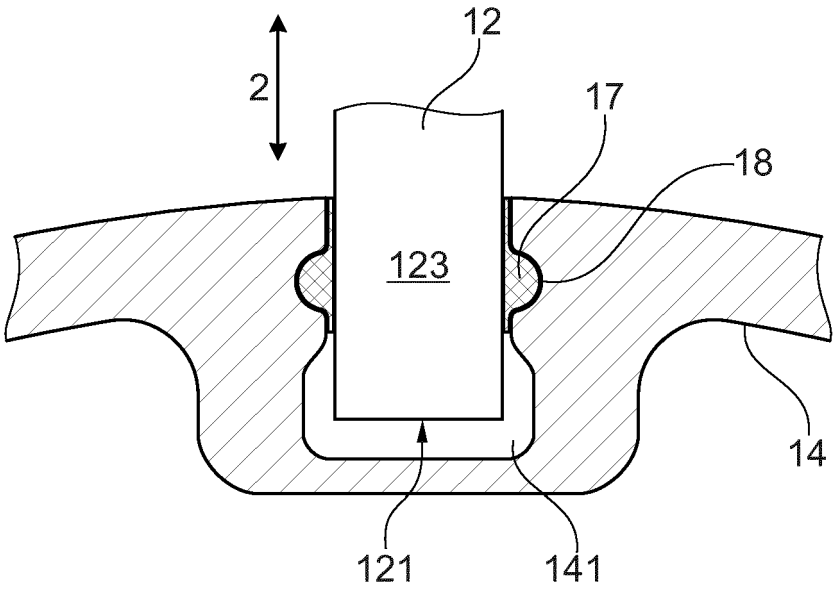

Fig. 3

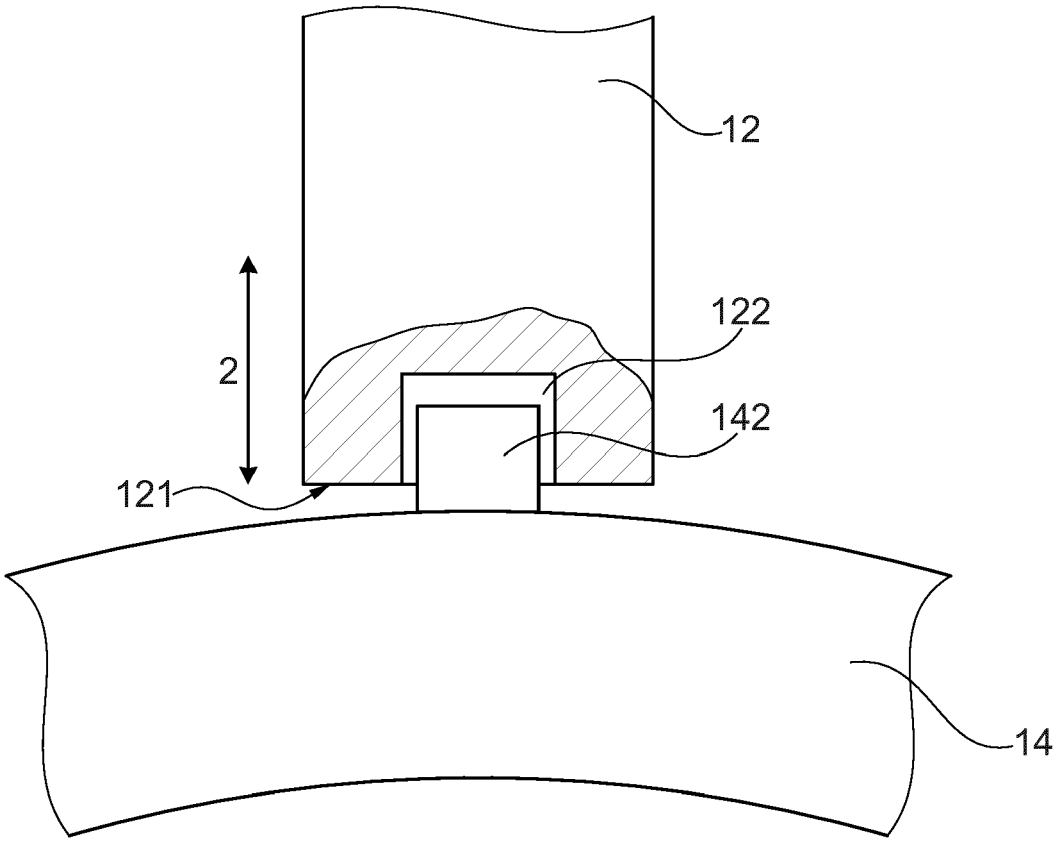

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 15 16 1814

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 November 2015	Mielimonka, Ingo

CATEGORY OF CITED DOCUMENTS

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