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(54) **Damper for compressor blade feet**

Dämpfer für Kompressorschaufelfüße

Amortisseur pour pieds d'aubes de compresseur

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(56) References cited:
DE-C- 554 119 GB-A- 2 169 664

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an intermediate part inserted in a circumferential groove between adjacent compressor blades in a high pressure axial compressor, in particular to an intermediate part used between adjacent blades of a row in a high pressure axial compressor used in gas turbines.

BACKGROUND

[0002] In a gas turbine engine, a single turbine section is made up of a disc or hub that holds many turbine blades. That turbine section is connected to a compressor section via a shaft. In the compressor, air is compressed, raising its pressure and temperature, the high temperature and high pressure exhaust gases passing then through the turbine stages. The turbine stages extract energy from this flow, lowering the pressure and temperature of the air.

[0003] The type of high pressure compressors widely used for heavy gas turbines (see Figure 1) are axial compressors, in which the working fluid principally flows parallel to the axis of rotation: a shaft drives a central drum having a plurality of circumferential grooves, where a plurality of blades are inserted, the blades rotating around the shaft. Axial flow compressors produce a continuous flow of high temperature compressed gas, having high efficiencies and large mass flow capacity, particularly in relation to their cross-section. They do, however, require several rows of blades to achieve large pressure rises making them complex and expensive.

[0004] Different devices and solutions exist in the state of the art between adjacent compressor blades of a row in a compressor used in gas turbines. For example, it is known in the state of the art, as per document US 2010/0135782 A1, a compressor having a plurality of blades arranged in a circumferential direction, comprising ring segments held by a seal holder with respect to a shaft, such that a seal member is provided on an inner peripheral side of the seal holder to ensure sealability with the shaft. However, during start-up of the compressor, when typically the highest stresses occur, undesired stress can happen between adjacent blades that can potentially damage the compressor structure.

[0005] Document GB 687,507 discloses a distance piece being located in the space between the intermediate portions of two adjacent compressor blades: this distance piece is made such that it follows the shape of the intermediate gap where it is located, either being able to swing about a bolt (two pairs of knuckles are located in its lower side) or are secured rigidly. In any case, no deformation is possible with this distance pieces so they are subjected to very high stresses that can damage the pieces and the compressor blades, also being this solution both complex and expensive.

[0006] Document GB2169664 discloses an elastomeric seal with pre-bending sections for preventing air leakage between platforms and between blade roots of the compressor of a gas turbine engine.

[0007] Also known in the art are intermediate parts used in the circumferential grooves of a compressor row, between adjacent compressor blades. Typically, these intermediate parts are made of a material with limited elastic properties such that plastic deformation occurs during start-up, a critical condition in which strong lateral compressive forces act on the intermediate parts. As a result, these intermediate parts, which are made from a softer material than the compressor blades, deform plastically to a significant degree, allowing the formation of large circumferential gaps between adjacent blades causing that some of the intermediate pieces are not retained in place, leading to extensive damage to the compressor blades, resulting in a forced outage of the gas turbine.

[0008] Plastic deformation, as it is not reversible, should be avoided in a too big extent; elastic deformation instead, as it is reversible, should be targeted for.

[0009] Therefore, an intermediate part that avoids plastic deformation would avoid large circumferential gaps, thus avoiding the escape of the intermediate-part, also avoiding undesired turbine forced outage. The present invention is oriented towards these needs.

SUMMARY OF THE INVENTION

[0010] The present invention relates to an intermediate part according to claim 1, and a gas turbine according to claim 5.

[0011] When start-up of the high pressure axial compressor occurs, the intermediate part is forced to deform tangentially, in the circumferential direction, with respect to its pre-bending shape in order to absorb the compressive forces resulting from the reduced space between the adjacent compressor blades: with the design of the invention, when start-up takes place, the deformation of this intermediate part is effected by the elastic deformation of the whole intermediate part material acting as an elastic element, typically acting as a spring, without any plastic deformation in the intermediate part.

[0012] Compared to the prior art, the pre-bending of the intermediate part of the invention requires a lower thickness of this intermediate part, allowing at the same time that the distance between adjacent blades is maintained at any given operational condition, steady (base load) or transient (start-up), and also while the compressor is not in operation.

[0013] Besides, this elastic deformation of the pre-bended intermediate part material of the invention during start-up avoids any plastic deformation in the intermediate part material, thus avoiding any plasticity (surface imprint) in the joined adjacent compressor blades, such that the dimensions of the circumferential gap between adjacent blades remains unchanged, and thus the inter-

mediate part is prevented from escaping.

BRIEF DESCRIPTION OF DRAWINGS

[0014] The foregoing objects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings, wherein.

Figure 1 shows a heavy gas turbine engine, comprising a high pressure axial compressor, known in the prior art.

Figure 2 shows an intermediate part inserted in a circumferential groove in a high pressure axial compressor as the one shown in Figure 1, between two adjacent compressor blades in a row, according to the present invention.

Figure 3 shows in section an intermediate part having certain degree of pre-bending according to the present invention, used between adjacent compressor blades in a high pressure axial compressor, as the one shown in Figure 1.

Figures 4a and 4b show details of an intermediate part without any pre-bending, used between adjacent blades in a high pressure axial compressor, according to the known prior art. Figures 4c and 4d show details of an intermediate part having certain degree of pre-bending according to the present invention, used between adjacent compressor blades in a high pressure axial compressor.

Figures 5a and 5b show details of an intermediate part having certain degree of spherical pre-bending according to a first embodiment of the present invention.

Figures 6a and 6b show details of an intermediate part having certain degree of pre-bending in two opposite directions, according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] The present invention discloses an intermediate part 1 located in a circumferential groove 4 between two adjacent compressor blades 2 and 20, typically in a compressor row in a high pressure axial compressor used in a heavy gas turbine 100, as the one shown in Figure 1. In the heavy gas turbine 100, a shaft 5 drives a central drum 6 having a plurality of circumferential grooves 4, where a plurality of blades 2 are inserted, the blades 2 rotating around the shaft 5. The intermediate part 1 presents in its rest position (shown in Figure 3) certain degree of pre-bending A in the circumferential direction 200, thanks to the elastic properties of the material making up the intermediate part 1. The material making up the intermediate part 1 must avoid any plastic deformation of said intermediate part 1. The thickness

and width of the intermediate part 1 will depend on the properties of the material configuring it.

[0016] When start-up of the compressor occurs, the drum 6 is still cold but the intermediate part 1 and the adjacent blades 2 and 20 are heated up more quickly due to air compression, which results in the intermediate part 1 being deformed. The deformation of this intermediate part 1 is effected by the elastic deformation of the material configuring said intermediate part 1, without any plastic deformation.

[0017] According to an embodiment of the invention, the intermediate part 1 is made of Nimonic 90 ® material, which is a material having an elastic behaviour similar to a spring. However, other types of materials can also be used for the intermediate parts 1, selected upon the temperature and pressure of the axial compressor.

[0018] According to a first embodiment of the invention, the intermediate part 1 is spherically pre-bended, in the circumferential direction 200 and also in the diametric direction 300, with respect to the drum 6, as shown in Figures 5a and 5b. According to a second embodiment of the invention, the intermediate part 1 is pre-bended in two opposite directions, typically in two substantially perpendicular directions: Figures 6a and 6b show an embodiment where the intermediate part 1 is pre-bended in the circumferential direction 200 and also following a direction 400 that is substantially perpendicular to the circumferential direction 200.

[0019] Any other shape of the intermediate part 1 making it to be pre-bended in such a way that the intermediate part 1 acts like a spring in the circumferential direction 200 with respect to the drum 6 is possible.

[0020] Besides, the elastic bending of the pre-bended intermediate part 1 of the invention during start-up allows avoiding any plastic deformation in the intermediate part 1, which leads to keeping in the circumferential gap between adjacent compressor blades 2 and 20, thus preventing the intermediate piece 1 from escaping during start-up of the compressor.

[0021] Different materials can be used for the intermediate part 1: the main requirement for the material choice is its good elastic properties at high temperatures; in principle, elastic - ideal plastic behavior should be targeted for. Besides, its hardness should be less than that of the material configuring the drum 6 in the compressor.

[0022] Although the present invention has been fully described in connection with preferred embodiments, it is evident that modifications may be introduced within the scope thereof, not considering this as limited by these embodiments, but by the contents of the following claims.

LIST OF DESIGNATIONS

[0023]

1	Intermediate part
2	Compressor blade
20	Adjacent compressor blade

- A Pre-bending value of the intermediate part in the circumferential direction
- 4 Circumferential groove in the drum
- 100 Heavy Gas Turbine
- 200 Circumferential direction in the drum
- 5 Shaft in the heavy gas turbine
- 6 Central drum in the compressor
- 300 Diametric direction in the drum
- 400 Direction substantially perpendicular to the circumferential direction of the drum

Claims

1. Intermediate part (1) located in a circumferential groove (4) of a drum (6) where blades (2) are inserted, the intermediate part (1) being located between two adjacent compressor blades (2, 20) in a high pressure axial compressor and presenting in its rest position certain degree of pre-bending (A) provided by the elastic properties of the material of which the cited intermediate part (1) is made, wherein the degree of pre-bending (A) is in the circumferential direction (200) with respect to the drum (6), **characterized in that** it is further pre-bended in the diametric direction (300) with respect to the drum (6), thus being configured this intermediate part (1) in a substantially spherical shape.
2. Intermediate part (1) according to claim 1, **characterized in that** it is pre-bended in two substantially perpendicular directions.
3. Intermediate part (1) according to any of the previous claims, **characterized in that** it is made of a material having high elastic properties at high temperature, and with hardness less than that of the material configuring the drum (6).
4. Intermediate part (1) according to any of the previous claims, **characterized in that** it is made of Nimonic 90 ® material.
5. Gas turbine (100) with a high pressure axial compressor, such that an intermediate part (1) according to any of claims 1-4 is located between each two adjacent compressor blades (2, 20).

Patentansprüche

1. Zwischenteil (1), das in einer Umfangsnut (4) einer Trommel (6), in die Schaufeln (2) eingeführt werden, positioniert ist, wobei das Zwischenteil (1) zwischen zwei benachbarten Verdichterschaufeln (2, 20) in einem Hochdruck-Axialverdichter positioniert ist und in seiner Ruheposition ein gewisses Maß an Vorbiegung (A) zeigt, das durch die Elastizitätseigenschaf-

ten des Materials, aus dem das angeführte Zwischenteil (1) hergestellt ist, bereitgestellt wird, wobei das Maß an Vorbiegung (A) in der Umfangsrichtung (200) bezüglich der Trommel (6) vorliegt, **dadurch gekennzeichnet, dass** es in der diametralen Richtung (300) bezüglich der Trommel (6) weiter vorgebogen wird, wodurch dieses Zwischenteil (1) in einer im Wesentlichen sphärischen Form konfiguriert ist.

2. Zwischenteil (1) nach Anspruch 1, **dadurch gekennzeichnet, dass** es in zwei im Wesentlichen senkrechte Richtungen vorgebogen wird.

3. Zwischenteil (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es aus einem Material mit Hochelastizitätseigenschaften bei hoher Temperatur und mit einer Härte, die unter der des Materials, aus dem die Trommel (6) konfiguriert ist, liegt, hergestellt ist.

4. Zwischenteil (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es aus Nimonic 90®-Material hergestellt ist.

5. Gasturbine (100) mit einem Hochdruck-Axialverdichter, wobei ein Zwischenteil (1) nach einem der Ansprüche 1-4 zwischen jeweils zwei benachbarten Verdichterschaufeln (2, 20) positioniert ist.

Revendications

1. Partie intermédiaire (1) située dans une rainure circumférentielle (4) d'un rotor (6) où sont insérées des aubes (2), la partie intermédiaire (1) étant située entre deux aubes de compresseur (2, 20) adjacentes dans un compresseur axial haute pression et présentant, dans sa position de repos, un certain degré de préflexion (A) produit par les propriétés élastiques du matériau dont la partie intermédiaire (1) est constituée, le degré de préflexion (A) étant dans la direction circonférentielle (200) par rapport au rotor (6), **caractérisée en ce qu'elle** est en outre préfléchie dans la direction diamétrale (300) par rapport au rotor (6), ladite partie intermédiaire (1) étant ainsi configurée de façon à présenter une forme essentiellement sphérique.

2. Partie intermédiaire (1) selon la revendication 1, **caractérisée en ce qu'elle** est préfléchie dans deux directions essentiellement perpendiculaires.

3. Partie intermédiaire (1) selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'elle** est constituée d'un matériau présentant des propriétés de haute élasticité à haute température, et présentant une dureté inférieure à celle du maté-

riau dont est constitué le rotor (6).

4. Partie intermédiaire (1) selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'elle** est constituée du matériau Nimonic 90®. 5
5. Turbine à gaz (100) comportant un compresseur axial haute pression, tel qu'une partie intermédiaire (1) selon l'une quelconque des revendications 1 à 4 est située entre chaque paire d'aubes de compresseur (2, 20) adjacentes. 10

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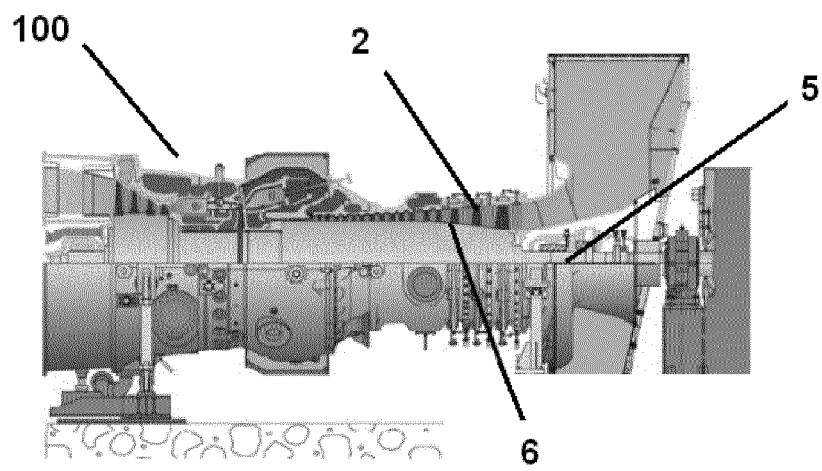


FIG. 1

1.

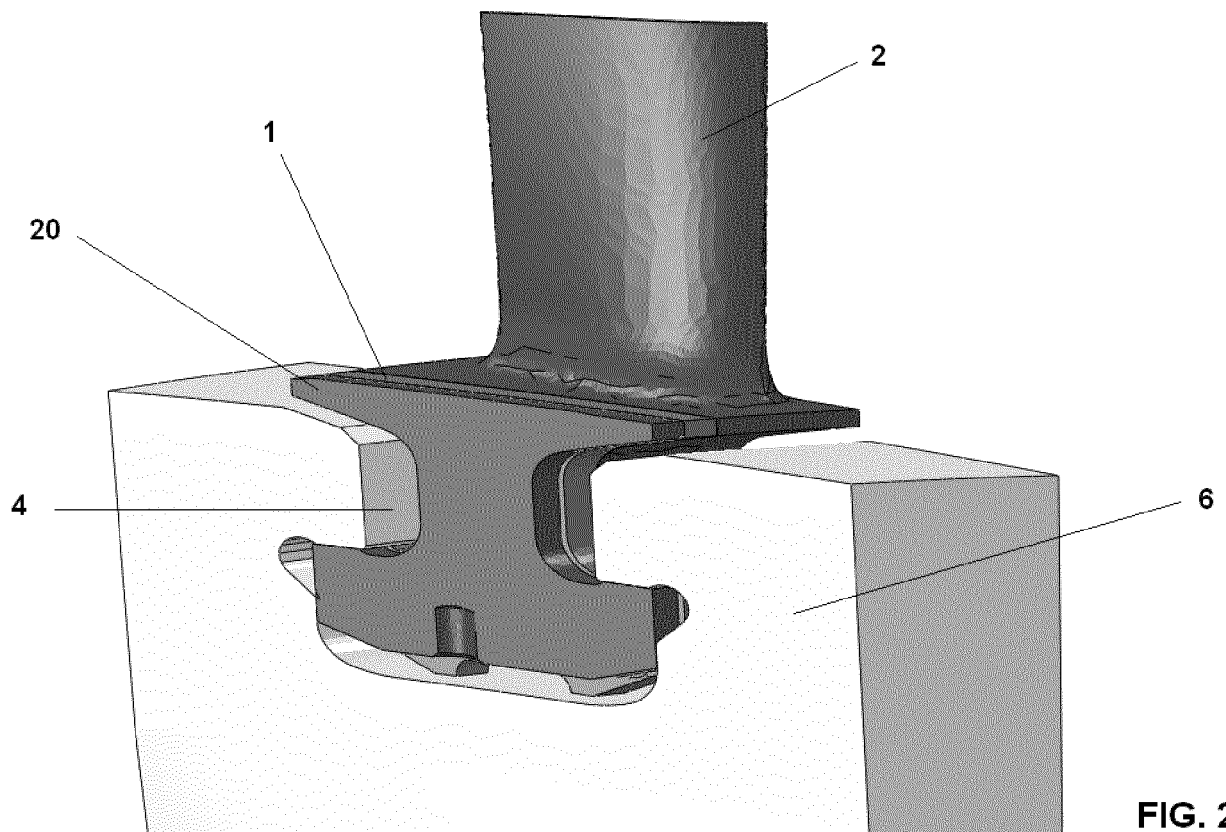


FIG. 2

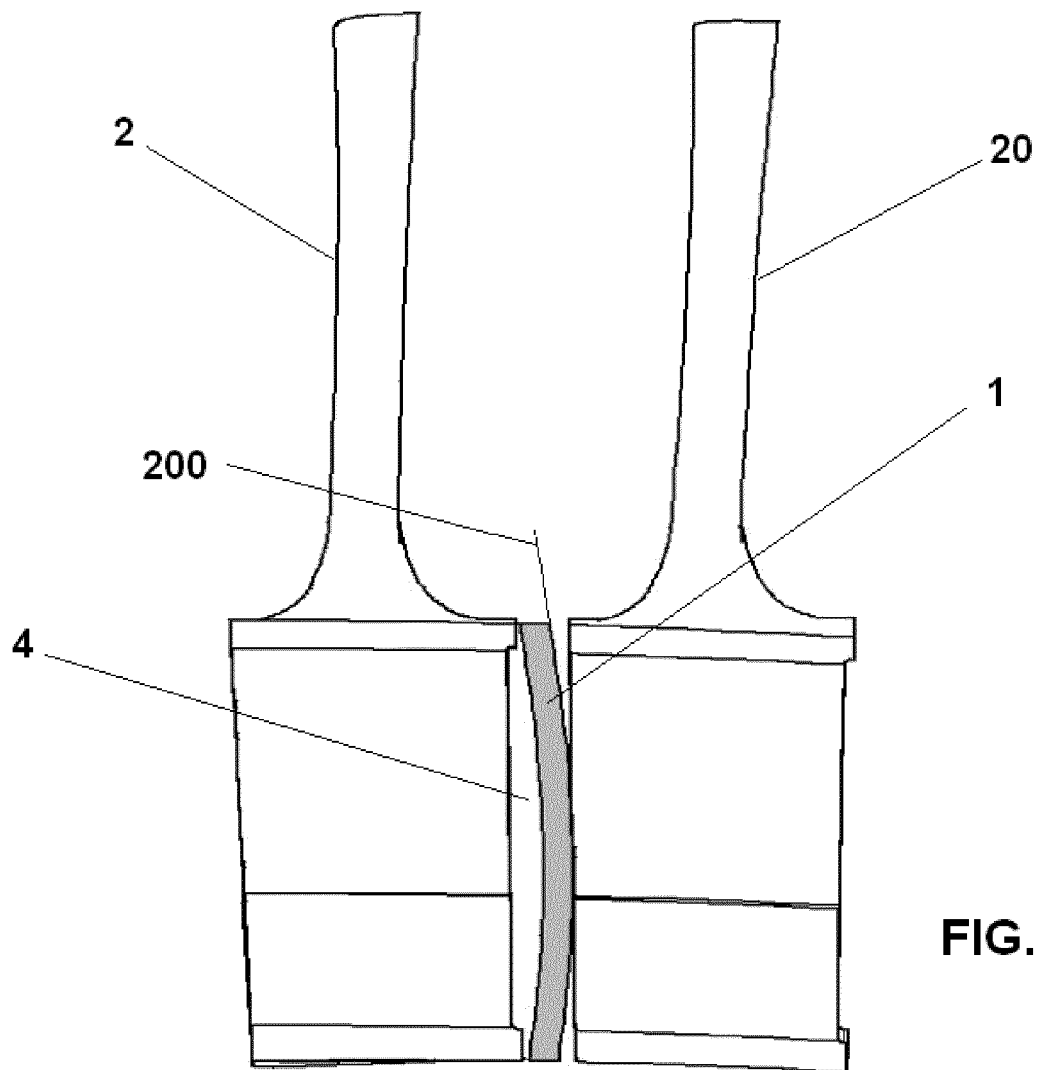


FIG. 3

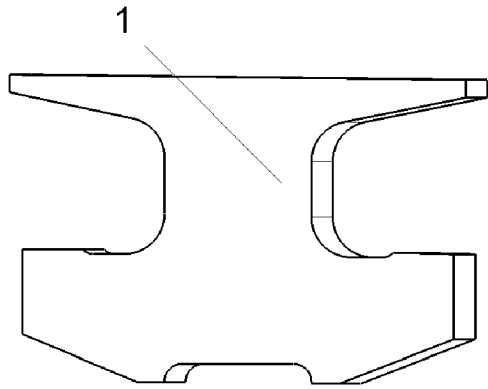


FIG. 4a
P Art

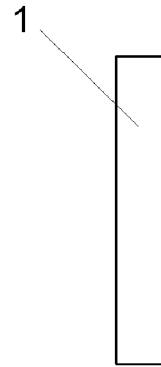


FIG. 4b
P Art

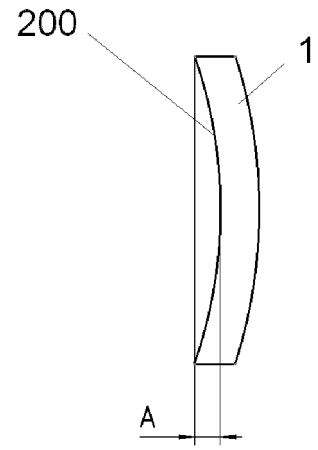


FIG. 4c

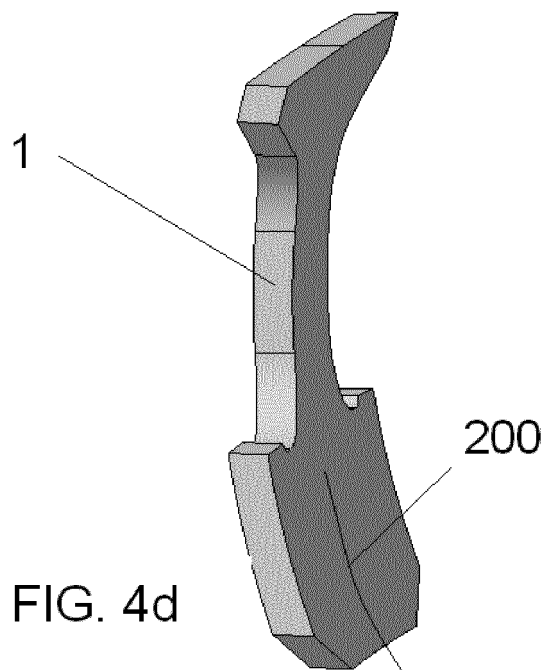
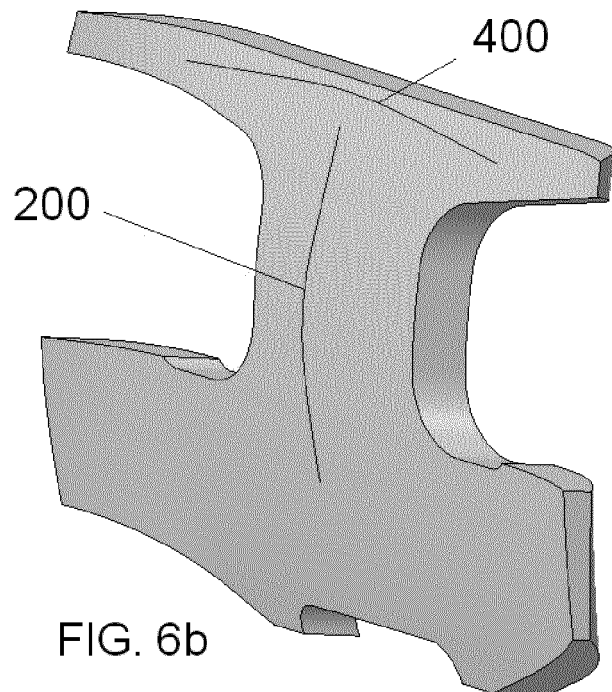
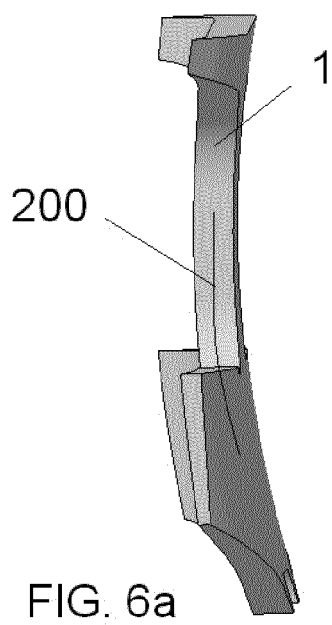
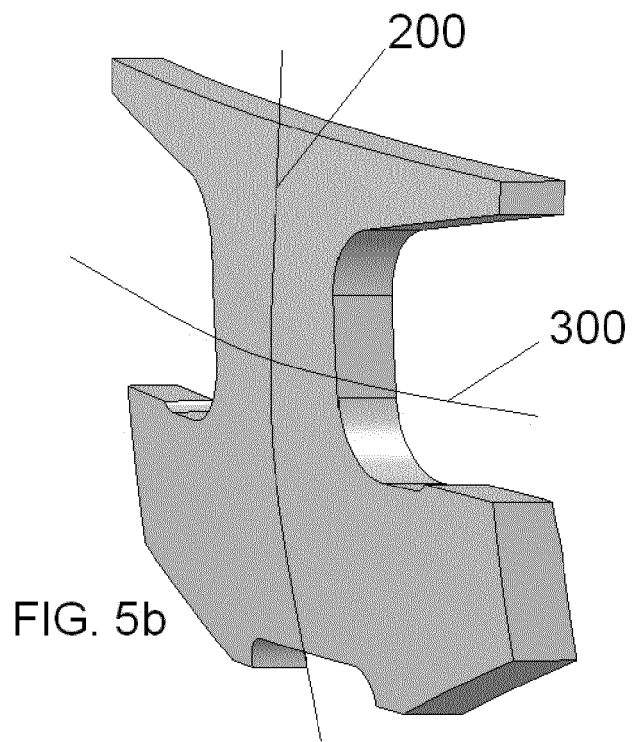
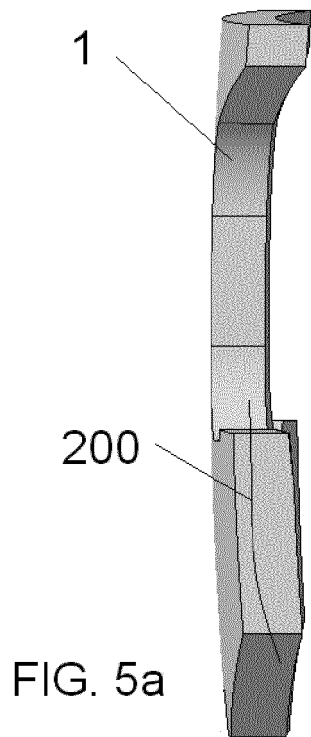


FIG. 4d



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20100135782 A1 [0004]
- GB 687507 A [0005]
- GB 2169664 A [0006]