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(54) **FASTENING OF A TURBINE BLADE WITH TREE-SHAPED ROOT IN A TURBINE ROTOR BY MEANS OF A DEFORMABLE FIXATION WEDGE AND A SECURING ELEMENT**

FIXIERUNG EINER TURBINENSCHAUFEL MIT TANNENBAUMFÖRMIGEN FUSS IN TURBINENROTOR MITTELS EINES DEFORMIERBAREN FIXIERKEILS UND SICHERUNGSELEMENTS

FIXATION À UN ROTOR DE TURBINE D'UNE AUBE ROTORIQUE DE TURBINE AVEC PIED DE SAPIN PAR UNE CALE DÉFORMABLE ET UN ÉLÉMENT DE FIXATION

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Description

Technical field

[0001] The invention relates to an arrangement of a turbine blade with a straight or circular tree-shaped root in a groove in a rotor of a turbine, in particular a steam or gas turbine.

[0002] The invention also relates to a turbine, in particular a steam or gas turbine, in which at least some of the turbine blades are arranged in this manner.

Background art

[0003] Several different types of arrangement and securing of a turbine blade with a straight or circular tree-shaped root in a groove in a turbine rotor are currently known. For example, U.S. 4,767,275 discloses an arrangement of a blade with a circular tree-shaped root where adjacent blades are interconnected by a shaped lock formed at the root base and the blade is secured by a pin which extends over the entire width of the root base of one blade to the root base of the adjacent blade. This pin is fixedly mounted in an aperture in the root base of the first blade and is loosely received in an aperture in the root base of the adjacent blade which allows the adjacent blades to vibrate independently of one another. The disadvantage of this solution is above all the fact that the apertures for the pins are provided in high stress regions of blades, and thus weaken their structure.

[0004] EP 1643082 describes an arrangement of a turbine blade with a circular tree-shaped root, in which a widening longitudinal groove is provided at the tip of a blade root. In the groove is mounted a wedge-shaped bent spring which is mounted with its end folds in radial grooves in a rotor, whereas its straight ends rest against the faces of the blade root, by which means it prevents the turbine blade from undesirable movement in the direction of the axis of the turbine rotor. The disadvantage of this solution is the limited capability of cushioning some of the forces acting on the blade, which may cause unwanted displacement of the blade in the groove. In addition, it is not possible to check the condition of the bent spring during installation and after it and confirm that it has not been damaged during installation. A further disadvantage is the fact that it is quite difficult to predefine the compressive force applied to each turbine blade and to make sure that the same compressive force is applied to all the turbine blades.

[0005] Document EP2299060 discloses a securing device for axially and radially securing turbine blade to a rotor, wherein the rotor comprises a blade groove and the turbine blade comprises a turbine blade root, wherein the blade groove and the turbine blade root are designed such that the turbine blade root is adapted in the blade groove, wherein the securing device essentially comprises three components - a shear pin, a clamping piece and securing element. The shear pin is introduced into a bore in the blade root and rests against an edge/face of the rotor. The securing element is designed as locking plate having a projection resting in a corresponding groove and an end piece, which is bent perpendicularly in relation to a main piece and prevents clamping piece from falling out of the groove. Clamping piece having an upper leg and lower leg is pushed into the groove in such a way that the shear pin rests on its lower leg. In this setup, the clamping device, which is pushed in the groove in rotor of the turbine is secured against axial displacement outwardly from the groove by means of securing element, and at the same time supports, without contact with the rotor the shear pin, positioned in a bore in the blade root and resting against an edge/face of the rotor and thus securing the blade root against axial movement.

[0006] Document US 2012/177498 discloses an axial retention device for a turbine system, the axial retention device comprising a pocket defined in a mating surface of one of a turbine component (e.g. blade) and a support structure (e.g. rotor). The pocket includes a first axial load surface and a latch comprising a base member and a pivotal member, the base member being associated with a mating surface of the other of the turbine component and the support structure, the pivotal member being configured to engage the pocket and including a first mating axial load surface. Engagement of the pivotal member and the pocket allows the first axial load surface and the first mating axial load surface to interact, preventing axial movement of the turbine component with respect to the support structure in at least one direction. In general, the pocket may be defined in one of the turbine component and the support structure, and the base member of the latch may be associated with the other of the turbine component and the support structure. For example, the pocket may be associated with the support structure and the base member may be defined in the turbine component or vice versa.

[0007] Furthermore, an arrangement of a turbine blade is known from practice in which a wedge is arranged in the bottom of a groove in a rotor to secure the turbine blade. A metal hook is arranged on the wedge towards the tip of the turbine blade root, whereby the opposite ends of the hook are curved to opposite sides, one of them being mounted in a transverse groove formed at the tip of the blade root, the other constituting a support surface for the outer face of the wedge. The drawback of this solution is a low level of cushioning some components of forces acting on the blade, which may cause unwanted displacement of the blade in the groove.

[0008] The aim of the invention is to provide an arrangement of a turbine blade with a straight or circular tree-shaped root in a groove in a turbine rotor, which would not suffer from the drawbacks of the types of arrangement which have been used so far.

[0009] In addition, the aim of the invention is a turbine in which at least some of the turbine blades are arranged in this manner.

Principle of the invention

[0010] The aim of the invention is achieved by an arrangement of a turbine blade with a straight or circular tree-shaped according to claim 1.

[0011] Between the tip of the root of the turbine blade and the bottom of the groove in the rotor, a locking wedge deformed in a controlled manner is inserted with an overlap in the radial direction, whereby the locking wedge is on its inner side over its entire width provided with a deformation groove and is in contact with the face of the recess at the tip of the root of the turbine blade and from the outer side is secured against axial displacement outwardly from the groove in the rotor by means of a securing element arranged demountably in the groove in the rotor or extending to the groove in the rotor. The securing element is formed by a securing pin arranged in a radial aperture in the bottom of the groove in the rotor. The locking wedge is provided with a means which extends to the space between the pin and the tip of the root of the turbine blade and secures the securing pin against unwanted movement in the radial direction, such a means being a pair of lamellas, which, after installation, are bent to the space above the top of the securing pin.

[0012] To facilitate the assembly and, in case of need, also disassembly, it is advantageous if the locking wedge is provided with an elevated bearing surface on its lower and/or upper surface, whereby the radial overlap of its mounting in the space between the tip of the root of the turbine blade and the bottom of the rotor groove is realized only in the space of the bearing surface/surfaces.

[0013] In addition to the arrangement of the turbine blade, the aim of the invention is also achieved by a turbine, especially a steam or gas turbine, having turbine blades with a straight or circular tree-shaped root mounted in a groove in the turbine rotor, whose principle consists in that at least some turbine blades are arranged in the manner according to the invention.

Description of drawings

[0014] In the drawings, Fig.1 schematically shows a part of a sectional view of a steam turbine rotor with turbine blades arranged in exemplary embodiment of the arrangement of the turbine blade according to the invention with a locking wedge and a securing pin; Fig. 2 schematically shows a detail of this embodiment of the arrangement of the turbine blade and Fig. 3 schematically shows a view of the locking wedge and the securing pin of Figure 2 in the direction of the axis of the turbine rotor.

Examples of embodiment

[0015] An arrangement of a turbine blade in a groove in a rotor according to the invention will be further described with reference to a variant of arrangement of terminal turbine blade of a steam turbine with a circular tree-shaped root, which is schematically shown in different views in Fig. 1 to Fig. 3. However, as is obvious to the person skilled in the art, this arrangement can also be used without further adaptations for the arrangement of a moving blade with a straight tree-shaped root, or the elements used may be created and/or arranged in a manner different than shown and described.

[0016] The turbine blade **1** of the turbine is provided in its lower part with a well-known tree-shaped root **10** with conical contact surfaces **100**. The tree-shaped root **10** is arranged in a groove **20** of a corresponding shape in the turbine rotor **2**. To secure the turbine blade **1** against undesirable displacement in the direction of the axis of the rotor **2** of the turbine (arrow A), recesses **110** are formed from the outer side on both sides of the tip **11** of the tree-shaped root **10**, that is, from the side of the inlet and outlet, and within the space of these recesses **110** between the tip **11** of the root **10** of the turbine blade **1** and the bottom **21** of the groove **20** in the rotor **2** locking wedges **3** deformed in a controlled manner are inserted, with overlap in the radial direction. These locking wedges **3** are on their inner side along their entire width provided with a deformation groove **30**, which increases their deformability. The locking wedges **3** are in contact with the faces **111** of the recesses **110**. Preferably, but not necessarily, the deformation grooves **30** are widening continuously towards the end of the locking wedges **3**. From the outer side, the locking wedges **3** are secured against unwanted movement in the direction of the axis of the turbine rotor **2** by a securing element demountably arranged in the groove **20** in the rotor **2** or extending to the groove **20** in the rotor **2**. The securing element is a securing pin **4** arranged in a radial aperture **40** formed in the bottom **21** of the groove **20** in the rotor **2**. Preferably, the locking wedge **3** is on the outer side against which rests the securing pin **4** provided with a suitably shaped bearing surface, which is rounded in the shown variant of embodiment. Preferably, it is provided at the same time with a means which extends to the space between the securing pin **4** and the surface of the recess **110** and secures the securing pin **4** against undesirable movement in the radial direction (arrow B). In the illustrated variant of embodiment, this means is formed by a pair of lamellas **31** arranged on the outer side of the locking wedge **3**. Between the lamellas **31**, there is sufficient space for insertion of the securing pin **4** into the radial aperture **40** in the bottom **21** of the groove **20** in the rotor **2**. After insertion of the securing pin **4**, these lamellas **31** are bent towards each other and above the top of the securing pin **4**. In other embodiments not shown, a securing means can be, for example, a suitable rigid projection on the outer side of the locking wedge **3**, or, alternatively, the locking wedge **3** and the securing pin **4** may be connected by a suitable shaped lock or a connecting element, such as a bolt, a pin, etc. The illustrated variant in which the locking wedge **3** is secured from the outer side by the securing pin **3** seems to be the most appropriate in terms of manufacturing, mounting and reliability, but in other embodiments not covered by the

invention, other structural elements and measures can be used - for example, as a securing element it is possible to use a bolt which passes from the outer side askew into a skew aperture in the bottom **21** of the groove **20** in the rotor **2**, etc. Alternatively, in a variant not covered by the invention, the securing pin **4** can be inserted in an aperture arranged in the wall of the groove **20** in the rotor **2** such that it extends directly or askew at least over a part of the width of the groove **20**, etc.

[0017] In the embodiment shown, the locking wedge **3** is provided with an elevated contact surface **32** on its upper surface, whereby radial overlap in the arrangement of the locking wedge **3** in the space between the tip **11** of the root **10** of the turbine blade **1** and the bottom **21** of the groove **20** in the rotor **2** only occurs on this contact surface **32**. However, this embodiment is not a necessary condition and the elevated contact surface **32** can be formed in other variants of embodiment also or only on the lower surface of the locking wedge **3**. In other variants of embodiment, the contact surface **32** is formed by the entire upper and/or by the lower surface of the locking wedge **3**.

[0018] In order to ensure mutual fitting and uniform surface contact, it is preferable, but not necessary, if a recess **210** is provided in the bottom **21** of the groove **20** in the rotor **2** with a bearing surface for the locking wedge **3**.

[0019] In the illustrated variant of embodiment, the locking wedge **3** is on its inner side, on the upper and lower surfaces, provided with a chamfer **33**, which facilitates the insertion of the locking wedge **3** into the space between the tip **11** of the root **10** of the turbine blade **1** and the bottom **21** of the groove **20** in the rotor **2**. In other variants, however, the chamfer **33** may be formed only on one surface of the locking wedge **3**, or it may be formed on at least one side surface of the locking wedge **3**, or it does not have to be formed at all.

[0020] Due to its location, the locking wedge **3** cushions components of forces acting on the turbine blade **1** on its surface which is in contact with the face **111** of the recess **110** and reliably prevents displacement of the turbine blade **1** in the direction of the axis of the turbine rotor **2**. Moreover, due to its controlled deformation, occurring during insertion, the locking wedge **3** pushes the contact surfaces **100** of the root **10** of the turbine blade **1** into contact with the respective surfaces of the groove **20** in the rotor **2**, thereby fixing the turbine blade **1** also in the radial direction. Compared to the known method of securing, this radial compressive force is lower and the turbine blade **1** is not inserted in the rotor **2** on tight.

[0021] The arrangement and securing of the turbine blades **1** is then performed in a position with the paddle of the turbine blade **1** directed downwards, whereby each turbine blade is inserted into the respective groove **20** in the rotor **2** and aligned radially according to the blading plan. Once aligned axially, the locking wedge **3** is inserted into the space between the tip **11** of the root **10** of the turbine blade **1** and the bottom **21** of the groove **20** in the rotor **2**, until it contacts the face **111** of the recess **110**. Then the securing element is arranged and, if necessary, it is secured against unwanted movement in the radial direction - in the illustrated variant of embodiment, by bending the lamellas **31** on the outer side of the locking wedge **3** above it, etc.

[0022] The described method of the arrangement and securing of a turbine blade **1** can be combined with other well-known methods, when, for example, on the opposite sides of one turbine blade **1** different methods are used.

[0023] In the case of a turbine, especially a steam or gas turbine, at least a part of the moving blades **1** arranged in the grooves **20** in the rotor **2** are arranged in this manner. This applies particularly, but not necessarily, to terminal turbine blades **1**.

List of references

[0024]

1	turbine blade
10	tree-shaped root of the turbine blade
100	contact surface of the tree-shaped root of the turbine blade
11	tip of the tree-shaped root of the turbine blade
110	recess at the tip of the tree-shaped root of the turbine blade
111	face of the recess at the tip of the tree-shaped root of the turbine blade
2	rotor of the turbine
20	groove in the rotor of the turbine
21	bottom of the groove in the rotor of the turbine
210	recess in the bottom of the groove in the rotor of the turbine
3	locking wedge
30	deformation groove of the locking wedge
31	lamella of the locking wedge
32	contact surface of the locking wedge
33	chamfer of surface of the locking wedge
4	securing pin
40	radial aperture for the securing pin

Claims

1. An arrangement of a turbine blade (1) with a straight or circular tree-shaped root (10), the arrangement comprising:

   - a turbine blade (1) with a straight or circular tree-shaped root (10), said root (10) having a tip (11);
   - a rotor (2) of a turbine comprising a groove (20) with a bottom;
   - a locking wedge (3) comprising on its inner side over its entire width a deformation groove (30); and
   - securing element;
   - wherein the turbine blade (1) is arranged by its

root (10) in the groove (20) of the rotor (2);
- wherein at the tip (11) of the root (10) of the turbine blade (1) at least from one side of the turbine blade (1), a recess (110) is formed from an outer side; and
- within a space of the recess, between the tip (11) of the root (10) of the turbine blade (1) and the bottom of the groove (20) in the rotor (2) the locking wedge (3) deformed in a controlled manner is inserted with an overlap in the radial direction,
- wherein the locking wedge (3) is in contact with a face (111) of the recess (110) at the tip (11) of the root (10) of the turbine blade (1); and
- wherein from an outer side is secured against the axial displacement outwardly from the groove (20) in the rotor (2) by means of the securing element arranged demountably in the groove (20) in the rotor (2) or extending to the groove (20) in the rotor (2);
- wherein the securing element is formed by a securing pin (4) arranged in a radial aperture (40) in the bottom (21) of the groove (20) in the rotor (2), and
- wherein the locking wedge (3) is provided with a means which extends to the space between the securing pin (4) and the tip (11) of the root (10) of the turbine blade (2) and secures the securing element against movement in the radial direction.

2. The arrangement according to claim 1, **characterized in that** the means extending to the space between the securing pin (4) and the tip (11) of the root (10) of the turbine blade (1) and securing it against movement in the radial direction is a pair of lamellas (31) arranged on the outer side of the locking wedge (3).

3. The arrangement according to claim 1 or 2, **characterized in that** the locking wedge (3) is provided on its lower and/or upper outer surface with an elevated contact surface (32), whereby the radial overlap of its arrangement in the space between the tip (11) of the root (10) of the turbine blade (1) and the bottom (21) of the groove (20) in the rotor (2) of turbine is realized only in the space of the contact surface/surfaces (32).

4. A turbine, especially a steam or gas turbine, having turbine blades (1) with a straight or circular tree-shaped root (10) arranged in a grooves (20) in a rotor (2) in a manner according to any of claims 1 to 3.

Patentansprüche

1. Lagerung einer Laufschaufel (1) mit einem direkten oder kreisförmigen Tannenbaumfuß (10), die:

- eine Laufschaufel (1) mit einem direkten oder kreisförmigen Tannenbaumfuß (10), wobei dieser Fuß (10) eine Spitze (11) aufweist;
- einen Rotor (2) einer Turbine, der eine Nut (20) mit einem Boden aufweist;
- einen Sicherungskeil (3), der auf der Innenseite auf seiner ganzen Breite eine Verformungsnut (30) aufweist; und
- ein Sicherungselement aufweist;
- wobei die Laufschaufel (1) mit ihrem Fuß (10) in der Nut (20) des Rotors (2) angeordnet ist;
- wobei auf der Spitze (11) des Fußes (10) der Laufschaufel (1) mindestens von einer Seite der Laufschaufel (1) von der Außenseite her eine Ausnehmung (110) gebildet wird; und
- im Raum von dieser Ausnehmung zwischen der Spitze (11) des Fußes (10) der Laufschaufel (1) und dem Boden der Nut (20) im Rotor (2) mit einem Überhang in der Radialrichtung ein gesteuert verformter Sicherungskeil (3) gelagert ist,
- wobei der Sicherungskeil (3) mit der Stirnseite (111) der Ausnehmung (110) auf der Spitze (11) des Fußes (10) der Laufschaufel (1) im Kontakt steht; und
- wobei dieser von der Außenseite her gegen axiale Verschiebung in der Richtung nach außen aus der Nut (20) im Rotor (2) durch ein Sicherungselement gesichert ist, das in der Nut (20) im Rotor (2) lösbar gelagert ist oder das in die Nut (20) im Rotor (2) eingreift;
- wobei das Sicherungselement durch einen Sicherungsstift (4) gebildet wird, der in einer Radialöffnung (40) im Boden (21) der Nut (20) im Rotor (2) gelagert ist, und
- wobei der Sicherungskeil (3) ein Mittel aufweist, das in den Raum zwischen den Sicherungsstift (4) und die Spitze (11) des Fußes (10) der Laufschaufel (2) eingreift und das Sicherungselement gegen die Bewegung in der Radialrichtung sichert.

2. Lagerung nach dem Anspruch 1, **dadurch gekennzeichnet, dass** das Mittel, das in den Raum zwischen den Sicherungsstift (4) und die Spitze (11) des Fußes (10) der Laufschaufel (1) eingreift und diesen gegen die Radialbewegung sichert, ein Paar von Lamellen (31) ist, die auf der Außenseite des Sicherungskeiles (3) angeordnet sind.

3. Lagerung nach dem Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** der Sicherungskeil (3) auf seiner unteren und/oder oberen Außenfläche eine erhöhte Auflagefläche (32) aufweist, wobei der radiale Überhang seiner Lagerung im Raum zwischen der Spitze (11) des Fußes (10) der Laufschaufel (1)

und dem Boden (21) der Nut (20) des Rotors (2) nur im Raum von dieser Auflagefläche/diesen Auflageflächen (32) erfolgt.

4. Turbine, insbesondere eine Dampf- oder Gasturbine, mit Laufschaufeln (1) mit einem direkten oder kreisförmigen Tannenbaumfuß (10), der in den Nuten (20) im Rotor (2) der Turbine mit dem Verfahren nach dem Anspruch 1 bis 3 gelagert ist.

Revendications

1. Agencement d'une lame orbitale (1) avec charnière arborescente droite ou circulaire (10) comprenant :

- une lame orbitale (1) avec charnière arborescente droite ou circulaire (10), où la charnière (10) dispose d'un sommet (11) ;
- un rotor (2) de turbine qui comprend une rainure (20) avec un fond ;
- une cale d'immobilisation (3) qui est, sur le côté intérieur et sur toute sa largeur, équipée d'une rainure de déformation (30) ; et
- un élément de sécurité ;
- où la lame orbitale (1) est disposée à l'aide de sa charnière (10) dans la rainure (20) du rotor (2) ;
- où un évidement (110) est formé au sommet (11) de la charnière (10) de la lame orbitale (1) sur au moins un côté de la lame orbitale (1) de l'extérieur ; et
- dans l'espace de cet évidement est disposée, entre le sommet (11) de la charnière (10) de la lame orbitale (1) et le fond de la rainure (20) dans le rotor (2), avec un chevauchement dans la direction radiale, une cale d'immobilisation (3) à déformation contrôlée,
- la cale d'immobilisation (3) est en contact avec la face (111) de l'évidement (110) au sommet (11) de la charnière (10) de la lame orbitale (1) ; et
- la cale est sécurisée de l'extérieur contre un déplacement axial vers l'extérieur de la rainure (20) dans le rotor (2) à l'aide de l'élément de fixation, disposé de manière démontable dans la rainure (20) dans le rotor (2) ou étendu jusqu'à la rainure (20) dans le rotor (2) ;
- l'élément de fixation comprend une broche de fixation (4) disposée dans l'ouverture radiale (40) dans le fond (21) de la rainure (20) dans le rotor (2), et
- la cale d'immobilisation (3) est munie d'un outil qui s'étend dans l'espace entre l'élément de fixation (4) et le sommet (11) de la charnière (10) de la lame orbitale (2) et protège l'élément de fixation contre tout mouvement dans la direction radiale.

2. Agencement selon la revendication 1, **caractérisé en ce que** l'outil qui s'étend dans l'espace entre la broche de fixation (4) et le sommet (11) de la charnière (10) de la lame orbitale (1) pour le protéger contre un mouvement radial, est une paire de lamelles (31) disposées sur le côté extérieur de la cale d'immobilisation (3).

3. Agencement selon la revendication 1 ou 2, **caractérisé en ce que** la cale d'immobilisation (3) est pourvue, sur sa surface extérieure inférieure et/ou supérieure, d'une surface d'appui surélevée (32), où le chevauchement radial de son agencement dans l'espace entre le sommet (11) de la charnière (10) de la lame orbitale (1) et le fond (21) de la rainure (20) du rotor (2) est réalisé uniquement dans l'espace de cette/ces surface/s d'appui (32).

4. Turbine, notamment à vapeur ou à gaz, comportant des lames orbitales (1) avec charnière arborescente (10) droite ou circulaire, montée dans les rainures (20) du rotor (2) de la turbine de la manière selon les revendications 1 à 3.

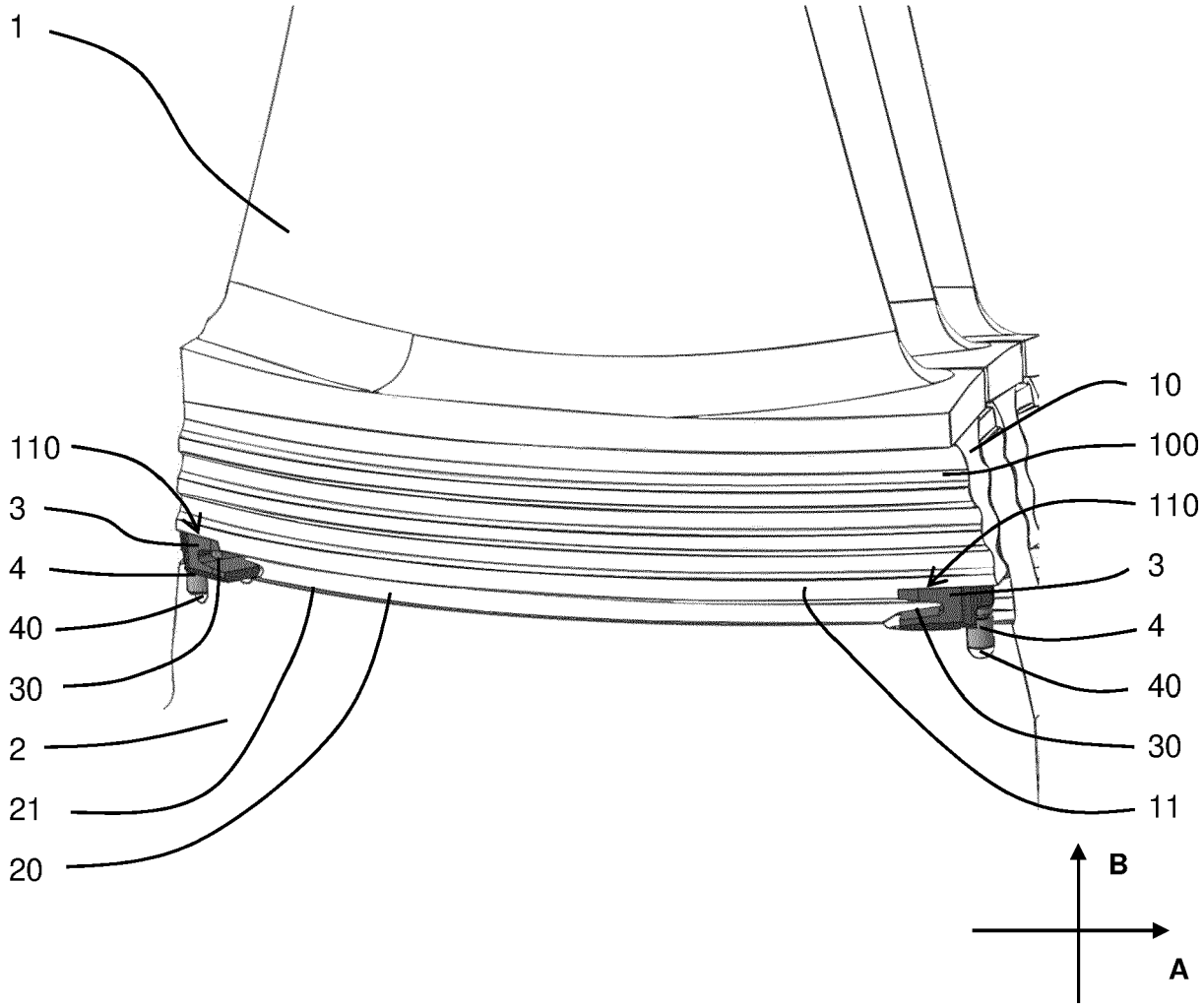

Fig. 1

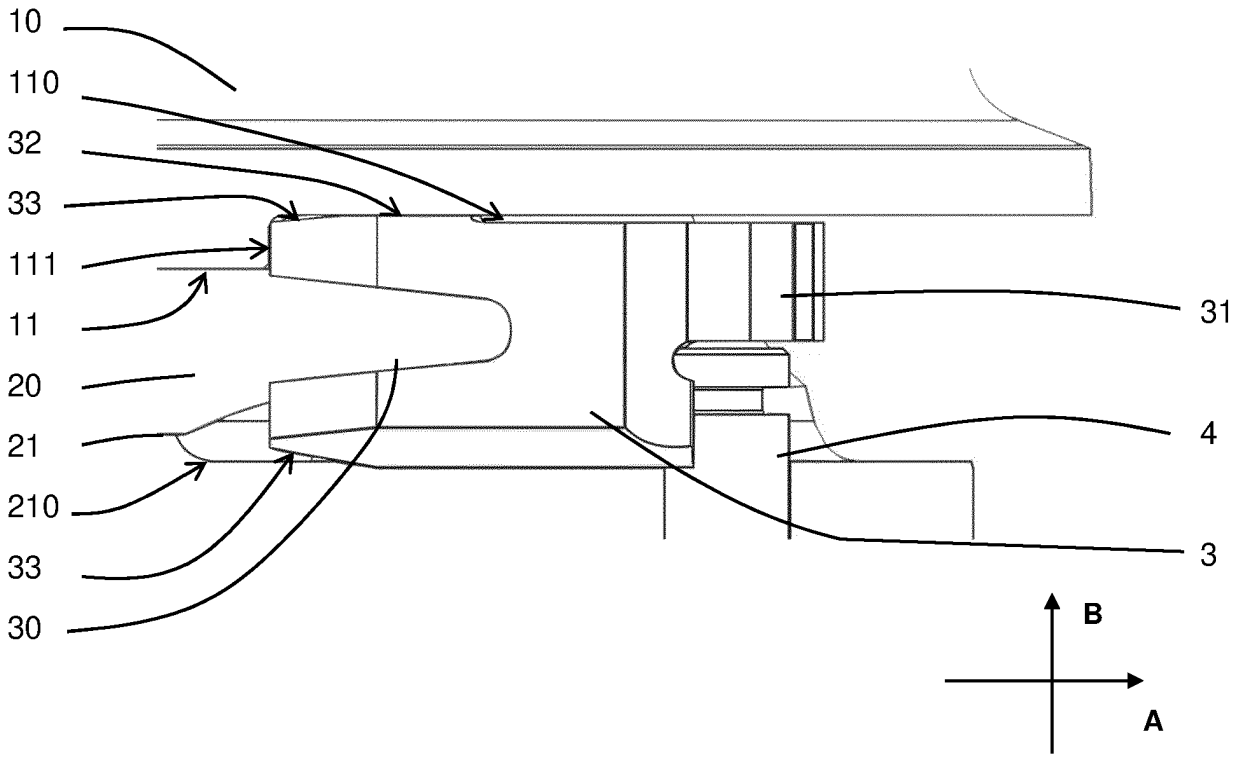
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Fig. 2

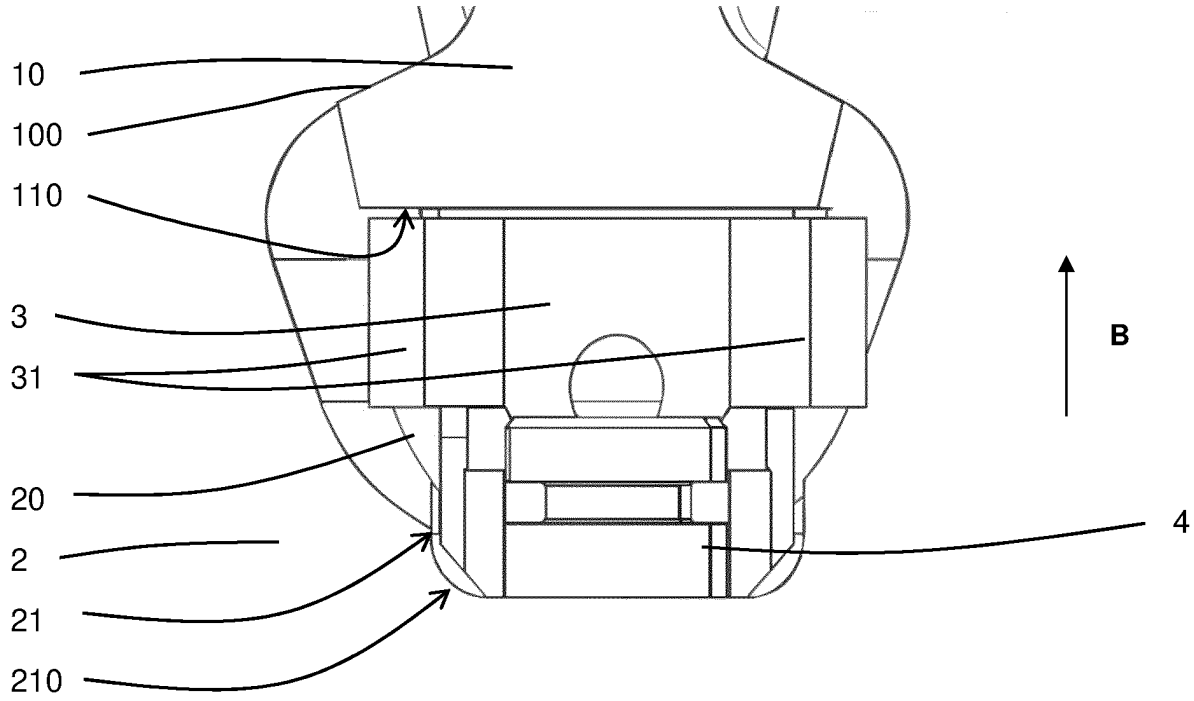
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Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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