US 20110299989A1

(19) **United States**

(12) **Patent Application Publication**

**Richter**

(10) **Pub. No.: US 2011/0299989 A1**

(43) **Pub. Date: Dec. 8, 2011**

(54) **BLADE UNION OF A TURBO MACHINE**

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(21) Appl. No.: **13/201,893**

(22) PCT Filed: **Jan. 27, 2010**

(86) PCT No.: **PCT/EP2010/050936**

§ 371 (c)(1),
(2), (4) Date: **Aug. 17, 2011**

(30) **Foreign Application Priority Data**

Feb. 17, 2009 (EP) ..... 09002224.5

**Publication Classification**

(51) **Int. Cl.**
*F01D 5/22* (2006.01)

(52) **U.S. Cl.** ..... **416/189**

(57) **ABSTRACT**

A damping system for damping the vibrations of a blade union is provided. The blades arranged in a neighboring manner are coupled to one another via a coupling element, wherein the coupling element is arranged fixed in a first blade and extends into the second blade, wherein the coupling element is not arranged in the second blade but rather solely contacts there such that, as a consequence of centrifugal forces, a free end of the coupling element presses against the second blade and a friction force thus occurs, leading to an energy dissipation and vibrations being thus damped.

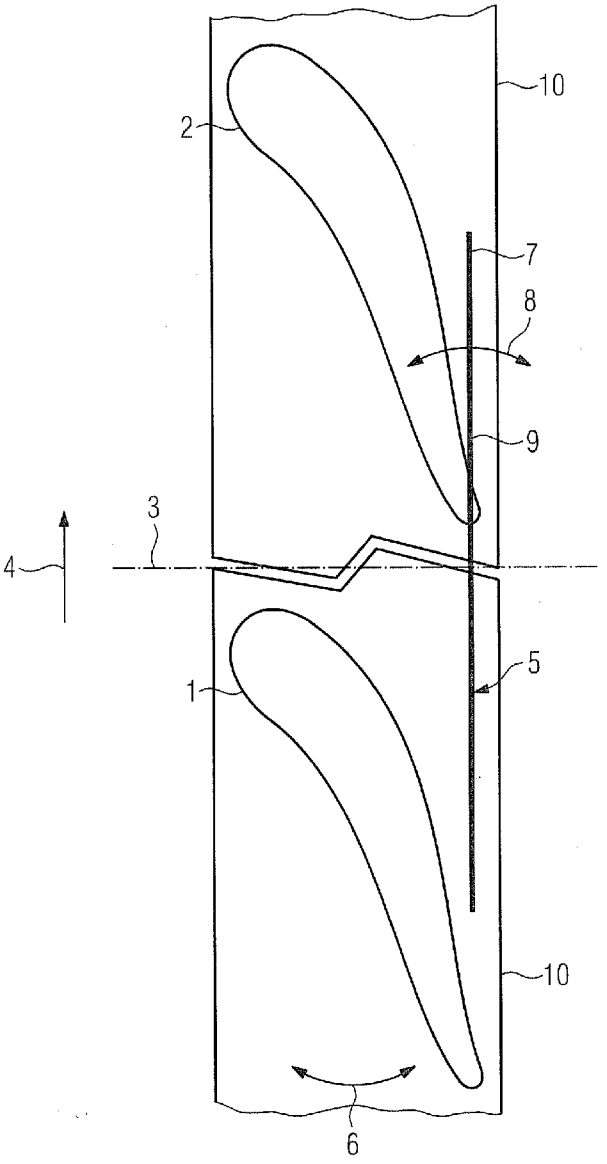


FIG 1

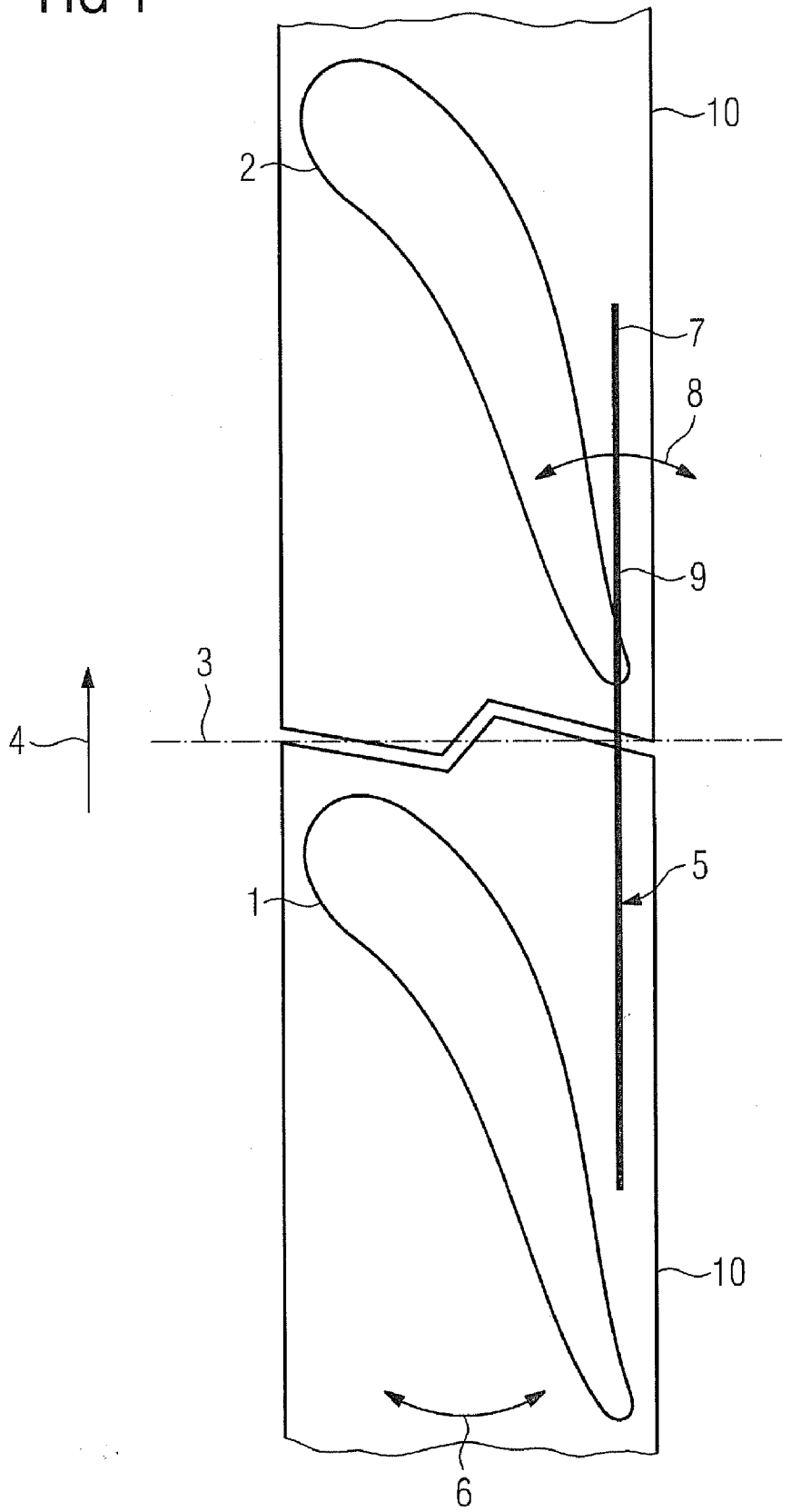


FIG 2

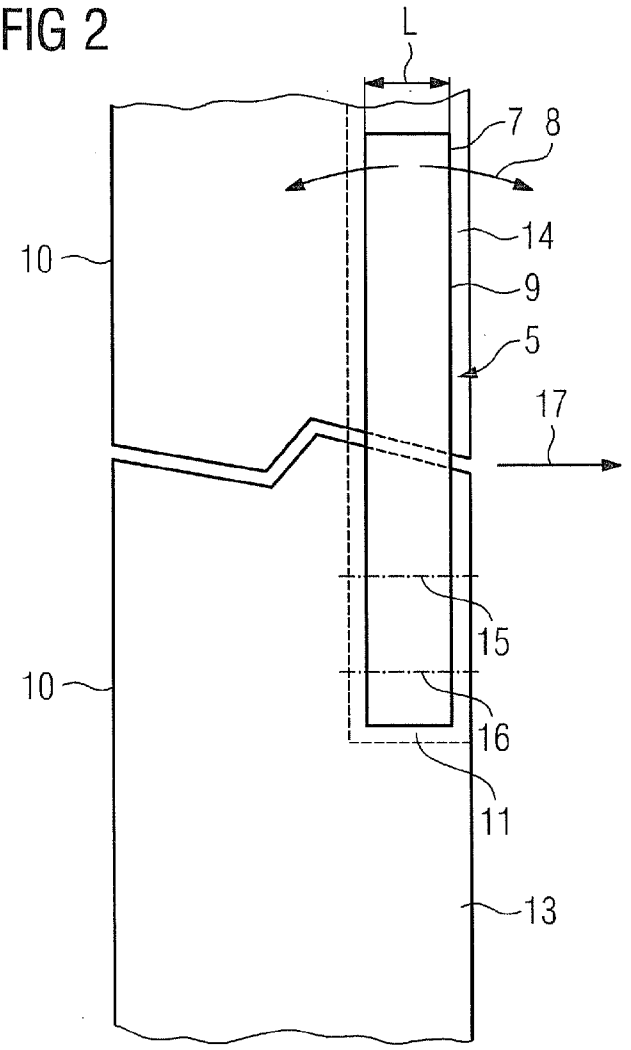
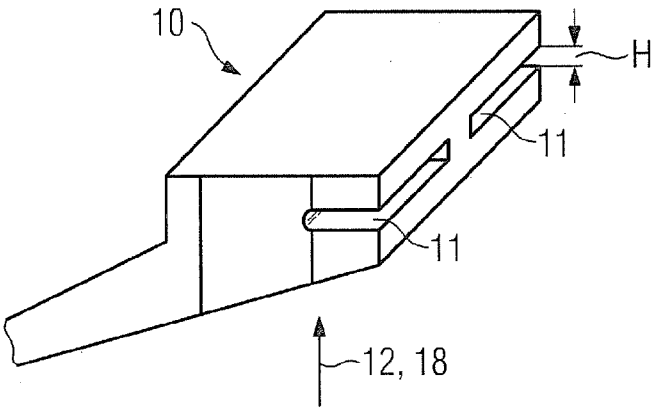



FIG 3



# BLADE UNION OF A TURBO MACHINE

## CROSS REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is the US National Stage of International Application No. PCT/EP2010/050936, filed Jan. 27, 2010 and claims the benefit thereof. The International Application claims the benefits of European Patent Office application No. 09002224.5 EP filed Feb. 17, 2009. All of the applications are incorporated by reference herein in their entirety.

## FIELD OF INVENTION

**[0002]** The invention refers to an arrangement comprising a first blade and a second blade which is arranged adjacent to the first blade.

## BACKGROUND OF INVENTION

**[0003]** Compressors, gas turbines or steam turbines, for example, are to be understood by turbomachines in the sense of this application. The aforesaid turbomachines have in common the fact that they comprise a casing and a rotor which is rotatably mounted in the casing, wherein a flow passage, through which flows a flow medium, is formed between the rotor and the casing. The flow medium is steam in steam turbines. During operation of the steam turbine, there is the risk that the flow over the streamlined rotor blades creates vibration of the blades, which leads to disturbing effects. For example, a rotor blade could be damaged in the form of a crack. Therefore, attempts are undertaken to modify the rotor blades in such a way that vibrations are avoided or damped so that no damage to the rotor blades occurs.

**[0004]** It is known to connect the shrouds of rotor blades by a single wire so that vibrations are damped, with the result that relative movements between the shrouds are prevented.

**[0005]** From DE 697 04 001 T1 it is known to arrange a pin in shrouds, which pins are movably arranged in so-called blind holes.

**[0006]** In DE 102 56 778 A1, the shrouds are not rotordynamically intercoupled, but rather the root shrouds are.

**[0007]** A further problem of vibration excitations is that the rotor blades execute vibrations as a consequence of the vibration excitations, which vibrations lead to material fatigue both of the turbine blade and of the rotor steeple in which the turbine blade is arranged. It would be desirable to achieve a reduction of the vibration amplitudes, which leads to a reduction of the material stress.

**[0008]** It is furthermore known to arrange holes in turbine blades and to insert a dry granulate into these. Vibrations in the region of the volume which is filled with granulate lead to movements of the granulate. Since this movement is accompanied by internal friction, damping is also associated therewith.

**[0009]** It is also furthermore known to arrange granulates in liquids which are also arranged in holes in the blade.

## SUMMARY OF INVENTION

**[0010]** It is the object of the invention to disclose an arrangement which by simple means is effectively protected against disturbing vibration excitations.

**[0011]** This object is achieved by means of an arrangement comprising a first blade and a second blade, which is arranged adjacent to the first blade, according to the claims.

**[0012]** Advantageous developments are disclosed in the dependent claims.

**[0013]** In a coupled blade assembly, so-called nodal diameter vibrations develop. These nodal diameter vibrations are characterized in that the amplitudes of the vibrations have a sinusoidal shape over the circumference of the blades. This means that for adjacent blades a relative rotation with regard to the nearest or more distant neighboring blades ensues. One advantage of the invention is that such relative rotations of the nearest or more distant neighboring blades are damped according to the invention. To this end, adjacent blades are modified in such a way that a sub-quantity of the blades is provided with a coupling element which is fixedly connected to the blade. This coupling element is designed in such a way that it extends as far as the next neighboring blade, or even as far as the next but one neighboring blade, but is not fixedly connected to the adjacent blade.

**[0014]** If a blade in the arrangement executes a vibration, then the blade moves together with the fixedly connected bar. The adjacent blade, which is not fixedly connected to the coupling element, presses this—as a result of the centrifugal force which occurs during operation—against the blade, as a result of which a frictional contact is carried out, wherein energy dissipation is carried out as a result of friction, and consequently vibration energy disappears, as a result of which the disturbing vibration is damped.

**[0015]** The first blade has a first blade tip and the second blade has a second blade tip, wherein the coupling element is arranged in the region of the first and second blade tips. For construction related reasons, the vibrations are greatest at the blade tips. Therefore, it is advantageous if the damping device is arranged in the blade tip. The coupling element is therefore advantageously arranged in the region of the first and second blade tips. The amplitudes of the disturbing vibrations are greatest there and are therefore damped the most effectively.

**[0016]** The first blade tip has a first shroud, wherein the coupling element is fixedly arranged in the first shroud. As a result of the arrangement of a coupling element, which is basically an external element, a suitable place has to be found where the coupling element can be arranged. The shrouds are arranged at the blade tips and have a construction which is comparatively large in relation to the overall blade. The coupling element is fixedly arranged in this shroud.

**[0017]** This can be carried out by means of soldering, screw-fastening or riveting, for example.

**[0018]** The second blade tip, which is associated with the adjacent blade, has a second shroud, wherein the coupling element is arranged in the second shroud. According to the invention, the coupling element is arranged loosely in the second shroud, i.e. not fixedly connected to the second shroud. The second shroud in this case is arranged in such a way that a centrifugal force which occurs during operation leads to the coupling element being pressed against the second shroud. This means that the coupling element rubs in the second shroud in the event of an occurring vibration. Consequently, energy dissipation takes place, as a result of which the vibration is damped.

**[0019]** The first shroud and the second shroud have in each case a slot in which the coupling element is arranged. Using a slot, a comparatively simple solution which is favorable to production engineering can be made available in order to effectively arrange the coupling element in the shroud.

**[0020]** The slot is arranged at the side in the first shroud and in the second shroud. As a result of the side arrangement, it is possible to easily remove the coupling element during maintenance operations.

**[0021]** In an advantageous development, the coupling element is of a longish and narrow design. The effective damping of the blade vibrations depends essentially upon the shape and the material of the coupling element. The longer the coupling element is, the greater are also the vibration amplitudes of the tip of the coupling element. The longer the coupling element is, the greater are therefore the vibration amplitudes at the tip. Furthermore, the material should be selected in such a way that it can be connected to the blade as rigidly and fixedly as possible, wherein the strength values of the coupling element should be such that the coupling element itself is hardly able to execute separate vibrations.

**[0022]** In an advantageous development, the coupling element is constructed as a plate. The plate advantageously has a rectangular shape, as seen in cross section, with a width L and a height H, wherein it is necessary that L is greater than H and that the coupling element is arranged in the shroud in such a way that the surface with the width L butts against the shroud during operation. The coupling element therefore has the shape of a flat knife blade. As a result of this construction, the coupling element is comparatively easily bendable in a radial direction, i.e. in the direction in which the centrifugal forces prevail, which leads to the coupling element being able to be easily pressed against the other shroud. In contrast, bending in the axial direction, i.e. perpendicularly to the centrifugal force direction is hardly possible. This means that vibration of the blade, on which the coupling element is fixedly arranged, entrains sufficiently well. As a result, effective damping is possible.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0023]** The invention is explained in more detail in the figures based on an exemplary embodiment. In the drawing:

**[0024]** FIG. **1** shows a detail of an arrangement as seen in the radial direction, looking onto the shrouds;

**[0025]** FIG. **2** shows a detail of two adjacent shrouds;

**[0026]** FIG. **3** shows a perspective view of a shroud.

## DETAILED DESCRIPTION OF INVENTION

**[0027]** FIG. **1** shows a detail of an arrangement in the radial direction, i.e. the radial direction perpendicular to the plane of the drawing. The arrangement comprises a first blade **1** and a second blade **2** which is arranged adjacent to the first blade **1**. The first blade **1** and the second blade **2** are fixedly arranged via rotor steeples on a rotor, which is not shown in more detail. The rotor rotates around a rotational axis **3**. The first blade **1** and the second blade **2** are of a longish design in the radial direction and are exposed to inflow during operation by a flow medium, which is not shown in more detail, wherein the first blade **1** and the second blade **2** execute a rotation in a rotational direction **4**.

**[0028]** The first blade **1** is arranged adjacent to the second blade **2**. The first blade **1** comprises a coupling element **5** which is fixedly connected to the first blade **1** in a way which is not shown in more detail. The coupling element **5** can be fixedly connected to the first blade **1** by means of screw-fastening, riveting or soldering, for example. A vibration **6** of the first blade **1** leads to a vibration of the tip **7** of the coupling element. This also leads to a harmonic vibration **8** of the tip **7** of the coupling element. It is necessary to minimize this harmonic vibration **8**, which is carried out by the coupling element **5** butting against the second blade **2**. As a result of the centrifugal forces which occur during operation, a free end **9** of the coupling element **5**, which is arranged outside the first blade **1**, is pressed outwards in the radial direction against the second blade **2**. This leads to friction between the free end **9** of the coupling element **5** and the second blade **2**.

**[0029]** The coupling element **5** is arranged in a blade tip of the first blade **1** and in a blade tip of the second blade **2**, which is not shown in more detail in FIG. **1**.

**[0030]** FIG. **3** shows a shroud **10** of the first or second blade **1** or **2**. The shroud **10** in this case is arranged at the blade tip of the first blade **1** and of the second blade **2**. The shroud **10** has slots **11** in which the coupling element **5** is arranged. In the case of the first blade **1**, the coupling element **5** is fixedly arranged in the slot **11**. In the case of the second blade **2**, the coupling element **5** is only loosely arranged in the slot **11**. A centrifugal force which occurs during operation acts in the centrifugal force direction **12** which is identical to the radial direction.

**[0031]** FIG. **2** shows an alternative representation of a part of an arrangement. The first blade **1** has a first shroud **13** and the blade **2** has a second shroud **14**. The shrouds are arranged at the blade tip of the first blade **1** and of the second blade **2**. The coupling element **5** is arranged at the side in the first shroud **13** and also in the second shroud **14**. In this case, the coupling element **5** is of a longish and narrow design and constructed as a plate. The coupling element **5** has a rectangular shape, as seen in cross section, with a width L and a height H. The height H is essentially identical to the height H of the slot **11**. At least the height H of the plate **5** should be slightly smaller than the height H of the slot **11**. In this case it is necessary that L is greater than H and that the coupling element is arranged in the shroud **14** in such a way that the surface with the width L butts against the shroud **14** during operation. As a result, friction is generated, which leads to energy dissipation and therefore a vibration reduction is brought about.

**[0032]** The coupling element **5** is fixedly connected to the first shroud **13**, which can be carried out by means of a screw fastening, for example. For this, screws which fixedly connect the coupling element **5** to the first blade **1** are used. Screwed connections **15**, **16** result from this. The screwed connection **15**, **16** may be oriented in the axial direction **17**, for example. The screwed connection **15**, **16** can naturally also be carried out in the radial direction **18**.

**1**.-**4**. (canceled)

**5**. An arrangement, comprising:

a first blade;

a second blade which is arranged adjacent to the first blade;

a coupling element,

wherein the coupling element is fixedly arranged in the first blade and a part of the coupling element butts against the second blade,

wherein the first blade includes a first blade tip,

wherein the second blade includes a second blade tip,

wherein the coupling element is arranged in a region of the first and second blade tip,

wherein the first blade tip includes a first shroud and the coupling element is arranged in the first shroud,

wherein the second blade tip includes a second shroud and the coupling element is arranged in the second shroud,

wherein the first shroud and the second shroud include in each case a slot in which the coupling element is arranged, and

wherein the slot is arranged at a side in the first shroud and in the second shroud.

**6**. The arrangement as claimed in claim **5**, wherein the coupling element is of a longish and narrow design.

**7**. The arrangement as claimed in claim **5**, wherein the coupling element is a plate.

**8**. The arrangement as claimed in claim **5**,

wherein the coupling element includes a rectangular shape, as seen in cross section, with a width and a height, and

wherein the width is greater than the height and the coupling element is arranged in the shroud in such a way that a surface with the width butts against the shroud during operation.

**9**. The arrangement as claimed in claim **7**,

wherein the coupling element includes a rectangular shape, as seen in cross section, with a width and a height, and

wherein the width is greater than the height and the coupling element is arranged in the shroud in such a way that a surface with the width butts against the shroud during operation.

**10**. The arrangement as claimed in claim **5**, wherein the coupling element is fixedly connected to the first shroud.

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