(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) EP 2 573 328 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
27.03.2013 Bulletin 2013/13

(51) Int Cl.:
F01D 9/04 *(2006.01)* ***F01D 25/06*** *(2006.01)*
F01D 25/24 *(2006.01)*

(21) Application number: **11181917.3**

(22) Date of filing: **20.09.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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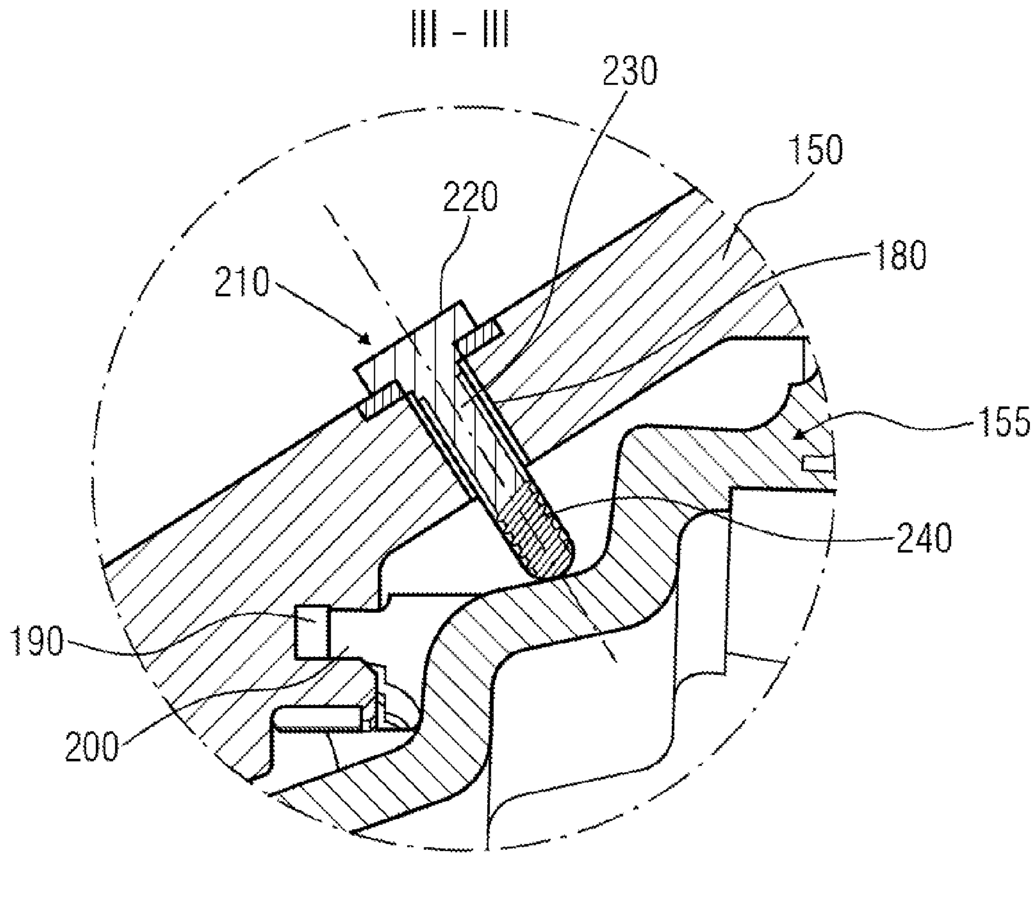
(54) **Stator ring for a turbomachine and a method for operation of the stator ring**

(57) The invention relates to a stator ring (150) for a turbo machine (10) and a method for operation of the stator ring (150). The stator ring (150) is coupled with a vane (155) by means of a coupling means. An adjustment means (170) is provided on the stator ring (150) in a manner such that it interacts with the vane (155). The actuation of the adjusting means (170) influences the vibrations of the vane (155) during the operation of the turbomachine (10).

FIG 4



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Description

[0001] The present invention relates to a stator ring for a turbomachine

[0002] A turbomachine is a device that is used for generating thrust by means of increasing the velocity of air flowing through it. It is used in different fields, for example, power generation, gas turbines, jet engines, et cetera. The mechanism of operation of the turbomachine primarily spans four sequential stages, viz., intake, compression, combustion, and exhaust. Air flows from outside through an air inlet into the turbomachine during the intake stage, during which the air is streamlined and directed towards a compressor. In the compression stage, the compressor compresses the air, which packs the air in a tight manner, thereby increasing its pressure. This results in an increased quantity of oxygen available per unit volume of air used during combustion. The combustion stage involves mixing the compressed air with fuel and igniting the mixture in one or more combustors at a constant pressure. The ignition of the mixture leads to an expansion of the air and an increase in temperature. During the exhaust stage, the expanded air is directed towards a nozzle, which is construed to be an outlet of the turbomachine. An outflow of the expanded air at high pressure through the nozzle results in the generation of thrust in a direction opposite to the direction of outflow.

[0003] In a turbomachine, a turbine with a rotor comprising blades and a stator ring comprising vanes is located between the one or more combustors and the nozzle. The turbine is in turn coupled to an electric generator. The hot and expanded air flowing out of the combustor acts on the blades of the turbine, which in turn rotates the turbine and consequently the generator, thereby generating electric power. A major portion of this power is fed back to the compressor for running the compressor.

[0004] The stator ring comprising the vanes is arranged such that the vanes direct the flow of air from the combustor onto the blades of the turbine. For example, the stator ring can be spatially arranged in a circumferential manner around the rotor.

[0005] During operation of the turbomachine, various forces come into play on a multitude of different mechanical entities of the turbomachine, and these mechanical entities are susceptible to vibrations. These entities have their respective vibration frequencies and Eigen frequencies, respectively. It is detrimental to the turbomachine when two different entities that have similar Eigen frequencies. For example, if the Eigen frequency of a vane substantially coincides with the Eigen frequency of the combustor, it leads to excitation and High Cycle Fatigue. This results in component or equipment damage and underperformance of the turbomachine.

[0006] The aforesaid problem can be solved by influencing the vibration frequency of the vane. Currently, the vibration frequency of a single vane is adjusted by modifying the design of the vane. This entails changing the geometry of the vane, which is an expensive solution. It involves casting and tooling changes, which is not only inflexible but also non-retrofittable.

[0007] It is an object of the present invention to propose a cost effective, retrofittable and flexible solution for a robust operation of a stator ring of a turbomachine.

[0008] The above object is achieved by a stator ring for a turbomachine according to claim 1 and a method for operation of the stator ring according to claim 13.

[0009] In accordance with the invention, a stator ring for a turbomachine comprises a vane coupled to the stator ring by a coupling means and an adjusting means in interaction with the vane. By this, the adjusting means is capable of influencing vibrations of the vane during operation of the turbomachine. This influence of the adjusting means on the vane, for example, results in a dampening of the vibrations and the vibration frequency respectively. When the vibrations are dampened, the mechanical damage incurred by both the stator ring and the vane is minimized, thereby increasing the lives of both the stator ring and the turbomachine.

[0010] According to an embodiment of the invention, the coupling means is made of a first coupling means provided on the stator and a second coupling means provided on the vane. The coupling between the first coupling means and the second coupling means secures the vane onto the stator ring, advantageously rendering a stable coupling.

[0011] According to another embodiment of the invention, the activation of the adjusting means tightens the first coupling means and the second coupling means. The tightening of the first and second coupling means stiffens the coupling, thereby fixing the vane tightly onto to the stator ring. Furthermore, this renders a provision of influencing the vibration frequency by tightening the adjusting means.

[0012] According to yet another embodiment of the invention, the activation of the adjusting means changes the mechanical tension of the vane. The activation increases the mechanical tension on the vane when the adjusting means is further tightened, thereby influencing the vibration frequency of the vane to a greater extent.

[0013] According to yet another embodiment of the invention, the adjusting means is arranged in a manner that establishes a mechanical contact between the stator ring and the vane. The operation of the turbomachine results in vibration of the vane at certain frequencies. The manner of arrangement has an influencing effect on these vibrations, such that the adjusting means dampens the vibrations of the vane. This maintains smooth operation of the turbomachine and causes fewer disruptions.

[0014] According to yet another embodiment of the invention, the adjusting means is in the form of a hole on the stator ring along with a fastener provided through the hole. The fastener interacts with the vane and the activation of the fastener displaces the fastener by changing its position relative to the stator ring. The frequency of vibration of the vane is capable of being influenced and reduced from outside by this simple mechanism. The fastener is controllable from the outside, thereby rendering the capability to dampen the vibrations. Furthermore, this is a retrofittable solution and obviates the problem of re-designing and re-moulding the vane to dampen certain vibration frequencies.

[0015] According to yet another embodiment of the invention, the fastener is either a bolt or a rivet or a screw. These fasteners are based on simple operating mechanisms and are easy to fix and activate through the hole provided on the stator ring to interact with the vane. Furthermore, the movement and operation of the fastener is controllable from the outside of the stator ring, thereby increasing the convenience of operation of the stator ring.

[0016] According to yet another embodiment of the invention, the adjusting means has an actuator for adjusting the position of the fastener. The actuator increases the convenience of operation as the fastener is capable of being operated from a distance. Furthermore, the fastener driven by an actuator is controllable by an electric source, which increases the accuracy and flexibility of its operation.

[0017] According to yet another embodiment of the invention, the coupling means is in the form of flanges provided on the stator ring and the vane. A flange on the stator ring and a flange on the vane are coupled that secures the vane onto the stator ring. A flange is one of the simplest and efficient means to couple two dissimilar mechanical components, for example, the stator ring and the vane, in a secured manner.

[0018] According to an alternate embodiment, a turbomachine has the stator described according to any of the aforementioned embodiments. During the operation of the turbomachine, the vibrations of the vane of the stator in the turbomachine, is capable of being dampened by adjusting the adjusting means. The turbomachine comprises a combustor, and the combustor has a vibration frequency. A resonance of the vibration frequencies of the combustor and the vane is obviated by the stator ring, in which the vibration frequency of the vane is capable of being influenced. Furthermore, the turbomachine comprise either a steam turbine or a gas turbine or a turbofan.

[0019] In accordance with the invention, in a method of operation of a stator ring of a turbomachine, the stator ring has a vane coupled to the stator ring. An adjusting means interacting with the vane is actuated to influence the vibration of the vane. The influence of the adjusting means on the vane, for example, results in a dampening of the vibrations and the vibration frequency respectively. When the vibrations are dampened, the mechanical damage incurred by both the stator ring and the vane is minimized, thereby increasing the lives of both the stator ring and the vane.

[0020] In accordance with an embodiment of the invention, a hole is provided on the stator ring, and a fastener is activated through the hole to interact with the vane. By actuating the adjusting means, the position of the fastener with respect to the stator ring is varied by tightening the fastener. This influences the vibration frequency of the vane, as the fastening results in stiffening of the coupling between the stator and the vane, thereby damping the vibration frequency of the vane. This also reduces rattling of the vane, if the coupling is loose. Further tightening of the fastener results in an increase in the mechanical tension of the vane and further dampens the vibration frequency.

[0021] In accordance with another embodiment of the invention, the fastener is adjusted in a manner that annuls the vibration frequency of the vane. This has the advantage of increasing the life of the stator ring and a turbomachine comprising the stator ring, as vibrations are annulled resulting in a smooth operation.

[0022] The aforementioned and other embodiments of the invention related to a stator ring for a turbomachine and a method will now be addressed with reference to the accompanying drawings of the present invention. The illustrated embodiments are intended to illustrate, but not to limit the invention. The accompanying drawings contain the following figures, in which like numbers refer to like parts, throughout the description and drawings.

[0023] The figures illustrate in a schematic manner further examples of the embodiments of the invention, in which:

FIG 1 depicts a block diagram of a turbomachine comprising various parts including a turbine,

FIG 2 depicts a front view of a stator ring of the turbine of the turbomachine referred to in FIG 1,

FIG 3 depicts a perspective view of the external surface of the stator ring, referred to in FIG 2, with a plurality of holes on its periphery,

FIG 4 depicts a technical drawing of a cross-sectional view of the stator ring referred to in FIG 2, along the section III—III, at a location where a vane is attached to the stator ring,

FIG 5 depicts a flowchart of a method for adjusting the vibration frequency of a vane of a stator ring for a turbomachine.

[0024] FIG 1 depicts a turbomachine 10 with an external casing 20 for generating thrust by means of increasing the velocity of air flowing through it.

[0025] The turbomachine 10 comprises various sections, viz., an intake section 21, a compression section 22, a combustion section 23, a turbine section 24, and an exhaust section 25, which respectively correspond with various operational stages in a sequential manner. The intake section 21 comprises an air inlet 30, which is interfaced with a compressor 40 of the compression section 22. The compressor 40 is interfaced with a combustor 50, a major entity of the combustion section 23. The combustor 50 is connected to a fuel tank 55 through a pipe

57, which provides fuel for mixing it with the air during combustion. The turbine section 24 is subsequent to the combustor 50 and comprises a turbine 60, which is in turn connected using a turbine shaft 65 to a generator 70. A nozzle 80 subsequent to the turbine 60 serves as an outlet for the air, and marks the final section, i.e., the exhaust section 25.

[0026] The turbomachine 10 takes in air 90 through the air inlet 30, processes it, and exhausts it from the nozzle 80. During this process, the air 90 is acted upon by various factors related to the different parts of the turbomachine 10. The process is cyclical, and the air 90 being acted upon is the same throughout a cycle. However there is a change in the properties exhibited by the air 90 at various operational sections 21-25 of the turbo machine 10. For example, its pressure, volume, temperature and velocity, are different at the various aforesaid sections, thereby possessing different capabilities at various operational stages.

[0027] Air 90 at the inlet 30 of the turbomachine 10 is at atmospheric pressure and is directed towards the compressor 40. The air 100 at the inlet of the compressor 40 is streamlined, and is still at atmospheric pressure. The compressor 40 acts upon the air 100 by way of compressing it and subsequently feeding it to the combustor 50. The compressed air 110 is at a higher pressure and occupies lesser volume compared to the air 100 at the inlet of the compressor 40. It also contains more oxygen per unit volume. The fuel in the fuel tank 55 is injected into the combustor 50 through a fuel pipe 57 and mixed with the compressed air 110 inside the combustor 50. The fuel and air 110 mixture is then ignited. The process of combustion takes place at constant pressure, thereby leading to a volumetric expansion of the compressed air 110. Air 120 at the outlet of the combustor 50 possesses higher volume and higher temperature compared to the air 110 at the inlet of the combustor 50. The air 120 acts on the turbine 60, which is in turn connected to the generator 70 using the turbine shaft 65, and rotates the generator 70 and produces power. Subsequently, air 130 after its action on the turbine 60, expands through the nozzle 80 and exhausts the turbomachine 10. Air 140 at the exit of the turbo machine 10 returns to the atmosphere, but possesses higher velocity, temperature and pressure, thereby creating a thrust in a direction opposite to the direction of the air 90.

[0028] FIG 2 depicts a front view of the turbine of the turbomachine 10 in accordance with an embodiment of the invention. It has a stator in the form of a stator ring 150 comprising a plurality of vanes 155, and a rotor 160 comprising a plurality of blades 165. The rotor 160 comprising the plurality of blades 165 is mounted on the turbine shaft 65. During operation of the turbomachine 10, the rotor 160 rotates under the influence of the air 120 coming from the combustor 50.

[0029] The stator ring 150 comprising the plurality of vanes 155 is a stationary body, and the plurality of vanes 155 act as a means to guide the air 120 entering the turbine 60. The air 120 is guided by the plurality of vanes 155 and it impinges on the plurality of blades 165 of the rotor 160 in a direction axial to the rotor 160. The plurality of blades 165 is arranged in a manner to convert the axial impingement of the air 120 into a rotary motion, thereby rotating the rotor 160, causing the generator 70 to generate power.

[0030] The flow of the air 120 on the plurality of vanes 155 during the operation of the turbomachine 10 and the structural geometry of the plurality of the vanes 155 result in vibrations of the vanes 155. These vibrations correspond to different frequencies. A plurality of adjusting means 170, which interact with the plurality of vanes 155, are provided on the stator ring 150 to adjust the vibration frequency of the plurality of the vanes 155. The frequency adjustment of the vanes 155 may include either stopping a frequency completely by annulling the frequency or damping the vibrations by reducing the amplitude of the vibrations. Furthermore, the frequency adjustment may also include the flexibility to discretely choose certain frequencies that is to be stopped or damped by means of adjusting the adjusting means 170.

[0031] The structure and the operating mechanism of the adjusting means 170 for adjusting the vibration frequency of the plurality of the vanes 155 are explained with reference to FIG 3.

[0032] The external surface of the stator ring 150 referred to in FIG 2 having a plurality of holes 180 at designated locations corresponding to the locations of the vanes 155 is depicted in FIG 3. A designated location is defined as that location on the stator ring 150 from which the adjusting means 170 is capable of influencing the vibration frequency of a vane 155. The designated location depicted in FIG 3 and the role of the plurality of adjusting means 170 in adjusting the vibration frequency of the plurality of vanes 155 is to be read and construed with reference to FIG 4.

[0033] FIG 4 depicts a technical drawing of a cross-sectional view of the stator ring 150 referred to in FIG 3, along the section III—III. A flange is an extended portion and is beneficial in attaching either two similar or dissimilar mechanical structures. A first coupling means is provided in the form of a first flange 190 on the internal periphery of the stator ring 150, and a second coupling means is provided in the form of a second flange 200 on a section of the vane 155. The first flange 190 and the second flange 200 interact with one another by coupling with one another. This means of physical contact facilitates securing the vane 155 onto the stator ring 150. A loose -fit between the first flange 190 and the second flange 200 results in vibrations of the vane 155 during the operation of the turbomachine 10.

[0034] The plurality of holes 180 on designated locations of the stator ring 150 forms a part of the adjusting means 170. The adjusting means 170 further comprises corresponding fasteners 210 inserted through the holes 180 and they interact with the first flange 190 and the second flange 200. In accordance with an embodiment of the invention, fasteners 210 are bolts that are inserted through the corresponding holes 180. A bolt 210 comprises a head 220, a body 230 and a thread 240. The hole 180 is provided with a thread, and the body 230 of the bolts 210 is provided with a complementary thread 240 such that the bolt 210 is capable of being fastened into the hole 180 to interact with the vane 155. Additionally, the radius of the hole 180 and the radius of the body 230 of the bolt 210 are substantially similar, such that the thread of the hole 180 and the complementary thread 240 of the bolt 210 are capable of being fastened in a facile and tight manner.

[0035] Functionally, the bolt 210 either tightens or loosens the contact that couples the first flange 190 with the second flange 200. The tightening or loosening of the bolt 210 alters the position of the bolt 210, as it changes the pitch of the thread 240 of the bolt 210.

[0036] The influence of the fastener 210, that is, the adjusting means 170, on the vibration of the vane 155 depends on the position of the fastener 210. The fastener is provided in the form of a bolt 210. For example, if the bolt 210 is activated, by means of tightening it, first the position of the vane 155 relative to the stator ring 150 is influenced, resulting in a tight fit of the vane 155. This increases the stiffness of the coupling between the first coupling means 190 and the second coupling means 200. The mechanical property of the vane 155 changes when the bolt 210 is further tightened.. For example, property change can be a change in the mechanical tension or the stiffness of the vane 155. The resulting effects, that is, the tight-fit that increases the stiffness between the first coupling 190 and the second coupling 200, and the change of the mechanical property of the vane 155, result in a change of vibration frequency of the vane 155. The tightening of the vane 155 dampens the vibration frequency of the vane 155, thereby obviating the vibrations. Depending on the position of the bolt 210 and its interaction with the vane 155 the vibrations finally can be completely stopped.

[0037] Furthermore, other possible fasteners 210 of the adjusting means 170 can include screws, clamps, rivets, et cetera, which can achieve the aforementioned object. Also, the fasteners can be interfaced with actuators, for example, piezoelectric actuators for tightening or loosening the contact accordingly, thereby being able to adjust the position of the fastener. In principle, the adjusting means 170 is a means with a movable component, for e.g., a bolt 210, where the relative position of the bolt with respect to the stator ring 150 is modifiable, thereby generating a force on a vane 155 of the stator ring 150. This force results in a displacement of the vane 155 and in tightening of the coupling means, e.g. flanges 190, 200, which couple the vane 155 to the stator ring 150. Further tightening of the fastener 210 increases the mechanical tension of the vane 155.

[0038] In an actuator based adjusting means 170, the actuator is interfaced with the adjusting means 170 for activating the adjusting means 170. The actuator drives the adjusting means 170 in a manner that it displaces the position of the adjusting means 170, for example, tightening or loosening the adjusting means 170. For example, a piezoelectric actuator driving an adjusting means 170, in the form of a bolt 210 activated through the hole 180, the actuator drives the bolt 210 which can either tighten or loosen the coupling between the stator ring 150 and the vane 155. The activation, and the subsequent tightening or loosening of the coupling influences the frequency of vibration of the vane 155.

[0039] FIG 5 depicts a flowchart of a method for operation of the stator ring 150. This is by adjusting the vibration frequency of a vane 155 attached to a stator ring 150. The stator ring 150 is provided with a hole 180 on its external surface at a designated location and in step 250 the adjusting means 170 is actuated to influence the vibrations of the vane 155. A fastener 210 is fastened though the hole 180 such that the fastener 210 interacts with the vane 155. In step 260, the position of the fastener is adjusted such that the fastener is tightened or loosened such that the coupling means of attachment between the stator ring 150 and the vane 155 is adjusted. This adjustment first increases or decreases the mechanical stiffness of the vane 155 and adjusts the vibration frequency of the vane 155. The fastener is adjustable in a manner such that if the fastener is tightened adequately, such that the stiffness of the vane 155 is maximized. Further tightening of the fastener 210 results in by increasing the mechanical tension of the vane 155, for example leading to a change of shape of the vane 155, and influences the vibration frequency further. This can also lead to a near total reduction of the vibration frequency of the vane 155.

[0040] A turbomachine 10 of FIG 1, which can either be a steam turbine or a gas turbine or a turbofan, comprises the aforementioned stator ring 150. The vibration frequency of the vane 155 of the stator ring 150 in such a turbomachine 10 is adjustable by means of the adjustable means 170. The adjusting means 170 adjusts the vibration frequency of the vane 155 such that the vibration frequency can be dampened even leading to annulment.

[0041] Though the invention has been described with reference to specific embodiments, this description is not meant to be construed in a limiting sense. Various examples of the disclosed embodiments, as well as alternate embodiments of the invention, will become apparent to persons skilled in the art upon reference to the description of the invention. It is therefore contemplated that such modifications can be made without departing from the embodiments of the present invention as defined.

Claims

1. A stator ring (150) for a turbomachine (10), the stator ring (150) comprising:

   - a vane (155) coupled to the stator ring (150) by a coupling means, and

- an adjusting means (170) in interaction with the vane (155), wherein the adjusting means (170) is capable of influencing vibrations of the vane (155).

2. The stator ring (150) according to claim 1, wherein the coupling means comprises a first coupling means (190) provided on the stator ring (150) and a second coupling means (200) provided on the vane (155) for coupling the vane (155) to the stator ring (150).

3. The stator ring (150) according to claim 1 and/or claim 2, wherein the adjusting means (170) upon activation tightens the first coupling means (190) and the second coupling means (200) .

4. The stator ring (150) according to any of the claims 1 to 3, wherein the adjusting means (170) upon activation alters the mechanical tension of the vane (155).

5. The stator ring (150) according to any of the claims 1 to 4, wherein the adjusting means (170) is arranged in mechanical contact with the stator ring (150) and the vane (155) such that a vibration frequency of the vane (155) during the operation of the turbomachine (10) is dampened.

6. The stator ring (150) according to any of the claims 1 to 5, wherein the adjusting means (170) comprises a hole (180) provided on the stator ring (150) and a fastener (210) provided through the hole (180), wherein

- the position of the fastener (210) relative to the stator ring (150) is displaceable, and
- the fastener (210) activated through the hole (180) is capable of interacting with the vane (155) such that the fastener (210) is capable of influencing vibrations of the vane (155).

7. The stator ring (150) according to claim 6, wherein the hole (180) is provided with a thread and the fastener (210) is provided with a corresponding complementary thread (240).

8. The stator ring (150) according to claim 6 and/or claim 7, wherein the fastener (210) comprises a bolt (210), a rivet, or a screw.

9. The stator ring (150) according to any of the claims 6 to 8, wherein the adjusting means (170) further comprises an actuator for adjusting the position of the fastener (210).

10. The stator ring (150) according to any of the claims 2 to 8, wherein the first coupling means (190) is a first flange (200) provided on a first portion of the periphery of the stator ring (150) and the second coupling means (200) is a second flange (200) provided on a second portion of the vane (155), wherein the first flange (190) and the second flange (200) interact with one another for coupling the vane (155) to the stator ring (150).

11. A turbomachine (10) comprising the stator ring (150) according to any of the claims 1 to 10.

12. The turbomachine (10) according to claim 11, wherein the turbomachine (10) comprises a steam turbine, a gas turbine or a turbofan.

13. A method for operation of a stator ring (150) of a turbomachine (10), wherein the stator ring (150) comprises a vane (155) coupled to the stator ring (150) and an adjusting means (170) in interaction with the vane (155), wherein the method comprises a step of actuating the adjusting means (170) to influence vibrations of the vane (155).

14. The method according to claim 13 further comprising:

- providing a hole (180) on the stator ring (150),
- activating a fastener (210) through the hole (180) for interacting with the vane (155),

wherein the step of actuating the adjusting means (170) comprises a step of adjusting a position of the fastener (210) relative to the stator ring (150) such that the position of the fastener (210) influences vibrations of the vane (155).

15. The method according to claim 14, wherein the position of the fastener (210) is adjusted such that the vibration frequency of the vane (155) is annulled.

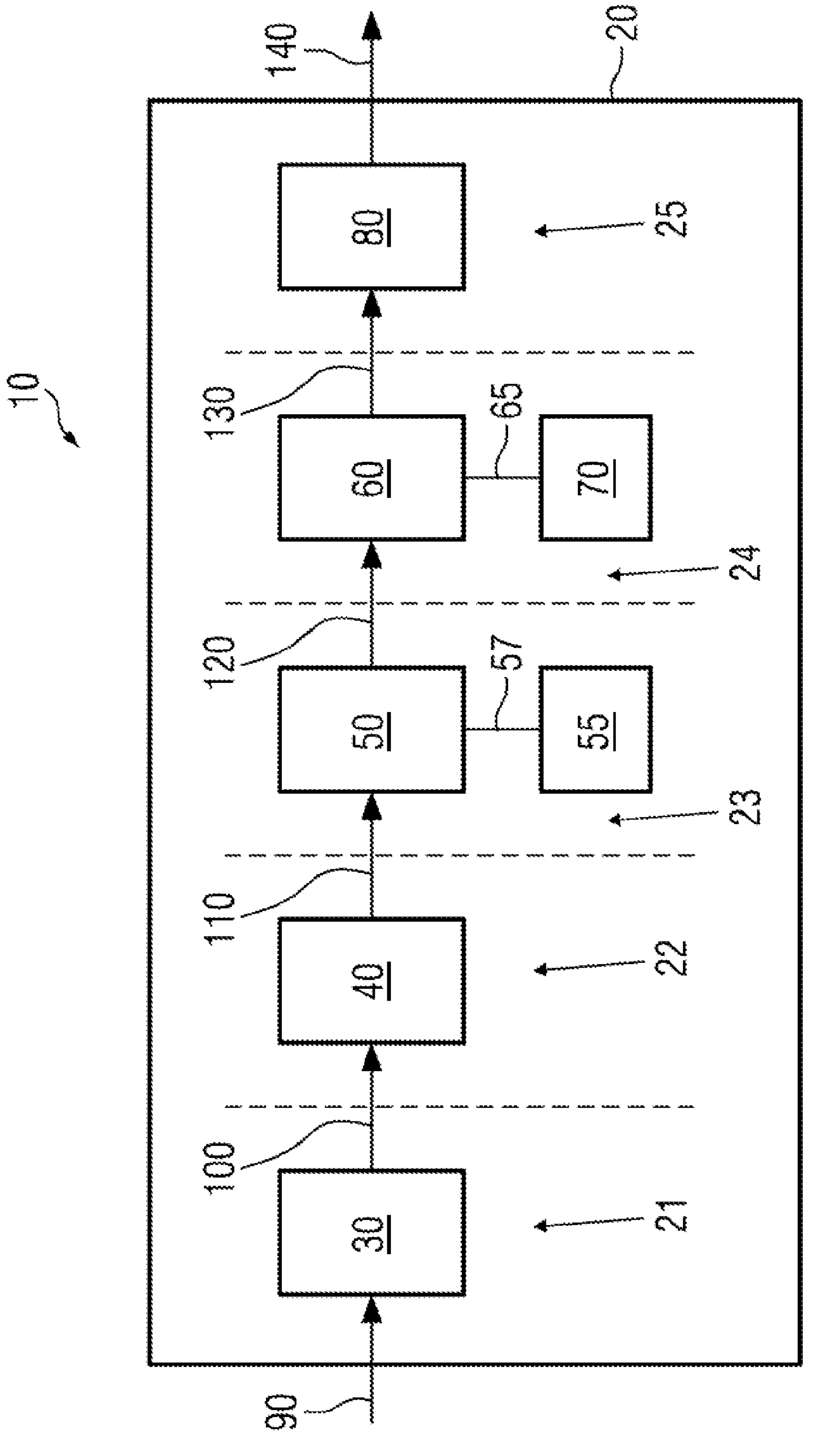


FIG 1

FIG 2

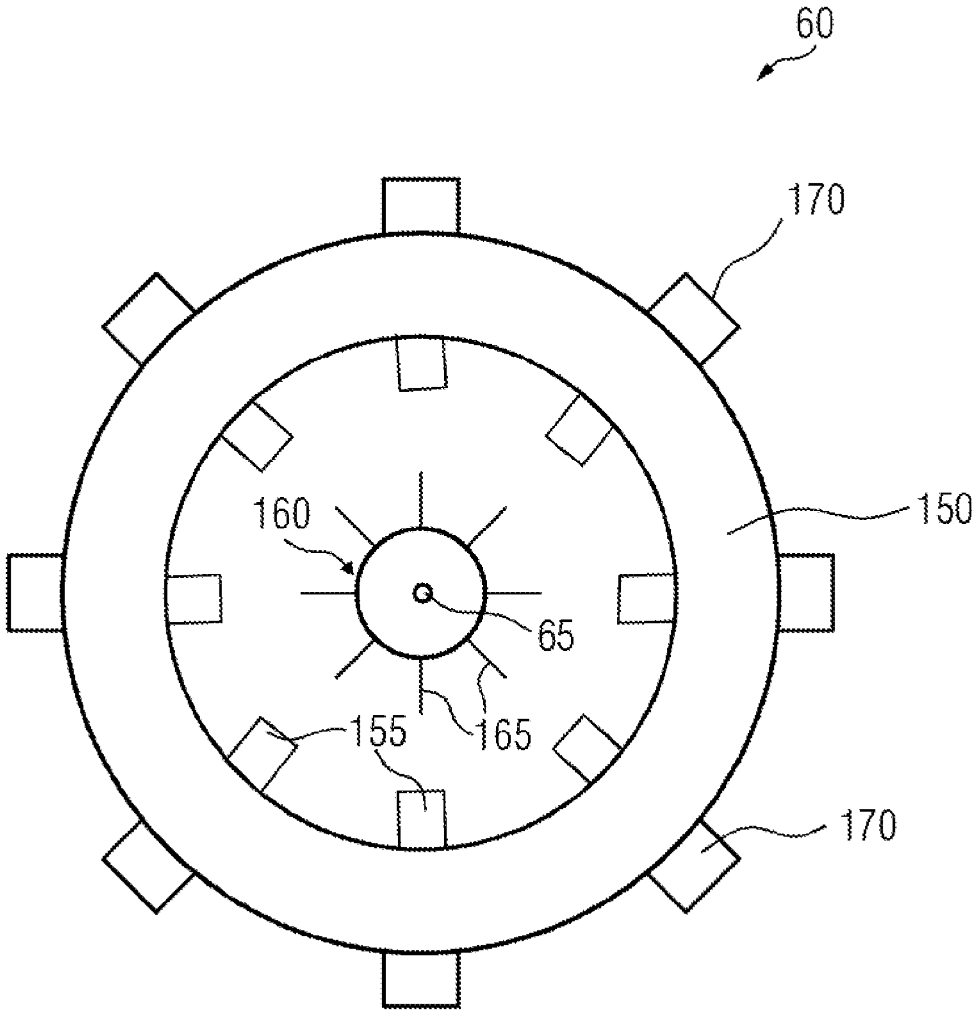


FIG 3

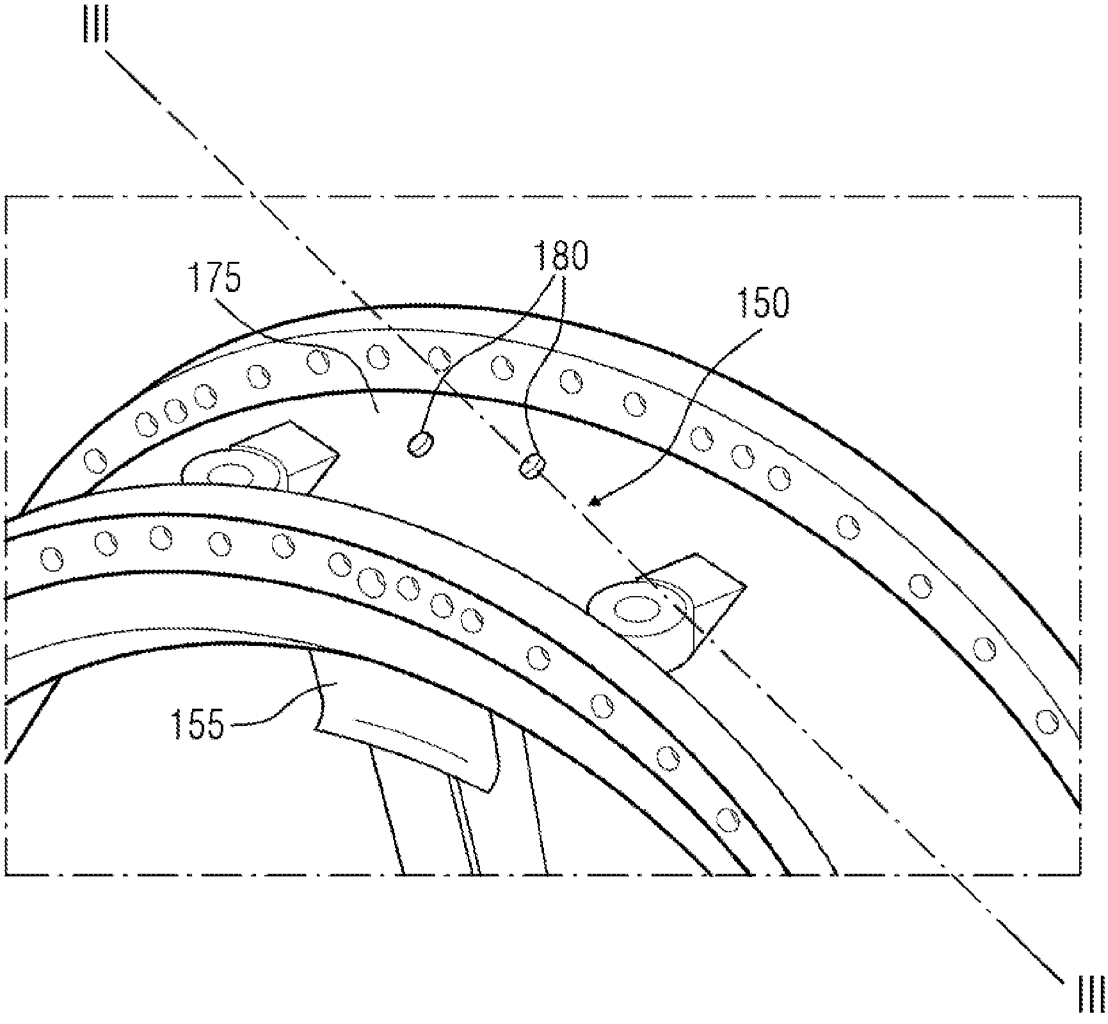


FIG 4

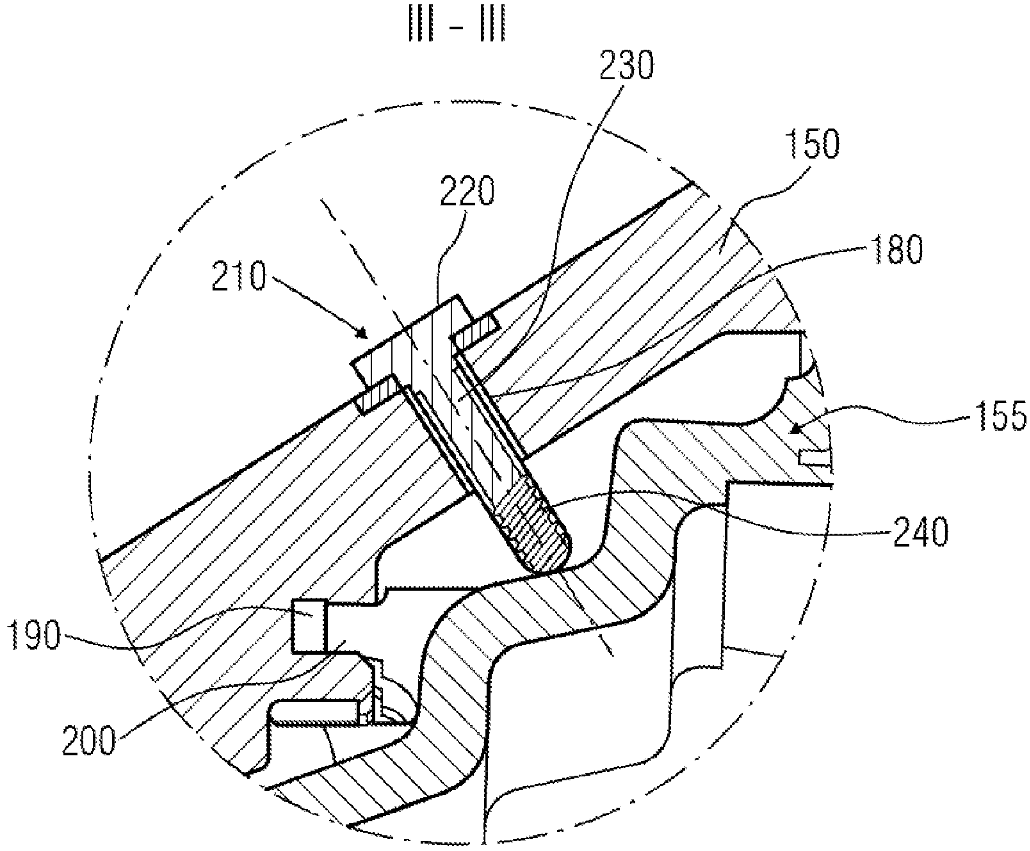
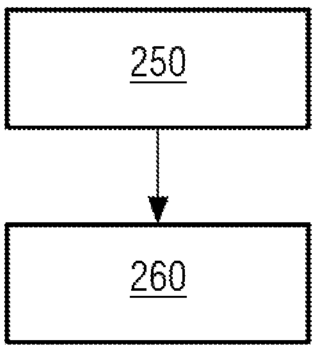


FIG 5



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EUROPEAN SEARCH REPORT

Application Number
EP 11 18 1917

DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2003/185683 A1 (SEYDEL CHRISTIAN [DE] ET AL) 2 October 2003 (2003-10-02) * the whole document * * paragraphs [0009], [0011], [0022] * * claims 14-17 * * figure 3 *	1-15	INV. F01D9/04 F01D25/06 F01D25/24
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	2 February 2012	Gombert, Ralf

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 11 18 1917

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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