TURBINE ASSEMBLY WITH SELECTIVELY COUPLABLE ROTOR SEGMENTS AND CORRESPONDING METHOD

TECHNICAL FIELD

[0001] The technical field relates to turbine assemblies, and more particularly to turbine assemblies with multiple rotor segments and to corresponding methods.

BACKGROUND

[0002] Turbines are commonly used to extract energy from a fluid flow and convert it into useful work. The turbines might comprise a plurality of rotor segments rotatably mounted to a turbine shaft but there is still room for performance improvement of such multiple rotor turbines.

[0003] In view of the above, there is a need for a turbine assembly which would be able to overcome or at least minimize some of the above-discussed prior art concerns.

BRIEF SUMMARY

[0004] It is therefore an aim of the present invention to address the above-mentioned issues.

[0005] According to a general aspect, there is provided a turbine assembly comprising: a turbine shaft having a turbine axis and comprising at least an upstream portion and a downstream portion; an upstream rotor segment rotatably mounted to the upstream portion of the turbine shaft and rotatable about the turbine axis in a rotation direction; a downstream rotor segment rotatably mounted to the downstream portion of the turbine shaft and rotatable about the turbine axis in the rotation direction; a one-way rotation driving system operatively coupled to the upstream and downstream rotor segments and driving the downstream rotor segment into rotation upon rotation of the upstream rotor segment while allowing a downstream rotational speed of the downstream rotor segment to be greater than an upstream rotational speed of the upstream rotor segment; and a deactivatable coupling system selectively configurable into an activated configuration wherein a rotation of the downstream rotor segment is coupled with a rotation of the upstream rotor segment and into a disabled configuration wherein the downstream rotor segment is free from rotating with respect to the upstream rotor segment.

[0006] According to another general aspect, there is provided a method for operating a turbine assembly comprising an upstream rotor segment and a downstream rotor segment rotatably mounted to a turbine shaft, the method comprising: circulating a fluid along the turbine shaft from an upstream portion of the turbine shaft towards a downstream portion of the turbine shaft, thereby engaging in rotation the upstream rotor segment at an upstream rotational speed and the downstream rotor segment at a downstream rotational speed; physically coupling the upstream and downstream rotor segments to rotate at a same rotational speed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Fig. 1 is a downstream perspective view of a turbine assembly in accordance with a first embodiment, the turbine assembly comprising upstream and downstream rotor segments and a deactivatable coupling system configured in a disabled configuration;

[0008] Fig. 2 is a downstream perspective view of the turbine assembly of Fig. 1, the deactivatable coupling system being configured in an activated configuration;

[0009] Fig. 3 is a downstream partially exploded view of the turbine assembly of Fig. 1;

[0010] Fig. 4 is a downstream perspective view of a turbine assembly in accordance with another embodiment, the turbine assembly further comprising an electric generator system;

[0011] Fig. 5 is an upstream perspective view, partially exploded, of the turbine assembly of Fig. 4, upstream and downstream blade assemblies of the upstream and downstream rotor segments being removed;

[0012] Fig. 6 is an enlarged view of the turbine assembly of Fig. 5;

[0013] Fig. 7 is a partially exploded side perspective view of a turbine assembly in accordance with another embodiment, the turbine assembly being a hydraulic turbine;

[0014] Fig. 8 is an upstream perspective view of a turbine assembly in accordance with another embodiment, the turbine assembly comprising four rotor segments;

[0015] Fig. 9 is a side perspective view of a turbine assembly in accordance with another embodiment, the upstream rotor segment being part of a compressor of the turbine assembly and the downstream rotor segment being part of a turbine thereof; and

[0016] Fig. 10 is a block diagram representing the different steps of a method for operating a turbine assembly comprising an upstream rotor segment and a downstream rotor segment rotatably mounted to a turbine shaft.

DETAILED DESCRIPTION

[0017] In the following description, the same numerical references refer to similar elements. Furthermore, for the sake of simplicity and clarity, namely so as to not unduly burden the figures with several references numbers, not all figures contain references to all the components and features, and references to some components and features may be found in only one figure, and components and features of the present disclosure which are illustrated in other figures can be easily inferred therefrom. The embodiments, geometrical configurations, materials mentioned and/or dimensions shown in the figures are optional and are given for exemplification purposes only.

[0018] Moreover, it will be appreciated that positional descriptions such as "above", "below", "forward", "rearward", "left", "right" and the like should, unless otherwise indicated, be taken in the context of the figures only and should not be considered limiting. Moreover, the figures are meant to be illustrative of certain characteristics of the turbine assembly and are not necessarily to scale.

[0019] To provide a more concise description, some of the quantitative expressions given herein may be qualified with the term "about". It is understood that whether the term "about" is used explicitly or not, every quantity given herein is meant to refer to an actual given value, and it is also meant to refer to the approximation to such given value that would reasonably be inferred based on the ordinary skill in the art, including approximations due to the experimental and/or measurement conditions for such given value.

[0020] In the following description, an embodiment is an example or implementation. The various appearances of "one embodiment", "an embodiment" or "some embodiments" do not necessarily all refer to the same embodiments. Although various features may be described in the context of a single embodiment, the features may also be provided separately or in any suitable combination. Conversely, although the invention may be described herein in the context of separate embodiments for clarity, it may also be implemented in a single embodiment. Reference in the specification to "some embodiments", "an embodiment", "one embodiment" or "other embodiments" means that a particular feature, structure, or characteristic described in connection with the embodiments is included in at least some embodiments, but not necessarily all embodiments.

[0021] It is to be understood that the phraseology and terminology employed herein is not to be construed as limiting and are for descriptive purpose only. The principles and uses of the teachings of the present disclosure may be better understood with reference to the accompanying description, figures and examples. It is to be understood that the details set forth herein do not construe a limitation to an application of the disclosure.

[0022] Furthermore, it is to be understood that the disclosure can be carried out or practiced in various ways and that the disclosure can be implemented in embodiments other than the ones outlined in the description above. It is to be understood that the terms "including", "comprising", and grammatical variants thereof do not preclude the addition of one or more components, features, steps, or integers or groups thereof and that the terms are to be construed as specifying components, features, steps or integers. If the specification or claims refer to "an additional" element, that does not preclude there being more than one of the additional element. It is to be understood that where the claims or specification refer to "a" or "an" element, such reference is not be construed that there is only one of that element. It is to be understood that where the specification states that a component, feature, structure, or characteristic "may", "might", "can" or "could" be included, that particular component, feature, structure, or characteristic is not required to be included.

[0023] The descriptions, examples, methods and materials presented in the claims and the specification are not to be construed as limiting but rather as illustrative only. Meanings of technical and scientific terms used herein are to be commonly understood as by one of ordinary skill in the art to which the invention belongs, unless otherwise defined. It will be appreciated that the methods described herein may be performed in the described order, or in any suitable order.

Turbine assembly

[0024] Referring now to the drawings, and more particularly to Figs. 1 to 3, there is shown a turbine assembly 100 in accordance with a first embodiment.

[0025] In the embodiment shown, the turbine assembly 100 comprises a turbine shaft 110 having a turbine axis X and comprising at least an upstream portion 120 and a downstream portion 130. For clarity purposes, in the embodiment shown, the turbine shaft 110 corresponds to the turbine axis X in the different drawings. The turbine assembly 100 also comprises a first rotor segment 200 (or upstream rotor segment or parent rotor segment) rotatably mounted to the upstream portion 120 of the turbine shaft about the turbine axis X in a rotation direction and a second rotor segment 300 (or downstream rotor segment or child rotor segment) rotatably mounted to the downstream portion 130 of the turbine shaft about the turbine axis X in the rotation direction.

[0026] The turbine assembly 100 also comprises a one-way rotation driving system 400 operatively coupled to the first and second rotor segments 200, 300 and driving the second rotor segment 300 into rotation in the rotation direction upon rotation of the first rotor segment 200 in the rotation direction while allowing a second (or downstream) rotational speed of the second rotor segment 300 to be greater than a first (or upstream) rotational speed of the first rotor segment 200.

[0027] The turbine assembly 100 also comprises a deactivatable coupling system 500 (or escamotable coupling system or retractable coupling system) selectively configurable into an activated configuration (Fig. 2) wherein the second rotor segment 300 is physically coupled to the first rotor segment 200 and into a disabled configuration (Fig. 1) wherein the second rotor segment 300 is free from rotating with respect to the first rotor segment 200.

[0028] As detailed below, the turbine assembly 100 is thus configured to allow the second rotor segment 300 – or downstream rotor segment 300 – to rotate about the turbine axis X faster than the first rotor segment 200 – or upstream rotor segment 200 – and to benefit from a difference in the upstream and downstream rotational speeds of the upstream and downstream rotor segments 200, 300.

Upstream and downstream rotor segments

[0029] In the embodiment shown, the second rotor segment 300 has a second – or downstream - weight smaller than a first – or upstream - weight of the first rotor segment 200. For instance, the second weight is smaller than about 95% of the first weight. In another embodiment, the second weight is smaller than about 80% of the first weight. In another embodiment, the second weight is smaller than about 70% of the first weight. In yet another embodiment, the second weight is smaller than about 50% of the first weight.

[0030] In the embodiment shown, the first rotor segment 200 has a first – or upstream - blade assembly 210 with an upstream diameter D1 and the second rotor segment 300 has a second – or downstream - blade assembly 310 with a downstream diameter D2, the second diameter D2 being greater than the first diameter D1. In the embodiment shown, the downstream diameter D2 is greater than about 105% of the upstream diameter D1. In another embodiment, the second diameter D2 is greater than about 115% of the first diameter D1. In another embodiment, the second diameter D2 is greater than about 130% of the first diameter D1. In yet another embodiment, the second diameter D2 is greater than about 200% of the first diameter D1.

[0031] It is thus understood that the one-way rotation driving system 400 and the first and second rotor segments 200, 300 are shaped and dimensioned so that the downstream rotational speed can be greater than the upstream rotational speed.

[0032] It is appreciated that the shape, the configuration, and the respective location of the first and second rotor segments can vary from the embodiment shown. For instance, it could be conceived first and second rotor segments having more than one blade assembly. As mentioned below, the present disclosure is not limited to a turbine assembly comprising two rotor segments.

One-way rotation driving system

[0033] In the embodiment shown, the one-way rotation driving system 400 comprises a one-way bearing 410.

[0034] For instance, the one-way bearing 410 comprises a downstream rotor-mounting portion 420 and an upstream rotor-mounting portion 430. For instance, the one-way bearing 410 comprises an inner face 422 operatively coupled to the downstream rotor segment 300 and an outer face 432 operatively coupled to the upstream rotor segment 200.

[0035] As mentioned above, the one-way rotation driving system 400 is shaped and dimensioned to ensure that the downstream rotor segment 300 rotates about the turbine axis X upon rotation of the upstream rotor segment 200 about the turbine axis X, while allowing the second rotational speed (or downstream rotational speed) to be greater than the first rotational speed (or upstream rotational speed). In other words, the one-way rotation driving system 400 ensures that the upstream and downstream rotor segments 200, 300 are in a child-parent relationship while allowing the second rotational speed (or downstream rotational speed) to be greater than the first rotational speed (or upstream rotational speed). The turbine assembly 100 is shaped and dimensioned for the downstream rotor segment 300 (or child rotor segment) to receive more fluid flow energy and/or to be lighter than the upstream rotor segment 200 (or parent rotor segment 200).

[0036] In yet other words, the turbine assembly 100 and the one-way rotation driving system 400 thereof are shaped and dimensioned to ensure that the upstream rotor segment 200 drives the rotation of the downstream rotor segment 300 and that the second – or downstream - rotational speed be equal to or greater than the first – or upstream - rotational speed.

[0037] It is appreciated that the shape, the configuration, and the location of the one-way rotation driving system can vary from the embodiment shown.

Deactivatable coupling system

[0038] In the embodiment shown, the deactivatable coupling system 500 (or escamotable or retractable coupling system 500) comprises one or more retractable rods 510 operatively coupled (for instance mounted) to one of the upstream and downstream rotor segments 200, 300 and one or more stoppers 520 operatively coupled (for instance mounted) to the other one of the upstream and downstream rotor segments 200, 300.

[0039] In the embodiment shown in Figs. 1 to 3, only two retractable rods 510 are represented but it could be conceived a deactivatable coupling system having more than two retractable rods or only one retractable rod, and a corresponding number of stoppers.

[0040] In the embodiment shown, the retractable rods 510 are substantially parallel to the turbine axis X and are mounted to the downstream rotor segment 300. The retractable rods 510 extend towards the upstream rotor segment 200 and the stoppers 520 are mounted to the upstream rotor segment 200.

[0041] The retractable rods 510 comprise a stopper-contacting portion 512 and are configurable into a coupling configuration wherein the stopper-contacting portions 512 of the retractable rods 510 are axially aligned with the stoppers 520 (with reference to the turbine axis X), and into a retracted configuration (not represented) wherein the stopper-contacting portions 512 of the retractable rods 510 are axially offset (i.e. spaced-apart) – considered along the turbine axis X - with respect to the stoppers 520.

[0042] In the embodiment shown, a rod-receiving slot 220 is formed in the upstream rotor segment 200 which is shaped and dimensioned to contain the stoppers 520 and the stopper-contacting portion 512 of the retractable rods 510 when in the coupling configuration.

[0043] When the retractable rods 510 are in the coupling configuration, the deactivatable coupling system 500 is configurable into the disabled configuration wherein the stopper-contacting portions 512 are spaced-apart from the stoppers 520, thus allowing the second rotor segment 300 to rotate with respect to the first rotor segment 200 (Fig. 1). Upon rotation of the second rotor segment 300 with respect to the first rotor segment 200 (i.e. upon the second rotational speed being greater than the first rotational speed during a predetermined duration), with the retractable rods 510 being in the coupling configuration, the stopper-contacting portions 512 contact the stoppers 520 so as to configure the deactivatable coupling system 500 in the activated configuration (i.e. so as to physically couple the upstream and downstream rotor segments 200, 300) (Fig. 2).

[0044] In the embodiment shown, the deactivatable coupling system 500 further comprises one or more dampening members 530 (for instance spring members) arranged between at least one of retractable rods 510 (for instance the stopper-contacting portion 512 thereof) and a corresponding stopper 520 when the retractable coupling system 500 is configured in the activated configuration. For instance, the dampening members 530 protrude from a rod-contacting face 522 of the stopper 520. The dampening members 530 are thus shaped and dimensioned to substantially dampen the contact between the retractable rods 510 (the stopper-contacting portion 512 thereof) and the stoppers 520 upon coupling of the upstream and downstream rotor segments 200, 300. In other words, the dampening members 530 are shaped and dimensioned to limit the risk of damage incurred to the turbine assembly 100 upon coupling of the upstream and downstream rotor segments 200, 300 and/or to limit vibrations and other possible deficiencies.

[0045] When the deactivatable coupling system 500 is configured in the activated configuration (i.e. upon contact of the stopper-contacting portions 512 and the corresponding stopper 520, in the embodiment shown), extra kinetic energy of the second rotor segment 300 – which second rotational speed is greater than the first rotational speed – is transmitted to the first rotor segment 200, thus increasing overall performance of the turbine assembly 100.

[0046] In the embodiment shown, the turbine assembly 100 further comprises a controller 600 operatively coupled to the retractable coupling system 500 to configure the retractable coupling system 500 in one of the diasabled and activated configurations based for instance on a measure of at least one of the upstream and downstream rotational speeds or on a measure of a difference between the upstream and downstream rotational speeds. In the embodiment shown, the controller 600 is shaped and dimensioned to configure the retractable rods 510 in one of the coupling and retracted configurations based on a measure of at least one of the upstream and downstream rotational speeds.

[0047] In another embodiment, the retractable coupling system could manually be configured in at least one of the disabled and activated configurations. In yet another embodiment, the configuration of the retractable coupling system in at least one of the disabled and activated configurations by the controller could be based on measures different from the difference between the upstream and downstream rotational speeds. For instance, in an embodiment wherein the turbine assembly comprises, as described below, a gas turbine comprising a rotating gas compressor, a downstream turbine and a combustor located between the gas compressor and the turbine, the configuration of the retractable coupling system in at least one of the disabled and activated configurations by the controller could be based, for instance, on a detection of a compressor surge and/or a pressure measure in the combustor.

[0048] For instance, when the first and second rotational speeds are substantially equal following the angular coupling of the upstream and downstream rotor segments 200, 300, the controller 600 configures the retractable rods 510 into the retracted configuration, for the second rotor segment 300 to be free again from rotating with respect to the first rotor segment 200 (i.e. for the second rotational speed to be free again to be greater than the first rotational speed).

[0049] In the embodiment shown, when a difference between the first and second rotational speeds reaches a predetermined difference value, the controller 600 configures the retractable rods 510 into the coupling configuration, for the stopper-contacting portions 512 to be axially aligned with the stoppers 530 (i.e. to engage the stopper-contacting portions 512 in the rod-receiving slot 220 of the upstream rotor segment 200 in the embodiment shown) for the second rotor segment 300 to be physically coupled to the first rotor segment 200 upon rotation of the second rotor segment 300 with respect to the first rotor segment 200.

[0050] In other words, the physically coupling and uncoupling of the upstream and downstream rotor segments 200, 300 is repeatable upon actuation of the controller 600.

[0051] In the embodiment shown, the same retractable rods 510 could be used in two successive cycles. It could also be conceived a turbine assembly wherein the retractable coupling system 500 would comprise several series of retractable rods 510 which would be successively deployed and retracted in successive coupling/uncoupling cycles.

[0052] It is appreciated that the shape, the configuration, and the location of the deactivatable coupling system, and the shape, the configuration, the location and the number of the retractable rods, the stoppers and the dampening members thereof can vary from the embodiment shown.

Electric generator system

[0053] It is appreciated that the shape and the configuration of the turbine assembly can vary from the embodiment shown.

[0054] As represented in Figs. 4 to 6, it could also be conceived a turbine assembly 1100 which would further comprise an electric generator system 1700 comprising a rotor 1710 arranged on one of the upstream and downstream rotor segments 1200, 1300 and the turbine shaft 1110 and a stator 1720 comprising one or more permanent magnets arranged on another one of the upstream and downstream rotor segments 1200, 1300 and the turbine shat 1110. In the embodiment shown, the rotor 1710 is arranged on the downstream rotor segment 1300 and the stator 1720 of the electric generator system 1700 is arranged on the upstream rotor segment 1200.

[0055] The electric generator system 1700 is thus shaped and dimensioned so that upon rotation of the second rotor segment 1300 about the first rotor segment 1200 when the deactivatable coupling system 1500 is in the disabled configuration, the rotor 1710 and the stator 1720 of the electric generator system 1700 rotate with respect to each other, thus generating an electric power. In other words, the electric generator system 1700 is configured to generate additional electric power. The electric generator system 1700 is also shaped and dimensioned to slow down the downstream rotor segment 1300 in order to limit a chock that could incur when the upstream and downstream rotor segments 1200, 1300 are physically coupled (i.e. upon configuration of the deactivatable coupling system 1500 into the activated configuration). In other words, the electric generator system 1700 might also have a dampening function.

[0056] In the embodiment shown, the turbine assembly 1100 might further comprise an electric motor (not represented) operatively coupled to the electric generator 1700 and the turbine shaft 1110, for instance to rotate the turbine shaft 1110 about the turbine axis X in a direction opposed to the rotation direction of the upstream and downstream rotor segments 1200, 1300. By doing so, the electric generator 1700 and the electric motor operatively coupled thereto further increase the performance of the turbine assembly 1100.

[0057] It is appreciated that the shape, the configuration, and the location of the turbine assembly can vary from the embodiments shown.

[0058] It could for instance also be conceived a turbine assembly which would for instance comprise a gas turbine and a turbine shaft, the turbine shaft of the turbine assembly being operatively coupled to a generator shaft of a static generator. The rotor of the electric generator system could be arranged on one of the turbine shaft of the turbine assembly and the generator shaft of the static generator, the stator of the electric generator system being arranged on the other one of the turbine shaft of the turbine assembly and the generator shaft of the static generator. Besides generating additional electricity, the electric generator system could also be used to reduce a rotational speed of the turbine shaft prior to its physical coupling with the generator shaft of the static generator, thus replacing a gear box assembly that can be found in existing energetic plants comprising a gas turbine and a static generator.

Possible applications

[0059] Multiple applications of the turbine assembly in accordance with the described embodiments could be conceived.

[0060] For instance, the upstream and downstream rotor segments could be rotated about the turbine axis by different kinds of flows, such as an air flow or a water flow. In other words, as represented in Fig. 7, the turbine assembly 2100 could form or be part of a hydraulic turbine.

[0061] A turbine assembly comprising more than two rotor segments could also be conceived: the turbine assembly could comprise three rotor segments, as represented in Figs. 4 to 6, four rotor segments, as shown in the turbine assembly 3100 represented in Fig. 8, wherein each of the four rotor segments has a blade assembly with decreasing diameters from an upstream portion of the turbine shaft towards a downstream portion of the turbine shaft. The turbine assembly could also comprise more than four rotor segments.

[0062] As schematically represented in Fig. 9, the turbine assembly 4100 could also comprise a gas turbine. It is known that a gas turbine, which is also called a combustion turbine, is a type of continuous and internal combustion engine, comprising an upstream rotating gas compressor, a combustor and a downstream turbine on the same shaft as the compressor.

[0063] For instance, the upstream rotating gas compressor comprises the upstream – or first – rotor segment 4200, and the downstream turbine comprises the second – or downstream - rotor segment 4300.

[0064] The turbine assembly could also comprise a turbofan (not represented) comprising a fan and a gas turbine engine, the gas turbine engine comprising the first rotor segment and the fan comprising the second rotor segment.

General principle

[0065] The turbine assembly as described in the disclosed embodiments thus presents different advantages with respect to existing multiple rotor turbines and has an improved performance.

[0066] It is appreciated that, for instance for maintenance and/or installation purposes, the upstream and downstream turbine segments can be individually isolated and/or stopped from each other.

[0067] In the embodiment wherein the turbine assembly comprises an electric generator system, electrical power generated by the electric generator system could be used, for instance, to recharge or feed an electric motor. The electrical power generated by the electric generator system might also be used to rotate the turbine shaft about the turbine axis in a rotation direction opposed to the rotation direction of the upstream and downstream rotor segments, in order, for instance, to accelerate the fluid flow circulating along the turbine axis and/or to increase a fluid flow volume circulating in a turbine housing containing the turbine shaft and the upstream and downstream rotor segments. In other words, the turbine assembly could further comprise a turbine housing at least partially delimiting a turbine-containing cavity, the turbine-containing cavity being shaped and dimensioned to receive at least partially the turbine shaft and the upstream and downstream rotor segments. The turbine shaft would be rotated in the turbine-containing cavity about the turbine axis in the rotation direction opposed to the rotation direction of the upstream and downstream rotor segments upon actuation of the electric motor operatively coupled to the electric generator and the turbine shaft. The electrical power could also be used to heat or cool areas of the turbine assembly (for instance the gas turbine thereof), for example next to a nozzle thereof to increase an exhaust gas speed or to keep a high temperature therein.

Method for operating a turbine assembly comprising an upstream rotor segment and a downstream rotor segment of a turbine assembly

[0068] According to another aspect of the disclosure, there is provided a method 800 for operating a turbine assembly 100 comprising an upstream rotor segment 200 and a downstream rotor segment 300 rotatably mounted to a turbine shaft 110. In the embodiment shown, the method comprises a step 810 of circulating a fluid along the turbine shaft 110 from an upstream portion of the turbine shaft towards a downstream portion of the turbine shaft, thereby engaging in rotation the upstream rotor segment 200 at an upstream rotational speed and the downstream rotor segment 300 at a downstream rotational speed; and a step 840 of physically coupling the upstream and downstream rotor segments to rotate at a same rotational speed. In the embodiment shown, the method 800 further comprises a step 820 of measuring the upstream and downstream rotational speeds; a step 830 of calculating a rotation speed difference between the upstream and downstream rotational speeds; and the step 840 of physically coupling the upstream and downstream rotor segments to rotate at a same rotational speed if the rotation speed difference is equal to or above a predetermined difference threshold. As mentioned above, other measures than the rotation speed difference could be used to physically couple the upstream and downstream rotor segments to rotate at a same rotational speed.

[0069] The method according to embodiments of the present disclosure may be carried out with a turbine assembly as those described above.

[0070] The method 800 might further comprise a step of physically uncoupling the upstream and downstream rotor segments 200, 300 when the upstream and downstream rotational speeds are substantially equal (i.e. if the rotation speed difference is substantially null).

[0071] In the embodiment wherein the turbine assembly comprises an electric generator system comprising a rotor arranged on one of the upstream and downstream rotor segments and the turbine shaft and a stator arranged on another one of the upstream and downstream rotor segments and the turbine shaft, and an electric motor operatively coupled to the electric generator and the turbine shaft, the method might further comprise a step of capturing electricity generated by the electric generator system if the rotation speed difference is equal to or above a predetermined difference threshold and a step of rotating the turbine shaft about the turbine axis in a direction opposed to the first rotation direction of the first and second rotor segments.

[0072] Several alternative embodiments and examples have been described and illustrated herein. The embodiments of the invention described above are intended to be exemplary only. A person of ordinary skill in the art would appreciate the features of the individual embodiments, and the possible combinations and variations of the components. A person of ordinary skill in the art would further appreciate that any of the embodiments could be provided in any combination with the other embodiments disclosed herein. It is understood that the invention may be embodied in other specific forms without departing from the central characteristics thereof. The present examples and embodiments, therefore, are to be considered in all respects as illustrative and not restrictive, and the invention is not to be limited to the details given herein. Accordingly, while the specific embodiments have been illustrated and described, numerous modifications come to mind. The scope of the invention is therefore intended to be limited by the scope of the appended claims.

CLAIMS:

1. A turbine assembly comprising:

a turbine shaft having a turbine axis and comprising at least an upstream portion and a downstream portion;

an upstream rotor segment rotatably mounted to the upstream portion of the turbine shaft and rotatable about the turbine axis in a rotation direction;

a downstream rotor segment rotatably mounted to the downstream portion of the turbine shaft and rotatable about the turbine axis in the rotation direction;

a one-way rotation driving system operatively coupled to the upstream and downstream rotor segments and driving the downstream rotor segment into rotation upon rotation of the upstream rotor segment while allowing a downstream rotational speed of the downstream rotor segment to be greater than an upstream rotational speed of the upstream rotor segment; and

a deactivatable coupling system selectively configurable into an activated configuration wherein a rotation of the downstream rotor segment is coupled with a rotation of the upstream rotor segment and into a disabled configuration wherein the downstream rotor segment is free from rotating with respect to the upstream rotor segment.

2. The turbine assembly according to claim 1, wherein the deactivatable coupling system comprises one or more retractable rods mounted to one of the upstream and downstream rotor segments and one or more stoppers mounted to the other one of the upstream and downstream rotor segments.

3. The turbine assembly according to claim 2, wherein the deactivatable coupling system further comprises at least one dampening member arranged between at least one of said one or more retractable rods and

a corresponding stopper when the deactivatable coupling system is configured in the activated configuration.

4. The turbine assembly according to any one of claims 1 to 3, further comprising a controller operatively coupled to the deactivatable coupling system to configure the deactivatable coupling system in one of the disabled and activated configurations based on a measure of at least one of the upstream and downstream rotational speeds.

5. The turbine assembly according to any one of claims 1 to 4, further comprising an electric generator system comprising a rotor arranged on one of the upstream and downstream rotor segments and the turbine shaft and a stator arranged on another one of the upstream and downstream rotor segments and the turbine shaft.

6. The turbine assembly according to claim 5, further comprising an electric motor operatively coupled to the electric generator and the turbine shaft to rotate the turbine shaft about the turbine axis in a direction opposed to the rotation direction.

7. The turbine assembly according to any one of claims 1 to 6, wherein the one-way rotation driving system comprises a one-way bearing.

8. The turbine assembly according to any one of claims 1 to 7, wherein the downstream rotor segment has a downstream weight smaller than an upstream weight of the upstream rotor segment.

9. The turbine assembly according to any one of claims 1 to 8, wherein the upstream rotor segment has an upstream blade assembly with an upstream diameter and the downstream rotor segment has a downstream blade assembly with a downstream diameter greater than the upstream diameter.

10. The turbine assembly according to any one of claims 1 to 9, wherein the turbine assembly comprises a gas turbine comprising a rotating gas compressor, a downstream turbine and a combustor located between the gas compressor and the turbine, wherein the rotating gas compressor comprises the upstream rotor segment and the downstream turbine comprises the downstream rotor segment.

11. The turbine assembly according to any one of claims 1 to 9, wherein the turbine assembly comprises a turbofan comprising a fan and a gas turbine engine, the gas turbine engine comprising the upstream rotor segment and the fan comprising the downstream rotor segment.

12. A method for operating a turbine assembly comprising an upstream rotor segment and a downstream rotor segment rotatably mounted to a turbine shaft, the method comprising:

circulating a fluid along the turbine shaft from an upstream portion of the turbine shaft towards a downstream portion of the turbine shaft, thereby engaging in rotation the upstream rotor segment at an upstream rotational speed and the downstream rotor segment at a downstream rotational speed;

physically coupling the upstream and downstream rotor segments to rotate at a same rotational speed.

13. The method according to claim 12, further comprising:

measuring the upstream and downstream rotational speeds;

calculating a rotation speed difference between the upstream and downstream rotational speeds; and

physically coupling the upstream and downstream rotor segments to rotate at a same rotational speed if the rotation speed difference is equal to or above a predetermined difference threshold,

14. The method according to claim 13, wherein if the rotation speed difference is substantially null, the method further comprises physically uncoupling the upstream and downstream rotor segments.

15. The method according to claim 13 or 14, wherein the turbine assembly further comprises an electric generator system comprising a rotor arranged on one of the upstream and downstream rotor segments and the turbine shaft and a stator arranged on another one of the upstream and downstream rotor segments and the turbine shaft, and an electric motor operatively coupled to the electric generator and the turbine shaft, the method further comprising capturing electricity generated by the electric generator system if the rotation speed difference is equal to or above a predetermined difference threshold and engaging in rotation the turbine shaft about the turbine axis in a direction opposed to a rotation direction of the upstream and downstream rotor segments.

ABSTRACT

The present disclosure concerns turbine assembly comprising a turbine shaft with a turbine axis and comprising upstream and downstream portions, an upstream rotor segment rotatably mounted to the upstream portion about the turbine axis in a rotation direction; a downstream rotor segment rotatably mounted to the downstream portion in the rotation direction; a one-way rotation driving system operatively coupled to the upstream and downstream rotor segments and driving the downstream rotor segment into rotation upon rotation of the upstream rotor segment while allowing a downstream rotational speed of the downstream rotor segment to be greater than an upstream rotational speed of the upstream rotor segment; and a deactivatable coupling system to physically couple the downstream rotor segment to the upstream rotor segment.

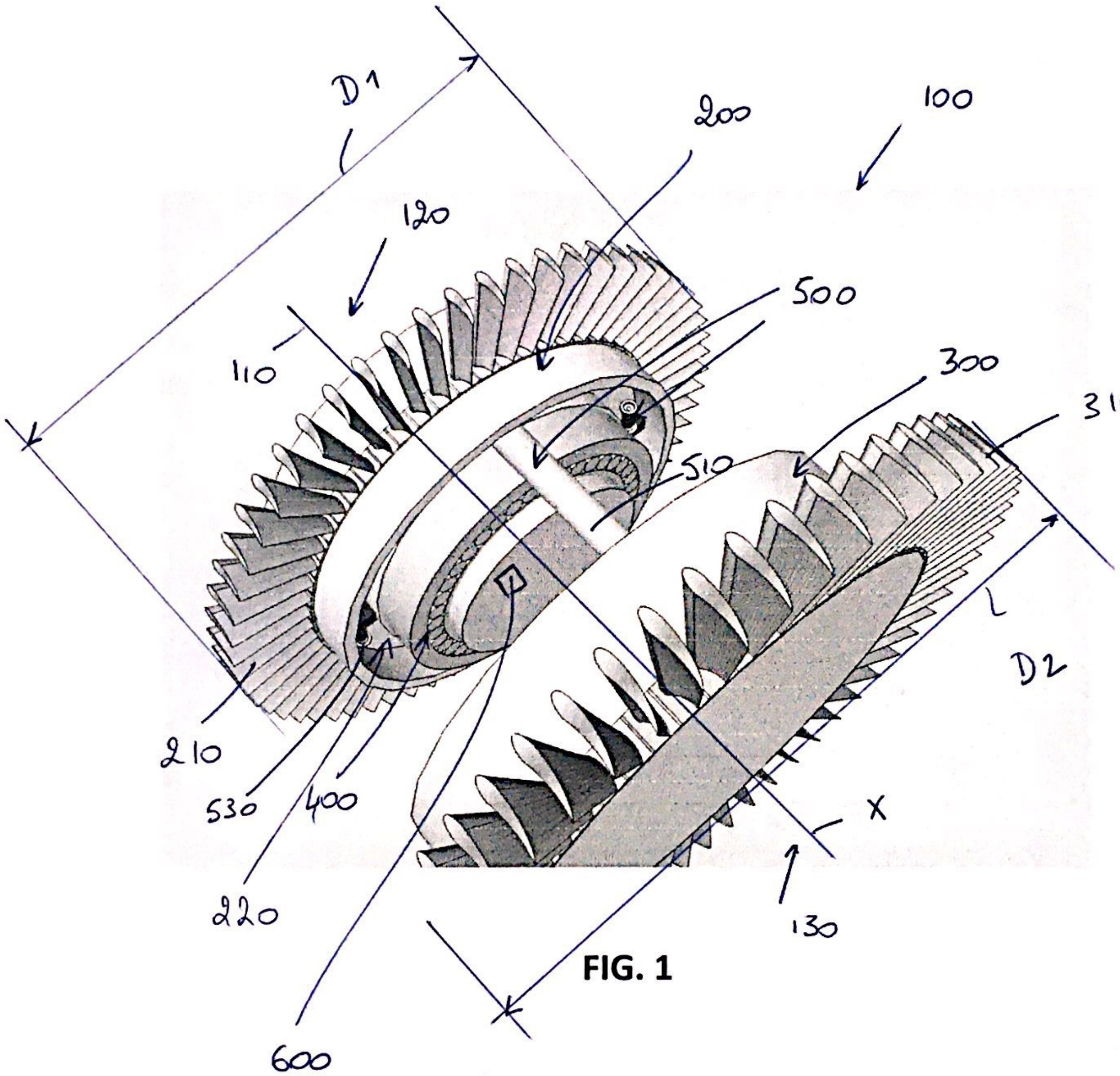

FIG. 1

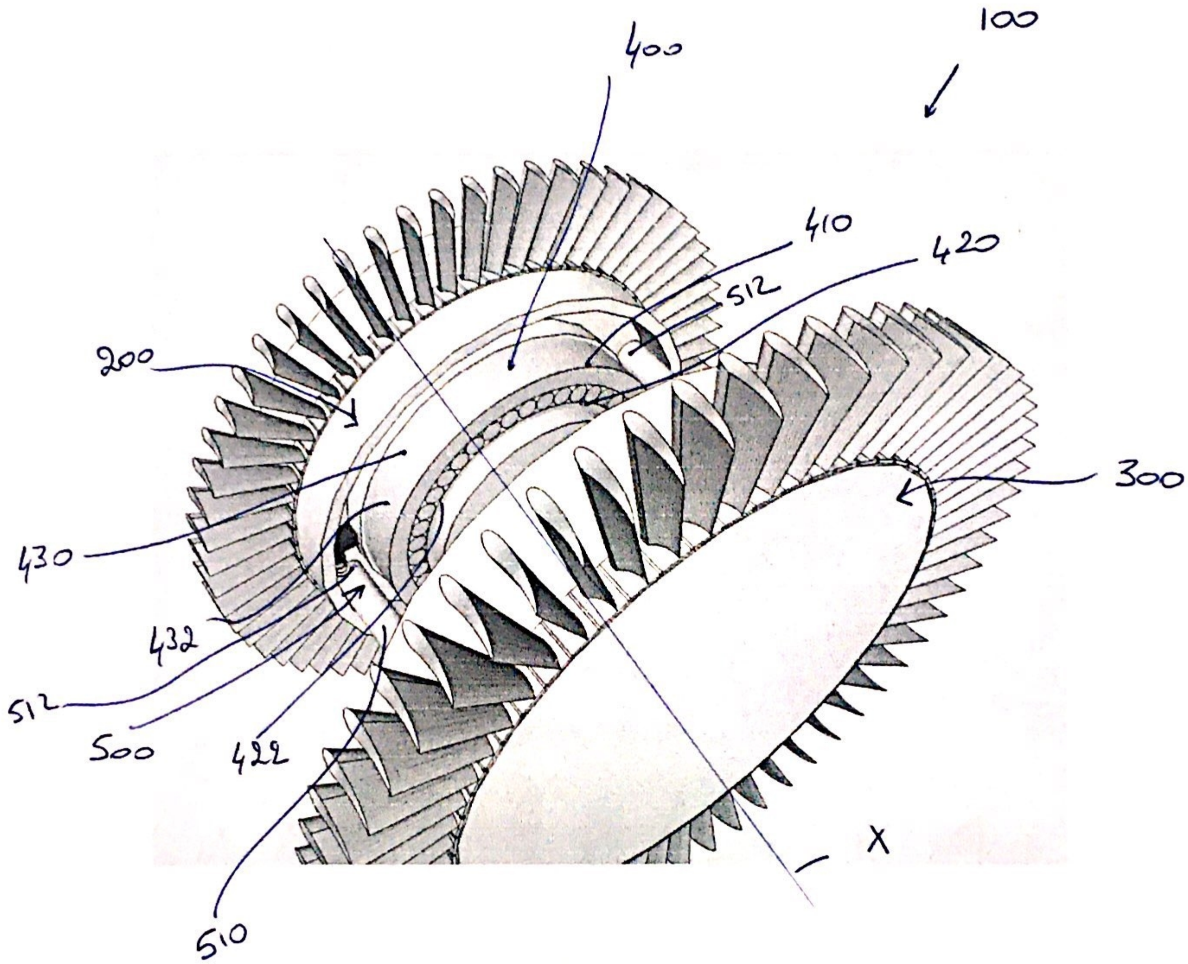

FIG. 2

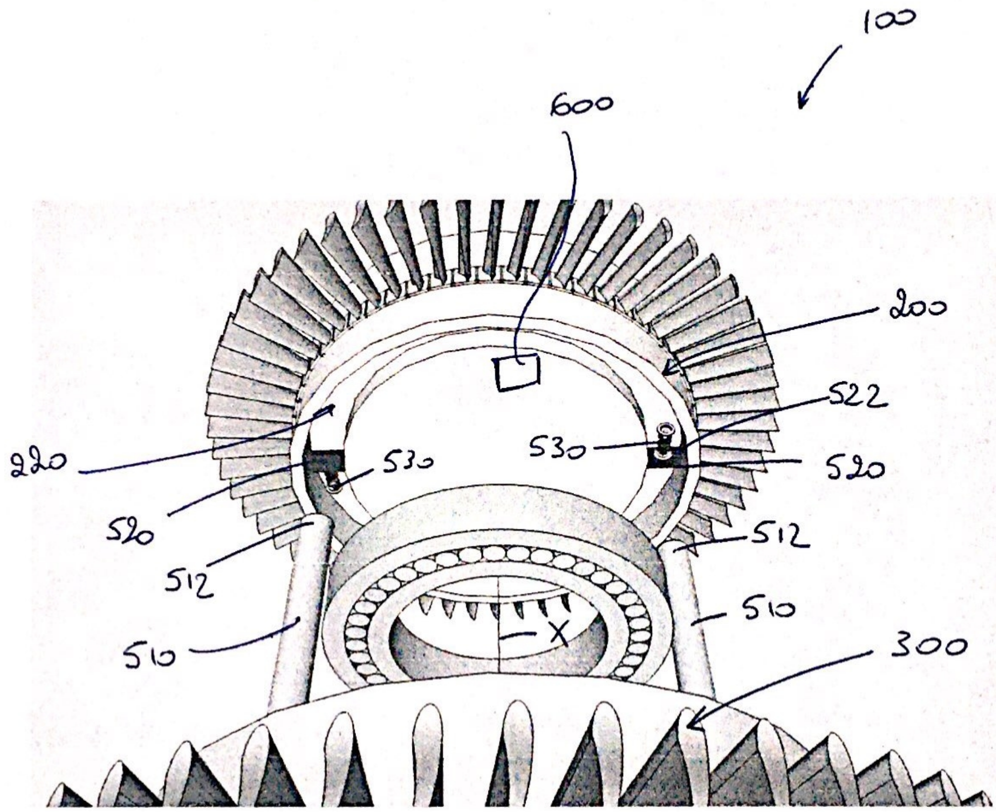

FIG. 3

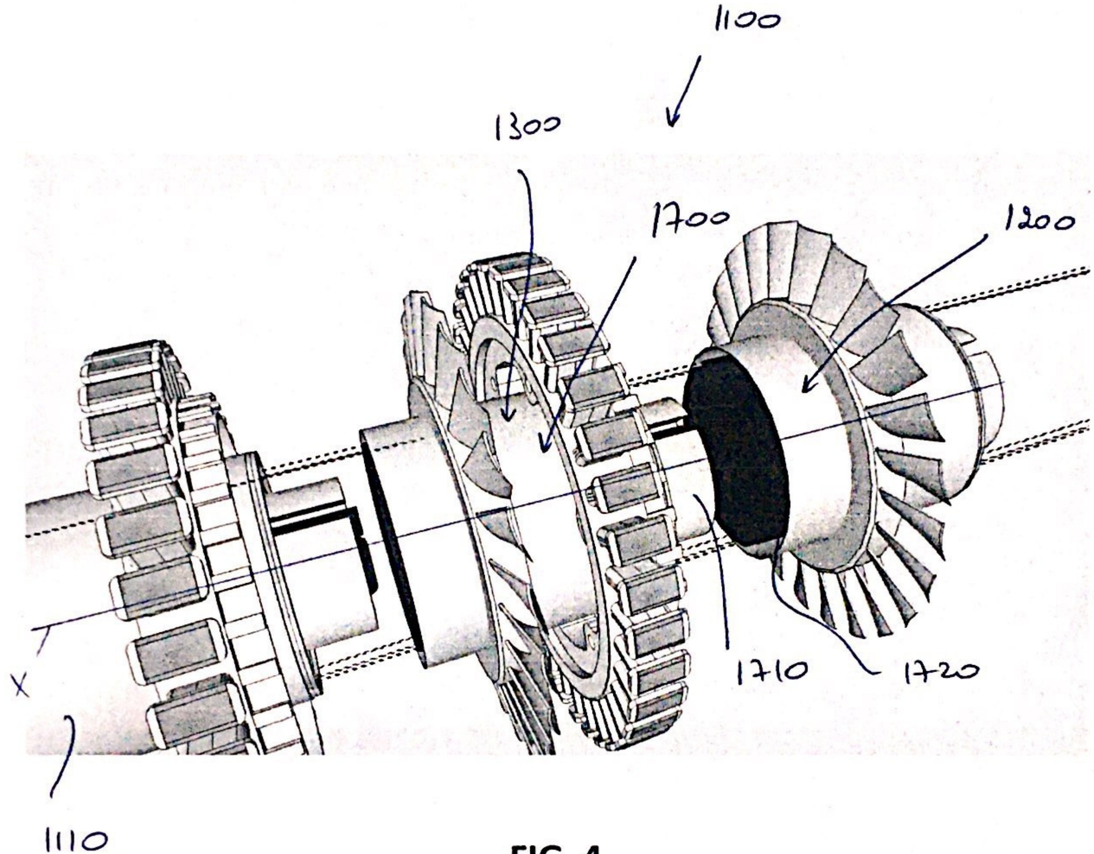

FIG. 4

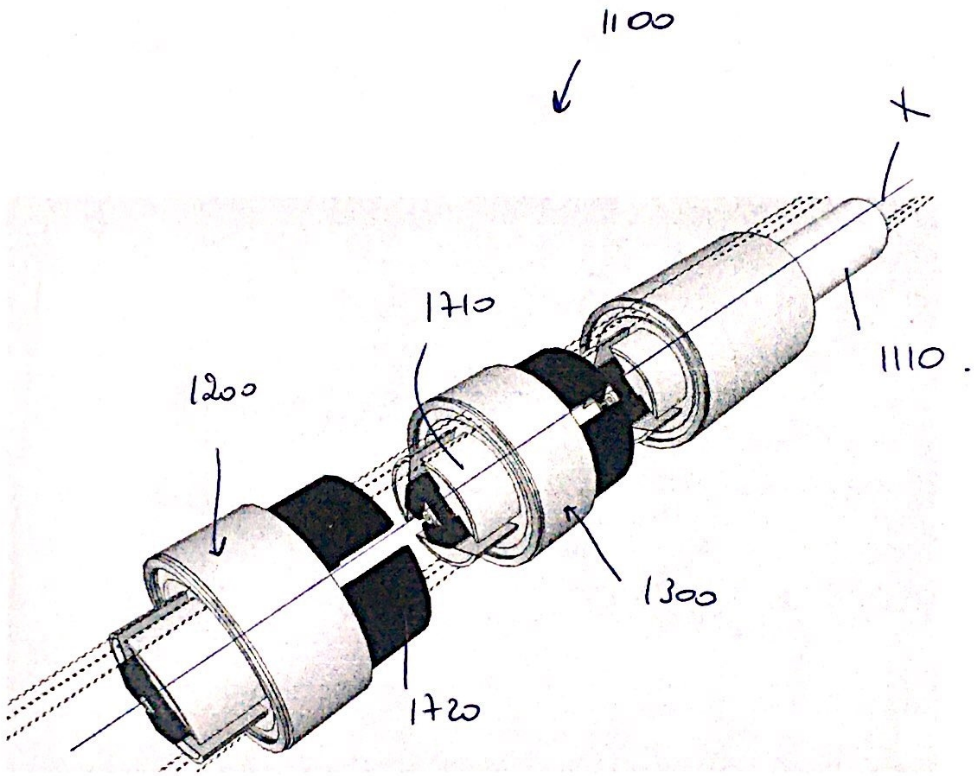

FIG. 5

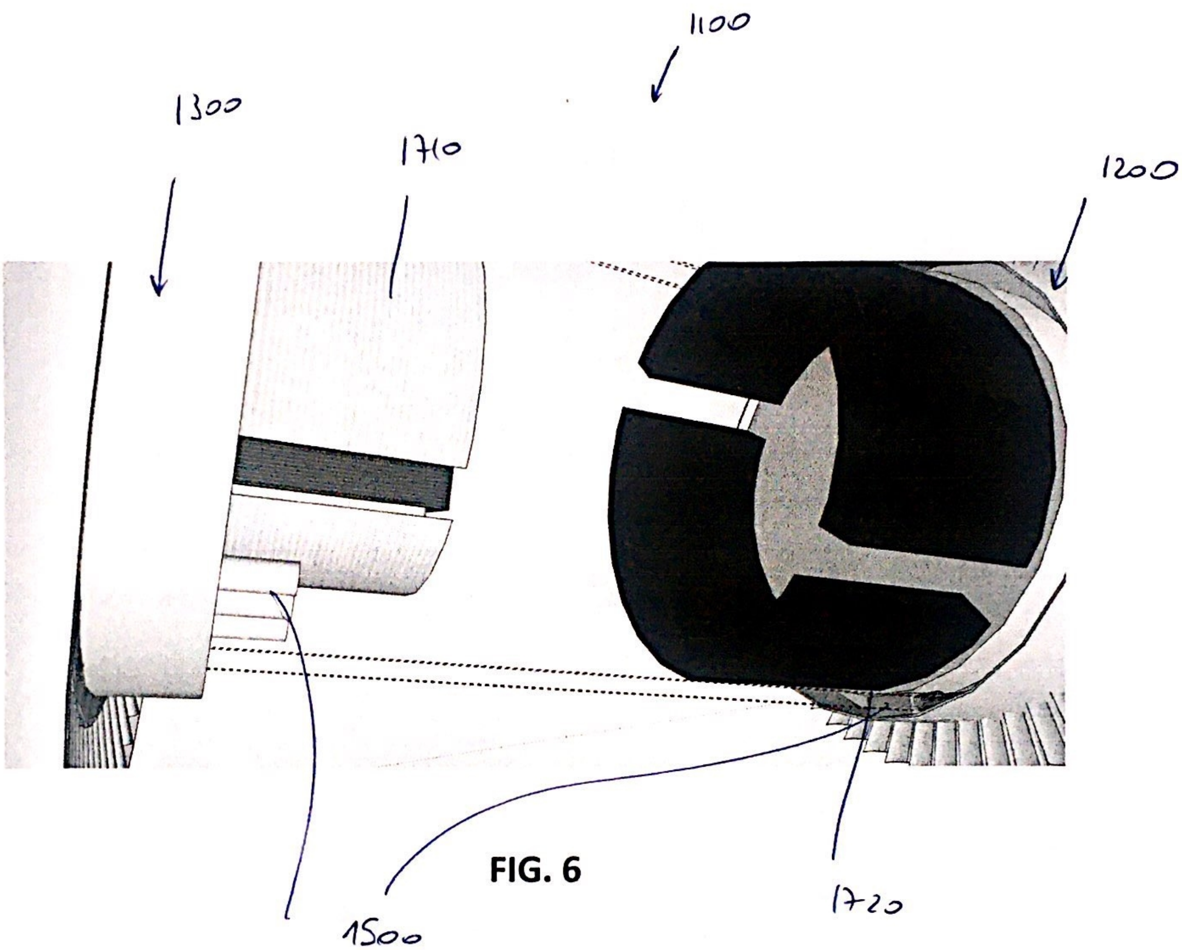

FIG. 6

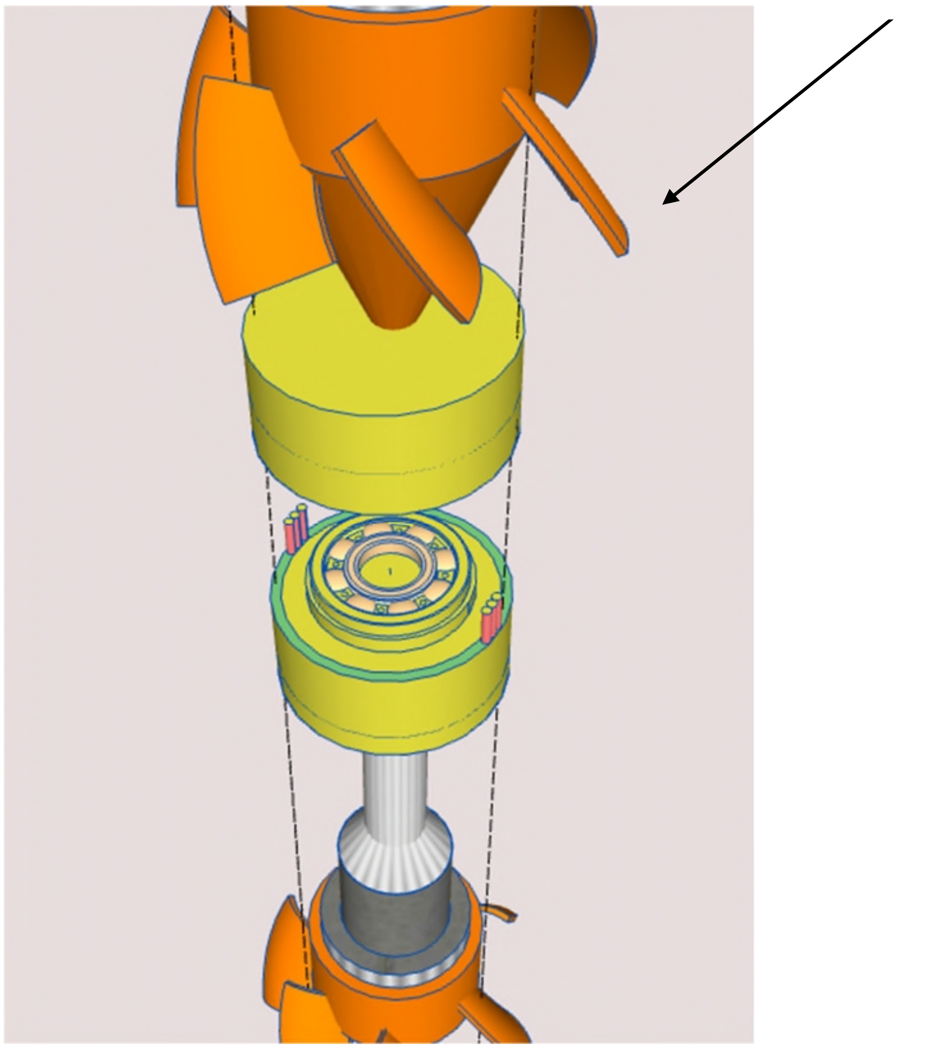

FIG. 7

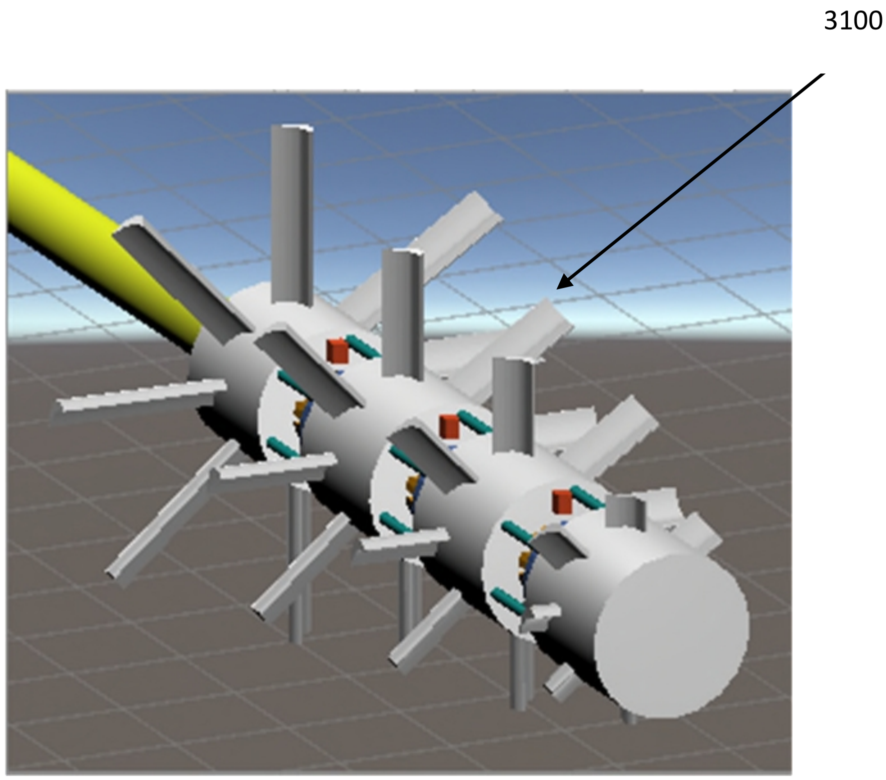

FIG. 8

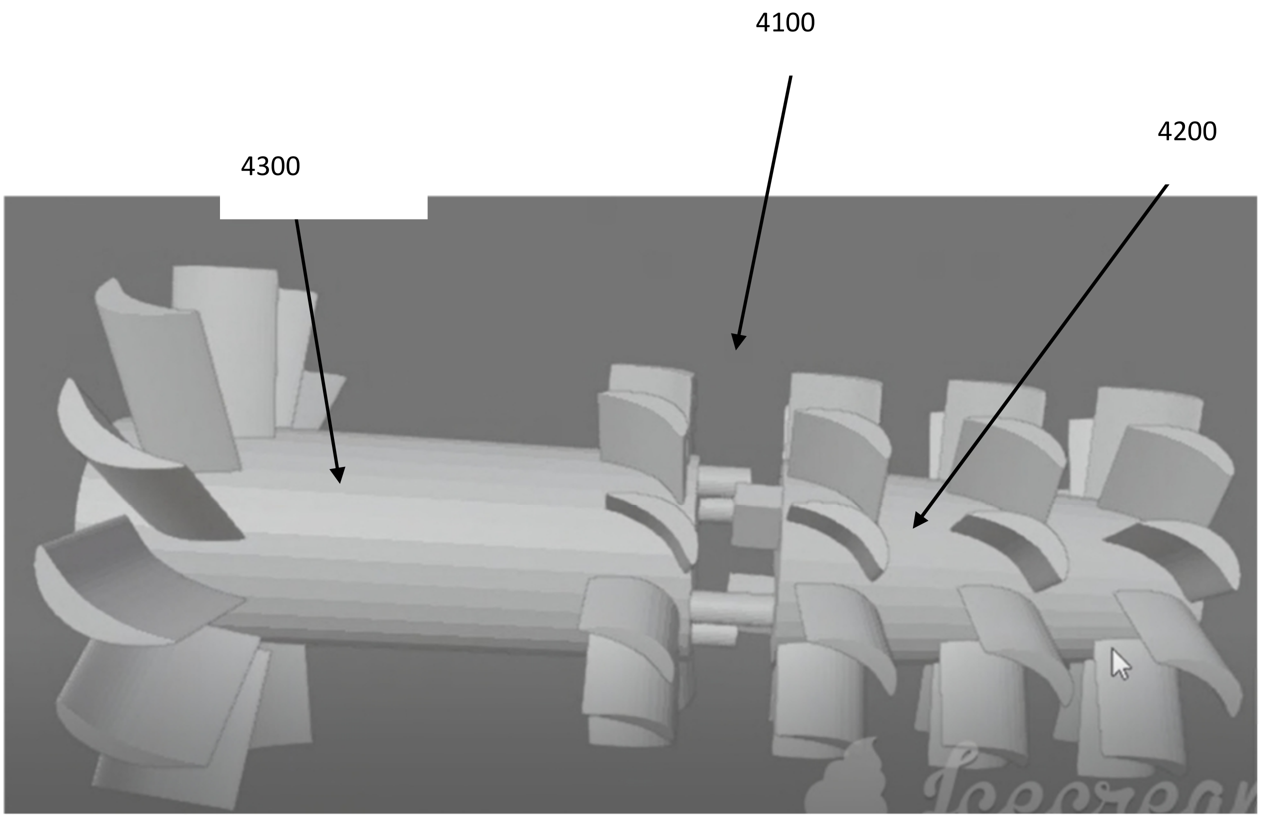

FIG. 9

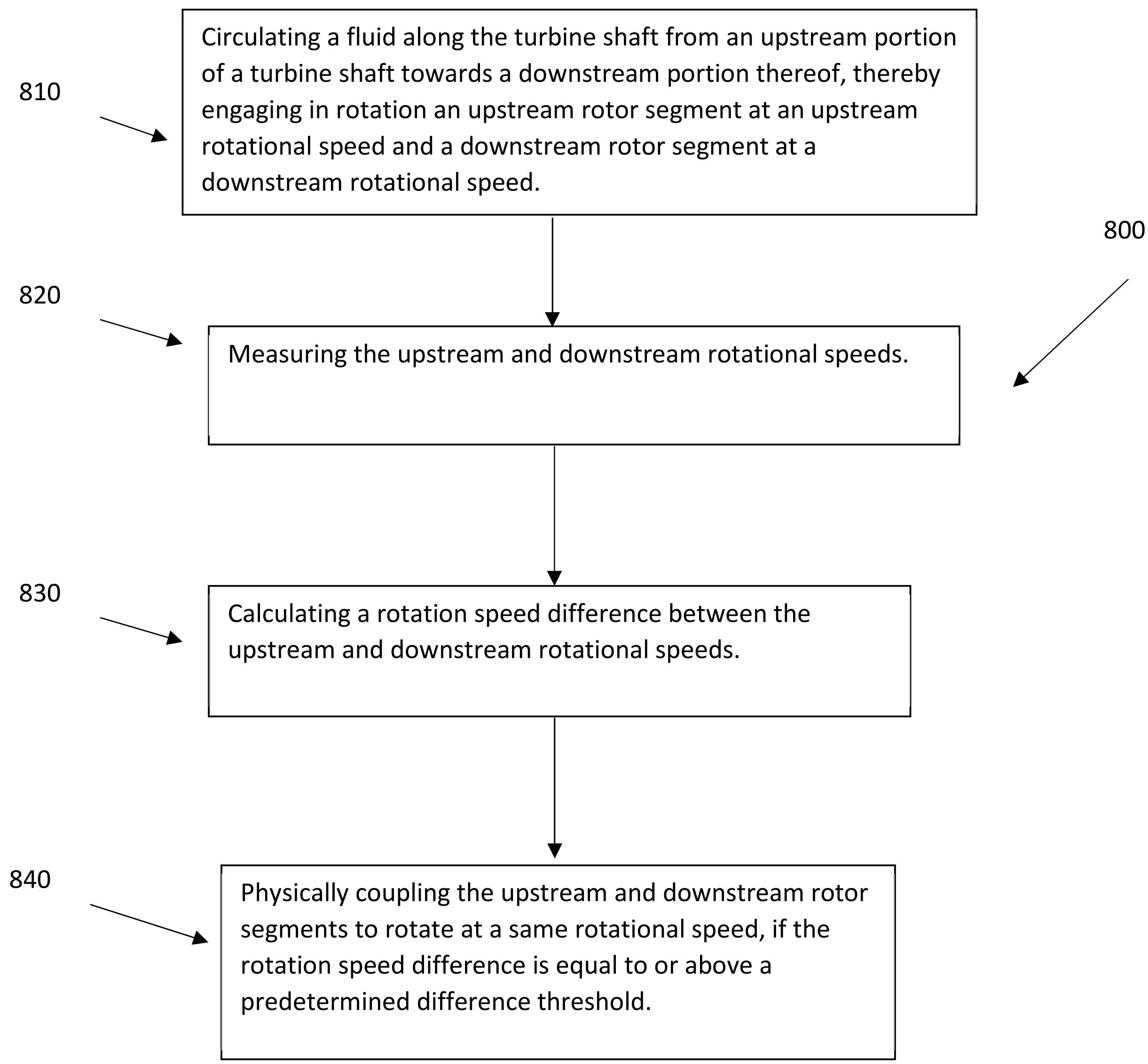
810
Circulating a fluid along the turbine shaft from an upstream portion of a turbine shaft towards a downstream portion thereof, thereby engaging in rotation an upstream rotor segment at an upstream rotational speed and a downstream rotor segment at a downstream rotational speed.
800
820
Measuring the upstream and downstream rotational speeds.
830
Calculating a rotation speed difference between the upstream and downstream rotational speeds.
840
Physically coupling the upstream and downstream rotor segments to rotate at a same rotational speed, if the rotation speed difference is equal to or above a predetermined difference threshold.

FIG. 10