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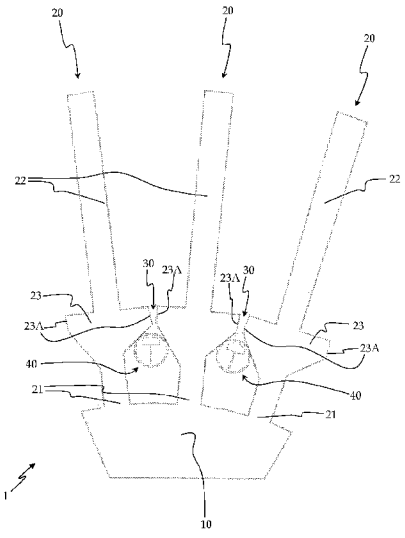


Fig. 1

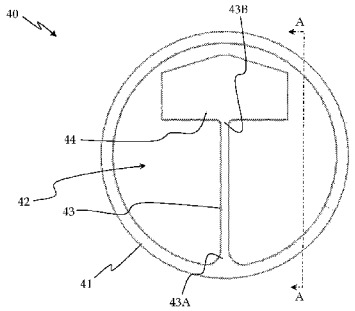


Fig. 2A

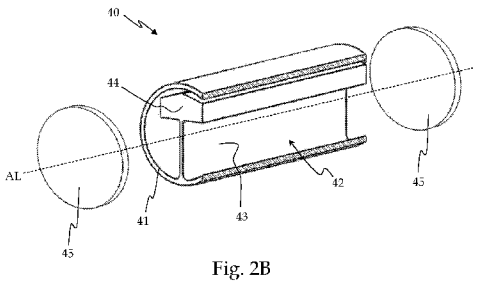


Fig. 2B

(57) Abstract: A gas turbine (1) comprises a disc (10), at the periphery of which a plurality of blades (20) are mounted and extend radially from said disc. Each blade comprises a neck (21) adapted to be coupled to a peripheral zone of the disc, an airfoil (22) extending radially from said neck, and a platform (23) interposed between the neck and the airfoil. Said platform develops substantially tangent to the peripheral zone of the disc and ends with an edge (23A) adapted to define a gap or a slot (30) with the edges of the platforms of the adjacent blades. A damper element (40) is comprised for damping the vibrations of the blade, and is positioned in correspondence with the slot and in contact with a lower portion of said platforms of adjacent blades. The damper element comprises: an internally hollow casing (41) that develops along a longitudinal axis (AL) and a pendulum (42) comprising a lamina (43) provided with a first end (43A) joined to an inner wall of the casing and with a second end (43B) joined to a mass (44). The pendulum develops along the longitudinal

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axis of the casing and is adapted to oscillate within and relative to the casing.

GAS TURBINE AND CORRESPONDING DAMPER ELEMENT

DESCRIPTION

The present invention relates to a gas turbine according to the preamble of claim 1. The present invention also relates to a damper element of said gas turbine.

In this frame, the present invention is applicable for damping the vibrations induced in the blades of gas turbines. It should be noted that, in the present description, reference will mainly be made to gas turbines, but it is clear that the features of the present invention are also applicable to other turbine types, e.g. steam turbines.

The characteristics of gas turbines make them suitable for the production of large amounts of energy, in some cases in very limited spaces; as a consequence, they are mostly used for propulsion purposes, particularly in the aircraft and shipbuilding industries, and for power generation.

When used for aircraft propulsion, the gas turbine finds application in the engine, where it performs the task of generating a thrust either directly (in a turbojet engine) or indirectly (by driving a propeller in a turbopropeller engine); auxiliary power units (APUs) may also be installed on the aircraft for producing electric energy, compressed air or hydraulic pressure for the on-board systems when the main engines are off.

As far as the generation of electric energy is concerned, the gas turbine may be either coupled to a simple steam cycle (combined-cycle power station) or directly connected to alternators (as in a gas power station). In a combined-cycle station, the residual heat in the exhaust gas of the gas turbine is recovered by means of a heat exchanger that supplies a steam turbine, which in turn is connected to a generator; this energy recovery improves efficiency from 40% of the simple cycle to 60% of the combined cycle.

According to the state of the art, it is known that gas turbines are so designed as to comprise a rotor with which at least one disc is associated, at the periphery of which a plurality of vanes or blades are mounted, in particular in a close and angularly spaced configuration; such blades project into the hot gas flow to convert the kinetic energy of said gas flow into rotational mechanical energy. It should be noted that gas turbines may also comprise a plurality of bladed discs; for example, multi-stage turbines include a plurality of bladed discs mounted in succession on the same rotor, such bladed discs having a gradually increasing diameter and alternating with stators, wherein each pair

made up of one rotary disc and one stator constitutes a stage.

Typically, each blade has a neck adapted to be coupled to a peripheral zone of the disc, an airfoil extending radially from said neck, and a platform interposed between the neck and the airfoil, wherein said platform develops tangent to the peripheral zone of the disc and ends with an edge adapted to define a gap or a slot with the edges of the platforms of the adjacent blades. The neck usually has a "fir" shape and is housed in slots having a complementary shape and formed in the peripheral zone of the disc; in this regard, the coupling between the neck of the blade and the peripheral zone of the disc is effected by means of an interlocking connection, in particular a dovetail joint.

When the turbine is in operation, vibrations of the turbine's blades are produced; if such vibrations are not duly taken into account and at least damped to a certain extent, they may cause turbine malfunctions or even premature damage to the blades.

In this respect, it must be pointed out that vibration damping is a contribution of primary importance.

In addition to vibration stresses induced by the gases, the bladed discs of the turbine are subjected to high thermal and centrifugal stresses. If the revolution speed of the disc becomes a multiple of one of the resonance frequencies of the bladed disc, or if gas fluctuations have a frequency close to one or the resonance of the blades, thus generating self-energized vibrations (flutter), fatigue failure at a high number of cycles becomes a real risk. Of course, engineers try to design turbines in such a way as to minimize the probability that one of the frequencies of the system will be energized; however, it is actually impossible to completely avoid approaching all critical resonances, because of the high modal density and the wide range of revolution speeds of the bladed discs.

It is therefore evident that ensuring an effective damping of vibrations that may be harmful for the integrity of the blade is a goal of primary importance.

Therefore, it is known in the art to use some devices which perform the function of damping vibrations that may be detrimental to blade integrity, and also a sealing function by separating the upper part (airfoil) from the lower part (neck or root) of the turbine blade, such devices being usually referred to as "sealing strips" or "underplatform dampers".

Such damping devices are positioned in the space between the edges of the platforms of adjacent blades and in contact with the lower portion of such platforms, i.e. with the platform portion facing towards the disc; in particular, such contact is obtained by means

of the centrifugal force generated by the rotation of the turbine.

In this regard, two types of underplatform dampers are currently in use, i.e. rigid dampers and flexible dampers; when the blades start to vibrate, the relative displacement between the blade platforms and the damper generates friction, which is useful for damping such vibrations. The geometric shape and the mass of the damper have a significant influence on the effect thereof on the bladed disc.

Flexible dampers (sealing strips) almost always provide an effective sealing function but, particularly because of their low mass and their shape, are less effective in damping vibrations; if two adjacent blades vibrate in phase according to a flexional mode, the effect will even be null, in that the flexible damper will alternately move away from either platform, thus also compromising the sealing function.

Rigid dampers may have different shapes, such as a cylindrical shape, a wedge (or "cottage roof") shape, a curved-flat shape (like a cylinder with a flattened portion); a cylindrical damper has a lower damping effect because of its small contact area, whereas a wedge damper and a curved-flat damper are more effective, but the contact between the flat surfaces of the damper and of the platforms is a source of uncertainty, in that such contact is never uniform.

In this context, document US2019/345830 shows a conical damper, i.e. having a gradually increasing cross-section, for damping modes characterized by a long vertical travel of the platforms. Document EP3054103A1 proposes a flexible seal containing a rigid damper. Document US2014/0271206A1 relates to a rigid cylindrical sealing device, which is inserted into a cavity between the platforms, not perpendicular to the tangential direction, but at an angle of a few degrees, so as to obtain different distances from the centre of the disc between the "pressure side" and the "suction side". Document US5281097A shows a flexible underplatform damper exploiting the centrifugal force to damp vibrations and provide sealing functions. Document US5156528A relates to a "wedge" or "cottage roof" damper, wherein the damper walls in contact with the blade platforms have protuberances for providing contact in specific zones and increasing the efficiency on flexional modes, particularly on the first one.

The damping function of the dampers known in the art, whether rigid or flexible, depends on the extent and direction of the relative displacement between the blades and the damper. Relative displacement is affected by several factors, the most important ones

being:

- extent of the applied force (gas fluctuations on the blades);
- modal form of the blade, which is related to its specific resonance frequency.

This performance dependency brings along negative consequences on the designer's predictive ability; in fact, since the extent of the applied force is not exactly known, it is difficult to precisely estimate the effectiveness of the damper and optimize its configuration. Moreover, the dampers known in the art are more effective for blades and/or vibration modes wherein sufficient mobility of the area where the damper is located is ensured; the blades being equal, the effectiveness will generally be higher for the first resonance, while it will tend to decrease for superior modes, often characterized by high mobility at airfoil level, but low mobility at platform level.

Consequently, also the solutions shown in the above-mentioned documents have some drawbacks, since they cannot act as dynamic vibration dampers and are not suitable for damping modes with little platform movement.

As a matter of fact, the dampers currently known in the art only exploit, as a single damping mechanism, the friction between damper and platforms, so that, while they provide damping of the first vibration modes, they are however ineffective in damping superior modes.

Document JP2010-265891A concerns the use of inserts arranged on adjoining platforms, which utilize magnetic fields for damping vibrations of different modes. However, this solution has some drawbacks as well, in that it requires power to create the magnetic field, thus inevitably implying more complexity in the turbine construction.

In order to avoid fatigue failures at a high number of cycles, some solutions are also known in the art which resort to using other vibration damping sources, like the so-called "shrouds" and "snubbers"; these devices, integrated with the blades, are arranged on the airfoil, and they too utilize friction to damp vibrations. Nevertheless, such solutions have some drawbacks as well, in that they disturb the gas flow, sensibly decreasing the efficiency of the turbine. Moreover, the presence of a "shroud" and/or a "snubber" considerably increases the stress undergone by the airfoil due to the centrifugal force.

In this frame, it is therefore the main object of the present invention to provide a gas turbine which is so realized as to overcome the drawbacks of the prior art.

In particular, it is one object of the present invention to provide a gas turbine comprising a damper element so realized as to act as a dynamic vibration damper while being capable

of damping modes with much platform movement and also modes with little platform movement.

It is another object of the present invention to provide a gas turbine comprising a damper element so conceived as to not increase the turbine construction complexity and to not require any additional equipment and/or components for the damper element to operate properly.

It is another object of the present invention to provide a gas turbine comprising a damper element so conceived as to ensure optimal results without decreasing the efficiency of the turbine, without disturbing the gas flow, and without increasing the stress undergone by the airfoil.

It is a further object of the present invention to provide a gas turbine comprising a damper element so realized as to ensure adequate sealing and optimal separation of the area surrounding the blade airfoil from the underlying area around the blade neck.

Further objects, features and advantages of the present invention will become apparent in the light of the following detailed description and the annexed drawings, which are provided herein merely by way of non-limiting explanatory example, wherein:

- Fig. 1 is a front view of a portion of a gas turbine according to the present invention;
- Fig. 2A is a cross-sectional view of a first embodiment of a damper element for a gas turbine according to the present invention;
- Fig. 2B is a perspective view of the damper element of Figure 2A, in particular the view of Fig. 2B representing a section of the damper element along a plane A-A, indicated in Fig. 2A by a double dashed-dotted arrow;
- Fig. 3A is a cross-sectional view of a second embodiment of a damper element for a gas turbine according to the present invention;
- Fig. 3B is a perspective view of the damper of Figure 3A, in particular the view of Fig. 3B representing a section of the damper element along a plane B-B, indicated in Fig. 3A by a double dashed-dotted arrow;
- Fig. 4 is a cross-sectional view of a third embodiment of a damper element for a gas turbine according to the present invention.

Referring now to the annexed drawings, in Figure 1 reference numeral 1 designates as a whole a gas turbine according to the present invention; it should be noted that only a portion of the turbine 1 is shown in Figure 1.

The turbine 1 comprises at least one disc 10, at the periphery of which a plurality of blades

20 are mounted, which extend radially from the disc 10, in particular in a close and angularly spaced configuration relative to the disc 10; as is known in the art, the blades 20 project into the hot gas flow to convert the kinetic energy of said gas flow into rotational mechanical energy.

Each blade 20 comprises a neck 21 adapted to be coupled to a peripheral zone of the disc 10, an airfoil 22 extending radially from said neck 21, and a platform 23 interposed between the neck 21 and the airfoil 22, wherein said platform 23 develops substantially tangent to the peripheral zone of the disc 10 and ends with an edge 23A adapted to define a gap or a slot 30 with the edges 23A of the platforms 23 of the adjacent blades 20.

Preferably, the neck 21 substantially has a "fir" or "Christmas tree" shape and is housed in slots having a complementary shape and formed in the peripheral zone of the disc 10; in this respect, the coupling between the neck 21 of the blade 20 and the peripheral zone of the disc 10 is effected by means of an interlocking connection, in particular a dovetail joint.

It should be noted that such coupling between each blade 20 and the disc 10 is not shown in Figure 1; it should also be noted that said coupling between each blade 20 and the disc 10 may also be effected otherwise.

The turbine 1 according to the present invention comprises at least one damper element (designated as a whole by reference numeral 40 in the annexed drawings) for damping the vibrations of at least one blade 20, wherein said at least one damper element 40 is positioned in correspondence of the slot 30 between the edges 23A of the platforms 23 of adjacent blades 20 and in contact with a lower portion of said platforms 23 of adjacent blades 20.

It must be pointed out that the term "lower portion" refers to that portion of each platform 23 which faces substantially towards the disc 10; also, it should be noted that the contact between the damper element 40 and the lower portion of the platform 23 is obtained by means of the centrifugal force generated by the rotation of the turbine 1.

As is known in the art, each damper element 40 also performs a sealing function, in that it allows separating the area surrounding the airfoil 22 of the blade 20 from the area under the platform 23 surrounding the neck 21 of the blade 20.

As can be noticed in Figures 2A to 4, in accordance with the present invention said damper element 40 comprises:

- an internally hollow casing 41, wherein said casing 41 develops along a longitudinal

axis (indicated by a dashed line AL in Figures 2A and 3A);

- a pendulum 42 comprising a lamina 43 provided with a first end 43A joined to an inner wall of the casing 41 and with a second end 43B joined to a mass 44, wherein said pendulum 42 develops along the longitudinal axis AL of the casing 41 and is adapted to oscillate within and relative to the casing 41.

In substance, the development of the casing 41 and of the pendulum 42 along said longitudinal axis AL corresponds to the length of such components.

In this regard, the development of the pendulum 42 along the longitudinal axis AL substantially corresponds to the development of the casing 41 along said longitudinal axis AL (i.e. the length of the pendulum 42 is substantially the same as that of the casing 41).

It must be pointed out that the frequency of oscillation of the pendulum 42 relative to the casing 41 can be controlled by suitably modifying the characteristics, in particular the geometric and dimensional ones, of the lamina 43 and of the mass 44; moreover, the junction between the casing 41 and the lamina 43 and the junction between the lamina 43 and the mass 44 are designed to increase the service life of the damper element 40 by reducing the strain amplitude.

As can be seen in Figure 2B, the damper element 40 may be provided with at least one cover 45 for closing at least one terminal portion of the casing 41; preferably, the damper element 40 comprises a pair of covers 45 for closing both terminal portions of the casing 41. In this regard, the length of the casing 41 may slightly exceed that of the pendulum 42, so as to leave a gap between the pendulum 42 and said at least one cover 45 useful to allow the pendulum 42 to oscillate without contact with said at least one cover 45; as an alternative, still in order to allow the pendulum 42 to oscillate without contacting the cover 45, the length of the casing 41 and the length of the pendulum 42 may be substantially the same, and said at least one cover 45 may be designed with a concave conformation of the portion thereof that faces towards the pendulum 42.

In accordance with a preferred embodiment, the casing 41 and/or the pendulum 42 are made of metallic material, in particular such components being realized by moulding and/or by means of an additive manufacturing process.

In this respect, said at least one cover 45 is also made of metallic material, in particular by moulding and/or by means of an additive manufacturing process.

It is to be understood that the casing 41 and/or the pendulum 42 and/or said at least one cover 45 may also be made of other materials, e.g. plastic material or composite material;

in particular, such components may be manufactured by moulding.

Figures 2A to 4 show some different possible embodiments of the casing 41.

In accordance with a first embodiment shown in Figures 2A and 2B, the casing 41 has a substantially cylindrical shape and is internally hollow (that is, it has a substantially tubular shape, i.e. a hollow prism having a substantially circular base).

In a second embodiment shown in Figures 3A and 3B, the casing 41 is substantially shaped like an internally hollow wedge-shaped prism, in particular a pentagonal-base prism; it should be noted that such a shape may also be defined as "wedge" or "cottage roof".

In a third embodiment shown in Figure 4, the casing 41 has the same shape as the second embodiment, wherein the casing 41 is substantially shaped like an internally hollow wedge-shaped prism; in addition, the casing 41 has a first wall 41A and a second wall 41B provided with at least three supports 46 adapted to define at least three points of contact with the respective platforms 23. In this regard, it should be noted that in the third embodiment shown in Figure 4 the first wall 41A comprises two supports 46, whereas the second wall 41B comprises only one support 46; it is however clear that in the third embodiment the supports 46 may be distributed or positioned differently than in Figure 4 (e.g. the first wall 41A may comprise only one support 46 and the second wall 41B may comprise two supports 46). It is also clear that the first wall 41A and the second wall 41B are those walls of the casing 10 which face towards the respective platforms 23 of two adjacent blades 20.

The peculiar features of the damper element 40 according to the present invention ensure adequate damping of the vibrations of the blade 20.

Indeed, in addition to the damping obtained by friction between the platform 23 of each blade 20 and the casing 41 of the damper element 40, the provisions of the present invention make it possible to attain:

- a dynamic damping of vibrations associated with a specific resonance frequency of the blade 20, due to an appropriate design of the pendulum 42 comprising the lamina 43 and the mass 44;
- an additional damping of the vibrations of the blade 20, due to a possible impact between the mass 44 of the pendulum 42 and the inner surface of the casing 41. This third damping mechanism is activated when the oscillation amplitude of the pendulum 42 exceeds the travel allowed by the internal volume of the casing 41, and permits

preserving the integrity of the pendulum 42, in that the impact against the inner surface of the casing 41 avoids an excessive oscillation amplitude of the pendulum 42.

It is therefore apparent that the specific configuration of the damper element 40 according to the present invention ensures optimal damping not only of the first vibration modes (as is often the case with the dampers currently known in the art), but also of superior modes, for which prior-art dampers are generally ineffective.

The shape and thickness of the casing 41 are optimized to ensure optimal damping of flexional modes, particularly of the first vibration mode, while the configuration of the pendulum 42 is calibrated to damp a specific resonance of interest for a particular turbine 1.

While the unit cost of the damper element 40 according to the present invention is higher than that of those currently known in the art, it must however be considered that dampers are *per se* inexpensive components that will only slightly affect the total cost of a turbine.

Furthermore, the peculiar provisions of the present invention make it possible to effectively control the vibration amplitude of the blade 20, thereby allowing a reduction in the weight of said blade 20, resulting in a significant efficiency improvement.

The damper element 40 made in accordance with the teachings of the present invention is also very effective in damping modes characterized by high mobility of the airfoil 22 and low mobility of the region of the platforms 23, and this makes it unnecessary to design the airfoil 22 with additional dampers, such as, for example, those known in the art as "shrouds" or "snubbers"; this makes it possible to achieve the following important advantages:

- better gas flow, resulting in increased efficiency of the turbine stage.
- reduced weight of the blade 20, resulting in even higher efficiency of the turbine 1.
- reduced cost incurred for manufacturing the blade 20.

To design the damper element 40 according to the present invention, it is therefore important to know the first resonance frequency of the pendulum system 42 because, if one succeeds in equalizing the first resonance frequency of the pendulum system 42 to that of the system composed of the blades 20 and the casing 41, the pendulum 42 will be transformed into a dynamic vibration damper.

Dynamic vibration damping, which was first explained by Den Hartog (Mechanical Vibrations. J. P. Den Hartog. Courier Corporation, Jan 1, 1985 - Technology & Engineering), is a concept that has already been exploited in the civil field. It has been

demonstrated that, if two systems having the same resonance frequency are placed in contact with each other, any energy introduced in the vibrating system by a field of forces will be transferred to the smaller body (i.e. the pendulum 42 according to the present invention), leaving the remaining portion of the system (i.e. the blades 20 according to the present invention) in a state of rest.

It is of fundamental importance to point out that the pendulum system 42, being a dynamic vibration damper, dissipates no energy; on the contrary, it will absorb the energy associated with the forced movement of the system and will tend to confine it within itself as kinetic energy and elastic potential energy.

This vibration absorption or damping mechanism turns out to be effective also for those modes for which friction damping fails because the modal form shows little mobility of the platforms 23.

This became apparent after a quantitative comparison that was carried out between a prior-art rigid damper and a damper element 40 made in accordance with the provisions of the present invention; in particular, for this comparison we selected a simple cylindrical damper as a control case and a damper element 40 with an internal pendulum 42 and a casing 41 that was, like the traditional damper, cylindrical in shape and of the same size.

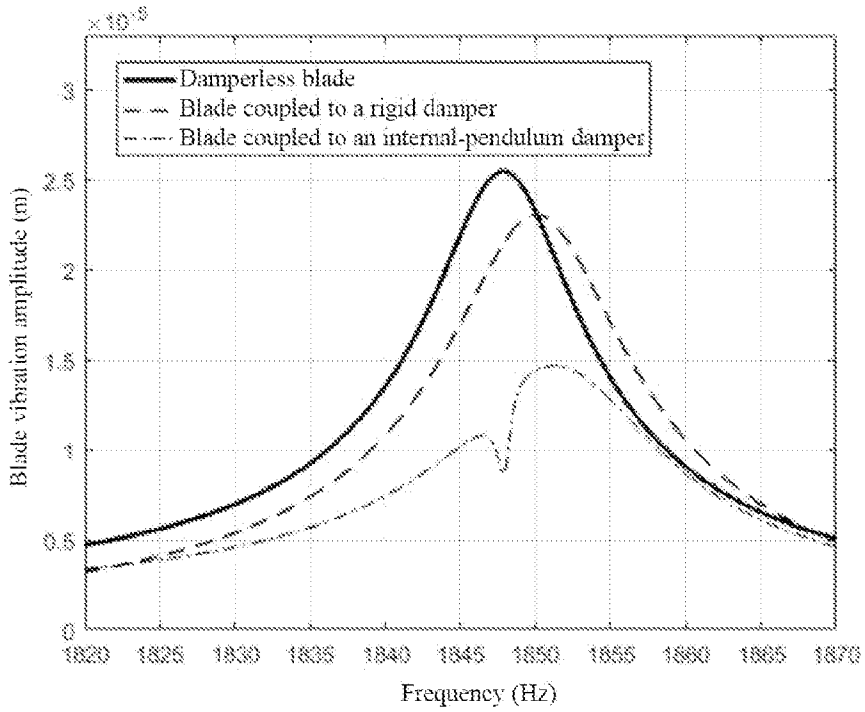
The result of the simulations, in terms of frequency response, are shown in the following diagram, wherein the damper element 40 made in accordance with the provisions of the present invention is defined as an “internal-pendulum damper”.

In such diagram, the continuous line represents the response of a damperless blade, and serves as reference, while the dashed curve shows the response of the blade system equipped with a traditional damper.

Due to the low mobility of the platforms, the traditional cylindrical damper introduces no damping by friction, but simply couples together two adjacent blades, thus moderately stiffening the global structure. In such a configuration, the vibration amplitude of the blade tip (which is proportional to the strains) is substantially equal to that of the damperless blade.

In the following diagram, the dashed-dotted line shows the response of the blade system equipped with a damper element 40 according to the present invention. In this diagram, two peaks are clearly visible in proximity to the original resonance, whose amplitude is however considerably reduced; it is therefore evident that the residual energy has been

transferred to the pendulum 42 inside the casing 41.



The internal oscillations of the pendulum 42 during the dynamic damping of the vibrations might compromise the integrity of the lamina 43, which could be subject to fatigue failure. It should be reminded that turbines are usually designed for working away from resonances, so that stresses close to resonance mainly occur when starting ("run-up") and stopping ("run-down") the disc 10, i.e. in transient situations. Such being the case, the service life of the damper 40 becomes a non-critical parameter, which safeguards the integrity of the more expensive blade 20 and can be replaced during periodic overhauls of the turbine 1.

A mechanism is nonetheless available for protecting the pendulum 42, which stores the energy absorbed from the blade 20 and can damp it through the mass 44 of the pendulum 42 impacting against the inner walls of the casing 41; it is thus possible to adjust the dimensions of the mass 44 and of the casing 41 in such a way that the impact will occur for oscillation amplitudes of the pendulum 42 that are potentially harmful for its integrity.

The features of the turbine 1 and of the damper element 40 according to the present invention, as well as the advantages thereof, are apparent from the above description.

In particular, the provisions of the present invention make it possible to provide a turbine 1 comprising a damper element 40 so realized as to act as a dynamic vibration damper

while being capable of damping modes with much platform movement as well as modes with little platform movement.

Moreover, the damper element 40 according to the present invention is so conceived that it will not increase the construction complexity of the turbine 1 and will not require any additional equipment and/or components for said damper element 40 to operate properly.

A further advantage of the present invention lies in the fact that the damper element 40 is so conceived as to provide optimal results without decreasing the efficiency of the turbine 1 and without disturbing the gas flow.

Yet another advantage of the present invention lies in the fact that the damper element 40 is so realized as to ensure adequate sealing and optimal separation of the area surrounding the airfoil 22 of the blade 20 from the area under the platform 23 surrounding the neck 21 of the blade 20.

The turbine 1 and the damper element 40 described herein by way of example may be subject to many possible variations without departing from the novelty spirit of the inventive idea; it is also clear that in the practical implementation of the invention the illustrated details may have different shapes or be replaced with other technically equivalent elements.

It can therefore be easily understood that the present invention is not limited to the above-described turbine 1 and damper element 40, but may be subject to many modifications, improvements or replacements of equivalent parts and elements without departing from the inventive idea, as clearly specified in the following claims.

* * * * * * * * *

CLAIMS

1. Gas turbine (1) comprising:

- at least one disc (10), at the periphery of which a plurality of blades (20) are mounted, which extend radially from said at least one disc (10), in particular in a close and angularly spaced configuration relative to the disc (10),
  wherein each blade (20) comprises a neck (21) adapted to be coupled to a peripheral zone of the disc (10), an airfoil (22) extending radially from said neck (21), and a platform (23) interposed between the neck (21) and the airfoil (22),
  and wherein said platform (23) develops substantially tangent to the peripheral zone of the disc (10) and ends with an edge (23A) adapted to define a gap or a slot (30) with the edges (23A) of the platforms (23) of the adjacent blades (20);
- at least one damper element (40) for damping the vibrations of at least one blade (20), wherein said at least one damper element (40) is positioned in correspondence of the slot (30) between the edges (23A) of the platforms (23) of adjacent blades (20) and in contact with a lower portion of said platforms (23) of adjacent blades (20),

said at least one damper element (40) being characterized in that it comprises:

- an internally hollow casing (41), wherein said casing (41) develops along a longitudinal axis (AL);
- a pendulum (42) comprising a lamina (43) provided with a first end (43A) joined to an inner wall of the casing (41) and with a second end (43B) joined to a mass (44), wherein said pendulum (42) develops along the longitudinal axis (AL) of the casing (41) and is adapted to oscillate within and relative to the casing (41).

2. Turbine (1) according to claim 1, characterized in that the development of the pendulum (42) along the longitudinal axis (AL) substantially corresponds to the development of the casing (41) along said longitudinal axis (AL).

3. Turbine (1) according to one or more of the preceding claims, characterized in that the casing (41) and/or the pendulum (42) are made of metallic material, in particular such components being realized by moulding and/or by means of an additive manufacturing process.

4. Turbine (1) according to one or more of the preceding claims, characterized in that said damper element (40) is provided with at least one cover (45) for closing at least one terminal portion of the casing (41).

5. Turbine (1) according to claim 4, characterized in that said at least one cover (45)

is made of metallic material, in particular being realized by moulding and/or by means of an additive manufacturing process.

6. Turbine (1) according to one or more of the preceding claims, characterized in that the neck (21) substantially has a "fir" or "Christmas tree" shape and is housed in slots having a complementary shape and formed in the peripheral zone of the disc (10).

7. Turbine (1) according to claim 6, characterized in that the coupling between the neck (21) of the blade (20) and the peripheral zone of the disc (10) is effected by means of an interlocking connection, in particular a dovetail joint.

8. Turbine (1) according to one or more of the preceding claims, characterized in that the casing (41) has a substantially cylindrical shape and is internally hollow.

9. Turbine (1) according to one or more of the preceding claims 1 to 7, characterized in that the casing (41) is substantially shaped like an internally hollow wedge-shaped prism, in particular a pentagonal-base prism.

10. Turbine (1) according to claim 9, characterized in that the casing (41) has a first wall (41A) and a second wall (41B) provided with at least three supports (46) adapted to define at least three points of contact with the respective platforms (23).

11. Damper element (40) for a gas turbine (1) according to one or more of claims 1 to 10.

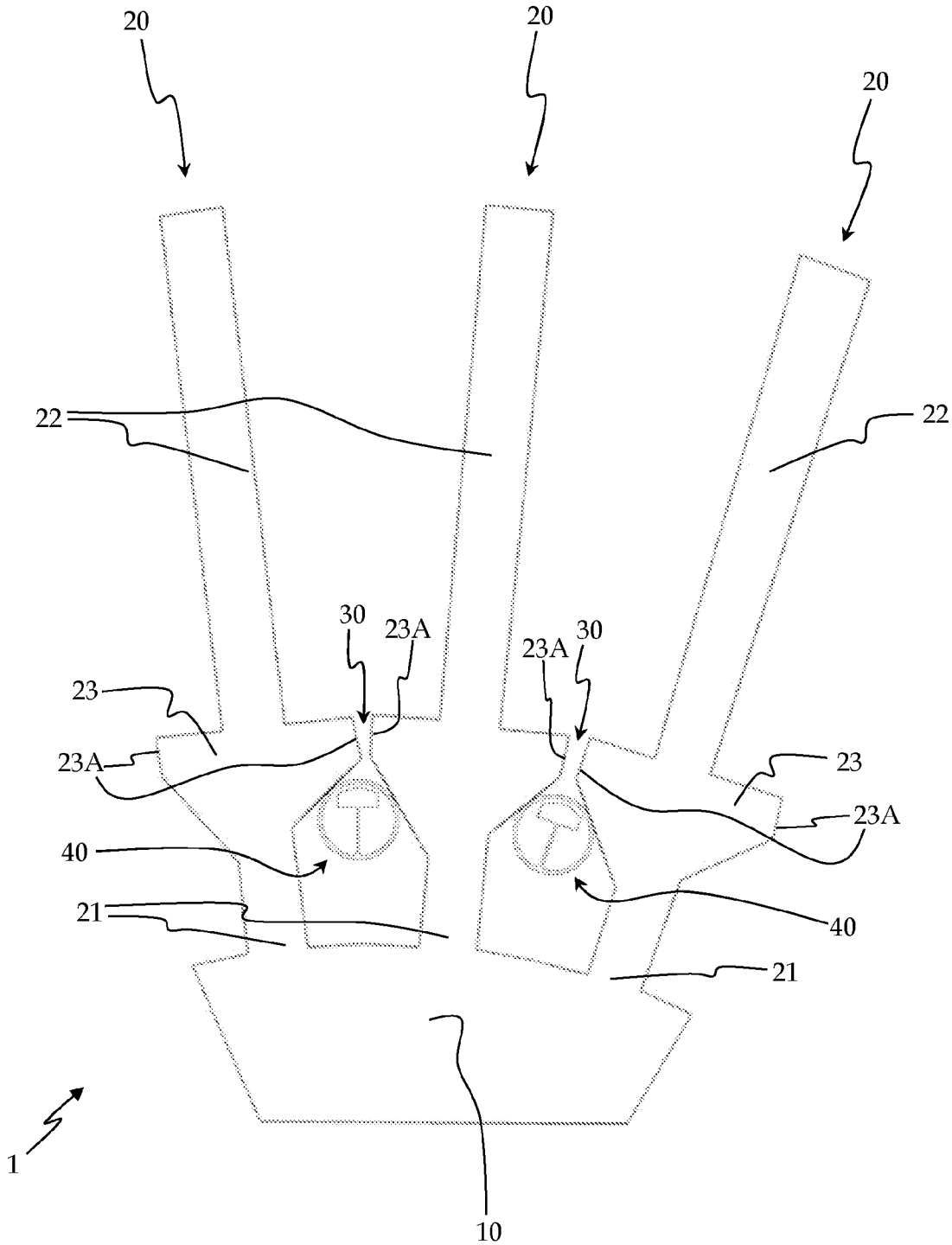


Fig. 1

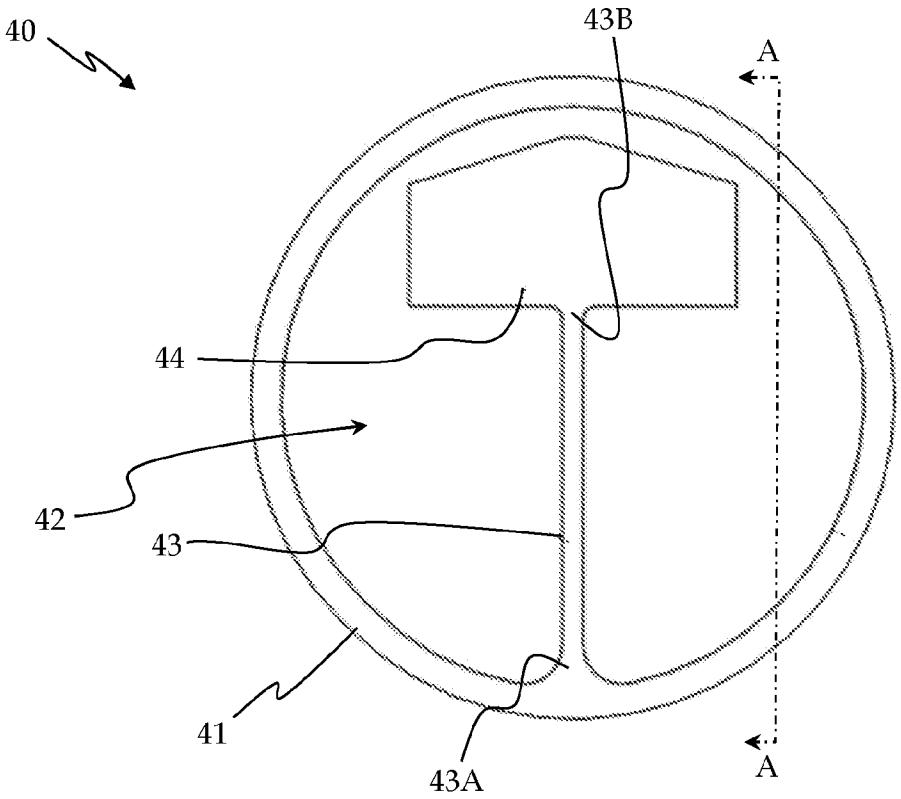


Fig. 2A

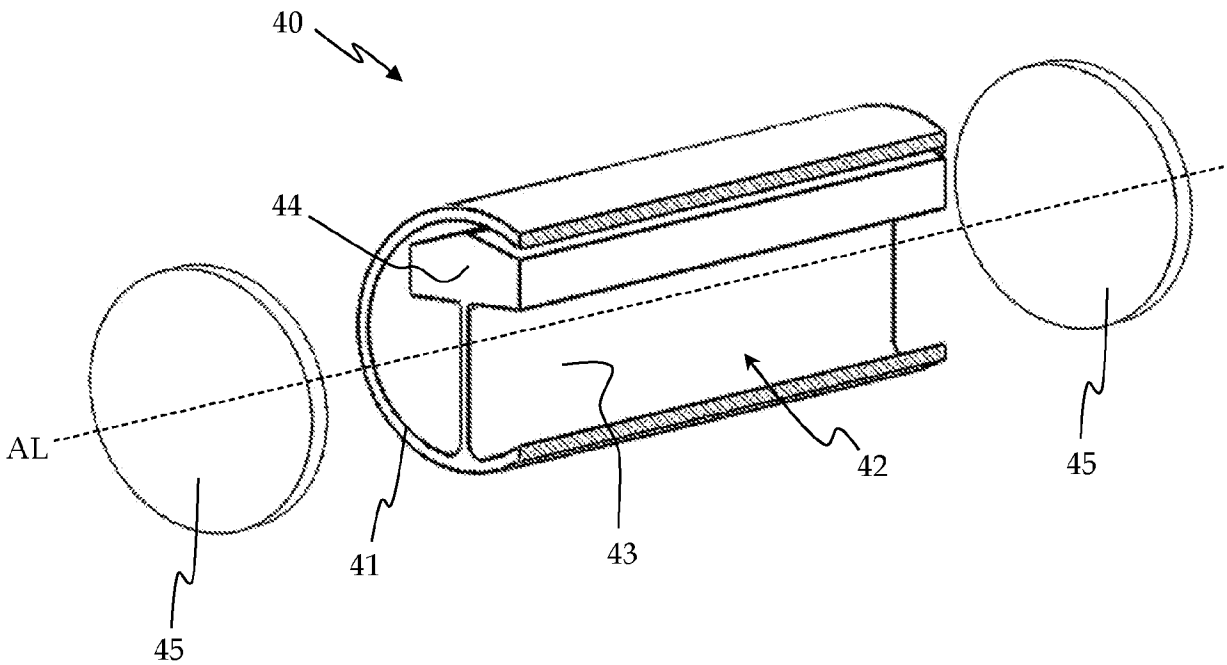


Fig. 2B

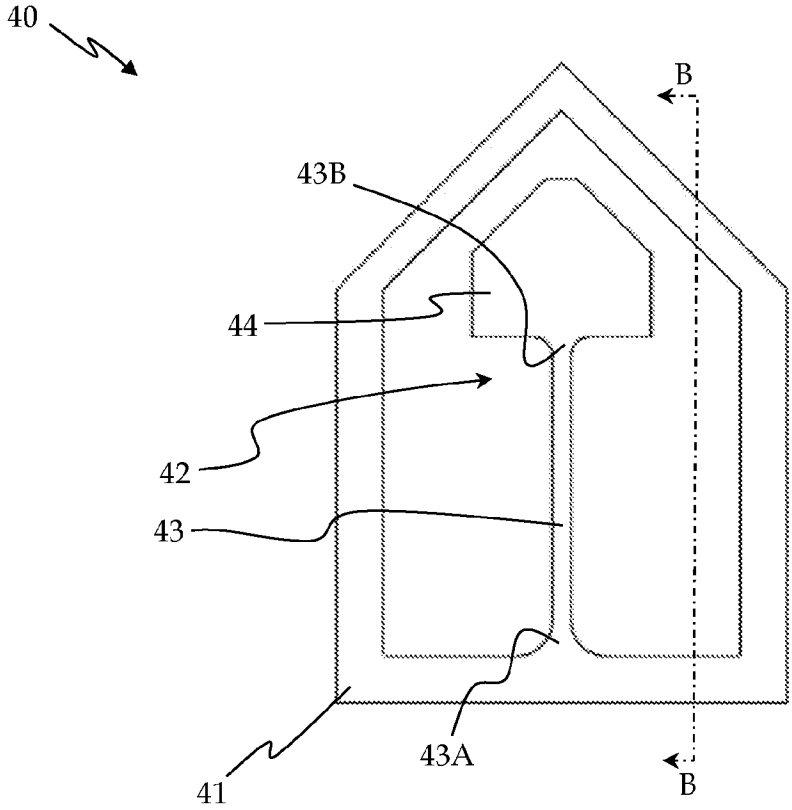


Fig. 3A

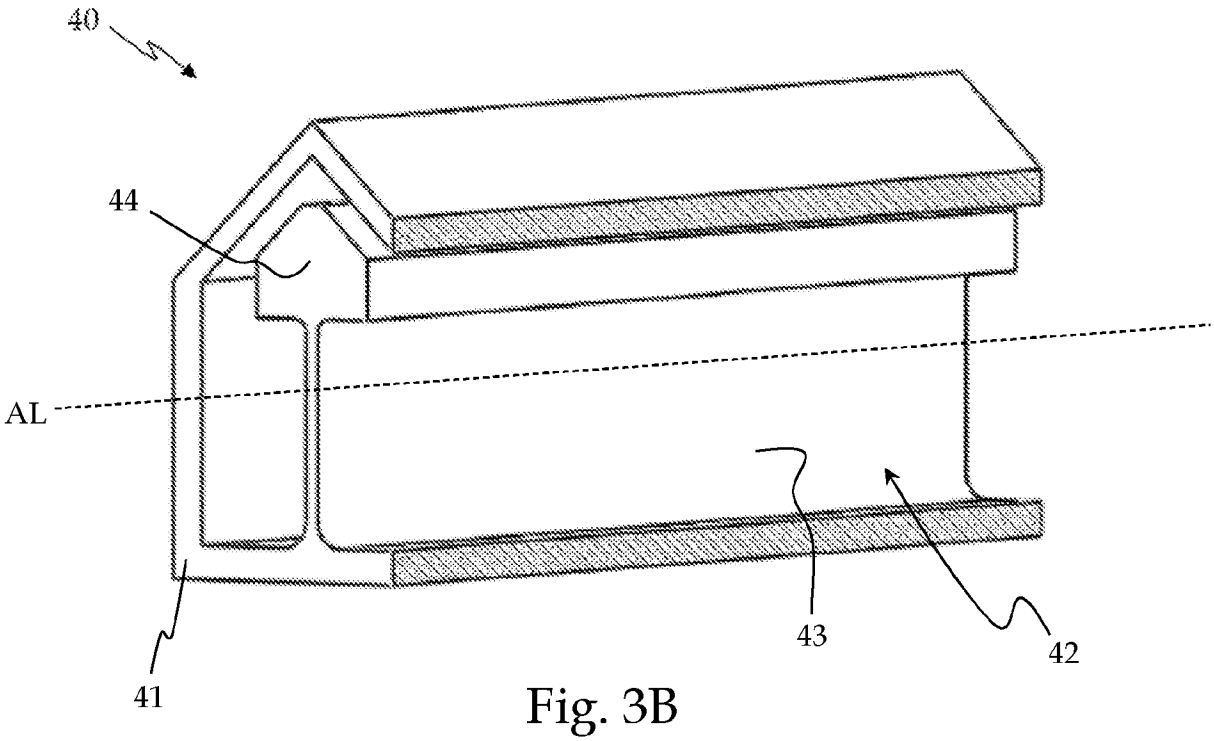


Fig. 3B

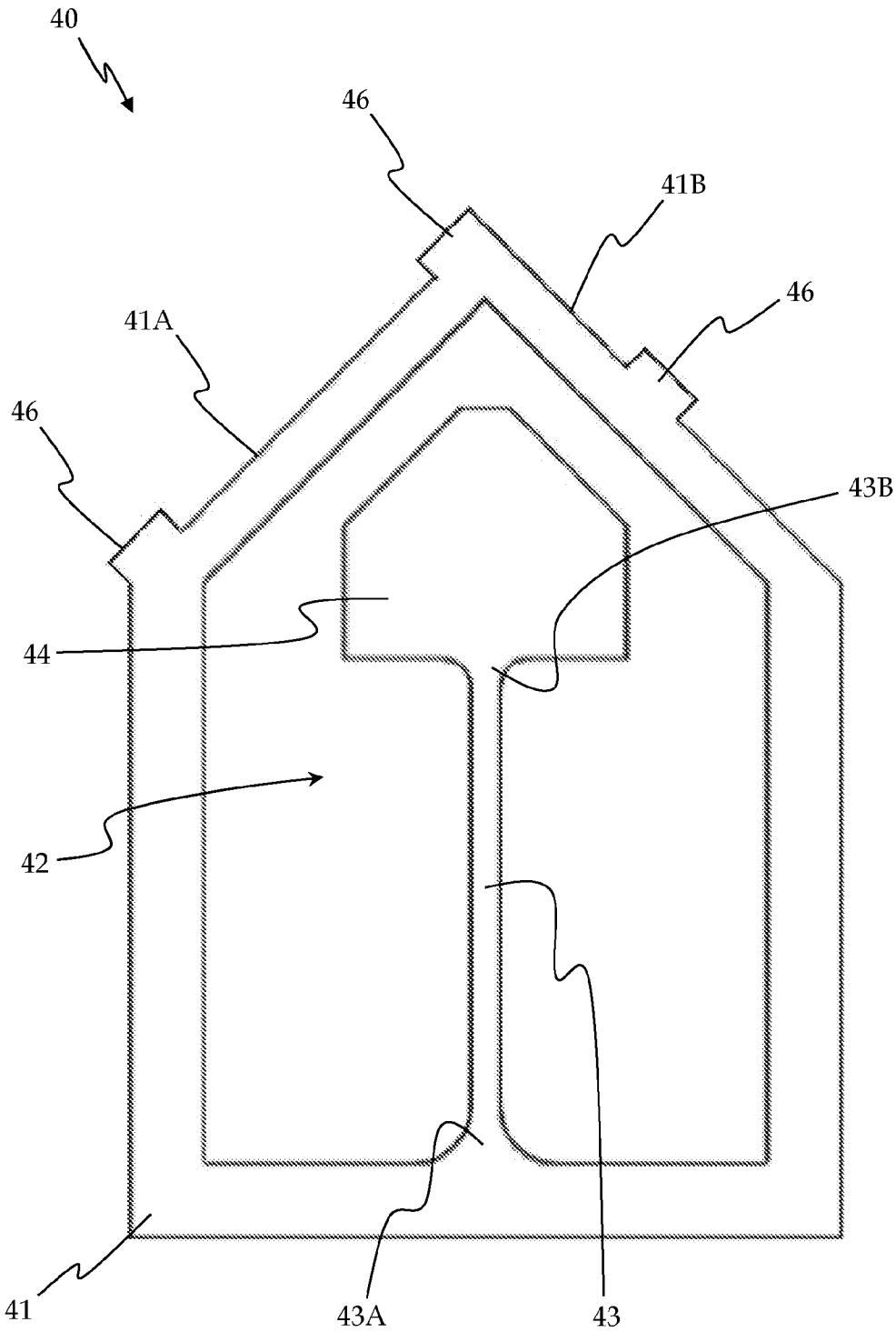


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2021/060269

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D5/16 F01D5/22
ADD. F16F7/104

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 484 870 A1 (MTU AERO ENGINES GMBH [DE]) 8 August 2012 (2012-08-08) figures	1-11
A	US 2018/142558 A1 (SCHARL RICHARD [DE]) 24 May 2018 (2018-05-24) figure 2	1-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2021	20/12/2021

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Raspo, Fabrice

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2021/060269

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2484870 A1	08-08-2012	NONE	
US 2018142558 A1	24-05-2018	DE 102016222869 A1	24-05-2018
		EP 3330485 A1	06-06-2018
		ES 2800172 T3	28-12-2020
		US 2018142558 A1	24-05-2018