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(71) Applicant *(for all designated States except US)*: **ALSTOM TECHNOLOGY LTD** [CH/CH]; Brown Boveri Strasse 7, CH-Baden 5400 (CH).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MICHELI, Marco** [IT/CH]; Dorfwisenstrasse 22, CH-8156 Schöfflisdorf (CH). **BOLDT, Peter** [SE/CH]; Schartenstrasse 6, CH-5400 Baden (CH). **PUERTA, Luis, Federico** [IT/CH]; Landstrasse 64, CH-5415 Rieden (CH). **KAPPIS, Wolfgang** [DE/CH]; Leemattenweg 6, CH-5442 Fislisbach (CH).

(74) Common Representative: **ALSTOM TECHNOLOGY LTD**; CHTI Intellectual Property, Brown Boveri Str. 7/664/2, CH-Baden 5401 (CH).

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(54) Title: AIRFOIL FILLET

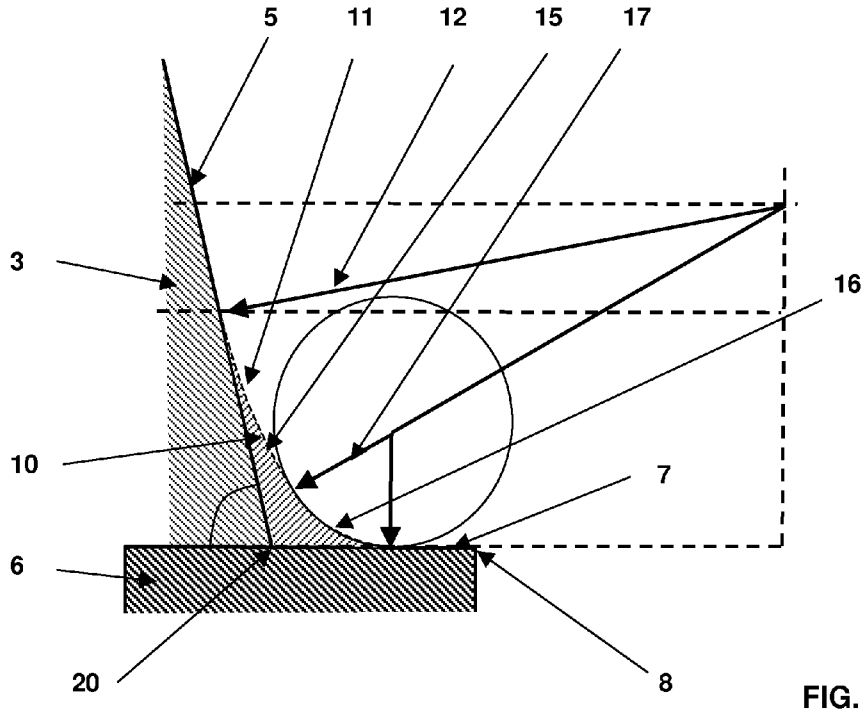

FIG. 3

(57) Abstract: A fillet (10) for a turbine blade (1) that covers an airfoil to platform join (20) and is configured to comprise a radial surface (15) with a first arc (11) that tangentially joins an airfoil surface (5) and not-tangentially joins the platform surface (7) at one of the platform edges (8) or alternatively the fillet comprising a second arc (16) that joins non-tangentially the platform surface (7) at one of the platform edges (8). In this way the fillet (10) footprint on the platform surface (7) is reduced, providing the design engineer greater freedom to design and configure the platform (6).

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Airfoil fillet

TECHNICAL FIELD

The invention relates generally to turbine blade designs and more specifically to fillets for gas turbine blades or vanes.

Throughout this specification an arc is defined as continuous part portions of a circle.

BACKGROUND ART

A gas turbine engine typically includes at least one rotor assembly in which a plurality of blades or vanes that comprise airfoils radially extending from platforms, are circumferentially fitted and distributed around a rotor disk. During operation, centrifugal forces generate circumferential rim stress in the rotating blades/vanes. This stress can concentrate at the join between the platform and airfoil. Through the use of fillets formed using curved milling tools to avoid corner edges, this stress concentration can be minimised as such a fillet can provide a concave easing of the interior corner of the join. Adequate stress relief can however only be achieved with an adequately sized and shaped fillet. A known shape criteria is to ensure that the fillet tangentially joins both the airfoil and platform.

This known shape criteria however creates an artificial minimum separation distance requirement between the airfoil and platform edge which may result in some circumstances in the need to provide a larger platform size than desired.

SUMMARY OF THE INVENTION

Provided is a fillet extending between an airfoil of a turbine blade and a blade platform edge that requires less space compared to fillets of the prior art while maintaining the mechanical integrity of the airfoil / blade platform join.

This problem is solved by means of the subject matters of the independent claims. Advantageous embodiments are given in the dependant claims.

It has been found by the Finite Element Method and confirmed by field tests, that for a filled with a radial surface formed by two tangent arcs with different radii, wherein the first arc tangentially joins the airfoil surface and has a larger radius than the second arc that joins the platforms surface, the fillet can be shortened so as not to form a tangential join at the platform when the fillet ends at the platform edge. Taking this concept to its limit the second arc can be totally eliminated without affecting the mechanical integrity of the blade if the fillet joins the platform surface at the platform's edge. If the fillet non-tangentially joins the platform surface at a location other than at the platform edge the end of the fillet forms a notch where the stress is theoretically infinite. By ending the fillet at the platform edge this can be avoided.

In any case, a fillet based on this concept can be formed when space between airfoils and the platform edge of a turbine blade is limited so by at least in part addressing some of the problems known in the art related to the amount of space on the platform i.e. the fillet footprint, required by a fillet.

One aspect provides a turbine vane or blade that comprises a platform with a surface and a plurality of platform edges. Each of the platform edges defines the boundary of the platform surface. Extending radially from the platform surface is an airfoil that has a surface and a fillet with a concave radial surface disposed at the base of the airfoil for reducing stress concentration between the platform and the airfoil. The fillet surface comprises one or more concave circular arcs wherein the fillet surface non-tangentially joins the platform surface at least one of the platform edges at, at least one location.

In a further aspect at the at least one location at which the fillet surface joins the platform surface at one of the platform edges, the radial surface consists of in one aspect and comprises in another aspect a first concave circular arc with a first radius tangentially joining the airfoil surface and a second concave circular arc with a second radius joining the platform surface. The second radius is smaller than the radius of the first arc.

In other aspect, at a location, the fillet surface tangentially joins the platform surface away from the platform edges.

In a yet further aspect, at a location, the fillet surface consists of a first concave circular arc that tangentially joins the airfoil surface and non-tangentially joins the platform surface at one platform edge

Each of these aspects provides optimal use of platform space to form a fillet giving the design engineer greater design freedom to configure and design the turbine blade platform.

Other advantages of the present invention will become apparent from the following description, taken in connection with the accompanying drawings wherein by way of illustration and example, an embodiment of the invention is disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

By way of example, an embodiment of the present disclosure is described more fully hereinafter with reference to the accompanying drawings, in which:

FIG. 1 is a schematic view of an exemplary turbine blade with a fillet of the invention applied;

FIG. 2 is a top view of the turbine blade of FIG. 1;

FIG. 3 is a sectional view at location III in FIG. 2 showing an exemplary fillet portion configuration that joins the turbine blade at the platform surface;

FIG. 4 is a sectional view at location IV in FIG. 2 showing an exemplary fillet portion configuration that joins the turbine blade at the platform edge; and

FIG. 5 is a sectional view at location V in FIG. 2 showing another exemplary fillet portion configuration that joins the turbine blade at the platform edge.

DETAILED DESCRIPTION

Preferred embodiments of the present disclosure are now described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the disclosure. It may be evident, however, that the disclosure may be practiced without these specific details.

FIG. 1 shows a turbine blade 1 with an exemplary fillet 10 with a radial surface 15 that consists of circular arcs. The application of exemplary fillets 10 is not limited to turbine blades 1 having features as shown and could be applied to other turbine components such as compressor rotor blades and stator vanes or nozzles. The turbine blade 1 comprises a platform 6 having a surface 7 that is bound by platform edges 8 defining the outer extent of the platform surface 7. Radially R extending from the platform surface 7 is an airfoil 3 with an airfoil surface 5. In this configuration the join between the airfoil surface 5 and the platform surface 7 defines an airfoil to platform join 20.

FIG. 2 shows a top view of the turbine blade 1 of FIG. 1 showing a fillet 10 disposed on the platform surface 7 at the based of the airfoil 3. FIG. 2 further shows locations were the fillet surface 15 joins the platform surface 7 at one of the platform edges, see location IV and V, and other locations III where the fillet surface 15 joins the platform surface 7 away from any of the platform edges 8.

FIG. 3 is a sectional view at location III in FIG. 2 showing a cross sectional view of a fillet 10 whose radial surface 15 joins the platform surface 7 away from any of the platform edges 8. In the shown exemplary embodiment the fillet surface 15 comprises two concave circular arcs 11, 16 each with a radius 12, 17 wherein the first arc 11 tangentially joins the airfoil while the second arc 16 tangentially joins the platform surface 7. In this arrangement the first arc 11 provides primary stress dissipation for the airfoil to the platform join 20 while the second arc 16 provides a smooth interface between the first arc 11 and the platform surface 7 so as to avoid stress build-up at this interface. For this reason and for the reason that increasing the second radius 17 would not provide additional mechanical integrity, the first radius 12 is made larger than the second radius 17, thus the footprint of the fillet 10 on the

platform surface 7 is minimised. The tangential joining further ensures that stress points are not created between the second arc 16 and the platform surface 7.

FIG. 4 is a sectional view at location IV in FIG. 2 showing where a second concave circular arc 16 of the fillet surface 15 joins the platform surface 7 non-tangentially at one of the platform edges 8. The fillet radial surface 15 consists of a first arc 11 with a first radius 12 that tangentially joins the airfoil surface 5 and a second arc 16 with a second radius 17 that non-tangentially joins the platform surface 7. This non-tangentially joining of the second arc 16 reduces the amount of platform surface 7 required to form the fillet 10 without compromising mechanical integrity as a notch is not formed between the fillet 10 and the platform surface 7 due to the joining being at one of the platform edges 8. Further, as the join is at the platform edge 8 the typically curved milling tool is capable of forming this non-tangential join. In another not shown exemplary embodiment the fillet surface 15 further includes one or more concave circular arcs between the first 11 and second arcs 16

FIG. 5 is a sectional view at location V in FIG. 2 showing a portion of a fillet surface15 consisting of a first arc 11 that non-tangentially joins the platform surface 7 at one of the platform edges 8. This non-tangential joining of the second arc 16 reduces the amount of platform surface 7 required to form the fillet 10 without compromising mechanical integrity by enabling the full forming of the first arc 11 when the airfoil 3 is located very close to a platform edge 8 without the need to rework the blade design in order to increase the platform surface 7 space in order to fit a conventional fillet 10.

In an exemplary embodiment the fillet 10 covers at least part of the platform join 20 and consists of the exemplary portions as described and illustrated in FIG. 3 and FIG. 4. In another exemplary embodiment, where it is desirable for potions of the airfoil 3 to be located very close to the platform edge 8 the fillet 10 covers at least part of the airfoil to platform join 20 and consists of the exemplary portions as described and illustrated in FIG. 3, FIG. 4 and FIG. 5.

Although the disclosure has been herein shown and described in what is conceived to be the most practical exemplary embodiment, it will be appreciated by

those skilled in the art that the present invention can be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restricted. The scope of the invention is indicated by the appended claims rather that the foregoing description and all changes that come within the meaning and range and equivalences thereof are intended to be embraced therein.

REFERENCE NUMBERS

New	
1	blade
3	airfoil
5	surface
6	platform
7	surface
8	edge
10	fillet
11	first arc
12	radius
15	radial surface
16	second arc
17	radius
20	airfoil to platform join
R	Radial direction
A	Axial direction

Claims

1. A turbine vane or blade (1) comprising:

a platform (6) with a surface (7) and a plurality of platform edges (8) each defining a boundary of the platform surface (7);

an airfoil (3) with a surface (5), extending radially from the platform surface (7); and

a fillet (10) with a concave radial surface (15) disposed at a base of the airfoil (3) for reducing stress concentration between the platform (6) and the airfoil (3),

the fillet surface (15) comprising,

one or more concave circular arcs (11, 16) wherein the fillet surface (15) non-tangentially joins the platform surface (7) at, at least one of the platform edges (8) at, at least one location.

2. The vane or blade (1) of claim 1 wherein at the at least one location at which the fillet surface (15) joins the platform surface (7) at one of the platform edges (8), the radial surface consists of:

a first concave circular arc (11) that tangentially joins the airfoil surface (5) and has a first radius (12); and

a second concave circular arc (16) that joins the platform surface (7) and has a second radius (17),

wherein the second radius (17) is smaller than the radius of the first arc (11).

3. The vane or blade (1) of claim 1 wherein at the at least one location at which the fillet surface (15) joins the platform surface (7) at one of the platform edges (8), the fillet surface (15) comprises:

a first concave circular arc (11) that tangentially joins the airfoil surface (5) and has a first radius (12); and

a second concave circular arc (16) that joins the platform surface (7) and has a second radius (17),

wherein the second radius (17) is smaller than the radius of the first arc (11).

4. The vane or blade (1) of any one of claims 1 to 3 wherein at locations the fillet surface (15) joins the platform surface (7) away from any of the platform edges (8).

5. The vane or blade (1) of claim 4 wherein the fillet surface (15) tangentially joins the platform surface (15).

6. The vane or blade of any one of claims 1 to 5 wherein the fillet surface (15) consists of a first concave circular arc (11) that tangentially joins the airfoil surface (5) and non-tangentially joins the platform surface (7) at one of the platform edges (8).

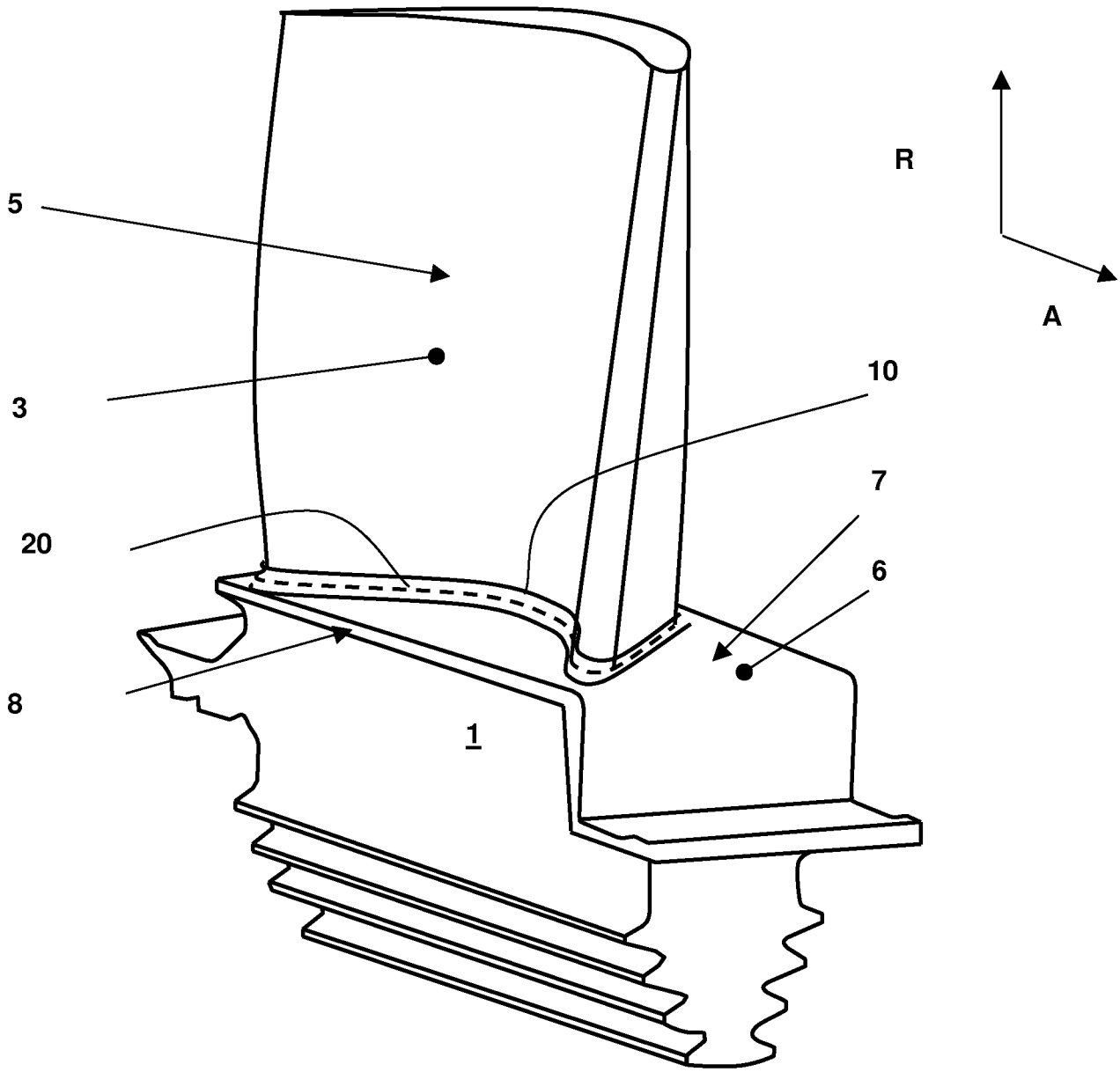

FIG. 1

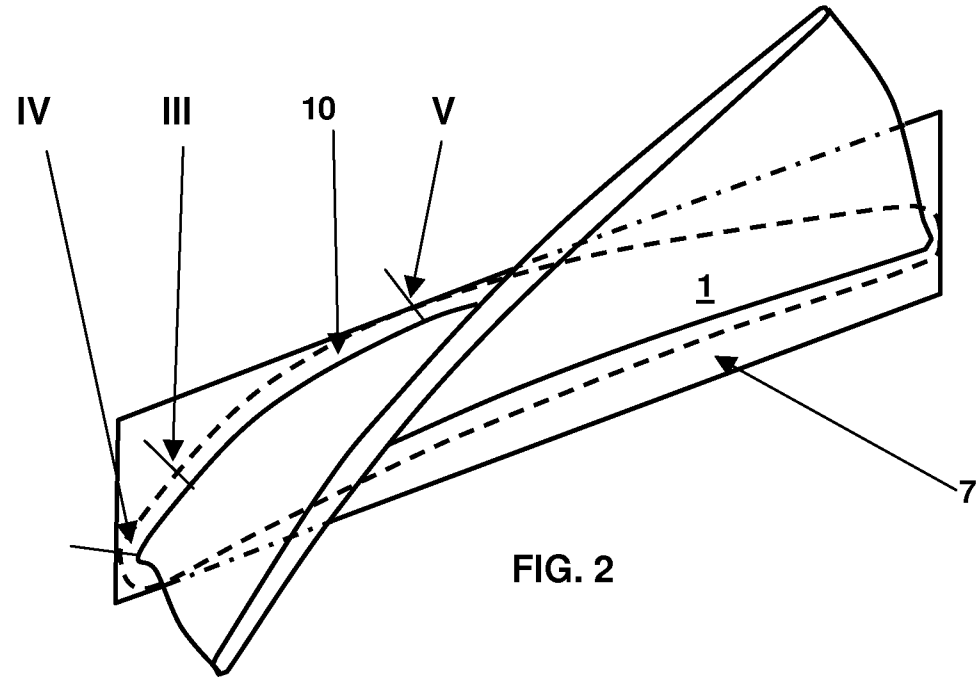

FIG. 2

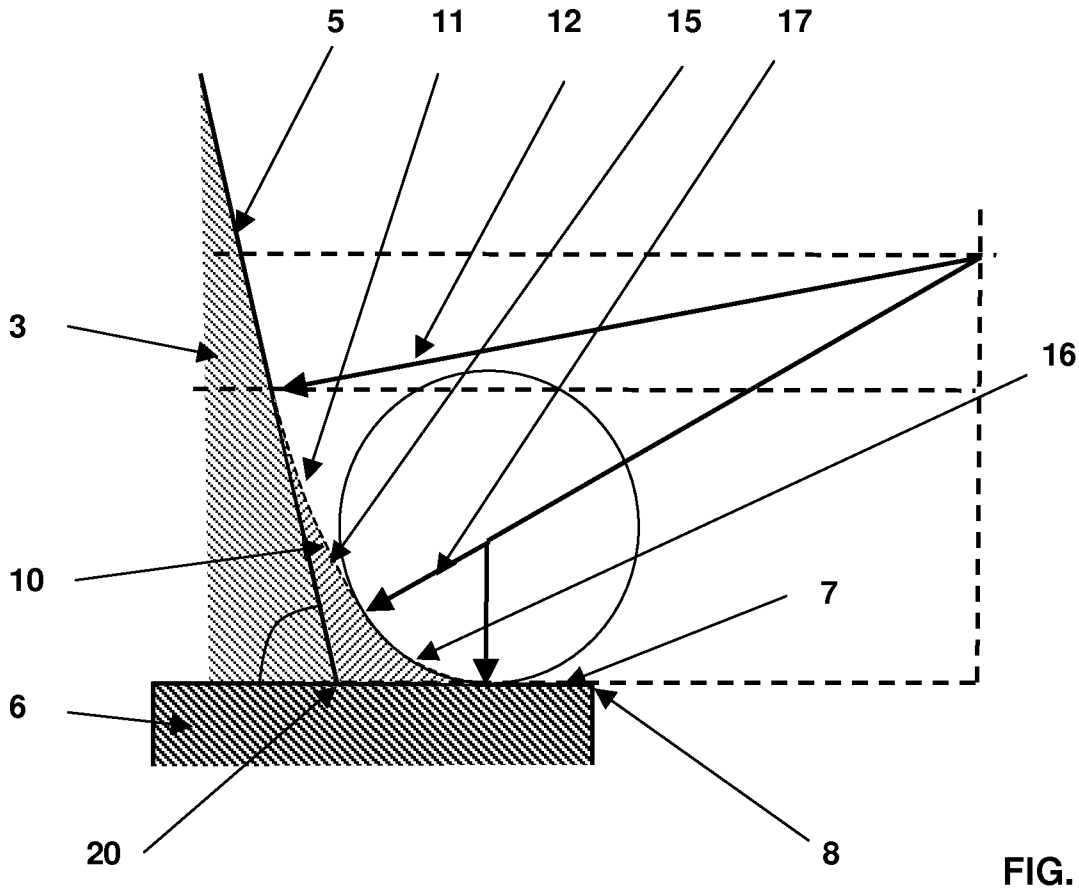

FIG. 3

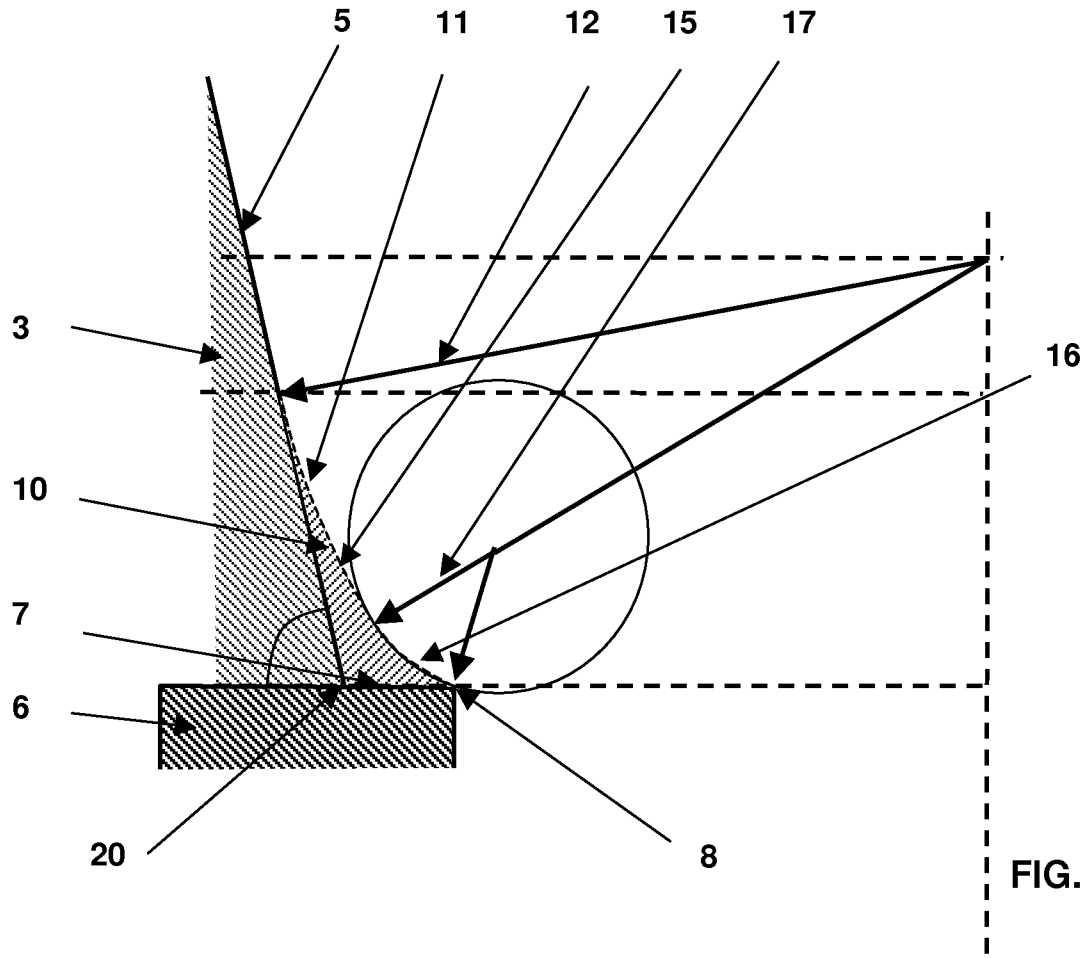

FIG. 4

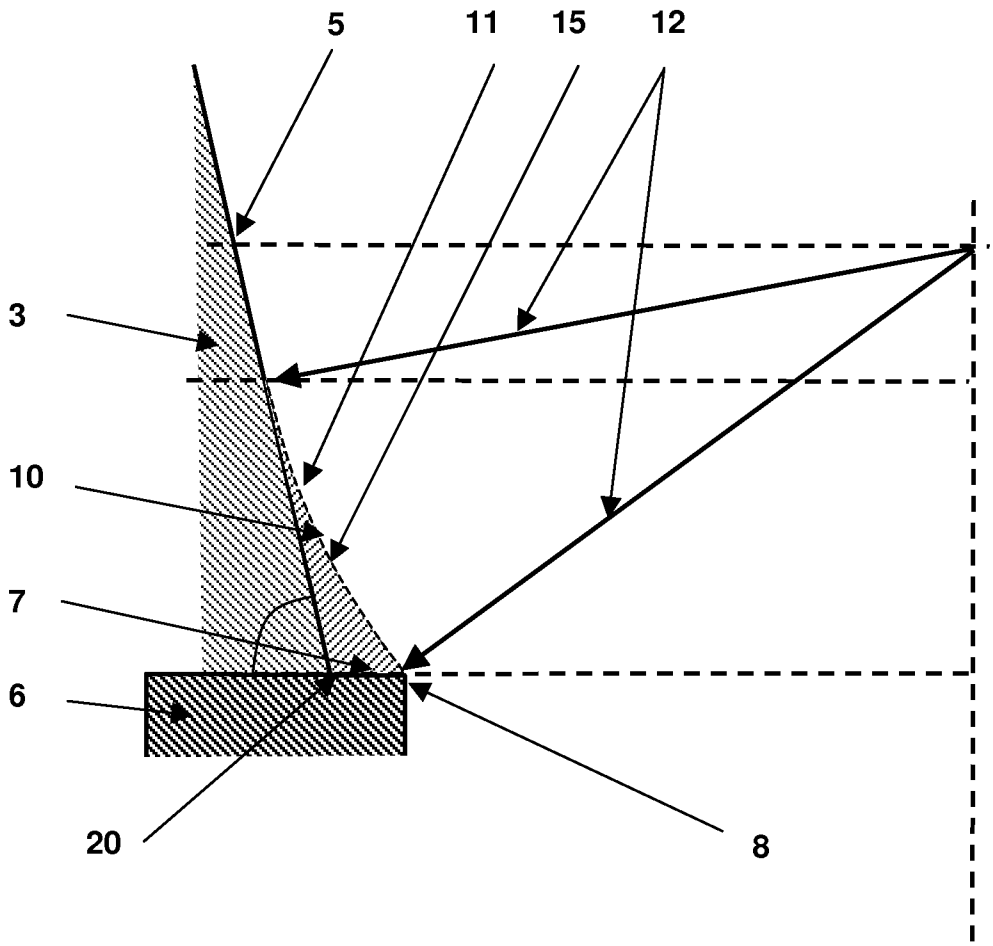

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/064487

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01D5/14

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 practical, 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.
X	DE 199 41 134 C1 (MOTOREN TURBINEN UNION [DE]) 28 December 2000 (2000-12-28) column 3, line 56 - line 62; figure 2	1-6
X	US 2002/194733 A1 (SURACE RAYMOND C [US] ET AL) 26 December 2002 (2002-12-26) paragraph [0020]; figure 4	1-6
X	SU 556 238 A1 (VILNER ET AL) 30 April 1977 (1977-04-30) claim; figures	1,6
X	EP 1 731 712 A (GEN ELECTRIC [US]) 13 December 2006 (2006-12-13) claims 1,7,10; figures	1-6

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[X] Further documents are listed in the continuation of Box C.

[X] 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 document 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
26 January 2010	05/02/2010

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/064487

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2007/224043 A1 (BLATCHFORD DAVID PAUL [GB] ET AL) 27 September 2007 (2007-09-27) figures 2-3d	1,4-6
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Information on patent family members

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