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(71) Applicant: **Alstom Technology Ltd**
5400 Baden (CH)

(72) Inventors:
- **Micheli, Marco**
  8165 Schöfflisdorf (CH)
- **Boldt, Peter Erik**
  5400 Baden (CH)
- **Puerta, Luis Federico**
  5415 Rieden (CH)
- **Kappis, Wolfgang**
  5442 Fislisbach (CH)

(54) Airfoil fillet

(57) A compound fillet (10) for a turbine blade (1) that covers an airfoil to platform join (20) and is configured to comprise a first arc and a second arc. The first arc (11) having a first end tangential to the airfoil surface (5). The second arc (16) having a first end tangentially adjoining the second end of the first arc(11) and a second end adjoining the platform surface. The radius (12) of the first arc(11) is larger than the radius (17) of the second arc (16). In an aspect the compound fillet (10) comprises a first portion configured to consist of the first arc (11) and the second arc (16) wherein the second arc (16) adjoins non-tangentially the platform surface (7) at the platform edge (8). In this way the compound fillet (10) footprint on the platform surface (7) is reduced, providing the design engineer greater freedom to design and configure the platform (6).

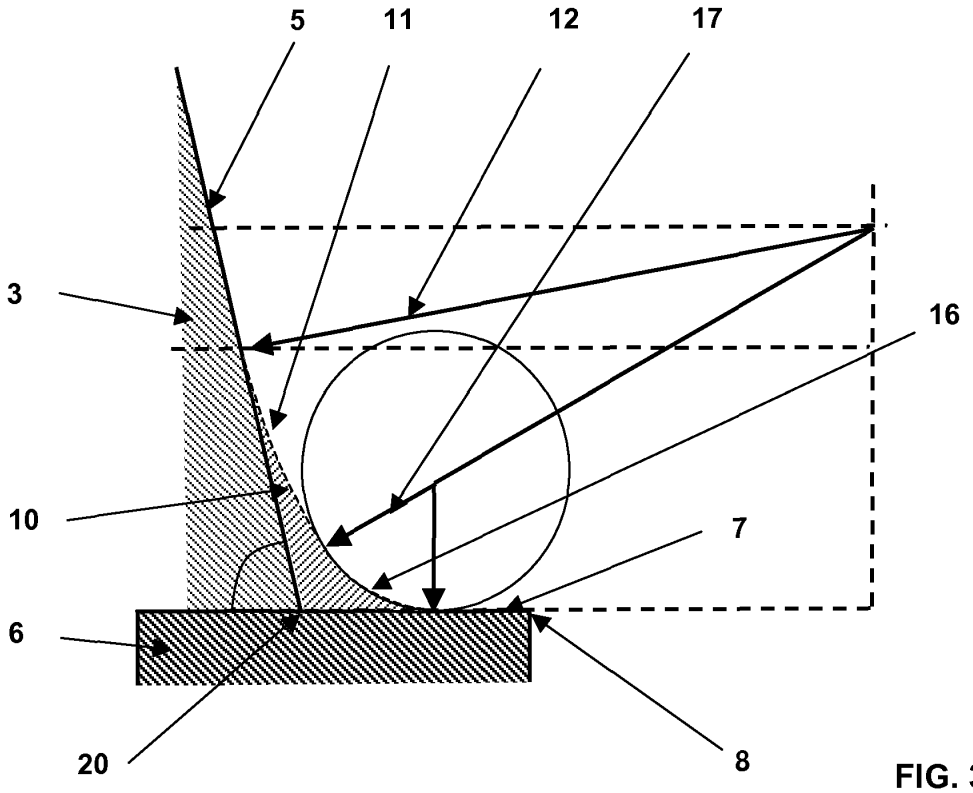

FIG. 3

EP 2 184 442 A1

Description

TECHNICAL FIELD

[0001] The invention relates generally to turbine blade designs and more specifically to compound fillets for gas turbine blades.

[0002] Throughout this specification:

a compound fillet is defined as a fillet in which at least a portion of the fillet consists of two arcs of different radii that in combination extend between two substantially perpendicular surfaces.; and
an arc is defined as a continuous portion of a circle and excludes curved portions that are not portions of a circle.

BACKGROUND ART

[0003] A gas turbine engine typically includes at least one rotor assembly in which a plurality of blades, comprising 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, which can concentrate at the join between the platform and airfoil. This stress concentration can be minimised by fillets at the platform / airfoil join, which provide a concave easing of the interior corner at the join. Adequate stress relief can however only be achieved with an adequately sized and shaped fillet. For compound fillets this includes adjoining the fillet tangentially to the airfoil and platform to avoid forming notches which concentrate stress.

[0004] It may, however, be desirable to reduce the size of the platform, or alternatively avoid reworking of a blade when it is discovered in final design stages that there is insufficient space between the airfoil and platform edge to enable tangentially joining of the fillet to the platform surface. It is therefore desirable to provide a compound fillet that requires less platform surface space without compromising mechanical integrity.

SUMMARY OF THE INVENTION

[0005] 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.

[0006] This problem is solved by means of the subject matters of the independent claims. Advantageous embodiments are given in the dependant claims.

[0007] It has been found by the Finite Element Method and confirmed by field tests, that for a compound filled formed by two tangent arcs with different radii, wherein the first arc tangentially adjoins the airfoil surface and has a larger radius than the second arc that adjoins the platforms surface, the fillet can be shortened by not forming 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 but only if the fillet adjoins the platform surface at the platform's edge. If the fillet non-tangentially adjoins the platform surface at a point 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.

[0008] 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 compound fillet footprint, required by a compound fillet.

[0009] Provided, therefore in one aspect is a compound fillet for a turbine blade airfoil to platform join wherein the turbine blade comprises:

- a platform that has a platform surface with a platform edge defining the outer extent of the platform surface ;and
- an airfoil extending from the platform surface with an airfoil surface.

The join between the airfoil surface and the platform surface defines the airfoil to platform join. In addition the compound fillet, extends from the airfoil surface to the platform surface and at least in part covers the airfoil to platform join and is configured to comprise a first arc and a second arc. The first arc having:

- a first end tangential to the airfoil surface;
- a second end, and
- a first radius.

The second arc having;

- a first end tangentially adjoining the second end of the first arc;
- a second end adjoining the platform surface; and
- a second radius,

wherein the first radius is larger than the second radius.

[0010] The compound fillet is characterized by comprising a first portion configured to consist of the first arc and the second arc wherein the first end of the second arc adjoins non-tangentially the platform surface at the platform edge.

[0011] In a further aspect the compound fillet comprises a second portion configured to consist of the first arc wherein the second end of the first arc adjoins the platform surface at the platform edge.

[0012] In a yet further aspect the compound fillet is configured to consist of the first portions and the second portions.

[0013] In a further aspect the compound fillet compris-

es a third portion configured to consist of the first arc and the second arc wherein the second arc second end adjoins tangentially the platform surface.

[0014] In a yet further aspect the compound fillet is configured to consist of the first portions and the third portions.

[0015] In a yet further aspect the compound fillet consists of the first portions, the second portions and the third portions.

[0016] Each of these aspects provides a fillet with portions that require less platform space. This give the design engineer greater design freedom to configure and design the turbine blade platform.

[0017] 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

[0018] 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 point III in FIG. 2 showing an exemplary compound fillet portion configuration that adjoins the turbine blade at the platform surface;

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

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

DETAILED DESCRIPTION

[0019] 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.

[0020] FIG. 1 shows a turbine blade 1 with an exemplary compound fillet 10 for a turbine airfoil to platform join 20. The application of the compound fillet 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 that has a platform surface 7 with a platform edge 8 defining the outer extent of the platform surface 7. Radially R extending from the platform surface 7 is an airfoil 3 that has an airfoil surface 5. In this configuration the join between the airfoil surface 5 and the platform surface 7 defines the airfoil to platform join 20.

[0021] FIG. 2 shows a top view of the turbine blade 1 of FIG. 1 showing the coverage of a compound fillet 10 on the platform surface 7.

[0022] FIG. 3 is a sectional view at point III in FIG. 2, showing where a portion of a compound fillet 10 comprising a second arc 16 that tangentially adjoins the platform surface 7 could be located. In some turbine blade 1 arrangements, the compound fillet 10 could at other locations consist of this fillet arrangement.

[0023] The fillet arrangement of FIG. 3 consists of a first arc 11 with a first radius 12 and has a first end tangentially adjoining the airfoil surface 5 and a second end. As shown in FIG. 3 the fillet arrangement further consists of a second arc 16 with a second radius 17 and has a first end tangentially adjoining the second end of the first arc 11 and a second end that tangentially adjoins the platform surface 7.

[0024] The first arc 11 primarily provides stress dissipation for the airfoil to platform join 20 while the second arc 16 only 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. In this way the footprint of the compound fillet 10 on the platform surface 7 is minimised. To further ensure that stress points are not created by the joining of the second arc 16 to the platform surface 7, the join is made tangential.

[0025] FIG. 4 is a sectional view at point IV in FIG. 2 showing where a portion of a compound fillet 10 comprising a second arc 16 that non-tangentially adjoins the platform surface 7 at the platform edge 8 could be located. In some turbine blade 1 arrangements, the compound fillet 10 could at other locations consist of this fillet arrangement.

[0026] The fillet arrangement of FIG. 4 consists of a first arc 11 and a second arc 16. The first arc 11 has a first radius 12 and consists of a first end tangentially adjoining the airfoil surface 5 and a second end, while the second arc 16 has a second radius 17 and consists of a first end tangentially adjoining the second end of the first arc 11 and a second end non- tangentially adjoining platform surface 7. This non-tangentially adjoining of the second arc 16 reduces the amount of platform surface 7 required to form the compound fillet 10 without compromising mechanical integrity as a notch is not formed between the compound fillet 10 and the platform surface 7, as it adjoins the platform surface 7 at the platform edge 8.

[0027] FIG. 5 is a sectional view at point V in FIG. 2 showing where an portion of a compound fillet 10 consisting only of a first arc 11 that non-tangentially adjoins the platform surface 7 at the platform edge 8 could be located. In some turbine blade 1 arrangements, the compound fillet 10 could at other locations consist of this fillet arrangement.

[0028] The fillet arrangement of FIG. 5 consists of a first arc 11 and does not comprise the second arc 16 shown in FIG. 3 and FIG. 4. The first arc has a first end tangentially adjoining the airfoil surface 5 and a second end that adjoins the platform surface 7 non-tangentially at the platform edge 8. This non- tangential adjoining of the second arc 16 reduces the amount of platform surface 7 required to form the compound fillet 10 without compromising mechanical integrity by enabling the full forming of the first arc 11 made possibility by the adjoining occurring at the platform edge 8 so as not to form a notch. As a result the platform surface 7 covered by this portion of a compound fillet 10 is particularly small, further reducing the likelihood for additional reworking of the blade design to overcome fillet layout requirements and providing greater design freedom to size and shape the platform 6.

[0029] In an exemplary embodiment the compound 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 and FIG. 4. In another exemplary embodiment, where it is desirable for parts of the airfoil 3 to be located very close to the platform edge 8 the compound fillet 10 covering at least part of the airfoil to platform join 20 consists of the exemplary portions as described and illustrated in FIG. 3, FIG. 4 and FIG. 5.

[0030] 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

[0031]

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

Claims

1. A compound fillet (10) for a turbine blade (1) airfoil to platform join (20) wherein the turbine blade comprises:

a platform (6) that has a platform surface (7) with a platform edge (8) defining the outer extent of the platform surface (7); and
an airfoil (3) extending from the platform surface (7) with an airfoil surface (5),

wherein the join between the airfoil surface (5) and the platform surface (7) defines the airfoil to platform join (20),
wherein further the compound fillet (10), extends from said airfoil surface (5) to said platform surface (7) and at least in part covers said airfoil to platform join (20) and is configured to comprise:

a first arc (11) having:

a first end tangentially adjoining said airfoil surface (5);
a second end; and
a first radius (12), and

a second arc (16) having;

a first end tangentially adjoining said second end of the first arc (11);
a second end adjoining said platform surface; and
a second radius (17),

wherein the first radius (12) is larger than the second radius (17),
the compound fillet **characterized by** comprising a first portion configured to consist of the first arc (11) and the second arc (16) wherein the second arc (16) second end adjoins non-tangentially said platform surface (7) at said platform edge (8).

2. The compound fillet (10) of claim 1 further comprising a second portion configured to consist of the first arc (11) wherein the second end of the first arc (11) adjoins said platform surface (7) at said platform edge (8).

3. The compound fillet of claim 2 configured to consist of said first portions and said second portions.

4. The compound fillet (10) of claim 1 comprising a third portion configured to consist of the first arc (11) and the second arc (16) wherein the second arc (16) second end adjoins tangentially said platform surface (7);

5. The compound fillet (10) of claim 4 configured to consist of said first portions and said third portions.

6. The compound fillet (10) of claim 4 and claim 2 configured to consist of said first portions, said second portions and said third portions.

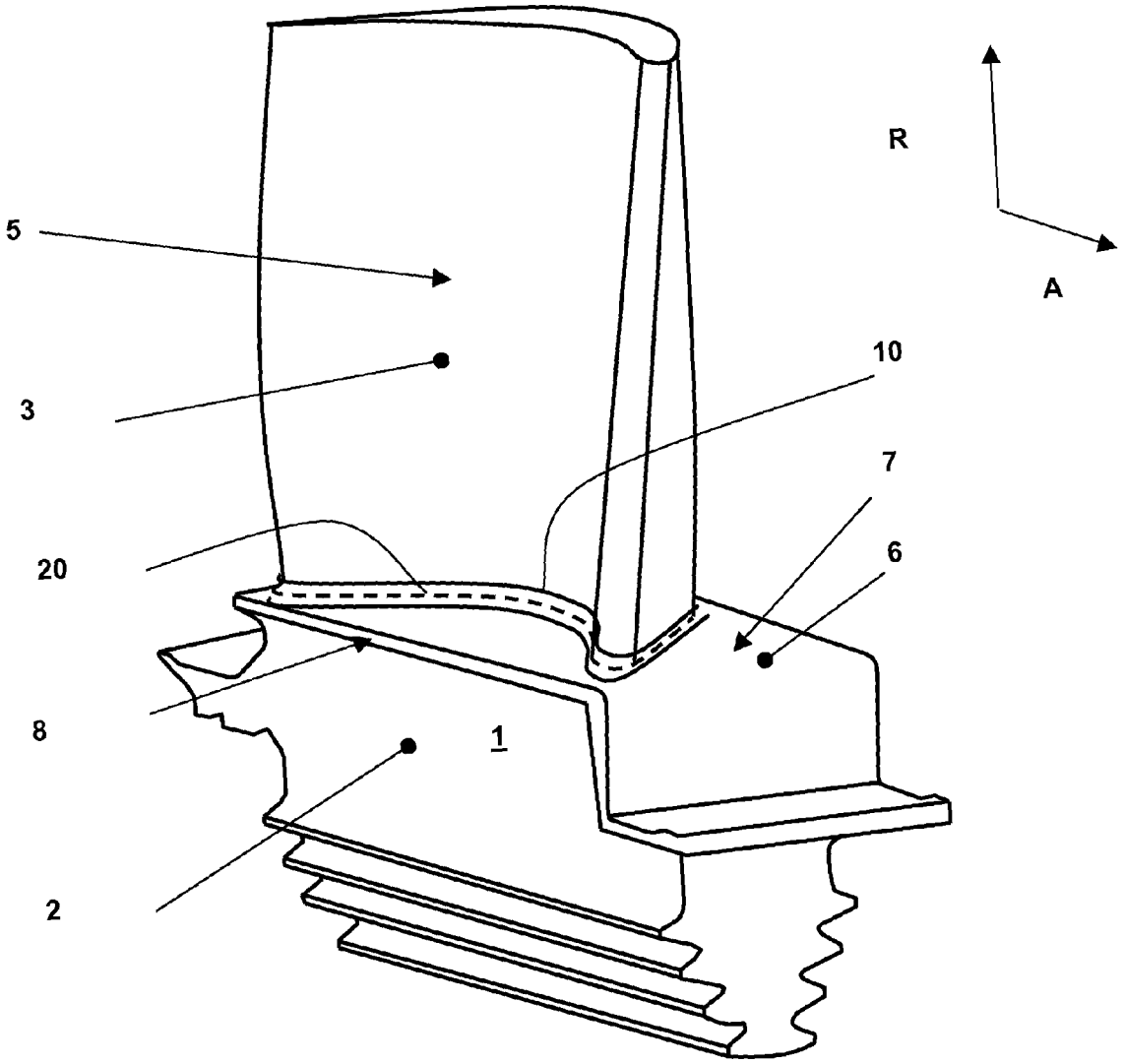

FIG. 1

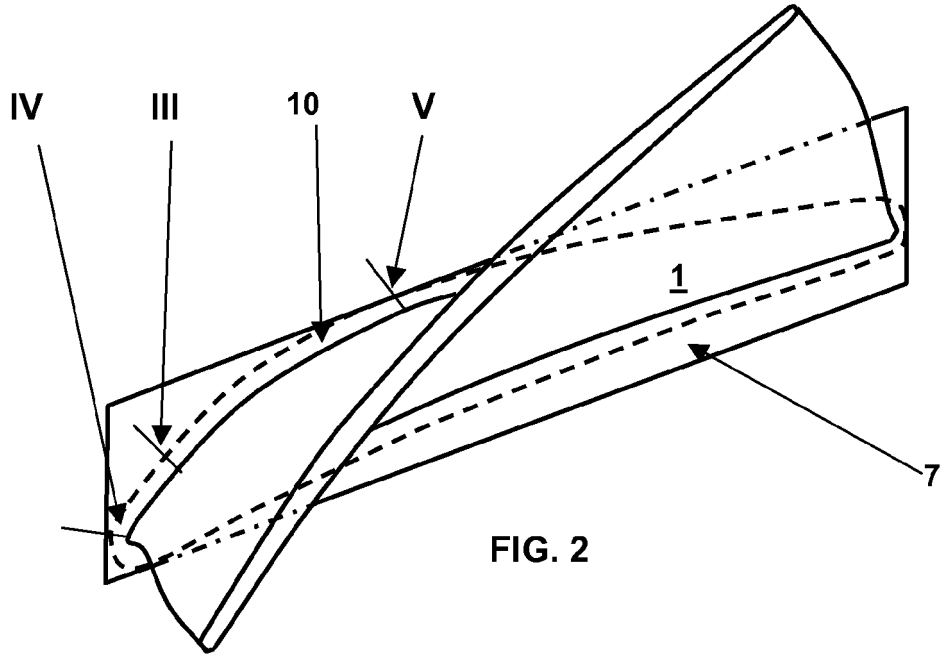

FIG. 2

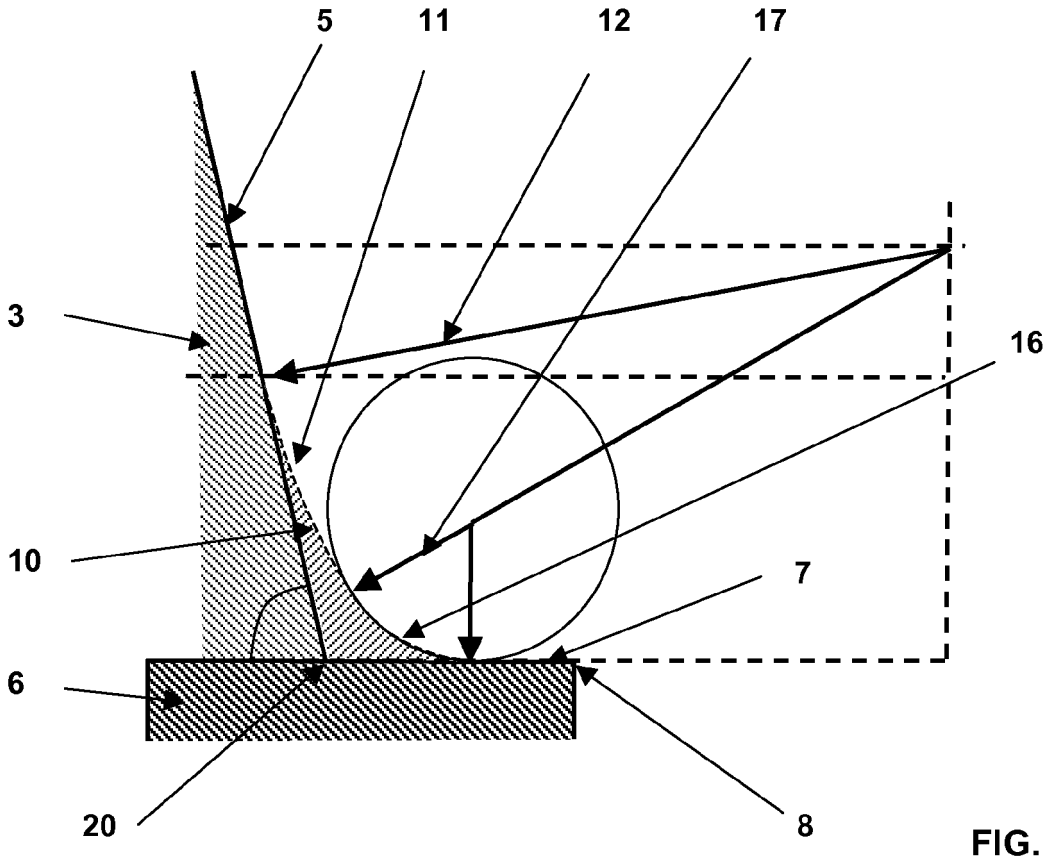

FIG. 3

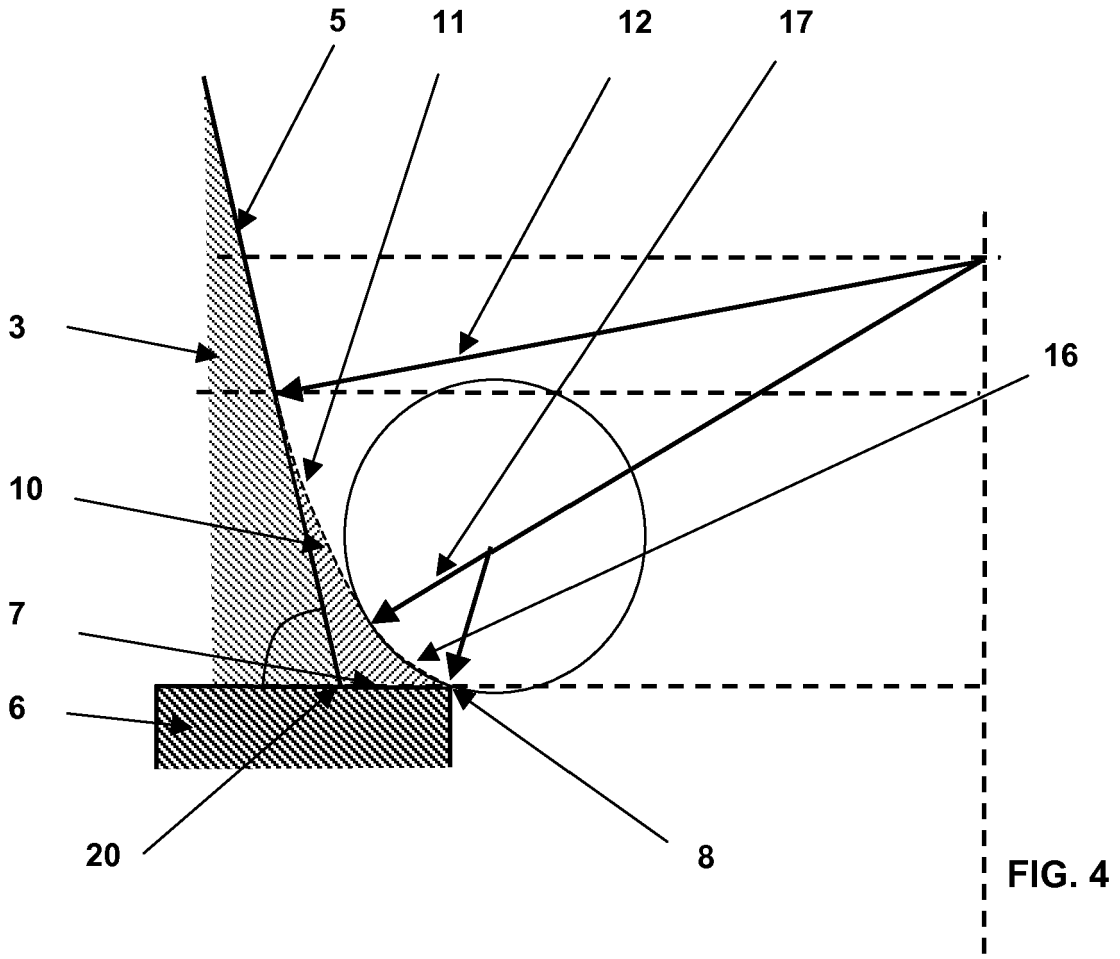

FIG. 4

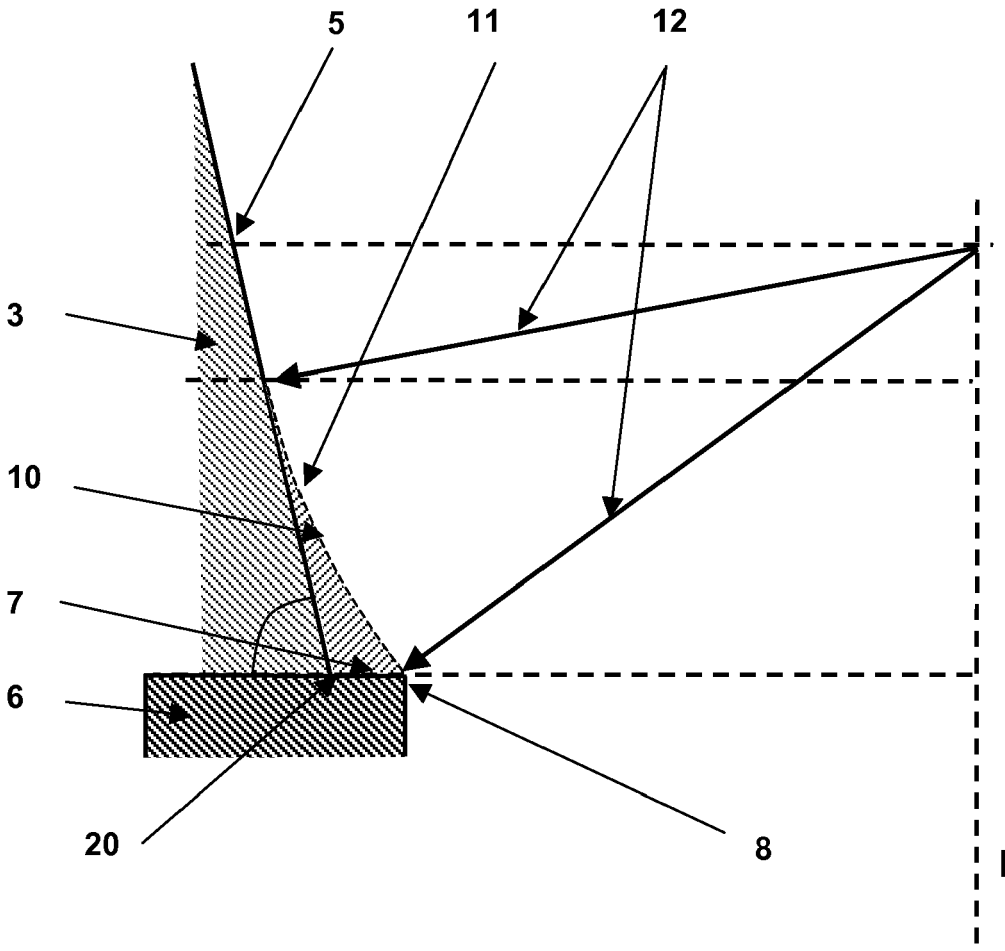

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 08 16 8866

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	* figure 3a *	1-6	
			TECHNICAL FIELDS SEARCHED (IPC) F01D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 April 2009	Raspo, Fabrice

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 16 8866

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