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**Datasheet for the decision  
of 1 April 2011**

**Case Number:** T 0293/09 - 3.2.03

**Application Number:** 99969597.6

**Publication Number:** 1131176

**IPC:** B22D 25/00, C22C 19/05,  
C30B 11/00, C30B 29/52

**Language of the proceedings:** EN

**Title of invention:**  
Single crystal vane segment and method of manufacture

**Patentee:**  
Rolls-Royce Corporation

**Opponent:**  
SIEMENS, AKTIENGESELLSCHAFT

**Headword:**  
-

**Relevant legal provisions:**  
EPC Art. 100(c), 54, 56

**Relevant legal provisions (EPC 1973):**  
-

**Keyword:**  
"Extension of subject-matter (no)"  
"Novelty (main and first auxiliary request) (no)"  
"Inventive step (second auxiliary request) (yes)"

**Decisions cited:**  
-

**Catchword:**  
-

**Case Number:** T 0293/09 - 3.2.03

**DECISION**  
**of the Technical Board of Appeal 3.2.03**  
**of 1 April 2011**

**Appellant I:**  
(Opponent)

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**Respondent:**  
(Patent Proprietor)

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**Decision under appeal:**

Interlocutory decision of the Opposition  
Division of the European Patent Office posted  
18 December 2008 concerning maintenance of the  
European patent No. 1131176 in amended form.

**Composition of the Board:**

**Chairman:** U. Krause  
**Members:** G. Ashley  
K. Garnett

## Summary of Facts and Submissions

I. European patent EP-B1-1 131 176 relates to a multiple-airfoil vane segment produced as a single crystal casting, a gas turbine engine component comprising such a vane segment and a method for making the vane segment. Grant of the patent was opposed on the grounds set out in Articles 100(a) to (c) EPC.

II. The opposition division decided that the patent could be maintained on the basis of the claims of the 16th auxiliary request filed during the oral proceedings. The decision, which was posted on 18 December 2008, was appealed by both the patent proprietor and the opponent.

III. Appellant I (hereinafter referred to as the "opponent") filed both notice of appeal and a statement containing the grounds of appeal and paid the appeal fee on 28 January 2009.

Appellant II (hereinafter referred to as the "patent proprietor") filed notice of appeal on 27 February 2009, paying the appeal fee on the same day. A statement containing the grounds of appeal was filed on 28 April 2009.

IV. Oral proceedings were held on 1 April 2011.

V. Requests

The patent proprietor requested that the decision under appeal be set aside and the patent be maintained on the basis of the main alternatively the first auxiliary request filed with the letter dated 28 April 2009,

alternatively on the basis of the second auxiliary request filed during the oral proceedings before the Board.

The opponent requested that the decision under appeal be set aside and the patent be revoked.

## VI. Claims

### (a) Main Request

Independent claims 1, 3 and 13 of the main request read as follows:

"1. A vane segment component comprising a cast single crystal structure formed of a directional solidified alloy type material, said single crystal structure has at least one airfoil integrally connected between a first endwall member and a second endwall member."

"3. A gas turbine engine component, comprising an integrally cast single crystal vane segment including a plurality of vanes, each of said plurality of vanes including a leading edge and a trailing edge and a first end and a second end, said vane segment has a first endwall member integrally connected with each of said first ends and a second endwall member integrally connected with each of said second ends, said vane segment formed of a directionally solidified alloy type material."

"13. A method for producing a single crystal vane segment, comprising:

- providing a directionally solidified type alloy material;
- melting the directionally solidified type alloy material;
- pouring the molten directionally solidified type alloy material into a casting mold, the casting mold including an endwall forming cavity and a vane forming cavity that are in fluid communication;
- filling the endwall forming cavity with the molten directionally solidified type alloy material;
- solidifying the directionally solidified type material to produce an integrally cast vane segment having a structure consistent with a single crystal casting."

Dependant claims 2, 4 to 12 and 14 to 19 relate to preferred embodiments of the vane segment component of claim 1, the gas turbine engine component of claim 3 and the method of claim 13 respectively.

(b) First Auxiliary Request

The three independent claims of the first auxiliary request (claims 1, 3 and 12) correspond to those of the main request. Dependent claim 10 of the main request has been deleted.

(c) Second Auxiliary Request

Independent claims 1, 2 and 9 of the second auxiliary request read as follows:

"1. A vane segment component comprising a single cast single crystal structure formed of a directional

solidified alloy type material, said single crystal structure has a plurality of airfoils integrally connected between a first endwall member and a second endwall member, said single crystal structure has its <001> crystal direction substantially parallel with a tangent to one of said endwall members and its <010> crystal direction substantially parallel with an average airfoil stacking axis."

"2. A gas turbine engine component, comprising an integrally cast single crystal vane segment including a plurality of vanes, each of said plurality of vanes including a leading edge and a trailing edge and a first end and a second end, said vane segment has a first endwall member integrally connected with each of said first ends and a second endwall member integrally connected with each of said second ends, said vane segment formed of a directionally solidified alloy type material and having its <001> crystal direction substantially parallel with a tangent to one of said endwall members and its <010> crystal direction substantially parallel with an average airfoil stacking axis."

"9. A method for producing a single crystal vane segment, comprising:

- providing a directionally solidified type alloy material;
- melting the directionally solidified type alloy material;
- pouring the molten directionally solidified type alloy material into a casting mold, the casting mold including an endwall forming cavity and a vane forming

cavity defining a plurality of vanes that are in fluid communication;

- aligning a starter seed such that its <001> crystal direction is substantially parallel with a tangent to the vane segment and the starter seeds <010> crystal direction is substantially parallel with an average airfoil stacking axis;
- filling the endwall forming cavity and the vane forming cavity with the molten directionally solidified type alloy material;
- melting a portion of the starter seed extending into the casting mold with the molten directionally solidified type alloy material; and
- solidifying the directionally solidified type material to produce an integrally cast vane segment having a structure consistent with a single crystal casting with its <001> crystal direction substantially parallel with a tangent to one of said endwall members and its <010> crystal direction substantially parallel with an average airfoil stacking axis."

Dependant claims 3 to 8 relate to preferred embodiments of the vane segment component of claim 1 and the gas turbine engine component of claim 2; dependent claims 10 to 14 concern the method of claim 9.

#### VII. Prior Art

The following documents, amongst others, were cited in the contested decision and referred to by the opponent in the statement of the grounds of appeal:

D10: US-A-3 494 709

D25: EP-A-0 789 087.

VIII. Submissions of the Parties

*Main Request and First Auxiliary Request*

(a) Article 100(c) EPC

The opponent submitted that the amendment of the expression "integrally cast", as used in the patent application, to "integrally connected" in claims 1 and 3 of the granted patent amounts to an extension of subject-matter beyond that originally filed, as it includes methods other than casting for joining the airfoil to the end walls.

The patentee referred to the original application (WO-A-00/25959) as stating that the vanes are "coupled to" the end wall members (page 6, lines 18 to 20), and that the leading and trailing edges of the vane "extend" between the ends (page 7, lines 4 to 5). Seen in the context of the patent, which does not concern the joining of components that are not integrally cast, the amendment does not amount to an extension of claimed subject-matter.

(b) Novelty (Article 54 EPC)

The opponent submitted that the subject-matter of the independent claims lacks novelty in light of D10. The independent claims do not give a clear definition of an alloy that can be distinguished from that of D10. The expression "directionally solidified material" includes both columnar grained and single crystal (SX) materials (see for example D25, page 2, lines 16 to 18), and the

alloy of D10 can be used for producing columnar growth typical of directionally solidified (DS) alloys. Consequently, D10 discloses a single crystal vane cast from a directional solidified alloy type material.

The patent proprietor argued that the expression "directional solidified alloy type material" relates to the composition of the material, and that the skilled person is fully aware of the types of materials that are classed as DS alloys. D10 discloses blades and vanes made from a generic superalloy material, which would not have been considered by a skilled person as a DS alloy because of the absence of Hf and the low amounts of B and Zr. The statement in D10 that the presence of B and Zr is disadvantageous (column 3, lines 64 to 69) is a further indication that the alloy of D10 is not intended for directional solidification applications.

*Second Auxiliary Request - Inventive Step*

The patent proprietor argued that D10 only discloses a vane segment having a single airfoil. Starting from this document, the problem to be solved is how to make a vane segment having a plurality of airfoils, and there is no indication in D10 of how this can be achieved.

Compared with the vane segment of D10, the airfoils of the invention are turned through 90°, and the crystal orientation is aligned along two axes. Although D10 teaches orientation of the <001> direction, there is no hint to align the other axes. According to the invention, a single crystal vane segment having

multiple airfoils can be made by using a seed crystal, whose alignment is known, to give controlled growth in both directions. Since there is no hint of this solution in D10, the claimed subject-matter is inventive.

The opponent submitted that D10 discloses a vane segment component made from a cast DS alloy material that has a single crystal structure, and teaches that the <001> crystal direction must be oriented parallel to the length of the cast object.

The skilled person is aware that crystallographic directions must be aligned to provide the optimum mechanical properties in a given direction, and that orientation of the <001> and <010> directions improves fatigue properties in these directions. Therefore, faced with the problem of casting a vane segment having a plurality of airfoils, it is clear that orientation of the crystal axes in two directions is necessary. In addition, D10 explicitly teaches that a single crystal structure can be obtained by using a seed crystal aligned to give the required orientation. The claimed subject-matter therefore lacks an inventive step.

## **Reasons for the Decision**

1. The appeals are admissible.

*Main Request*

2. Article 100(c) EPC

2.1 The opponent submitted (see section VIII(a) above) that amendment of the expression "integrally cast" to "integrally connected" leads to an extension of subject-matter, as the latter includes methods other than casting for connecting the airfoils to the end walls.

2.2 Claim 1 defines a cast single crystal structure made up of at least one airfoil and two end walls - there is no indication that structure could be made from separate components joined together, and the Board agrees with the view of the patent proprietor that such an interpretation would be contrary to the teaching of the patent. In addition, the application as originally filed uses the expressions "coupled to" and "extend between", which are seen as being equivalent to "connected to". Consequently, there is no extension of subject-matter beyond the original application.

3. Novelty (Article 54 EPC)

3.1 Document D10 discloses a cast single crystal vane segment having an airfoil connected between first and second end walls (see Figure 9); the vane segment is made from a nickel-based superalloy (column 2, lines 25 to 28). The question is whether the alloy disclosed in D10 can be considered to be a directional solidified alloy type material, as is defined in the independent claims of the main request.

3.2 Directional solidification in the strict sense of the expression merely relates to the progressive

solidification of molten metal from one end of the casting. This technique is used to produce both single crystal (SX) material and material having elongated columnar grains (see for example D25, lines 16 to 17).

3.3 Although the SX structure of D10 is produced by directional solidification (see Figure 6, and column 5, line 72 to column 6, line 3), the patent proprietor argues that, to a person skilled in the art, directionally solidified (DS) alloys only refer to those producing elongated columnar grains and not to those resulting in SX material. The patent proprietor also argues that the skilled person assessing the invention at the priority date of the contested patent would be able to recognise immediately whether an alloy is intended for DS or SX applications. In particular, the low amounts of B and Zr and the absence of Hf in the alloy of D10 indicates that it is not a DS alloy; the teaching of D10 that B and Zr are undesirable in a single crystalline structure is a clear indication that D10 only relates to SX material.

3.4 It should be noted that for the purpose of assessing novelty, the content of a prior art document is interpreted in the manner in which it would have been understood by the skilled person at the time it was made available, ie in 1970. Knowledge that has become available between the publication date and the priority date is an issue relating to inventive step (see Case Law of the Boards of Appeal of the EPO, 6th edition 2010, I.C.1.1 page 64).

3.5 In 1970 the skilled person would have been aware that the elements B, Zr and Hf can, in appropriate amounts,

be present in both DS and SX alloys; indeed the SX alloy of D10 itself contains some B and Zr. There is no evidence to support the assertion that absence of Hf inevitably means that an alloy is not DS. The independent claims do not define an alloy composition, which means that it is not possible to distinguish the claimed material on the basis of the amounts of the elements present in the alloy.

3.6 The Board is of the view that the expression "directional solidified alloy type material" defines an alloy from which DS material can be produced. Figure 6 of D10 shows that at the onset of directional solidification, controlled columnar growth (61) is produced. It is clear from D10 that, although the alloy is described in the context of making an SX material, it can also be used to make DS material.

3.7 Since the alloy used to make the single crystal vane segment of D10 can also be used to make DS material, it can be seen as being a directional solidified alloy type material, and hence the subject-matter of the independent claims of the main request lacks novelty.

*First Auxiliary Request*

4. Since the independent claims of the first auxiliary request correspond to those of the main request, the subject-matter of these claims also lacks novelty.

*Second Auxiliary Request*

5. Inventive Step (Article 56 EPC)

- 5.1 Since D10 discloses a vane segment component comprising a cast single crystal structure formed of a directional solidified alloy type material, it provides a suitable starting point for the assessment of inventive step.
- 5.2 The vane segment component of claim 1 differs from that of D10 in that it has a plurality of airfoils with the single crystal structure having a defined orientation.
- 5.3 A vane segment having several airfoils is a more complex structure than one having just one airfoil that basically lies in one plane (compare Figure 5 of the disputed patent with Figure 9 of D10). Starting from D10, the objective problem to be solved is therefore how to improve the manufacture of vane segments.
- 5.4 According to the disputed patent, this problem can be solved by producing a multi-airfoil vane segment as a single crystal casting. This is achieved by aligning a starter seed such that the  $\langle 001 \rangle$  crystal direction is parallel with a tangent to the vane segment and the  $\langle 010 \rangle$  direction is parallel with an average airfoil stacking axis.
- 5.5 D10 teaches that the  $[001]$  direction should be parallel to the length of the cast object (column 2, lines 32 to 45). However, as D10 is just concerned with making a vane segment having a single airfoil, there is no mention of orientating the  $[010]$  direction, which lies in a plane at  $90^\circ$  to the  $[001]$  direction. According to D10 a single crystal structure is produced by growing columnar grains into a restricted passageway (see column 6, lines 57 to 68), and although the alternative use of an oriented seeding crystal is mentioned as a

possible way of making a single crystal object (column 4, lines 57 to 64), there is no indication that this might be a useful way for making a vane segment having multiple airfoils.

- 5.6 In summary, D10 is concerned with making single vanes, and there is no indication in the document that a vane segment having several airfoils can be produced with a cast single crystal structure. In addition, none of the other documents referred to by the opponent suggest such a vane segment. Consequently, the claimed subject matter has an inventive step.

**Order**

**For these reasons it is decided that:**

1. The decision under appeal is set aside.
  
2. The case is remitted to the opposition division with the order to maintain the patent on the basis of:
  - (a) Claims 1 to 14 according to the second auxiliary request filed during the oral proceedings;
  
  - (b) Pages numbered 2, 2A, 2B, 3, 4 and 5 of the amended description filed during the oral proceedings;
  
  - (c) Figures 1 to 5 as granted.

The Registrar:

The Chairman:

A. Counillon

U. Krause