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Datasheet for the decision of 14 October 2022

Case Number: T 0440/16 - 3.2.06

Application Number: 11176354.6

Publication Number: 2388437

IPC: F01D5/18

Language of the proceedings: EN

Title of invention:
Cooling circuit flow path for a turbine section airfoil

Patent Proprietor:
Raytheon Technologies Corporation

Opponent:
Siemens Aktiengesellschaft

Headword:

Relevant legal provisions:
EPC Art. 56

Keyword:
Inventive step - (yes)

Decisions cited:

Catchword:

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Case Number: T 0440/16 - 3.2.06

D E C I S I O N
of Technical Board of Appeal 3.2.06
of 14 October 2022

Appellant: (Opponent)	Siemens Aktiengesellschaft Werner-von-Siemens-Straße 1 80333 München (DE)
Respondent: (Patent Proprietor)	Raytheon Technologies Corporation 10 Farm Springs Road Farmington, CT 06032 (US)
Representative:	Dehns St. Bride's House 10 Salisbury Square London EC4Y 8JD (GB)
Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 23 December 2015 concerning maintenance of the European Patent No. 2388437 in amended form.**

Composition of the Board:

Chairman	M. Harrison
Members:	M. Hannam
	W. Sekretaruk

Summary of Facts and Submissions

I. An appeal was filed by the appellant (opponent) against the interlocutory decision of the opposition division in which it found that European patent No. 2 388 437 in an amended form met the requirements of the EPC. The appellant requested that the decision under appeal be set aside and the patent be revoked.

II. The respondent (patent proprietor) requested that the appeal be dismissed.

III. The following documents are relevant to the present decision:

D2 US-B-6 890 153
D4 US-A-2006/0083614
D5 US-B-6 220 817
D9 DE-T-600 25 988
E1 Stationäre Gasturbinen, Lechner, Seume, Pages 611 to 613
E2 Experimental Leading-Edge Impingement Cooling Through Racetrack Crossover Holes, ASME TURBO EXPO 2001
E3 Novel Blade Cooling Engineering Solution, ASME TURBO EXPO 2000
E4 Experimental Investigation on Impingement Heat Transfer From Rib Roughened Surface, ASME TURBO EXPO 2000
E5 An Experimental Evaluation of Advanced Leading Edge Impingement Cooling Concepts, ASME TURBO EXPO 2000

IV. The Board issued a summons to oral proceedings and a subsequent communication containing its provisional opinion, in which it indicated *inter alia* that the subject-matter of claim 1 appeared to involve an

inventive step and that dismissal of the appeal should be expected.

V. Oral proceedings were held before the Board on 14 October 2022. At the close of the oral proceedings, the parties' requests were unchanged from points I. and II. above.

VI. Claim 1 of the main request reads as follows:

"A cooled airfoil (38) within a gas turbine engine (10) comprising:
a rib (54) which at least partially defines a forward cavity (34A) within an airfoil (38), said forward cavity (34A) in communication with a cooling circuit flow path (26); and
at least one opening (58) through said rib (54), said at least one opening (58) offset within said forward cavity (34A) relative a longitudinal axis (L) of said airfoil (38), wherein said at least one opening (58) communicates with a leading edge cavity (56) adjacent said forward cavity (34A);
a multiple of showerhead holes (60) within a leading edge (36) of said leading edge cavity (56);
characterised in that said cooled airfoil (38) further comprises:
a multiple of turbulators (64) within said leading edge cavity (56), said at least one opening (58) adjacent said multiple of turbulators (64);
wherein said turbulators (64) are defined on the inner wall of said leading edge cavity (56);
wherein said multiple of turbulators are angled trip strips (64A) defined along a pressure side (40P) of the cooled airfoil (38);
wherein said multiple of turbulators (64) are opposite a multiple of gill holes (62)."

VII. The appellant's arguments may be summarised as follows:

The subject-matter of claim 1 lacked an inventive step. Starting from D2, this failed to disclose solely the following features of claim 1:
- said at least one opening (42 in D2) being offset within said forward cavity relative a longitudinal axis of said airfoil; and
- turbulators in the form of angled trip strips defined along a pressure side of the cooled airfoil.

The showerhead holes were known from D2 as a separate embodiment to that without showerhead holes and that former was chosen as the most promising starting point. D2 did not indicate any additional modifications that had to be made in order to address low cycle fatigue resulting from including the showerhead holes. There was thus no basis to conclude that including showerhead holes would necessitate further modifications to the leading edge flow channel 32 of D2.

Irrespective of whether the technical problem to be solved was formulated as being to use less cooling air or to provide alternative cooling of the leading edge, D4 provided the skilled person with the necessary teaching as to how to modify D2 and reach the claimed subject-matter. Paragraph [0044] of D4 disclosed the cooling being improved by offsetting the impingement cooling passages towards the pressure side of the airfoil which would improve cooling due to Coriolis forces altering the cooling air flow. Providing angled trip strips offered no surprising effect to the cooling and thus could not provide the basis for an inventive step to be recognised. This was supported by the Guidelines for Examination, G-VII, 10.1 in which an

arbitrary choice of possible features could not justify the presence of an inventive step to be recognised. E1 further supported the understanding that angled trip strips were known to the skilled person.
Alternatively, when starting from D5, this failed to disclose:
- said at least one opening being offset within said forward cavity relative a longitudinal axis of said airfoil;
- turbulators in the form of angled trip strips defined along a pressure side of the cooled airfoil;
- the at least one opening being adjacent said turbulators; and
- the turbulators are opposite a multiple of gill holes.

D9 provided the skilled person with the necessary teaching as to how to modify D5 and reach the claimed subject-matter. Paragraph [0044] of D9 disclosed turbulators arranged in the cooling channels to improve the efficiency of cooling. The positioning of the turbulators in the vicinity of the trailing edge (see for example paragraphs [0036] and [0044]) was simply exemplary such that the skilled person would also consider using these at the leading edge of the airfoil. The requirement for cooling existed at both the leading and the trailing edges such that the same features enabling this would thus implicitly be used in both locations.

E2 to E5 were filed as general evidence to counter the opposition division's statement that the skilled person would be reluctant to make modifications to airfoil cooling channel geometry and components.

VIII. The respondent's arguments may be summarised as follows:

The subject-matter of claim 1 involved an inventive step.

When starting from D2, this failed to unambiguously disclose the showerhead holes in combination with the other features of the primary embodiment. The cooling airflow in D2 was directed onto the fins 44 and the introduction of showerhead holes would require a redesign of the cooling airflow envisaged for the leading edge cavity. Paragraph [0021] of the patent indicated the technical problem but this could not be solved to reach claim 1 when applying the teaching of D4. D4 was directed to problems relating to blades having a large fillet and so would not be considered by the skilled person wishing to improve the efficiency of cooling in the leading edge cavity of an airfoil. Even if it were considered, D4 failed to guide the skilled person to offset the air inlet opening towards the pressure side since, again, the entire cooling design for the leading edge cavity would need to be changed.

When starting from D5, this failed to disclose an offset opening and turbulators. D9 failed to guide the skilled person to the claimed subject-matter as it addressed cooling requirements at the trailing edge of an airfoil which were not unambiguously transferable to the leading edge cavity. There was no clear statement made as to why E2 to E5 were relevant.

Reasons for the Decision

1. Inventive step (Article 56 EPC)

1.1 *D2 in combination with the technical teaching of D4*

1.1.1 D2 discloses the following features of claim 1:

A cooled airfoil (14) within a gas turbine engine (col. 1, lines 7 to 8) comprising:
a rib (forward bridge, 26) which at least partially defines a forward cavity (the 2nd cavity from the left in Fig. 2) within an airfoil (14), said forward cavity in communication with a cooling circuit flow path (serpentine flow circuit 34; col. 3, lines 13 to 38); and
at least one opening (cross-over hole, 42) through said rib (26), wherein said at least one opening (42) communicates with a leading edge cavity (leading edge flow channel, 32) adjacent said forward cavity;
said cooled airfoil (14) further comprises:
a multiple of turbulators (46) within said leading edge cavity (32), said at least one opening (42) adjacent said multiple of turbulators (46);
wherein said turbulators (46) are defined on the inner wall (see Fig. 2) of said leading edge cavity (32);
wherein said multiple of turbulators (46) are opposite a multiple of gill holes (50).

1.1.2 D2 fails to disclose (in any single embodiment):

- a multiple of showerhead holes within a leading edge of said leading edge cavity;
- said at least one opening (42 in D2) being offset within said forward cavity relative a longitudinal axis of said airfoil; and

- turbulators in the form of angled trip strips defined along a pressure side (i.e. the concave surface side) of the cooled airfoil.

1.1.3 The appellant's contention that the showerhead holes were also known from D2 is not accepted. Col. 4, lines 3 to 13 of D2 discloses a primary embodiment without showerhead cooling holes and further mentions 'other embodiments' of the invention which include such holes. The skilled person would however be unsure which features of the primary embodiment would remain unmodified when including the showerhead holes.

1.1.4 In this regard the respondent referred to the low cycle fatigue resulting from the showerhead holes being included in the leading edge of the airfoil (see col. 4, lines 11 to 13) and the statement that "this would then have to be addressed". The Board concurs that this issue would clearly need to be considered by the skilled person, D2 providing no guidance as to what design impacts this may have on e.g. the fins 44 or the turbulators 46, 48 in the leading edge flow channel 32.

1.1.5 Beyond this, in the primary embodiment of D2, the crossover holes 42 direct the cooling air 40 onto the fins 44 at the leading edge of the channel 32 for dispersing heat from the airfoil sidewalls (see col. 3, lines 39 to 48). Thereafter the cooling air is directed to the gill holes 50 for emitting cooling air from the channel 32 (col. 3, lines 60 to 65). It is thus evident that introducing showerhead holes at the leading edge of the airfoil would materially affect the cooling air flow in the channel 32 such that the fins 44 and gill holes 50 would be expected to require redesigning.

1.1.6 Consequently, contrary to the opinion of the appellant, should the showerhead holes be included in the airfoil of D2, there is no unambiguous disclosure of which features of the primary embodiment would still be included in such an embodiment. The Board thus finds there to be no unambiguous disclosure in D2 of the features of claim 1 indicated to be known in point 1.1.1 above in combination with the showerhead holes.

1.1.7 Based on the features in point 1.1.2 differentiating claim 1 over D2, the objective technical problem to be solved may be seen as being 'how to improve the cooling efficiency in the leading edge cavity of the airfoil of D2'. Both parties essentially accepted this problem as being objective.

1.1.8 The Board finds the skilled person not to be guided to the necessary modification of D2 through the technical teaching of D4. Firstly, the skilled person would not consider D4 for combination with D2 since, as also argued by the respondent, D4 is directed to addressing problems relating to blades having a large fillet (see e.g. paragraphs [0001], [0003] and [0037]). However, even if this incompatibility between D2 and D4 were to be ignored, the off-setting of the cooling passages 28 in D4 to the pressure side of the airfoil would not be an obvious modification to make to the cooling passages 42 in D2 since the direct impingement cooling of the fins 44 would be lost and the cooling airflow in the channel 32 would be completely changed, thus requiring significant redesign of the fins/turbulator/gill holes of D2. In addition, D4 is silent regarding the further differentiating features of claim 1 over D2, namely the angled trip strips on a pressure side of the airfoil or showerhead holes at its leading edge. Thus, even if D2 were to be combined with the technical teaching of D4,

the subject-matter of claim 1 would not be reached unless an inventive step were involved.

1.1.9 The appellant's reference to the Coriolis effect disclosed in D4 also applying to D2 is not denied. However, this merely results in the cooling air emitted from the cooling passages 28 of D4 being directed towards the pressure side of the airfoil which, if applied in D2 would still not guide the skilled person to providing the claimed angled trip strips and showerhead holes.

1.1.10 The appellant's argument that angled trip strips offered no surprising cooling effect and so could not provide the basis for an inventive step to be recognised is accepted as far as this argument goes. However, the cooling air flow in D2 is of a very specific nature, air first impinging on the fins 44 before passing over the turbulators and then exiting via the gill holes. Introducing angled trip strips into the channel 32 of D2 would be expected to not insignificantly change the cooling air flow, thus putting into question the entire cooling concept envisaged and its efficacy.

1.1.11 This outcome is not changed through the appellant's reference to G-VII, 10.1 of the Guidelines for Examination (which are anyway not binding on the Board), in which an arbitrary choice of possible features could not justify the presence of an inventive step being recognised. Even if the technical effect of the angled trip strips in isolation were well known, and the selection of these (rather than for example bumps or pins) were arbitrary, the inclusion of the angled trip strips in D2 was not a simple addition with a known technical effect due to the resultant impact of

this change on the fundamental cooling air flow in the airfoil of D2.

1.1.12 The appellant's further reference to E1 to prove that angled trip strips were well known is accepted; they indeed are known to the skilled person and this was not denied by the respondent. Nonetheless, as held above, their introduction into the cooling structure disclosed in D2 would not be obvious to the skilled person.

1.1.13 In summary, therefore, when starting from D2 and wishing to solve the posed objective technical problem, D4 would not guide the skilled person to the subject-matter of claim 1 without their exercising an inventive step.

1.2 *D5 in combination with the technical teaching of D9*

1.2.1 D5 discloses the following features of claim 1:

A cooled airfoil (12) within a gas turbine engine (see col. 1, lines 6 to 8) comprising:
a rib (span rib, 71) which at least partially defines a forward cavity (41) within an airfoil (12), said forward cavity (41) in communication with a cooling circuit flow path (36); and
at least one opening (74) through said rib (71), wherein said at least one opening (74) communicates with a leading edge cavity (leading edge cooling plenum, 70) adjacent said forward cavity (41);
a multiple of showerhead holes (44) within a leading edge (20) of said leading edge cavity (70).

1.2.2 It was undisputed by the parties that D5 fails to disclose:

- said at least one opening offset within said forward cavity relative a longitudinal axis of said airfoil;
- a multiple of turbulators within said leading edge cavity, said at least one opening adjacent said multiple of turbulators;
- wherein said turbulators are defined on the inner wall of said leading edge cavity;
- wherein said multiple of turbulators are angled trip strips defined along a pressure side of the cooled airfoil; and
- wherein said multiple of turbulators are opposite a multiple of gill holes.

1.2.3 The objective technical problem to be solved can thus be seen as being 'how to improve the cooling efficiency in the leading edge cavity of the airfoil of D5'. Both parties accepted this as the problem to be solved.

1.2.4 The technical teaching of D9 does not lead the skilled person to the claimed subject-matter without becoming inventively active. Firstly, D9 is directed to cooling in the trailing edge cavity of an airfoil and so would not be consulted by the skilled person for a teaching relating to the leading edge cavity of D5. Even if it were to be considered, D9 fails to disclose an offset of the inlet hole 42 to the trailing edge cavity, rather the hole is angled towards the turbulators 46 (see paragraph [0038]). Thus, even if the teaching of D9 were to be applied to the leading edge cavity of D5, the claimed offset of the opening relative to the longitudinal axis would not be realised. D9 also fails to disclose turbulators in relation to the leading edge cavity of the airfoil, the entire disclosure of D9 being directed to cooling in the region of the trailing edge cavity.

1.2.5 The appellant's argument that Fig. 3 of D9 showed the inlet hole 42 being offset towards the pressure side of the airfoil is not accepted. It is not appropriate to infer relative dimensions from a figure if these are not clearly understood to be so intended. There is nothing in D9 to suggest, even if it could be inferred from the depiction in Fig. 3 (which is certainly not unambiguously the case), that an offset of inlet hole 42 relative to the longitudinal axis towards the pressure side of the airfoil is deliberate. Rather as paragraph [0038] discloses, the inlet hole 42 is simply angled towards the pressure side of the airfoil. Therefore, no unambiguous disclosure of an offset of inlet hole 42 towards the pressure surface can be inferred from D9.

1.2.6 The appellant's argument that the turbulators in the vicinity of the trailing edge of D9 (see for example paragraphs [0036] and [0044]) were simply given as an example such that the skilled person would also consider employing these at the leading edge of the airfoil is not accepted. An exemplary disclosure of a feature at the trailing edge of an airfoil does not implicitly disclose the same at the leading edge. Even though it is accepted that cooling at both the trailing and leading edges of an airfoil is important, explicit disclosure at one location as an example cannot result in an implicit disclosure at the other. Such a transfer of teaching from leading to trailing edge can also not be seen as routine adaptation for the skilled person. As remarked by the respondent, paragraph [0029] of D9 discloses that the other aerofoil cavities shown in the Figures (which are there to provide cooling) were not the subject of the invention in D9, such that the author of D9 also gave no indication of the immediate relevance of the trailing edge structure to that of the

leading edge.

1.2.7 The appellant's argument that the requirement for cooling exists at both the leading and the trailing edges and that the same features enabling this would thus implicitly be used in both locations is not accepted. It is true that a cooling requirement exists at both edges, but the way in which this is achieved in cavities, the cross-section of which are of different shape and size, is not necessarily the same in all instances. There is thus no direct inference possible from D9 that the presence of turbulators in the vicinity of the trailing edge would implicitly result in turbulators being seen as appropriate for cooling the leading edge cavity.

1.2.8 The appellant's further reference to E2 to E5 as having been filed to counter the opposition division statement that the skilled person would be reluctant to make modifications to airfoil cooling channel geometry and components is irrelevant to whether the skilled person would find a teaching in D9 as to how to modify D5. Indeed, there is no such teaching in D9 to guide the skilled person to any modification of the leading edge cavity, let alone to the particular arrangement of offset cooling air opening directing air onto angled trip strips on the pressure side of the airfoil.

1.2.9 In conclusion, therefore, when starting from D5 and wishing to solve the posed objective technical problem, D9 would not guide the skilled person to the subject-matter of claim 1 without their exercising an inventive step.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

D. Grundner M. Harrison

Decision electronically authenticated