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D E C I S I O N
of 25 July 1995

Case Number: T 0157/93 - 3.2.3

Application Number: 86106295.8

Publication Number: 0203431

IPC: F23R 3/02, F01D 9/02, F01D 25/12

Language of the proceedings: EN

Title of invention:
Impingement cooled transition duct

Patentee:
GENERAL ELECTRIC COMPANY

Opponent:
Asea Brown Boveri AG

Headword:
-

Relevant legal provisions:
EPC Art. 56
EPC R. 29(1)

Keyword:
"Inventive step - (yes) after amendment"
"Two-part form of the claim"

Decisions cited:
T 0013/84

Catchword:
-

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Case Number: T 0157/93 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 25 July 1995

Appellant: (Proprietor of the patent)
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Representative:
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Respondent: (Opponent)
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Representative:
-

Decision under appeal:
Decision of the Opposition Division of the European Patent Office dated 20 November 1992, posted on 18 December 1992, revoking European patent No. 0 203 431 pursuant to Article 102(1) EPC.

Composition of the Board:

Chairman: C. T. Wilson
Members: H. Andrä
W. Moser

Summary of Facts and Submissions

I. European patent No. 0 203 431 was granted on 22 November 1990 on the basis of European patent application No. 86 106 295.8 filed on 7 May 1986.

II. The patent was opposed by the Respondent (Opponent) on the ground that its subject-matter did not involve an inventive step (Article 100(a) EPC).

The following documents were cited:

(D1) US-A-3 652 181
(D2) DE-A-2 836 539.

III. The patent was revoked by the Opposition Division with a decision dated 20 November 1992, posted with letter dated 18 December 1992. According to the decision, the skilled person starting out from DE-A-2 836 539 (corresponding to US-A-4 339 925) would arrive at the claimed solution by generally known engineering calculations based on physical laws.

IV. The Appellant (Patentee) filed an appeal against this decision on 11 February 1993, the appeal fee being paid on the same day.

The Statement of Grounds of Appeal was filed on 22 April 1993.

V. Oral proceedings, the summons to which was accompanied by a communication pursuant to Article 11(2) RPBA, were held on 25 July 1995.

VI. The Appellant requests that the decision under appeal be set aside and that the patent be maintained on the basis of the following documents:

(a) Main request:

- Claims 1 to 5 as submitted during the oral proceedings

- description: columns 2, 3, 5 and 6 as submitted during the oral proceedings; columns 1, 4, 7 to 13 as granted.

- drawings as granted.

(b) Auxiliary request:

- Claims 1 to 4 filed on 22 April 1993 as second auxiliary request.

Claim 1 according to the main request reads as follows:

"Impingement cooled transition duct in a gas turbine of the type comprising a turbine casing connected to a compressed air supply and including within the turbine casing a plurality of combustors (12) and transition ducts (18) for delivering hot gas to a turbine stage; said impingement cooled transition duct comprising an impingement sleeve (66) surrounding each transition duct approximately coextensive therewith and having a combustor end (32), a turbine end (36) and a closed end between the impingement sleeve (66) and the transition duct (18) at said turbine end (36);

a plurality of apertures (70) being formed in the impingement sleeve (66), the apertures being spaced apart, characterized in that the distance between said

apertures and the size of the apertures increases from said turbine end (36) to said combustor end, and

the impingement sleeve (66) is spaced at a variable radial distance from the transition duct (18) along its axial length, said radial distance being larger at the combustor end (32) than at the turbine end (36)."

The arguments of the Appellant can be summarised as follows:

- The object underlying the invention is not only to ensure an efficient use of the cooling air and an increased thermal efficiency for a gas turbine transition duct but also to minimize the air flow pressure drop ahead of the combustion system while achieving the required cooling intensity.

- DE-A-1 150 696, cited by the Opponent, is not relevant to the invention since its primary teaching deals with the use of water jets as the cooling fluid and not with air. Besides, only a regular spacing of the apertures in the cooling fluid channel is disclosed.

- US-A-2 873 944, referred to in the Search Report, is concerned with turbine blade cooling and proposes to introduce the cooling air into the blade in a manner providing for a very uniform distribution of cooling air. Again, a constant spacing of the apertures is described in this citation. Furthermore, it does not disclose an impingement type cooling, teaching thus away from the invention.

- According to (D1), the impingement sleeve surrounds only part of the transition duct providing thus a lateral flow in the sleeve in contrast to the longitudinal flow according to the invention. The impingement sleeve does also not have a turbine end and a combustor end and the spacing of the apertures in the sleeve is constant. This citation cannot, therefore, give any lead to the subject-matter according to the invention.

- The object underlying (D2) is to cool the hot gas casings of the combustion chambers of gas turbine power plants more uniformly than in the known configurations in order to avoid the thermal stresses and cracks produced by non-uniform cooling. According to the invention, however, tailoring the cooling distribution according to the transition duct design requirements is aimed at so that (D2) directs away from the invention already in view of the inherent problems.

- Finally, it should not be forgotten that the technology of gas turbines is a highly competitive field reflecting intensive research and development activities. In such a field, even apparently small improvements may have an enormous impact due to the high standard of turbine technology.

VII. The Respondent requests that the appeal be dismissed. He argues essentially as follows:

- Document (D2) discloses an impingement cooled transition duct in a gas turbine comprising the features according to the pre-characterising portion of Claim 1. Additionally, (D2) discloses

the feature that a plurality of apertures is formed in the impingement sleeve, the apertures being spaced apart.

- From DE-B-1 150 696 it is known that in impingement cooling the diameter of and the distance between the apertures in the flow direction as well as the distance between the walls, that is the duct wall and the impingement sleeve wall, are the relevant parameters in the design of the impingement cooling. With this teaching in his mind, the skilled person, starting out from (D2), would arrive in an obvious way at the subject-matter of Claim 1 according to the main request. The feature that the impingement sleeve is spaced at a variable radial distance from the transition duct along its axial length, the radial distance being larger at the combustor end than at the turbine end is self-evident. Under the provision that the cooling air is to be conducted towards the combustor end of the impingement sleeve, the flow cross-section of the channel formed between the impingement sleeve and the transition duct must increase to be able to take in the air added continuously along the channel. The size of the apertures in the impingement sleeve would have to increase towards the combustor end due to the mass flow between the impingement sleeve and the transition duct increasing in this direction.

- US-A-2 873 944 deals with turbine blade cooling, that is a technical field close to gas turbine transition ducts and would, therefore, be taken into account by the skilled person. The citation suggests that in areas of the blade in which greater cooling may be desired greater flow of the

cooling fluid may be provided by increasing the size of, or decreasing the spacing between, the perforations.

- Minimising the cooling air required and making an efficient use thereof are measures customarily followed by the skilled person in the field of gas turbine cooling. It is not required to show by written evidence that the subject-matter of Claim 1 is known identically as it had been demonstrated that it lacks an inventive step.

- Claim 1 has not been delimited correctly vis-à-vis the prior art known from (D2). The concept originating from this citation, that by corresponding dimensioning of the cooling air inlet apertures and of the distance between the outer sleeve and the wall to be cooled the cooling effect can be adapted to the requirements, should have been incorporated into the preamble of Claim 1.

Reasons for the Decision

1. The appeal is admissible.

Main request:

2. *Amendments*

2.1 Claim 1 is supported by the original Claims 1, 7 to 10 and 12.

Claim 2 derives from original Claim 12 in combination with page 22, lines 4 to 7 and Figure 4 of the original description and drawings, respectively. Claim 3 derives

from original Claim 12 in combination with page 21, paragraph 2 of the original description and Claims 4 and 5 derive from original Claim 21 in combination with page 23, paragraph 1 to page 24, line 5 and page 25, line 23 to page 27, line 11 of the original description. Claims 1 to 5 comply with the requirement of Article 123(2) EPC.

2.2 The last line of the granted Claim 1 was amended from "... said combustor end to said turbine end" to "... said turbine end (36) to said combustor end" according to present Claim 1.

This amendment was allowed by the first instance as a correction under Rule 88 EPC, see the passage bridging pages 2 and 3 of the decision under appeal. It is supported by the passage from page 20, line 24 to page 21, line 1 of the original description and Figures 3A and 3B of the original drawings. The description and the drawings of the patent (see column 10, lines 23 to 45 and Figures 3A and 3B, respectively), show clearly that the distance between the apertures formed in the impingement sleeve and the size thereof increases from the turbine end (36) to the combustion end (32). Thus, the correction is obvious in the sense that it is immediately evident that nothing else would have been intended than what is offered by the correction and it is therefore allowable.

The additional features of Claim 1 with regard to the granted version that the size of the apertures increases from the turbine end (36) to the combustor end (32) and that the impingement sleeve (66) is spaced at a variable radial distance from the transition duct (18) along its

axial length, said radial distance being larger at the combustor end (32) than at the turbine end (36), limit the scope of protection of the granted Claim 1.

Claims 2 to 5 correspond in substance to Claims 3 to 6 according to the patent as granted.

Claims 1 to 5 comply also with the requirement of Article 123(3) EPC.

3. *Novelty*

3.1 The nearest prior art document is considered to be DE-A-2 836 539 (D2).

Document D2 which corresponds to US-A-4 339 925 discussed in the description of the patent in suit, describes an impingement cooled transition duct in a gas turbine of the type comprising a turbine casing connected to a compressed air supply and including within the turbine casing a plurality of combustors (12) and transition ducts (18) for delivering hot gas to a turbine stage; said impingement cooled transition duct comprising an impingement sleeve (66) surrounding each transition duct approximately coextensive therewith and having a combustor end (32), a turbine end (36) and a closed end between the impingement sleeve (66) and the transition duct (18) at said turbine end (36); a plurality of apertures (70) being formed in the impingement sleeve (66), the apertures being spaced apart, in accordance with the pre-characterising portion of Claim 1.

The impingement cooled transition duct according to Claim 1 is distinguished from this state of the art by the features of the characterising clause of the claim, that is

(a) the distance between said apertures and the size of the apertures increases from said turbine end (36) to said combustor end

(b) the impingement sleeve (66) is spaced at a variable radial distance from the transition duct (18) along its axial length, said radial distance being larger at the combustor end (32) than at the turbine end (36).

No other prior art is available which discloses, in combination, all the features of Claim 1.

As the issue of novelty of the transition duct according to Claim 1 is not in dispute, further explanation on this point is unnecessary.

The subject-matter of Claim 1 is therefore novel and the claim meets Article 54 EPC.

4. *Inventive step*

4.1 In comparison with the nearest state of the art according to (D2) the problem to be solved by the invention is to provide an improved impingement cooled transition duct which ensures an efficient use of the cooling air and an increased thermal efficiency for an advanced heavy gas turbine engine. Furthermore, the air flow pressure drop ahead of the combustion system is to be minimized while achieving the required cooling intensity according to design requirements (see

column 5, paragraph 2 and column 6, lines 24 to 28 of the patent in suit as granted and the corresponding passages of the present description).

This aim is achieved by the features (a) and (b) of the characterising portion of Claim 1 as identified above.

The narrower spacing of the apertures near the turbine end of the transition duct as compared to the combustor end provides for the increased cooling intensity required in the region of the transition duct near the turbine end.

By increasing the size of the apertures in the direction from the turbine end to the combustor end the impingement jets are enabled to penetrate the increased mass of cross-flow air, that is air flowing towards the combustor perpendicularly to the axes of the apertures. An efficient cooling due to an improved penetration of the cross-flow may be achieved while at the same time for a required cooling intensity a smaller number of impingement jets can be afforded which due to a reduced number of flow interference jets may lead to a reduced pressure loss.

Finally, feature (b) as indicated above enables the cross-flow air velocity to be reduced leading thus to a reduction of the pressure drop of the impingement sleeve flow.

To the Board it is, therefore, credible that Claim 1 solves the problem as identified above.

4.2 DE-B-1 150 696, which is regarded by the Respondent as being of particular relevance to Claim 1, deals with impingement cooling in general. In accordance with the problem underlying this citation an increase of the heat

transfer coefficient is aimed at whereby the usual fluids such as water should be used. No connection with an impingement cooled transition duct in a gas turbine in which the issue of minimizing the cooling air pressure loss is a relevant factor can be recognised.

The passage of the citation in column 5, lines 46 to 53 referred to in particular by the Respondent is worded as follows:

"It is clear that for a given use of the heat exchanger the five conditions referred to above define the features of the heat exchanger, that is the diameter D of the apertures, the distance e between the axes of the apertures, the distance d between the two surfaces and the velocity v of the fluid in the jets."

The five conditions referred to concern particular values and relations, respectively, of the Reynolds-Number, the Nusselt-Number, the Prandtl-Number and of dimensions of the heat exchanger.

The skilled person is taught by the citation that for the purpose of maximizing the heat transfer coefficient he has to take into consideration the above-cited basic conditions in order to arrive by appropriate calculations at the characteristic dimensions and physical parameters of the heat exchanger.

According to the embodiments disclosed in the citation (see for example Figure 3 and 6), only a constant size and spacing of the apertures (6, 16) can be recognised and the width of the channel (17) formed by the impingement sleeve and the duct wall does not increase in the downward flow direction.

Thus, the citation neither tackles the issue of avoiding pressure losses of the cooling medium nor does it give a hint at any of the features according to the characterising portion of Claim 1.

4.3 US-A-2 873 944 is concerned with the neighbouring technical field of turbine blade cooling. Cooling air is supplied through a passage in the turbine wheel to a blade liner which extends through the blade. The cooling air escapes from the liner through perforations in the faces of the liner and is directed against the inside of the blade.

The liner may be constructed "so as to provide substantially uniform air flow at all comparable areas of the liner". In case, however, greater cooling is desired at certain areas, greater flow of the cooling fluid may be provided in these areas by increasing the size of, or decreasing the spacing between, the perforations to make the liner more pervious adjacent such critical areas (see column 2, line 63 to column 3, line 4 of the citation).

The skilled person is thus informed that in critical areas of the turbine blade, cooling may be intensified by increasing the cooling flow cross-section, either by increasing the size of the respective perforations or increasing the density of the distribution thereof.

It is, however, clear that due to the constructional differences between an impingement cooled transition duct and the known turbine blade the latter does not comprise an impingement sleeve surrounding a transition duct nor a combustor end and a turbine end, according to features of the pre-characterising portion of Claim 1.

As a consequence of the absence of these components, the citation does also not teach an increase of the spacing and the size of the perforations from the turbine end to the combustor end (feature (a)). In particular, variations of the perforation size and spacing are taught in the citation to be alternatives in view of an increase of the flow cross-section whereas according to Claim 1 variations of both the aperture spacing and the aperture size at identified ends of the transition duct are proposed taking into account thereby not only the specific cooling requirements but also the particular problems of the penetration of the impingement jets and the pressure loss involved. As a further measure which contributes also to a low pressure loss a variable spacing of the cooling flow channel along the length thereof is taught in Claim 1 (feature (b)) to which the citation does also not give any lead.

It follows from the above considerations that the incorporation of the disclosure of US-A-2 873 944 into the teaching of (D2) does not lead in an obvious way to the subject-matter of Claim 1.

4.4 The Respondent argues that minimizing the air required for cooling and making an efficient use thereof are measures customarily followed by the skilled person in the field of gas turbine cooling.

The Board agrees with this view but would point out that Claim 1 does not seek protection for such a concept but goes far beyond. It specifies in which manner three different parameters, that is the aperture spacing, the aperture size and the radial distance between the impingement sleeve and the surface to be cooled, of a specific component, namely an impingement cooled transition duct in a gas turbine, have to be varied over

the duct length in order to achieve an efficient cooling and at the same time a minimisation of the cooling air pressure drop ahead of the combustion system.

The further citation (D1) is more remote from the subject-matter of Claim 1 than (D2). As can be seen in particular from Figure 3 of (D1), the impingement sleeve surrounds the transition duct only partially so that a lateral flow in the sleeve is provided opposite to the longitudinal flow according to the subject-matter of Claim 1. Moreover, the spacing of the apertures in the sleeve is constant.

Thus, (D1) can also not lead to Claim 1 in an obvious way. This citation was also not discussed by the parties during the oral proceedings.

4.5 Summarising, the Board comes to the conclusion that the subject-matter of Claim 1 cannot be derived in an obvious manner from the cited prior art and accordingly involves an inventive step (Article 56 EPC).

4.6 Having regard to the Respondent's argument that Claim 1 has not been delimited properly vis-à-vis the prior art known from (D2) the Board would note the following:

In accordance with Rule 29(1) EPC, the claims wherever appropriate shall contain a statement indicating the designation of the subject-matter of the invention and those technical features which are necessary for the definition of the claimed subject-matter but which, in combination, are part of the prior art. Further, they shall contain a characterising portion stating the technical features which, in combination with the first part, it is desired to protect.

Rule 29(1) EPC specifies the contents of the claims as "those technical features which are necessary for the definition of the claimed subject-matter". The Rule does not stipulate that it would be permissible or even required to incorporate in a claim additionally to the claimed technical features any general idea or basic concept underlying the state of the art as well as the claimed subject-matter.

In this context, it is also pointed out that it is not the characterising portion of the claim in which the invention resides. It is the subject-matter of the claim as a whole which embodies the invention and the inventive step involved (see also T 13/84, OJ EPO 1986, 253; Section 15).

Thus, in the view of the Board, the delimitation of Claim 1 with regard to (D2) is in accordance with Rule 29(1) EPC. This is corroborated by the circumstance that the Respondent was unable to cite any feature according to Claim 1 which, in his opinion, should be shifted from the characterising clause to the first portion of the claim.

5. If follows from the foregoing that Claim 1 and Claims 2 to 5 depending thereupon according to the main request can be maintained (Article 52(1) EPC).

Auxiliary request:

Since the claims according to the main request are found to comply with the requirements of the EPC, consideration of the auxiliary request is not necessary.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to maintain the patent with the documents according to the main request.

The Registrar:

N. Maslin

The Chairman:

C. T. Wilson