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**Datasheet for the decision
of 17 July 2012**

Case Number: T 2395/10 - 3.2.03

Application Number: 02251651.2

Publication Number: 1239222

IPC: F23Q 7/00, H05B 3/14

Language of the proceedings: EN

Title of invention:

Ceramic heater device and method for manufacturing the device

Patentee:

NGK Spark Plug Company Limited

Opponent:

BorgWarner BERU Systems GmbH

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step - (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 2395/10 - 3.2.03

D E C I S I O N
of the Technical Board of Appeal 3.2.03
of 17 July 2012

Appellant: BorgWarner BERU Systems GmbH
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Decision under appeal: Interlocutory decision of the Opposition
Division of the European Patent Office posted
17 November 2010 concerning maintenance of
European patent No. 1239222 in amended form.

Composition of the Board:

Chairman: U. Krause
Members: G. Ashley
I. Beckedorf

Summary of Facts and Submissions

- I. European patent EP-B1-1 239 222 concerns a ceramic heater, in particular a glow plug for starting diesel engines or igniting a petroleum fan heater. Grant of the patent was opposed on the grounds that the invention could not be carried out (Article 100(b) EPC) and that the claimed subject-matter was not new or inventive (Article 100(a) EPC).
- II. The Opposition Division concluded that the patent could be maintained on the basis of the set of amended claims submitted as the main request. The decision was posted on 17 November 2010.
- III. The Opponent (hereafter the Appellant) filed notice of appeal on 4 December 2010, paying the appeal fee on the same day. A statement containing the grounds of appeal was filed on 24 February 2011.
- IV. In accordance with Article 15 of the Rules of Procedure of the Boards of Appeal, the Board issued a preliminary opinion of the case, together with a summons to oral proceedings. In response (letter dated 21 June 2012), the Appellant withdrew its request for oral proceedings, stating that it would not be represented at the oral proceedings should they take place, and requested a decision on the basis of the written procedure.
- V. Requests

The Appellant requests that the above decision be set aside and that the patent be revoked.

The Respondent (Patent Proprietor) requests that the appeal be dismissed and that the patent be maintained on the basis of the claims considered by the opposition division (main request), alternatively on the basis of one of the fifteen auxiliary requests filed in response to the grounds of appeal.

VI. Claims

(a) Claim 1 of the main request reads as follows:

"1. A ceramic heater device having a structure in which an axial ceramic heater (2) is arranged in a metallic cylinder (3) so that its leading end (2a) protrudes from the leading end (3a) of said metallic cylinder member (3), wherein said metallic cylinder member (3) and said ceramic heater (2) are fixed to each other with a solder layer (10) interposed between their inner circumference and outer circumference respectively, and wherein the ceramic heater device comprises a body (4) holding the metallic cylinder member (3) therein;

characterized in that

the ceramic heater (2) comprises a ceramic substrate made of a ceramic insulator in which is buried and sintered a resistive heating element made of conductive ceramics or a high-melting point metal;

a convergent taper portion (2t) is formed at the leading end of said ceramic heater (2);

the leading end (3a) of said metallic cylinder

member (3) is disposed on the leading end side of the taper starting point (P1) of said taper portion (2t); and

at least a portion of said solder layer (10) is also disposed on the leading end side of the taper starting point (P1) of said taper portion (2t)."

(b) Independent claim 2 reads:

"2. A ceramic heater device having a structure in which an axial ceramic heater (22) is arranged in a metallic cylinder (3) so that its leading end (2a) protrudes from the leading end (3a) of said metallic cylinder member (3) and in which said metallic cylinder member (3) and said ceramic heater (22) are fixed to each other with a solder layer (10) interposed between their inner circumference and outer circumference respectively, and wherein the ceramic heater device comprises a body (4) holding the metallic cylinder member (3) therein;

characterized in that

the ceramic heater (2) comprises a ceramic substrate made of a ceramic insulator in which is buried and sintered a resistive heating element made of conductive ceramics or a high-melting point metal;

in said ceramic heater (22), a diametrically smaller portion (2s) having a smaller diameter (D2) than that (D1) of the remaining portion (6) in said metallic cylinder member (3) is formed at a portion located in said metallic cylinder member (3) and

corresponding to the portion proximate to the leading end (3a) of said metallic cylinder member (3); and

a solder layer (10) is disposed at said diametrically smaller portion (2s) for preventing sliding out of at least a portion of said ceramic heater (22) toward the leading end with respect to said metallic cylinder member (3)."

(c) Dependent claims 3 and 4 concern preferred embodiments of the ceramic heater of claim 2.

(d) Independent claim 5 reads:

"5. A ceramic heater device having a structure in which an axial ceramic heater (32,42) is arranged in a metallic cylinder (3) so that its leading end (2a) protrudes from the leading end (3a) of said metallic cylinder member (3) and in which said metallic cylinder member (3) and said ceramic heater (32;42) are fixed to each other with a solder layer (10) interposed between their inner circumference and outer circumference respectively, and wherein the ceramic heater device comprises a body (4) holding the metallic cylinder member (3) therein;

characterized in that

the ceramic heater (2) comprises a ceramic substrate made of a ceramic insulator in which is buried and sintered a resistive heating element made of conductive ceramics or a high-melting point metal;

at least one recess (32s; 42s) is formed in the outer circumference of said ceramic heater (32; 42) at a portion located in said metallic cylinder member (3) and corresponding to the portion proximate to the leading end (3a) of said metallic cylinder member (3), wherein a solder layer (10) is disposed in said at least one recess (32s; 42s) for preventing sliding out of at least a portion of said ceramic heater (32; 42) toward the leading end with respect to said metallic cylinder member (3)."

(e) Independent claim 6 reads:

"6. A ceramic heater device having a structure in which an axial ceramic heater (2) is arranged in a metallic cylinder member (3) so that its leading end (2a) protrudes from the leading end (3a) of the metallic cylinder member (3),

characterized in that:

the ceramic heater comprises: a column portion (6) having a straight circular section of an equal diameter; and a convergent taper portion (2t) having a frustoconical shape from the leading end portion of the column portion (6) and tapered to the leading end of said ceramic heater (2);

said ceramic heater (2) is so press-fitted in said metallic cylinder member (3) that the taper starting point (P1) of said taper portion (2t) is positioned at a portion proximate to the leading end (3a) of said metallic cylinder member (3) but within said metallic cylinder member (3); and

the inner and outer surfaces of the portion of the metallic cylinder member (3) proximate to the leading end (3a) of said metallic cylinder member (3) converge at said taper portion (2t)."

(f) Independent claim 7 relates to a method:

"7. A method for manufacturing a ceramic heater device having a structure in which an axial ceramic heater (2) is arranged in a metallic cylinder member (3) so that its leading end (2a) protrudes from the leading end (3a) of said metallic cylinder member (3),

characterized by the steps of:

forming the ceramic heater (2) comprising: a column portion (6) having a straight circular section of an equal diameter; and a convergent taper portion (2t) having a frustoconical shape from the leading end portion of the column portion (6) and tapered to the leading end of said ceramic heater (2); and

press-fitting said ceramic heater (2) into said metallic cylinder member (3), starting with the leading end (2a) of the ceramic heater (2), to such a position that the taper starting point (P1) of the taper portion (2t) does not go beyond the leading end (3a) of said metallic cylinder member (3), whereby the inner and outer surfaces of the portion of the metallic cylinder member (3) proximate to the leading end (3a) of said metallic cylinder member (3) converge at said taper portion (2t)."

VII. Prior Art

The following documents are cited in the contested decision and referred to in the grounds of appeal:

- D1: GB-A-2106181
- D2: US-A-5 880 432
- D3: US-A-6 084 212
- D4: JP-A-04 009 517
- D8: US-A-4 475 029
- D9: DE 612 533
- D10: DE 613 426
- D11: Schott Technical Glasses, Physical and technical properties, pages 28 to 30, "Solder Glasses", October 2007.
- D12: JP-A-61 029 619 (abstract)

The following documents are referred to for the first time in the grounds of appeal:

- D14: US-A-4 521 641
- D15: DE-C2-43 34 438

VIII. Submissions of the Parties concerning Inventive Step of the Claimed Subject-Matter of the Main Request

(a) Claim 1

- Starting from D12:

- (i) The Appellant argued that the claimed device lacks an inventive step with respect to D12 and D4.

- (ii) Document D12 corresponds to the preamble of the claim. According to the Appellant, the characterising feature of a ceramic heater comprising a resistive heating element embedded in a ceramic insulator is well known in the art, such that the claimed device differs only in that the heater tapers and that the solder layer extends to the tapered section.

- (iii) Starting from D12 the objective problem to be solved is how to improve the solder connection. The heater of D4 is soldered directly to the housing, whereas in the disputed patent it is soldered to a metal cylinder. However, the Appellant argued that this is of no relevance to the main teaching of D4, which is that a better solder connection is achieved when the heater is tapered. Consequently, starting from D12, the claimed subject-matter is obvious in light of the teaching of D4.

- (iv) The Respondent disagreed with the Appellant's definition of the objective problem. Rather, as set out in the patent, the novel features of claim 1 address the problem of the tendency of ceramic heaters to fracture. The important features of the claim are that the leading end of the heater is tapered and that the solder extends into the tapered portion. These features ensure that any portion of the ceramic heater that breaks off is retained in the device. D4

does not discuss the problem of fracturing. Further, should the glow plug of D12 be adapted in accordance with D4, then the taper would not be at the end of the ceramic heater, but further up, as shown in the Figure of D4. If a break occurs in such an arrangement, a significant length of ceramic heater could still fall into the combustion chamber. Hence D4 does not provide a solution to the objective problem.

- Starting from D1:

- (v) The Appellant also argued that there is a lack of inventive step starting from D1, which discloses a heating element in the form of a metal tape wound around an electrically conducting rod that has been coated with an insulating enamel; the heating element is fixed within a metallic cylinder by means of fused glass. Since fused glass falls with the technical meaning of "solder layer", as evidenced by D11, D14 and D15, the claimed device differs only in that the heater comprises a ceramic substrate containing a resistive heating element. D1 alerts the reader to the problem of fracture in glow plugs (column 1, lines 51 to 52), hence the objective problem is to provide an alternative or improved heating element. It is obvious to the skilled person that a ceramic heating element of the type shown in D9 or D10 can solve the objective problem.

(vi) The Respondent submitted that D1 is not a suitable starting point for assessing inventive step. The disputed patent concerns the problems of fracturing in ceramic heaters, and these problems are not shared by metal heaters of the type disclosed in D1. Since D12 discloses a ceramic heater having the features of the preamble of the claim and which suffers from the problem addressed by the patent, it is a more relevant piece of prior art.

(vii) Notwithstanding this submission, the combination of D1 and D9 or D10 does not lead to the claimed invention. In particular, the fused glass of D1 functions as a seal and is thus not a solder. D9 and D10 concern heaters with fully enclosed heating elements, which according to D1 lead to a delay in starting the motor. Thus the skilled person starting from D1 would not consult these documents. Even if D19 and D10 were to be considered, the combination with D1 does not result in a device having all the features of claim 1.

(b) Claim 2

(i) According to independent claim 2, rather than a taper, the ceramic heater is defined as having a diametrically smaller diameter than that of the remaining portion (see Figure 4 of the disputed patent).

(ii) The Appellant argued that this wording corresponds to the reduction in diameter associated with the taper of claim 1, and that it does not define a stepped structure, as construed by the Opposition Division. Consequently, the device of claim 2 lacks an inventive step for the same reasons given in respect of claim 1. The Respondent also referred to its arguments put forward for claim 1.

(c) Claim 5

(i) According to claim 5, the ceramic heater comprises a recess or groove around the circumference which fills with solder (see Figure 5 of the disputed patent).

(ii) The Appellant submitted that starting from D12, and faced with the problem of improving the joint between the ceramic heater and the outer cylinder, the skilled person would turn to D8. This document discloses a heating element having slits (21), into which solder can flow. The skilled person would realise that applying such a construction to the heater of D12 would provide a solution to the problem. Hence the device of claim 5 lacks an inventive step in light of D12 and D8.

(iii) The Respondent argued that the heating element of D8 is of a different type in

which the ceramic itself heats up due to electrical resistance. The purpose of the slits is to direct current through the ceramic, and since the slits are axial to the heater, they are not capable of preventing a broken portion from sliding into the combustion chamber. Hence the skilled person would not consult D8, and even if he did so, would not discover the claimed solution.

(d) Claim 6

- (i) Claim 6 is directed to the embodiment in which the ceramic heater is press-fitted into the metal cylinder.
- (ii) The Appellant submitted that there is a lack of inventive step with respect to the glow plug described in D2 and D3. Document D3 discloses a glow plug having a tapered ceramic heater surrounded by a metal sleeve. D3 specifically refers to the method of making the glow plug described in D2, in which the ceramic heater is frictionally engaged in the sleeve in a wedged manner; this corresponds to a press-fit in the sense of claim 6, since it is inevitable that some deformation, albeit minor, of the metal sleeve will take place.
- (iii) The ceramic heater is defined in claim 6 as being tapered to its leading end. The expression "tapered to" merely indicates the

direction of the taper, rather than defining that the taper extends to the end of the heater, particularly as the end of the ceramic heater is shown in Figures 8 and 9 of the disputed patent as having a round section. Hence the claimed ceramic heater differs from that of D2/D3 only in that the tapered section commences from the leading end portion of the straight column section.

- (iv) The central straight column of the glow plug of D2/D3 is filled with epoxy resin, so that the objective problem to be solved is to improve the heat resistance of the glow plug. It is obvious to solve the problem by extending the ceramic heater section into the central straight column and thereby increase the distance between the epoxy resin and the tip of the heater. This would result in a glow plug having the features of claim 6.

- (v) In addition to the difference identified by the Appellant (the taper begins at the end of the column portion of the ceramic heater), the Respondent identified further differences.

- (vi) The Respondent disagreed that D2/D3 discloses a press-fit, because a press-fit implies elastic deformation, which is not necessary for mere frictional engagement. Elastic deformation of the annular sleeve does not occur in D2/D3 because it is

relatively thick, and if the ceramic heater was forced into it, it is likely that the ceramic heater would break. In addition, the purpose of the wedged sleeve of D2/D3 is to assist the removal of the ceramic heater, and this does require a press-fit.

(vii) According to the Respondent, a further difference is that the outer surfaces of the metal sleeve of D2/D3 do not converge at the taper portion, as required by claim 6, but have a constant diameter; this is necessary so that the metal sleeve can engage with the lip of the outer housing of the glow plug.

(viii) Yet a further difference is that the taper does not extend to the end of the ceramic heater, as can be construed from a plain reading of claim 6.

(ix) Consequently, a glow plug having all of the features of claim 6 cannot be derived in an obvious manner starting from that of D2/D3.

(e) Claim 7

Claim 7 concerns a method for manufacturing a ceramic heater device, which the Appellant alleges lacks an inventive step for the same reasons as given for claim 6.

Reasons for the Decision

1. The appeal is admissible.

Main Request - Inventive Step (Article 56 EPC)

2. Claim 1

- 2.1 Starting Point:

- 2.1.1 The contested patent is directed to a ceramic heater device or glow plug, in which a ceramic heater is fixed within a metal cylinder by means of solder or a press-fit. In particular, the problems addressed by such a heater are identified in the patent as being the breakage of the ceramic heater within the metal cylinder (paragraph [0004]), parts of the ceramic heater falling into the combustion chamber (paragraph [0005]), and the quality of the bond between the ceramic surface of the heater and the solder (paragraph [0006]).

- 2.1.2 The Opposition Division considered that the closest prior art is given in D12, which discloses the ceramic heater referred to in the introduction to the contested patent and which forms the preamble to the claim, ie one in which a ceramic heating rod is soldered within a metal cylindrical sleeve.

- 2.1.3 The Appellant also sees D1 as being a relevant starting point for assessing the invention. D1 describes a glow plug in which a heating element is made from a conductive metal tape wound around and spot welded to an electrically conducting rod (17) that has been

coated with an insulating enamel (D1, page 1, lines 100 to 106 and page 2, lines 7 to 11). The heating element of D1 is fixed within a metallic cylinder element (14) by means of a fused glass filling (21).

2.1.4 D1 does not therefore concern a heater made from ceramic which would be susceptible to the problems outlined in the disputed patent. Given the more relevant disclosure of D12 it does not represent an appropriate starting point for the invention. Thus inventive step is to be assessed only starting from D12.

2.2 Differences:

The subject-matter of claim 1 differs from the glow plug of D12 in terms of the following features:

- the heater is specified as comprising a ceramic substrate made of a ceramic insulator, in which a resistive heating element made of conductive ceramics or high melting point metal is buried and sintered;
- a convergent taper is formed at the leading edge of the ceramic heater;
- the leading end of the metal cylinder is disposed in the leading end side of the starting point of the taper portion;
- a portion of solder is disposed on the leading end side of the of the taper starting point.

2.3 Problem to be Solved:

Starting from D12, the Appellant sees the problem as achieving a better solder connection or facilitating the soldering process. However, as set out above, the problem underlying the disputed patent concerns the tendency of ceramic heaters to fracture, resulting in large ceramic fragments falling into the combustion chamber (smaller fragments originating from the tip of the ceramic heater might still fall into the chamber, but these are apparently not so problematic).

Irrespective of the problem defined by the Appellant, the problem of fracturing must also be solved.

2.4 Solution:

2.4.1 According to the claimed invention, a taper portion is formed at the leading edge of the ceramic heater, such that, if the ceramic heater fractures, the lower portion is still held in place by the metal cylinder and is prevented from falling into the combustion chamber of the engine.

2.4.2 The main argument of the Appellant is that the advantage of a tapered shape is described in D4 and hence the skilled person would apply it to D12.

2.4.3 D4 discloses a heating element, the upper portion of which is tapered to ensure that a satisfactory braze is produced between it and the housing. However, D4 does not relate to a ceramic heater (the heater of D4 is in the form of a metal tube (3A) containing an insulated heating element), and therefore there is no mention of

the problem of fracturing that exists with ceramic heaters. In addition, the taper shown in the figure of D4 is not formed at the leading end of the heater but towards the upper end. This means that, as argued by Respondent, should the heater fracture below the taper, a large part can still fall into the combustion chamber.

2.4.4 Although D4 discloses a taper which improves brazing, it is not of the type that would provide the skilled person with a solution to the problem of fracturing. Consequently, the claimed subject-matter has an inventive step with respect to D12 and D4.

3. Claim 2

3.1 Independent claim 2 is directed to the embodiment shown in Figure 4 of the disputed patent, in which the ceramic heater has a stepped construction rather than a taper.

3.2 The Appellant argues that the wording of claim 2 also encompasses a continuous transition, which would correspond to the tapered construction of claim 1. Hence the subject-matter of claim 2 lacks an inventive step for the same reasons as given for claim 1, ie there is a lack of inventive step with regard to the combined teachings of D1 and D9, or D12 and D4.

3.3 Irrespective of the interpretation of the wording of claim 2, the reasoning given above for claim 1 also applies to claim 2. That is, given the teaching of D12, it is not realistic to assess inventive step starting from D1, and D4 does not disclose a ceramic heater having either a tapered or a stepped construction

proximate to the leading end of the metal cylinder that houses the heater.

3.4 The ceramic heater device of claim 2 thus has an inventive step for the same reasons as set out above for claim 1.

4. Claim 5

4.1 Independent claim 5 relates to the embodiment shown in Figure 5 of the disputed patent, and defines the ceramic heater as having a recess formed in its outer circumference at a portion proximate to the leading edge of the metallic cylinder. The recess fills with solder, thus preventing a broken portion of the heater from sliding out.

4.2 Starting from D12, the same objective problem as set out above is addressed, namely the prevention of large broken portions of ceramic heater from falling into the combustion chamber. The Appellant suggests that the solution can be derived from document D8.

4.3 Rather than having a resistance wire embedded in an insulating ceramic as disclosed in the disputed patent, the heating element of D8 comprising a rod of ceramic, which is itself heated. The rod is made from a ceramic having a specific resistance and is heated by passing a current through it (D8, column 4, lines 35 to 38). The ceramic rod is divided into electrode portions by means of axial slits that create a route through the rod along which the current flows to provide efficient heating (see column 2, lines 4 to 8 and column 4, lines 56 to 64).

4.4 As argued by the Respondent, D8 does not deal with the problem of fracturing of the ceramic; also the axial slits of D8 have a completely different function to the circumferential slits of claim 5, and are not capable of preventing a fractured piece from breaking away. Consequently, it is not possible to derive the claimed solution from D8.

5. Claim 6

5.1 Independent claim 6 is directed to the embodiment in which the ceramic heater is press-fitted into the metal cylinder. The appellant submits that there is a lack of inventive step starting from the glow plug disclosed in D3 and D2.

5.2 D3 discloses a ceramic heater element (10) which is said to be "wedgingly held" in metallic sleeve (46) (see D3, column 4, lines 59 to 65), and refers specifically to the method of assembling the glow plug as described in D2. Here it is said that the ceramic heater is "inserted into bore 14 to become frictionally engaged within conductive annular sleeve 40 in a wedged manner" (see D2, column 3, lines 3 to 6). The Appellant submits that this is a press-fit in the sense of claim 6, whereas the view of the Respondent and of the Opposition Division is that this does not correspond to a press-fit, because a press-fit implies elastic deformation.

It is, however, not necessary for the Board to establish with certainty whether or not D2/D3 discloses press-fitting the ceramic heater into the metal sleeve,

since there are further differences between the claimed glow plug and that disclosed in D3/D2, which justify an inventive step.

- 5.3 Firstly, the outer surface of the metal cylinder (indicated by (40) in Figure 1 of D2 and by (46) in Figure 4 of D3) does not converge at the taper portion of the ceramic heater, as is required by claim 6 (see also Figure 8 of the disputed patent). This is because the ceramic heater of D2/D3 is held in the housing by a lip (indicated by (16) in Figure 1 of D2).
- 5.4 Secondly, the ceramic heater is not tapered to the leading end, rather, the heater of D2/D3 is shown to have a straight portion in this region. Here the Board does not agree with the submission of the Appellant that "to" in claim 6 merely indicates the direction of the taper. The skilled person would conclude from a plain reading of the claim in the context of the description and figures that the taper extends to the end of the ceramic heater.
- 5.5 Thirdly, D2/D3 does not disclose that the tapered portion is formed from the leading edge of the column portion of the ceramic heater.
- 5.6 Starting from D2/D3, and as with the other independent claims, the objective problem solved by the heater device of claim 6 is seen as avoiding detrimental effects when the ceramic heater fractures.
- 5.7 The Appellant submits that, given that central column of the glow plug of D2/D3 is filled with epoxy resin and the limited tolerance of resin to high temperatures,

it would be obvious to extend the ceramic heater into the central column to improve the heat resistance of the glow plug, thereby creating a glow plug having the features of claim 6. This, however, neglects the further differences identified above.

- 5.8 In particular, the act of extending the ceramic heater into the central column would not necessarily lead to the taper extending to the leading end of the ceramic heater, but rather it would end short of the leading end, as shown in Figure 1 of D2 and Figure 4 of D3.

It would also be necessary to modify the metal sleeve (40, 46) so that it has converging walls; this is not an obvious step, since the metal sleeve (40, 46) cooperates with lip (16) to hold the ceramic heater in the glow plug; its elimination would require an alternative means of fixing the ceramic heater in the glow plug.

- 5.9 Irrespective of whether or not D2/D3 discloses a press-fit, it is not obvious starting from this prior art to derive a glow plug having all of the features of claim 6. The differing features identified above contribute to solving the objective problem of the ceramic heater fracturing. Consequently, the subject-matter of claim 6 has an inventive step.

6. Method Claim

- 6.1 Claim 7 relates to a method for manufacturing a ceramic heater device, which is defined as having a ceramic heater with a tapered portion from a column portion to the leading end. The method includes the step of press-

fitting the ceramic heater into a metal sleeve having inner and outer surfaces that converge at the taper portion.

6.2 Consequently, the method has an inventive step for the same reasons given above in respect of claim 6.

7. Auxiliary Requests and Oral Proceedings

7.1 Given that the claims of the main request are considered to be novel and have an inventive step, it is not necessary to take into account those of the auxiliary requests filed by the Respondent.

7.2 Since the Board finds for the Respondent and the Appellant has withdrawn its request for oral proceedings, there is no reason to hold such proceedings.

Consequently, the oral proceedings have been cancelled and the decision has been taken on the basis of the reasons submitted by the parties in the written procedure, as summarised above in section VIII.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

D. Hampe

U. Krause