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Case Number: T 0143/06 - 3.3.05

Application Number: 00200077.6

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Title of invention:
Nanocomposite dense sintered silicon carbonitride ceramic cutting tool

Patentee:
Metalloceramica Vanzetti S.p.A., et al

Headword:
-

Relevant legal provisions:
EPC Art. 84, 123(2)

Relevant legal provisions (EPC 1973):
-

Keyword:
"Clarity (yes): functional feature of the product inextricably linked to the process conditions for obtaining said product (reasons, point 12.2)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0143/06 - 3.3.05

D E C I S I O N
of the Technical Board of Appeal 3.3.05
of 20 December 2010

Appellant: Metalloceramica Vanzetti S.p.A.
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 20 September 2005 refusing European patent application No. 00200077.6 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: G. Raths
Members: E. Waeckerlin
C. Vallet

Summary of Facts and Submissions

I. The present appeal was lodged by the applicant (hereinafter "the appellant") against the decision of the examining division refusing the European patent application No. 00 200 077.6 under Article 97(2) EPC on grounds of inadmissible amendments (Article 123(2) EPC) and lack of clarity (Article 84 EPC).

II. In the decision under appeal, the examining division held that the inclusion of the feature *"near net shape"* in claims 1, 2 and 7 of the main request then on file was open to objection under Article 123(2) EPC. This feature was disclosed in the application as originally filed, but not in the context of the claimed invention.

Having regard to claim 2 of the main request then on file, the examining division observed that the features of said claim were drawn in part from example 1 and in part from the general disclosure of the application as originally filed. The resulting combination of features defined subject-matter which was not seen in the original application. In particular, the use of *"inert gas"* in the sintering step was a broader concept than the disclosure of *"nitrogen gas"* in example 1. Moreover, example 1 contained no statement that the mean particle size of α-Si_3N_4 and SiC was lower than 200 nm.

For these reasons the application as amended was not in conformity with Article 123(2) EPC.

The examining division held further, that the application was open to objections under Article 84 EPC, because various claims lacked clarity.

Thus, according to claims 1, 2, 3 and 7 of the main request then on file, the density of the claimed product was "***close*** *to the theoretical maximum*" (emphasis added by the board), but it was unclear **how close** the density had to be.

Claims 1, 2 and 7 of the main request then on file referred to the *"sintered* ***near*** *net shape blank"* (emphasis added by the board). It was not clear, however, **how close** to the net shape the blank had to be.

Moreover, an essential feature of the invention was lacking in claims 1 and 7 of the main request then on file, namely the feature that *"the particle size of the starting powders should be within the size range 50-200 nm"*.

III. Together with the grounds of appeal dated 20 January 2006, the appellant submitted five sets of amended claims representing the main request and the first to fourth auxiliary request, respectively.

Independent claims 1, 7 and 11, respectively, read as follows:

"1. An uncoated nanocomposite dense sintered silicon carbonitride ceramic cutting tool, obtainable by cold pressing a spray-dried flowable granulate of a nanosized powder of α-Si_3N_4 and SiC, the mean particle

size of α-Si_3N_4 and SiC being lower than 200 nm, containing an amount lower than 30% by weight of nanosized SiC particles, in the presence of an amount of from 3% to 6% of sintering aids Y_2O_3 and Al_2O_3 and of further additives consisting of polyethylene glycol with a molecular weight ranging of from 400 to 12000, by sintering the so obtained pressed products at a temperature of from 1800°C to 1900°C, for a time of from 0.5 to 2 hours and with an over-pressure of inert gas to a product having density close to the theoretical maximum and by machining the cutting tool from the so obtained sintered near net shape blank.

7. A process for preparing an uncoated nanocomposite dense sintered silicon carbonitride ceramic cutting tool, according to the preceding claims, characterised by the following steps:
a) cold pressing a spray-dried flowable granulate of a nanosized powder of α-Si_3N_4 and SiC, the mean particle size of α-Si_3N_4 and SiC being lower than 200 nm, containing an amount lower than 30% by weight of nanosized SiC particles, in the presence of an amount of from 3% to 6% of sintering aids as Y_2O_3 and Al_2O_3 and of further additives consisting of polyethylene glycol with a molecular weight ranging of from 400 to 12000, by sintering the so obtained pressed products at a temperature of from 1800°C to 1900°C, for a time of from 0.5 to 2 hours and with an over-pressure of inert gas to a product having density close to the theoretical maximum and
b) machining the so obtained sintered near net shape blank into a cutting tool.

11. Use of the cutting tool according to claim 1, for metal cutting operations in the automotive, steel working and machinery industries, in particular for machining Fe-based and other alloys."

Dependent claim 2 reads as follows:

"2. An uncoated cutting tool according to claim 1, characterised in that it is obtainable by cold pressing a spray-dried flowable granulate of a nanosized powder of α-Si_3N_4 and SiC, containing an amount of 25% by weight of nanosized SiC particles, in the presence of an amount of 4.5% of sintering aids as Y_2O_3 and Al_2O_3 and of 3% by weight of a further additive consisting of polyethylene glycol with a molecular weight ranging of from 400 to 12000, by sintering the so obtained pressed products at a temperature of 1850°C, for a time of 1 hour and with an overpressure of nitrogen gas to a product having density close to the theoretical maximum with a mean grain size of α-Si_3N_4 lower than 300 nm and by machining the cutting tool from the obtained sintered near net shape blank."

Dependent claims 3 to 6 concern particular embodiments of the cutting tool according to claim 1.

Dependent claims 8 to 10 concern particular embodiments of the process according to independent claim 7.

IV. Together with the grounds of appeal, the appellant submitted a set of amended claims 1 to 11 representing the main request. In addition, the appellant submitted four further amended sets of claims representing the first, second, third and fourth auxiliary request.

In the grounds of appeal, the appellant objected to the findings of the examining division. In its view, the amendments effected to the claims did not extend the subject-matter beyond the content of the application as originally filed.

Regarding the clarity of the claims, the appellant argued that the term *"near net shape"* was of common use in the manufacturing industry. In this respect the appellant referred to the following handbook:

H1: McColm, I. J.: Dictionary of Ceramic Science and Engineering, 2nd Edition, New York and London, Plenum Press, 1994, page 214.

In the appellant's view, there was no need to indicate the range of the particle size of the starting powders, i.e. 50 to 200 nm, in claims 1 and 7. This feature was already covered by the indication that the starting powders were *"nanosized"*.

Regarding the question of how close to the theoretical maximum the density of the product had to be, the appellant referred to the description, where it is explained that the *"fired parts"* contain *"little or no porosity"*. In example 1 the value of the density of the sintered product was found to be 3.26 g/cm^3. This was nearly 100 % of the theoretical full density. Similar results were found in examples 2 and 3, respectively.

V. The appellant requested that the decision to refuse the application be set aside and that a patent be granted

on the basis of the amended claims submitted together with the grounds of appeal.

In case that the board did not accept the above request, oral proceedings according to Article 116 EPC were requested.

Reasons for the Decision

Allowability of the amendments (Article 123(2) EPC) - main request

1. Claim 1 is based on claim 1 of the application as originally filed, but various features have been specified in more detail by means of amendments.

1.1 In particular, claim 1 has been limited to **uncoated** nanocomposite dense sintered silicon carbonitride ceramic cutting tools. In the description as originally filed, coating of the cutting tools with a refractory material is disclosed as an optional step (see page 11, lines 1 to 3; page 18, lines 3 to 6),thus implying that the cutting tools according to the invention are normally uncoated. In fact, all examples relate to uncoated cutting tools (see page 10, line 12 to page 18, line 3, examples 1 to 5).

1.2 Further it has been specified in claim 1 that the **mean particle size of α-Si_3N_4 and SiC** is **lower than 200 nm**. This feature is disclosed in the description as originally filed on page 7, lines 4 to 6 (*"using nanosized (<200 nm) particles of α-Si_3N_4 and SiC"*), as

well as on page 8, lines 5 to 8 (*"nanosized <200 nm mean particle size) α-Si_3N_4 and SiC"*).

1.3 The figure of 30 % for the amount of nanosized SiC particles has been specified to mean 30 % **by weight**. This follows from page 14, lines 1 to 2 and likewise from page 14, lines 15 to 16 of the description as originally filed, where it is stated that silicon nitride and silicon carbide were mixed in a ratio of aproximatively 3: 1 *"by mass"*.

1.4 Regarding the sintering aids, claim 1 has been amended to specify that an amount of **3% to 6% of Y_2O_3 and Al_2O_3** are present. This feature is disclosed on page 9, lines 21 to 22 of the description as originally filed.

1.5 Moreover it is stated in claim 1 that the further additives consist of **polyethylene glycol with a molecular weight ranging of from 400 to 12000**. The corresponding disclosure can be found on page 7, lines 12 to 16 of the description as originally filed.

1.6 The density of the product is qualified to be **close to the theoretical maximum**. This is disclosed on page 10, lines 14 to 15 of the description as originally filed, although in slightly different wording, namely *"the so fired parts have densities which are close to the theoretical maximum, that is, they contain little or no porosity"*.

1.7 Eventually, it is stated in claim 1 that the product obtained in the sintering step has the form of a **near net shape blank**. This is in conformity with page 5, lines 21 to 22 of the description as originally filed,

where it is stated that the cutting tool is machined from *"the sintered blank"*. According to page 9, lines 3 to 7 the sintering step is required, because *"fast semiautomatic production of near net shape items must be possible"*. It follows from the two statements that the product of the sintering step is a near net shape blank.

2. Dependent claim 2 is based on claim 1 in combination with example 1. The features of claim 2 have the following basis in the description as originally filed:

- ***"Cold pressing a spray-dried flowable granulate of a nanosized powder of α-Si_3N_4 and SiC"*** is disclosed on page 5, lines 13 to 17 and page 12, lines 13 to 26;

- an amount of ***"25 % by weight of nanosized particles"*** is disclosed on page 12, lines 13 to 16, although in different wording, namely as *"three parts of α-silicon nitride"* and *"one part of silicon carbide"* (i.e. nanosized particles), respectively;

- an amount of ***"4.5 % of sintering aids as Y_2O_3 and Al_2O_3"*** is disclosed on page 12, line 19;

- an amount of ***"3 % by weight of polyethylene glycol having a molecular weight ranging from 400 to 12000"*** is disclosed on page 12, lines 22 to 23;

- a sintering temperature of ***"1850 °C"*** for a time of ***"1 hour"*** is disclosed on page 13, lines 2 to 4;

– an ***"overpressure of nitrogen gas"*** is disclosed on page 13, line 1 (*"under nitrogen gas"*) in combination with page 10, lines 10 to 11 (*"under an overpressure of inert gas"*);

– a ***"density close to the theoretical maximum"*** is disclosed in claim 1 and on page 13, lines 5 to 6 *("nearly 100 % of the theoretical full density")*;

– a ***"mean grain size of α-Si_3N_4 lower than 300 nm"*** is disclosed on page 13, lines 21 to 22 (*"Si_3N_4 grain size, mean linear intercept method according to ASTM E112 or CEN ENV 623-3: < 0.3 µm"*).

2.1 According to claim 2, the inert gas used in the sintering step is nitrogen. In this respect, claim 2 corresponds now exactly to example 1 of the application as originally filed.

2.2 The feature in claim 2, according to which the particle size of α-Si_3N_4 and SiC has to be lower than 200 nm, corresponds to the amended claim 1, on which claim 2 depends. This feature forms part of the disclosure of the application as originally filed (see above, point 1.2). Moreover, there is no doubt, that the mixture of α-Si3N4 and SiC used in example 1 fulfilled the requirement of a particle size of less than 200 nm, although this is not expressly mentioned in the text of example 1. According to example 1, a mixture consisting of α-Si_3N_4 having originally a particle size lower than 1 µm, SiC manufactured by carbothermal reduction of silica, yttrium oxide and aluminium oxide was prepared (see page 12, lines 13 to 19). Subsequently, the total mass was *"intensively milled in a silicon nitride lined*

attritor mill for one hour using demineralized water as a liquid vehicle" (see page 12, lines 19 to 22). In the absence of any evidence to the contrary, it has to be assumed that under these conditions the powder thus obtained was, in fact, *"nanosized"*, the particles having a size of less than 200 nm.

2.3 Regarding the feature of *"near net shape"* blanks in claim 2, the board observes that this feature has been disclosed in the application as originally filed as a general feature of the claimed process (see above, point 1.7). Machining of the sintered blanks forms part of the mandatory features of the process (see claims 1 and 7, respectively). This implies, that the blanks have to be slightly oversized compared to the final cutting tools, because otherwise the machining step would necessarily lead to products falling short of the required dimensions. Consequently, the feature of *"near net shape"* blanks applies to all embodiments of the claimed process, including the products obtained according to example 1. Although example 1 addresses neither the size of the blanks, nor the machining step in an explicit manner, it is beyond any reasonable doubt that the claimed process requires the blanks to be slightly oversized. For this reason it is acceptable under the terms of Article 123(2) EPC to combine the feature of *"near net shape"* blanks with the specific conditions set out in example 1.

3. Dependent claim 3 is based on claim 1. The remaining features, namely the range of the hardness, the Palmqvist toughness and the flank wear pattern, are disclosed on page 7, lines 17 to 22 of the description as originally filed. The feature of a *"density close to*

the theoretical maximum" (see claim 1) has been specified to have the value of 3.26 g/ml. This value has its origin on page 13, line 8 of the description as originally filed.

4. Dependent claim 4 is based on claim 1 in combination with claim 11 of the application as originally filed.

5. Dependent claim 5 is based on claim 1 in combination with claim 2 of the application as originally filed, except that the term *"effective diameter"* has been replaced by the term *"diameter"*. As can be seen in the description as originally filed, both terms are used as synonyms throughout the description in the meaning of *"mean particle size"* (see page 7, lines 1 to 3 as opposed to page 7, lines 4 to 5, page 8, lines 6 to 7 and page 14, line 15, respectively.

6. Dependent claim 6 is based on claim 1 in combination with claim 5 of the application as originally filed.

7. Independent claim 7 is based on claim 14 of the application as originally filed. The process features have been specified further, however, in order to bring them into conformity with the corresponding features of claim 1. In particular the following features are concerned:
An **uncoated** cutting tool; the **mean particle size of α-Si_3N_4 and SiC** being **lower than 200 nm**; an amount lower than 30 % **by weight** of nanosized SiC particles; an amount of from **3% to 6% of sintering aids as Y_2O_3 and Al_2O_3**; further additives consisting of **polyethylene glycol with a molecular weight ranging from 400 to 12000**; a product having **density close to the**

theoretical maximum; and a **sintered near net shape blank**. The basis for these amendments is the same as in the case of claim 1 (see above, paragraphs 1.1 to 1.7).

8. Dependent claims 8, 9 and 10 correspond to claims 8, 9 and 10, respectively, of the application as originally filed.

9. Independent claim 11 corresponds to the combination of claims 15 and 16 of the application as originally filed.

10. All amendments effected to the claims have a basis in the application as originally filed. Thus, the amended claims 1 to 11 of the main request are in conformity with Article 123(2) EPC.

Clarity of the claims (Article 84 EPC) - main request

11. It has to be decided, whether the following features are sufficiently clear within the meaning of Article 84 EPC, or not:
(i) a density *"**close** to the theoretical maximum"*;
(ii) *"the sintered **near** net shape blank"*.

12. As to the first feature, the board notes that neither the claims nor the description contain an indication, **how close** the density is in respect to the theoretical maximum.

12.1 According to the description, the sintered blanks are characterised by high densities (see, for example, page 7, lines 4 to 8). Such high densities are achieved by using the process for preparing the cutting tools set out in claims 1 and 7, respectively, particularly

by cold pressing of the spray-dried flowable granulate of a nanosized powder of α-Si_3N_4 and SiC in the presence of Y_2O_3 and Al_2O_3 as sintering aids, followed by gas-pressure assisted sintering (see page 7, line 25 to page 8, line 4; page 9, lines 8 to 10; page 9, lines 21 to 22). It has been found that the sintered blanks thus obtained have densities which are close to the theoretical maximum, which means that they contain little or no porosity (see page 10, lines 14 to 16). In the case of example 1, a value of 3.26 g/cm^3 or *"nearly 100 % of the theoretical full density"* was achieved (see page 13, lines 4 to 6; 8). Compared to the theoretical full density of 3.27 g/cm^3, i.e. the theoretical density of a product having no porosity at all, this corresponds to about 99.7 % of the theoretical maximum (see, in this respect, page 15, lines 23 to 26 of the grounds of appeal). In example 2, nearly the identical result was obtained (see page 14, lines 4 to 6), whereas in example 3, a density of *">98.5%"*, i.e. at least 98.5 % of the theoretical maximum was found (see page 14, line 26).

12.2 Ideally, the product of the sintering step is free of pores, so that a density of 100 % of the theoretical maximum is achieved. In practice, it will hardly be possible to reach the theoretical maximum. Minor deviations towards lower values will occur and may be tolerated, as long as the densities are *"close"* to the theoretical maximum. The examples 1 to 3 provide specific information on acceptable densities in terms of percents of the theoretical maximum, namely 99,7 % (examples 1 and 2) and > 98.5 % (example 3). In particular, the density of > 98.5 % in example 3 has to be regarded as representing a specific value, which is

sufficiently close to the theoretical maximum of 100 %, to be qualified as acceptable.

In example 1, it is stated that after analysis and characterisation, the product was *"found to be fully dense (nearly 100% of the theoretical full density) and pore free"* (see page 13, lines 4 to 6). Thus, the density of the product is a functional feature of the process conditions and, as such, inextricably linked to these conditions.

The density of the sintered product, which is obtained whenever the claimed process is carried out, is a property of said product, as opposed to the features of the process as such. In other words, it is a technical effect or a function of the process steps set out in claims 1 and 7, respectively.

Having regard to the specific densities obtained in examples 1 to 3, and in the absence of any evidence to the contrary, the board is of the opinion that it is justified to assume that, whenever the process features set out in claims 1 and 7 are put into practice, the resulting densities of the products will reach values of some 98.5 % or more, compared to the theoretical maximum. Such high values may be regarded without difficulty as being *"close to"* 100 %.

12.3 In the board's view it would not be appropriate to restrict the scope of the claims by defining a fixed numerical value of the minimum density, since the effect of the density on the mechanical properties of the sintered products is gradual. In this respect, the examples 1 and 3 are informative: Whereas the product

of example 1 with its density of about 99.7 % of the theoretical maximum gave rise to a hardness HV5 of 1785 ± 25 and a Palmqvist toughness of 7.0 ± 0.7 MPa $m^{1/2}$, the somewhat reduced density of roughly 98.5 % of the theoretical maximum of the product of example 3 led to a hardness HV5 of 1552 ± 26 and a Palmqvist toughness of 6.5 ± 0.7 MPa $m^{1/2}$ (see page 13, lines 8 to 11; page 14, lines 21 to 26).

Under these circumstances, the relative term *"close to the theoretical maximum"* can be considered as sufficiently clear in the context of the application read as a whole. Therefore no objection of lack of clarity arises under Article 84 EPC.

13. Another issue, which has to be examined, is whether the expression *"the sintered near net shape blank"* has a sufficiently clear meaning within the context of the present application, or not.

In this respect, the appellant referred to page 9, lines 3 to 7 of the description, where it is stated that in order to obtain a cost-effective manufacture of ceramic cutting tools, production of *"near net shape items"* is required.

What is meant by the term *"near net shape"* can be derived from the following explanation contained in the description:

"For the preparation of cutting tools meeting the dimensional specifications laid down in the standard ISO products, hard metal dies of appropriate geometry and dimensions are used such that the parts after

sintering are of dimensions larger, by a controlled amount, than the required final tool dimensions in order to allow for machining to precise final dimensions" (see page 10, lines 1 to 7).

13.1 For practical reasons the amount of machining, which is required for bringing the sintered blanks into the final dimensions, is kept to a minimum in order to achieve an effective manufacture of the cutting tools, while avoiding unnecessary loss of material. Therefore the sintered blanks are only slightly oversized. This is illustrated by example 4, where special care was taken to adjust the size of the pressing die and the pressing pressure to the shrinkage characteristics of the powder during firing, *"such that* ***slightly oversized*** *cutting tool* ***blanks*** *were produced appropriate for the accurate diamond grinding of the standard tool geometry"* (see page 15, lines 12 to 15; emphasis added by the board).

13.2 Consequently, the term *"near net shape"* has to be construed to mean that the dimensions of the blanks are only slightly larger than the precise final dimensions of the cutting tools.

Such a definition is in conformity with the recognised terminology in the technical field of ceramics. It concurs also with relevant handbooks, for example the *"Dictionary of Ceramic Science and Engineering"* (H1), referred to by the appellant. There, the following definition of the term *"near net shaping"* is given: "*Forming process* ***designed to limit the amount of final grinding and polishing needed*** *to meet specification"*

(see H1, p. 214, left hand column, 10th entry; emphasis added by the board).

13.3 Having regard to the considerations set out above, it is clear that, although it is desirable to limit the amount of final machining, the degree of oversizing of the blanks may vary within wide ranges. In the board's view, it is acceptable to define the oversizing in relative terms such as "near net shape", particularly because the degree of oversizing has no impact on the essential properties of the claimed cutting tools, namely the mechanical characteristics.

13.4 For these reasons the board is satisfied that the feature *"the sintered near net shape blank"* is sufficiently clear within the context of the present application, so that no objection of lack of clarity arises under Article 84 EPC.

14. In the decision under appeal, the examining division argued that the range of 50 to 200 nm for the particle size of the starting powder forms part of the essential features. Therefore, said range should have been included in the independent claims relating to the cutting tool and the process for its preparation. In this respect, the examining division relied on a statement made by the applicant (now the appellant), according to which the present application teaches the preparation of an uncoated cutting tool material by using spray dried powder *"obtained with raw materials based on silicon nitride - silicon carbide* ***having a particle size distribution in the range of about 50-200 nm"*** (see applicant's letter dated 3 February 2005, page 10, lines 11 to 12; emphasis added by the board).

14.1 The board notes that no corresponding statement is comprised in the application. In particular, nowhere in the application there is any disclosure of a lower limit of the particle size of 50 nm. According to claims 1 and 7, respectively, a *"**nanosized** powder of α-Si_3N_4 and SiC, the **mean particle size** of α-Si_3N_4 and SiC being **lower than 200 nm**"* (emphasis added by the board) is used in the spray-drying step.

14.2 As far as the examples are concerned, it is indisputable that the treatment of the starting material in example 1 led to a nanosized powder having a mean particle size of α-Si_3N_4 and SiC lower than 200 nm, as required by claims 1 and 7, respectively (see above, point 2.2). Nothing in example 1 or the remaining examples implies, however, that there was a lower limit of 50 nm of the particle size.

14.3 It follows from the foregoing, that the statement made by the applicant in its letter dated 3 February 2005, according to which the silicon nitride and the silicon carbide have a particle size distribution in the range of *"about 50-200 nm"*, has to be regarded merely as an indication of a typical range of the distribution of the particle size. It cannot be derived from said statement, that the value of 50 nm represents the lower limit of the particle size of α-Si_3N_4 and SiC, let alone that this value is an essential feature of the claimed subject-matter.

14.4 For these reasons the board is of the opinion that there is no need to include the feature of a range of 50 to 200 nm in the claims.

The board observes that, in any case, the specific range of 50 to 200 nm does not have a proper basis in the application as originally filed. Thus, its incorporation into the claims would contravene Article 123(2) EPC.

15. The board concludes that the set of amended claims 1 to 11 according to the main request, submitted together with the grounds of appeal, concurs with the requirements laid down in Articles 123(2) EPC and Article 84 EPC.

Remittal of the case to the department of first instance

16. In the decision under appeal, only the issues of the basis of the amendments (Article 123(2) EPC) and the clarity of the claims (Article 84 EPC) were addressed.

The board notes, that the examining division has not yet examined, whether the subject-matter of the amended claims 1 to 11 of the main request is novel and involves an inventive step.

Under these circumstances the board considers it appropriate to exercise its power conferred to it by virtue of Article 111(1) EPC and to remit the case to the examining division for further prosecution.

Auxiliary request for oral proceedings

17. Since the case is remitted to the examining division for further prosecution, there is no need to hold oral proceedings.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance for further prosecution on the basis of claims 1 to 11 according to the main request filed with the grounds of appeal.

The Registrar: The Chairman:

C. Vodz G. Raths