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D E C I S I O N
of 14 January 2003

Case Number: T 0431/00 - 3.5.2

Application Number: 92903728.1

Publication Number: 0522177

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Language of the proceedings: EN

Title of invention:
Anisotropic Rare Earth Magnet

Applicant/Patentee:
MITSUBISHI MATERIALS CORPORATION

Opponent:
SIEMENS AG

Headword:
-

Relevant legal provisions:
EPC Art. 84, 56

Keyword:
"Clarity of the amendments - main request (no)"
"Inventive step - auxiliary request (yes)"

Decisions cited:
G 0009/91

Catchword:
-



Case Number: T 0431/00 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 14 January 2003

Appellant:
(Proprietor of the patent) MITSUBISHI MATERIALS CORPORATION
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Respondent:
(Opponent) Siemens AG
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Representative: -

Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 24 February 2000
revoking European patent No. 0 522 177 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: J.-M. Cannard
B. J. Schachenmann

Summary of Facts and Submissions

I. The proprietor appealed against the decision of the opposition division to revoke European patent No. 0 522 177. The reason given for the revocation was that the subject-matter of claim 1, as amended in accordance with the proprietor's request filed on 26 January 2000, did not involve an inventive step.

II. Prior art documents:

D1: EP-A-0 304 054,

D2: JP-A-63 211 705 with the "JAPIO" and "Derwent" abstracts,

D3: JP-A-63 235 406 with the "JAPIO" and "Derwent" abstracts,

D4: JP-A-63 178 505 with the "JAPIO" and "Derwent" abstracts,

D5: JP-A-2 263 404 with the "JAPIO" and "Derwent" abstracts,

D6: EP-A-0 306 599, and

D9: JP-A-2 138 706 with the "JAPIO" and "Derwent" abstracts,

considered during the proceedings before the opposition division, remain relevant to the present appeal.

Further documents:

D10: EP-A-0 274 034,

D11: EP-B-0 101 552, and

a full translation into German of document D9, were referred to during the appeal proceedings.

III. Independent claims 1 and 3 of the appellant's main request filed with the letter of 5 March 2001, read as follows:

Claim 1:

"A Rare Earth-Fe-Co-B system anisotropic magnet which is a hot press moulded body or a hot isostatic press moulded body comprising:

a rare earth element including Y,

B,

0.001-5 atomic% in total of one or more of Ga, Zr and Hf, and

0.1-50 atomic% Co;

with the remainder being Fe and unavoidable impurities; said body having an aggregate structure of crystallised grains comprising materially only a phase of an $R_2(TM)_{14}B$ type intermetallic compound with a tetragonal structure, wherein R is at least one rare earth element including Y, and TM is Fe and Co, the crystallised grains having dimensions of 0.05-20 μm , and in which a grain boundary phase is almost non-existent; and

the ratio of the largest grain diameter b to the smallest grain diameter a is less than two for individual crystallised grains constituting more than 50 volume % of the total crystallised grains of the aggregate structure."

Claim 3:

"A Rare Earth-Fe-Co-B system anisotropic magnet which is a hot press moulded body or a hot isostatic press moulded body comprising:

a rare earth element including Y,
B,
0.001-5 atomic% in total of one or more of Ti, V,
Nb, Ta, Al and Si, and
0.1-50 atomic% Co;

with the remainder being Fe and unavoidable impurities; said body having an aggregate structure of crystallised grains comprising materially only a phase of an $R_2(TM)_{14}B$ type intermetallic compound with a tetragonal structure, wherein R is at least one rare earth element including Y, and TM is Fe and Co, the crystallised grains having dimensions of 0.05-20 μm , and in which a grain boundary phase is almost non-existent; and

the ratio of the largest grain diameter b to the smallest grain diameter a is less than two for individual crystallised grains constituting more than 50 volume % of the total crystallised grains of the aggregate structure."

Claim 2 is dependent on claim 1 and claim 4 is dependent on any preceding claim.

IV. Independent claims 1 and 3 of the auxiliary request filed during the oral proceedings on 14 January 2003, read as follows:

Claim 1:

"A method for preparing a Rare Earth-Fe-Co-B system anisotropic magnet which is a hot press moulded body or a hot isostatic press moulded body comprising:

a rare earth element including Y,
B,
0.001-5 atomic% in total of one or more of Ga, Zr
and Hf, and
0.1-50 atomic% Co;

with the remainder being Fe and unavoidable impurities; said body having an aggregate structure of crystallised grains comprising materially only a phase of an $R_2(TM)_{14}B$ type intermetallic compound with a tetragonal structure, wherein R is at least one rare earth element including Y, and TM is Fe and Co, the crystallised grains having dimensions of 0.05-20 μm ; and the ratio of the largest grain diameter b to the smallest grain diameter a is less than two for individual crystallised grains constituting more than 50 volume % of the total crystallised grains of the aggregate structure,

the method comprising the steps of:

- (i) heating a R-Fe-Co-B mother alloy including one or more of Ga, Zr and Hf in an atmosphere of hydrogen gas, optionally including an inert gas, at 500-1000°C,
- (ii) removing hydrogen from the atmosphere at a temperature of 500-1000°C so as to produce a vacuum atmosphere having a hydrogen gas pressure

of less than 0.13 kPa (less than 1 Torr) or an inert gas atmosphere in which the partial pressure of hydrogen gas is less than 0.13 kPa (less than 1 Torr),

- (iii) cooling the alloy to obtain a R-Fe-Co-B system permanent magnetic powder having a recrystallised aggregate structure comprising materially only $R_2(Fe,Co)_{14}B$ type intermetallic compound phase,
- (iv) pressing the magnetic powder into a green compact in a magnetic field, and
- (v) subjecting the green compact to hot press moulding or hot isostatic press moulding at a temperature of 600-900°C."

Claim 3:

"A method for preparing a Rare Earth-Fe-Co-B system anisotropic magnet which is a hot press moulded body or a hot isostatic press moulded body comprising:

a rare earth element including Y,
B,
0.001-5 atomic% in total of one or more of Ti, V,
Nb, Ta, Al and Si, and
0.1-50 atomic% Co;

with the remainder being Fe and unavoidable impurities; said body having an aggregate structure of crystallised grains comprising materially only a phase of an $R_2(TM)_{14}B$ type intermetallic compound with a tetragonal structure, wherein R is at least one rare earth element including Y, and TM is Fe and Co, the crystallised grains having dimensions of 0.05-20 μm ; and the ratio of the largest grain diameter b to the smallest grain

diameter a is less than two for individual crystallised grains constituting more than 50 volume % of the total crystallised grains of the aggregate structure,

the method comprising the steps of:

- (i) heating a R-Fe-Co-B mother alloy including one or more of Ti, V, Nb, Ta, Al and Si in an atmosphere of hydrogen gas, optionally including an inert gas, at 500-1000°C,
- (ii) removing hydrogen from the atmosphere at a temperature of 500-1000°C so as to produce a vacuum atmosphere having a hydrogen gas pressure of less than 0.13 kPa (less than 1 Torr) or an inert gas atmosphere in which the partial pressure of hydrogen gas is less than 0.13 kPa (less than 1 Torr),
- (iii) cooling the alloy to obtain a R-Fe-Co-B system permanent magnetic powder having a recrystallised aggregate structure comprising materially only $R_2(Fe,Co)_{14}B$ type intermetallic compound phase,
- (iv) pressing the magnetic powder into a green compact in a magnetic field, and
- (v) subjecting the green compact to hot press moulding or hot isostatic press moulding at a temperature of 600-900°C."

Claim 2 is dependent on claim 1 and claim 4 is dependent on any preceding claim.

V. The arguments of the appellant/proprietor can be summarised as follows:

Main request:

Lack of novelty of claims 1 and 3 in view of document D9 was a new ground for opposition which could not be introduced into the appeal proceedings. D9 did not disclose a magnet which had a pure phase material and no boundary phase, because its powder contained an excess of rare earth element beyond that required to give a $R_2(TM)_{14}B$ phase compound and was prepared by means of rapid quenching which produced R-rich boundary phases. There was no teaching in D9 for selecting from the broad ranges of content in R, Fe, Co and B elements a material which had no boundary phase. The scope of claims 1 and 3 had been restricted in a manner which was supported by the description of the patent (page 6, lines 11 to 16) and the examples therein relating to the third and fourth anisotropic magnets.

Auxiliary request:

The method according to claims 1 and 3 were not rendered obvious by the combination of documents D1 and D9. D1, whose primary object was to provide a powder which exhibited much superior magnetic properties when used in a bonded magnet, was not a justifiable starting point for producing a pressed magnet. It was not obvious to apply the hot working technique described in D9 to the magnetic powder prepared by a HDDR process according to D1. At the time of the invention the skilled person was aware that an anisotropic magnet could be prepared by sintering a R-Fe-Co-B magnetic powder at a high temperature, or by hot pressing and subsequently hot working such a powder, when produced by means of rapid quenching. A person with ordinary skill in the art had however no

reason to consider conducting only a hot pressing step or HIP process at low temperature which is a mere compacting step of an anisotropic powder produced by an HDDR process. The appropriate temperatures for such a hot pressing step were not obvious.

VI. The arguments of the respondent/opponent can be summarised as follows:

Main request:

The composition in rare earth R, B, Fe and Co elements of the magnets disclosed in document D9, and more specifically by Example 1 of D9, was closer to the composition of a $R_2(TM)_{14}B$ type intermetallic compound than that of some examples of the third and fourth anisotropic magnets of the invention described in the patent in suit. It was not true that a pure phase $R_2(TM)_{14}B$ compound cannot be prepared by rapid quenching. The expression "in which a grain boundary phase is almost non-existent" in claims 1 and 3 was unclear. Since the scope of claims 1 and 3 was so broad as to cover the examples of the invention, the subject-matter of said claims lacked novelty in view of D9, or at least lacked an inventive step in view of D9 and the general knowledge of the skilled person.

Auxiliary request:

Document D1 was essentially concerned with the preparation of a magnetic powder. This powder was similar to the powder of the invention. The magnetic properties of the magnet in D1 were determined by the properties of the magnetic powder. Although the powder was mixed with an adhesive, the teaching of D1 was not necessarily restricted to the production of bonded magnets, and the skilled person would also consider using the powder for producing pressed magnets. The

preparation of a magnetic powder and the production of a magnet were two independent processes. It was part of the general knowledge of the skilled man that any possible magnetic powder could be used for producing either a bonded magnet or a pressed magnet. The method for preparing a magnet according to D9 included a hot pressing step and a plastic deformation step for increasing the anisotropy of the magnet. However, it was obvious for the skilled man to convert a powder with some degree of anisotropy to a magnet having a magnetic anisotropy, and then reduce this magnet to powder and produce a bonded magnet, as explained in D6 or D10. Moreover, the Derwent abstract relating to D9 mentioned only a hot working step which could be understood as hot pressing. The method for preparing a magnet according to claims 1 and 3 of the auxiliary request thus lacked an inventive step in view of the combination of the powder according to D1 and the method for producing a magnet taught in D9, the starting point being either D1 or D9.

VII. The appellant requested that the decision under appeal be set aside and that the patent be maintained in amended form in the version according to the main request:

- claims: 1 to 4 filed with letter of 5 March 2001;

- description: pages as in the patent specification: 34, 38, 40, 41, 43, 44, 48 to 50, 53; pages filed with letter dated 13 December 2002: 2, 5 to 7, 30, 39, 42, 54, textblock A (on page 4 of the specification); pages filed during the oral proceedings: 31, 32, 35, 36, 45, 47, 51, 52; cancelled pages: 3, 8 to 29, 33, 37, 46;

or in the version according to the auxiliary request:

- claims: 1 to 4 filed in the oral proceedings;
- description: pages as in the patent specification: 31 to 38, 40, 41, 43 to 53; pages filed with letter dated 13 December 2002: 5 to 7, 30, 39, 42, 54, textblock A (on page 4 of the specification); pages filed during the oral proceedings: 2, textblock C to be inserted on page 2; cancelled pages: 3, 8 to 29.

VIII. The respondent requested that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

Main request

2. The subject-matter of claims 1 and 3 according to the present main request differs from the respective subject-matter of claims 1 and 3 as granted, *inter alia*, by the incorporation of the feature "in which a grain boundary phase is almost non-existent". The description has been adapted by deleting from the tables of examples those examples which were considered by the appellant as having an atomic% of elements Nd and B deviating by more than 6,8% from a $R_{11.8}Fe_{bal}B_{5.9}$ (atomic%) composition.
 - 2.1 The respondent objected that this feature rendered claims 1 and 3 unclear. According to paragraph 19 of the decision of the Enlarged Board G 9/91 (OJ EPO 1993, 218) amendments made in the course of opposition or appeal proceedings are to be fully examined as to their compatibility with the requirements of the EPC.

Thus, *inter alia*, the Board has to examine whether these claims, as amended according to the main request, meet the requirements of Article 84 EPC.

2.2 The structure and composition in rare earth R, B, and Fe,Co elements of the magnets according to claims 1 and 3 are defined, *inter alia*, by specifying that the magnet body has an aggregate structure of crystallised grains comprising materially only a phase of an $R_2(Fe,Co)_{14}B$ type intermetallic compound in which "a grain boundary phase is almost non-existent". A clear determination of the structure and composition of the magnets cannot be inferred from these features because the word "almost" is of undetermined scope.

2.3 The magnets according to claims 1 and 3 correspond to the third and fourth anisotropic R-Fe-Co-B magnets described in the description of the patent in suit as granted and to the corresponding examples of these magnets shown in Tables 20 to 22 and 28 to 34. The description (page 6, lines 11 to 16) specifies that when the magnetic powder "has a recrystallised aggregate structure comprising materially only $R_2(Fe, Co)_{14}B$ type intermetallic compound phase in which a grain boundary phase is almost non-existent," it is possible to raise the magnetization values and the resistance to corrosion increases. This passage does not help to clarify the feature "an almost non-existent grain boundary phase", but simply mentions qualitative (but not quantitative) effects provided by this feature. Similarly, the passage at page 5, lines 35 to 37, according to which, when the magnet has a crystallized grain aggregate structure, it has superior magnetic anisotropy and a high coercive force in the vicinity of a $R_{11.8}(Fe,Co)_{ba1}B_{5,9}$ (atomic%) composition, does not help to clarify this feature either. According to the specification (page 5, lines 23 to 31; page 6, lines 41 to 49), the third and fourth magnets, when

their body "has an aggregate structure of crystallized grains having as main phase thereof a $R_2(Fe,Co)_{14}B$ type intermetallic compound having a tetragonal structure", have "a composition comprising 10-20 atomic% of R (rare earth element), 0.1-50 atomic% of Co, 3-20 atomic% of B, and one or a plurality of Ga, Zr, and Hf in a total amount of 0.001-5.0 atomic%, wherein the remainder comprises Fe or unavoidable impurities". This composition is consistent with the composition of the magnets exemplified in the tables mentioned above. However, it cannot be deduced from the disclosure in the patent, in which examples of the magnets in the tables of the patent as granted "the grain boundary phase is almost non-existent", or that the examples remaining in the amended tables are the ones in which the boundary phase may be regarded as "almost non-existent". Accordingly, these examples do not help to clarify the feature "an almost non-existent boundary phase".

- 2.4 Moreover the appellant has neither provided, nor is the Board aware of, any unequivocal quantitative definition or meaning generally accepted by those skilled in the relevant art for an almost non-existent grain boundary phase. This unclear feature does not allow an unambiguous determination of the structure and composition of the claimed magnets. In these circumstances, claims 1 and 3 according to the main request do not satisfy the requirements of Article 84 EPC and the main request of the appellant has to be rejected.

Auxiliary request

3. Claims 1 and 3 according to the auxiliary request, which relate to methods for preparing a Rare Earth-Fe-Co-B system anisotropic magnet according to claims 1 and 3 of the main request respectively, do not specify

that the magnet body has a grain boundary phase which is almost non-existent. The Board is satisfied that these claims satisfy the requirements of Article 84 EPC and do not contravene Article 123(2) and (3) EPC.

4. The novelty of the subject-matter of claims 1 and 3 according to the auxiliary request has not been disputed.
5. Claims 1 and 3 both recite a step (iv) of pressing the magnetic powder into a green compact in a magnetic field before subjecting it, step (v), to a hot (isostatic) press moulding at a temperature of 600 to 900°C. This implies that the powder prepared by means of the HDDR process in steps (i) and (ii) of the claims has magnetic anisotropy and that the hot (isostatic) press moulding of step (v) is a mere compacting process for hardening the magnet without modifying the structure of the powder and not a plastic deformation for giving the powder the required grain aspect and anisotropy (appellant's statement of grounds of appeal, points 9, 14 and 19). This was not disputed by the opponent.
6. D1 (see in particular page 7, line 10 to page 8, line 36; Examples 22 and 35; Figures 5 and 6) discloses a method for preparing a Rare Earth-Fe-Co-B system anisotropic magnet.
 - 6.1 The features (i) to (iii) of the method according to claim 1 of the auxiliary request are disclosed in D1 (page 8, lines 25 to 36; page 32, line 47 to page 33, line 4). Regarding step (iv) of the claim, page 32, lines 4 to 7 of D1 mentions blending the powder with a resin and subjecting it to compression moulding in a magnetic field.

6.2 The composition and the structure of the powder and magnet disclosed in D1 are similar to those of the powder and magnet specified in claim 1; the magnetic powder of D1 has magnetic anisotropy (page 6, line 28 to page 8, line 12). The feature "the ratio of the largest grain diameter b to the smallest grain diameter a is less than two for individual crystallised grains constituting more than 50 volume% of the total crystallised grains of the aggregate structure" is considered as implicitly contained in D1 because the composition of the magnetic powder and the process for producing it are similar both in D1 and in the claimed method. Accordingly, D1 discloses the powder obtained at step (iii) of claim 1. This was acknowledged by the appellant (grounds of appeal, point 17).

6.3 Accordingly, the method for preparing an anisotropic magnet according to claim 1 of the present auxiliary request differs from the method disclosed in D1 by:

- requiring no step of mixing the magnetic powder with an adhesive before step (iv), contrary to the teaching of D1, and
- subjecting the green compact to hot press moulding or hot isostatic press moulding at a temperature of 600 to 900°C according to step (v) of claim 1.

7. D9 (see the Japio abstract and the German translation: pages 2 to 4; Example 1) discloses a method for preparing a Rare Earth-Fe-Co-B system anisotropic magnet.

7.1 The features recited in step (iii) of the method according to claim 1 are disclosed in D9, and the composition of the powder disclosed in D9 is similar to that of the powder specified in claim 1. However, in D9 the powder is not prepared by a HDDR process and has

neither the anisotropy nor the grain aspect ratio required by claim 1 and thus differs in these respects from the powder obtained in step (iii) of claim 1.

7.2 The method for preparing an anisotropic magnet according to claim 1 of the present auxiliary request differs from the method disclosed in D9 by:

- heating a R-Fe-Co-B mother alloy in an atmosphere of hydrogen gas and removing the hydrogen according to step (i) and step (ii) of claim 1,
- pressing the magnetic powder into a green compact a magnetic field according to step (iv) of claim 1, and
- hot press moulding or isostatic press moulding at a temperature of 600 to 900°C according to step (v) of the claim, it being noted that this step is a mere compacting process for hardening the magnet and not a plastic deformation for giving the powder the required anisotropy and grain aspect, as taught by D9.

8. The opponent submitted that the preparation of a magnetic powder and the production of a magnet were two independent processes, more particularly that it was part of the general knowledge of the skilled man that any given magnetic powder could be used with any known method for producing a magnet. Therefore, according to the opponent, the method of claim 1 did not involve an inventive step in view of the combination of D1 and D9. The Board cannot share this view.

9. Starting from D1, the technical problem can be seen as providing a magnet having better magnetic properties.

- 9.1 The powder according to D1, which is prepared by a HDDR process, already has a magnetic anisotropy (D1, page 7, line 53) and a grain aspect ratio as required by claim 1 (see paragraph 6.2 above). Therefore there is no need to use a method for producing a magnet from the powder which involves plastic deformation for adjusting the aspect ratio of the crystallised grain and the magnetic anisotropy of the magnet, as taught in D9. In the judgement of the Board, a person skilled in the art would not consider doing this, because it would risk losing the desired magnetic properties of the powder.
10. Starting from D9, the technical problem can be seen as providing a magnet having high magnetic anisotropy without using a plastic working, which disadvantageously increases the temperature coefficient of the coercive force. This problem corresponds to the problem mentioned in the patent in suit (page 1, lines 50 to 54).
- 10.1 There is no obvious reason for the skilled person faced with this problem to replace the magnetic powder, which, in the production method according to D9, is prepared by a rapid quenching method, by the powder according to D1.
11. Moreover, even if the powder according to D1 was processed to produce a magnet by the method disclosed by D9, such a process would still differ from the claimed method, because it would not involve the steps (iv) and (v) recited in the claims. Neither D1 nor D9 remotely suggests that merely hot pressing at a temperature of 600 to 900°C a magnetic powder prepared by an HDDR process could be used for hardening a magnet.

12. D6 and D10 essentially teach that a magnetic powder can be converted into a powder having magnetic anisotropy by plastic working and thus add nothing relevant to the teaching of D9. The other cited documents are less relevant and were not discussed in the oral proceedings.
13. In view of the foregoing, the Board judges that claim 1 according to the auxiliary request involves an inventive step within the meaning of Article 56 EPC.
14. Claim 3 of the auxiliary request merely differs from claim 1 of the auxiliary request in that elements Ga, Zr and Hf are substituted by elements Ti, V, Nb, Ta, Al and Si. Accordingly claim 3 involves an inventive step for the same reasons as claim 1 of the auxiliary request.
15. In the Board's judgement, taking into account the amendments according to the auxiliary request the patent in suit and the invention to which it relates satisfy the requirements of the Convention.

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 with the order to maintain the patent in amended form in the version according to the auxiliary request:

-claims: 1 to 4 filed in the oral proceedings;

- description: pages as in the patent specification: 31 to 38, 40, 41, 43 to 53; pages filed with letter dated 13 December 2002: 5 to 7, 30, 39, 42, 54, textblock A (on page 4 of the specification); pages filed during the oral proceedings: 2, textblock C to be inserted on page 2; cancelled pages: 3, 8 to 29.

The registrar:



D. Sauter

The chairman:



W. J. L. Wheeler