Europäisches Patentamt
Beschwerdekammern

European Patent Office
Boards of Appeal

Office européen des brevets
Chambres de recours

Veröffentlichung im Amtsblatt ~~Ja~~/Nein
Publication in the Official Journal ~~Yes~~/No
Publication au Journal Officiel ~~Oui~~/Non

001474

Aktenzeichen / Case Number / N° du recours : T 377/87 - 3.3.1

Anmeldenummer / Filing No / N° de la demande : 81 107 559.7

Veröffentlichungs-Nr. / Publication No / N° de la publication : 0 055 327

Bezeichnung der Erfindung: / Title of invention: / Titre de l'invention : Amorphous metal alloys having enhanced AC magnetic properties

Klassifikation / Classification / Classement : C22C 1/00

ENTSCHEIDUNG / DECISION

vom / of / du 1 June 1989

Anmelder / Applicant / Demandeur :

Patentinhaber / Proprietor of the patent / Titulaire du brevet : Allied Corporation

Einsprechender / Opponent / Opposant :

Stichwort / Headword / Référence : Alloys/Allied

EPÜ / EPC / CBE Article 56

Schlagwort / Keyword / Mot clé : "Inventive step (confirmed)"

Leitsatz / Headnote / Sommaire

Case Number : T 377/87 - 3.3.1

D E C I S I O N
of the Technical Board of Appeal 3.3.1
of 1 June 1989

Appellant : (Proprietor of the Patent)	Allied Corporation Columbia Road and Park Avenue P.O. Box 2245R (Law Dept.) Morristown, New Jersey 07960 (US)
Representative :	Weber, Dieter, Dr. Dr. Dieter Weber und Klaus Seiffert Patentanwälte Gustav-Freytag-Strasse 25 Postfach 6145 D-6200 Wiesbaden 1 (DE)
Respondent : (Opponent)	
Representative :	
Decision under appeal :	Decision of the Opposition Division of the European Patent Office of 22.05.87 posted on 03.08.87 revoking European patent No. 0 055 327 pursuant to Article 102(1) EPC

Composition of the Board :

Chairman : K.J.A. Jahn

Members : R.W. Andrews

G.D. Paterson

Summary of Facts and Submissions

I. The mention of the grant of the European patent No. 0 055 327 in respect of patent application No. 81 107 559.7, filed on 23 September 1981 and claiming priority of 29 December 1980 from a prior application filed in the United States of America, was announced on 8 August 1984 (cf. Bulletin 84/32) on the basis of ten claims.

II. A notice of opposition was filed on 19 April 1985 in which the revocation of the patent was requested on the ground that its subject-matter lacked novelty and did not involve an inventive step. In a letter filed on 22 May 1987 the Opponent withdrew his opposition.

III. By a decision delivered orally on 22 May 1987, with written reasons posted on 3 August 1987, the Opposition Division revoked the patent. The Opposition Division considered that, even if the subject-matter of Claim 1 filed on 11 May 1987 was novel in the light of "Magnetische Werkstoffe and Bauelemente in der Nachrichten- und Datentechnik", Vorträge der Frühjahrstagung vom 16. bis 18. April 1980 in Bad Nauheim, published in NTG-Fachberichte, Volume 76, pages 307 to 311 (document (4)), it did not involve an inventive step in the light of the teaching of this document.

Furthermore, US-A-4 219 355 (document (8)) discloses field annealing of amorphous alloys of slightly different composition to the present ones in order to improve the magnetic properties of the alloys at higher temperatures. The rates of cooling disclosed in this document are the same as the ones presently claimed. Therefore, a combination of teachings of documents (4) and (8) renders the subject-matter of Claims 1 and 5 obvious.

The Opposition Division also concluded that the Patentee had not produced any evidence to support his claim that a special selection of alloy composition and a special heat treatment was necessary to solve the problem of providing amorphous alloys with enhanced magnetic properties at relatively high temperatures and, in the absence of such evidence, the conditions of a selection invention were not met.

IV. An appeal was lodged against this decision on 26 September 1987 together with payment of the prescribed fee. A statement of grounds of appeal and an amended statement of claim was filed by a duly confirmed telecopy on 11 December 1987. Claim 1 of this amended statement of claim reads as follows:-

"A metal alloy which is at least 90% amorphous, containing apart from incidental impurities iron, silicon and boron and is producible by a process comprising the steps of heating said amorphous alloy to a temperature in the range of about 340° to 440°C and sufficient to achieve stress relief but less than that required to initiate crystallization, cooling said alloy at a rate of about 0.5°C/min to 75°C/min; and applying a magnetic field to said alloy during said heating and cooling, characterised in that it consists of a composition having the formula $Fe_aSi_bB_c$ wherein "a", "b" and "c" are atomic percentages ranging from about 75 to 78.5, 4 to 10.5 and 11 to 21, respectively, with the proviso that the sum of "a", "b" and "c" equals 100".

Claims 2 to 5 relate to preferred embodiments of Claim 1. Claim 6 claims a magnetic core comprising an alloy as claimed in Claim 1.

V. The Appellant's submissions in the grounds of appeal and in a response to the Board's letter of 11 July 1988 filed on 18 January 1989 were essentially as follows:

The Appellant contended that document (4) could not be considered to be prior art since it was not clear whether this document was made available to the public before the claimed priority date of 29 December 1980 and whether it was an accurate reproduction of the lecture delivered in April 1980.

The Appellant also argued that document (8) and not document (4) represented the closest prior art since this document is directed to the same objective as the disputed patent of providing amorphous alloys whose magnetic properties render them suitable as core materials for power transformers and similar electromagnetic devices which operate at temperatures of up to about 150°C.

The Appellant also submitted that magnetic materials intended for use in transformer cores should possess high saturation magnetism, low AC core loss and low exciting power requirements at about 100°C. However, low coercivity, which is a property of the amorphous alloys disclosed in document (4), is not related to these properties. Furthermore, Figure 1 of document (4) reports the coercive field strength of the alloys in the non-heated condition and it is well known in the art that coercive field strength changes dramatically on heat treatment. In view of the fact that there is no relationship between low coercivity and those properties essentially for materials for transformer cores, the skilled person would not necessarily expect that field annealing treatment which results in low coercivity would improve the three essential properties for transformer cores. Furthermore, the disclosure in document (4) that the maximum permeability of the alloy $Fe_{77}Si_{10}B_{13}$ is stable during heating to about 200°C would not suggest to the skilled person that the key magnetic properties for materials for transformer cores would remain stable at about 150°C since, in particular, core loss is not related to permeability.

The Appellant has also argued that a prejudice existed against reducing the iron content of FeSiB alloys below 80 atomic % in view of the teaching in document (8) and IEE Transactions on Magnetics, Volume 15(4), pages 1146 to 1148, 1979 (12), which discloses that, for the highest saturation magnetisation combined with ease of preparation, stability and lowest losses, the alloys between $Fe_{81}B_{17}Si_2$ and $Fe_{82}B_{12}Si_6$ are preferred. In his search for a solution to his technical problem, the skilled person would only consider those alloys which possess not only low coercivities but, more importantly, high saturation magnetisations. However, the teaching of document (12) is clearly to select those alloys with an iron content of 80 to 82 atomic percentage.

VI. The Appellant requests that the decision under appeal be set aside and a patent granted on the basis of Claims 1 to 6 filed on 11 December 1987.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and is, therefore, allowable.

2. There are no formal objections under Article 123 EPC to the present claims since they are adequately supported by the original disclosure and do not extend the protection conferred. The present Claims 1 to 6 are based on Claims 1 to 9 as originally filed and granted.

3. The patent in suit relates to metal alloys containing iron, silicon and boron which are at least 90% amorphous and whose magnetic properties, particularly their high saturation magnetisation, low core loss and low volt-ampere demand at about 100°C render them suitable for use in the cores of electromagnetic devices such as transformers. Document (8), which may be considered to represent the closest prior art, discloses metal alloys which are at least 90% amorphous having the formula $Fe_aB_bSi_cC_d$, wherein a, b, c and d are atomic percentages ranging from about 80.0 to 82.0, 12.5 to 14.5, 2.5 to 5.0 and 1.5 to 2.5 respectively (cf. Claim 1). The magnetic properties of these alloys also make them suitable for use in the cores of electromagnetic devices (cf. column 2, lines 25 to 31 and column 3, lines 13 to 25). The magnetic properties of the alloys in accordance with the disputed patent and those of the prior art alloys are said to remain stable at temperatures up to 150°C (cf. disputed patent, page 2, lines 55 and 56 and (8), column 2, lines 25 to 27).

3.1 In the light of this closest prior art, the technical problem underlying the disputed patent may be seen in providing further amorphous alloys whose magnetic properties and the stability of these magnetic properties at temperatures up to about 150°C render them suitable for use in electromagnetic devices such as transformer cores.

3.2 According to the disputed patent the above-defined technical problem is solved by providing an amorphous alloy having the formula $Fe_aSi_bB_c$, wherein a, b and c are atomic percentages ranging from about 75 to 78.5, 4 to 10.5 and 11 to 21 respectively, with the proviso that the sum of a, b and c equals 100, which is prepared by heating said alloy to a temperature in the range of 340° to 40°C and cooling it at a rate of 0.5°C/min to 75°C/min with a magnetic field applied during heating and cooling.

3.3 In view of the results in Table 1 on page 4 of the disputed patent, the Board is satisfied that the technical problem underlying the disputed patent is plausibly solved.

4. After examination of the cited documents the Board has concluded that the claimed subject-matter is novel.

4.1 The exact date in 1980 upon which document (4), which is marked "Copyright 1980", and which reproduces a lecture given in April 1980, was made available to the public has not been established. The Appellant has also expressed doubts as to whether the document gives a true account of the lecture, however, in the absence of sound reasons for contesting the accuracy of the account given in document (4) the Board considers that on the balance of probabilities the above-mentioned lecture was reproduced in document (4) and forms part of the state of the art within the meaning of Article 54(1) EPC before the claimed priority date of 29 December 1980.

4.2 Documents (4) and (12) both disclose a metal alloy of the composition $Fe_{77}Si_{10}B_{13}$ (cf. (4) page 310 and (12) the abstract on page 1146). However, neither of these documents disclose the presently claimed conditions for magnetic field annealing the alloys. In view of the fact that it is these specified conditions which provide the present alloys with their useful magnetic properties, the Board is satisfied that the presently claimed subject-matter is novel in the light of the disclosure of documents (4) and

(12). None of the other cited documents describe Fe-Si-B amorphous alloys with compositions falling within the range defined in the present Claim 1.

5. It still remains to be examined whether the requirement of inventive step is met by the claimed subject-matter.

5.1 As previously mentioned, document (8) discloses amorphous alloys consisting of iron, boron, silicon and carbon. The atomic percentages of iron and carbon are in the range of 80.0 to 82.0 and 1.5 to 2.5 respectively. It is also disclosed in this document that the magnetic properties of the alloys can be enhanced by heating them to a temperature sufficient to achieve stress relief but less than that required to initiate crystallisation, cooling and applying a magnetic field during heating and cooling. Generally, a temperature in the range of about 340° to 385°C and a rate of cooling of about 0.5°C/min to 75°C/min are employed (cf. column 3, lines 1 to 11). Although this document discloses amorphous alloys with high saturation magnetisations, low core losses and low exciting powers or volt-ampere demands and the enhancement of these properties by magnetic field annealing, it does not provide any indication that the solution to the technical problem underlying the disputed patent lay in alloys containing no carbon and having 75 to 78.5 atomic percentage of iron.

5.2 Document (4) reproduces a lecture reporting the results of an investigation into the magnetic properties of amorphous FeSiB alloys. Within the shaded area of Figure 1 on page 307 of this document some amorphous alloys falling within the scope of the formula in Claim 1 of the patent in suit are disclosed. This shaded area represents non-heat treated alloys with the lowest coercivities for which good soft magnetic properties could be expected. On page 308 of this document it is reported that certain magnetic properties of cores made from alloy ribbons are improved by magnetic field annealing. Furthermore, on pages 310 and 311 the results of the investigation of the thermal stability of the maximum permeability of an alloy falling within the formula in the present Claim 1 ($Fe_{77}Si_{10}B_{12}$) are reported.

The skilled person is aware that in order to solve the technical problem underlying the patent in suit it is essential that the amorphous alloys possess high saturation magnetisations, low AC core losses and low exciting power demands (volt-ampere demands) at about 100°C, which is the normal operating temperature for transformer cores. However, document (4) does not provide any information with regard to these magnetic properties. Tables I and II of document (8) clearly demonstrate that coercive force, AC core loss and volt-ampere demand are independent from each other. Thus, the alloy of Example 6 possesses the highest coercive force value (7.2 A/m) reported in this Table but one of the lowest values for volt-ampere demand and a low AC core loss of 0.24 w/kg, whereas the alloys of Examples 3 and 4 with the lowest coercive force value of 3.2 A/m have higher values for AC core loss and volt-ampere demand than those of the alloy of Example 6 viz. 0.31 and 0.32 w/kg and 0.35 and 0.79 VA/kg, respectively. Similarly, the alloys of Examples 7, 8 and 11 in Table II have the same coercive force value but different values for AC core loss and volt-ampere demand.

Therefore, in the absence of any relationship between coercivity and these two magnetic properties the skilled person could not have expected that the solution to the technical problem underlying the disputed patent lay in applying the magnetic field annealing conditions described in document (8) to some of the alloys disclosed in document (4).

5.3 The disclosure in document (4) of the thermal stability of the maximum permeability of an amorphous alloy composition falling within the scope of the formula in the present Claim 1 up to a temperature of about 200°C would not allow the skilled person to draw any conclusion with regard to the thermal stability of the saturation magnetisation, core loss and exciting power requirements in the absence of any direct relationship between maximum permeability and these three other magnetic properties. Thus, this teaching would not provide the skilled person with any incentive to subject this particular alloy to the magnetic field annealing process disclosed in document (8) in the expectation of solving the technical problem underlying the disputed patent.

5.4 Document (12) discloses that the coercivity of FeBSi amorphous alloys exhibit a broad minimum, both before and after stress relief annealing, in the region around $Fe_{81}B_{15}Si_4$ and that this extends to at least $Fe_{77}B_{13}Si_{10}$. Moreover, the room temperature saturation magnetisation is relatively constant for alloy compositions $Fe_{80}B_{20}$ to $Fe_{82}B_{12}Si_{16}$ (cf. Abstract on page 1146). From these results the authors conclude that amorphous alloys containing silicon with atomic percentages of iron in the range of 80 to 82 are the preferred alloys since they possess the highest saturation magnetisations combined with low coercivities (cf. conclusions on page 1148). Since in order to solve the above defined technical problem it is highly desirable that the amorphous alloys possess a saturation magnetisation as high as possible, the skilled person's attention would be directed towards those alloys having a maximum saturation magnetisation rather than towards those alloys with a minimum coercivity, i.e. towards alloys containing atomic percentages of iron in the range 80 to 82. Therefore, the teaching of this document would not provide the skilled person with any encouragement to consider subjecting amorphous alloys having atomic percentages of iron in the range 75 to 78.5 to the magnetic field annealing conditions disclosed in document (8).

6. Therefore, in the Board's judgement the subject-matter of Claim 1 involves an inventive step. Claims 2 to 5, which, relate to preferred embodiments of Claim 1, derive their patentability from this claim.

Claim 6, which relates to a magnetic core comprising the alloy as claimed in Claim 1, is also patentable for the foregoing reasons.

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 on the basis of Claims 1 to 6 filed on 11 December 1987 and a description which has been amended to bring it into agreement with these claims.

The Registrar: The Chairman:

R.W.A.