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D E C I S I O N
of 16 March 2005

Case Number: T 0647/02 - 3.4.2

Application Number: 97300921.0

Publication Number: 0791974

IPC: H01M 4/86

Language of the proceedings: EN

Title of invention:

Catalytically active gas diffusion electrodes comprising a nonwoven fibrous structure

Patentee:

JOHNSON MATTHEY PUBLIC LIMITED COMPANY

Opponent:

OMG AG & Co. KG

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (yes) - ex-post-facto analysis"

Decisions cited:

T 0229/85

Catchword:

-



Case Number: T 0647/02 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 16 March 2005

Appellant: JOHNSON MATTHEY PUBLIC LIMITED COMPANY
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Representative: Wishart, Ian Carmichael
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Respondent: OMG AG & Co. KG
(Opponent) Standort Hanau - Postfach 1351
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Representative: -

Decision under appeal: Decision of the Opposition Division of the
European Patent Office posted 26 April 2002
revoking European patent No. 0791974 pursuant
to Article 102(1) EPC.

Composition of the Board:

Chairman: A. G. Klein
Members: F. J. Narganes-Quijano
C. Rennie-Smith

Summary of Facts and Submissions

- I. The appellants (patent proprietors) lodged an appeal against the decision of the opposition division revoking European patent No. 0 791 974 (based on European patent application No. 97300921.0).

The opposition was filed against the patent as a whole on the grounds of lack of novelty and lack of inventive step (Article 100(a) together with Articles 52(1), 54 and 56 EPC) and on the grounds of insufficiency of disclosure (Article 100(b) EPC).

- II. In its decision the opposition division held that the patent satisfied the requirements of sufficiency of disclosure and that the subject-matter of the amended claims then on file was novel over the documents considered during the proceedings but did not involve an inventive step with regard to the disclosure of the following documents:

D1: JP-A-62184768 and English language translation
D2: JP-A-62156285 and English language translation
D3: JP-A-62232860 and English language translation
D6: US-A-4185131.

The opposition division held in particular that the closest prior art was represented by document D6, that the claimed subject-matter solved the problem of the provision of a catalysed gas diffusion fibrous web electrode having the catalyst particles embedded within the fibre network, but that the claimed solution was rendered obvious by the disclosure of any of documents D1 to D3.

III. The appellants requested that the decision under appeal be set aside and the patent be maintained on the basis of a set of amended claims filed with the statement setting out the grounds of appeal.

The respondents (opponents) submitted no request and declared by letter dated 15 October 2002 that they would take no further part in the proceedings.

IV. In reply to an official communication in which the Board expressed its preliminary opinion on the case and drew the attention of the parties to some deficiencies in the amended patent documents, the appellants submitted by letter dated 26 January 2005 a new set of amended claims 1 to 21 replacing the previous set of claims and description pages 6, 6A and 9 to 11 replacing the corresponding passages of the description of the patent specification.

No observations were received from the respondents in reply to the Board's communication or to the appellants' reply to this communication.

V. Independent claims 1, 2 and 18 according to the present request of the appellants read as follows:

" 1. A gas diffusion electrode comprising a flexible, free-standing catalyst layer containing a continuous, non-woven network of fibres and a polymeric substance, wherein the catalyst is embedded within the fibre network and the non-woven fibres are pre-coated with one or more polymeric substance(s); and, optionally, a

second or more layer(s) applied to the flexible, free-standing catalyst layer."

" 2. A gas diffusion electrode comprising a flexible, free-standing layer that comprises a mixture of

- (a) non-woven fibres;
- (b) one or more catalyst material(s); and
- (c) one or more polymeric substance(s);

wherein the catalyst is embedded within the fibre network and the non-woven fibres are pre-coated with one or more polymeric substance(s); and, optionally, a second or more layer(s) applied to the flexible, free-standing layer."

" 18. A method for the manufacture of a gas diffusion electrode comprising a flexible, free-standing catalyst layer containing a continuous, non-woven network of fibres and a polymeric substance, wherein the catalyst is embedded within the fibre network; and, optionally, a second or more layer(s) applied to the flexible, free-standing catalyst layer, comprising the step of mixing the fibres with at least one catalyst component and a polymeric substance and thereafter forming the gas diffusion electrode by adapting a continuous manufacturing process."

Dependent claims 3 to 17 all refer back to the gas diffusion electrode defined in independent claims 1 and 2, dependent claim 19 refers back to the method defined in independent claim 18, and claims 20 and 21 are directed to a membrane electrode assembly and to a fuel cell including a gas diffusion electrode as defined in claims 1 to 17, respectively.

VI. The arguments of the appellants in support of their requests can be summarised as follows:

Documents D1 to D3 teach that embedding carbon-PTFE mixtures into carbon paper in the manufacture of gas diffusion electrodes provides layers with increased rigidity such that warping and bending can be eliminated. Therefore, the skilled person would not expect that embedding carbon-PTFE into the carbon paper of document D6 would provide gas diffusion electrodes with a flexible layer as claimed. Furthermore, the carbon paper of document D6 is water-proofed and it is not trivial to embed carbon particles into this substrate.

In addition, the patent specification (paragraphs [0008] and [0030]) refers to carbon fibre paper substrates of the prior art as being rigid. Therefore, the term "flexible" is to be interpreted in the claims as meaning "more flexible than carbon fibre paper" and consequently the flexibility of the catalyst layers according to the subject-matter of the claims constitutes a further distinguishing feature that is neither disclosed nor rendered obvious by the disclosure of documents D1 to D3 and D6.

VII. The respondents for their part have made no substantive submission during the appeal proceedings.

Reasons for the Decision

1. The appeal complies with the requirements mentioned in Rule 65(1) EPC and is therefore admissible.

2. *Amendments*

Except for the omission in independent claims 1 and 2 of the expression "dimensionally stable" which was not present in claims 1 and 2 as granted, the omission in method claim 18 of the feature relating to the fibres being pre-coated which was not present in method claim 19 as granted, and the replacement in claim 18 of a reference to the preceding claims by a recitation of the features of claim 1 as granted, the present set of claims corresponds essentially to the set of claims on which the decision under appeal was based. In addition, the opposition division already concluded in its decision that the amendments made to the claims then on file were admissible and allowable and during the appeal proceedings the respondents made no submission concerning this finding of the opposition division. After consideration of the amendments made to the claims as granted and the reasoning followed by the opposition division and leading to the aforementioned conclusion, the Board sees no reason to depart from the conclusion reached by the opposition division in the decision under appeal.

The description has been amended during the appeal proceedings to make it consistent with the amended set of claims (Article 84 and Rule 27(1,c) EPC).

The Board is therefore satisfied that the amendments to the patent documents according to the present request of the appellants are admissible (Rule 57a EPC) and satisfy the formal requirements of the EPC (in particular Articles 84, 123(2) and 123(3) EPC).

3. *Grounds for opposition under Article 100(b) EPC*

The arguments submitted by the respondents in support of the ground for opposition under Article 100(b) EPC initially invoked by the respondents in the notice of opposition were not considered persuasive by the opposition division (point II above). In addition, during the appeal proceedings the respondents have made no submission in this respect and, after due consideration of the assessment of the sufficiency of disclosure of the invention made by the opposition division in the decision under appeal, the Board sees no reason to deviate from the conclusion of the opposition division in this respect.

Accordingly, the Board concludes that the grounds for opposition under Article 100(b) EPC do not stand in the way of maintaining the patent as amended according to the present request of the appellants.

4. *Grounds for opposition under Article 100(a) EPC*

4.1 The prior art

4.1.1 Document D1

Document D1 discloses a gas diffusion electrode for use in fuel cells (page 2 of the English translation, section "Field of industrial utility"). To solve the problem of prior art electrodes being extremely thin, having inadequate strength, and easily warping and twisting and cracking when being handled (page 3, second paragraph), the document proposes an electrode

structure with improved strength and which is resistant to warping and bending and does not distort or develop cracks in handling (page 3, third paragraph, page 4, first paragraph, paragraph bridging pages 4 and 5, and page 5, two last paragraphs). The electrode structure 6 (Figure 1) is manufactured by coating on and impregnating in a non-woven reaction layer base sheet 2 of carbon paper 1 a liquid coating containing water-repellent carbon-black, hydrophilic carbon-black and PTFE (polytetrafluoroethylene) powder in the relative proportions 3:7:3, press-bonding a gas diffusion layer base sheet 3 containing water-repellent carbon-black and PTFE powder to the reaction layer base sheet 2, thus forming a gas diffusion electrode base sheet 4, and coating on and impregnating into the reaction layer base sheet a platinum compound to form a reaction layer 5 (page 3, last paragraph to page 4, middle paragraph together with Figure 1).

4.1.2 Document D2

The disclosure of document D2 is essentially analogous to that of document D1 (see Figures 1 and 2 and the corresponding description in the English translation), except that it makes use of a heat-sealing instead of a press-bonding technique in the formation of the gas diffusion electrode base sheet (claim 2 and page 5, middle paragraph).

4.1.3 Document D3

Also the disclosure of document D3 is essentially analogous to that of document D1, except that the step of press-bonding a gas diffusion layer base sheet of

water-repellent carbon-black and PTFE powder is omitted (Figures 1 and 2 and the corresponding description).

4.1.4 Document D6

Document D6 discloses the fabrication of gas diffusion electrodes for fuel cells (abstract together with column 1, lines 6 to 20). The electrodes are manufactured by first forming a dry floc powder of carbon particles and PTFE and suspending the powder in an inking vehicle, then wet-proofing a porous carbon paper made of carbon fibres by impregnation of the carbon paper with a hydrophobic polymer such as PTFE and screen-printing the ink suspension as a layer onto the resulting wet-proofed carbon paper, and finally catalysing the layer with platinum after the electrode structure has been sintered (column 3, line 26 to column 5, line 68).

4.2 *Novelty - Claims 1, 2 and 18*

The amendments to present independent claims 1, 2 and 18 (see point 2 above) do not affect the opposition division's conclusion in the contested decision that the subject-matter of the claims was novel over the prior art considered during the opposition proceedings. In particular, document D6 discloses a gas diffusion electrode comprising a free-standing catalyst layer made of a fibre paper substrate, i.e. a continuous non-woven network of fibres (point 4.1.4 above), the wet-proofing pre-treatment of the fibre paper substrate by dipping it into a solution of PTFE or other hydrophobic polymer (column 3, lines 52 to 55, and column 4, lines 1 to 15) resulting in a polymeric pre-coat of the

fibres of the substrate; however, document D6 refers consistently to catalysing the floc layer screen-printed onto the fibre paper substrate (column 2, lines 20 to 29 and 33 to 38, and column 3, lines 26 to 36) and therefore does not anticipate embedding the catalyst within the fibre network as required by the subject-matter of claims 1, 2 and 18. As regards documents D1 to D3, the non-woven network of fibres of the carbon paper is treated with a mixture of hydrophobic carbon black, water-repellent carbon-black and PTFE (see points 4.1.1 to 4.1.3 above) but the fibres are not properly pre-coated with a polymeric substance within the meaning of claims 1, 2 and 18 and, in addition, the resulting catalysed structure has improved strength and is resistant to warping and bending (points 4.1.1 to 4.1.3 above) and does not appear to be flexible within the meaning of the claimed subject-matter.

In view of the above the Board concludes that independent claims 1, 2 and 18 define new subject-matter over the prior art considered during the opposition proceedings (Articles 52(1) and 54 EPC).

4.3 Inventive step - Claim 1

4.3.1 One of the primary aspects of the invention is the provision of flexible gas diffusion electrodes (see paragraphs [0008], [0010] and [0017] of the patent specification). Contrary to document D6, documents D1 to D3 (see points 4.1.1 to 4.1.3 above) teach expressly in the opposite direction, i.e. they teach increasing the bending strength and eliminating warping and bending of the electrodes (see in particular document

D1, two last paragraphs on page 5 of the English translation). For this reason the Board concurs with the opposition division and the appellants in considering document D6 as representing the closest prior art.

- 4.3.2 The electrode defined in claim 1 differs from that disclosed in document D6 in that the catalyst is embedded within the fibre network (see point 4.2 above).

The appellants have submitted that the flexibility of the catalyst layer constitutes an additional distinguishing feature over the disclosure of document D6. However, according to document D6 the substrates are of carbon paper manufactured by "well known paper making processes" (column 3, lines 44 to 52), which generally imply a predetermined degree of flexibility of the processed paper substrates and, in addition, none of the processing steps disclosed in document D6 appears to impair the flexibility of the substrates. Accordingly, and notwithstanding the fact that - as submitted by the appellants, see point VI above - predetermined paper substrates of the prior art are regarded in the description of the patent as being "rigid", in the absence of any proper limitation in claim 1 as to the degree of flexibility required for the catalyst layer the Board is not in a position to endorse the appellants' contention that the flexibility of the catalyst layer constitutes a further distinguishing feature of the subject-matter of claim 1 over the disclosure of document D6.

- 4.3.3 According to the disclosure of the patent, the technical effects of the distinguishing feature identified in point 4.3.2 above is the reduced complexity of the electrode structure (column 3, lines 18 to 26) as well as the improved performance of the same due to the presence of fibres in the catalyst layer (column 5, lines 2 to 17).
- 4.3.4 In the decision under appeal the opposition division formulated the technical problem solved by the subject-matter of claim 1 over the disclosure of document D6 in terms of the catalyst particles being embedded within the fibre network (see point II above). The feature relating to the catalyst particles being embedded, however, is not derivable from the claimed features that are already known from the closest prior art document D6 and, in addition, constitutes a feature - in fact the essential feature, see point 4.3.2 above - of the solution laid down in claim 1. Thus, the problem formulated by the opposition division contains pointers to the solution and implicitly anticipates essential aspects of the claimed solution and consequently any subsequent assessment of inventive step relying on such a formulation of the problem would necessarily result in an inadmissible *ex post facto* reasoning (see decision T 229/85, OJ EPO 1987, 237, point 5 of the reasons and other decisions also cited in "Case Law of the Boards of Appeal", 4th ed., 2001, chapter I, section D.4.2).

Consequently, the technical problem formulated by the opposition division cannot be seen as an objective formulation of the technical problem solved by the claimed invention over the disclosure of document D6.

In view of the technical effects achieved by the subject-matter of claim 1 over document D6 (point 4.3.3 above), the technical problem solved by the claimed subject-matter rather resides in the reduction of the structural complexity and in the improvement of the performance of the electrode structure without detriment to the flexibility of the catalyst layer.

4.3.5 Each of documents D1 to D3 teaches a manufacturing method resulting in electrodes having the catalyst embedded into the fibre layer. However, these documents do not address the objective problem formulated above and therefore there is *a priori* no reason for considering the potential application of the teaching of documents D1 to D3 to the electrode structure of document D6. Furthermore, documents D1 to D3 rather teach to stiffen the layer structure (points 4.1.1 to 4.1.3 above) and therefore teach against one of the aspects of the problem formulated above, i.e. preserving the flexibility of the catalyst layer, and the skilled person would therefore refrain from considering the application of the teaching of these documents to the disclosure of document D6.

In addition, even it were assumed that the skilled person would nonetheless have considered the application of the teaching of documents D1 to D3 relating to embedding the catalyst within the fibre network to the disclosure of document D6, in the Board's view he would not have reached in an obvious way the claimed subject-matter. The reason for this is that document D6 teaches pre-coating the fibres with PTFE (column 3, lines 52 to 55 and column 4, lines 1 to 15) only as a wet-proofing pre-treatment of the

substrate for the purpose of screen-printing the substrate with a floc layer to be subsequently catalysed (column 5, lines 1 to 68). Thus, in order not to impair the embedding mechanism underlying the teaching of documents D1 to D3 to the detriment of the efficiency of the embedding technique taught in these documents, when considering the application of the teaching of documents D1 to D3 to the disclosure of document D6 the skilled person would then have followed the precise teaching of the documents and would therefore have replaced the pre-coat pre-treatment step of document D6 by the pre-treatment step required by the embedding technique taught by documents D1 to D3 and involving impregnation with a liquid coating containing water-repellent carbon-black, hydrophilic carbon-black and PTFE powder (see point 4.1.1 above). Therefore, the application of the teaching of documents D1 to D3 to the disclosure of document D6 would have resulted in a pre-treatment of the fibres as disclosed in document D1 to D3, but would not have properly resulted in the fibres being pre-coated with a polymeric substance as required by claim 1.

In view of the above, the subject-matter of claim 1 does not result in an obvious way from the disclosure of documents D1 to D3 and D6. In addition, the remaining documents considered during the opposition proceedings are not more relevant to inventive step than documents D1 to D3 and D6. The Board thus does not see a convincing line of argument challenging inventive step of the subject-matter of claim 1 (Articles 52(1) and 56 EPC).

4.4 Inventive step - Claim 2

The subject-matter of independent claim 2 differs in essence from that of claim 1 in that it does not require the network of fibres to be "continuous" as required in claim 1. This difference does not affect the reasoning in point 4.3 above relating to the assessment of inventive step of the subject-matter of claim 1 and for this reason the conclusion drawn in point 4.3 also applies to independent claim 2 (Articles 52(1) and 56 EPC).

4.5 Inventive step - Claim 18

The manufacturing method defined in claim 18 differs in essence from the manufacturing method disclosed in document D6 in that the catalyst is embedded within the fibre network and in that the electrode is formed by mixing the fibres with the catalyst and a polymeric substance by adapting a continuous manufacturing process. According to the disclosure of the patent, these two features improve the yield of the manufacturing method due to the lower structural complexity of the electrode structure (column 3, lines 18 to 34) and to the reduction of the number of steps required in the manufacture of the same (column 5, lines 50 to 55).

None of the documents considered during the proceedings addresses this problem or discloses or suggests mixing the fibres with the catalyst and a polymeric substance before forming the fibre substrate. Accordingly, the manufacturing method defined in claim 18 involves an inventive step (Articles 52(1) and 56 EPC).

4.6 Claims 3 to 17 and 19 to 21

The same conclusions drawn in points 4.2 to 4.5 above apply to dependent claims 3 to 17 and 19 by virtue of their dependence on claims 1 and 2 and on claim 18, respectively, as well as to claims 20 and 21 directed to devices including a gas diffusion electrode according to any of claims 1 and 2.

5. In view of the foregoing, and noting that the respondents have had due opportunity to comment on the Board's preliminary opinion and on the amendments to the patent, the Board concludes that the patent as amended and the invention to which it relates meet the requirements of the EPC. Accordingly, the patent can be maintained as amended according to the present request of the appellants (Article 102(3) EPC).

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 as amended in the following version:
 - claims 1 to 21 filed with the letter dated 26 January 2005,
 - description of the patent specification with the passage which extends between the word "comprising" in column 3, line 36 and the word "diffusion" in column 4, line 13 being replaced by the text on pages 6 and 6A filed with the letter dated 26 January 2005, and the passage which extends between the word "is" in column 5, line 22 and the word "membrane" in column 7, line 1 being replaced by the text on pages 9 to 11 filed with the letter dated 26 January 2005, and
 - drawing sheets as in the patent specification.

The Registrar:

The Chairman:

P. Martorana

A. G. Klein