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D E C I S I O N
of 8 December 1999

Case Number: T 0483/97 - 3.4.2

Application Number: 89201479.6

Publication Number: 0345908

IPC: H01M 8/06

Language of the proceedings: EN

Title of invention:

A process for converting fuel into electricity

Patentee:

KTI Group B.V.

Opponent:

Linde Aktiengesellschaft

Headword:

-

Relevant legal provisions:

EPC Art. 56

Keyword:

"Inventive step (yes)"

Decisions cited:

-

Catchword:

-



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Boards of Appeal

Chambres de recours

Case Number: T 0483/97 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 8 December 1999

Appellant:
(Opponent)

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Zentrale Patentabteilung
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Representative:

-

Respondent:
(Proprietor of the patent)

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Representative:

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Decision under appeal:

Interlocutory decision of the Opposition Division
of the European Patent Office posted 10 March
1997 concerning maintenance of European patent
No. 0 345 908 in amended form.

Composition of the Board:

Chairman: E. Turrini
Members: R. Zottmann
B. J. Schachenmann

Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal against the interlocutory decision of the Opposition Division to maintain the European patent No. 0 345 908 (application No. 89 201 479. 6) in amended form.

In the opposition proceedings only the ground of opposition laid down in Article 100(a) EPC that the patent lacks inventive step had been introduced.

II. The following prior art documents have been cited during the appeal proceedings:

D1: GB-A-2 182 195;

D2: US-A-4 200 682; and

D3: Linde-Berichte aus Technik und Wissenschaft, Nr. 57, 1985, pages 26 to 35.

III. Oral proceedings before the Board of Appeal were held at the end of which the decision was announced.

IV. The appellant requested that the decision under appeal be set aside and the patent be revoked.

V. The respondent (patentee) requested that the appeal be dismissed and that the patent be maintained as amended in the interlocutory decision under appeal (main request) or, as auxiliary request, on the basis of claim 1 as submitted during the oral proceedings and claims 2 to 15 according to said interlocutory decision.

The claims as amended in the interlocutory decision under appeal which are identical with the claims of the main request in the appeal proceedings are contained in "ANNEX II" of that decision.

VI. The independent claims of the main request read as follows:

"1. A process for converting a fuel on the basis of hydrocarbon into electricity, comprising the following stages:

- (a) catalytically converting said fuel into an H₂ and CO containing gas, and converting said gas in a shift reactor into H₂ containing gas
- (b) passing said H₂ containing gas through at least one "pressure-swing" adsorption unit to produce a H₂ gas stream of high purity, as well as a desorption gas, wherein the adsorption conditions are such that the H₂ gas stream of high purity has a H₂ content of at least 98% by volume, and
- (c) supplying said H₂ gas stream of high purity to the anode compartments of at least one fuel cell stack operating at a temperature of at least 140°C, said fuel cell stack consisting of fuel cells based upon phosphoric acid, in which electricity is generated."

"15. Apparatus for carrying out the process as claimed in any of claims 1-14, comprising

- (a) means for catalytically converting fuel on the basis of hydrocarbon into an H₂ and CO containing gas, means for converting said gas in a separate water-shift reactor, means for cooling said gas, and removing condensed products from it,
- (b) a "pressure-swing" adsorption unit, means for supplying said cooled gas to said "pressure-swing" adsorption unit, means for supplying a purified H₂ gas formed therein to a fuel cell stack, and
- (c) a fuel cell stack comprising a plurality of fuel cells based upon phosphoric acid, each comprising an anode compartment and a cathode compartment, the anode compartments including means for supplying and discharging H₂ containing gas, and the cathode compartments being provided with means for supplying and discharging O₂ containing gas."

The remaining claims 2 to 14 are dependent on claim 1.

VII. The arguments of the appellant with respect to the main request are summarized as follows:

A fuel cell is a chemical reactor. Laboratory tests are carried out before big scale production of such cells and usually begin with pure hydrogen and then increasing concentrations of additional gas components such as CO are added. Such tests would have shown that removal of CO extends the lifetime of the fuel cell. Moreover, the skilled person knows that CO reduces the lifetime of a fuel cell and CO is therefore only tolerated.

The dilution effect due to inert gas components and CO is detrimental to the efficiency of the reactor. Moreover, the concentration of the components other than hydrogen and thus the dilution of H₂ even increases along the reaction zone of the cell in the direction of the gas flow since hydrogen is consumed. If the concentrations of the gases not participating in the reaction is too high the reaction has to be terminated.

Fuel cells are relatively expensive and the lifetime can be extended with purified hydrogen gas. In the process according to D3, in a big scale production of pure H₂ other components are separated from hydrogen by pressure swing adsorption (hereinafter called PSA) method after reforming and shift reaction.

These technical considerations alone would motivate the skilled person, when starting from the nearest prior art disclosed in D2, to remove the gas components other than hydrogen, in particular CO, from the fuel gas. For this purpose the skilled person would take into consideration the relatively cheap and well-known PSA method as disclosed in document D3 for purifying hydrogen.

VIII. The arguments of the respondent with respect to the main request are summarized as follows:

The appellant has not furnished documentary proof for his allegations concerning the technical considerations allegedly obvious to the skilled person at the priority date of the patent. The average skilled person is not a scientist in the laboratory but a technician in the industry. The considerations of the appellant are of the *ex post facto* type. It is admitted that the skilled person could have applied the PSA step but he would not have done it.

The teachings of D3 have no connection with fuel cells.

According to D1, for certain fuel cells CO₂ can be tolerated; when CO₂ does not disturb, PSA would be unnecessary.

D2 also states that a few percent of CO can be tolerated and that the shift reaction of D2 is sufficiently effective in reducing CO for phosphoric acid electrolyte fuel cells. Therefore, the skilled person would not have to make tests with pure H₂. The PSA is only used in D2 for regeneration of the desorption gas.

A further purification of the fuel gas leaving the shift reactor is off-the-track and causes higher costs. With the shift reaction CO can be reduced to below 1%.

Reasons for the Decision

1. *Main Request*

1.1 Amendments and Novelty (Requirements of Articles 123(2) and (3) and 54 EPC)

The Board sees no reasons why it should deviate from the opinion of the Opposition Division that the claims comply with Article 123(2) and (3) EPC and that the claimed subject-matters are novel in the sense of Article 54 EPC. Since novelty and admissibility of the amendments have not been in dispute, it is not necessary to give detailed reasons for these findings. As to novelty, reference is also made to sections 1.2 and 1.4 below.

1.2 Inventive Step of Claim 1

- 1.2.1 It is undisputed that document D2 discloses the nearest prior art with respect to the subject-matter of claim 1.

D2 refers to the production of hydrogen for a fuel cell that may be designed as phosphoric acid fuel cell stack (see column 6 at the bottom to column 7 paragraph 1, column 13 lines 12 to 15, the sentence bridging columns 14 and 15 and claims 5 and 12). The hydrogen-rich gas is produced using a pair of regenerative reformers that are used alternatively, that is when one reactor is producing hydrogen the other is being regenerated (see e.g. Figures 1, 4, 5A and 5B). The hydrogen-rich gas is obtained from hydrocarbon fuel by subjecting the gas stream to catalytic reformation and to a water-shift reaction, in order to convert CO and H₂O into additional H₂ and CO₂. This is reported to be desirable when the gas stream is to be fed to a phosphoric acid fuel cell which cannot tolerate more than a few percent of CO (see column 6 at the bottom to column 7 paragraph 1). There it is also suggested that CO₂ could be removed, if desired, using well known scrubbing techniques. However, this is not considered necessary with phosphoric acid electrolyte fuel cells.

It is indicated (see column 3 lines 61 to 66) that additionally also the purge gas from a PSA unit may be used for the hydrogen purification. It is not disclosed that this purification should be used in any way in providing hydrogen for fuel cells, in particular for phosphoric acid fuel cells, or is to be used for another purpose.

1.2.2 As a consequence, the subject-matter of claim 1 is distinguished from the prior art disclosed in D2 mainly in that the hydrogen-rich gas stream, already subjected to the shift reaction and therefore containing low CO concentration, is further purified by PSA.

This measure has the effects that the service life is considerably increased and that the process can be carried out at a low load for some time without the need of taking the cell stack off-stream. Nevertheless, the efficiency of the system as a whole is approximately the same. The description of the patent furnishes plausible evidence that these advantages can in substance be achieved (see e. g. EP-B-0 345 908 column 3 lines 7 to 38 and column 4 lines 16 to 38).

Therefore, the problem underlying the invention according to claim 1 is to improve a process for converting a fuel on the basis of hydrocarbon into electricity based on a phosphoric acid fuel cell according to D2 such that the above-mentioned effects are obtained.

1.2.3 It is evident from section 1.2.1 above that D2 does not provide any teaching or suggestion to further purify the hydrogen-rich gas stream already subjected to the water-shift reaction and therefore containing low concentrations of CO which are said to be tolerated by the type of fuel cell used here. Said concentrations are very low - it is credible that concentrations considerably below 2% are obtained - and therefore less than "a few percent" mentioned in column 6 at the bottom.

1.2.4 Document D1 does not provide any teaching or suggestion to further purify the gas stream. Removal of CO from a hydrogen-rich gas stream obtained by reforming and water-shift reaction is not mentioned and thus seems to

be no problem. Removal of CO₂ is discussed, either by scrubbing it with aqueous potassium carbonate solution or by a PSA unit (see page 2 paragraph 4). It is, however, pointed out that said removal can be omitted with fuel cells which can tolerate CO₂ (see page 2 lines 60 to 61). Since, according to D2, removal of CO₂ is not considered necessary when using phosphoric acid electrolyte fuel cells, the skilled person would not envisage any removal of components from the hydrogen-rich gas stream.

1.2.5 Document D3 reports that commercial PSA units are capable of purifying raw gas having been steam-reformed and subjected to a water-shift reaction. If desired, purities up to 99.999% can be obtained. However, it is nowhere disclosed or suggested that such purified gas is to be used for fuel cells or the like, let alone that they are particularly advantageous when the process according to D3 is combined with the generation of electricity in fuel cells based on phosphoric acid electrolytes.

1.2.6 The appellant takes the view that purification of the hydrogen-rich gas stream fed to the fuel cell stack is part of the normal experimental work of the skilled person. In a first step he would use pure hydrogen for fuel cells on a laboratory scale. Routine research then includes running the stack with different degrees of purities of hydrogen, in particular in admixtures with different amounts of CO. The result of such tests would show that a high purity hydrogen gas leads to an increase of the lifetime of the stack. In order to implement this result on a big scale, the obvious choice to obtain such a gas stream directly leads to the PSA method.

The appellant, however, does not provide convincing arguments why the skilled person should have focussed his efforts on the question of purity of the hydrogen-rich gas in order to solve the above-mentioned problem. Moreover, the prior art presented by the appellant does not provide any hint that the problem can be solved by improving the purity of the gas fed to the stack beyond the level found sufficient by the cited documents. Even if it could be expected that use of hydrogen of a very high degree of purity would have a positive effect on the performance of the stack, the skilled person had to consider not only the performance of the stack alone but also that of the process as a whole. In the present case, the cited prior art confers the impression that the skilled person would not try to improve a parameter which is believed to be already fitting.

Moreover, even if the skilled person envisaged further reduction of CO, he would rather try to improve the shift reaction than to provide a further process step. The argument of the respondent that a much lower concentration of CO than 1% can be obtained seems to be plausible. Application of the PSA method would be an additional step requiring relatively high technical investments. Furthermore, PSA is not the only method suitable to reduce the CO concentration of the hydrogen-rich gas leaving the shift reactor.

The appellant alleges that in the presence of inert gases the increasing dilution of H₂ along the reaction zone of the cell in the direction of the gas flow is responsible for a lower efficiency of the cell, whereby said dilution is originating from the consumption of the hydrogen. However, it seems that in any case the consumed hydrogen molecules are replaced by the same number of molecules of the reaction product, namely water. Thus, the skilled person would take into account

that the improved efficiency, possibly achieved by removal of the inert gas components, e.g. in a PSA unit, would be largely invalidated by said generation of water in the cell.

1.3 For these reasons, the subject-matter of claim 1 is not obvious with respect to the cited prior art and, therefore, is considered to involve an inventive step in the sense of Article 56 EPC.

1.4 The same conclusion applies to independent apparatus claim 15, which comprises, in the form of device features, the same essential features as claim 1.

The dependent claims concern particular embodiments of the subject-matter of claim 1. Therefore, they are likewise inventive.

1.5 Hence, the Board takes the view that the claims of the main request comply with the requirements of the EPC. Since this applies also to the other documents of the main request, the patent can be maintained on the basis of the documents according to the main request (which is identical with ANNEX II of the decision under appeal).

2. *Auxiliary request*

In view of this finding, it is not necessary to consider the auxiliary request.

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

P. Martorana

E. Turrini

For information of the Board of Directors

The Board of Directors

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