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D E C I S I O N
of 20 July 2005

Case Number: T 0192/04 - 3.4.2

Application Number: 99110660.0

Publication Number: 0964466

IPC: H01M 8/12

Language of the proceedings: EN

Title of invention:
Process integrating a solid oxide fuel cell and an ion transport reactor

Patentee:
Praxair Technology, Inc

Opponent:
Air Products and Chemicals, Inc.

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - main request (no) - first auxiliary request (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0192/04 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 20 July 2005

Appellant: (Opponent)	Air Products and Chemicals, Inc. 7201 Hamilton Boulevard Allentown PA 18195-1501 (US)
Representative:	Teipel, Susanne Schwabe, Sandmaier, Marx Patentanwälte Stuntzstrasse 16 D-81677 (DE)
Respondent: (Proprietor of the patent)	Praxair Technology, Inc. 39 Old Ridgebury Road Danbury CT 06810-5113 (US)
Representative:	Schwan, Gerhard, Dipl.-Ing. Schwan Schwan Schorer Patentanwälte Bauerstrasser 22 D-80796 München (DE)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted 12 December 2003 rejecting the opposition filed against European patent No. 0964466 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: A. G. Klein
Members: M. A. Rayner
M. J. Vogel

Summary of Facts and Submissions

I. The opponent lodged an appeal against the decision of the opposition division rejecting the opposition against European patent 964 466 (application number 99 110 660.0). The patent concerns a process providing a solid oxide fuel cell and ion transport reactor.

II. In the decision under appeal, reference was made to documents including the following:

D2 "Integration of fuel cells and electrically driven oxygen, separation systems", Research Disclosure (Anonymous), Nov. 1996, pages 695-699, Kenneth Mason Publications, Ltd,

D3 Topical Report "Advanced Oxygen Separation Membranes", Sept. 1990, Pages 54, 55, 58, Figs. 5-8,

D7 US-A- 5 562 752,

The opposition division considered document D2 to represent the closest prior art, the division not identifying therein any series flow of air from a solid oxide fuel cell to a solid electrolyte oxygen system. In Figure 1, concerning a radial design, the air feed to the solid oxide fuel cell and solid electrolyte oxygen system is shown to be the same, there is no conduit leading from the exhaust of the solid oxide fuel cell tubes to the solid electrolyte oxygen system tubes. The division saw an improvement in efficiency achieved because oxygen concentration and temperature of retentate from the solid oxide fuel cell was high

enough for the solid electrolyte oxygen system. The division was therefore satisfied as to substantive patentability.

III. In its appeal, the appellant requests that the decision under appeal be set aside and the patent revoked. The respondent (=patentee) requests that the appeal be dismissed, or should the board not be able to comply with this request, maintenance of the patent on the basis of a first to third auxiliary request. Oral proceedings were requested on an auxiliary basis by both parties, which led to appointment thereof by the board.

IV. The wording of the independent claim according to the main and first auxiliary request is as follows.

Main Request

"1. A process for the generation of electric power and a product gas stream from a mixture of an oxygen—containing stream gas (28) and a first gaseous fuel stream (30), comprising:
(a) providing a solid oxide fuel cell (10) having a first cathode side (14) and a first anode side (16);
(b) providing a first ion transport reactor (11) having an oxygen-selective ion transport membrane (44) disposed therein, said oxygen-selective ion transport membrane having a second cathode side (40) and a second anode side (50) and being capable of transporting oxygen ions and electrons;
(c) contacting said oxygen-containing gas stream (28)with said first cathode side (14) and contacting

said first gaseous fuel stream (30) with said first anode side (16);
(d) transporting a first oxygen portion of said oxygen-containing gas stream from said first cathode side to said first anode side;
(e) reacting said first oxygen portion with said first gaseous fuel stream (30) at said first anode side (16) and generating a flow of electrons (34) from said first anode side to said first cathode side (14);
(f) recovering said flow of electrons (34) as electric power;
(g) directing a remainder of said oxygen-containing gas stream (28) as a first retentate stream (38) from said first cathode side (14) to said second cathode side (40);
(h) contacting said first retentate stream (38) with said second cathode side (40) arid transporting a second oxygen portion from said second cathode side to said second anode side (50); and
(i) recovering a gas stream as said product gas stream (52) from at least one of said first cathode side (14), said first anode side (16), said second cathode side (40) and said second anode side (50)."

First Auxiliary Request

Claim 1 of this request differs from claim 1 of the main request in that

its 15th to 17th words "a mixture of" have been deleted

and in that

the following words have been added at the end of feature (b), i.e. after (50), "and being capable of transporting oxygen ions and electrons"

The wording of the independent claims according to the second and third auxiliary request is not given as they are not subject of the present decision (see section 4.1 of the reasons below).

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

Consequent to a recitation of a "mixture" of an oxygen-containing stream gas and a first gaseous fuel stream in claim 1 of the main request, the teaching of the patent is insufficient because use of a single feed stream is not enabled by the patent.

In its submissions concerning substantive patentability of claim 1 of the main request, the appellant argued that the claim does not require that all of the retentate gas of the first cathode side be contacted with the second cathode side and that any forcing of a solid oxide fuel cell exhaust to the cathode side of a solid electrolyte oxygen system device meets the claimed wording "directing" to the cathode side of an ion transport reactor. It is not necessary to have a specific conduit as mentioned in the decision under appeal. Indeed the patent does not explain exactly how the directing is to be achieved. This is illustrated by the use of words in the specification such as discharging, conducting and delivering for the function concerned. In any case the skilled person knows that gas flow will be defined by baffles in document D2, as is usual with heat exchangers. There is a flow from the solid oxide fuel cell to solid electrolyte oxygen system in the lower part of Figure 1 of document D2 and

a particular order of the devices would not involve any inventive step as it is a matter of routine. In Figure 1 of document D2, the solid electrolyte oxygen system tubes are cooler simply because they are outwardly disposed as explained in the document.

So far as the first auxiliary request is concerned, it is apparent that part of the electricity generated according to document D2 is used to power the oxygen generation device, an obvious route for optimising recovery of electricity would be reduction of electricity necessary for oxygen production. Documents D3 and D7 show that both pressure and electrically driven membranes are known for the ion transport reactor. In D7 this is in the context of a combustion reaction, which produces a similar exhaust gas to a solid oxide fuel cell. There is thus no inventive step involved in selecting a pressure driven membrane to save electric power. In addition, an ion transport reactor with an electrically driven membrane is rather similar to a solid oxide fuel cell and the components shown for example in Figure 4 onwards of the patent specification indicate that even the use of two solid oxide fuel cells is contemplated by the patent. This is not consistent with claim 1 according to the first auxiliary request.

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

Feature (g) of claim 1 implies that a means for directing is present. During the oral proceedings, the respondent explained that claim 1 is not limited to a situation where the solid oxide fuel cell and solid

electrolyte oxygen system are contained in physically separate units and does not exclude a configuration like that shown in Figure 1 of document D2, i.e. a radial design of tubular solid oxide fuel cell and solid electrolyte oxygen system. Document D2 does not disclose a flow of depleted gas to an ion transport reactor. Figure 1 of document D2 is to be understood as involving a radial air flow, i.e. inwardly towards the axis, and not a top to bottom flow as indicated by the arrow in Figure 1, as for thermal reasons gas must always go to the cooler outer solid electrolyte oxygen system before the inwardly disposed hotter solid oxide fuel cell. This is confirmed by the temperature profile. The skilled person would also avoid passing a hot retentate gas to the solid electrolyte oxygen system of document D2 as the latter has an electrically driven membrane susceptible to thermal runaway. An arrangement as claimed with the hotter solid oxide fuel cell first cannot therefore be obvious.

With respect to the claim 1 of the first auxiliary request utilising a conductor capable of transporting oxygen ions and electrons in the ion transport reactor is beneficial in enabling energy to be recovered from the retentate under pressure and no electrical power is required for the oxygen separation, enhancing efficiency. Since document D2 relates to electrically powering the oxygen generator, it cannot be obvious to use a pressure driven device.

VII. The board gave its decision at the end of the oral proceedings.

Reasons for the Decision

1. The appeal complies with the provisions referred to in Rule 65(1) EPC and is therefore admissible.

2. *Main Request*

2.1 In the arguments of the parties pertaining to substantive patentability, only feature (g) of claim 1 was in dispute, i.e. a feature pertaining to directing an oxygen depleted remainder of an oxygen-containing gas stream from the cathode side of the solid oxide fuel cell to the cathode side of the ion transport reactor. In the context of deciding patentability, the board also sees no reason for effecting a detailed analysis of other claimed features.

2.2 According to the respondent, a radial design like that shown in Figure 1 of document D2, i.e. a number of tubes around an axis of a common tubular casing, is not, in principle, excluded by the wording of the claim, i.e. it is not necessary, for example, for the solid oxide fuel cell and the ion transport reactor each to be in its own separate enclosure, as might be thought from the diagrammatic presentation of 38 in say Figure 1 of the patent. The position of the respondent means that "directing" as performed in the Figure 1 embodiment of document D2 by whatever means must, as such, therefore satisfy the "directing" wording of claim 1 in view of a radial design being concerned in both cases. Unlike the opposition division, the board is not therefore able to attach any weight in its assessment of patentability to a lack of a conduit being shown in Figure 1 of document D2.

2.3 In the fuel on bore side arrangement of radial design (Figure 1 with Figure 3 of document D2), the skilled person knows that, consequent to flowing in the arrangement, the air flow around the outside of the tubular units will not remain completely separated between solid oxide fuel cell tubes and solid electrolyte oxygen system tubes. There is therefore flow of oxygen depleted gas from a solid oxide fuel cell tube to a solid electrolyte oxygen system tube. This is all the more so in a case where the solid oxide fuel cells and solid electrolyte oxygen system devices are interspersed as mentioned in item 2 (right side of page 697 of document D2). As a radial design of device is not excluded by the claim in dispute, the board agrees with the argument of the appellant that no more than flow of an unquantified remainder of depleted retentate to the cathode side of the ion transport reactor can be required by the claim. Even taking a, for the respondent, generous approach to novelty, no more can be at issue than whether more or less oxygen depleted retentate from a solid oxide fuel cell reaches any specific solid electrolyte oxygen system, dealing with which amounts to no more than a routine task for the skilled person. The board therefore came to the conclusion that whether it be "discharging, conducting or delivering", directing an oxygen depleted remainder in accordance with feature (g) of claim 1 can be considered obvious to the skilled person in the light of the radial system shown in Figure 1 of document D2.

2.4 The arguments about thermal performance of the solid oxide fuel cell and solid electrolyte oxygen system devices in relation to feature (g) of the claim are

somewhat less relevant in the board's view because (1) the claim is not limited to thermal properties of the devices, and (2) document D2 discloses constructions with both similar and different operational temperatures of the devices. The case of the respondent is also weakened by underlining that an electrically driven membrane, of the type shown in document D2, is susceptible to thermal runaway. This is because this approach relies more on the description of say pressure driven ion transport reactor 11 in Figure 1, than what is actually claimed in claim 1, in which the type of membrane is not so limited. Moreover, since the board considers the circumferentially arranged units in Figure 1 to be cooler simply because they are at the periphery, the respondent also failed to persuade the board that, despite only a downward arrow being shown in Figure 1 of document D2, a radial arrangement requires a radial input of the air stream around the circumference of the casing to provide a lower temperature at the periphery of the casing.

2.5 The subject matter of claim 1 according to the main request cannot therefore be considered to involve an inventive step within the meaning of Article 56 EPC.

2.6 Since the subject matter of claim 1 does not meet the requirements of substantive patentability, the main request fails and it is not necessary to delve further into the submissions of the parties in relation to sufficiency.

3. *First Auxiliary Request*

3.1 Amendments

The board considers it permissible for the patentee to have made the two amendments effected to claim 1 (in the first line and in the last line of feature (a), respectively), as both were in response to an objection from the other party. The board is moreover satisfied as to compliance with Article 123(2) and (3) EPC as deleting a "mixture" is a limitation excluding any question of a single feed stream which is supported by the description of the patent and the particular process steps claimed. Support for the amendment concerning the ion transport membrane, which also limits the claim can be found in the documents as filed (see line 33 on page 5 of the "A" specification).

3.2 Sufficiency (Article 83, Article 100(b) EPC)

The approach of the appellant was predicated on the wording "a mixture of" which was contained in granted claim 1. As this wording is no longer present in claim 1 according to the auxiliary request, this approach cannot be persuasive in relation to the wording of claim 1 of the first auxiliary request.

3.3 Patentability (Articles 54 and 56 EPC)

3.3.1 Aside from the deletion, claim 1 according to the first auxiliary request differs from the main request by virtue of the feature "and being capable of transporting oxygen ions and electrons". This feature is novel over the teaching of document D2 because the

teaching of the latter document is restricted to electrically driven membranes, i.e. oxygen ion transport membranes which do not conduct electrons. In providing a solid oxide fuel cell and ion transport reactor, a problem solved by this subject matter is increase efficiency because electrical energy is not required for the membrane of the ion transport reactor.

3.3.2 While the board agrees with the appellant that both pressure and electrically driven members for an ion transport reactor are known from say documents D3 and D7, the appellant did not deliver a convincing chain of reasoning as to why, in the case of document D2, this means it is obvious to the skilled person to change the electrically driven membrane to a pressure driven membrane. The idea underlying the teaching of document D2 is after all to replace a power supply for a solid electrolyte oxygen system device with a solid oxide fuel cell, particularly in areas which do not have a power supply grid (see the introduction). It is therefore not obvious that there should be any possibility of using a pressure driven ion transport membrane according to the present claim because there is not then any power supply to replace. In fact, if a pressure driven ion transport reactor were simply to replace the solid electrolyte oxygen system of document D2, it would, owing to electron conduction, tend to short out the solid oxide fuel cell. The approach of the appellant that the skilled person would seek to save electricity and thus use a pressure driven device is tinged with hindsight as contrary to the underlying idea of document D2 a solid oxide fuel cell would then no longer be needed to provide an electrical power supply. With respect to document D7, a combustor (like

105 in Figure 1) is not a solid oxide fuel cell and therefore has a different configuration involving not an oxygen depleted stream but oxygen depleted combustion products being fed to the membrane separator. The skilled person would not therefore have taken this document into consideration in the way suggested by the appellant. Accordingly, the arguments of the appellant about combinations of the prior art documents did not persuade the board, which considers the subject matter of claim 1 of the first auxiliary request cannot be considered obvious and can therefore be considered to involve an inventive step within the meaning of Article 56 EPC.

3.3.3 The remaining claims of the first auxiliary request are in dependent form and thus likewise directed to subject matter which can be considered to involve an inventive step. The description has been amended for consistency with the amended claim and to acknowledge the prior art. It does not contain any subject matter which obviously contradicts the claims, in particular, it cannot be concluded from membrane materials mentioned that Figures 4 onwards concern only electrically driven membranes, as, for example, electrodes are not shown in the Figures. Contrary to the submissions of the appellant, the board does not therefore see any reason why the description as amended should not be considered to satisfy the requirements of the Convention.

4. *Second and Third Auxiliary Requests*

4.1 Since the board was satisfied as to inventive step of the subject matter of the claims according to the first auxiliary request, there was no reason to consider the

second and third auxiliary requests in the present decision.

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 1-10 of the first auxiliary request, filed during the oral proceedings;

- description,
  - pages 3, 5, as filed during the oral proceedings;
  - pages 2, 4, 6-11, as granted;

- drawings, as granted.

The Registrar The Chairman

P. Martorana A. G. Klein