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Datasheet for the decision
of 28 May 2009

Case Number: T 0128/08 - 3.3.05

Application Number: 99902690.9

Publication Number: 1054722

IPC: B01D 53/94

Language of the proceedings: EN

Title of invention:
System for NO_x reduction in exhaust gases

Patentee:
JOHNSON MATTHEY PUBLIC LIMITED COMPANY, et al

Opponent:
Umicore AG & Co. KG

Headword:
Combination of SCR and CRT Systems/JOHNSON MATTHEY et al

Relevant legal provisions:
EPC Art. 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Novelty: yes"
"Inventive step: no"
"Improvement (yes) - technical solution suggested in prior art regardless of whether an extra effect (here: extent of improvement) is obtained"

Decisions cited:

T 0021/81, T 0231/97

Catchword:

-

Case Number: T 0128/08 - 3.3.05

DECISION
of the Technical Board of Appeal 3.3.05
of 28 May 2009

Appellant:
(Opponent)

Umicore AG & Co. KG
Rodenbacher Chaussee 4
D-63457 Hanau-Wolfgang (DE)

Representative:

Vossius & Partner
Siebertstrasse 4
D-81675 München (DE)

Respondent:
(Patent Proprietor)

JOHNSON MATTHEY PUBLIC LIMTED COMPANY
2-4 Cockspur Street
Trafalgar Square
London SW1Y 5BQ (GB)

Daimler AG
Mercedesstrasse 137
D-70327 Stuttgart (DE)

HJS Fahrzeugtechnik GmbH & Co. KG
Dieselweg 12
D58706 Menden (DE)

Representative:

Steimle, Josef
Dreiss, Fuhlendorf, Steimle & Becker
Patentanwälte
Postfach 10 37 62
D-70032 Stuttgart (DE)

Decision under appeal:

Decision of the Opposition Division of the European Patent Office posted 30 November 2007 rejecting the opposition filed against European patent No. 1054722 pursuant to Article 102(2) EPC.

Composition of the Board:

Chairman: G. Raths
Members: E. Waeckerlin
H. Preglau

Summary of Facts and Submissions

I. This appeal is from the decision of the opposition division to reject the opposition against European patent No. 1 054 722.

II. Independent claims 1 and 9 of the patent as granted read as follows:

"1. An improved SCR system for treating combustion exhaust gas containing NO_x *and particulates, comprising in combination and in order, an oxidation catalyst effective to convert at least a portion of NO in said* NO_x *to* NO_2 *and enhance the* NO_2 *content of the exhaust gas, a particulate trap, a source of reductant fluid, injection means for such reductant fluid located downstream of said particulate trap and an SCR catalyst."*

"9. A method of reducing pollutants, including particulates and NO_x*, in gas streams, comprising passing such gas stream over an oxidation catalyst under conditions effective to convert at least a portion of NO in the gas stream to* NO_2 *and enhance the* NO_2 *content of the gas stream, removing at least a portion of said particulates in a particulate trap, reacting trapped particulate with* NO_2*, adding reductant fluid to the gas stream to form a gas mixture downstream of said trap, and passing the gas mixture over an SCR catalyst under* NO_x *reduction conditions."*

III. In the decision under appeal the opposition division held that the claimed subject-matter was novel and inventive over the disclosures of the documents referred to during the opposition proceedings, including in particular the following documents:

D2:	EP 0 341 832 B1
D3:	EP 0 758 713 A1
D13:	Besprechungsprotokoll "Vorstellung SCRT-System durch Fa. HJS" dated 21 July 1997, with annex: "Das neue SCRT System. Eine Kombination aus SCR-Katalysator und CRT-System".
D14:	Letter from "Leipziger Verkehrsbetriebe (LVB) GmbH" to "Sächsisches Staatsministerium für Wirtschaft und Arbeit, Dresden" dated 1 October 1997, with annex: "Projektbeschreibung Forschungsvorhaben "Schadstoffarme Busantriebe"".
D15:	Hüthwohl, G.; Maurer, B.; Vogel, H.: Emissionen von Dieselmotoren. Der Nahverkehr, 7-8/97, 1997, p. 22 - 27.
D16:	[P. Rodenbüsch]: "CRT" und "SiNO$_x$" zur Senkung von Lastwagenabgasen. Autotechnik, Nr. 12/1996, p. 17.
D18:	Brandin, J. et al.: Catalytic reduction of nitrogen oxides on mordenite; some aspect on the mechanism". Catalysis Today, 4, 1989, p. 187 - 203.
D30:	JP 8 103 636 A
D30/A:	English translation of D30

IV. The opposition division held that the system according to claim 1 of the patent in suit had not been made available to the public by prior use. In particular document D13 relating to the presentation of the combination called "SCRT system" of the "SCR system" with the "CRT system" at a meeting held on 21 July 1997 was not prejudicial to the novelty of the claimed system, because the opponent had failed to prove beyond any reasonable doubt that the contents of D13 were available to the public at the material time. Having regard to document D14 the opposition division expressed the view that this document was, in fact, available to the public from 5 December 1997 onwards, but it did not disclose the system as defined in claim 1.

Document D15 revealed two separate systems, namely the CRT filter for removing hydrocarbons, carbon oxide and particles from diesel exhaust gases on the one hand, and the SCR system for transforming NO_x into N_2 on the other hand. The juxtaposition of the CRT and SCR systems was, however, not disclosed in D15.
Neither D15 nor any other document referred to during the opposition proceedings disclosed all the features of claim 1 as granted.

Regarding inventive step the opposition division observed that document D2 discloses a CRT system comprising an oxidation catalyst for converting NO into NO_2. Subsequently the latter is used to combust the particulates trapped in the filter. There is no disclosure in D2, however, that the exhaust gas needs further treatment for reducing the content of NO. A skilled person looking for such further treatment on its own initiative would primarily turn to document D3, not necessarily D15. The opposition division expressed the view that the teaching of D3 leads away from placing injection means for reductant fluid downstream of the particulate trap. Regarding D15, the opposition division held that the document did not reveal that the CRT and the SCR systems can be combined with each other. Moreover, the opposition division pointed out that the system of claim 1 shows an unexpected technical effect in terms of an increased *"conversion of* NO_x *to* N_2 *at a temperature below 200 °C when compared with a SCR system alone"*.

The opposition division concluded that neither the combination of D2 with D15, nor any other combination of documents referred to during the opposition procedure, led the skilled person *"in an obvious way to the system of granted claim 1 and to the unexpected effect obtained by such system"*.

V. Notice of appeal was given by the appellant (opponent) with letter dated 14 January 2008. The grounds of appeal were submitted with letter dated 10 April 2008. The appellant introduced seven new documents, including in particular the following references:

D31: Maurer, B.: Dieselmotoren schadstoffarm betreiben. TÜ, Bd. 39, Nr. 7/8, Juli/August 1998, p. 18 - 20.

D37: Hüthwohl, G.: Der Dieselmotor - Ein gleichzeitig wirtschaftliches und umweltfreundliches Antriebsaggregat durch Abgasreinigung. In:

Umweltgerecht und Bezahlbar. Antriebskonzepte des Nahverkehrs mit Zukunft. Tagungsband, 2. Nahverkehrsforum Paderborn, 11. - 12. März 1998, p. 39 - 50.

Further submissions were made by the appellant with letters dated 3 November 2008, 28 January 2009, 27 March 2009 and 7 May 2009, respectively.

VI. The respondent submitted its comments with letters dated 15 August 2008, 10 March 2009 and 28 April 2009, respectively. Together with the letter dated 28 April 2009, 35 sets of claims were filed as auxiliary requests.

VII. Observations by third parties under Article 115 EPC were filed on 16 February 2009. In reply, the respondent submitted its comments with letter dated 8 April 2009.

VIII. Oral proceedings were held on 28 May 2009. During the course of the oral proceedings, the respondent filed various new requests replacing its previous requests. Finally two sets of claims representing the main request and a single auxiliary request, replacing all previous requests, were submitted.

IX. Independent claims 1 and 6, respectively, of the main request read as follows:

"1. An improved SCR system for treating vehicle engine combustion exhaust gas containing NO_x *and soot-type particulates, comprising in combination and in order, a* Pt/Al_2O_3 *oxidation catalyst carried on a ceramic or*

metal through-flow honeycomb support containing 1 - 150 g Pt/ft^3 *(0.035 - 5.3 g Pt/litre) effective to convert at least a portion of NO in said* NO_x *to* NO_2 *and enhance the* NO_2 *content of the exhaust gas, a wall-flow filter removing at least a portion of said particulates and reacting trapped particulates by combustion at relatively low temperatures in the presence of* NO_2*, a source of reductant fluid, injection means for such reductant fluid located downstream of said filter and an SCR catalyst using urea as a reductant."*

"6. A method of reducing pollutants, including soot-type particulates and NO_x*, in vehicular exhaust gas streams, comprising passing such gas stream over a Platinum oxydation catalyst carried on a ceramic or metal through-flow honeycomb support containing 1 - 150 g Pt/ft*^{3} *(0.035 - 5.3 g Pt/litre) under conditions effective to convert at least a portion of NO in the gas stream to* NO_2 *and enhance the* NO_2 *content of the gas stream, removing at least a portion of said particulates in a wall-flow filter, reacting trapped particulates with* NO_2*, adding urea as a reductant fluid to the gas stream to form a gas mixture downstream of said filter, and passing the gas mixture over an SCR catalyst under* NO_x *reduction conditions, wherein the NO to* NO_2 *ratio in the gases is adjusted to a level pre-determined to be optimum for the SCR catalyst, by oxidation of NO over the oxidation catalyst."*

Claim 1 of the auxiliary request reads as follows:

"1. A method of reducing pollutants, including soot-type particulates and NO_x*, in vehicular exhaust gas streams, comprising passing such gas stream over a*

Platinum oxidation catalyst carried on a ceramic or metal through-flow honeycomb support containing 1 - 150 g Pt/ft^3 *(0.035 - 5.3 g Pt/litre) under conditions effective to convert a portion of NO in the gas stream to* NO_2 *and enhance the* NO_2 *content of the gas stream, removing at least a portion of said particulates in a wall-flow filter, reacting trapped particulates with* NO_2*, adding urea as a reductant fluid to the gas stream to form a gas mixture downstream of said filter, and passing the gas mixture over an SCR catalyst under* NO_x *reduction conditions, wherein the NO to* NO_2 *ratio in the gases is adjusted by means of the oxidation catalyst together with the filter in order to improve the* NO_x *reduction using the SCR catalyst."*

X. The arguments presented by the appellant, as far as they still apply to the claims according to the main and auxiliary requests reproduced hereinabove under point IX, may be summarised as follows:

Claim 1 of the patent in suit is not entitled to the priority date of 6 February 1998. The sequence of the elements of the system, i.e. the specific arrangement of the oxidation catalyst, the source of reductant fluid and the SCR catalyst, is not defined in the priority document. According to claim 1 of the patent, however, these elements have to be present *"in combination and in order"*.

Furthermore, the priority document does not disclose a *"tank"* or *"reservoir"* of reductant fluid located outside the exhaust gas stream. What the priority document discloses is a source of reductant fluid arranged in the exhaust gas stream between the particulate trap, as well as injection means for such reductant fluid.

For the rest, the priority document provides no basis for the general term *"injection means"*.

The claim directed to the method is not entitled to the priority either. According to the priority document, the gas stream to which the reductant fluid is added contains an *"enhanced* NO_2 *content"*. This implies that the reductant fluid is injected as far as possible immediately after the oxidation catalyst, but not after the particulate trap, where trapped particulates are reacted with NO_2, thus leading to a reduction of the NO_2 content in the exhaust gas stream. According to the patent in suit, it is suggested however to add reductant fluid to the gas stream at some injection point downstream of the particulate trap. In view of these circumstances the appellant concludes that the claimed method cannot be derived directly and unambiguously from the priority document.

Consequently the effective date of the patent in suit is the filing date of the international application, i.e. 28 January 1999, with the effect that documents D31 and D37 are comprised in the state of the art.

The claimed subject-matter was publicly available by public prior use before the effective date of the patent in suit. This can be derived from the fact that members of the *"Verband Deutscher Verkehrsunternehmen"* (VDV) attended various meetings, in particular the meeting summarised in D13. At these meetings there existed neither an explicit nor a tacit agreement of confidentiality. In support of this, the appellant requested the hearing of two witnesses, namely Prof. Müller-Hellmann, who attended one of the meetings as a representative of VDV, and Dr. Hüthwohl, who was author, recipient and/or participant of important evidence, for example in respect of D13.

Document D30 discloses a method for removing NO_x from exhaust gas streams by means of the SCR process using NH_3 as reductant fluid. Typically, the system consists of a catalyst for oxidizing NO to NO_2, followed in downstream direction by a particle filter in the form of a bag filter, injection means for injecting NH_3 into the exhaust gas stream, and a denitration catalyst, i.e. an SCR catalyst.

Thus, document D30 discloses the same arrangement of elements and process steps as the patent in suit.

D15 is concerned with noxious emissions of diesel engines. It discloses that the amount of particulate pollutants can be reduced by means of the CRT system. Having regard to the need to reduce the content of NO_x, it is stated in D15 that *"for the time being the SCR process has the highest potential"*. According to the appellant, the skilled person learns from D15 that the treatment of exhaust gas streams with a CRT system alone is not sufficient because there is only a small reduction of NO_x. Therefore the skilled person concludes from D15 that effective reduction of pollutants including NO_x requires the combination of the CRT and the SCR systems. Thus, the subject-matter of the patent in suit lacks either novelty or at least inventive step.

Lack of inventive step is also evident having regard to the disclosure of document D3 or various combinations of other documents.

Regarding the presence of a surprising technical effect in the form of an increased conversion of NO_x to N_2 at temperatures below 200°C, the appellant points out that no such effect is supported by the disclosure of the patent in suit. On the basis of comparative data given in the patent, it can be concluded that systems equipped with a particulate filter have an improved conversion of NO_x at 225°C, when compared to systems without such a filter. This result is not significant however, because it does not apply to the whole range of operating temperatures extending from roughly below 200°C to 500°C. In any case the results are not unexpected, let alone *"synergistic"*. The effect observed at 225°C can be explained by the fact that in the case of systems equipped with a particulate filter the engine power has to be increased in order to keep the temperature at the entrance of the SCR catalyst at the same level as in systems without a filter. Dynamic operation of vehicles does, however, not allow such a steering of the engine power.

Moreover, experimental tests carried out by the appellant show that the conversion of NO_x of a system according to the state of the art is better than the performance of a system according to claim 1 of the patent in suit.

XI. The respondent dissents with the views of the appellant. In its view the claims are clearly entitled to the priority date of 6 February 1998.

Regarding the alleged public prior use, the respondent observes that the meetings referred to by the appellant were subject to an implicit obligation of confidentiality. Moreover, nothing suggests that participants passed on the information gathered at these meetings to third parties.

Having regard to the documents contained in the prior art, the novelty of the claimed subject-mater is not at stake.

D30 relates to exhausts from stationary engines, not from vehicle engines. Moreover, the bag filter used in the system according to D30 has a different function to that of the particulate trap of the system according to the patent in suit.

D15 discloses the use of either the CRT system or the SCR system for treating exhaust gas streams, but not the combination of the two systems as defined in claim 1. Nor does D15 specifically disclose that the reductant fluid is injected downstream of the particulate trap.

As far as inventive step is concerned, the closest prior art is represented by D3. Starting from D3, the skilled person would have to relocate the injector and the associated source of engine fuel (i.e. reductant) from upstream of the oxidation catalyst to a position between the particulate trap and the reduction catalyst. Only then he would arrive at a system as defined in claim 1. This would, however, subvert the principle of operation of the system according to D3, which consists in injecting fuel upstream of the oxidation catalyst for heating said catalyst. Therefore the skilled person would avoid such a course of action.

In D15 the CRT system is mentioned, but D15 does not give any guidance regarding the combination of both the CRT and the SCR system. At the relevant time, i.e. at the priority date, the skilled person did not contemplate to combine the two systems in order to solve the technical problem posed. Rather he looked for alternative solutions, especially by improving the combustion technology. In contrast to that, the patent in suit provides for the first time a clear teaching of the combination of the systems. Moreover, the improvement in terms of reduction of pollutants, including particulates and NO_x in exhaust gas streams, is surprising. For these reasons, the claimed invention involves an inventive step.

In the respondent's view the analysis provided by the appellant and relating to examples 1 to 3 of the patent in suit is based on hindsight.

As far as the appellant's experimental data are concerned, which purport to reproduce the examples of the patent in suit, the respondent argued that the results are flawed and inconclusive, because a more modern engine was used compared to that which was used in the patent. Furthermore unsuitable ratios of NO_2 : NO_x were used, and in the light duty diesel vehicle tests the system was not optimised for use in a Euro IV light duty diesel vehicles.

XII. Requests of the parties

The appellant requested that the decision under appeal be set aside and that the European patent No. 1 054 722 be revoked.

The respondent requested that the decision under appeal be set aside and that the patent be maintained on the basis of a set of claims according to the main request or the auxiliary request, both requests filed during the oral proceedings.

Reasons for the Decision

1. *Admissibility of the claims filed during oral proceedings*

1.1 Pursuant to Article 13(3) RPBA, amendments sought to be made after oral proceedings have been arranged shall not be admitted if they raise issues which the board or the other party cannot reasonably be expected to deal with without adjournment of the oral proceedings.

1.2 In the present case, the respondent asked to restrict claim 1 of the main request by adding the following features:
The combustion exhaust gas is from a *"vehicle engine"*, the particulates are of *"soot type"*, and the oxidation catalyst is *"a* Pt/Al_2O_3 *oxidation catalyst carried on a ceramic or metal through-flow honeycomb support*

containing 1 - 150 g Pt/ft^3 *(0.035 - 5.3 g Pt/litre)"*. Further, the particulate trap is a *"wall-flow filter removing at least a portion of said particulates and reacting trapped particulates by combustion at relatively low temperatures in the presence of* NO_2*"*. As reductant fluid, *"urea"* is used.

Corresponding amendments were effected to claim 6 of the main request and claim 1 of the auxiliary request.

1.3 These restrictions were made in reply to objections of lack of novelty and lack of inventive step, raised by the appellant and discussed during oral proceedings before the board. The technical significance of said restrictions is clear having regard to the contents of the patent in suit. Moreover, all amendments effected to the claims are clearly based on the text of the patent (see col. 2, lines 9 - 11; col. 3, lines 48 - 51; col. 2, lines 40 - 44; col. 3, line 57; col. 3, lines 2 - 3) and of the application as filed (page 2, lines 18 - 20; page 4, lines 23 - 24; page 3, lines 9 - 11; page 4, line 28; page 3, lines 22 - 23).

1.4 The board considers that the amendments to the claims effected by the respondent did not raise issues under Article 123 EPC which required adjourning the oral proceedings. Under these circumstances the board decided to admit the amended claims to the proceedings.

2. *Priority - Article 88 EPC*

2.1 In the priority document it is stated that the claimed system comprises in combination an oxidation catalyst effective to convert NO to NO_2, a source of reductant fluid and downstream of said source an SCR catalyst. A preferred system incorporates a particulate filter as a further component interposed between the oxidation catalyst and the source of reductant fluid (see page 1, lines 23 - 27). The arrangement may comprise an annular injector ring mounted in the exhaust pipe (see page 2, line 29 to page 3, line 1). Details regarding a typical arrangement of the components are given step by step in a series of tests 1 to 3. In test 1 a conventional SCR system comprising an SCR catalyst and injection means for NH_3 located upstream of the catalyst was used (see page 4, lines 26 - 28). This arrangement was modified in test 2 by inserting into the exhaust pipe upstream of the injection means a platinum oxidation catalyst (see page 5, lines 12 - 13). A further modification was effected in test 3 by interposing a particulate trap between the oxidation catalyst and the injection means for the reductant fluid (page 1, lines 25 - 27; page 5, lines 22 - 23). On the basis of this information, taken together, the board concludes that the priority document discloses an SCR system comprising, in combination and in order, an oxidation catalyst, a particulate trap, a source of reductant fluid, injection means for the reductant fluid, and an SCR catalyst.

2.2 The appellant argued that according to the priority document the source of reductant fluid is arranged in the exhaust gas stream and not outside it. Furthermore, the appellant contested that there is a basis for the general term "*injection means*".

The board is not convinced by these arguments, for the following reasons: It is stated in the priority document that the source of reductant fluid *"conveniently uses existing technology to inject fluid into the gas stream"*. In the board's view the wording of this statement implies that both an external source of reductant fluid, for example NH_3 from a cylinder of compressed gas (see priority document, page 4, lines 28 - 30), and suitable injection means for injecting the reductant fluid into the gas stream, form part of the disclosure.

2.3 Regarding the claimed method of reducing pollutants in gas streams, the appellant argued that there is no disclosure in the priority document that the reductant fluid is injected after the particulate trap.

The board does not accept this argument, because the priority document reveals clearly and unambiguously, that the particulate trap may be located *"between the oxidation catalyst and the source of the reductant fluid"* (see page 1, lines 25 - 27). Thus, it is expressly foreseen to inject the reductant fluid into the gas stream at a point downstream of the particulate trap.

2.4 For the reasons set out above the board is satisfied that the priority has been validly claimed. Therefore the effective date of the claims according to the main request and the auxiliary request is the priority date, i.e. 6 February 1998. Consequently documents D31 and D37 are not comprised in the state of the art within the meaning of Article 54(2) EPC.

3. *Public prior use - Article 54(2) EPC*

3.1 The board notes that according to the decision under appeal it has not been established beyond reasonable doubt that the claimed subject-matter was available by what is called *"public prior use"* before the date of priority. This view was contested by the appellant who asked for hearing witnesses.

3.2 Since the patent in suit has to be revoked for other reasons than *"public prior use"* or, more exactly, oral disclosure, it is immaterial for the outcome of the present appeal, whether the public had access to the disclosure of the documents relating to public prior use or oral disclosure, particularly D13 and D14, or not.

Thus, the board considers that it would not be appropriate to investigate the matter further. In particular, there was no need to hear witnesses.

4. *Novelty - Article 52(1) and 54 EPC*

4.1 Claim 1 of the main request is directed to what is called *"an improved SCR system"*. The conventional SCR (Selective Catalyst Reduction) process can be described as passing hot exhaust gas over a reduction catalyst in the presence of a reductant, particularly urea, thereby reducing the amount of NO_x in the exhaust gas (see description, page 2, lines 18 - 22). A conventional SCR system comprises therefore a source of reductant fluid, injection means for said reductant fluid, and an SCR catalyst. The *"improved SCR system"* as defined in claim 1 comprises further components, namely an oxidation catalyst for the conversion of NO to NO_2 and a particulate filter (see description, page 2, lines 40 - 48).

The board is satisfied that the subject-matter of claim 1 and claim 6 of the main request, as well as the subject-matter of claim 1 of the auxiliary request is novel. In particular, none of the documents referred to by the appellant discloses an SCR system or method comprising a Pt/Al_2O_3 oxidation catalyst carried on a ceramic or metal through-flow honeycomb support containing 1 - 150 g Pt/ft^3 (0.035 - 5.3 g Pt/litre) in combination with a particulate filter of the wall-flow type.

The board concludes that the requirement of novelty laid down in Article 54(1)(2) EPC is met. Since the patent in suit is revoked for other reasons, there is no need to give further details.

5. Inventive step - Article 52(1) and 56 EPC

Claim 1 of the main request

5.1 The patent in suit concerns a system for NO_x reduction in exhaust gases.

5.2 As the starting point for assessing inventive step, the board takes document D15. This document, like the patent in suit, addresses the problem of reducing pollutants from exhaust gases, including three different groups, namely oxidisable gaseous pollutants such as hydrocarbons and CO, oxidisable soot-type particulates, and NO_x (see D15, page 24, column to the middle, third paragraph; column to the right, second last and last paragraphs; patent page 2, paragraphs [0006], [0007] and [0009]). Further, the board underlines the constructional and functional similarity of the concepts for treating vehicle engine combustion exhaust gas between the system according to claim 1 of the main request and that disclosed in D15, respectively.

5.3 Document D15 is a paper assessing the possibilities for reducing emissions from diesel engines used in local traffic operation, for example in vehicles circulating in inner city areas (see page 22, title and column to the left, first paragraph). It is stated in D15 that oxidisable gaseous pollutants of exhaust gas from diesel engines, mainly CO and HC, can be combusted in a converter containing an oxidation catalyst (page 25, column to the left, first paragraph). In this context reference is made to the CRT system (see page 25, column to the right, second paragraph). CRT is an abbreviation for *"Continuously Regenerating Trap"* or *"Continuously Regenerating Technology"*, which has been registered as a trademark. It stands for a two-stage passive diesel particulate filter system, where a wall-flow filter is regenerated using NO_2 generated over an oxidation catalyst located upstream of the filter. Thus the configuration of the CRT system comprises two functional components, namely an oxidation catalyst (upstream) and a wall-flow particulate filter (downstream) packaged into one housing (page 26, column to the left, second paragraph and illustration fig. 9). By using NO_2 to oxidise soot-type particles the filter can be regenerated at relatively low temperatures.

Having regard to the reduction of nitrogen oxides, the following explanations are given in D15:

"Of the possible methods, the SCR process, known from power station technology, currently has the greatest potential attributed to it. In this process, the unwanted nitrogen oxides are converted by adding a selectively acting reductant to suitable catalysts, thus specifically forming N_2 *and* H_2O*. Whereas in stationary installations, ammonia is used as the reductant, safety reasons require switching in vehicles to substances, which are harmless to health. In this connection, numerous investigations regarding the use of urea have been made. Urea, when injected into the hot exhaust gas stream, is capable of releasing* NH_3 *and can therefore act as an indirect ammonia source."* (see page 26, column to the right, first paragraph).

The effects of the CRT and the SCR processes are summarised in the last section of D15 as follows:

"Simultaneous reductions of HC, CO and particulates by over 90 % are possible with the utilisation of a CRT system. The deposited soot is oxidised by NO_2 *formed on the oxidation catalyst at temperatures above about 250 °C."*
"In order to reduce the nitrogen oxides with the aid of the SCR process, an additional reductant, for example urea, has to be added to the exhaust gas, so that the NO_x *can be specifically converted to* N_2*."* (see page 27, column to the left, first paragraph).

D15 does not specifically reveal that the oxidation catalyst is of the Pt/Al_2O_3 type carried on a ceramic or metal through flow honeycomb support containing 1 - 150 g Pt/ft^3 (0.035 - 5.3 g Pt/litre). There is no explicit disclosure either of the specific sequence of the elements, namely the oxidation catalyst and, in downward direction, the wall-flow filter, the source of reductant fluid, the injection means for said reductant fluid, and the SCR catalyst.

5.4 In the written proceedings before the board the respondent argued that D3 represents the closest prior art (see letter dated 15 August 2008, page 13; letter dated 28 April 2009, page 6).

5.4.1 Document D3 is concerned with the purification of exhaust gas from vehicle engine combustion. It discloses *inter alia* a system comprising, in combination and in order, a Pt/Al_2O_3 oxidation catalyst (see Figure 1 and page 3, column 4, lines 50 - 56, reference sign 5), a soot-type particulate filter (page 4, column 5, lines 22 - 23, reference sign 7) and an NO_x absorber (page 4, column 5, lines 44 - 47, reference sign 9). Depending on the composition of the exhaust gas, NO_x is either absorbed in the absorption device, or reduced to N_2 under the influence of reductants such as hydrocarbons, CO or CO_2 (column 6, lines 11 - 48; column 8, lines 3 - 20).

5.4.2 D3 does not disclose the use of urea as the reductant, and it does not disclose either the injection of a reductant downstream of the particulate filter. In this respect the system of D3 is remote from the claimed system. Therefore, the board considers that D15 represents a closer prior art than D3.

5.5 Starting from D15, the technical problem underlying the patent in suit can be seen in the provision of an improved system for treating vehicle engine combustion exhaust gas which is capable of reducing efficiently the levels of hydrocarbons, CO and soot-type particulates, the improvement consisting in reduced levels of NO_x.

5.6 As the solution to this problem, the patent in suit proposes a system according to claim 1 which is characterised in that it combines CRT technology with SCR technology.

As has been explained above (see point 5.3 above), the CRT system is a two-stage particulate filter system, where a filter is continuously regenerated using nitrogen dioxide (NO_2) generated by means of an oxidation catalyst positioned upstream of the filter. On the other hand the SCR system is the selective catalytic reduction of NO_x by a nitrogenous reductant, such as ammonia or urea, in the presence of a reduction catalyst.

5.7 Having regard to the question whether the problem is actually solved by the claimed system, the respondent relied on the example of the patent in suit (see column 5, lines 6 - 18, "Test 3"; lines 20 - 30, "Test 4").

5.8 Although the tests referred to by the respondent have been carried out by using NH_3 as the reductant fluid, and not urea as foreseen in claim 1 of the main request, the board assumes to the benefit of the respondent that the test results are conclusive. It is known in the art that urea evaporates in the hot exhaust gas stream to release NH_3. Therefore, urea can be regarded as an indirect source of ammonia (see D15, page 26, column to the right, lines 11 - 21; page 27, references 8 to 13). In test 3 of the patent in suit a conversion of NO_x of consistently more than 90% was achieved over a range of temperature from 225°C to about 435°C (see column 5, lines 13 - 16; Figure 3), whereas test 4 of the patent in suit gave 88.77% conversion of hydrocarbons, 87.09% conversion of CO, 67% (Fig. 4: 68.57%) conversion of soot-type particulates, and 87% (Fig. 4: 81.08%) conversion of NO_x (see column 5, lines 23 - 25; Figure 4). It follows from these results that the reduction of NO_x of more than 90% and 87%, respectively, represents a significant improvement over the reduction obtained by a conventional CRT system (7.3% and 1.1%, respectively, see point 5.9.1 below).

The board concludes from these results that the technical problem is in fact solved by the claimed solution.

5.9 It remains to be decided whether or not the proposed solution, namely the system according to claim 1 of the main request, was obvious to the skilled person in view of the state of the art. More precisely, the question arises, whether the prior art contained any hints towards combining the CRT and SCR technologies in the manner defined in claim 1.

5.9.1 In D15 it is stated that the effects of exhaust gas after-treatment systems on pollutant emissions have to be analysed in a differentiated manner, depending on the specific pollutant components (page 90, column to the right, second last and last paragraphs). Thus, separate considerations for hydrocarbons and CO, soot-type particulates and NO_x, respectively, are envisaged. D15 goes on to explain that suitably designed CRT systems lead to efficiency levels of over 90% for hydrocarbons and CO, even in city bus operation (see page 25, column to the right, second paragraph; page 26, column to the left, second last line to column to the middle, line 4; Figures 10 and 11). This is confirmed by the experimental data contained in two charts (figures 10 an 11) representing the influence of the CRT system on exhaust emissions. In addition, the charts show a substantial reduction of soot-type particulates, namely from a particle mass (PM) of 0.127 g/kWh to 0.01 and 0.013 g/kWh, respectively, depending on the test conditions (see page 26, fig. 10 and fig. 11). On the other hand, there is only a very minor effect on the levels of NO_x, which decrease in the *"13 point test"* from 5.62 to 5.21 g/kWh (7.3%) and in the *"city bus cycle test"* from 6.48 to 6.41 g/kWh (1.1%). The conclusion is that the CRT system is highly effective for hydrocarbons, CO and soot-type particulates, but not for NO_x.

5.9.2 Regarding the reduction of nitrogen oxide (NO_x) emissions from diesel engines, the authors of D15 explain that *"a considerably higher effort"* is needed in the after-treatment of the exhaust gas. The SCR process is identified as the most promising technology. In vehicles, NH_3 has to be replaced by urea, since the latter is harmless in respect of health risks (see D15, page 26, column to the right, lines 3 - 21). According to D15 *"such systems are presently undergoing development and trial, respectively. For instance, the* *so called SiNO$_x$-system from Siemens is evaluated in field tests since about one year by a consortium made up of MAN, Daimler-Benz, Iveco and Siemens"* (see page 26, column to the right, lines 26 - 32). Relevant information regarding the SiNO$_x$-system referred to in D15 is given in D16, where it is stated that in the pilot test *"involving MAN, Mercedes and Iveco"* urea is admixed as a reductant to the exhaust gases, and gases are subsequently passed over a catalyst on the basis of titanium dioxide (see D16, page 17, column to the right, last paragraph). In other words, the SiNO$_x$-system for vehicles comprises a source of urea as a reductant, injection means for the urea, and a titanium oxide based SCR catalyst located downstream the injection means. This system is said to be primarily designed for reducing NO$_x$ levels *"even under rapidly changing load conditions"* (D16, page 17 column to the right, second last and last paragraphs).

5.9.3 The authors of D15 explain, after having pointed out the high efficiency of the CRT system for the reduction of the levels of hydrocarbons, CO and particulates, that *"an additional reductant, for example urea, has to be added to the exhaust gas, in order to reduce the nitrogen oxides by means of the SCR process and, thus, convert the NO$_x$ into N$_2$."* (see page 27, column to the left, lines 3 - 16; 22 - 27). The reference to an **additional** reductant can only mean that the authors of D15 considered, that the CRT system was not sufficient for the treatment of the exhaust gas because of the low performance regarding the reduction of NO$_x$. Further action for reducing the NO$_x$ levels was therefore suggested, namely the addition of a reductant.

This interpretation is in line with the teaching of D15, in particular with findings (i) to (iii) below:
(i) that the effect of aftertreatment systems on various types of pollutants has to be contemplated in a differentiated manner (see page 24, column to the right, second last paragraph);
(ii) that nitrogen oxides NO and NO_2 have to be converted into N_2 by reduction (see page 24, column to the right, last paragraph); and
(iii) that the SCR process using a selective reductant is the most promising method (see page 26, column to the right, lines 6 - 13).

5.9.4 A further pointer to the combination of an SCR system, using urea as the reductant, with an oxidation catalyst and a particulate filter is provided by SAE technical paper SAE 930363, to which D15 refers expressly (see page 26, column to the right, line 21, reference 9; page 27, reference 9). Already the title of the paper, i.e. *"Off-Highway Exhaust Gas After-Treatment: Combining Urea-SCR, Oxidation Catalysis and Traps"*, gives an unambiguous and sufficient hint to the skilled person for combining the two key technologies concerned.

5.9.5 In the respondent's view the CRT and SCR systems are presented in D15 as two distinct technologies, which are to be used as alternatives, but not in combination (see letter dated 15 August 2008, page 14, second paragraph).

The board does not agree with this argument. In this respect, the board observes that nothing in D15 leads the skilled person to the conclusion that the CRT and SCR technologies are mutually exclusive, or that they cannot be joined together in order to achieve combined effects in systems for treating vehicle engine combustion exhaust gas.

5.9.6 The board does not ignore that the exact order of the CRT system and the SCR system in the combined arrangement is not expressly defined in D15. However, for technical reasons the skilled person will install the SCR system downstream of the CRT system, and not vice versa. The respondent argued that having regard to the disclosure of D15, the sequence could be reversed, so that the SCR system would be arranged upstream of the CRT system. In the board's view, such an interpretation of the contents of D15 does not sufficiently consider the functional relationship between the two steps of the system. It is generally known in the art that the regeneration of the particulate filter forming part of the CRT system requires an enhanced level of NO_2. On the other hand, the primary function of the SCR system consists in removing NO_x, i.e. NO and NO_2, from the exhaust gas stream by reduction to N_2. To install the SCR system upwards of the CRT system would not only impair the proper functioning of the filter, but it would also mean that any NO_2 released by the filter remained in the exhaust gas stream without being converted to N_2. Obviously such an arrangement would not be effective.

5.9.7 As far as the individual features of the first part of the combined arrangement are concerned, i.e. the oxidation catalyst and the particulate filter, D15 is of no avail. The skilled person will therefore look for another document dealing specifically with CRT technology. Such a document is D2. It relates to

certain improvements in the removal of particulates from diesel exhaust gas, including exhaust gas produced by vehicle engines such as a 2.5 liter Peugeot diesel engine (see page 2, lines 3 - 4; page 7, line 33). Figure 1 of D2 shows a system for treating combustion exhaust gas containing NO_x and soot-type particulates, comprising in combination and in order:
(i) a Pt/Al_2O_3 oxidation catalyst carried on a ceramic through-flow honeycomb support (Figure 1, reference sign 1; page 2, line 50: page 3, lines 20 - 21; page 3, lines 42 - 44) containing, for example, 2.8 g Pt/litre (80 g/ft^3, see page 4, line 10; or 38 g Pt/825 in^3, see page 8, line 48), effective to convert at least a portion of NO in said NO_x to NO_2 and enhance the NO_2 content of the exhaust gas; and
(ii) a particulate filter, for example a wall-flow filter (Figure 1, reference sign 3; page 3, lines 27 - 28) removing at least a portion of the particulates and reacting trapped particulates by combustion at relatively low temperatures, for example 225 to 300°C (see page 2, lines 25 - 26) in the presence of NO_2.

Thus, D2 discloses all the features of claim 1 of the main request, as far as they relate to the oxidation catalyst and the filter device.

5.9.8 By combining the technical teachings of D15 and D2, the skilled person arrives at the invention as defined in claim 1 of the main request. Such a combination of documents is obvious, because D2 describes in specific manner the CRT technology, which is presented in D15 as one of the key elements of efficient treatment of vehicle engine combustion exhaust gas.

5.9.9 Regarding the alleged presence of a surprising technical effect of the claimed system in terms of an unexpected improvement of the NO_x conversion, particularly at low temperatures, the board notes that there is no evidence in support of the statement made in the decision under appeal, according to which the claimed system shows an increased or even *"synergistically enhanced"* conversion of NO_x to N_2 at temperatures below 200°C (see decision by the opposition division dated 30 November 2007, page 7, second paragraph, lines 11 - 16: third paragraph, lines 1 to 6). Figures 1 and 3 of the patent in suit, to which reference is made in the decision, contain no data relating to 200°C or below, but only to temperatures of 225°C and above. Therefore the relevant statement in the decision appears to be based on an error.

5.9.10 Regarding the experimental evidence in support of the performance of the claimed system, the parties to the proceedings have expressed controversial views (see appellant's letter dated 10 April 2008, pages 41 to 51 and annexes 1, 2; appellant's letter dated 27 March 2009, pages 31 to 44 and annex 3; respondent's letter dated 15 August 2008, pages 17 to 28; respondent's letter dated 28 April 2009, pages 7 to 8).

5.9.11 In view of the case law of the boards of appeal, there is no need to enter into the details of this debate. Given the fact that the system according to claim 1 of the main request is obvious to the skilled person in view of the relevant state of the art, it is immaterial for the assessment of inventive step, whether an extra effect - possibly unforeseen - (here: the extent of the improvement in terms of a particularly high reduction of the NO_x levels) is achieved. In this respect the board refers to the decision T 21/81, wherein it is stated in headnote 1 that *"if, having regard to the state of the art, something falling within the terms of a claim would have been obvious to a person skilled in the art, because the combined teaching of the prior art documents could be expected to produce an advantageous effect, such claim lacks inventive step, regardless of the fact that an extra effect (possibly unforeseen) is obtained."* (see T 21/81, OJ EPO 1983, 15; see also T 231/97, reasons 5.7.5.2).

Claim 6 of the main request

5.10 As far as claim 6 of the main request is concerned, the board notes that the claim contains only one technical feature going beyond what is already implied by the system according to claim 1. Claim 6 requires, in fact, that *"the NO to* NO_2 *ratio in the gases is adjusted to a level pre-determined to be optimum for the SCR catalyst, by oxidation of NO over the oxidation catalyst"*.

In the board's view this feature cannot make a contribution to inventive step, because it is generally known in the prior art that the ratio of NO to NO_2 has an impact on the performance of the SCR process. This general knowledge is illustrated, for example, by D30 and D30/A, respectively, where it is stated that *"the* NO_x *removal performance is raised, when the NO:*NO_2 *ratio in the exhaust gas is 1:1"*, and *"an increase in the denitration performance can be expected if the proportions of NO and* NO_2 *present can be controlled"* (see D30/A, page 5, section [0012]). A further example is D18, where the impact of the NO_2 to NO ratio on NO_x reduction is discussed in some detail (see page 191, line 5 to page 192, line 2). Therefore, in the absence of any non-obvious features, claim 6 lacks an inventive step.

Claim 1 of the auxiliary request

5.11 Claim 1 of the auxiliary request corresponds to claim 6 of the main request, with the exception that the step relating to the adjustment of the NO to NO_2 ratio is worded differently. Whereas claim 1 of the auxiliary request requires the ratio to be adjusted *"by means of the oxidation catalyst together with the filter in order to improve the* NO_x *reduction using the SCR catalyst"*, it is stated in claim 6 of the main request that the adjustment is effected *"to a level pre-determined to be optimum for the SCR catalyst, by oxidation of NO over the oxidation catalyst"*. The board considers that this difference of wording is purely formal and, consequently, not relevant for the assessment of inventive step. In both cases the purpose of the adjustment of the NO to NO_2 ratio lies in achieving the best possible conversion of NO_x to N_2 in the SCR process. Since NO_2 is produced by the oxidation catalyst and subsequently consumed at least in part for the combustion of trapped particulate in the filter, the ratio of NO to NO_2 depends inevitably on the operating conditions of both the oxidation catalyst and the filter device, irrespective of whether both elements are explicitly mentioned, or not. Therefore, from a technical standpoint, there is no material difference between claim 1 of the auxiliary request and claim 6 of the main request. Thus, the assessment of inventive step is the same for both claims.

6. In view of the reasons set out above the board concludes that claims 1 and 6 of the main request, as well as claim 1 of the auxiliary request, do not involve an inventive step as required by Article 52(1) and Article 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

G. Rauh G. Raths