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**D E C I S I O N**  
**of 14 April 1999**

**Case Number:** T 0775/96 - 3.2.4

**Application Number:** 91402247.0

**Publication Number:** 0477046

**IPC:** F02M 25/07

**Language of the proceedings:** EN

**Title of invention:**  
Direct injection diesel engine

**Patentee:**  
Nissan Motor Company Limited

**Opponent:**  
Robert Bosch GmbH

**Headword:**  
-

**Relevant legal provisions:**  
EPC Art. 56

**Keyword:**  
"Inventive step - (yes) after amendment"

**Decisions cited:**  
T 0144/85, T 0389/86, T 0438/90, T 0859/90, T 0767/91

**Catchword:**  
-



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Boards of Appeal

Chambres de recours

Case Number: T 0775/96 - 3.2.4

**D E C I S I O N**  
**of the Technical Board of Appeal 3.2.4**  
**of 14 April 1999**

**Appellant:** Robert Bosch GmbH  
(Opponent) Postfach 30 02 20  
70442 Stuttgart (DE)

**Representative:** -

**Respondent:** Nissan Motor Company Limited  
(Proprietor of the patent) No. 2, Takara-cho  
Kanagawa-ku  
Yokohama-city  
Kanagawa-prefecture (JP)

**Representative:** Beauchamps, Georges  
Cabinet Weinstein  
20, avenue de Freidland  
75008 Paris (FR)

**Decision under appeal:** Interlocutory decision of the Opposition Division  
of the European Patent Office posted 22 July 1996  
concerning maintenance of European patent  
No. 0 477 046 in amended form.

**Composition of the Board:**

**Chairman:** C. A. J. Andries  
**Members:** H. A. Berger  
J. P. B. Seitz

## Summary of Facts and Submissions

I. The appellant (opponent) lodged an appeal, received on 27 August 1996, against the interlocutory decision of the opposition division, dispatched on 22 July 1996, on the amended form of the European patent No. 0 477 046. The appeal fee was also paid on 27 August 1996. The statement setting out the ground of appeal was received on 22 November 1996.

Opposition was filed against the patent as a whole and based on Article 100(a) and (c) EPC. The following prior art documents were cited during the opposition proceedings and have again been taken into account in the appeal proceedings:

D1: EP-A-0 345 431 (mentioned in the patent specification)

D7: DE-A-3 606 246

D9: DE-A-2 849 508

D10: DE-A-3 444 877

D11: MTZ Motortechnische Zeitschrift 33 (1972) 3, pages 100 to 108

D12: MTZ Motortechnische Zeitschrift 51 (1990) 2, pages 46 to 52

D13: Bosch Technische Berichte 5 (1976) 4, pages 176 to 186

II. During the appeal proceedings the following prior art documents were cited for the first time by the appellant:

D14: Pounder's Marine Diesel Engines, sixth edition 1984, Butterworths, London, pages 225 to 227, 233 to 239, 244, 250, 277 to 279, 299 to 303, 326 to 331, 334 and 335, 343 to 345, 366, 388 to 391, 402 to 403

D15: Pounder, Diesel Engine Principles and Practice, 1955, George Newnes Limited, London, pages 18-11 to 18-13, 20-8 to 20-15

D16: Bussien, Automobiltechnisches Handbuch, erster Band, 18. Auflage, 1965, Technischer Verlag Herbert Cram, Berlin, pages 696 to 699, 704 and 705, 746 and 747

D17: Taschenbuch für den Kraftfahrzeug-Ingenieur, Heinrich Buschmann-Paul Koeßler, 1963, 7. Auflage, Deutsche Verlags-Anstalt, Stuttgart, pages 144 to 147, 314 to 315

D18: Gestaltung und Hauptabmessungen der Verbrennungskraftmaschine, Harald Maass, 1979, Springer Verlag, Wien, pages 246 to 248

D19: Die Konstruktion schnelllaufender Verbrennungsmotoren, Hermann Mettig, Walter de Gruyter Verlag, Berlin, 1973, pages 488 to 491, 501 to 506

III. Oral proceedings before the board were held on 14 April 1999, during which the respondent (patentee) submitted a new claim 1 as the basis of the main request and further three new claims 1 as the basis of three auxiliary requests.

Claim 1 of the main request reads as follows:

- "a) A diesel engine having a combustion chamber (5) defined by a cylinder (2) having an axis, a piston (3) and a cylinder head (10) situated above said piston, a fuel injection valve (6) supported in said cylinder head for injecting high pressure fuel directly into said combustion chamber,
- b) two air intake valves (8) fitted to said cylinder head for providing air to said combustion chamber,
- c) two exhaust valves (9) fitted to said cylinder head for discharging a burnt gas in said combustion chamber,
- d) said air intake and exhaust valves being disposed symmetrically around said injection valve,
- e) means for recirculating a part of the gas discharged from said exhaust valves into said combustion chamber via said air intake valves depending on the running condition of the engine,
- f) said fuel injection valve (6) comprising an injection nozzle (7) having spray holes (47) opening to said combustion chamber,

- g) said injection nozzle being supported concentrically with said cylinder axis and facing the centre of the combustion chamber, said nozzle (7) having a lower cylindrical portion and an upper conically enlarging portion, said lower portion being located between the openings in the cylinder head in which the valve seats are arranged,
- h) a needle valve (34) lifting axially in said nozzle in two stages according to a pressure of said high pressure fuel for opening and closing said spray holes (47),  
characterized in that
- i) each axis of said air intake and exhaust valves is set to be in parallel with said cylinder axis,
- j) and a guide (43) is provided on said needle valve (34) which slides on said inner circumference of said injection nozzle (7) for guiding said needle valve (34) concentrically with said nozzle (7) and said cylinder axis, said guide (43) having a passage to allow the flow of the fuel being provided to said spray holes (47)
- k) said guide being provided on the needle valve in the said lower nozzle portion and located next to the spray holes (47)."

IV. The appellant argued that claim 1 contravenes Article 123(2) EPC because according to the original disclosure (page 7, lines 1 to 5 and page 8, lines 8 to 10 of the description) the injection nozzle is arranged

parallel to the axis of the cylinder, whereas in present claim 1 the injection nozzle is defined to be concentrically positioned to the cylinder axis. Even the position in the centre of the cylinder head with the tip of the injection nozzle close to the centre of the combustion chamber, mentioned in the originally filed description, is not a position concentric with the cylinder axis, since it is not disclosed in the originally filed application that the combustion chamber is located centrically or eccentrically in the cylinder. Furthermore, the meaning of a centric position is not clear, since a centre usually is a point.

With regard to inventive step the appellant argued that the features of claim 1 do not have a synergetic effect and must be considered separately. If the features had a combinatory effect, then this must have been disclosed in the originally filed application. The appellant has cited in this respect several decisions of the boards, i.e. T 144/85, T 389/86, T 438/90, T 859/90 and T 767/91.

The appellant divided the features of claim 1 into three groups: Group 1 comprises the cylinder head features, group 2 the exhaust gas recirculation features and group 3 the injection valve features.

In assessing inventive step the appellant started from the engine 120 V8 described in document D16, pages 697 and 698, "Alsthom, Paris, Frankreich". This diesel engine comprises two air intake valves and two exhaust valves positioned parallel to the cylinder axis, an injection valve being supported concentrically with the

cylinder axis and being provided with an injection nozzle with several spray holes. In the appellant's view, therefore this engine comprises the essential features of the cylinder head of claim 1 of the main request.

According to the appellant the most relevant prior art document with regard to the group of features 2 is document D9 or document D10. These documents describe the well known features of exhaust gas recirculation.

The appellant further cited document D7, which discloses an injection valve lifting in two stages with a guide provided with fuel passages and positioned as close as possible to the valve seat of the injection valve (see page 7, the sixth to the fourth last lines), and explained in this respect the difference between an injector with the injection holes in the needle seat and an injector with the injection holes starting from a fuel chamber downstream of the needle seat.

The appellant further argued that the subject-matter of claim 1 only concerns the optimization of a diesel engine with features already well known in the technical field of combustion engines. Document D12 (for instance page 47) discloses the basis for using the teaching of documents D9 and D7 in a normal diesel engine as disclosed in document D16 in order to cope with the actual demands for low noxious exhaust emission. In the opinion of the appellant the engine of claim 1 (main request) therefore does not involve an inventive step.

V. The respondent explained the features of claim 1 of the



main request and pointed out that according to feature (d) the intake and exhaust valves are disposed symmetrically around the injection valve, i.e. since the exhaust valve outlet diameter and the intake valve diameter are different, the air intake valves and the exhaust valves around the injection valve clearly are disposed symmetrically with respect to a plane which includes the axis of the injection nozzle and which is located between the two intake valves as well as between the two exhaust valves, as is shown in Figure 4 of the patent. According to feature (e) exhaust gas is discharged from the exhaust gas valves into the combustion chamber via the air intake valves, i.e. exhaust gas is discharged in the usual way from the manifold downstream of the exhaust gas valve to the intake manifold upstream of the intake valve. According to feature (h) a needle valve for opening and closing the spray holes lifts in two stages at least during the opening operation.

With regard to the arguments of the appellant concerning Article 123(2) EPC the respondent stated that the positioning of the injection valve concentrically with the cylinder axis is clearly disclosed in the originally filed application, in particular on page 8, lines 8 and 9 in conjunction with Figures 3 and 4.

The respondent also countered to the arguments of the appellant with respect to inventive step and was of the opinion that the engine of claims 1 of the main and of the three auxiliary requests was new and inventive taking into account the cited prior art documents.

VI. Requests

The appellant (opponent) requested that the decision under appeal be set aside and the patent be revoked.

The respondent (patentee) requested that the decision under appeal be set aside and that the patent be maintained on the basis of his main request, or on the basis of either one of his three auxiliary requests, all filed during the oral proceedings on 14 April 1999.

**Reasons for the Decision**

1. The appeal is admissible.
2. *Allowability with regard to Article 123 EPC (main request)*
  - 2.1 Claim 1:

The features (a) to (e) are disclosed in claim 1 and Figures 1, 3 and 4 of the originally filed application. The interpretation of the respondent that the air intake valves and the exhaust valves around the injection valve are disposed symmetrically to a plane which includes the axis of the injection nozzle and which is located between the two intake valves, as well as between the two exhaust valves can be accepted with regard to the disclosure of Figure 4. Furthermore, with regard to the content of the originally filed application it also can be accepted, that the recirculated exhaust gas is discharged in the usual way

from the manifold downstream of the exhaust gas valve to the intake manifold upstream of the intake valve. No other arrangement is disclosed in this application and in the granted patent.

Feature (f) is disclosed on page 7, line 25 to page 8, line 4 of the originally filed description.

Feature (g) is disclosed on page 7, lines 1 to 5; page 8, lines 8 and 9; in claim 1 ("facing the center of said combustion chamber") and in Figures 3 and 4 of the originally filed application, which clearly show the position concentric with the cylinder axis. The word "parallel" in the originally filed claim 1 might have been misleading, but in connection with the description in which the centric position of the injection valve is described and with the drawings in which this position is shown, it is clearly disclosed that the nozzle is supported concentrically with the cylinder axis. It must be noted with regard to the argument of the appellant that the injection nozzle, according to feature (g), faces the centre of the combustion chamber and is, according to the disclosure of the originally filed application (see Figure 3), not positioned in a centric point of the combustion chamber. The additional feature according to which "said nozzle (7) having a lower cylindrical portion and an upper conically enlarging portion, said lower portion being located between the openings in the cylinder head in which the valve seats are arranged" is disclosed in Figures 3 and 5 in conjunction with the description page 10, lines 16 to 22 of the originally filed application. This feature was added for precisely defining the position of the guide in the injection

nozzle and its position in the cylinder head. The guide was already part of the originally filed claim 1 and of the granted claim 1.

Feature (h) is disclosed in claim 1 and in Figure 5 of the originally filed application.

Feature (i) is disclosed in the originally filed description page 7, lines 6 to 9.

Feature (j) is disclosed in claim 1; on page 9, line 20 to page 10, line 3 and in Figure 10 of the originally filed application.

Feature (k) is disclosed in Figures 3, 5 and 9. According to the interpretation of both the appellant and the respondent, the expression next to the spray holes is understood by the skilled person such that the guide is provided as close as possible to the spray holes, which includes a short passage between the guide and the spray holes in order to stabilize the fuel flow for equal distribution.

Claim 1 of the main request therefore does not contravene Article 123(2) EPC. Since the additional features restrict the protection conferred by the granted claim 1, present claim 1 does not contravene Article 123(3) EPC either.

2.2 Description:

The description was adapted to the new claim 1 and also does not contravene Article 123 EPC.

3. *Novelty (main request)*

None of the cited prior art documents discloses a diesel engine with all the features of claim 1. The subject-matter of claim 1 therefore is new in the meaning of Article 54 EPC. Novelty was not disputed by the appellant.

4. *Closest prior art (main request)*

The appellant argued that the features of claim 1 do not lead to a combinatory effect and therefore, in assessing inventive step, must be considered and compared separately with the prior art. With respect to the claimed features of the cylinder head the appellant considered the engine 120 V8 of document D16, pages 697 and 698 (Alsthom, Paris, Frankreich) as the closest prior art. With regard to the other features concerning exhaust gas recirculation and two stage fuel injection, documents D9 or D10 and document D7 were the most relevant prior art documents, in the appellant's view.

Although the problem of smoke generation in connection with exhaust gas recirculation in an engine and with injection in two stages is not mentioned in the document D16, pages 697 and 698 (Alsthom), the board agrees to take this document as the starting point for assessing inventive step.

5. *Problem and solution (main request)*

5.1 Problem:

The object of the invention is to promote uniform mixing of fuel and air in the combustion chamber of direct injection diesel engines, and thereby to reduce generation of smoke when exhaust gas is recirculated (column 2, lines 14 to 17).

5.2 Solution:

5.2.1 Contrary to the opinion of the appellant the respondent maintained that all the features of claim 1 contribute to the solution of the problem of smoke generation in combination with one another by generating a surprising combinatory effect. According to the respondent's arguments the danger of smoke generation with exhaust gas recirculation was known on the one hand and the effect of smoke reduction with a two stage injection was known *per se* on the other hand, but it was found that with a two stage injection in an engine with exhaust gas recirculation even more smoke was generated (see patent column 1, lines 32 to 56). The problem of smoke reduction in such an engine with exhaust gas recirculation and a two stage injection was solved mainly by positioning the injection valve concentrically with the cylinder axis, in order to arrive at an even injection of fuel into the combustion chamber and an uniform distribution of fuel therein. This even injection however was only possible with the exact concentric position of the needle in the valve which was obtained by positioning the guide next to the spray holes (see patent column 5, lines 42 to 51). For

positioning the injection nozzle concentrically with the cylinder axis and for positioning the needle guide next to the spray holes it was essential that instead of one inlet valve and one exhaust valve, two inlet valves and two exhaust valves were provided, in order to retain sufficient installation space in the centre of the cylinder head for the injection nozzle. According to the respondent also the arrangement of the inlet and exhaust valves around the injection valve and parallel with the cylinder axis have an important influence on the improvement of the combustion and therefore for smoke reduction.

This statement of the respondent cannot be contested, since it is generally known that the uniform distribution of fuel droplets and the direction of the gas flow in the combustion chamber have a decisive influence on the combustion and therefore on smoke generation and that constructional features in combination with one another, such as for instance air inlet direction and the direction of fuel injection, have a great influence on the gas flow and the air/fuel mixture in the combustion chamber. The board therefore is of the opinion that all features of claim 1 contribute to a combinatory effect by which the problem is solved.

5.2.2 The appellant has cited several board decisions to support his view that the features of claim 1 must be considered separately in assessing inventive step.

According to the decision T 144/85, the different effects of the different features contribute to the optimization of the operation of the element but do not

arrive at a surprising combinatory effect which is more than the addition of single known effects. In the decision T 438/90 it was again set out that the known or obvious different steps are unrelated to one another and only lead to an expected result. Also the decision T 767/91 came to the conclusion that the claim was an aggregation of features without any combinatory effect, and it was stated therein that, in this case, every block of features can be dealt with separately.

In the present case, in which fuel combustion is concerned and in which fuel injection and the gas flow in the combustion chamber is of essential importance, it cannot be contested that a combinatory effect is obtained by the contribution of all the features of claim 1, since it is commonly known that even small changes in the combustion chamber, its fuel injection and its gas entrance means have an important influence on the gas flow in the combustion chamber as well as the fuel/air mixture and therefore on the combustion itself. With regard to the argument of the appellant that the effect of exhaust gas recirculation and the effect of a two stage injection is known in this technical field, it must be considered that the technical problem of the impugned patent was not solved only by these features. On the contrary, according to the description of the patent the two stage injection in an engine with exhaust gas recirculation even led to an increase of smoke production.

The cited board decision T 389/86 deals with a case with two technical problems and two groups of features, each for solving one of the problems. In the further cited decision T 859/90 it was criticized (section 2.5,



last paragraph) that no information was available from the patent specification or other document on file concerning the correlation between the means considered therein. It was further stated that synergy could only be established if the correlations were either known or if particular correlations could be fairly assumed to exist, e.g. on the basis of the common general knowledge.

In the present case the only problem is the prevention of smoke. It is true that with regard to the inlet and outlet valves only their arrangement parallel to the centre axis of the cylinder was described in the originally filed application without mentioning details of the effect thereof, however it is general knowledge that the effect of the structural features influencing the flow in the combustion chamber, i.e. inlet and outlet valves, are of great importance in combination with the fuel injection to the quality of the fuel/air mixture in the combustion chamber and therefore to the combustion. The further correlation between exhaust gas recirculation, two stage injection and precise guiding of the valve needle and the importance of the centred position of the needle valve was clearly described in the patent, see for instance column 1, lines 44 to 56, (and in the originally filed application page 2, lines 15 to 25) and granted claim 1 as well as originally filed claim 1.

6. *Inventive step (main request)*

- 6.1 Document D16, pages 697 and 698 (Alsthom, Paris, Frankreich), discloses a diesel engine 120 V8 with a combustion chamber defined by a cylinder having an

axis, a piston and a cylinder head situated above the piston, a fuel injection valve supported in the cylinder head for injecting high pressure fuel directly into the combustion chamber. Two air intake valves are fitted to the cylinder head for providing air to the combustion chamber and two exhaust valves are fitted to the cylinder head for discharging a burnt gas from the combustion chamber. As can be derived from Figure 2 on page 698 the air intake and exhaust valves are disposed symmetrically around the injection valve, and each axis of the air intake and exhaust valves is set to be parallel with the cylinder axis. The injection valve comprises an injection nozzle having spray holes opening to the combustion chamber (see page 698, lines 4 and 5) and being supported concentrically with the cylinder axis (see Figure 2 on page 698 and description on page 697, small letter paragraph, lines 16 to 19).

6.2 The engine of claim 1 differs therefrom by means for recirculating a part of the gas discharged from the exhaust valves into the combustion chamber via the air intake valves depending on the running condition of the engine,

by the nozzle having a lower cylindrical portion and an upper conically enlarging portion, said lower portion being located between the openings in the cylinder head in which the valve seats are arranged,

by a needle valve lifting axially in the nozzle in two stages according to the pressure of the high pressure fuel for opening and closing the spray holes,

by a guide provided on the needle valve which slides on the inner circumference of the needle nozzle for guiding the needle valve concentrically with the nozzle and the cylinder axis, the guide having a passage to allow the flow of the fuel being provided to the spray holes

and by said guide being provided on the needle valve in the lower nozzle portion, and located next to the spray holes.

Document D16, dated 1965, describes on pages 697 and 698 an engine 120 V8 in which exhaust gas recirculation was apparently not considered, let alone the two stage injection. The problem of smoke generation is not mentioned.

- 6.3 The importance of exhaust gas recirculation for NO<sub>x</sub> reduction is however generally known in modern combustion engines and is for instance described in document D10 (page 17, last line to page 18 line 3) and in document D12 (see page 47, column in the middle). It is furthermore known that the danger of smoke is increased with exhaust gas recirculation (see document D10, page 9, second paragraph, last sentence).
- 6.4 It is also known that a needle valve lifting axially in the nozzle in two stages according to the pressure of the high pressure fuel for opening the spray holes, leads to the reduction of NO<sub>x</sub> emission and smoke (see document D12, page 47 last paragraph of the left hand column to first paragraph of the second column and third paragraph of the second column; and document D7, page 4, first paragraph).

- 6.5 With regard to modernising of engines it must firstly be taken into account that, according to document D12 (see page 50, right hand column), the tendency for small diesel engines leads to the eccentric and inclined position of the injection valves in the cylinder head.
- 6.6 Since the size of the engine is not clearly disclosed in the patent, normal sized engines must be considered in assessing inventive step. It might be that the skilled person would design a modern engine on the basis of the generally known old diesel engines and change their construction in order to cope with the modern demands for clean exhaust gas emission using thereby the means known for reduction of NO<sub>x</sub> and smoke. Due to the advantages listed in document D12 (see page 47) concerning the exhaust gas recirculation and the two stage injection, it might even be that the skilled person would try to provide the engine 120 V8 of document D16 (pages 697 and 698) with an exhaust gas recirculation device and with an injection nozzle for injecting fuel in two stages, but then he would arrive at an engine in which the problem of smoke increases, as disclosed in the present patent (see column 1, lines 36 to 56). A skilled person therefore would not be guided to the use of both these features, i.e. recirculation and two-stage injection.
- 6.7 Furthermore, document D7 describes per se a two stage injection nozzle with guides on the needle and gives the hint to position the lower guide as close as possible to the valve seat to prevent decentring of the needle (see page 7, sentence before the last). However, there is no information about the exact positioning of

the injection valve in the cylinder head with regard to the cylinder axis. Even if the skilled person were to provide this two stage injection nozzle in the engine 120 V8 (document D16) in combination with an exhaust gas recirculation, he would not arrive at the engine of claim 1 of the main request. Although it is proposed in this document D7 to position the guide in this injection valve as close as possible to the valve seat, it is located in the upper conical portion and not in the lower cylindrical portion of the nozzle. However, according to claim 1, it is this position next to the spray holes and located between the openings in the cylinder head in which the valve seats are arranged, which is important for the precise centred guiding of the needle and the uniform distribution of injected fuel. It must be taken into account that besides the problem of space in the centre of the cylinder head the high temperature in the vicinity to the combustion chamber and therefore the danger of sticking of the needle valve would keep away the skilled person from providing the guide in this region.

Furthermore, there is no hint in document D7 that particularly this guiding means would reduce the smoke generation which increases due to the combination of recirculation and two-stage injection.

- 6.8 The other prior art documents cited in the appeal proceedings are not more relevant than the documents D16 (pages 697 and 698), D7, D9, D10 and D12 and were no longer considered during the oral proceedings by the participants. These other documents also cannot lead to the engine of claim 1 of the main request.

- 6.9 The engine according to claim 1 of the main request therefore involves an inventive step in the meaning of Article 56 EPC with respect to the cited prior art documents.
7. Claim 1 of the main request, as well as claims 2 to 6, the adapted description and the drawings therefore can form the basis for the maintenance of the patent as amended (Articles 52 and 102(3) EPC).
8. Having allowed the respondent's main request, the board does not need to consider his auxiliary requests.

## **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 in the following version:

**Claims:** 1 of the main request, filed during the oral proceedings on 14 April 1999;  
2 to 6 as granted.

**Description:** pages 1 to 3 as filed on 9 July 1996 and as maintained by the opposition division;  
column 2, line 51 to column 6, line 34 as granted.

**Drawings:** Figures 1 to 12 as granted.

The Registrar:

The Chairman:

N. Maslin

C. Andries