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File No.: T 0924/91 - 3.2.4
Application No.: 88 112 246.9
Publication No.: 0 301 548
Classification: F02D 41/04
Title of invention: Fuel injection system of an internal combustion engine

D E C I S I O N
of 4 August 1993

Applicant: TOYOTA JIDOSHA KABUSHIKI KAISHA

Proprietor of the patent:

Opponent:

Headword:

EPC: Art. 111(1) EPC

Keyword: "Claim 1 allowable" - "Remittal to Examining Division to consider the unexamined dependent claims"

Headnote
Catchwords



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Boards of Appeal

Chambres de recours

Case Number: T 0924/91 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 4 August 1993

Appellant:

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Decision under appeal:

Decision of the Examining Division of the European
Patent Office dispatched on 23 July 1991 refusing
European patent application No. 88 112 246.9
pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: C.A.J. Andries
Members: M.G. Hatherly
J.-P.B. Seitz

Summary of Facts and Submissions

- I. European patent application No. 88 112 246.9, filed on 28 July 1988 and published with the publication No. 0 301 548, was refused by a decision of the Examining Division dispatched on 23 July 1991.

- II. The result of the interview held on 13 December 1990 between the Representative of the Appellant (Applicant) and the Primary Examiner states that Claim 1 of that date was agreed upon, that Claims 6 to 9 would be adapted as dependent claims, and that further amendment of the claims would not be allowed and would lead to refusal of the application (Rule 86(3) EPC).

With the letter of 19 June 1991, the Appellant indeed filed Claims 2 to 5 corresponding to Claims 6 to 9 basically agreed at the interview, but filed a version of Claim 1 which differed from that agreed at the interview and moreover filed dependent Claims 6 to 10.

In its decision, the Examining Division refused the request to grant a patent on the basis of Claim 1 filed with the letter of 19 June 1991, arguing that this was a request to replace the text of the application on whose basis a patent could be granted, with one that had been extensively revised, without giving good reasons for the changes at that stage of the proceedings.

The decision also stated that it was left open whether the dependent Claims 6 to 10 were in accordance with Claim 1.

- III. The Applicant's appeal against the decision was filed on 23 September 1991, the appeal fee was paid

simultaneously and the Statement of Grounds was filed on 25 November 1991.

IV. In reply to a communication and a telephone call from the Board the Appellant filed new application documents and now requests that the decision of the Examining Division be set aside and that a patent be granted on the basis of:

Claims: Claim 1 filed with the letter dated 29 July 1993; and

Claims 2 to 10 filed with the letter of 19 June 1991.

Description: pages 1, 2, 3a, 3b and 4 to 12 filed with the letter of 10 August 1990;

page 3c filed with the letter of 19 June 1991;

page 3d filed with the letter of 29 July 1993;

pages 13 to 38 as originally filed.

Drawings: sheets 1/9 to 4/9 and 6/9 to 8/9 as originally filed; and

sheets 5/9 and 9/9 filed with the letter of 29 June 1992.

The Appellant requests oral proceedings only if the patent is not to be granted as requested on the written submissions.

V. Claim 1 reads as follows:

"A fuel injection system of an internal combustion engine (M2) for determining a fuel injection amount q of a fuel injection valve (M4) based on a physical model describing a relationship between an amount f_w of fuel adhering to an inner wall of an intake pipe (M1), an amount f_v of vapor fuel in the intake pipe (M1), the fuel injection amount q , a fuel amount f_c coming into the cylinder (M3), and a fuel evaporating amount at every intake stroke V_f/ω , the system comprising:

an operating state detection means (M5, M15) for determining a rotating speed ω of the engine (M2), an evaporating amount per unit time V_f of the fuel adhering to the inner wall of the intake pipe (M1) as a function of the measured engine temperature, and an amount m of air flowing in the intake pipe of the engine;

a dividing means (M6, M16) for dividing the evaporating amount per unit time V_f by the engine speed ω ;

an estimation means (M7, M17) for calculating estimation values f_w and f_v of the adhering fuel amount f_w and the vapor fuel amount f_v based on said division V_f/ω at the dividing means (M6, M16) and the fuel injection amount q according to said physical model;

a fuel injection amount calculation means (M9, M19) for calculating the fuel injection amount q , based on the division V_f/ω , the estimation values f_w and f_v , and a product $\lambda_r \cdot m$ of the detected air amount m and a target fuel/air ratio λ_r ;

wherein said physical model is described by the following equations:

$$f_c = \alpha_1 \cdot q + \alpha_2 \cdot f_w + \alpha_3 \cdot f_v$$

$$f_w(k+1) = (1-\alpha_2) \cdot f_w(k) + \alpha_4 \cdot q(k) - \alpha_5 \cdot V_f(k) / \omega(k)$$

$$fv(k+1) = (1-\alpha_3).fv(k) + \alpha_6.q(k) + \alpha_5.Vf(k)/\omega(k)$$
$$\lambda(k).m(k) = \alpha_2.fw(k) + \alpha_3.fv(k) + (1 - \alpha_4 - \alpha_6).q(k)$$

where subscript k denotes calculation at the k-th intake cycle time and k+1 denotes calculation at the (k+1)-th intake cycle time and coefficients α_1 to α_6 are pre-determined values."

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 The original independent Claim 1 concerns a first embodiment of a fuel injection system wherein the fuel/air ratio λ is detected whereas the original independent Claim 6 concerns a second embodiment wherein the fuel/air ratio λ is not detected.

The first part of the present Claim 1 (up to the words "and a target fuel/air ratio λ_r ") is based on the original independent Claim 6 which, by not using a measurement of the fuel/air ratio λ , is less specific than Claim 1 and therefore more appropriate as a starting point when drafting a claim to cover both embodiments.

2.2 To arrive at the present Claim 1, the original Claim 6 has been clarified by stating that the evaporating amount is the evaporating amount per unit time and made more specific by stating that this is determined as a function of the measured engine temperature (based on the original page 23, lines 23 and 24 and on the original page 5, lines 5 to 10).

2.3 The second part of the present Claim 1 (from the words "wherein said physical model is described by the following equations") contains four equations which are absent from both the original independent Claims 1 and 6.

2.3.1 The first of these equations is equation number (3) on page 6 of the original application. While equation (3) is given in connection with the first embodiment which includes measuring the fuel/air ratio λ , it does not contain the term λ and merely describes the relationship between the quantities f_c , q , f_w and f_v . The equation thus plainly holds also for the second embodiment wherein the fuel/air ratio λ is not measured.

2.3.2 The second and third of the equations in the present Claim 1 are equations (4) and (5) on page 7 of the original application. These equations together make equation (7) on page 8. While these equations (4), (5) and (7) are given in connection with the first embodiment, the equation (7) is also used in connection with the second embodiment (see equation (79) on page 30 of the originally filed application and page 33, lines 18 to 20). Therefore equations (4) and (5) also apply to the second embodiment.

2.3.3 The fourth equation in the present Claim 1 corresponds to equation (8) on page 8 of the original application and given in connection with the first embodiment. However equation (8) is also used for the second embodiment (see equation (80) on page 30 of the originally filed application and page 37, lines 4 to 6).

2.4 Thus the present single independent Claim 1 covering both embodiments is fairly based on the original application and does not contravene Article 123(2) EPC.

3. *Differences between the interview version of Claim 1 and the present Claim 1*

3.1 In the version of Claim 1 agreed at the interview between the Representative and the Primary Examiner, the last coefficient in the third equation is $-\alpha_6$ and in the present version it is $+\alpha_5$. Since both α_6 and α_5 are predetermined values the difference is less than it might at first sight appear, moreover the latter version is more restricted since the last coefficient in the third equation can now not be different to the last coefficient in the fourth equation i.e. they must now each be α_5 . The present version of the third equation is furthermore supported by equation (5) on page 7 of the original application, so that it is even doubtful whether the interview version of Claim 1 was allowable with respect to Article 123(2) EPC.

3.2 In the interview version of Claim 1 the fourth equation commences with the term $\lambda_r(k)m(k)$ whereas the corresponding term in the present version is $\lambda(k).m(k)$.

As set out in section 2.3.3 above, the fourth equation in the present Claim 1 is in agreement with the original application. Moreover the equation describes a physical model and sets out the relationship between the fuel/air ratio λ and other parameters at a particular time so that fuel/air ratio λ in the equation is the correct fuel/air ratio λ (provided that the other terms in the equation are also correct) rather than the measured value (which being a measured value can never be completely correct) and rather than a target value (which may never actually be achieved). When making use of these four equations in a practical fuel injection system the skilled person uses the target fuel/air ratio λ_r (see the feature in Claim 1 of "calculating the fuel injection amount q ... based on ... a target fuel/air

ratio λr^*) and can use the measured fuel/air ratio λ if this is available (as in the first embodiment).

The text book "Introduction to Dynamic Systems: Theory, Models, and Applications" by D.G. Luenberger, J. Wiley and Sons, Inc., New York, USA, 1979 explains on pages 300 and 301 that if all variables of a physical system cannot be measured then an avenue of approach of control system design is to construct an approximation on the basis of what measurements are in fact available. Thus in the first embodiment of the present application the measurement of the fuel/air ratio λ is available and can be used whereas in the second embodiment it is not available and something else must be used instead.

3.3 These differences can therefore not give rise to an objection under Rule 86(3) EPC leading to a refusal of the filing of the current Claim 1.

4. *Novelty*

The version of Claim 1 filed at the interview of 13 December 1990 was found allowable so that the novelty of its subject-matter was undisputed, the slightly amended present version of Claim 1 cannot change this finding. None of the cited documents discloses a fuel injection system having all the features set out in the present Claim 1. The subject-matter as set forth in Claim 1 is thus to be considered novel within the meaning of Article 54 EPC.

5. *Closest prior art, problem and solution*

5.1 The closest prior art documents are:

D1: EP-A-184 626; and

D2: EP-A-152 019.

Both are discussed on pages 3a and 3b of the description of 10 August 1990. These prior art systems involve physical models of the behaviour of fuel in an internal combustion engine to enable a calculation to be made for the fuel quantity to be injected under different engine conditions. The Board considers the system closest to that of the present invention to be that disclosed by document D2 since this system - unlike the system of document D1 - recognises for example that not all the fuel evaporated from the film on the intake manifold wall is sucked into the cylinder but that a part thereof remains in the intake manifold in the form of vapour fuel, this being a phenomenon also utilised in the present invention.

5.2 While this prior art system involves a physical model of the behaviour of fuel in an internal combustion engine, this physical model ignores some parameters necessary for an exact calculation of the fuel quantity to be injected. Accordingly a high precision of control is unobtainable. For example the prior art system ignores redeposition onto the intake manifold of vapour fuel evaporated from the liquid film on the intake manifold and from the injected fuel.

5.3 The Board sees the problem that the invention sets out to solve when starting from the fuel injection system according to document D2 is to determine the fuel injection amount with greater accuracy and without needing to resort to switching between a number of control laws each valid for only a particular region of engine operation (see present description, page 3c, lines 3 to 5).

5.4 The system according to the invention solves this problem by having a more exact physical model for engine operation i.e. considering more exactly the behaviour of

fuel injected into an engine. The significance of the four equations in the present Claim 1 is explained in the following passages in the originally filed application:

the first equation (3) on page 6, line 25 to page 7, line 9;

the second equation (4) on page 7, lines 10 to 20;

the third equation (5) on page 7, lines 21 to 27; and

the fourth equation (8) on page 7, line 21 to page 8, line 20.

5.5 From the physical model expressed by the four equations in Claim 1 the skilled person can calculate the fuel injection quantity q . Although this calculation uses as one component the fuel injection quantity injected in the previous engine cycle, it is known when starting up control systems to use initial values for parameters and then to use successive calculations in many rapidly recurring cycles to produce closer values.

6. *Inventive step*

Neither document D2 nor the slightly less relevant document D1 suggests the more exact physical model of fuel behaviour of an internal combustion engine described by the four equations in Claim 1. Moreover the Board sees no hint towards this physical model in any of the other prior art documents available to it and cannot see a combination of the available documents which would be prejudicial to Claim 1.

The fuel injection system according to Claim 1 thus involves an inventive step within the meaning of Article 56 EPC.

7. The subject-matter of Claim 1 is thus patentable as required by Article 52 EPC. The remainder of the application (see above section IV) will however need to be considered before a patent can be granted. The Board considers it appropriate to remit the case in accordance with Article 111(1) EPC to the Examining Division for further prosecution.

8. *Dependent claims*

8.1 The result of the consultation (interview) held on 13 December 1990 states that Claims 6 to 9 filed with the letter dated 10 August 1990 would be adapted as dependent claims to the allowable claim; and that further amendment of the claims would not be allowed and would lead to refusal of the application (Rule 86(3) EPC).

With the letter of 19 June 1991, the Applicant indeed filed Claims 2 to 5 corresponding to these Claims 6 to 9 basically agreed at the interview, but also filed new dependent Claims 6 to 10.

The Examining Division's decision of refusal stated that it was left open whether these new dependent Claims 6 to 10 were in accordance with Claim 1.

8.2 These Claims 6 to 10 correspond to Claims 4, 5, 10, 11 and 12 filed with the letter of 10 August 1990 and in turn correspond to, or are based upon, original Claim 8, original equation (86), original Claim 2, original Claim 3 and original equation (20) respectively. Thus these claims were not newly introduced into the

application with the letter of 19 June 1991 and could not have been a surprise to the Examining Division since they had already not only been present in the application but had also been filed as claims with the letter of 10 August 1990.

It may have been agreed at the interview on 13 December 1990 - as the result of consultation implies - that the only dependent claims to be submitted after the interview would be those based on Claims 6 to 9 of 10 August 1990. However the result of consultation does not specifically state that Claims 4, 5, 10, 11 and 12 of the same set of claims had been abandoned and, unless they had been abandoned, their refiling with the letter of 19 June 1991 could not have constituted an extensive revision of the application. There are no substantive reasons on file as to why the Examining Division objected to these five claims (even though three of them had been in the application since its filing date).

- 8.3 The Examining Division views dependent Claims 2 to 5 filed with the letter of 19 June 1991 as allowable and the Board sees no reason to disagree with this.

Regarding Claims 6 to 10, the Board, as provided for by Article 111(1) EPC, exercises a power within the competence of the Examining Division to decide that upon remittal the Examining Division shall not invoke Rule 86(3) EPC against these Claims 6 to 10 but that the Examining Division shall examine said claims substantively.

9. *Points which may require attention*

The following non-exclusive list of apparent errors and obscurities noticed by the Board in the description and drawings should be considered during the further

prosecution. All page, line and Figure numbers refer to the present version of the application.

Description: page 17, lines 13 and 14: P4 should be P3, P10 should be P9;

The last term of equations (53) and (54) on page 27 and of equation (103) on page 37 should be $8.Vf(k)$ divided by $\omega(k)$;

Drawings: Figure 1B: Arrow head missing from line entering the top of the "Estimation Means M17";

Figures 2 and 6: Signal W entering the "Input Port 46" should be ω and signal T should be t;

Figure 3: Arrow head missing from line entering the top of "1st Calculator P1". Arrow head missing from line entering the top of "2nd Multiplier P6"; and

Figure 7: Arrow head missing from line entering the top of "Multiplier P26".

10. *Oral proceedings*

The Appellant requests oral proceedings if the patent is not to be granted on the basis of the written submissions.

While remittal to the first instance means that the case is not yet to be granted, it also means that the decision under appeal is being set aside and that the application is not being refused. There is therefore no

need to appoint oral proceedings (see decision T 222/87, section 5, not published).

The Appellant was moreover informed in the communication of 24 February 1992 and in the telephone conversation of 23 July 1993 that the Board would be likely to remit the case to the first instance but made no unconditional request for oral proceedings.


The Board emphasises that the Appellant's conditional request for oral proceedings is a request in the present appeal proceedings and has no effect in the further proceedings before the Examining Division.

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:
 - that the application be further prosecuted with Claim 1 filed with the letter of 29 July 1993; and
 - that the dependent claims, description and drawings (see above section IV) be adapted to this Claim 1.

The Registrar:



N. Maslin

The Chairman:


C. Andries