BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

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File Number: T 276/89 - 3.2.4

Application No.: 82 107 219.6

Publication No.: 0 072 025

Title of invention: An internal combustion engine and a fuel injection control system for an internal combustion engine

Classification: F02D 41/30

D E C I S I O N
of 1 April 1992

Proprietor of the patent: MITSUBISHI DENKI KABUSHIKI KAISHA

Opponent: Siemens Aktiengesellschaft, Berlin und München

Headword:

EPC Article 56

Keyword: "Inventive step (yes)"

Headnote

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number : T 276/89 - 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 1 April 1992

Appellant : (Opponent)
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Decision under appeal :
Decision of Opposition Division of the European Patent Office dispatched on 14 February 1989 rejecting the opposition filed against European patent No. 0 072 025 pursuant to Article 102(2) EPC.

Composition of the Board :

Chairman : H.J. Seidenschwarz
Members : M.G. Hatherly
J.P.B. Seitz

Summary of Facts and Submissions

I. European patent application No. 82 107 219.6, filed on 10 August 1982 and published with the publication No. 0 072 025, was granted on 12 November 1986.

II. The patent was opposed by the Appellant and a decision was taken by the Opposition Division at oral proceedings on 26 January 1989 to reject the opposition. The reasons for the decision were dispatched on 14 February 1989.

III. An appeal against this decision was received on 14 April 1989 together with the grounds of appeal. The fee was paid the same day.

IV. The following documents were referred to in the appeal proceedings:

(D1) DE-B-2 306 007
(D8) US-A-3 991 727

V. Both parties requested oral proceedings which were accordingly held on 1 April 1992.

(i) The discussion was based on the patent as granted.

Claim 1 reads as follows:

"A fuel injection control system for an internal combustion engine provided with a fuel injection valve (4) and comprising: fuel flow calculation means (50) for calculating a fuel flow amount in accordance with predetermined operating parameters of said engine; and drive means (70, 40) for driving said fuel injection valve (4) with driving times determined in accordance with the calculated fuel

flow amount, characterised by: memory means (60) storing values of valve driving times necessary to obtain respective fuel flow amounts through said valve at a predetermined fuel supply pressure; said memory means (60) having an address input coupled to an output of said calculation means (50) and being arranged to supply said values of valve driving times to said drive means (70, 40) in accordance with the output of said calculation means (50); and at least some of the values stored in said memory means (60) relating to a non-linear portion of the flow-time characteristic of said valve (4), whereby said driving times are compensated for non-linearity in the non-linear portion of said flow-time characteristic of said valve."

(ii) The Appellant (Opponent) maintains that the subject-matter of the disputed Claim 1 does not involve an inventive step. He argues essentially as follows:

- The problem underlying the present invention and concerning a non-linear fuel injection valve characteristic is known from document D1.

- The problem is moreover typical for all those transducers with a non-linear relationship between input value and output value.

- Document D8, in the same technical field as document D1, teaches a linearisation method for a an air measuring device which leads to the solution to the above problem, namely using a memory storing the characteristic of the device, this solution being applicable independent of the specific type of transducer.

- It would be obvious for the skilled person in the fuel injection field, knowing of the problem set in document D1, to look around for documents in the same field. By combining documents D1 and D8 he would necessarily arrive at the subject-matter of Claim 1.

(iii) The Respondent (Proprietor) argues for the allowability of Claim 1 essentially as follows:

- Document D1 teaches that the non-linear portion of the fuel injection valve characteristic involves difficulties. Prior to the priority date of the patent in suit the skilled person would only use the linear portion of the fuel injection valve. Document D1 maintains that it is necessary to improve the valve's response times and gives no alternatives.

- Document D8 also teaches proportionality between fuel injection valve driving time and fuel injection quantity. The skilled person would not immediately see that the linearisation method used for the air measuring device according to this document could also be used for the fuel injection valve.

- A combination of the documents D1 and D8 would not necessarily lead to the subject-matter of Claim 1. Moreover document D8 gives no hint to lead the skilled person in the direction of said subject-matter.

VI. The Appellant requests that the decision under appeal be set aside and that the patent be revoked in its entirety.

The Respondent requests that the appeal be dismissed.

Reasons for the Decision

1. The appeal is admissible.

2. Novelty

The parties do not dispute that the subject-matter of Claim 1 is novel. The Board agrees with them. Therefore no substantiation is necessary.

The subject-matter of Claim 1 is novel (Article 54 EPC).

3. Closest prior art, problem and solution

3.1 The Board considers the closest prior art and starting point for the invention to be the fuel injection control system disclosed by document D1.

This prior art fuel injection control system is for an internal combustion engine provided with a fuel injection valve (see Claim 1, lines 1 to 3). Although not specifically stated in document D1, such a control system necessarily includes means for calculating a fuel flow amount in accordance with predetermined operating parameters of the said engine. Document D1 discloses drive means for driving the fuel injection valve (see Figure 3), the driving time depends on the necessary fuel flow amount.

Thus document D1 discloses (explicitly or implicitly) the features of the pre-characterising portion of the disputed Claim 1.

3.2 Document D1 discusses a disadvantage of fuel injection valves in practice, that the time lag for their opening and closing causes the fuel quantity delivered to be inaccurate (see line B on Figure 2 and column 4, line 44 to column 5, line 13).

Document D1 states that in practice the fuel injection valve cannot be opened if the commanded opening time is very short (see column 4, line 64 to 67). The commanded opening time corresponding to the minimum fuel quantity Q1 lies in a non-linear portion of the line B, this complicates the control device and reduces the accuracy of the control operation (see column 5, lines 34 to 41). Under circumstances set out in column 5, lines 41 to 53, the non-linear portion of the line near the minimum fuel quantity Q1 increases, with the result that the accuracy in the control operation may be greatly reduced or, sometimes, it may become impossible to perform the control operation.

3.3 The Board sees the objective technical problem to be solved arising from the fuel injection control system according to document D1 to be how a fuel injection valve is to inject the correct amount of fuel (as calculated dependent on engine operating parameters) when the valve has a non-linear relationship between the amount of fuel it injects and its driving time.

The Appellant adds (see Appeal of 14 April 1989, page 2, last paragraph) that the technical problem is thus to determine the opening time to inject the calculated amount of fuel even though the relationship of amount to time is non-linear. However this addition, in the opinion of the Board, leads towards the solution and so is invalid (see decision T 229/85, OJ 1987, 237, section 5).

3.4 The solution proposed in the patent in suit is to provide a memory means which stores values of valve driving times necessary to obtain injection of respective fuel amounts, including values in the non-linear portion. The fuel flow calculation means is connected to the input of the memory means, the input of the memory means thus being the value of the fuel amount needed and the output of the memory means being the value of the valve driving time needed to inject this fuel amount - even if the time and amount lie in the non-linear portion of the valve characteristic.

When the non-linear portion of the fuel injection valve is used, correction for thermal or pressure effects is no longer simple. In the non-linear portion, the valve driving time cannot be merely increased or decreased but must take the complete characteristic into account. The present invention uses a memory means between the fuel flow arithmetic unit and the fuel injection valve, this memory means being different from the converter. Thus any calculations and corrections which are carried out by the fuel flow arithmetic unit are converted in the memory means and driving signal generating circuit into an appropriate opening command.

The Board is satisfied that the problem set out in section 3.3 above can be solved by the fuel injection control system defined in Claim 1, and in particular by the features appearing in its characterising portion.

4. Inventive step

4.1 Document D1 teaches improvement of the responsiveness in opening and closing operation of a fuel injection valve in order to improve the accuracy of the fuel feed control (see column 2, lines 41 to 45 and column 5, lines 59 to

63), i.e. reducing the non-linear portion of the valve characteristic by speeding up opening and closing of the valve.

4.2 The Board considers that the person skilled in the art, faced with the problem of a non-linear valve characteristic as disclosed by document D1, might well seek an alternative solution to that already contained in said document. One document in the same field that would then come to his attention would be document D8.

Document D8 teaches generation of an injection activation pulse signal having a time width **proportional** to the fuel injection quantity signal (see Claim 1, column 11, lines 20 to 23). Thus it would not be apparent to the skilled person that document D8 could help him to solve his problem concerning the non-linearity of the fuel injection valve.

If nevertheless he were to continue to consider document D8 then he would see that (in column 6, lines 18 to 32, column 7, lines 20 to 27 and Figures 7 and 8) it discloses an air flow measuring plate mounted in the suction duct of an engine. An output voltage is **proportional** to the angle of the plate but these have a **non-linear relationship** to the air flow. A ROM stores the non-linear characteristic, an input to the ROM then generating a preliminarily programmed output so that said output voltage when fed into the ROM is converted into a signal (directly) **proportional** to the air flow.

In the system according to document D8 the driving time is not corrected before driving the fuel injection valve. The document not only does not discuss linearity of the fuel injection valve but states in column 9, lines 55 to 60 that "the power amplification circuit and the fuel

injection nozzles will not be described in any detail since they are well known in the art". Thus the idea of dealing with the non-linearity of the fuel injection valve characteristic did not occur to the drafter of document D8. The Board sees no hint in document D8 to lead the skilled person to decide to correct the driving time or even to look at the air sensor to solve a problem connected with the fuel injection valve.

Therefore it is not obvious for the skilled person to apply the teaching of document D8 regarding linearisation of the characteristic of the air measuring device to the fuel injection valve of the fuel injection control system according to Claim 1.

4.3 There is no hint in the prior art towards the claimed solution. On the contrary, the prior art teaches the skilled person who is faced with the non-linearity problem three other ways to proceed, namely:

- speed up opening and closing of the valve to reduce its non-linear portion (document D1),

- if the driving time would be in the non-linear portion, then not to drive the valve but to save the driving time in an accumulator and then drive the valve when the accumulated drive time is sufficient (GB-A-2 028 541 - see column 1, lines 19 to 36 of the patent in suit), and

- if the valve is not correctly calibrated then correct the data for the valve driving time with a calibration value, this calibration value being stored in RAM at an address related to the engine characteristics rather than the valve characteristic (FR-A-2 389 001 - see column 1, lines 37 to 57 of the patent in suit).

Still further, it is known that the sensor disclosed by document D8 is non-linear, if the skilled person wishes to use it at all then he must accept and deal with the non linearity. A fuel injection valve is another matter, it has a large linear portion, the skilled person is not forced to use it in the non-linear position.

4.4 The Appellant questions why the skilled person should not combine the documents D1 and D8 but, according to the jurisprudence of the Boards of Appeal, the question for deciding whether an inventive step is present in the subject-matter of the present Claim 1 over the state of the art is not whether the skilled person could have done something but whether he **would** have done so in the expectation of an improvement or advantage (see decision T 2/83, OJ 1984, 265: "could-would approach").

Considering sections 4.1 to 4.3 above, the Board does not consider that the skilled person **would** have made the combination in the particular way needed to arrive at the presently claimed subject-matter.

5. The Board has also considered the further available documents and has found them non-prejudicial to the present Claim 1, either alone or in combination with the documents cited above.

6. For the reasons given above, the subject-matter of Claim 1 involves an inventive step (Article 56 EPC) and is patentable within the meaning of Article 52 EPC. Claims 2 and 3 are dependent upon Claim 1 and Claim 4 includes all the features of Claim 1. Claims 2 to 4 are therefore also patentable. The patent can thus be maintained with these claims.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar: **The Chairman:**

N. Maslin H. Seidenschwarz

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