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D E C I S I O N
of 7 December 1994

Case Number: T 0140/92 - 3.2.4

Application Number: 87630040.1

Publication Number: 0239524

IPC: F02D 41/38

Language of the proceedings: EN

Title of invention:
Stepper motor control for fuel injection

Patentee:
AIL CORPORATION

Opponent:
Robert Bosch GmbH

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes"

Decisions cited:
-

Catchword:
-



Case Number: T 0140/92- 3.2.4

D E C I S I O N
of the Technical Board of Appeal 3.2.4
of 7 December 1994

Appellant: Robert Bosch GmbH
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Representative: -

Respondent: AIL CORPORATION
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Decision under appeal: Decision of the Opposition Division of the
European Patent Office dispatched on 10 December
1991 rejecting the opposition filed against
European patent No. 0 239 524 pursuant to
Article 102(2) EPC.

Composition of the Board:

Chairman: C. A. J. Andries
Members: H. A. Berger
J. C. M. de Preter

Summary of Facts and Submissions

I. The Appellant (Opponent) lodged an appeal, received on 11 February 1992, against the decision of the Opposition Division, dispatched on 10 December 1991, on the rejection of the opposition against the patent No. EP-B-0 239 524, and paid the appeal fee on 11 February 1992. The statement setting out the grounds of appeal was received on 14 February 1992.

Opposition was filed against the patent as a whole and was based on Article 100(a) EPC.

The Opposition Division based its decision on the following documents:

(D1) EP-A-0 069 111

(D2) DE-A-3 237 498

II. Additionally the following prior art documents were cited during the appeal:

(D3) DE-A-3 237 499

(D4) US-A-4 502 437

III. Oral proceedings were held on 7 December 1994 during which the Respondent filed new sets of Claims and new parts of the description for a main and an auxiliary request.

Claim 1 of the main request reads as follows:

"A fuel injection system for an engine (12) comprising:

- a fuel injection pump (18);
- movable and positionable plunger means (20) for injecting, and metering fuel to the cylinder(s) of the engine (12);
- camshaft means (16) connected to the engine (12) for moving the plunger means (20) and for causing the injecting of fuel to the cylinder(s);
- positionable pump rack means (32A) connected to the plunger means (20) for positioning the plunger means (20) and for causing the metering of fuel to the cylinder(s); and
- a stepper motor (40) connected via a compliant preloaded linkage to the pump rack means (32A) for positioning the pump rack means (32A) in response to an engine operating parameter, wherein a distal rack member (52) of the linkage is engaged with a stepper motor output pinion gear (48);
- controller means (28) providing a desired position signal (44) to the stepper motor (40);
- stop means (98) limiting the distal movement of the distal portion of the linkage;
- a position sensor (100) adjacent the distal portion of the linkage providing a signal to the controller indicative of a predetermined reference position of the distal portion, wherein the reference position is displaced from the stop;
- means for storing a value for the predetermined reference position in the controller;
- means for providing pulses from the controller to the stepper motor to cause the distal portion of the linkage to move away from the stop to the reference position; and

- means for rereferencing the pulse count in the controller in response to the signal from the position sensor indicating that the distal portion of the linkage is at the reference position."

IV. The Appellant (Opponent) argued as follows:

With regard to the injection pump defined in the impugned Claim 1, document D4 can be taken as the starting point in assessing inventive step since it describes a plunger pump with positionable pump rack means.

However, documents D2 and D3, although they disclose distribution pumps with a control ring, would be relevant for the particular problem discussed in the patent. Documents D2 and D3 describe the necessity of a clear reference signal indicating a reference position as a starting point for counting the calculated impulses with which a stepper motor is rotated to control, via a control lever, a pressure release orifice of the pump. They furthermore propose to turn the spindle of the stepper motor a defined number of steps beyond said reference position, i.e. an end stop of the lever in one embodiment and a switch in the other embodiment, in order to attain the clear reference signal. In the embodiment of document D3 the control lever therefore is stopped together with the spindle at a distance beyond the reference position since it is pressed against the spindle by a spring and since the spindle is turned this defined number of steps beyond that reference position. There is also mentioned the possibility of counting the calculated impulses only when the spindle or the control lever actuates (opens or closes) the switch and thereby produces the reference signal, on the way leaving the stop position (document D2, page 6, last sentence and document D3, the sentence bridging pages 7 and 8,

handwritten numbering). Any failure of the counted pulses between the stop position of the spindle and the reference position therefore would be cancelled.

The Appellant further stated that it belongs to the normal practice of the skilled person to use the knowledge about the distribution plunger pumps disclosed in documents D2 and D3 in rack controlled plunger pumps, since the problem of controlling the injected fuel amount by a fuel release orifice is similar in all these pumps. It would be obvious, with the teaching of documents D2 and D3, to provide in the pump of document D4 a switch for the reference signal at a distance of the end position of the rack, if difficulties with that end position were encountered.

The provision of a compliant preloaded linkage between the stepper motor and the pump rack means would have no effect on the positioning of the reference signal sensor. The use of such a compliant preloaded linkage is disclosed in document D1 which describes a rack controlled plunger pump similar to that described in document D4.

In the opinion of the Appellant the fuel injection systems defined by Claim 1 of the main and of the auxiliary request therefore do not involve an inventive step.

V. The Respondent (Proprietor) argued as follows:

The most relevant prior art document is document D4. The problem which arose in this known pump system was the inaccurate reference position obtained by the physical stop and used as the basis for the step count of the stepper motor. The construction of the stepper motor has the effect that several magnetic half-steps are

occasionally necessary at the end stop position of the rack, before the stepper moves to the position in which it begins to retract the rack from the end stop.

There is no information or hint given in documents D2 and D3 to provide an end stop in combination with an additional position sensor provided at a distance from this end stop. A transfer of the teaching of documents D2 and D3 to the pump system of document D4 would not be obvious because of the different construction of the systems.

Furthermore, the only prior art document which describes a compliant preloaded linkage between the stepper motor and a rack is document D1, which however is silent about a reference signal sensor and an additional end stop.

In reply to a question from the appellant, the Respondent explained that a rack member is a member provided with teeth.

The Respondent is of the opinion that the fuel injection system of Claim 1 of the main request and of the subsidiary request is inventive.

VI. Requests

The Appellant requests that the decision under appeal be set aside and the patent be revoked.

The Respondent requests that the decision under appeal be set aside and that the patent be maintained according to the main request on the basis of the following documents:

Claims: 1 and 2 as filed during the oral proceedings on 7 December 1994;

Description: Column 1 according to the patent specification EP-B-0 239 524; columns 2 to 6, as filed during the oral proceedings on 7 December 1994;

Drawings: Figures 1 and 2 according to the patent specification EP-B-0 239 524.

The Respondent also filed an auxiliary request.

Reasons for the Decision

1. The appeal is admissible.
2. *Amendments (main request)*
 - 2.1 In the present Claim 1 the following feature is modified vis-a-vis the granted Claim 1 which is based on the originally filed Claim 1: "a distal rack member (52) of the linkage is engaged with a stepper motor output pinion gear (48)".

The replacement of "distal portion (52)" of the granted Claim 1 by "distal rack member (52)" according to the present Claim 1, is based on the description column 3, lines 23 to 34 (originally filed description page 5, line 27 to page 6, line 7). The replacement of "stepper motor output shaft (46)" by "stepper motor output pinion gear (48)", is based on the description column 3, lines 20 to 29 (originally filed description page 5, line 24 to page 6, line 2).

- 2.2 These amendments define the correspondent features of the granted Claim 1 more precisely, so that the protection conferred is not extended compared with the granted Claim 1.
- 2.3 The amendments in the description relate only to the cited state of the art documents, to the adaptation to the new Claim 1 and to minor corrections.
- 2.4 The amendments therefore do not contravene Article 123(2) and (3) EPC. This was not disputed by the Appellant.

3. *Novelty (main request)*

The Board ascertained during the examination of the cited prior art documents that none of them discloses a fuel injection system with all the features of Claim 1. Novelty of Claim 1 was no longer disputed .

4. *Closest state of the art (main request)*

- 4.1 The Appellant and the Respondent took as the starting point for assessing inventive step a system according to document D4. Compared with document D1 which also describes a rack controlled plunger pump with a stepper motor, document D4 in addition discloses the necessity of a reference position sensor and therefore comes closer to the whole concept of the system of the impugned patent.

- 4.2 In particular, document D4 discloses a fuel injection system for an engine comprising: a fuel injection pump (column 6, lines 14 and 15); movable and positionable plunger means for injecting, and metering fuel to the cylinder of the engine; camshaft means connected to the engine for moving the plunger means and for causing the

injection of the fuel to the cylinder (these features are implicit in this type of pump, which was not disputed by the respondent); positionable pump rack means (Figure 6) connected to the plunger means for positioning the plunger means and for causing the metering of fuel to the cylinder; a stepper motor (106, column 6, lines 14 to 24) connected via a linkage (arm 202 and pivot point 208) to the pump rack means (200) for positioning the pump rack means in response to engine operating parameters, wherein a portion of the linkage is connected to the stepper motor (Figure 6); controller means (column 6, lines 29 to 34) providing a desired position signal to the stepper motor (column 8, lines 42 to 51); stop means (230) limiting the distal movement of the distal portion of the linkage; a position sensor (stop means 230) providing a signal to the controller indicative of a predetermined reference position of the distal portion (column 11, lines 37 to 51); means for storing a value for the predetermined reference position in the controller (column 11, line 52 to column 12, line 2); and means for referencing the pulse count in the controller in response to the signal from the position sensor indicating that the distal portion of the linkage is at the reference position.

5. *Problem and solution (main request)*

5.1 Problem

In the pump system of the most relevant prior art document D4 it occasionally happened that counting of the calculated steps for the stepper motor on the basis of the reference position indication signal produced by the end stop was inaccurate.

The objective problem of the invention therefore is the provision of an accurate working control device for fuel metering, controlling mainly in an open-loop manner the position of pump rack means by a stepper motor, in a system with a physical end stop for the rack means.

The Board wants to emphasize that the above problem is a technical problem which not only occurs in a system where a stepper motor forces a rack against a wall (the reference stop) but also in a system which was already used (D4) to establish an initial reference position from which exact counting can always take place.

5.2 Solution

By displacing the reference position from the end stop erroneous counting of steps for moving the stepper motor to a precalculated position is prevented.

6. *Inventive step (main request)*

6.1 The subject-matter of the impugned Claim 1 differs from the closest state of the art, disclosed in document D4, in that the stepper motor is connected via a compliant preloaded linkage to the pump, in that a distal rack member of the linkage is engaged with the stepper motor output pinion gear, in that the reference position is displaced from the stop (in document D4, the reference stop) and by means for providing pulses from the controller to the stepper motor to cause the distal portion of the linkage to move away from the stop to the reference position.

6.2 Document D4 does not give any information from which it could be derived that inaccurate controlling may occur by using the end stop as the reference signal indicator. On the contrary it is the teaching of document D4 to

drive the stepper motor against this positive end stop occasionally to reset its position in order to prevent an error in the stepper motor control (see column 11, line 52 to column 12, line 2).

- 6.3 Resetting the position of a stepper motor by using a reference signal as is done in document D4 is also known from documents D2 and D3, which describe a control system of a plunger pump with a release orifice controlled by a sliding ring. However, the teaching of this prior art cannot lead to the pump system of Claim 1. According to document D2 it is the end stop (18) of the control lever which functions as a position sensor, whereas according to document D3 a switch (23) is provided for sensing a reference position of the stepper motor spindle. It is true that in both embodiments the stepper motor spindle turns a predetermined number of steps beyond the reference position sensors in order to guarantee an accurate contact or an accurate opening of a contact at the sensor and therewith an accurate reference signal, but the end position of the spindle is determined by an additional predetermined number of steps of the stepper motor and not by an additional end stop.

Furthermore it should be emphasized that a technical problem which is due not only to the contacting of a rack with a stop wall, but also to the fact that that rack is engaged positively with a pinion gear of the stepper motor, cannot exist in documents D2 and D3, so that a person skilled in the art wanting to solve the above problem would not be inclined to try to find a teaching in these documents.

- 6.4 Furthermore, the end stop of the rack of the system of document D4, in conjunction with the therein provided pivot connection of the drive arm of the stepper motor

with the rotatable arm for moving the rack means, would not allow the drive arm or a stepper motor spindle to be retracted beyond the reference position, which is sensed in this system of document D4 by the end stop. Using however the teaching of documents D2 and/or D3 in the system of document D4 would result in a considerable modification of the pump control system of document D4 and would result in a control system which is still different from the system of the impugned Claim 1, having a positive end stop and comprising a compliant preloaded linkage for the connection of the stepper motor to the pump rack means and a distal rack member of the linkage which is engaged with the stepper motor output pinion gear.

Even if a skilled person, realizing that the reference signal of the end stop was faulty, were to use the teaching of documents D2 and D3, he would be more likely to arrive at a system in which the rotatable arm moving the rack means is biased against a stepper motor spindle by a spring, rather than at a system with a rack member engaged with the stepper motor output pinion gear. According to the teaching of document D2 a physical endstop functioning as a reference position switch still would be necessary, which would not encourage the provision of an additional reference signal indicator at a distance from the end stop. According to the teaching of document D3 a self arresting stepper motor spindle would be necessary and not a physical end stop. Furthermore, none of documents D2, D3 and D4 gives any hint for the provision of a compliant preloaded linkage connecting the stepper motor with the pump rack means.

- 6.5 Although document D1 describes a rack controlled plunger pump with a stepper motor and a compliant preloaded linkage provided between a distal rack member engaged with the stepper motor output pinion gear and the pump

rack means, this document D1 is silent about the provision of a physical end stop and a reference position sensor for resetting the position of the stepper motor. The particular construction of the compliant preloaded linkage with only one spring between two stops does not require a physical end stop. The system of document D1 would lead either to the use of a physical end stop or to the use of an electrical end switch but would not give any basis for the idea of using a physical end stop and displaced therefrom a reference position indicator. Even with the teaching of document D1 it would therefore not be obvious to arrive at the subject-matter of Claim 1.

- 6.6 The subject-matter of Claim 1 of the main request therefore involves an inventive step within the meaning of Article 56 EPC.
7. In view of the above, the patent in suit can be maintained on the basis of the documents of the respondent's main request.
8. Therefore, there is no need to examine the Respondent's subsidiary request.
9. At the oral proceedings, both parties had an opportunity to present their comments on the amended text of the patent submitted by the Respondent. It is therefore not necessary to issue a communication pursuant to Rule 58(4) EPC.

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 and 2 as filed during the oral proceedings on 7 December 1994 as main request;

Description: Column 1 according to the patent specification EP-B-0 239 524;
columns 2 to 6, as filed during the oral proceedings on 7 December 1994;

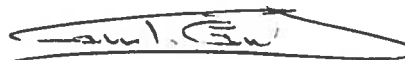
Drawings: Figures 1 and 2 according to the patent specification EP-B-0 239 524.

The Registrar:



N. Maslin

The Chairman:



C. Andries