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D E C I S I O N
of 24 May 1994

Case Number: T 0273/91 - 3.5.1

Application Number: 83401865.7

Publication Number: 0106743

IPC: F02D 41/20

Language of the proceedings: EN

Title of invention:
Switching type circuit for fuel injector

Patentee:
Allied-Signal Inc. (a Delaware corporation)

Opponent:
Robert Bosch GmbH

Headword:
-

Relevant legal norms:
EPC Art. 56

Keyword:
"Inventive step (yes, after amendment)"
"Maintenance in amended form (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0273/91 - 3.5.1

D E C I S I O N
of the Technical Board of Appeal 3.5.1
of 24 May 1994

Appellant: (Opponent)
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Respondent: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office dated 28 January 1991 rejecting the opposition filed against European patent No. 0 106 743 pursuant to Article 102(2) EPC.**

Composition of the Board:

Chairman: P.K.J. van den Berg
Members: C.G.F. Biggio
G. Davies

Summary of Facts and Submissions

I. European patent EP-B1-0 106 83 401 865.7 filed on 23 September 1983 and claiming priority from patent application No. 423 936 filed on 27 September 1982 in the United States of America, was granted on 4 January 1989 and opposed on 4 October 1989.

II. On 28 January 1991 the Opposition Division decided to reject the opposition. This decision was based on the patent as granted.

III. The following prior art documents were considered during the opposition procedure:
D1 = EP-A-0 049 183,
D2 = EP-A-0 034 076,
D3 = US-A-4 295 177,
D4 = US-A-4 327 394,
D5 = US-A-4 338 651, and
D6 = US-A-4 234 903.

Documents D1, D2, D3, D4 and D6 were explicitly mentioned in the appealed decision.

IV. The Appellant (Opponent) filed Notice of Appeal on 26 March 1991 and paid the appropriate appeal fee the same day.

Grounds of appeal were filed on 27 May 1991.

The Appellant requested that the appealed decision be set aside, that the patent be revoked in its entirety and, subsidiarily, to be heard at oral proceedings.

V. The Respondent's (Patentee's) submissions were filed on 7 October 1991.

The Respondent requested that the appeal be dismissed and, subsidiarily, that a preliminary written opinion be communicated to him, giving him an opportunity to submit a technical answer and/or amended claims.

VI. By a communication dated 29 October 1992, the Board
- expressed the preliminary view that, subject to suitable redrafting of Claim 1, the subject-matter of said claim might well be considered as involving an inventive step and
- summoned the parties to oral proceedings.

VII. At the oral proceedings, which were held on 17 December 1992, the parties made substantially the following submissions.

The Appellant submitted that, having regard to the disclosure of the patent at issue (see: col. 3, line 64 to col. 4, line 12, and col. 8, lines 40 to 43), the feature: "**pull-in signal generating means (62) for generating a pull-in signal time delayed relative to the on-control signal in response to a received metering pulse**", mentioned by Claim 1 as granted, was rendered obvious by the teaching which could be derived from D2 (see: page 5, lines 22 to 25 and fig. 1).

The Appellant further submitted that, having regard to the disclosure of the patent at issue (see: col. 12, lines 39 to 55; figs. 7 and 8), the feature: "**pulsed switching type boost voltage generator means**", also mentioned by Claim 1 as granted, represented nothing else than a frequency controlled circuitry in a DC-DC converter, whose principle of functioning and advantages were well-known by any person skilled in the art and that such a feature was, moreover, rendered obvious by

the teaching which could be derived either from D5 (see: col. 1, lines 33 to 37) or from D6 (see: col. 1, lines 25 to 27).

The Appellant, consequently, argued that the ground on which the Opposition Division had based its conclusion that the subject-matter of Claim 1 as granted involved an inventive step, as mentioned in the appealed decision (page 9, paragraphs 2 and 3), was wrong and did not permit such a conclusion.

In respect of the Appellant's first submission, the Respondent submitted that the delay time between the pull-in signal and on-control signal disclosed by D2 was nothing else than the well-known response time of a common logical electronic component ($10^{-8} \div 10^{-9}$ s.), which could not be said to be an intentionally generated delay, while on the contrary, in the patent at issue (see col. 4, lines 4 to 12), there was a true delay time ($1 \div 3\ 10^{-6}$ s.) generated by the RC circuit (R235 and C205 in fig. 4), which was explicitly and intentionally provided there.

With respect to the Appellant's second submission, the Respondent admitted that the energy supplied to a coil could indeed be controlled either by the pulse width or by the pulse frequency, but argued, that, according to the Appellant's submissions, the subject-matter of Claim 1 resulted from the combination of the teaching of four documents and that this clearly required splitting the invention into small parts, which was not admissible.

The Respondent, consequently, concluded that the rejection of the opposition by the Opposition Division was well-founded and that, subject to suitable

redrafting of Claim 1, the subject-matter of said claim was to be considered as involving an inventive step.

Amended Claims 1 to 7, indicating the kind of amendments the Respondent had the intention to bring into said claims were handed over during the oral proceedings.

After further discussion, the Respondent offered to make further substantial amendments to his claims, to the extent that the Board decided to resume the procedure in writing, to allow the Respondent to file a fair draft of Claims 1 to 7, amended in accordance with the indicated intention.

The Appellant indicated that, prima facie, claims so amended might meet his objections on inventive step, but nevertheless expressly reserved his right to comment on the new claims, once the fair draft thereof had been submitted to him.

VIII. The fair draft of the new Claims 1 to 7 was filed on 8 January 1993, together with a fairly clear manuscript indication of the various amendments and a specific mention of the passages, in the disclosure of the patent as granted, where support for said amendments could be found.

The Respondent requested that the appealed decision be set aside and the patent be maintained with the new Claims 1 to 7.

The new Claims 1 to 7 read as follows:

1. "A solenoid control unit (20) for controlling the operation of at least one fuel injector (50) of an engine, each injector (50) being of the type having a coil (52), the solenoid control unit (20) being

responsive to metering pulses generated by an electronic control unit (40) in response to at least one engine parameter, and wherein each fuel injector (50) has associated therewith a sense means such as a sense resistor (54) for generating a voltage indicative of the current flowing within a particular injector (50), the solenoid control unit (20) comprising:

- switching circuit means (60), one associated with each injector, adapted to receive a corresponding metering pulse, connected to a corresponding sense resistor (54) so as to receive as an input the voltage drop generated across said associated sense resistor, and comprising: pull-in pulse generating means (210, 220, 222, 230, 232, 234, 236) for generating a pull-in pulse in response to each corresponding metering pulse received; voltage source network means (280) responsive to the pull-in pulse for generating a current reference level signal having a first magnitude during the interval that the pull-in pulse is present and having a second and lower magnitude during an interval thereafter; and on-off switch control means (290) for selectively generating an on-control signal or an off-control signal by which the current flowing in said associated injector (50) is controlled;

- boost voltage generator means (70) responsive to pull-in pulses, one associated with each injector, for generating and storing in a boost capacitor (352), during intervals between the pull-in pulses, a boost voltage signal in excess of the voltage generated by a battery (32), the generation of said boost voltage signal being inhibited during the presence of the pull-in pulses while the boost voltage signal stored in the boost capacitor (352) is used; and

- power circuit means (80) one associated with each injector (50) and responsive to the boost voltage signal, the on-control signal, the off-control signal, and the pull-in pulses for communicating to the injector

(50) the boost voltage signal or battery potential in response to both the pull-in pulses and the on-control signal, and for causing the decay of the injector current in response to the receipt of the off-control signal, by a communication of said injector current to a degeneration or recirculation circuit,

characterized in that the boost voltage generator means (70) comprise a free running oscillator (360) for producing current pulses by which the boost voltage is stored in a stepwise manner in the boost capacitor (352) during each interval when no pull-in pulse is present, in that said on-off switch control means (290) comprise a comparator (292) having a first input (P18) connected to said voltage source network means for receiving said current reference level signal and a second input (P14) connected to said sense resistor (54) so as to permanently receive, as a feedback signal, the voltage generated across said sense resistor by whatever current circulating in said injector coil (52), said on-off switch control means (290) generating an on-control signal when the voltage across the sense resistor is below said current reference level signal and generating an off-control signal when the voltage across the sense resistor is above said current reference level signal, each one of said on-control and off-control signals being inhibited while the other is generated, in that said pull-in pulse generating means comprise a resistor-capacitor combination (235, 205) for delaying each generated pull-in pulse relative to the leading edge of the on-control signal, and in that said power circuit means (80) are of the hybrid type and comprise on the one hand a power source transistor (120) for connecting said injector coil (52) to a voltage source comprising the boost voltage generator (70) and the battery (32) in response to the generation of the on-control signal and for disconnecting said voltage source (70, 32) from said injector coil (52) in response

to the inhibition of said on-control signal, and on the other hand a re-circulating transistor (130) for connecting said injector coil to a re-circulating current path (132-ground) in response to the generation of the off-control signal and for disconnecting said injector from said re-circulating current path in response to the inhibition of the off-control signal".

2. "The solenoid control unit (20) as defined in Claim 1, characterized in that the means for generating the pull-in pulses comprise (figure 4):

- a second comparator (230) including a monostable multivibrator adapted to be connected to a second resistor-capacitor combination (R207-C201) for determining the nominal duration of the pull-in pulses;

- first inverter means (232) comprising an NPN transistor (270) having its emitter terminal grounded, having an input connected to the output of said second comparator (230) and having an output connected to said voltage source network means (280);

- second inverter means (234) having an input connected to the output of said first inverter means (232) and having an output terminal that is nominally maintained at a low logic level in the absence of a metering pulse; and

- output network means (236) for filtering the output of said second inverter means (234), for defining the pull-in pulses and for delaying each pull-in pulse relative to the leading edge of the on-control signal".

3. "The solenoid control unit (20) as defined in Claim 2 further including short circuit detect means for generating an output signal indicative of a short circuit within a particular injector coil (52) said short circuit detect means comprising:

- reference waveform generator means (314) for generating a reference waveform defining a level of current flow;

- comparator circuit means (316) connected to said sense resistor (54) and to said reference waveform generator means (314) so as to be responsive to the injector current flowing in a particular injector coil (52) and to the reference waveform, for generating an output signal when the current level established by the reference waveform generator (314) exceeds the level of current flowing in the particular injector coil (52), said reference waveform generator means and said comparator circuit means forming current monitor means (310) responsive to the level of current flow established by the reference waveform; and

- buffer means (312) responsive to the output of said comparator circuit means (316) for generating a normally high logic level output signal during intervals when the injector current level is below that level established by the reference waveform generator (314) and for generating a low logic level signal during intervals when the injector current exceeds that level established by the waveform generator (314)".

4. "The solenoid control unit (20) as defined in Claim 3 wherein said reference waveform generator means (314) comprise a charging capacitor (C202) and means including a switching transistor (318) for preventing charge accumulation from building upon said charging capacitor (C202) during intervals not involving metering pulses and for permitting the charging capacitor (C202) to charge during other times".

5. "The solenoid control unit (20) as defined in Claim 1 characterized in that said boost voltage generator means (70) comprise (figure 8):

- a boost coil (350) having a first terminal connected to said battery (32), a diode (103) having its anode connected to a second terminal of said boost coil (350); a boost capacitor (352) connected between the cathode of said diode and the first terminal of the boost coil;

- said free running oscillator (360) for generating said current pulses with a frequency depending upon the level of potential of said battery (32);

- buffer means (362) for generating an output signal of said free running oscillator;

- power driver means (364) for generating a series of drive pulses determined by the frequency of said current pulses, the output of said power driver means (364) being connected to the anode of said diode (103) and ground potential for selectively creating a current charge path through said boost coil (350) and for thereafter terminating said current path to permit electrical energy within the boost coil (350) to be transferred and stored on said boost capacitor (352);

- boost voltage indicating means including a level shifting means (368) for generating an output indicative of the voltage stored on said boost capacitor (352); and

- inhibit means (366) responsive to the pull-in pulses and to the output to the level of shifting means for inhibiting the operation of said free running oscillator (360) during those intervals when said boost capacitor (352) has been charged to a predetermined voltage level".

6. "The solenoid control unit (20) as defined in Claim 5 further including no-boost circuit means (370) for generating a signal indicative of the situation that said boost capacitor (352) has not attained its desired charge within a predetermined time interval, comprising an input transistor (430) having its collector-emitter junction paralleled by a storage capacitor (432); the

collector of said input transistor and the positive terminal of said capacitor (432) being connected to a reference voltage, the emitter terminal of said transistor (430) and the negative terminal of said capacitor (432) being connected to ground potential; and the base terminal of said transistor (430) being connected to the output of said level shifting means (368)".

7. "The solenoid control unit (20) as defined in Claim 6 further including diagnostic circuit means (90) responsive to the output of said no-boost signal means and to each short circuit detect signal generated by a particular one of said switching circuit means (60) for generating a low logic level fault detect signal indicative of the fact that a particular one of said switching circuit means or said boost voltage generating means (70) is inoperative; and further including start-up circuitry means (386) for preventing the generation of a false fault detect signal during start-up intervals when said reference voltage has not stabilized."

IX. The fair draft of the new claims, together with the fairly clear manuscript indication of the various amendments and the specific mention of the passages, in the disclosure of the patent as granted, where support for said amendments could be found, were communicated to the Appellant on 13 January 1993, without an explicit indication that any comment thereon should be filed within a given time limit, but merely with the mention: "for your information".

Up to the 29 September 1993 the Appellant did not file any comment on the new claims.

X. On 29 September 1993 the Board issued a communication pursuant to Article 110(2) EPC, stating its preliminary view that the newly drafted claims, which had never been submitted - not even as an auxiliary request- to the Opposition Division, appeared to be

- duly supported by the application, as filed, on which the patent at issue is based (Article 123(2) EPC), and limited with respect to the claims of the patent, as granted (Article 123(3) EPC), so that no objection under Article 123(2) or (3) EPC arose, and
- so specifically restricted that
- the objection of lack of an inventive step, either as raised by the Appellant or as pointed out in the Board's communication dated 20 October 1992, seemed no longer to apply, and
- the question - raised by the Board during the oral proceedings - whether or not the subject-matter of the newly drafted claims might overlap that claimed by the co-pending European Patent EP-B1-0 105 780, thereby providing for "double patenting", seemed also no longer to be relevant.

The Board stated, accordingly, its preliminary view that

- there was no longer any reason which would prevent the Board from deciding to grant the Respondent's request to maintain the patent with the newly drafted claims, unless the Appellant would raise further, strongly grounded objections against such a decision, and
- it seemed justified to assume that the Appellant had no further objection to such a decision.

XI. However, since the newly drafted claims were communicated to the Appellant without an explicit indication that any comment thereon should be filed within a given time limit, but merely with the mention:

"for your information", the Board considered it appropriate to draw the Appellant's attention to the fact that he should reply to the communication dated 13 January 1993, by confirming or denying that theassumption that he had no further objection against the newly draftedclaims was correct and, in case of denial, submit his objections.

XII. On 20 October 1993, the Appellant replied to the Board's said communication, stating that he maintained his request, i.e. that the appealed decision be set aside and the patent be revoked in its entirety.

The Appellant, however, did not put forward any new and specific objection against the subject-matter of the new claims.

Reasons for the Decision

1. The appeal complies with Articles 106 to 108 and Rule 64 EPC and therefore is admissible.

2. The newly drafted claims are duly supported by the application, as filed, on which the patent at issue is based (Article 123(2) EPC), and limited with respect to the claims of the patent, as granted (Article 123(3) EPC), so that no objection under Article 123(2) or (3) EPC arises.

Said claims are, moreover, so specifically drafted that the question - raised by the Board during the oral proceedings - whether or not the subject-matter of the newly drafted claims may overlap that claimed by the co-pending European Patent EP-B1-0 105 780, thereby providing for "double patenting", is no longer relevant.

3. The novelty of the subject-matter claimed by Claim 1, as granted, of the patent at issue was never questioned by the Appellant.

Nevertheless, before discussing whether or not the subject-matter claimed by the newly drafted Claim 1 involves an inventive step, the Board considers it appropriate to establish the specific differences shown by said subject-matter, in respect of the disclosure of the closest prior art on file, i.e. EP-A-0 034 076 = D2.

4. The Board finds that D2 discloses a solenoid control unit (Fig. 1) for controlling the operation of at least one fuel injector of an engine, each injector 54 being of the type having a coil 54a-n, the solenoid control unit being responsive to metering signals generated by an electronic control unit in response to at least one engine parameter, and wherein each fuel injector 54 has associated with it a sense means such as a resistor 64 for generating a voltage drop indicative of the magnitude of the current flowing into the coil of a particular injector 54; the solenoid control unit comprising:

- a boost voltage generator means 22 responsive to pull-in pulses, one associated with each injector for generating and for storing a boost voltage signal in excess of the voltage generated by a battery in synchronism with the pull-in pulses, wherein
- the boost voltage is generated during intervals between the pull-in pulses and inhibited during the presence of the pull-in pulses;
- switching circuit means 40, 70, one associated with each injector 54 adapted to receive a particular one of the metering pulses and connected to a particular sense resistor 64; the voltage drop

generated across said particular sense resistor being input to the switching circuit means 40, 70, which comprises;

- on/off switch control means 70 for generating an on-control signal during intervals in which the current flowing into the coil of its corresponding injector is at a first current reference level below a predetermined value and for generating an off-control signal when the injector current is at a second current reference level above a predetermined value (figs. 1 and 2, page 8, line 1 to page 9, line 23);
- a voltage source network means responsive to the pull-in signal for generating a first current reference level signal during the interval in which the pull-in signal is present and for generating a current level reference signal of lower magnitude during the interval thereafter;
- hybrid power circuit means, one associated with each injector 54 and responsive to the boost voltage signal, the on-control signal, the off-control signal, and the pull-in signal for communicating to the injector 54 the boost voltage signal or battery potential in response to the pull-in signal which is received after the on-control signal and for connecting the injector to a degeneration or recirculation circuit to permit the injector current to decay in response to the receipt of the off-control signal.

5. The Board finds, accordingly, that the apparatus claimed by the newly drafted Claim 1 differs from the apparatus disclosed by D2 because it further comprises, in combination, the following features, mentioned in the characterising clause of said claim:

a) the boost voltage generator means (70) comprise a free running oscillator (360) for producing current pulses by which the boost voltage is stored in a stepwise manner in the boost capacitor (352) during each interval when no pull-in pulse is present,

b) the on-off switch control means (290) comprise a comparator (292) having a first input (P18) connected to said voltage source network means for receiving said current reference level signal and a second input (P14) connected to said sense resistor (54) so as to permanently receive, as a feedback signal, the voltage generated across said sense resistor by whatever current circulating in said injector coil (52), said on-off switch control means (290) generating an on-control signal when the voltage across the sense resistor is below said current reference level signal and generating an off-control signal when the voltage across the sense resistor is above said current reference level signal, each one of said on-control and off-control signals being inhibited while the other is generated,

c) the said pull-in pulse generating means (210, 220, 222, 230, 232, 234, 236) comprise a resistor-capacitor combination (235, 205) for delaying each generated pull-in pulse relative to the leading edge of the on-control signal, and

d) the power circuit means (80) are of the hybrid type and comprise on the one hand a power source transistor (120) for connecting said injector coil (52) to a voltage source comprising the boost voltage generator (70) and the battery (32) in response to the generation of the on-control signal and for disconnecting said voltage source (70, 32)

from said injector coil (52) in response to the inhibition of said on-control signal, and on the other hand a re-circulating transistor (130) for connecting said injector coil to a re-circulating current path (132-ground) in response to the generation of the off-control signal and for disconnecting said injector from said re-circulating current path in response to the inhibition of the off-control signal.

6. The Board finds that features b) and c) above clearly express the combined action of transistors 214, 274 and 270, resistor R235 and capacitor C205 to produce the delay to which the leading edge of the pull-in signal is submitted, once the width thereof has been defined by the combined action of transistors 214 and 220, comparator 230, resistor R207 and capacitor C201, in accordance with the teaching disclosed by the patent at issue, which states:

"The on-control signal is transmitted to the power source transistor 120 through transistor 140 and turns transistor 120 into a fully conductive state just prior to the application of the boost voltage which is generated in response to the delayed pull-in signal.

The capacitor C205 with current source resistor R235 (FIGURE 4) provides a delay of 1 to 3 microseconds prior to the application of the rather high level boost voltage, the voltage stress reduces across the power source transistor 120. Another feature of the present invention is the reduction of the amount of boost voltage drain and excess drive current of the power source transistor 120. This is accomplished by the current limiter arrangement performed by the emitter resistors 124 and 144." (Col. 3, line 64 to Col. 4, line 17), and

"These metering signals or pulses are shown on lines 4, 8, 10 and 12 of FIGURE 7. As mentioned above and described in detail below each switching network 60 generates a pull-in signal in response to a metering signal. An exemplary pull-in signal is illustrated on line 1. Lines 2 and 3 of FIGURE 7 illustrate the switching nature of the on and off control signals.

It should be understood that each switching network 60 will generate its corresponding pull-in, on and off control signals. Lines 6 and 7 of FIGURE 7 illustrate the pulsed current flowing within a boost coil of the boost voltage generator and the boost voltage signal." (Col. 8, lines 38 to 51).

7. Since such a teaching, as expressed by said features b) and c), is neither disclosed nor hinted at by any of the prior art documents on file, the subject-matter of the newly drafted Claim 1 has to be considered as being novel pursuant to Article 54(1) EPC.

8. Contrary to the Appellant's first submission (**Item VII, 2nd sentence**), the Board is of the opinion that said features b) and c), as presently defined, are not rendered obvious by the teaching which may be derived from D2 (see: page 5, lines 22 to 25 and Fig. 1).

The Board is, in fact, of the opinion that the delay time between pull-in signal and on-control signal disclosed by D2 is nothing else than the well-known response time of a common logical electronic component ($10^{-8} \div 10^{-9}$ s.), which cannot be said to be an intentionally generated delay.

According to features b) and c), on the contrary, in the patent at issue (see col. 4, lines 4 to 12), there is a true delay time ($1 \div 3\ 10^{-6}$ s.) generated by the RC circuit

(R235 and C205 on Fig. 4), which is explicitly and intentionally provided there.

The subject-matter of Claim 1 thus involves an inventive step (Art. 56 EPC).

9. The Board is, moreover, of the opinion that, although feature a) might be considered as representing nothing else than a frequency controlled circuitry in a DC-DC converter, and although the principle of functioning and the advantages of such DC-DC converters, i.e. reducing the energy dissipation by reducing the voltage stress on the circuit elements such as the boost generator and the power transistors, are well-known to any person skilled in the art, the specific structure of the boost voltage generator means (70) specified by said feature a) cannot be derived from the teaching disclosed either by D5 (see: col. 1, lines 33 to 37) or by D6 (see: col. 1, lines 25 to 27).

Accordingly, although the Respondent himself admitted (**Item VII, 6th sentence**) that the energy supplied to a coil may indeed be controlled either by the pulse width or by the pulse frequency, the Board is of the opinion that the Appellant's second submission (**Item VII, 3rd sentence**) is no longer relevant in respect of the specific structure of the boost voltage generator means (70), as specified by said feature a).

10. The Board is, accordingly, of the opinion that the Respondent's final request, i.e. that the appealed decision be set aside and the patent maintained on the basis of the new Claims 1 to 7 (**Item IX**) may be granted, subject to the description of the patent at issue being suitably amended so as to bring it into conformity with the new claims.

Order

For these reasons, it is decided that:

1. The appealed decision is set aside.

2. The case is remitted to the first instance with the order to maintain the patent on the basis of new Claims 1 to 7 filed on 8 January 1993 and to ensure that the description of the patent at issue is suitably amended, to bring it into conformity with the new claims.

The Registrar: The Chairman:

M. Kiehl P.K.J. van den Berg