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D E C I S I O N
of 8 May 2001

Case Number: T 0866/99 - 3.2.3

Application Number: 94100446.7

Publication Number: 0607872

IPC: F23Q 7/00

Language of the proceedings: EN

Title of invention:
Glow plug for diesel engine

Patentee:
DENSO CORPORATION

Opponent:
Robert Bosch GmbH

Headword:
-

Relevant legal provisions:
EPC Art. 83, 84, 54, 56

Keyword:
"Clarity of amendments (yes)"
"Disclosure - sufficiency (yes)"
"Novelty and inventive step - (yes) after amendment"

Decisions cited:
G 0009/91, T 0301/87

Catchword:
-

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Case Number: T 0866/99 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 8 May 2001

Appellant: (Proprietor of the patent)
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Respondent: (Opponent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office posted 5 July 1999 revoking European patent No. 0 607 872 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: C. T. Wilson
Members: U. Krause
M. K. S. Aúz Castro

Summary of Facts and Submissions

I. The Appellant is proprietor of the European Patent No. 0 607 872 which was revoked by a decision of the Opposition Division, dated 5 May 1999 and issued in writing on 5 July 1999, for contravention of Articles 83, 84, 54 and 56 EPC. The objections under Articles 83 and 84 were raised by the Opposition Division of its own motion. With regard to Articles 54 and 56 the following documents were taken into consideration:

D3: DE-A-40 10 479

D5: Zeitschrift für technische Physik, 13.Jahrgang 1932, Nr.10, page 450

D6: DE-C-38 22 693

II. The Appellant filed a notice of appeal on 31 August 1999 and paid the appeal fee on the same day. A statement of the grounds of appeal was submitted on 12 November 1999. In this statement the Appellant made reference to the following further documents mentioned in D3:

D7: DE-C-28 02 625

D8: DE-A-38 25 012

and filed two fresh sets of claims, a first set of claims 1 to 9 as a main request and a second set of claims 1 to 7 as an auxiliary request.

III. During oral proceedings held on 8 May 2001 the appellant submitted a revised set of claims for the main request, together with an adapted description and new Figures 1 to 7. Independent claim 1 of this revised set reads as follows:

"1. An electric resistance element comprising:
a first resistance element (11) having a given electric resistance; and
a second resistance element (12) connected in series with said first resistance element (11), said second resistance element having a resistance temperature coefficient positively higher than that of said first resistance element and providing a function of regulating a current to said first resistance element (11),
wherein said second resistance element (12) is made of a Co-Fe alloy whose compositions fall in a range where a change in phase from a body-centered cubic lattice arrangement to a face-centered cubic lattice arrangement does not occur and a change in phase from a close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur even when the second resistance element is subjected to a temperature change from a given room temperature to 1000°C, and
wherein said first resistance element (11) is welded at its end to an end of said second resistance element (12) to form a connection (120) therebetween which includes part of material forming said first resistance element and part of the Co-Fe alloy forming said second resistance element (12),
characterized in that

the composition of the Co-Fe alloy in the connection (120) is defined by a Fe content of 5 to 22 At% by selecting the material forming said first resistance element (11) such that a change in phase of the composition of the Co-Fe alloy in the connection (120) from the body-centered cubic lattice arrangement to the face-centered cubic lattice arrangement and from the close-packed hexagonal lattice arrangement to the face-centered cubic lattice arrangement does not occur at temperatures from a given room temperature to 1000°C."

A second independent claim 5 of the main request is directed to a glow plug including a resistance element defined by the above features, using the terms "heating element" and "regulating element" for the first and second resistance element, respectively.

The auxiliary request was not upheld.

IV. The Appellant requests that the decision under appeal be set aside and that the patent be maintained in amended form on the basis of claims 1 to 9, an adapted description and Figures 1 to 7, all filed in the oral proceedings.

The Respondent (Opponent) requests that the appeal be dismissed.

V. The arguments of the parties as far as they are still relevant to the amended claims can be summarized as follows:

The Appellant:

In order to carry out the invention, claim 1 specified the Fe content and the lattice arrangement in the connection as conditions to be met, both conditions being easily verifiable with generally known techniques. It was evident from D8 that the admissible range of the Fe content was extended rather than narrowed if, as in the first embodiment, Ni was used in the first resistance element, and there was no evidence on the effect of other materials. In the case of the Fe-Cr-Al alloy of the second embodiment, any combination of values taken from claim 4 would still have to meet the requirement of a maximum Fe content of 22 At%, as specified in claim 1. As demonstrated by the example 2 in Figure 4, a homogeneous mixture with a defined volume ratio could be produced in the connection, within practical limits, by proper adjustment of the laser welding parameters, for example the output and focal depth indicated in column 7, lines 13 to 18. In claim 9, the higher density around the first resistance element could obviously be produced by compressing the heater tube.

Novelty vis-à-vis D3 was given because claim 1 excluded any substantial portion of the connection to be composed of a Co-Fe alloy which would undergo a phase change. Furthermore, the reference to a wire material with a temperature independent resistance for the heating coil in column 2, lines 24 to 29 of D3 did not disclose a material resulting in an Fe content of 5 to 22 At%, as specified in claim 1. The mentioning of Ni-Cr alloy in D6 could not be considered as part of the disclosure in D3.

The subject-matter of claim 1 also involved an inventive step because the available documents dealt

only with the resistance elements on their own as possible sources of failure (see in particular D3 and D8), and the authors of the patent under appeal were the first to recognize the welded connection as a further source and to identify the Fe-content therein as crucial, as well as the material of the heating element as a factor influencing this content. Other than on the basis of these considerations there was no reason for the skilled person to change the material of the heating element in D3, for example by selecting the Ni-Cr alloy disclosed in D6. The skilled person would not even consider D6 because this document was concerned with improving the regulating characteristics by contemplating materials for the heating element with a defined temperature dependent resistance, whereas D3 teaches that this resistance should be independent of temperature.

The Respondent:

There were four reasons why the skilled person was unable to carry out the invention. Firstly, the values for the Fe content specified in column 5, lines 15 to 19 and 24 to 28, were inconsistent, and, as evidenced by D8, the presence of Ni and Cr in the connection in the case where a Ni-Cr alloy was used for the first resistance element shifted the range of admissible Fe content in the connection, whereby a skilled person would not know how to select the material of the first resistance element in order to avoid the phase changes. Secondly, the two embodiments failed to give the skilled person sufficient information to carry out the invention in the entire claimed region. In particular, choosing from the ranges given in claim 4 an Fe content of 72 wt% and 9% in the first and second resistance

element, respectively, and a volume ratio of 1:0.25 would give an Fe concentration of 22.88 wt% in the connection which was outside the region of non-occurrence of the phase changes. Thirdly, whatever the operating parameters for the laser weld are, it was impossible to produce a connection with a homogeneous Fe content, whereby boundary portions of the connection would have an Fe content resulting in phase changes. Fourthly, there was no information available in the patent how the density difference of claim 9 could be obtained by the different diameters of the heater tube portions.

The subject-matter of claim 1 was not new because a portion of the connection in D3 close to the regulating element would exhibit an Fe content which was close to that of the regulating element, and therefore fell within the range of 5 to 22 At%. Furthermore, the selection of a material for the first resistance element such that the composition of the Co-Fe alloy in the connection is defined by an Fe content of 5 to 22 At% is indicated by the reference, in column 2, lines 24 to 29 of D3, to the use, in known manner, of wire material having a temperature independent resistance. In fact, the skilled person was aware that, as mentioned on page 2, lines 19 to 27, of D6, Ni-Cr alloy is a known example of such a material, and the disclosure in D6 should, therefore, be seen as part of the content of D3.

As to inventive step, a skilled person would identify the connection as being the cause for premature failure, and on the basis of the knowledge gained from D3, in particular column 1, lines 22 to 38, conclude that the Fe content in the connection could be

responsible. He would therefore search for solutions to reduce this content and find out, knowing that the Fe content in the welded connection is a function of the corresponding content in the first and second resistance elements, that the material of the first resistance element should be suitably selected. He would therefore choose from the known materials mentioned on page 2, lines 23 to 27, of D6 the Ni-Cr alloy rather than the Fe-Cr-Al alloy.

As a further objection, the values of 0.15 to 0.25 for the volume ratio given in column 7, line 30, of the patent were incorrect and inconsistent with claim 4 because they did not take the total amount of the components into account.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 Independent claims

As compared with claims 1 and 8 as granted, the independent claims 1 and 5 of the sole request include, as further limitations, the features that the composition of the Co-Fe alloy in the connection is defined by an Fe content of 5 to 22 At%, and that the temperature range where the phase change should not occur is from a given room temperature to 1000°C. The former feature is derivable from page 9, lines 12 to 18, of the original application, referring to Figure 7

which clearly shows, as also pointed out in the text bridging pages 7 and 8 of the original application, that no changes in the lattice arrangement occur in the range of 78 to 95 At% of Co, i.e. 5 to 22 At% of Fe, in a Co-Fe alloy. The latter feature is supported by the direct link in the original application between the prevention of the phase transformation and the temperature range in which such phase transformation may otherwise occur, for example in original claims 1 and 8 and on page 9, lines 11 and 12 of the original application.

Further, the condition to be met is defined in the amended independent claims 1 and 5 as being "such that a change in phase of the composition of the Co-Fe alloy in the connection ... does not occur", as compared with "to prevent compositions of the Co-Fe alloy in the connection from changing in phase from ...". This is considered to be a mere clarification in the sense that the condition should not be understood in the narrow sense to include only changes in one direction and only in parts of the connection. The new formulation reproduces the wording used on page 9, lines 12 to 18 of the original application.

The amended claims 1 and 5 therefore comply with Article 123(2) and (3) EPC.

2.2 Dependent claims

The dependent claims were amended by deleting the granted claims 4 to 6 and 11 to 13 and renumbering the remaining claims. This does not give rise to a problem under Article 123 either.

2.3 Description

Apart from adapting the description to the amended independent claims and renumbered dependent claims, the ratio of the fused volumes given in column 7, line 15, and in example 2 of Figure 4 was reversed. This is considered to be an allowable correction under Rule 88 EPC because it is immediately evident from Figure 2 and the concentration of Fe in the first and second resistance elements of the second embodiment that the volume of a fused portion of the first resistance element, having an Fe content of 70 wt%, must be smaller than the volume of a fused portion of the second resistance element, having an Fe content of 8 wt%, in order to obtain the Co-Fe atomic percentage ratio of 80:20 in the connection, as stated in line 24. The amended text is in conformity with the range defined in line 30 of column 7 which can be written as 0.15:1 to 0.25:1, and therefore corresponds to the range of 1:0.15 to 1:0.25 specified in original claims 7 and 14, now claims 4 and 8, for the inverse element. The argument of the Respondent that the values of the range defined in line 30 of column 7 are incorrect cannot be accepted because this volume ratio is based on the relative amounts of Fe and Co only, independent of the total amount of the components.

3. *Clarity*

3.1 Since a lack of clarity is not a ground for opposition, objections based upon Article 84 may be examined in opposition proceedings only if they arise out of the amendments made (see also T 301/87, OJ 1990, 335; G 9/91, OJ 1993, 408, 420). As pointed out by the Appellant, the clarity issues raised in the decision

under appeal concern features of the claims in their granted version and were not caused by any amendments after grant. Thus, neither the first instance nor the Board has the power to examine these issues. Since, however, the decision was not based on the clarity objections alone and the Appellant did not challenge the decision under appeal for this reason but amended the claims to overcome the objections, the Appellant is not adversely affected if these issues are not further considered.

3.2 A clarity objection arising out of the amendments made was raised by the Respondent who argued that a phase change as defined in the last feature of claims 1 and 5 cannot be avoided by limiting the Fe content in the connection to the range from 5 to 22 At% because an Fe content of 5 At% would correspond to 4.75 wt% which is shown in the phase diagram on page 450 of D5 to undergo a phase change from a face-centered cubic lattice arrangement to the close-packed hexagonal lattice arrangement in the temperature range of about 0 to 200°C. This argument is not convincing because, based on the atomic weights of 55.85 for Fe and 58.93 for Co, the range of 5 to 22 At% of Fe specified in claim 1 translates into a range of 4.75 to 20 wt% which is consistent with the limits of "etwa 95 v.H." and "80 v.H." for the Co content in wt% as specified on page 450, left-hand column, line 7, of D5.

4. *Sufficiency of Disclosure*

4.1 The decision under appeal mentions three reasons for insufficient disclosure of the invention: the invention defined in claims 4 to 6 was in conflict with claim 1, the functional definition of the material of the first

resistance element imposed an undue burden on the skilled person for reproducing the invention in the whole area claimed, and there was a lack of verifying or measuring means for determining whether the result was obtained.

The first objection is overcome by removing granted claims 4 to 6 and 11 to 13, and the second objection is overcome by specifying the Fe content in the connection which provides an indication as to how the intended result of non-occurring phase changes can be obtained, corresponding to the two embodiments described in connection with Figures 1 and 2 which are typical solutions to be used by a skilled person and varied as appropriate, for example by varying the parameters specified in claim 1, in particular the Fe content in the first resistance element and the fused volume ratio in the embodiment of Figure 2. The skilled person is therefore provided with sufficient information to obtain an Fe content in the range of 5 to 22 At%. The third objection is unfounded because the existence of Co-Fe state diagrams, shown for example in Figure 1 of D5, proves that there are methods available to determine the lattice arrangement and eventual changes thereof as a function of the composition of the alloy. D5 also mentions X-ray analysis as an example for an available method.

4.2 The Respondent correctly points out that the admissible range for the Fe content given in column 5, lines 25 and 26, in wt% is inconsistent with the values specified elsewhere in the patent in At%. This problem does not, however, prevent the skilled person from carrying out the invention because he will recognize the range of 5 to 22 At% used throughout the patent as

the correct range in conformity with the information provided in the prior art (see D5).

4.3 The presence of further components in the alloy, resulting from the use of these components in the material of the heating element, may indeed have some effect on the admissible range of the Fe content. In the case of Ni as additional component the effect is described in D8, page 2, lines 61 to 68, as increasing the upper limit of this range. Thus, the skilled person can safely use an Fe content up to the upper limit indicated in claims 1 and 5. Concerning the lower limit and other components no evidence is available on the effect on the phase change in a Co-Fe alloy. Thus, the corresponding objection cannot be verified and remains purely speculative. If, in any case, the allowable range is narrowed by some component, this can easily be recognized by checking, with known means, the lattice structure to find out whether the further condition in claims 1 and 5 relating to the non-occurrence of the phase change is met.

4.4 Similarly, a selection of particular values from claim 4 may lead to an Fe content outside the admissible range. This likewise does not render the invention unworkable because the skilled person is informed, e.g. in claim 1, about the admissible range of the Fe content. Thus, the skilled person will select the values from the ranges specified in claim 4 so that the resulting Fe content in the connection will be within the range of claim 1, for example by reducing the volume ratio to 0.15 in case of a high Fe content in the first and second resistance elements.

4.5 It is evident to the skilled person that the

concentration in the welded zone is not homogeneous in the entire zone of the fused volumes and that concentration gradients exist at boundaries of this zone adjacent to the first and second resistance elements, as pointed out by the Respondent. Thus, a skilled person will understand claims 1 and 5 as specifying that the Fe content of between 5 and 22 At% should prevail throughout the connection within practical limits, i.e. except in a narrow boundary zone at the first resistance element having a higher Fe-content. Using a laser for producing the weld, as described in column 7, lines 9 to 18, the skilled person will therefore adjust the parameters of the laser, e.g. the output (in power and time) and the focal depth, so that this condition is met. There is no evidence showing that this is impossible.

4.6 Concerning claim 9 there is indeed no description as to how the higher density of the insulating member at the smaller diameter end of the heater tube can be obtained. This is, again, no reason for insufficiency of disclosure because the skilled person will be aware, on the basis of his general knowledge, that this higher density can easily be obtained by compressing the heater tube around the insulating member at the heating element, thereby reducing the diameter of the heater tube at this end.

4.7 The grounds of Article 100(b) therefore do not prejudice the maintenance of the patent as amended.

5. *Novelty*

5.1 It is not in dispute that an electric resistance element and a glow plug as defined in the preamble of claims 1 and 5, respectively, are disclosed in D3. The connection between the heating element (20) corresponding to the first resistance element and the regulating element (21) corresponding to the second resistance element is not described but, typically, a welded connection is provided in glow plugs of this type. Considering the concentration profile in the fused volumes of the weld as outlined in above section 4.5, it can be assumed, as pointed out by the Respondent and in the impugned decision, that the Fe content is within the range specified in claim 1 in a narrow boundary region close to the regulating element (21) which is described to have an Fe content of between 6 and 18 wt%. As set out above, however, the amended claims 1 and 5 are to be understood in the sense that the defined Fe content should prevail in substantially the entire connection and not only in the boundary regions. Thus, the connection obtained in D3 does not exhibit the characteristics defined in claims 1 and 5.

5.2 In D3, column 2, lines 24 to 29 the heating element (20) is described as consisting "in known manner" of wire material having a substantially temperature independent resistance characteristic, for example a Cr-Al-Fe alloy. The Respondent argues that this passage includes, by reference through the "known manner", other known materials such as the Cr-Ni alloy described in D6, lines 19 to 27, as having a slightly positive temperature coefficient of resistance. Using the Cr-Ni alloy he would then automatically obtain, in

combination with the material of the regulating element (21) which is described as comprising between 6 and 18 wt% Fe, an Fe content within the limits given in claim 1, thereby also preventing any phase change.

The Board cannot follow this argument. In fact, the vague wording "in known manner" cannot overcome the lack of a clear reference, in D3, to the corresponding part of D6 which would be required to incorporate the teaching of D6 into D3. Furthermore, since there are a number of other materials having a substantially temperature independent resistance, the disclosure of a Cr-Ni alloy cannot be considered as being implicit to D3 even if the skilled person was aware of this alloy as being a suitable material. He still would have to do a selection amongst the known materials. Thus, the use of Cr-Ni alloy as a material of the heating element is not clearly and unambiguously derivable from D3, with the consequence that the Fe content of 5 to 22 At% in the connection required to prevent the phase changes is likewise not derivable from D3.

5.3 The subject-matter of independent claims 1 and 5 is, therefore, considered to be new.

6. *Inventive step*

6.1 It follows from the above considerations that the subject-matter of claims 1 and 5 differs from the prior art disclosed in D3 by the features defined in the characterising portions of the claims. The welded connection between the first resistance (heating) element and the second resistance (regulating) element is identified as a critical part of the resistance element and it is proposed to adjust the Fe content in

the connection to fall within a range of 5 to 22 At% by selecting a suitable material for the first resistance element. In this manner, phase changes in the material of the connection which would cause a premature failure of the resistance element are avoided. The claimed invention therefore solves the problem of providing an extended service life of the resistance element or glow plug, as stated in column 2, lines 46 to 48, of the patent.

6.2 The author of D3 has observed that the regulating element, corresponding to the second resistance element of claim 1, has a short lifetime because the material is destroyed by phase changes occurring during the heating and cooling cycles of the resistance material (see column 1, lines 22 to 38 and 42 to 47). The solution proposed in D3 is a selection of the material of the regulating element to have an Fe content of 6 to 18 wt% whereby such phase changes are avoided (see claims 1 and 2 and column 2, lines 29 to 57). Thus, D3 identifies a reason for wire breakdown and a solution to this problem, as pointed out in the impugned decision, but this is not "the" or the same reason and solution as claimed in claims 1 and 5. In fact, D3 concentrates on the material of the second resistance element, whereas the present invention identifies the connection as a source of premature failure. Furthermore, D3 is only cursorily concerned with the first resistance element by stating, in column 2, lines 24 to 29, that it should have a temperature independent resistance. Thus, D3 does not contain any indication that the material of the first resistance element should be selected according to a quite different criterion so as to determine the composition of the connection. Both the identification of the

connection as being crucial and the selection of the material of the first resistance element according to the criterion of the Fe content in the connection, therefore, require new considerations having no basis in D3.

As pointed out by the Respondent, starting from D3 the skilled person would have to carry out several steps consisting of identifying the connection and the Fe content thereof as a potential source of failure, realising that the Fe content in the connection is determined by the composition of the first and second resistance elements, and choosing the material of the first resistance element as a means for adjusting the Fe content in the connection. The Board cannot, however, follow the conclusion of the Respondent that these steps are based on normal considerations of a skilled person. Indeed, the number of steps involved and especially the fact that no indication of any of these steps can be found in D3 but, as set out above, new considerations are required, lead the Board to the opposite conclusion that the skilled person would not arrive at the solution claimed in claims 1 and 5 on the basis of D3 by merely using his normal competence.

6.3 The other documents are of no help in solving the problem underlying the invention. D6 discloses, on page 2, lines 19 to 27, an Fe-Cr-Al alloy or a Cr-Ni alloy as examples of prior art heating resistances having a slightly positive temperature coefficient, but disregards this prior art and contemplates the use of heating resistances having a positive temperature coefficient at lower temperatures and a negative temperature coefficient at higher temperatures, in order to improve the regulating characteristics. Since

the problem of improved regulating characteristics is unrelated to the problem of providing an extended service life the skilled person searching for a solution to the latter problem is discouraged to take D6 into consideration. Furthermore, D6 selects the material of the heating resistance, i.e. the first resistance element of the patent, only in view of the temperature dependence of the resistance and pays attention neither to the connection of the heating resistance to the regulating resistance, nor to the selection of the material of the heating resistance according to the criterion of Fe content in this connection. Thus, D6 cannot provide an indication to any of the above considerations to be made by the skilled person when departing from D3.

D5, D7 and D8 are even less relevant. D5 provides only general information on the Co-Fe alloy, D7 discloses a glow plug with two resistances welded to each other but is silent about the materials thereof, and D8 is concerned with the material of a regulating resistance having a highly positive temperature coefficient.

6.4 The Board concludes that the invention as defined in the amended claims 1 and 5 is based on considerations, in particular the identification of the connection and its Fe content as crucial for the service life of the resistance element and the selection of the material of the first resistance element with a view to adjusting the Fe content in the connection, which are not obvious in view of the available prior art. The subject-matter of independent claims 1 and 5 is therefore considered to involve an inventive step.

7. The grounds for opposition referred to by the

Respondent and introduced by the Opposition Division, therefore, do not prejudice the maintenance of the patent in amended form on the basis of the new independent claims 1 and 5 and the dependent claims 2 to 4 and 6 to 9.

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 amended form on the basis of claims 1 to 9, an adapted description and Figures 1 to 7, all filed in oral proceedings.

The Registrar: The Chairman:

A. Counillon C. T. Wilson