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Datasheet for the decision of 10 December 2008

Case Number: T 0685/06 - 3.5.02

Application Number: 98104619.6

Publication Number: 0881752

IPC: H02K 3/28

Language of the proceedings: EN

Title of invention:
Alternator for an automotive vehicle

Patentee:
Denso Corporation

Opponents:
Valeo Equipements Electriques Moteur
Koch, Alexander W., Prof. Dr.-Ing.

Headword:
-

Relevant legal provisions:
EPC Art. 123(2), 56

Relevant legal provisions (EPC 1973):
-

Keyword:
"Added subject-matter - yes (main request)"
"Inventive step - no (auxiliary requests 1 and 2)"

Decisions cited:
-

Catchword:
See points 3.1 to 3.3 of the reasons.

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0685/06 **-** 3.5.02

D E C I S I O N
of the Technical Board of Appeal 3.5.02
of 10 December 2008

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Decision under appeal:
Interlocutory decision of the Opposition Division of the European Patent Office posted 13 March 2006 concerning maintenance of European patent No. 0881752 in amended form.

Composition of the Board:

Chairman: M. Ruggiu
Members: M. Rognoni
E. Lachacinski

Summary of Facts and Submissions

I. Both the opponent 01 (appellant 01) and the opponent 02 (appellant 02) appealed against the interlocutory decision of the opposition division concerning the maintenance of European patent No. 0 881 752 in amended form.

II. In the contested decision, the opposition division held, *inter alia,* that the subject-matter of claim 1 of the second auxiliary request, filed during the oral proceedings of 1 February 2006, involved an inventive step within the meaning of Article 56 EPC.

III. Of all the prior art cited by the parties in the course of the appeal proceedings, the following documents remain relevant to the present decision:

D2: US-A-5 097 167
D6: EP-A-0 454 039
D10: US-A-1 826 295
D12: WO-A-92/06 527
SU7: SU-A-1 377 964
C14: A. Guilbert, "*Machines Synchrones",* Dunod, Paris 1965, pages 68 to 75

IV. In reply to a communication from the Board, the respondent (patent proprietor) filed, with a letter dated 10 November 2008, a new set of claims 1 to 4.

V. Oral proceedings before the Board were held on 10 December 2008.

VI. The appellant 01 and the appellant 02 requested that the decision under appeal be set aside and that the patent be revoked.

The respondent requested that the decision under appeal be set aside and that the patent be maintained in amended form on the basis of claim 1 to 4 filed with the letter dated 10 November 2008 (main request), or subsidiarily on the basis of claims 1 to 4 of auxiliary request 1, or on the basis of claims 1 to 3 of auxiliary request 2, both auxiliary requests received during the oral proceedings of 10 December 2008.

VII. Claim 1 according to the respondent's main request reads as follows:

"An alternator for an automotive vehicle, comprising:

a field rotor (3) with N and S poles formed alternatively in a circumferential direction, a stator (2) disposed around said motor in a confronting relationship, a frame (4) supporting said rotor and said stator, and a rectifier (5) rectifying AC power obtained from said stator into DC power, wherein

said stator comprises a laminated stator core (32) formed with a plurality of slots (35), and a plurality of electric conductors (33) are accommodated in said slots;

said electric conductors comprise a plurality of U-shaped segments (33), each having two straight portions (33a, 33b) of rectangular cross-section accommodated in different slots;

said plurality of U-shaped segments have turn portions (33c) each serving as a coil end protruding in an axial direction from one end face of said stator core, said turn portions being mutually spaced so as to form a first coil end group;

a plurality of said electric conductors accommodated in a same slot as different layers constitute a same phase winding;

a first winding comprises said electric conductors accommodated in said same slot, a second winding comprises other electric conductors accommodated in another slot adjacent to said same slot, and said first winding and said second winding are combined so as to generate a summed-up output;

said plurality of U-shaped segments have end portions (33e, 33d) protruding in an opposite axial direction from the other end face of said stator core, said end portions are connected according to a predetermined connecting pattern so as to constitute coil ends of a wiring, and said coil ends are mutually spaced so as to form a second coil end group;

said field rotor comprises a Lundel-type core (71,72) having a plurality of hooked magnetic poles serving as said N and S poles,

two ventilation passages (41, 43 and 42, 44) are provided at both axial ends of said field rotor, one ventilation passage extending in a radial direction so as to allow air to flow across said first coil end

group from an inside to an outside of said first coil end group along said radial direction, and the other ventilation passage extending in a radial direction so as to allow air to flow across said second coil end group from an inside to an outside of said second coil end group along said radial direction,

at least one of said turn portions of said first coil end group and said end portions of said second coil end group are spatially separated from each other so that air can flow across said electric conductors of at least one of said first and second coil end group,

said electric conductors constitute a plurality of pairs of inner and outer layers, said straight portions of said electric conductors accommodated in said same slot being disposed exclusively in a depth direction of said slot,

a plurality of joint portions (33d) are formed by connecting said U-shaped segments, and

said plurality of joint portions are arranged into multiple loops (l1, l2) and mutually spaced in both a circumferential direction and a radial direction in said second coil end group; and wherein

said electric conductors form a multi-phase stator winding having a predetermined phase number,

said stator core comprises a plurality of slot groups corresponding to respective phases, each slot group consisting of a plurality of slots spaced at predetermined intervals corresponding to a magnetic

pole pitch of said field rotor, a first slot set being constituted by slot groups of multiple phases corresponding to said phase number, and a second slot set being phase shifted from said first slot set by a predetermined electric angle, and

a multi-phase winding (2a) comprises electric conductors accommodated in the slots of said first slot set, another multi-phase winding (2b) comprises electrical conductors accommodated in the slots of said second slot set, and said multi-phase windings are combined so as to generate a summed-up output."

Claim 1 according to the respondent's auxiliary request 1 corresponds essentially to claim 1 of the patent as maintained by the opposition division. It differs from the independent claim of the main request in that the wording "from an inside to an outside of said first coil end group along said radial direction" and "from an inside to an outside of said second coil end group along said radial direction" has been deleted from the paragraph relating to the ventilation passages.

Claim 1 according to the respondent's auxiliary request 2 differs from the previous auxiliary request in that it further comprises the following features recited in claim 4 of the main request and of the auxiliary request 1:

"wherein said U-shaped segments are electric conductors each having an elongated rectangular cross section, and a longitudinal direction of said cross section is disposed along a radial direction at said coil end."

VIII. The arguments submitted by the appellant 01, which remain relevant to the present decision, may be summarised as follows:

Claim 1 of the respondent's main request was not supported by the application documents as originally filed and thus was not allowable under Article 123(2) EPC.

The contested patent related to an alternator for an automotive vehicle which was economical, compact and ensured a high power output even at low speeds. Document D6 showed a standard alternator for an automotive vehicle with internal ventilation and comprising a rotor with claw-shaped magnetic poles, two coils for each phase shifted by 30° and two rectifiers. On page 7, lines 23 to 25, D6 pointed out that the armature windings could be wound separated in two layers.

C14, which essentially reflected the general knowledge of the skilled person in the field of stator and rotor windings for electrical machines, taught, *inter alia*, that a rotor or stator winding could be made of conductive bars and also that a plurality of conductors could be arranged in each slot. Furthermore, C14 pointed out that all high-power, low-voltage alternators had a plurality of windings connected in parallel for each phase. A straightforward implementation of this teaching involved the disposition of more conductor segments in the same slot. An example of the arrangement was provided in SU7.

As to C14, it should also be considered that air could flow across the two-layer windings shown in this document. Concerning this aspect, the appellant 01 had already referred to several documents during the opposition, for instance column 7, lines 53 to 55 and Figures 12 to 15 of D2.

D12 related to a stator with a three-phase winding made of U-shaped segments. This stator would be suitable for a vehicle alternator as shown in D6. Although the segments shown in D12 did not have a rectangular cross-section, this document did not exclude such possibility. In fact, it was generally known that conductive segments with a rectangular cross-section increased the coil space factor.

It would be obvious to a person skilled in the art, wishing to improve the power output of the alternator known from document D6, to apply the general teaching of C14 and the skilled person's general knowledge in the field of stator and rotor windings. In doing so, such skilled person would arrive at the alternator according to claim 1 of the auxiliary request 1 without involving any inventive activity.

As to claim 1 according to the auxiliary requests 2, the subject-matter which was now claimed was not supported by the application as originally filed. In any case, it was known to implement the windings of a rotary electric machine by means of conductive segments with an elongated rectangular cross section. Thus, claim 1 of the auxiliary request 2 was based on a combination of features which were either known or obvious to a person skilled in the art.

IX. The arguments submitted by the appellant 02, which are still relevant to the present decision, may be summarised as follows:

Claim 1 according to the respondent's main request specified that cooling air flowed across the first and second coil end groups "from an inside to an outside". Since this feature found no support in the application documents as originally filed, the independent claim violated Article 123(2) EPC.

The auxiliary requests 1 and 2 were first filed in the oral proceedings before the Board and, as late-filed, should not be admitted into the proceedings.

As to the substance of the respondent's new requests, claim 1 of the auxiliary request 1 specified, *inter alia*, that the alternator of the present invention had ventilation passages which allowed air to flow across the first coil end group and the second coil end group. Given the broad wording of the claim, an alternator with this feature was already known from D6 which constituted the closest prior art document. The remaining features of claim 1, which were not covered by D6, related to the constitution of the stator winding and to its ventilation. Windings made of U-shaped segments were known, for instance, from documents D10 and D12. As the person skilled in the art was aware of the necessity of providing effective cooling to the stator of a high performance alternator, no inventive contribution to the state of the art could be seen in arranging the segments of the stator coil so as to increase the cooling effect of the centrifugal

air flow generated by the alternator's fans. Furthermore, the features of the claim relating to a multilayer winding were already known from C14, which reflected the skilled person's general knowledge.

In summary, the features recited in claim 1 of the auxiliary request 1 covered different independent aspects which were inherent to the design of a high-performance alternator for an automotive vehicle and which were, at least separately, covered by the cited prior art. It would have been obvious to a person skilled in the art, starting from D6 and wishing to develop a high-output automotive alternator, to rely on the relevant prior art knowledge. In doing so, the skilled person would have arrived at the subject-matter of claim 1 without involving an inventive step (Article 56 EPC).

Claim 1 according to the respondent's auxiliary request 2 was based on a combination of features which was not disclosed in any of the embodiments of the application as originally filed. Thus, this claim was not allowable under Article 123(2) EPC. In any case, windings made of U-shaped segments with an elongated rectangular cross section were known in the art. For a person skilled in the art, it would have been obvious to dispose such segments as recited in the claim.

X. The respondent's arguments which remain relevant to the present decision may be summarised as follows:

The amendment made to claim 1 of the main request was directed to clarifying that ventilation of the stator winding was achieved by air flowing through the turn

portions and the joint portions of the winding's U-shaped segments. This clarification, which was meant to highlight the differences between the claimed invention and the prior art, was fully supported by the application documents and, in particular, by paragraph [0079] of the published patent.
Hence, claim 1 according to the main request did not violate Article 123 (2) EPC.

Starting from the closest prior art document, namely D6, the technical problem underlying the present invention consisted in increasing the power output of a compact automotive alternator at low speeds, without affecting its performance at high operational temperatures, and in reducing its noise level. The solution according to claim 1 of the main request consisted essentially in providing a stator with a multi-phase winding comprising a plurality of U-shaped segments having a rectangular cross-section and arranged in circumferential layers so that a plurality of conductors were accommodated in each slot along a radial direction. The special radial arrangement of the winding segments in combination with ventilation passages as specified in the claim ensured that the heat generated by the alternator was efficiently removed and, consequently, that a high-power output could be consistently delivered.

D6 dealt with the problem of cooling the stator core of an alternator. However, as shown in Figure 13, the air stream generated by the axial fans did not flow across the coil ends but passed outside them. The tightly packed coils of the stator winding of D6 were in fact not designed to let air pass through them. As the

cooling provided by the known alternator was limited, this arrangement was not suitable for a high-performance generator of compact dimensions.

The expression "flow across" in claim 1 was clearly and exclusively defined such that air was allowed to flow between the individual coil ends which formed a coil end group. Thus, the wording of claim 1 implied that the coil ends were formed with the explicit intention of allowing cooling air to flow through them. Such intentional spacing of conductors in the coil end groups was not proposed in any of the cited prior art.

In D6, fans axially attached on either side of the rotor generated an air flow along the axial direction. As hardly any air flow along a radial direction was produced by this arrangement, no cooling air streamed across the coil end groups. In particular, no cooling air flowed from the inside to the outside of the coil end group along a radial direction.

C14 showed windings which could be implemented by means of conductive bars. However, when there were more than two conductors per slot, the coil end groups became more complicated and cooling of the coils more difficult. C14 failed to address this problem.

Document D12 related to the assembly of segmented U-shaped conductors in stators, whereas SU7 focused on simplifying the design and improving the reliability of high-voltage A/C electrical machines. As SU7 related to a high-voltage alternator, its teaching was not relevant to the development of an automotive alternator.

Furthermore, neither D12 nor SU7 addressed the problem of cooling the stator windings and neither document disclosed how cooling air flowed in response to the rotor's movement.

Even if it were assumed that an electric machine according to D12 had a rotor with a fan, it was difficult to cool efficiently coil ends which were formed by tightly packed conductors. SU7 showed indeed a stator comprising several conductors arranged in each slot. However, they were essentially different from the U-shaped segments of the present invention.

As to the late filing of the auxiliary requests, the claims of the auxiliary request 1 corresponded to the claims of the patent as maintained by the opposition division, whereas claim 1 of the auxiliary request 2 was a combination of claim 1 and 4 of the auxiliary request 1. Thus, the auxiliary requests related to subject-matter which was well known to the appellants and had already been considered in the opposition proceedings.

Since the subject-matter of claim 1 according to the auxiliary request 1 corresponded essentially to the main request, the same arguments in favour to its patentability applied.

Claim 1 according to the auxiliary request 2 additionally specified that the conductive U-shaped segments had an elongated rectangular cross section and that a longitudinal direction of such cross section, namely its longer side, was disposed along a radial direction at the corresponding coil end. Support for

this arrangement was found in Figure 13. The auxiliary request 2 was thus allowable under Article 123(2) EPC.

A stator winding comprising U-shaped segments with an elongated rectangular cross section and disposed as specified in the claim enhanced the air flow through the coil end portion and improved the stator's ventilation. Although D2 showed segments with a rectangular cross section, none of the prior art documents suggested the claimed radial disposition of coil ends with a rectangular cross section as a solution to the problem of cooling a high-power, low voltage alternator for an automotive vehicle. Hence, the subject-matter of claim 1 involved an inventive step within the meaning of Article 56 EPC.

Reasons for the Decision

1. The appeal is admissible.

Main request of the respondent

2.1 Claim 1 according to the main request differs from claim 1 of the patent as maintained by the opposition division essentially in that it specifies the air flow across the coil end groups as follows:

- *"one ventilation passage extending in a radial direction so as to allow air to flow across said first coil end group from an inside to an outside of said first coil end group along said radial direction, and the other ventilation passage extending in a radial direction so as to allow air*

to flow across said second coil end group from an inside to an outside of said second coil end group along said radial direction."

2.2 As submitted by the respondent in the oral proceedings, the underlined amendment was merely directed to clarifying what the claim already expressed, namely that air flowed through the coil end groups in a radial direction.
Support for the claim amendment was found in paragraph [0079] of the published patent and, in particular in the following passage:

- *"According to this arrangement, the ventilation means is disposed adjacent to the inside of the coil end group of the stator. The cooling air directing the centrifugal outer direction* (sic) *enters inside the coil end group and then exit* (sic) *the outside through the ventilation hole formed on the frame"* (published patent, column 14, paragraph [0079], lines 17 to 22).

As further evidence that the amended claim did not contain any added subject-matter, the responded had referred in the written proceedings (see letter dated 15 January 2007) to Figures 1, 18 and 19 and to the following passages of the application documents:

- *"Furthermore, the magnetic poles have a function of guiding cooling air in the axial direction when they rotate. This is utilized for adequately conveying the ventilation air in the axial direction or in the radial direction."* (page 9 of

the application as originally filed, lines 20 to 22 in connection with Figure 1)

- *"According to this arrangement, all of the electric conductors located out of the slot can be spaced in a radial direction of the stator. This prevents a plurality of coil ends from being brought into contact with each other. An air flow in the coil end group can be smoothed. Noises are reduced as a result of reduction of an interference between the cooling air and the coil ends."* (*ibid.* page 14, lines 1 to 5 and Figure 1)

- *"These coil ends are mutually spaced so as to form a second coil end group. The field rotor comprises a Lundel-type core having a plurality of magnetic poles serving as the N and S poles. Two ventilation passages are provided at both axial ends of the field rotor. One ventilation passage extends in a radial direction so as to allow air to flow across the first coil end group, while the other ventilation passage extends in a radial direction so as to allow air to flow across the second coil end group."* (*ibid.* page 25, lines 23 to 30 and Figure 1)

- *"It is possible to provide cooling fans at both end faces of the rotor, as shown in Fig. 18. According to this arrangement, another cooling fan 12 is provided at a front end side of the rotor. This arrangement improves the cooling characteristics. According to the Lundel-type rotor causing wind at a disk portion of the pole core, a satisfactory cooling ability can be*

attained by using only one cooling fan 11 shown in Fig. 1. However, providing the cooling fans at both ends of the rotor is effective to increase the cooling ability and reduce the size of the automotive alternator when the same power output is demanded." (*ibid.* page 45, lines 27 to page 46, line 3 and Figure 18)

- *"Furthermore, the arrangement shown in Fig. 19 can be adopted. An end face of the rotor 3, not provided with the cooling fan, confronts an inner wall surface 45 of the outer peripheral portion of the air inlet hole 41 of the frame 4. When the disk portion 72 of the pole core 7 functions as a fan, the inner wall surface 45 can serve as a fan shroud. The fan ability at the disk portion 72 is increased. Accordingly, compared with the above-described arrangement where the cooling fans are provided at the both ends of the rotor, it becomes possible to attain a comparable cooling ability without increasing the number of parts and man-hour. Furthermore, the size is reduced."* (page 46, lines 4 to 12 and Figure 19)

2.3 As shown above, the contested patent discloses an alternator comprising ventilation passages which are provided at both axial ends of the rotor and extend in a radial direction so as to allow air to flow across the first and second coil end groups. Although the wording used in the description indicates that cooling air flows from the inner side to the outer side of the coil end groups, it does not necessarily imply that the air flow passes through the coil end groups along a radial direction, as maintained by the respondent.

Indeed, the application documents do not disclose any means for preventing that at least part of the air flow is deflected by the turn portions or the joint portions of the U-shaped segments and, therefore, they do not support the assumption that the air stream generated by a fan on either side of the rotor has to follow a radial path through the turn or joint portions as it moves from the inner side to the outer side of the corresponding coil end group.

2.4 In conclusion the Board finds that claim 1 of the main request contains subject-matter extending beyond the content of the application as originally filed, and that consequently it violates Article 123(2) EPC.

Admissibility of the respondent's auxiliary requests 1 and 2

3.1 The auxiliary requests 1 and 2 were filed at the end of the oral proceedings before the Board and thus at a very late stage in the appeal proceedings.

3.2 The auxiliary request 1 is essentially the same as the request which the first instance considered allowable. It was filed to overcome an Article 123(2) EPC objection raised by the appellant 02 in a letter dated 3 November 2008 and maintained by both appellants in the oral proceedings.

Claim 1 of the auxiliary request 2 is a combination of claims 1 and 4 of the patent as maintained by the contested decision.

Hence, both requests are based on subject-matter known to the parties and already considered in the first

instance. Furthermore, in the letter dated 10 November 2008 written in response to the Board's communication, the respondent had announced, that, if necessary, they would defend the patent on the basis of any of the dependent claims in the framework of auxiliary requests to be concretized during the oral proceedings before the Board.

3.3 Under these circumstances, the Board finds that the late-filed auxiliary requests can be allowed into the appeal proceedings.

Auxiliary request 1

4.1 It is undisputed that D6 constitutes the closest prior art and that this document shows an alternator for an automotive vehicle comprising the following features recited in claim 1 of the auxiliary request 1:

- a field rotor 10 (see Figures 1 and 2) with N and S poles formed alternatively in a circumferential direction,

- a stator 20 disposed around said rotor 10 in a confronting relationship,

- a frame 2 supporting said rotor 10 and said stator 20,

- a rectifier 5 and 6 rectifying AC power obtained from said stator into DC power, wherein

- said stator comprises a laminated stator core 20a (page 5, lines 31 to 34) formed with a plurality

of slots 21 to 26 (see Figures 3 and 4), and a plurality of electric conductors 31 to 36 are accommodated in said slots,

- a plurality of said conductors 31 accommodated in a same slot as different layers constitute a same phase winding (see Figure 10 and page 7, lines 23 to 25),

- a first winding comprises said electrical conductors 31 accommodated in said same slot, a second winding comprises other electrical conductors accommodated in another slot adjacent to said same slot, said first winding and said second winding are combined so as to generate a summed-up output (Figures 10, 11 and 12, page 7, lines 23 to 25 and 54 to 56),

- said field rotor comprises a Lundel-type core (see Figure 2) having a plurality of hooked magnetic poles serving as said N and S poles,

- two ventilation passages are provided at both axial ends of said field rotor (see Figures 1 and 13, page 7, lines 27 to 30 and page 8, lines 24 to 27), one ventilation passage extending in a radial direction, and the other ventilation passage extending in a radial direction (see air flow in Figure 13),

- said electric conductors form a multi-phased stator winding having a predetermined phase number (Figures 11 and 12),

- said stator core comprises a plurality of slot groups corresponding to respective phases, each slot group consisting of a plurality of slots spaced at predetermined intervals corresponding to the magnetic pole pitch of said field rotor, a first slot set being constituted by slot groups of multiple phases corresponding to said phase number, and a second slot set being phase shifted from said first slot set by a predetermined electric angle (Figures 11 and 12, page 7, lines 41 to 56),

- a multi-phase winding comprises electric conductors accommodated in the slots of said first slot set, another multi-phase winding comprises electric conductors accommodated in the slots of said second slot set and said multi-phase windings are combined so as to generate a summed-up output (Figures 11 and 12).

4.2 According to the respondent, the remaining features of claim 1 can be separated into a first group relating to the constitution of the stator winding and a second group concerning its cooling.

The first group comprises the following features:

(i) said electric conductors comprise a plurality of U-shaped segments, each having two straight portions of rectangular cross-section accommodated in different slots;

(ii) said plurality of U-shaped segments have turn portions each serving as a coil end protruding

in an axial direction from one end face of said stator core, said turn portions being mutually spaced so as to form a first coil end group;

(iii) said plurality of U-shaped segments have end portions protruding in an opposite axial direction from the other end face of said stator core, said end portions are connected according to a predetermined connecting pattern so as to constitute coil ends of a wiring, and said coil ends are mutually spaced so as to form a second coil end group;

(iv) said electric conductors constitute a plurality of pairs of inner and outer layers, said straight portions of said electric conductors accommodated in said same slot being disposed exclusively in a depth direction of said slot;

(v) a plurality of joint portions are formed by connecting said U-shaped segments;

(vi) said plurality of joint portions are arranged into multiple loops and mutually spaced in both a circumferential direction and a radial direction in said second coil end group.

The second group comprises the following features:

(vii) at least one of said turn portions of said first coil end group and said turn portions of said second coil end group are spatially separated from each other so that air can flow

across said electric conductors of at least one of said first and second coil end group;

(viii) one ventilation passage extending in a radial direction so as to allow air to flow across said first coil end group, and the other ventilation passage extending in a radial direction so as to allow air to flow across said second coil end group;

4.3 The respondent has not contested that the above features of the claim can be separately found in some of the numerous documents referred to by the appellants. However, in the respondent's opinion, the cited prior art did not suggest using U-shaped segments with a rectangular cross-section as electric conductor for the stator winding of an alternator for an automotive vehicle and arranging them radially so as to promote the flow of cooling air through them. The contested patent addressed the problem of providing an automotive alternator which had to satisfy conflicting requirements, namely which was compact in size, capable of generating the required power in the low-speed region and had a low noise level. The gist of the present invention consisted not just in the use of U-shaped segments for the winding of a multi-phase stator but also in the radial arrangement of a plurality of such segments in each slot, so that the circumferential spacing between the U-shaped segments allowed an unimpeded flow of cooling air. The claimed combination of features ensured a high power output and efficient cooling of the stator winding even when the alternator was operated at low speed.

5.1 Apart from the features listed under item 4.1, D6 (page 7, lines 23 to 25) further specifies that *"as shown in Fig.10, a plural number of armature windings may be grouped in one bundle, and the armature windings may be wound in wave-shape and may be wound separated in two layers. In this case, the winding manufacturing operation becomes easier."*

In fact, Figures 1 and 10 show that the conductors of the windings have *"turn portions"* and that these portions protrude in opposite axial directions from the end faces of the stator core.

5.2 The alternator known from D6 thus comprises a plurality of conductors with turn portions, each serving as a coil end protruding in an axial direction from one end face of said stator core and in an opposite axial direction from the other end face of said stator core, so as to form a first coil end group and a second coil end group (cf. features (ii) and (iii) above).

5.3 In summary, the alternator according to claim 1 differs from the one shown in D6 in that its winding comprises U-shaped segments connected and arranged according to features (i), (iv), (v) and (vi), and in that ventilation is ensured by features (vii) and (viii).

6.1 As to the choice of U-shaped segments as electric conductors for the stator winding of an alternator, it is known from C14 that, in principle, stator or rotor windings can be implemented with conductive wires or bars, whereby the choice depends essentially on the number of turns and on the size of the conductors. In particular, C14 points out that two-layer windings can

be made of conductive bars when a high output current is desired (page 69, lines 10 to 14 and page 70, lines 1 to 5). As pointed out by the appellants, C14 is a textbook and thus its teaching is supposed to reflect the general knowledge of the skilled person in the field of windings for electric machines.

D12 relates, *inter alia*, to the stator of an electric machine. Its winding comprises individual conductive bars which are pre-bent into a U-shape with a separation corresponding to the pitch between the poles, inserted into the grooves of the lamination pack and then connected together in pairs (see Abstract and Figure 1). The stator winding according to D12 thus comprises feature (ii), (iii) and (v) referred to above.

Although the bars shown in D12 do not have a rectangular cross-section, it is generally known to the skilled person that conductive segments with a rectangular cross-section can be used for the winding of the stator or rotor of electric machines, in particular when a high coil space factor is desired (see, for instance, D10, Figure 8 and SU7, Figure 3). Consequently feature (i) represents a possible option available to the skilled person wishing to develop a high-performance alternator.

6.2 As to features (iv) and (vi), they relate to the fact that the stator according to the contested patent has two or more windings for each phase and that the straight portions of the corresponding conductor bars are accommodated in the same slot in the depth

direction so that the joint portions are arranged in multiple loops.

D6 (Figure 10) shows a plural number of armature windings grouped into one bundle. A plurality of electric conductors is accommodated in one slot, though not only in a depth direction.

In the case of a multilayer winding comprising a plurality of conductor segments accommodated in each slot, it is, however, known to dispose the straight portions of the segments exclusively in a depth direction of the slot (see, for instance, SU7, Figure 3). This arrangement presents some advantages which are apparent to a skilled person. For instance, the disposition of more conductors in the radial direction allows a multi-layer winding to be made without increasing the number of slots or without increasing the circumferential dimensions of the slots. Furthermore, as the pitch between the slots does not change, it is possible to have a plurality of windings with identical phases.

6.3 In summary, no inventive contribution to the art of designing high power alternators can be seen in the combination of features (i) to (vi).

7.1 Features (vii) and (viii) relate to the spatial separation of the first and second coil end groups and to the flow of air across such groups.

As pointed out in D6, page 7, lines 27 to 30, an "*a. c. generator is generally provided with a cooling fan radially inside of the coil ends of the armature*

windings projecting on both sides of the armature core (that is, radially inside of the portions of the three-phase armature windings projecting from slots of the armature core) so that the coil ends are forcibly cooled by an air flow produced by the fan." In other words, the arrangement of the ventilation passages, the fans and the armature coils of the alternator according to D6 (see Figures 1 and 13) is such that the protruding portions of the armature coils are invested by a centrifugal air flow (cf. page 8, lines 24 to 29).

If the stator of the alternator known from D6 is replaced by a stator comprising U-shaped segments as shown in Figure 1 of D12, it is evident that the U-turn portions and the joint portions of the stator winding will be located within the air flow generated by the fans. As the person skilled in the art is aware of the importance of efficient cooling in a high-performance automotive alternator, it is reasonable to assume that such skilled person will seek to arrange the coil ends in such a way as to prevent excessive crowding and thus promote a smooth air flow over and, as far as possible, across the coil ends (cf. D6, page 7, lines 35 to 38). In other words, the Board considers that it would be obvious to a skilled person to choose the arrangement of the coils ends which is more likely to promote a smooth flow of cooling air through them and its unimpeded extraction from the casing of the alternator.

7.2 In the result, the Board finds that, in the light of the cited prior art, it would be obvious to a skilled person, starting from D6 and wishing to implement a high-performance alternator for an automotive vehicle,

to arrive at an alternator falling within the terms of claim 1 of the contested patent.

Hence, the subject-matter of claim 1 according to the respondent's auxiliary request 1 does not involve an inventive step within the meaning of Article 56 EPC.

Auxiliary request 2

8.1 Claim 1 of the respondent's auxiliary request 2 differs from claim 1 of the auxiliary request 1 in that it further comprises the following features recited in dependent claim 4:

- *"wherein said U-shaped segments are electric conductors each having an elongated rectangular cross-section, and a longitudinal direction of said cross-section is disposed along a radial direction at said coil end."*

8.2 According to the appellant 02, claim 1 did not comply with Article 123 (2) EPC because none of the embodiments of the invention shown in the original application comprised the combination of claimed features.

On the other hand, the respondent referred essentially to Figure 13 to prove that the subject-matter of claim 1 had been properly disclosed.

8.3 Figure 13 is a perspective view of part of the joint portions of a stator winding comprising two pairs of conductors per slot according to the third embodiment of the invention. Though the joint portions appear to

have an elongated rectangular cross-section, it should be borne in mind that this is only a schematic drawing of the spatial arrangement of the second coil end group and, as such, it cannot be taken as a basis for the disclosure of the actual disposition of the conductive segments.

In fact, Figure 14, which according to the description (see original application, page 30, lines 11 and 12) *"is a cross-sectional view showing part of the stator in accordance with the third embodiment of the present invention"*, shows segments which are disposed in the slots with the shorter side of their rectangular cross-section along the radial direction.

In Figure 4, which relates to the first embodiment, a pair of conductor segments is radially arranged in the slot of a stator core. The straight portions of the U-shaped segments have an "elongated rectangular" cross-section and the longer side of this cross-section is disposed along a radial direction. However, the first embodiment and the embodiment of Figures 12a and b have only one pair of conductors per slot.

8.4 The application as originally filed teaches in connection with the first and second embodiments of the invention (Figures 4 and 12) that a disposition of the conductor segments with a rectangular cross-section in the radial direction would improve the cooling of the stator winding (application as filed, page 26, lines 16 to 24). For the person skilled in the art, it is clear that this teaching is not limited to the first and second embodiments but could also be applied to embodiments which have more than one pair of conductors

in each slot. Furthermore, the features now added to claim 1 correspond to the ones recited in claim 45 of the application as filed, which depends on *"any one of claims 42 through 44"*. Claim 1 is in effect based on claims 42 and 45 to 47 of the application as originally filed.

8.5 In summary it can be concluded that, although there is no explicit embodiment showing the combination of features which is now claimed, the person skilled in the art would have realised that the application as originally filed covered also embodiments with more than two conductor pairs per slot in which the longer side of the rectangular cross-section of the segments was disposed in the radial direction.

8.6 Hence, the Board considers that, on balance, the subject-matter of claim 1 of the respondent's auxiliary request 2 complies with Article 123(2) EPC.

9.1 The respondent has stressed that the radial arrangement of the segments with the longer side of their cross-section disposed along a radial direction at the coil end would improve the cooling of the stator winding, and that this arrangement was not obvious to a skilled person.

9.2 As pointed out by the appellants, it is known to use segments having an elongated rectangular cross section as conductors for the coil of a rotary electric machine (see for example D2, Figures 9, 10 and 12 to 15). It is also known that the portions of the segments which protrude from the axial faces of a stator core have to be bent in the circumferential direction in order to be

joined together and form a continuous winding. It is evident that conductive segments with a rectangular cross section are more easily bent in the direction parallel to the shorter side of their cross section. For this reason alone, it would be obvious to arrange segments of a stator winding in the slots as now specified in claim 1.

9.3 As to the improved cooling offered by the claimed arrangement, D6 teaches, inter alia, to adopt *"a cooling structure in which centrifugal fans 17, 18 are disposed beneath the coil ends to direct centrifugal air flow to the coil ends as shown in Fig. 13", so that "high cooling efficiency especially at the coil ends may be maintained, while windage noise, which has been inevitably produced at the coil ends, can be remarkably reduced"* (page 8, lines 24 to 27). The application of this teaching to an alternator comprising a stator winding made of U-shaped segments with a rectangular cross-section implies for the skilled person that the segments should be arranged so that the longer side of the cross-section is disposed along a radial direction at the coil ends. This arrangement minimizes in fact the resistance offered by the coil ends to a centrifugal air flow, promotes the extraction of cooling air from the alternator and thus reduces windage noise.

9.4 In summary, the Board finds that claim 1 according to the respondent's auxiliary request 2 specifies an arrangement of the first and second coil end groups of a stator winding made of conductive segments which it would be obvious to choose in order to favour segment bending, improve cooling and reduce windage noise.

Hence, the subject-matter of claim 1 according to the respondent's auxiliary request 2 does not involve an inventive step within the meaning of Article 56 EPC.

10. As none of the respondent's requests is allowable, the patent has to be revoked in accordance with the requests of the appellants 01 and 02.

Order

For the above reasons, it is decided that:

1. The decision under appeal is set aside.

2. The patent is revoked.

The Registrar: The Chairman:

U. Bultmann M. Ruggiu