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D E C I S I O N
of 2 December 1998

Case Number: T 0039/97 - 3.5.2

Application Number: 90311138.3

Publication Number: 0425132

IPC: H02K 21/04

Language of the proceedings: EN

Title of invention:
Alternating current generator

Patentee:
GENERAL MOTORS CORPORATION

Opponent:
Robert Bosch GmbH

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (no)"

Decisions cited:
-

Catchword:

Europäisches Patentamt | European Patent Office | Office européen des brevets

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Case Number: T 0039/97 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 2 December 1998

Appellant: (Opponent)
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Representative:
-

Respondent: (Proprietor of the patent)
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Decision under appeal:
Decision of the Opposition Division of the European Patent Office posted 6 November 1996 rejecting the opposition filed against European patent No. 0 425 132 pursuant to Article 102(2) EPC.

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: F. Edlinger

A. C. G. Lindqvist

Summary of Facts and Submissions

I. The appeal is against the decision of the opposition division rejecting the opposition against European patent No. 425 132. Opposition was filed against the patent as a whole. Lack of novelty and of inventive step were considered as grounds for opposition in the contested decision.

II. The following prior art documents considered in the proceedings before the opposition division are relevant to the appeal:

D1: DE-B-1 209 651

D2: US-A-4 636 706

D4: BOSCH "Technische Unterrichtung Drehstrom-Generatoren"; first edition, June 1982; pages 12 to 21

D8: JP-A-61-85 045 (English translation).

III. With the statement setting out the grounds of appeal the appellant filed a further document

D9: JP-A-54-116 610 (English translation) and

introduced additional pages 22 to 27 to D4.

IV. The respondent did not object to the introduction of the D9 or the new pages of D4. In response to the

Board's communication accompanying the summons to oral proceedings, the respondent filed with a letter dated 17 October 1998, a new single claim 1.

V. Oral proceedings were held on 2 December 1998.

VI. The appellant requested that the decision under appeal be set aside and that European patent No. 425 132 be revoked.

VII. The respondent requested as main request that the appeal be dismissed and as auxiliary request that the patent be maintained in amended form on the basis of the claim filed with the letter dated 17 October 1998, description to be adapted, and drawings as granted.

VIII. Claim 1 as granted is worded as follows:

"An alternating current generator comprising, a stator (14) including a stator core (16) formed of magnetic material and having slots therein; an output winding (18) including one or more conductors disposed within the slots of the stator core; a rotor (20) rotatably disposed within the stator core such that an air gap is provided between the rotor and the stator core, the rotor comprising a shaft (22), first and second members (30,32) formed of magnetic material carried by the shaft, the first member (30) having a plurality of first fingers (30B) spaced from one another and extending substantially axially of the rotor, the second member having a plurality of second fingers (32B) spaced from one another and extending substantially axially of the rotor, wherein the first

and second plurality of fingers are interleaved, a rotor core (34) formed of magnetic material carried by the shaft, interposed between the first and second members and having one end engaging the first member and a second and *(sic)* engaging the second member; a field coil (36) disposed around the rotor core; first and second slip rings (40,42) carried by the shaft and electrically connected to opposite ends of the field coil; first and second brushes (44,46) engaging the slip rings and adapted to be connected to a source of current to energize the field coil; a plurality of permanent magnets (54) each of which has a first face engaging a surface of a first pole finger and a second face engaging a surface of a second pole finger, the faces of the permanent magnets having opposite magnetic polarities and being so oriented that magnet faces of like magnetic polarity respectively engage opposed surfaces of a given pole finger, the first and second members and the rotor core defining a closed magnetic circuit formed substantially entirely of magnetic material; the magnetic circuit being adapted substantially to shunt the air gap between the rotor and stator core, whereby the flux developed by the permanent magnets is diverted from the air gap by the magnetic circuit and substantially only leakage flux developed by the permanent magnets traverses the stator core when the field coil is not energized, the field coil, when energized with current, being adapted to develop a field magneto-magnetic force in the magnetic circuit which opposes the magneto-magnetic force developed in the magnetic circuit by the permanent magnets, whereby flux developed by the permanent

magnets is caused to traverse the air gap through a path that includes adjacent first and second fingers, the flux developed by the field coil traversing the air gap and being applied to the stator core by the first and second fingers, the amount of permanent magnet flux applied to the stator core being dependant upon the magnitude of the current applied to the field coil."

Claim 2 as granted is dependent on claim 1.

The single claim of the auxiliary request is a combination of claims 1 and 2 as granted, the clerical error being corrected and the full stop at the end of claim 1 as granted being replaced by:

"; voltage regulating means (VS) for maintaining the output voltage of the generator at a desired regulated value, the regulating means applying direct field current to the field coil in only one direction through the field coil, and including means for varying the magnitude of the direct field current as an inverse function of the output voltage of the generator."

IX. The appellant essentially argued as follows:

(i) *Main request*

Document D9 anticipated the subject-matter of Claim 1 of the patent as granted even if some of the features could not be found *expressis verbis*. The person skilled in the art unambiguously included these features in the disclosure of D9. A slip ring body (12) as shown in

figure 1 inevitably consisted of first and second slip rings and the corresponding brushes to allow current to be supplied to the rotating field coil. The closed magnetic circuit including a core (7) was indistinguishable from that of the contested patent and caused the flux developed by the permanent magnets to be diverted from the air gap so that substantially only leakage flux traversed the stator core. No special values of the degree of shunting or special means for obtaining a degree of shunting different from that of D9 were disclosed in the contested patent. The leakage flux was thus as claimed in the contested patent.

In magnetizing the magnetic powder as described on page 5, paragraph 1 of D9, a plurality of magnets were built inevitably oriented in opposite direction to the stray field (Φ_1, Φ_2) of the previously known arrangements (shown in figure 2 of D9) and were thus formed as specified in the contested claim. If there was any doubt about how such magnets had to be oriented, document D8 (figures 1 and 2) showed the arrangement and orientation of such magnets. If not directly disclosed such features were at least obvious from the teaching of D9.

(ii) *Auxiliary request*

The voltage regulating means constituted the usual regulating means for such generators. Since the generator output voltage varied with its rotational speed and its load and the battery to be charged required an approximately constant charging voltage, a

regulator for varying the magnitude of the field current as an inverse function of the generator output voltage was the usual means resorted to. Unidirectional current through the field coil was always utilised in this context. This was evidenced eg by D4 (pages 16 and 17: "Prinzip der Spannungsregelung"; figures 23 to 26) and D2 (Abstract). In addition, such voltage regulating means was also used for generators with permanent magnets, without the need for reversing the current (D8, paragraph bridging pages 5 and 6).

X. The respondent essentially argued as follows:

(i) *Main request*

The leakage flux (Φ_1, Φ_2) mentioned in the paragraph bridging pages 2 and 3 in D9 did not traverse the gap between the rotor and the stator, and figures 2 and 3 (without and with permanent magnets, respectively) showed the same flux (Φ_g) between the stator and the rotor. D9 did not mention that the leakage flux (linked with the stator coil) was reduced to zero. Moreover, since the spaces between the claw poles were merely filled with magnetic powder (D9, page 4, paragraph 2) and magnetized by current in a direction opposite to the normal flow of current (page 5, paragraph 1), it was impossible to determine what poles were set up. This structure was therefore not as specified for the plurality of permanent magnets in Claim 1 of the contested patent.

There was no suggestion in the prior art to combine the

teaching of D9 with that of D8 because the latter did not disclose shunting of the permanent magnet flux. On the contrary, this document suggested that the permanent magnet flux across the air gap should meet substantially all of the normal power demand on the generator. Such a design required a substantial permanent magnet flux to be linked with the stator coil when no field current was supplied.

(ii) *Auxiliary request*

The generator of the contested patent made voltage regulation very simple because there was no need to reverse the direction of the field current to obtain full control of the generator output.

Reasons for the Decision

1. The appeal is admissible.

2. The combination of claims 1 and 2 as granted to form the claim of the auxiliary request constitutes the only amendment made to the patent. This is clearly allowable under Article 123(2) and (3) EPC.

3. *Respondent's main request*

3.1 Before it can be decided whether the subject-matter of claim 1 is novel and involves an inventive step, it is necessary to consider the significance of the following passage in claim 1 (column 7, lines 10 to 17 of the patent specification): "the magnetic circuit being adapted substantially to shunt the air gap between the rotor and stator core, whereby the flux developed by the permanent magnets is diverted from the air gap by the magnetic circuit and substantially only leakage flux developed by the permanent magnets traverses the stator core when the field coil is not energized".

3.1.1 The meaning of "substantially" has to be construed in the context of the claimed combination and its significance in the contested patent specification as a whole.

The objects referred to in the patent specification are as follows:

- to increase the power output and conversion efficiency of the generator (column 1, lines 7 to 16), and

- to control both field flux and permanent magnet flux by means of (preferably unidirectional) field current (column 1, lines 45 to 48).

3.1.2 Permanent magnets (54) engaging the surfaces of the pole fingers (54A, 54B) which are part of a closed

magnetic circuit defined by the first and second members (30, 32) and the rotor core (34) constitute the main structural feature of claim 1 for achieving these objects, in that the circuit is adapted substantially to shunt the air gap (claim 1, column 7, lines 3 to 12; and description: column 1, lines 31 to 33; column 4, lines 4 to 8). As a result, the flux developed by the permanent magnets is retained within the rotor, and only a small quantity of magnetic leakage flux is linked with the stator inducing a small voltage in the stator winding (column 4, lines 15 to 19). The total air gap flux can thus be controlled from some "near zero minimum to some maximum design value" (column 5, lines 19 to 21), with the advantage that a "simple voltage regulating arrangement" can be used and "there is no need to reverse the direction of current flow through field coil 36" (column 5, lines 40 to 48).

3.1.3 The degree of shunting the air gap and the amount of leakage flux are thus primarily determined by the characteristics of the magnetic circuit (substantially closed steel or iron circuit). It should also be borne in mind that in an electrical charging circuit referred to in the patent specification (column 1, lines 3 to 6; figure 4), a small voltage produced in the stator winding will only generate significant electrical power when this voltage is at least greater than the threshold level of the rectifier diodes (see also D1, column 1, lines 7 to 17) and more generally greater than the battery voltage which would otherwise block the rectifier diodes.

3.2 Document D9 discloses an alternating current generator comprising a stator core (9), an output winding (8), and a rotor (6) as specified in column 6, lines 30 to 37, of claim 1 of the contested patent. The (claw pole type) rotor (6) comprises a shaft (2) and first and second members (4) with a plurality of fingers as specified in lines 37 to 47 of claim 1. A field coil (5) is disposed around a rotor core (yoke 7; page 2, third full paragraph; figures 1 to 3) which is interposed between the first and second members. There is no doubt that the rotor core and said members (4) including the fingers are formed of magnetic material since they carry the magnetic flux of both the field coil (5) and the permanent magnets (15), cf paragraph bridging pages 2 and 3, and figure 3.

3.3 The space between the fingers of the members (13) and the space between the fingers and the field coil (5) is filled with magnetic powder (15) and magnetized with current in a direction opposite to the normal flow of current (cf paragraph bridging pages 4 and 5, and figure 3). The magnetic orientation of the powder magnetized in this manner will be a mirror image of the magnetic orientation of the claw pole fingers, both having a predetermined number of magnetic poles of predetermined polarity (cf Φ_1 and H_1 in figures 2 and 3). The permanent magnets created in this way thus effectively constitute a plurality of permanent magnets each of which has a first face engaging a surface of a first pole finger and a second face engaging a surface of a second pole finger. It follows from the foregoing that these faces have opposite magnetic polarities and

are so oriented that magnet faces of like magnetic polarity respectively engage opposed surfaces of a given pole finger (claim 1, column 6, line 57 to column 7, line 7, of the contested patent; D9, page 6, paragraph 1).

3.4 As in claim 1 (column 7, lines 7 to 17), the closed magnetic circuit in D9, formed by the first and second members (4) and the rotor core (7), is adapted to substantially shunt the air gap between the rotor and stator core, whereby the flux developed by the permanent magnets is diverted from the air gap by the magnetic circuit and substantially only leakage flux developed by the permanent magnets traverses the stator core when the field coil is not energized. This feature is an inherent characteristic of the structural feature "closed magnetic circuit" as defined in claim 1 (and disclosed in D9) because a closed magnetic (iron) circuit has a much lower magnetic resistance than air thereby shunting the higher resistance air path. Since the degree of shunting primarily depends on the closed magnetic circuit and the location of the permanent magnets, the closed magnetic circuit of D9 also has the same functional characteristic as that of the contested claim (see points 3.1 to 3.1.2 above). Since D9 is concerned with reducing the leakage flux Φ_1, Φ_2 (within the rotor; page 3, paragraphs 2 to 4), a representation of the permanent magnet "leakage flux" in the meaning of contested claim 1, which did not exist prior to the insertion of permanent magnets (figure 2) and which is an inevitable consequence of any not perfectly closed magnetic circuit, was not of concern in document D9.

3.5 The features of lines 17 to 31, column 7, of claim 1 of the contested patent describe the physical function of a claw pole type rotor with field coil and permanent magnets as in figure 3 of D9 and as in the contested patent. The person skilled in the art directly and unambiguously derives this information from the structure and function of the generator disclosed in D9 (in particular page 3, paragraph 2 - page 4, paragraph 2). The respondent has not contested this fact either.

3.6 Claim 1 (column 6, lines 52 to 57) of the contested patent further specifies first and second slip rings and brushes. Such slip rings and brushes constitute the usual means for feeding direct current to a rotating field coil of a generator of this kind (see for example D4, page 27, figures 43 and 44).

3.7 D9 (page 2, fourth full paragraph and figures 1 and 3) refers to "a slip ring 12". The question whether first and second slip rings and brushes are directly and unambiguously disclosed in D9 to the person skilled in the art needs not be definitely answered here, since two slip rings and brushes would at least constitute the usual choice, and even the only possible solution unless one ending of the winding was connected to the casing via the bearings (which is usually avoided). The subject-matter of claim 1 thus does not involve an inventive step in the meaning of Article 56 EPC.

4. *Auxiliary request*

4.1 The additional feature of claim 1 refers to voltage regulating means. Vehicle charging generators usually apply direct field current either from the storage battery or from the rectified generator output (see figure 4 of the patent specification) and require voltage regulation as specified because the generator output voltage changes with the rotation speed of the engine of the vehicle (see eg D8, figure 4 or D2, Abstract) and the battery needs a substantially constant charging voltage (see eg D4, pages 16 to 17: "Prinzip der Spannungsregelung").

4.2 Document D9 refers to a "charging generator for automobiles" (page 2, first full paragraph) but does not mention a voltage regulator, nor the manner of feeding the field coil (5). For the above reasons, the person skilled in the art would however provide a voltage regulator and feed the field coil with varying field current when the generator is used as indicated.

4.3 In view of the established practice with vehicle charging circuits, field current in only one direction would be the natural choice and the person skilled in the art would only consider reversing the field current if the leakage flux developed by the permanent magnets and linked with the stator coil, in the absence of field current, induced a generator output voltage above a certain level. This is however unlikely in the case of D9 where the magnetic path is substantially shunted by a closed magnet circuit as in the contested patent.

4.4 Document D8 (page 5, line 11 - page 6, line 11) confirms that such voltage regulating means constitute a preferred choice of the skilled person also in the case of a claw pole type generator with permanent magnets (3) arranged between fingers (1) of first and second members (figures 1 to 3). Although this generator makes use of the permanent magnet leakage flux linked with the stator coil to supply a basic load demand without field current (figure 4), thereby suggesting an intentional higher leakage flux, the above passage of the description implies that the normal voltage regulator can be used because "the generator output only by the permanent magnet does not exceed a required value for the vehicle load" and "a regulator used exclusively for the excitation of the permanent magnet is not required".

4.5 The same must therefore be true for the generator of document D9 where the closed magnetic circuit (in particular the rotor core) has the same characteristics as in the contested patent.

4.6 The combination of a generator with a voltage regulating means as specified in the single claim of the auxiliary request therefore constitutes a normal design possibility for the person skilled in the art in view of the disclosure of document D9 and the general knowledge in the technical field (charging generators in vehicles) envisaged by both document D9 and the contested patent.

4.7 The subject-matter of the single claim of the auxiliary

request thus does not involve an inventive step in the meaning of Article 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. European patent No. 425 132 is revoked.

The Registrar: The Chairman:

M. Beer W. J. L. Wheeler