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DECISION
of 8 December 1993

Case Number: T 1089/92 - 3.5.2

Application Number: 85112996.5

Publication Number: 0180815

IPC: H02P 7/00

Language of the proceedings: EN

Title of invention:
Variable speed variable reluctance electrical machines

Patentee:
Kollmorgen Corporation

Opponent:
Philips Patentverwaltung GmbH

Headword:

Relevant legal norms:
EPC Art. 56

Keyword:
"Inventive step - yes, after amendment"

Decisions cited:
-

Headnote/Catchword:
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Case Number: T 1089/92 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 8 December 1993

Appellant:
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Decision under appeal: Decision of the Opposition Division of the
European Patent Office dated 7 October 1992
revoking European patent No. 0180815 pursuant to
Article 102(1) EPC.

Composition of the Board:

Chairman: W.J.L. Wheeler
Members: A. Hagenbucher
B. Schachenmann

Summary of Facts and Submissions

- I. The Appellant contests the decision of the Opposition Division revoking European patent No. 0 180 815 on the ground that the subject-matter of Claim 1 then on file did not involve an inventive step.
- II. In the proceedings before the Opposition Division the following documents relating to the prior art were considered:
- E1: JP-A-59-10182 (on the basis of the drawings and the English abstract in Patent Abstracts of Japan)
- D2: P.H. Chappell et al, "Microprocessor control of a variable reluctance motor" in IEEE Proceedings, Vol. 131, Pt. B, No. 2, March 1984, pages 51 to 60
- E2: GB-A-2 064 897.
- III. In the course of the appeal proceedings the Respondent filed the following additional documents relating to the prior art:
- E3: EP-A-0 096 390
- E4: Ross Welburn, "Ultra High Torque Motor System For Direct Drive Robotics", Proceedings of Robots 8 Conference, Detroit, June 1984, Vol. 2, pages 19-63 to 19-71.
- IV. Oral proceedings were held on 8 December 1993, at which the Appellant filed amended Claims 1 to 8. Claim 1 is now worded as follows:

"A drive system comprising a saturable variable reluctance electrical motor (23), said motor comprising a stationary or driving member (50, 51) having a plurality of salient driving poles (52-59, 67, 68), a magnetising winding for each driving pole (52-59, 67, 68), and a movable or driven member (48, 60) having a plurality of salient driven poles (61-66), the number of driven poles (61-66) being less than the number of driving poles (52-59, 67, 68), the airgap between each driving pole (52-59, 67, 68) and a driven pole (61-66) positioned in alignment therewith being small relative to the dimensions of the poles transverse to said airgap and at least the driven poles (61-66) being formed so that in operation of the motor (23) magnetic saturation occurs substantially in the region of the mechanically variable interface or overlap between the driving and driven poles, the extents and dispositions of the driven poles (61-66) being related to those of the driving poles (52-59, 67, 68) so that in operation of the motor (23) the force-producing increment of driven member (48, 60) displacement resulting from the mechanical interface or overlap of each driven pole (61-66) with a driving pole (52-59, 67, 68) overlaps the force-producing increment of driven member (48, 60) displacement resulting from the overlap of another pole (61-66) with a further driving pole (52-59, 67, 68), and each driven pole (61-66) and each driving pole (52-59, 67, 68) having edge regions (71, 72) spaced apart in the direction of relative displacement of the driven and driving members, said spacing of said edge regions (71, 72) being substantially constant throughout the extent of the pole in a direction transverse to said direction of relative displacement and each said edge region (71, 72) being defined in said transverse direction of the pole by a succession of edge region portions, and the system also comprising driven member position-sensing means (25) for generating at least one signal, the instantaneous value

of which is dependent on the position of the driven member (48, 60), and power supply means (27, 28, 29, 79) including a voltage source or sources connectible across the driving pole windings, said windings being connectible across said source or a said source in a predetermined sequence during driven member (48, 60) displacement and each driving pole winding being thus connectible for a predetermined increment of driven member (48, 60) displacement, and the power supply means (27, 28, 29, 79) including means (27, 28) for regulating the instantaneous magnitude of the current in a driving pole winding when connected to said source or a said source, characterised in that said current-regulating means (27, 28) is responsive to the or a said driven member (48, 60) position-dependent signal of the driven member position-sensing means (25) to regulate said current magnitude so that the instantaneous value of said current set by said regulating means at any position of the driven member (48, 60) within said increment of driven member (48, 60) displacement during which the winding is connectible to said source or a said source relative to its value at any other said position is substantially determined by the instantaneous position of the driven member (48, 60), and in that said edge regions (71, 72) of each driven pole (61, 66) and/or each driving pole (52-59, 67, 68) are shaped by virtue of the pole face surface in said edge regions being progressively set back from a notional continuation of the central region of the poleface in said direction of relative displacement of the driven and driving members, so that the airgap between an edge region surface portion of the poleface and the poleface of an aligned pole is greater than the airgap between the central surface portion of the poleface and the poleface of an aligned pole and/or each said edge region portion of each said edge region (71, 72) of each driven pole (61-66) and/or each driving pole

is displaced in said direction of relative displacement with respect to the or each adjacent edge region portion of said edge region (71, 72), each said edge region portion being advanced in said direction of relative displacement with respect to the preceding edge region portion or each edge region portion being set back in said direction of relative displacement with respect to the preceding edge region portion so that said edge region is skewed relative to said direction of relative displacement, which, in conjunction with current shaping, enables the force transitions to be smoothed."

Claims 2 to 8 are dependent on Claim 1.

- V. The Appellant raised no objection to the "late filed" documents E3 and E4 being considered and the Board decided to admit them.
- VI. Regarding inventive step, the Appellant argued in effect that the preamble of the present Claim 1 was based on the prior art known from D2, which did not mention the problem of torque ripple in variable reluctance motors. According to D2, the signals derived from the rotor position-sensing means were used to determine the switching and commutation times, but there was no regulation of the current in the manner specified in the characterising part of the claim. In fact, there was a statement that the decaying current was of no interest (page 54, column 1, 7th line from the bottom). Furthermore, D2 did not disclose shaping the driving or driven poles in any of the ways specified in the characterising part of the claim. Although E2 and E3 disclosed a brushless dc motor and a variable reluctance motor, respectively, in which the current waveform of the pulses applied to the windings was controlled instant by instant in dependence on the rotor position, there was no lead in any of the documents D2, E2 and E3

which would prompt a person skilled in the art to consider introducing such waveform shaping in the drive system disclosed in D2. D2 described a 10 kW power motor, whereas E3 and E4 were concerned with robotics motors of less than 1 kW. Their rotors had no salient poles. None of the documents cited by the Respondent disclosed poles of a variable reluctance motor shaped in any of the alternative manners specified in the claim. The skilled person would not have thought of smoothing out torque ripple in the motor disclosed in D2 by combining pulse shaping and pole shaping as specified in Claim 1. Regarding the allowableness of the amendments, the Appellant pointed out the relevant passages in the description which supported them.

VII. The Respondent argued that it was known to persons skilled in the art that torque ripple was a problem in variable reluctance motors. This could be seen from E3 and E4. The skilled man would therefore not need to be told in D2 itself that torque ripple was a problem. There was no clear demarcation between brushless dc motors and variable reluctance motors, as could be seen from the abstract on the first page of E4, which mentioned a reluctance motor operated as a brushless dc motor. The skilled person seeking to reduce torque ripple in the D2 motor would consult, *inter alia*, E2 and E3. These documents disclosed a brushless dc motor and a variable reluctance motor, respectively, in which the current waveform of the pulses applied to the windings was controlled instant by instant in dependence on the rotor position. The pulses applied to successively energised pole windings overlapped in such away as to reduce torque ripple. Although no document showing pole shaping had been cited, it was generally known to persons skilled in the art that the shape of the poles and the size of the airgap influenced the magnetic field

distribution and the torque. The claimed drive system was merely a combination of theoretical options known to the skilled person.

VIII. The Appellant requested that the decision under appeal be set aside and that the patent be maintained in amended form on the basis of Claims 1 to 8 as filed at the oral proceedings.

IX. The Respondent requested dismissal of the appeal.

Reasons for the Decision

1. The appeal is admissible.
2. The claims of the patent in suit have been amended in the appeal proceedings, in response to the Respondent's arguments. In addition to all the features recited in Claim 1 as granted by the Examining Division, the present Claim 1 recites details of the poles, which were recited in Claims 7 and 8 as granted by the Examining Division and/or disclosed in the description as a second aspect of the invention. As pointed out by the Appellant, the details of the poleface shaping appearing on page 17, lines 19 to 34, of the printed patent specification, in the context of a rotary motor, are to be interpreted as being also applicable to linear motors, in accordance with the explanation on page 5, lines 45 to 53, of the printed patent specification. In the opinion of the Board, the amended claims do not contravene Article 123 EPC.

3. The novelty of the drive system according to Claim 1 has not been contested. The Board will now consider the question of whether this drive system involves an inventive step.

3.1 There is general agreement between the parties and the Board that the closest prior art is disclosed in D2 and that this prior art is in accordance with the preamble of Claim 1 now on file (see paragraph IV above).

3.2 The drive system according to Claim 1 differs from the prior art disclosed in D2 by the features specified in the characterising part of the claim. Briefly stated, these are:

(a) means for regulating the current waveform and

(b) shaping the driving and/or driven poles, the shaping being in the form of setting back the edge regions and/or skewing,

the combination of (a) and (b) being such as to enable the force transitions (torque ripple in the case of a rotary motor) to be smoothed.

3.3 Although the Respondent succeeded in persuading the Board that it was obvious to provide means for regulating the current waveform of the current pulses in the driving pole windings in the motor described in D2, at least at the level of generality specified in Claim 1, the Board is not convinced that it was obvious to provide a combination of means for regulating the current waveform and pole shaping as specified in the present Claim 1. The reason for this is the following. None of the documents D2, E2, E3 and E4 cited by the Respondent during the appeal (nor E1, which had been cited in the proceedings before the Opposition Division,

but not taken up during the appeal proceedings) discloses shaping of the pole pieces by setting back and/or skewing their edges.

3.4 Given the fact that the Appellant filed with the Statement of Grounds of appeal in February 1993 an amended Claim 1 which specified that "at least said driven pole edge regions are shaped to cause the reluctance of the motor to vary in a predetermined and controlled manner during initial overlap of a driven member with a driving member," and notwithstanding the fact that this feature was very broadly defined, it has been clear ever since then that the details of the pole shaping could become important. It appears that the Respondent did in fact search for more prior art because documents E3 and E4 were filed after the summons to the oral proceedings had been issued, but no prior art concerning pole shaping has been filed. In such circumstances, the Board cannot accept that pole shaping, in any of the alternative forms covered by the present claim, was already known in a variable reluctance motor.

3.5 Thus, the drive system as defined by the present Claim 1 differs from the closest prior art known from D2 by a combination of the features (a) and (b) mentioned in paragraph 3.2 above, as specified in detail in the characterising part of the claim, there being no cited document showing feature (b) in any of its alternative forms. In the opinion of the Board, it cannot be said that the subject-matter of the claim, read as a whole, is obvious.

3.6 The Board therefore agrees with the Appellant that the drive system according to Claim 1 involves an inventive step within the meaning of Article 56 EPC. Claims 2 to 8 are properly dependent on Claim 1, so their

subject-matter also involves an inventive step and ground (a) in Article 100 EPC does not prejudice maintenance of the patent on the basis of Claims 1 to 8 filed at the oral proceedings.

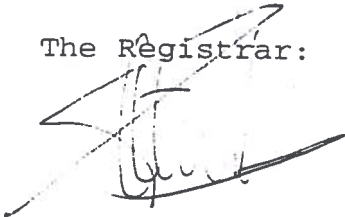
4. The Board therefore concludes that the patent may be maintained with the claims in the amended form in accordance with the Appellant's request.
5. The Board makes use of its powers under Article 111(1) EPC to remit the case to the first instance to adapt the description to the present form of the claims.
6. For avoidance of doubt, it is pointed out that according to Article 111(2) EPC the first instance is bound by the present decision only to the extent that it has been decided that the present claims do not infringe Article 123 EPC and that their subject-matter involves an inventive step.

Order

For these reasons, it is decided that:

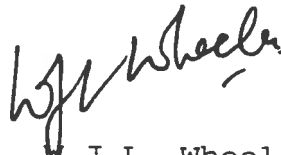
1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to maintain the patent with the claims filed in the oral proceedings, subject to the description being adapted to these claims (see paragraphs 5 and 6 above).

The Registrar:



M. Kiehl

The Chairman:



W.J.L. Wheeler