Internal distribution code:
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [X] To Chairmen

D E C I S I O N
of 8 March 1995

Case Number: T 1010/93 - 3.5.2

Application Number: 88104718.7

Publication Number: 0314860

IPC: H02K 1/16

Language of the proceedings: EN

Title of invention:
Stator and rotor lamination construction for a dymamo-electric machine

Applicant:
GENERAL ELECTRIC COMPANY

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes, after amendment"

Decisions cited:
-

Catchword:
-

Case Number: T 1010/93 - 3.5.2

D E C I S I O N
of the Technical Board of Appeal 3.5.2
of 8 March 1995

Appellant: GENERAL ELECTRIC COMPANY
1 River Road
Schenectady
New York 10022 (US)

Representative: Voigt, Reinhard, Dipl.-Ing.
Patentanwalt
Elsterweg 22
D-65812 Bad Soden (DE)

Decision under appeal: **Decision of the Examining Division of the European Patent Office dated 13 July 1993 refusing European patent application No. 88 104 718.7 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: W. J. L. Wheeler
Members: A. G. Hagenbucher
J.-C. Saisset

Summary of Facts and Submissions

I. The present appeal contests the decision of the Examining Division refusing the European patent application No. 88 104 718.7.

II. The reason given for the refusal was that the subject-matter of the independent claims then on file did not involve an inventive step having regard to

D1: GB-A-2 020 914,
D2: US-A-3 596 121 and
D3: DE-A-2 814 745.

III. In the course of the appeal proceedings, the Appellant amended the claims, description and drawings. In a communication prior to oral proceedings the Board referred also to

D4: EP-A-280 194 (under Art. 54(3) EPC) which had already been cited during the Examining proceedings.

IV. Introducing the sub-division (a) to (d) by the Board, Claim 1 reads now as follows:

"1. A dynamo-electric machine comprising:
a generally cylindrical casing (12);
a stator core (14) fixed in said casing and comprised of stator lamination plates (34) of magnetic material, said stator core having a cylindrical bore (16; 50);

a two pole stator winding embedded in stator slots (52) radially projecting from the bore and which slots extend generally axially along the core, with end turns (36) of said winding extending beyond end faces (48a, 48b) of said stator core;

a rotor (18) supported in said bore for rotational movement;

wherein each of said stator lamination plates comprises:

a flat plate (34) of magnetic material having a preselected outer periphery (59) and a generally circular inner opening of a preselected inner diameter (ID) which forms the stator bore (50) when like ones of said plates are stacked face-to-face with one another, said plate (34) having a number of uniformly circumferentially spaced slots (52) which project radially outwardly from the bore to an intermediate circumference of said plate to define teeth (56) between the slots, said slots forming said stator slots when corresponding slot openings in the like plates are substantially aligned to communicate with one another and the plates are stacked,

said plate (34) including a tooth portion (58) defined by said teeth (56) as having a radial extent between said intermediate circumference and said circular inner opening, and a yoke portion (60) defined between said intermediate circumference and said outer periphery (59) of said plate,

characterized in that

(a) said rotor (18) is comprised of rotor lamination plates (70) of ferromagnetic material, said rotor including conductive means (42) for interacting with a magnetic field produced in an air gap between an outer periphery (78) of said rotor and an inner periphery of the stator core (50) when said stator winding is energized;

wherein each of said rotor lamination plates (70) comprises a flat circular plate of ferromagnetic material having a number of equally circumferentially spaced closed slots (72) extending radially in a region near an outer periphery (78) of said plate,

said rotor slots (72) being formed to contain conducting members (42) which extend axially along the rotor when like ones of said plates are stacked face-to-face with corresponding slots in communication with one another,

(b) said stator lamination plates being annular plates (34) of ferromagnetic material having a preselected outer diameter (OD),

said spaced slots (52) of said stator lamination plates being equal to each other,

(c) wherein for a given ratio of said preselected inner diameter (ID) to said preselected outer diameter (OD) and for a given ratio of said tooth portion (58) to said yoke portion (60) for said annular plate (34) of each of said stator lamination plates, said teeth (56) having a circumferential width (T1) which is sufficiently wide relative to the width of said slot openings (52) wherein the width being defined as the opening between the teeth (56), so that the flux density in said tooth portion (58) is about 1.10 the flux density in said yoke portion (60) in response to energization of the stator winding for the number of poles in the operating configuration of said stator winding; and

(d) wherein the ratio of inner diameter to outer diameter of the annular plate (34) forming the stator lamination is greater than 0,5025 and up to 0,504, whereby improved efficiency can be achieved without increasing the stack height of the stator lamination plates."

Claims 2 to 10 are dependent on Claim 1.

V. The Appellant argued that the subject-matter of Claim 1 was not only new in comparison with the prior art but also involved an inventive step. Optimization of the dimensions of a dynamo-electric machine in order to improve efficiency was very difficult in view of the many parameters involved and depended on the respectively preferred crucial parameters. Figure 7 of the present application indicated prior art parameters (hereinafter called Figure 7 prior art), among others ratios of 0.535 or 0.556 of the inner diameter ID to the outer diameter OD of an annular plate forming a stator lamination. The Figure 7 prior art ratio of the flux density BT_1 in the tooth portion to the flux density BY_1 in the yoke portion of the stator was 1.144 or 1.442. On the other hand, the solution known from D1 tried to optimise flux density throughout the stator by having everywhere equal amounts of flux saturation. D1 explained that if one wanted to increase the flux density in the tooth portion, it would be necessary to increase the stack height in order to obtain an efficient product. The ratio ID ÷ OD was 0.05025 to 0.53.

Starting therefrom, the object of the present invention was to provide a dynamo-electric machine in which the ratio of the flux density in the tooth portion to the flux density in the yoke portion and the ratio of the inner diameter to the outer diameter of the stack lamination plates were optimised to achieve high efficiency with a small amount of winding material. The use of less winding material reduced the costs and resulted in smaller end turns at the end faces of the stator lamination stack and consequently in less flux leakage. The present application showed in Table 3 that claim 1 esp. features (c) and (d), defined optimal parameters for achieving high efficiency with a small amount of winding material.

VI. The Appellant requested that the decision of the Examining Division be set aside and that a patent be granted on the basis of the following documents:

Claims: 1 to 10 filed during the oral proceedings on 8 March 1995.

Description: pages 1, 2, 3, 3(a), 4, 5, 16, 17, filed during the oral proceedings on 8 March 1995.
Pages 6, 7, 8, 10, 11, 13, 15 and 18 as originally filed.
Pages 9, 12, 14 and 19 as filed on 31 March 1992.

Drawings: Figures 1 to 7 filed during the oral proceedings on 8 March 1995.

Reasons for the Decision

1. The appeal is admissible.

2. The amendments made to the documents (Claims, description and drawings) comply with the requirements of Article 123(2) EPC. All the features in present Claim 1 can be found in the original claims and description in conjunction with Figures 1, 3 and 7. The introduction of the reference T_2 in Figure 5 is consistent with T1 in Figure 3 as originally filed. The ratio of flux density "about 1.10" is disclosed in

Claim 4 as originally filed. The values 1.100 and 1.101 for BT_1/BY_1 in Figure 7 show that the indication "about 1.10" in claim 1 permits variations in the third decimal position. This is clear enough for practical purposes.

3. *Novelty*

Figure 7 of the present application shows parameter differences between the present invention and non documented prior art of AC induction motors. None of the cited pre-published documents D1 to D3 nor document D4 cited under Article 54(3) discloses all the features of the subject-matter defined in Claim 1. D4 mentions for a 2 pole stator winding a ratio of inner diameter to outer diameter of the annular stator plate greater than 0.45 and up to 0.50 but not feature (d) of Claim 1. Hence, the subject-matter of Claim 1 is novel.

4. *Inventive step*

4.1 Relevant prior art and problem

Optimising or even dimensioning a dynamo-electric machine is difficult for the following reasons:

In a dynamo-electric machine comprising a rotor and a stator, the dimensions of the rotor and stator cannot be chosen separately. If for instance wide rotor teeth are chosen, the rotor slots will be narrow so that little copper is required in the rotor; but the wide rotor teeth can conduct a high magnetic flux. Since the air-gap induction will now be high, much copper is required in the stator.

The machine may be considered as comprising an electrical and a magnetic circuit. The magnetic circuit, consisting of the iron of the rotor and stator, gives rise to iron loss. The electric circuit, consisting of the windings of the rotor and stator, causes copper loss. For a given amount of copper, copper loss increases if the diameter of the copper wires decreases. Use of less winding material in the stator results in smaller end turns at the end faces of the lamination stack, and thus, undesired flux leakage can be reduced. The electric and magnetic circuits are interdependent.

The present application refers in the description and in Figure 7 to parameters of corresponding known, but non-documented, motors without indicating further details of their construction, e.g. the shapes of casing and stator lamination plates and spacing and shape of stator slots. As far as the parameters of these prior art machines are concerned, ratios $BT_1 \div BY_1$ of 1.144 or 1.142 and ID ÷ OD of 0.535 or 0.556 for 2 pole machines are given. The number of stator slots is $S_1 = 36$ and it is clear from the values $T_1 \div T_S = 0.45$ and 0.404 (T_1: tooth width, $T_S =$ x ID ÷ S_1; S_1: number of stator slots) that the effective tooth width is relatively small and the number of stator slots is high. Even if the nett stator slot area available for insertion of windings is only 30.77 cm^2 (4.77 in^2), the amount of copper winding material is high in view of the high number of slots (36) and stack height of the stator lamination plates.

On the other hand, the most pertinent prior art document D1 shows a dynamo-electric machine with the features in the preamble of Claim 1 with a low ID ÷ OD of 0.52025 to 0.53 in order to implement a stator slot area for sufficiently thick winding wire in order to avoid great copper losses. The number of stator slots S_1 is reduced to 24 and the ratio $BT_1 \div BY_1$ is about 1 because the main concern of this prior art is optimising the flux density throughout this stator by having everywhere equal amounts of flux saturation. D1 makes it clear that if an increase of the flux density in the tooth portion was desired, it would be necessary to increase the lamination stack height in order to obtain an efficient machine. This would correspondingly increase the amount of winding material, however.

Starting from this prior art, the present invention provides a dynamo-electric machine in which the ratio of the flux density in the tooth portion to the flux density in the yoke portion and the ratio of the inner diameter to the outer diameter of the stator lamination plates are optimised to achieve high efficiency with a small amount of winding material. This design approach is new.

4.2 Solution

4.2.1 According to the present invention as now claimed, this optimisation is achieved by the features (c) and (d) of Claim 1. The basic concept behind this solution is a construction in which improvement is obtained through a greater amount of lamination material for both the stator core and the rotor of the machine with less winding conductors than used in the Figure 7 prior art. Features (c) and (d) of Claim 1 implicitly lead to a reduction of the number of slots S_1 (eg from 36 to 24 as shown in Fig. 7). As shown in Table 3 of the present application the use of wider teeth achieves a relatively high flux density in the air-gap between the stator and rotor and provides good efficiency with smaller amount of winding material although the nett stator slot area is increased in order to keep the copper loss small.

4.2.2 According to claim 1 (feature c) the flux density in the tooth portion is greater (about 1.10) than in the yoke portion and not equal as in D1. The examples given in the present application and those given in D1 use the same number of slots S_1 (24). The ID ÷ OD ratio of the claimed subject-matter (cf. feature c: 0.5025 to 0.504) constitutes a special selection within the range (0.5025 to 0.53) given in D1.

For the sake of completeness, it is noted that D1 does not disclose features (a) and (b). However, these features are well known per se for induction motors; cf. also the prior art indicated on pages 2 and 3 of the present application and the description of Figure 4 of D2.

4.2.3 The present invention is the result of an optimisation between the non documented Figure 7 prior art and D1. The combination of the parameters for ID ÷ OD and BT_1 ÷ BY_1 according to features (c) and (d) of Claim 1 cannot be derived in an obvious manner from the above considered prior artin view of the interdependence of these and many further parameters which interdependence is difficult to assess.

4.3 This applies also if the other prior art is additionally considered. D2 discloses an ID ÷ OD in the range of 0.5 to 0.552 for two windings but no BT_1 ÷ BY_1. D3 deals only with the construction of specific squirrel cages without indicating parameters of the stator lamination plates.

4.4 The Board, therefore comes to the conclusion that the subject-matter of Claim 1 cannot be derived in an obvious manner from the documented and Fig. 7 prior art. It must accordingly be seen as involving an inventive step as required under Article 52(1) and 56 EPC.

5. Independent Claim 1 together with dependent Claims 2 to 10 are allowable. In the opinion of the Board, the application meets the requirements of the EPC.

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 grant a patent in the form requested by the Appellant (see para. VI above).

The Registrar: The Chairman:

M. Kiehl W. J. L. Wheeler