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Datasheet for the decision of 8 February 2021

Case Number: T 0235/18 - 3.4.02

Application Number: 13815220.2

Publication Number: 2938983

IPC: G01L1/12, G01L3/10

Language of the proceedings: EN

Title of invention:
NON-CONTACT MAGNETOSTRICTIVE SENSING SYSTEMS AND METHODS

Applicant:
General Electric Company

Relevant legal provisions:
EPC Art. 52(1), 54, 56

Keyword:
Inventive step (yes - amended claims)

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Case Number: T 0235/18 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 8 February 2021

Appellant: (Applicant)	General Electric Company 1 River Road Schenectady, NY 12345 (US)
Representative:	Bryn Aarflot AS Patent Stortingsgata 8 0161 Oslo (NO)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 18 August 2017 refusing European patent application No. 13815220.2 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	R. Bekkering
Members:	F. J. Narganes-Quijano
	T. Karamanli

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the decision of the examining division refusing European patent application No. 13815220.2.

In its decision the examining division held in respect of the sole request then on file that the subject-matter of claim 1 did not involve an inventive step (Article 56 EPC) in view of the disclosure of the following documents:

D1: WO 2012/152720 A1
D4: EP 2420810 A1.

II. In reply to a communication of the board annexed to the summons to oral proceedings and to a further communication dated 19 January 2021, the appellant filed with the letter dated 22 January 2021 amended claims 1 to 10 and amended pages 1 to 9 of the description according to a main request replacing the previous requests on file. With the same letter the appellant requested as main and sole request that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 to 10 and pages 1 to 9 of the description filed with the mentioned letter, and drawing sheets 1/6 to 6/6 of the application as filed.

III. Subsequently, the oral proceedings were cancelled.

IV. Independent claims 1 and 6 of the main request read as follows:

" 1. A system (10) for sensing stress in a ferromagnetic material (12), said system comprising:

at least one magnetic flux device (22) configured to induce a first conditioning magnetic flux (23) in the ferromagnetic material (12); and

a sensor (14) positioned proximate to the ferromagnetic material (12), said sensor comprising:

a core (18);

at least one excitation coil (20) configured to induce a second magnetic flux (17) in the ferromagnetic material (12), wherein the at least one excitation coil (20) is wrapped around the core (18) and is configured to be driven simultaneously by both a direct current (DC) source and an alternating current (AC) source; and

wherein the at least one excitation coil (20) is configured to be operated simultaneously as an excitation coil (20) and as a detector (20) configured to detect changes in the second magnetic flux (17) caused by stress applied to the ferromagnetic material (12)."

"6. A method (600) for measuring stress in a ferromagnetic material (12), said method comprising:

inducing (602) a first conditioning magnetic flux (23) in the ferromagnetic material (12);

inducing (604) a second magnetic flux (17) in the ferromagnetic material (12) by using at least one excitation coil (20), wherein inducing a second magnetic flux in the ferromagnetic material comprises driving the at least one excitation coil (20) simultaneously by both a direct current (DC) source and an alternating current (AC) source; and

detecting (606) by using at least one detector (20) changes in the second magnetic flux (17) induced in the ferromagnetic material (12), wherein the changes in the second magnetic flux (17) are at least partially

correlated to stress in the ferromagnetic material (12), and

operating simultaneously the at least one excitation coil (20) as an excitation coil (20) and as said detector (20)."

The main request also includes dependent claims 2 to 5 and 7 to 10 referring back to independent claims 1 and 6, respectively.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 The board is satisfied that the claims of the present main request meet the requirements of Article 123(2) EPC. In particular,

- claim 1 is based on claim 1 as filed together with the embodiment defined in paragraph [0021] of the description of the application as filed and disclosed as an alternative embodiment of the embodiment previously disclosed in paragraphs [0013] to [0019] of the description by reference to Fig. 1, claim 1 containing, in addition, further amendments based on paragraph [0005], page 3, lines 5 and 6, and page 4, lines 1 and 2, of the description of the application as filed;

- independent claim 6 is based on independent claim 8 as filed, together with the passages of the description of the application as filed referred to above in connection with claim 1;

- dependent claims 2 to 4 and 7 to 10 are based on claims 2, 4, 6 and 9 to 12 as filed, respectively; and

- dependent claim 5 is based on claim 7 as filed together with paragraph [0034], first sentence, of the description of the application as filed.

2.2 The amendments made to the description relate to the adaption of its content to the invention as defined in the present claims (Rule 42(1)(c) EPC), and to the acknowledgement of the pertinent state of the art (document D1) in the introductory part of the description (Rule 42(1)(b) EPC).

3. *Novelty and inventive step*

3.1 Document D1 discloses a system (see Figs. 12 to 14 and the corresponding description on page 16, line 26, to page 19, line 25, which also refers to Figs. 8 to 11) for measuring a torque or a force applied to an object (object 2) made of a ferromagnetic material and also suitable for sensing the stress in the ferromagnetic material (see abstract, first sentence, and page 1, lines 11 to 19, together with page 15, lines 15 to 18, and the paragraph bridging pages 22 and 23). The system (see Figs. 12 to 14) comprises two excitation coils (10a and 10b) wrapped around a respective one of two cores (15a and 15b) disposed proximate to the object (2) on opposite sides thereof (page 19, lines 4 to 11, together with page 16, line 27, to page 17, line 5), and a detector coil device comprising one or two coils (20a and 20b) disposed proximate to the object (page 16, line 27, to page 17, line 4). Each of the excitation coils is configured to induce a magnetic flux in the object (page 19, lines 5 to 9), and the detector coil device is configured to detect changes in

the magnetic flux caused by stress applied to the object of ferromagnetic material (page 18, line 12, to page 19, line 2, and page 19, line 20, to page 20, line 9, together with the abstract).

The magnetic flux induced by a first one of the two excitation coils can be considered to constitute a conditioning magnetic flux within the meaning of the invention (see paragraphs [0013], [0022] and [0040] of the application as filed), while the arrangement constituted by the detector coil device and the second one of the two excitation coils can be considered to constitute - as held by the examining division in its decision - a sensor in which the detector coil device is configured to detect changes in the magnetic flux induced by the second excitation coil.

3.1.1 However, while the second excitation coil mentioned above is driven by either a direct current (DC) or an alternating current (AC) (page 21, lines 13 to 19, and the paragraph bridging pages 22 and 23; see also page 21, first paragraph, and page 28, line 9, to page 29, line 13), claim 1 requires that the second excitation coil is configured to be driven simultaneously by both a direct current and an alternating current source. Therefore, this feature constitutes - as already held by the examining division in its decision in respect of claim 1 then on file - a distinguishing feature of the system defined in claim 1.

3.1.2 In addition, during the appeal proceedings claim 1 has been amended to specify that the excitation coil configured to be driven simultaneously by both a direct current (DC) and an alternating current (AC) source is also configured to be operated simultaneously as an excitation coil inducing a magnetic flux in the

magnetic material and as a detector configured to detect changes in this magnetic flux caused by stress applied to the ferromagnetic material. Therefore, the sensor of the claimed system comprises a coil configured to be operated simultaneously as an excitation coil and as a detection coil.

It follows that the claimed system also differs from the system disclosed in document D1 in that the sensor, instead of being constituted by an excitation coil and a detection coil device, is constituted by the excitation coil configured to be driven simultaneously by both a direct and an alternating current source and configured to be operated simultaneously as such, i.e. as excitation coil, and as a detection coil configured to detect the changes in its induced magnetic flux caused by stress applied to the ferromagnetic material.

3.1.3 Therefore, the subject-matter of claim 1 is new over the disclosure of document D1.

3.2 Document D4 discloses a torque sensor (paragraph [0007], together with Fig. 2 and the corresponding description) for detecting the relative rotational position between two shafts (1 and 2 in Fig. 2). The torque sensor comprises at least one coil (11 and 12) to which an excitation AC signal is applied, and two magnetism-responsive members each coupled to a respective one of the two shafts and causing an impedance in the at least one coil that depends on the relative rotational position of the two shafts (claim 1, and paragraphs [0025] to [0028]). In addition, the excitation AC signal is biased by a predetermined DC voltage for obtaining information on a possible failure - such as a disconnection or the like - of the at least

one coil (abstract, and claim 1, together with paragraph [0009]), thus solving the problem of torque sensors of the prior art requiring multiple transmission lines for failure diagnostic of the sensor components (paragraphs [0002] and [0004] to [0006]).

3.2.1 However, document D4 is not directed to the detection of stress applied to a material - let alone to a ferromagnetic material - and, in addition, the torque sensor disclosed in the document would require structural and functional modifications (in particular, modifications of the coil arrangement (coils 11 and 12 in Fig. 2), modifications of the coil driving and torsional torque evaluation circuit (Fig. 1 and claim 1) coupled to the coil arrangement, etc.) to render it suitable for sensing stress applied to a material. Already for this reason, the claimed system is new over the disclosure of document D4.

3.2.2 Therefore, the subject-matter of claim 1 is also new over the disclosure of document D4.

3.3 The remaining documents on file are less pertinent than documents D1 and D4.

3.4 It follows from the above considerations that the subject-matter of claim 1 is new over the available documents of the state of the art (Articles 52(1) and 54 EPC).

3.5 As held by the examining division in its decision, the closest state of the art is represented by the system disclosed in document D1 and referred to in point 3.1 above.

3.5.1 In its decision the examining division held in respect of claim 1 then on file that the distinguishing feature referred to in point 3.1.1 above solved the objective problem of the detection of coil failure, like a disconnection of the coil. However, as regards present claim 1, this problem - which is not mentioned in the application as filed and the formulation of which appears to be motivated by the teaching of document D4 pertaining to a different technical field, see point 3.2 above - would, at the most, address the first, but not the second of the distinguishing features respectively identified in points 3.1.1 and 3.1.2 above. In addition, while the system of document D1 involves the use of different coils for inducing a magnetic field in the ferromagnetic material and for detecting the resulting magnetic field, the claimed system requires driving a coil simultaneously with a direct and an alternate current and simultaneously operating the coil as an excitation and as a detection coil, and in the board's opinion the claimed arrangement solves at least the objective problem of simplifying the system disclosed in document D1 (see page 9 of the description of the application as filed, last complete sentence).

3.5.2 Document D4 pertains to a different technical field (see point 3.2 above) and, even assuming that the skilled person would consider document D4 and would apply the teaching of the document relating to biasing the excitation AC signal fed to a coil by a predetermined DC voltage for the purpose of obtaining information on a possible failure of the coil, the skilled person would not arrive at the claimed system because neither document D1, nor document D4, nor the remaining documents on file disclose or suggest simplifying the system of document D1 by driving a coil

simultaneously with a direct and an alternate current and simultaneously operating the coil as an excitation coil for inducing a magnetic flux in a material and as a detection coil for detecting possible changes in the magnetic flux induced in the material.

3.5.3 Therefore, in the board's opinion the system defined in claim 1 involves an inventive step over the documents of the state of the art on file (Articles 52(1) and 56 EPC).

3.6 Independent claim 6 is directed to a method for measuring stress in a ferromagnetic material, and the steps of the method are substantially in one-to-one relationship with the structural and functional features of the system defined in claim 1. Therefore, the method of independent claim 6 is also new and involves an inventive step for reasons analogous to those set forth in points 3.1 to 3.5 above in respect of the system of claim 1 (Articles 52(1), 54 and 56 EPC).

The same conclusion applies to dependent claims 2 to 5 and 7 to 10 by virtue of the reference in these claims to independent claims 1 and 6, respectively.

4. In view of the above considerations, the board concludes that the application documents amended according to the present main request meet 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 department of first instance with the order to grant a patent in the following version:

   - claims: Nos. 1 to 10 filed with the letter dated 22 January 2021;

   - description: pages 1 to 9 filed with the letter dated 22 January 2021; and

   - drawings: sheets 1/6 to 6/6 of the application as filed.

The Registrar: The Chairman:

L. Gabor R. Bekkering

Decision electronically authenticated