BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

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File Number: T 809/91 - 3.4.2

Application No.: 85 304 476.6

Publication No.: 0 169 670

Title of invention: Proximity sensor

Classification: G01D 5/20

D E C I S I O N
of 7 August 1992

Applicant: Schlumberger Industries Limited

Headword:

EPC Article 123(2), 84, 54, 56

Keyword: "After amendments: additional subject-matter (no); clarity (yes); novelty (yes); inventive step (yes)"

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Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number : T 809/91 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 7 August 1992

Appellant : Schlumberger Industries Limited
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Representative : Stoole, B.D.
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Decision under appeal : Decision of Examining Division of the European Patent Office dated 19 April 1991 refusing European patent application No. 85 304 476.6 pursuant to Article 97(1) EPC.

Composition of the Board :

Chairman : E. Turrini
Members : M. Chomentowski
L. Mancini

Summary of Facts and Submissions

I. European patent application No. 85 304 476.6 (publication number 0 169 670) was refused by the Examining Division on the grounds that the subject-matter of valid Claim 1 did not involve an inventive step having regard to

D1: US-A-3 230 407.

In particular, the subject-matter of Claim 1 was considered as resulting from the substitution, in the known device, of a magnetic circuit for conveying magnetic signals by an electrical circuit for conveying electrical signals, which last circuit is generally known in the art and is an equivalent signal transmitting circuit.

D2: GB-A-2 053 489 and
D3: GB-A-2 082 859

had also been mentioned during the examination proceedings.

II. The Appellant (Applicant) filed an appeal against this decision.

III. In a communication dated 11 May 1992, the Board of Appeal expressed the provisional opinion that the subject-matter of Claim 1 lacked novelty because it was not distinguished from the device known from D3, that, in particular, the subject-matter of dependent Claim 3 did not involve an inventive step having regard to the teaching of D3 and that disclosed in D2, but that a new patent application containing in particular an amended Claim 1 as proposed by the Board could be allowable having regard to the available prior art.

IV. With a letter dated 6 July 1992, the Appellant filed a new Claim 1 as a preferred request to the claim proposed by the Board and requested that the decision under appeal be set aside and that a patent be granted.

V. Claim 1 of the preferred request reads as follows:

"1. A proximity sensor adapted to be positioned adjacent the path of a moving ferrous object to sense movement of the object, the sensor comprising a stationary magnetically energised pole piece (14) for producing a first magnetic flux pattern through which the object moves, and an electrical conductor (11) inductively coupled to the pole piece such that movement of the object through said first flux pattern induces a current in the conductor, characterised in that the conductor comprises an electrically conductive member (11) arranged to form a closed loop electrical circuit of very low resistance, whereby said current is relatively high, said member having a first end which is inductively coupled to said pole piece (14) and a second end which is remote from said first end and at which a second magnetic flux pattern is established by virtue of said current, the sensor being further characterised by means (16) located at the remote end of the conductive member for sensing changes in said second flux pattern."

Claims 2 to 13 are dependent claims.

VI. The Appellant submitted the following arguments in support of his request.

The features essential for the performance of the invention are a low resistance of the electrically conductive member and the fact that it forms a closed circuit; this results in a low voltage, high current being

induced in the conductive member, as mentioned on page 4, line 13 of the application; the high current results in turn in a strongly varying second voltage at the second end of the closed circuit constituted by the conductive member, which enables one or more output coils to be located in this flux pattern to produce one or more output voltages. In essence, the high current induced in the very low resistance closed circuit constituted by the conductive member has the effect of transferring the strongly varying magnetic flux pattern at the sensing pole piece, a location where there are usually severe space and/or temperature limitations, to a location where these limitations are not so severe. D1, which in particular uses magnetic transmitting circuit, relates to a totally different technique and is not relevant. D3 indeed discloses a sensing circuit as defined in the statement of present Claim 1 and including an electrically conductive member consisting of a coil, the ends of said coil being connected by the conductors of an electrical cable; however, contrary to the conductive member of present Claim 1, the coil does not form a closed-loop electrical circuit and thus has the drawbacks indicated in the present application. Therefore, since the prior art does not suggest the structure of the presently claimed sensor, the subject-matter of present Claim 1 is inventive.

Reasons for the Decision

1. The appeal is admissible.

2 Allowability of the amendments

2.1 Claim 1 is based on Claim 1 as originally filed with amendments, based on all the embodiments in the original application, to specify that the electrically conductive

member (11), which forms a closed electrical circuit, is arranged to form a closed-loop electrical circuit. As credibly argued by the Appellant, the amendments specifying that said closed loop electrical circuit is of very low resistance, whereby said current is relatively high, have a basis in the original description (see page 4, lines 11 to 15 and page 4, lines 27 to 30), which mentions in relation to the embodiment illustrated by Fig. 1 to 3 that the flux changes in the vicinity of the pole piece induce a low voltage high current emf (electromotive force) into the conductor whereby copper is disclosed as the material of said conductor; moreover, in the other embodiments, illustrated by Fig. 4 to 7, the originally disclosed strip-like conductors are directly derivable as having a very low resistance as a result of their shape.

2.2 It is to be noted that Claim 1 is further distinguished from original Claim 1 in that it does not specify that the electrically conductive member is elongate. The Appellant has submitted that the features of the conductive member which are essential to the invention are a very low resistance and the fact that it forms a closed circuit, and are these features which result in a low voltage, high current induced by the movement of the ferrous object and thus in an established flux pattern sensed at the second end of said closed circuit; by suitable shaping of the conductive member to ensure that the second end of the closed circuit formed by it is not subject to the same space and/or temperature limitations as the region round the pole piece of the sensor, the output coil or coils at said second end can have an adequate number of turns without too much difficulty; in other words, the high current induced in the very low resistance closed circuit has the effect of "transferring" the strongly varying magnetic flux pattern at the pole piece to another

location where the above-mentioned limitations are not so severe.

The following is to be noted in this respect. Original Claim 1 mentions that the conductive member is elongate and this feature, which is also repeated in the disclosure of the invention in the introduction of the original patent application (see page 2, lines 3 to 10), is further derivable from all the Figures illustrating embodiments of the invention. However, the original description (see page 4, lines 37 to 41) only mentions once more this feature, in relation to a result to be obtained in one of the disclosed embodiments, whereby a response at high temperatures is maintained provided the site of the secondary coil is maintained at 200°C or below, this being achieved by elongating the strip such that the coil is at a cooler location. Thus, since there is no derivable indication about any effect resulting from the elongated shape of the member as such, this feature is only related to the location of the secondary coil at a remote distance from the high temperature region where the first flux pattern is sensed. Indeed, original Claim 1 specifies that a magnetically energized pole piece is situated at a sensing region of the elongate conductive member and that means are situated at a remote region of the conductive member for detecting current in the circuit, and the original description (see for instance page 2, lines 15 to 26) constantly discloses the feature that these regions are at remote locations. Therefore, the Board is of the opinion that the feature that the conductive member is elongate is only a mere repetition of the feature that the sensing regions are at remote locations and is not related to any specific requirement concerning the shape of said member. In this respect, it is to be noted that original Claim 1, which mentions that the magnetically energized pole piece and the detecting means of the sensor are

located at remote regions of said member, does not specify any relation between said locations and the shape or orientation of said member, whereby no effect resulting from the elongated shape of the member on the working capabilities of the sensor is derivable. In this sense, the sensor of present Claim 1, wherein the remote locations are at remote ends of the member, does not differ from the sensor disclosed by original Claim 1.

2.3 Therefore, the Board is satisfied that the European patent application has not been amended in such a way that it contains subject-matter which extends beyond the content of the application as filed (Art. 123(2) EPC).

3. Clarity

The Appellant has argued that, since Claim 1 specifies, in the singular, that the electrically conductive member (11, 40, 60) of the sensor is a member, and since all the embodiments of the invention disclosed in the description and illustrated by the drawings comprise an electrically conductive member made of a single piece, this excludes a conductor consisting of a plurality of conductive pieces and of an external circuitry connected to form a closed loop electrical circuit; similarly, the expression "arranged to form a closed electrical circuit" is intended to mean a closed loop constituted wholly and entirely by the conductive member. This argument can be accepted because each of said conductive components and the external circuitry would indeed consist of individual members or of arrangements of individual members, in the plural, and because this is consistent with the embodiments disclosed in the present patent application. In this respect, it is to be noted that the Appellant's argument concerning the very low resistance of the electrically conductive member, which is intended to be

made of a single piece of electrically conductive material that is much more substantial than say a mere winding or wire, i.e. a substantial rod, bar or strip-conductor of bus-bar kind, which of its very nature would have a very low resistance, can also be accepted because they are consistent with the drawings, which disclose conductors with substantial thickness and/or width. Therefore, the Board is satisfied that, since Claim 1 discloses the structure of the sensor in an unambiguous way, it is clear in the sense of Article 84 EPC.

4. Novelty

4.1 A proximity sensor (12), adapted to be positioned adjacent the path of a moving ferrous object to sense movement of the object, is known from D3 (see page 1, lines 3 to 7, 45 to 67 and 91 to 105; page 1, line 118 to page 3, line 2; Fig.1 to 5 and 11); said sensor (12) comprises a stationary magnetically energised pole piece (66) for producing a first magnetic flux pattern through which the object moves, and an electrical conductor (64, 70, 71, 72), i.e. a coil (64) with its associated ends (70, 71) and leadout cables (72), inductively coupled to the pole piece such that movement of the object through said first flux pattern induces an emf in the conductor (64, 70, 71, 72).

However, contrary to the device of present Claim 1, in the known proximity sensor (12), the conductor, which indeed does comprise at least a conductive member consisting of the coil (64) and its ends (70, 71), and can even comprise the wires of the connecting cable (72), does not comprise an electrically conductive member arranged to form a closed loop electrical circuit because the ends (70, 71) of said coil (64), or the ends of the leadout cable (72) when said cable is attached to the ends (70, 71) of the

coil, form an open circuit. Moreover, the coil of D3 (see Fig.3) is not a member of very low resistance in the sense of the present patent application because it is a coil having a large number of turns which knowingly increase the resistance of said member. In this respect, it is to be noted that the Appellant's argument that in D3 (see Fig.11) a voltage is output by the sensor is credible because, indeed, a coil (64) with a large number of turns results in a large induced emf and, moreover, the output signal of the sensor (12) is transmitted to a comparator (160), and this is an indication of the use of a voltage signal. In relation with this argument, it is to be noted that D3 does not disclose any means for sensing a flux pattern established by virtue of a current induced by the movement of the ferrous object.

4.2 D2 (see page 1, lines 3 to 5 and 38 to 66; page 1, line 119 to page 2, line 95; Fig.2 to 6) discloses a proximity sensor adapted to be positioned adjacent the path of a moving ferrous object (14) to sense movement of the object, said sensor comprising a plate (22) of conductive material having a slot (aperture) where the ends (24) and (25) of a magnetic circuit may penetrate; however, since the known sensor does not comprise a stationary magnetically energised pole piece, but two pole pieces (4, 5) of a flat magnetic circuit in the form of a horse-shoe, D2 does not disclose one of the features of the statement of present Claim 1; moreover, since accordingly the known arrangement comprises a circuit which is formed as a pair of convolutions, and not in form of a single loop circuit, as for instance the conductor (64, 70, 71, 72) of D3 (see Fig.1 and 3 to 5), D2 is a less relevant prior art document. Incidentally, it is to be noted that, since the members of the sensors of D2 (see page 1, lines 38 to 66; Fig.2 to 6) are provided with connecting terminals (8, 9), there is no indication that

the sensor comprises any means for sensing the magnetic flux pattern established by the induced current in the vicinity of said member (22).

4.3 D1 (see column 1, lines 32 to 71; column 11, line 16 to column 12, line 36; Fig.30 to 33) discloses a proximity sensor adapted to be positioned adjacent the path of a moving ferrous object (1) to sense movement of the object and comprising a stationary magnetically energised pole piece (7) for producing a first magnetic flux pattern through which the object moves; however, since the sensor of D1 comprises in particular a magnetic circuit including a saturable element (15) with ends magnetically coupled in particular to the sensing pole (7), but does not comprise any electrical conductor inductively coupled to the pole piece such that movement of the object through said first flux pattern induces a current in the conductor, D1 does not even disclose the first part of present Claim 1 and, therefore, the Appellant's argument that D1 is not a relevant prior art document because it pertains to a different technique relying on magnetic transmitting means, and not on electrical transmitting means associated with means for sensing changes in a flux pattern established in said electrical transmitting means, can be accepted.

4.4 Therefore, the Board is satisfied that, since none of the prior art documents discloses a device having all the features of the presently claimed device, Claim 1 is novel in the sense of Article 54 EPC.

5. Inventive step

5.1 According to the present patent application (see page 1, lines 16 to 35; see also page 4, lines 33 to 37), a problem of the device known from D3 is that, in order to

provide a voltage output of reasonable level, a coil having many turns is required, and this leads to a bulky sensor, which may be inconveniently large compared to the installation space available; moreover, sensors are often required to be sited in areas of limited space and of high temperature, such as in a gas turbine engine and, since a multi-turn coil is employed, the performance of the interwinding insulation must be adequate over the expected temperature range.

The sensor of present Claim 1, with the features concerning the closed-loop electroconductive member and the associated sensing means, credibly solve these problems because, as mentioned in the present application (see for instance page 5, lines 4 to 12 and page 4, lines 31 to 39), more space is available at the sensing region and, since the conductive member may be bare of insulation, the high temperature performance is extended beyond the point at which normal insulation breaks down.

5.2 Neither the problems nor their solution are derivable from D3, which is directed to a torque measuring system employing digital signal processing techniques for alleviating the drawbacks of known analogue torque measuring circuits. In particular, D3 does not suggest to use a conductor comprising an electrically conductive member (11) arranged to form a closed loop electrical circuit of very low resistance, in the sense of the present Claim 1.

5.3 Indeed, the problems arising in multi- turn coils in movement sensors because of their use at high temperature are known from D2 (see page 1, lines 3 to 36); it is also known from D2 (see page 1, lines 38 to 66; page 1, line 119 to page 2, line 95; Fig.2 to 6) to use electrically conductive members (22) inductively coupled to pole pieces

(4, 5) such that movement of the object (14) through a first flux pattern induces a current in the conductor (22); because of its structure as a plate, said electrically conductive member (22) can credibly be arranged to form a closed loop electrical circuit of very low resistance and thus said current can be relatively high; said member (22) has a first end which is inductively coupled to said pole piece (4, 5) and a second end which is remote from said first end and at which indeed a second magnetic flux pattern is established by virtue of said current. However, in the arrangement of D2 (see page 1, lines 119 to 122; page 2, lines 71 to 79; Claim 1), a current connection is used, whereby the two convolutions of said known sensor are connected in parallel across two connection terminals (28, 29) on the member (22) itself and additional leads such as the leads shown in the device of the same type, in Fig.1, are thus to be provided; moreover, since it is advised to connect a voltage-boosting transformer to the known sensor, there is a further indication that there are additional conducting means for connection to the primary of the transformer; thus, the teaching of D2 does not lead to a flux pattern sensing means located at the remote end of the conductive member (22) for sensing changes in the magnetic flux pattern established by the induced current. It is also to be noted that the structure of D2, with two pole pieces, results in a bulky structure of the sensor. Therefore, if the person skilled in the art of D3 were aware of a problem of space in the sensing region, he would not be incited to use the technique disclosed in D2 for solving said problem because D2 is concerned with a bulky structure. Moreover, if the person skilled in the art of D3 were incited to use the technique disclosed in D2 for solving the problems mentioned in said last document, he would not arrive at the subject-matter of present Claim 1,

which requires magnetic flux pattern sensing means at the remote end of the electrically conductive member itself.

5.4 Therefore, the subject-matter of Claim 1 involves an inventive step in the sense of Article 56 EPC because it is not obvious to a person skilled in the art.

6. Conclusion

Thus, since Claim 1 is allowable in the sense of Article 52(1) EPC and since, in particular for this reason, the application according to the preferred request of the Appellant and the invention to which it relates meet the requirements of the Convention, a European patent can be granted on the basis of said preferred request.

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 on the basis of the following documents:

Description:
Pages 1 and 3 to 6 filed with the communication of the Board dated 11 May 1992,
Page 2 filed with the communication of the Board dated 11 May 1992, whereby the first section of said page is deleted and replaced by the words: "According to the present invention, there is provided a proximity sensor as defined in Claim 1.";

Claims:
No. 1 filed with Appellant's letter dated 6 July 1992,
Nos. 2 to 13 filed with the communication of the Board dated 11 May 1992;

Drawings:
Sheets 1/3 to 3/3 (Fig.1 to 7) filed with the communication of the Board dated 11 May 1992.

The Registrar The Chairman

E. Görgmaier E. Turrini