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D E C I S I O N
of 7 May 2001

Case Number: T 0704/99 - 3.4.2
Application Number: 93202794.9
Publication Number: 0590734
IPC: G01N 27/83, G01N 27/90,
G01N 27/82

Language of the proceedings: EN

Title of invention:

Apparatus and method of damage detection for magnetically permeable members

Applicant:

Canada Conveyor Belt Co., Ltd.

Opponent:

-

Headword:

-

Relevant legal provisions:

EPC Art. 54, 56

Keyword:

"Inventive step - main request, first auxiliary request (no)"
"Inventive step - second auxiliary request (yes)"

Decisions cited:

-

Catchword:

-



Case Number: T 0704/99 - 3.4.2

D E C I S I O N
of the Technical Board of Appeal 3.4.2
of 7 May 2001

Appellant: Canada Conveyor Belt Co., Ltd.
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 22 February 1999
refusing European patent application
No. 93 202 794.9 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: E. Turrini
Members: M. A. Rayner
B. J. Schachenmann

Summary of Facts and Submissions

- I. The present appeal lies against the decision of the examining division refusing European patent application No. 93 202 794.9. In the decision under appeal, reference was made to the following documents:

D1: EP-A-239 537

D2: US-A-4 427 940

The application concerns apparatus for detecting anomalies in a magnetically permeable material, particularly conveyor belts, and was refused for lack of novelty of claim 1 as then under consideration over document D2. The appellants requested the setting aside of the decision and the granting of a patent, oral proceedings being requested before issue of an unfavourable decision.

- II. During the written proceedings, the appellants submitted that:

Document D1 is the most relevant prior art and the invention is distinguished therefrom by the claimed apparatus providing first and second magnetic field components in the same direction and sensing means being arranged to respond to changes in the difference of the field intensities of the components.

Problems of the prior art are that high field intensities must be used to detect field leakage and the sensing means have to be placed near the wires to detect as much field leakage as possible. Measurement is dependent on distance so that flutter of the

magnetically permeable member, a belt, will influence measurement even to the extent of eliminating a peak in the magnetic field. These problems are eliminated by the invention because both field components extend through the belt and difference in field is measured which is independent of distance. Only when an anomaly is located will a field be detected because otherwise the difference between the fluxes is zero.

The teaching of document D2 is also based on field leakage and so will not provide the solution according to the invention.

III. During the written proceedings, the board indicated that two embodiments are described in the application, with reference respectively to Figures 1, 2 (sensor set 24) and 4,5 (sensor sets 124 and 126). It seemed that document D2, disclosing one sensor and field components in a wire rope in the same direction, was the closest prior art to the first embodiment and document D1, disclosing two longitudinally spaced apart sensors, the closest prior art to the second embodiment. The board observed that the submissions of the appellant related to the problem of belt flutter, with which the description indicated the second embodiment was concerned.

The claimed features identified by the appellant and also reading on to the first embodiment did not seem to differ from the disclosure of document D2, since according to this document the field components provided by coils are also in the same direction in the wire rope. Taking into account document D2 as referred to in the decision under appeal and the fact that longitudinally spaced sensing portions are not

explicitly recited in the claim and sensing location is used in the singular, it did not seem that the subject matter was novel. The board indicated that two sets of sensors and means responsive to linear speed of the belt appeared essential to the solution of the problem of belt flutter.

- IV. During the oral proceedings arranged consequent to the request of the appellants, a main and three auxiliary requests were submitted, the appellant arguing as follows:

An important factor is the difference in sensing means, which in the case of document D2 is a detection coil and thus sensitive to the first derivative of magnetic field, i.e. the sensing means is responsive to approaching and moving away from the coil (see column 4, lines 45 to 55 of document D2). An anomaly causes a pulse which is detected but which may be cancelled out by the counter movement of belt flutter, so that breakage may not be detected.

On the other hand, Hall sensors used in the invention are not dependent on movement but only on fluctuation, i.e. a Hall sensor measures absolute values. Therefore, the system is not defeated by flutter movement and belt speed. Even an anomaly in a stationary belt can be detected.

The board reiterated its doubts about whether the belt flutter problem really was overcome by the subject matter claimed in the independent claim of the main and first auxiliary requests, since even in the case of a Hall sensor, it did not seem to be in dispute that the field is affected by distance and thus flutter as well

as anomalies. The board also pointed out that Hall sensors were in any case a routine option in magnetic field detection as can be seen for example from page 8, line 20 of document D1.

- V. The independent claim of the main and first and second auxiliary request is worded as follows:

Main Request

Apparatus (16,116) for detecting anomalies in a magnetically permeable member (14), particularly conveyor belts (42), having a longitudinal axis, comprising means (20,22;120,122) providing a magnetic field at an operating area at which said magnetically permeable member (14) is located and magnetic field sensing means (24;124,126), said apparatus (16,116) being arranged relative to said member (14) so that said member is movable relative to said apparatus (16;116) along said longitudinal axis, said magnetic field having longitudinally spaced first and second field components at longitudinally spaced first and second field locations at said operating area, and said magnetic field sensing means (26,128), being arranged to respond to modification in each of said first and second field components, characterized in that said first and second field components are in the same direction and said sensing means (26,128) are arranged to respond to changes in the difference of the field intensities of said first and second field components at said sensing locations (16;116), said apparatus (16,116) comprises field coil means (20,22;120,122) arranged so that when there is substantially equal magnetic reluctance at said first and second field

locations, the first and second field components are of substantially equal intensity, and when said magnetic reluctance at said first and second field locations is different, the first and second components vary in strength, whereby when an anomaly is at said first field location and then at said second field location causing differing magnetic reluctance in said first and second field components, the magnetic field intensity at said sensing locations is modified, which modification results in a difference in the intensity of the magnetic fields at said sensing locations, which difference in the intensity causes said sensing means (26,128) to respond.

First Auxiliary Request

This request differs from the main request by insertion of ", comprising at least one Hall sensor," after "(26, 128)" in the second line of the characterising part of the claim.

Second Auxiliary Request

Apparatus for detecting anomalies in a magnetically permeable member (14), particularly conveyor belts (42), having a longitudinal axis, comprising means (120,122) for providing a magnetic field at an operating area at which said magnetically permeable member (14) is located, and magnetic field sensing means **comprising first and second sensing portions** (124,126), said apparatus being arranged relative to said member (14) so that said member is movable relative to said apparatus (116) along said longitudinal axis, said magnetic field having longitudinally spaced first and second field components

at longitudinally spaced first and second field locations at said operating area, and said magnetic field sensing **portions** being arranged to respond to modification in **respective** said field components, characterized in that said first and second field components are in the same direction and said sensing means are arranged to respond to changes in the difference of the field intensities of said first and second field components at **respective** sensing locations, said apparatus comprises field coil means (120,122) arranged so that when there is substantially equal magnetic reluctance at said first and second field locations, the first and second field components are of substantially equal intensity, and when said magnetic reluctance at said first and second field locations is different, the first and second components vary in strength, whereby when an anomaly is at said first field location and then at said second field location causing differing magnetic reluctance in said first and second field components, the magnetic field intensity at said sensing locations is modified to cause said sensing means (128) to respond, **and field coil frequency control means responsive to linear speed (85) of said member (42), relative to spacing of said first and second field components, in a manner to relate frequency of an alternating field of said coil means (120, 122) to a time interval of one portion of said member (14) moving, relative to said apparatus, from the first field location to the second field location.**

(NB The board has shown features differing from those of the main request in bold type for ease of understanding.)

Third auxiliary request

Since this request was not subject to decision (see point 8 of the Reasons below), its wording is not given.

- VI. At the end of the oral proceedings, the board gave its decision.

Reasons for the Decision

1. The appeal complies with the provisions mentioned in Rule 65(1) EPC and is therefore admissible.

The prior art - Documents D1 and D2

- 2.1 Document D1 (see especially Figure 6) discloses apparatus intended to detect anomalies in the form of area variations, broken wires and contact irregularities in a wire rope. The apparatus provides a construction of a composite magnetic test head including a first pair of permanent magnet stacks which are effectively arranged in parallel, and a second pair of permanent magnet stacks also arranged in parallel on a magnetic structure. The magnet stacks share a central north pole and have respective outer south poles. A wire rope can pass freely through holes which are in line and which are formed in the pole pieces. The test head magnetises the rope over the portion of its length which is exposed to the magnetic field of the test head, in two opposing directions. In use, the rope moves through the test head entering the leading south pole so the flux density rises and reaches the highest

saturation flux density which can be achieved with the first permanent magnet stack. This saturation flux density is maintained until the boundary of the central pole piece, where the effect of the magnetic field of the second stack in the reverse direction makes itself felt and the flux density decreases, passing through zero, and reaching the maximum value, in the reverse direction. This reverse saturation flux density is maintained before decreasing to a remnant value retained after the rope has left the test head. Irrespective of the magnetic conditions in the rope before or after a test the magnetisation path between saturation levels in either direction is always the same, ensuring repeatability of tests. Guide wheels are located on either side of the test head to engage the rope and ensure it is centrally positioned in the test head. Search coils are provided around the sheath. These coils provide a measurement of the flux variations for detecting area variations, broken wires and contact irregularities. The coils may be helical or of a saddle type. Any other appropriate flux measuring device, such as a Hall-effect device, may be used.

Instrumentation may include apparatus for measuring the rope speed or the rope length during a test, for providing signals for driving a recorder synchronously with rope travel or rope length, for providing signals for compensating rope speed variations in the signal processing system or for providing signals to ensure that the data is processed synchronously with rope speed or rope length.

- 2.2 Document D2 (see especially Figure 4) discloses electromagnetic inspecting apparatus for detecting anomalies in the form of a defect present in a wire

rope used for example in the traction of an elevator cage. A pair of magnetic poles, which can be energisable coils or permanent magnet blocks, are spaced apart by a predetermined distance from each other and disposed opposite to the wire rope, a detecting coil being disposed on a core intermediate the two magnetic poles, which have different polarities. The magnetic poles and the detecting core are magnetically coupled together by a common yoke. When the wire rope is moved and no defect is present, the magnetic flux flows from the N-pole through wire rope, the S-pole, and the yoke to the N-pole. In this case, no voltage is induced in the detecting coil because the magnetic flux does not flow through the core of the detecting coil. When a defect is present in the wire rope, at first a leakage flux flows through the N-pole and the defect in the wire rope and another leakage flux flows through the S-pole and the defect in the wire rope in addition to the main magnetic flux. Nevertheless, no voltage is induced in the detecting coil since the leakage fluxes do not interlinkage therewith. As the wire rope continues to move until the defect reaches the position directly opposite to the detecting core, the leakage magnetic fluxes make interlinkage with the detecting coil and then return to the N-pole and S-pole respectively. The leakage fluxes are in the same direction in the wire rope. Before and after the defect passes the position exactly opposite to the centre of the detecting core, the flux densities of the two leakage fluxes change with time making interlinkage with the detecting coil, and a voltage proportional to the time dependent change is induced in the detecting coil. Thus when a defect is present, the leakage fluxes flowing in the same direction at two longitudinally spaced apart locations in the wire rope

give rise to differential detection of the two leakage fluxes flowing in the detecting coil in directions opposite to each other.

Main and First Auxiliary Request

3. The appellant concentrated on explaining that a Hall and coil sensor sensed different parameters (magnetic field as opposed to first time derivative thereof). This was however never disputed by the board, which saw the issue of novelty of the subject matter of claim 1 of the main request as resolving down to whether, in the context of a moving magnetically permeable member, the wording of the claim really brought out any such difference. In particular, it is arguable whether the terminology relating to "changes in the differences of the field intensities" even with the further recitation of the "modification resulting in a difference in the intensity of the magnetic fields at said sensing location" is really limited to some kind of "Hall effect" type sensor and excludes the sensing coil known from document D2. Long winded discussions about this question are not however necessary in this decision, because once a Hall sensor is included in the claim, as is the case with the first auxiliary request, then novelty is present by virtue thereof and the features in question understood in accordance with operation of this particular sensor type.
- 4.1 The board considers document D2 to constitute the closest prior art to the subject matter of claim 1 of the first auxiliary request, the claim distinguishing only by using a Hall sensor in place of a coil sensor. The problem solved by the use of at least one Hall sensor as opposed to a sensing coil is to provide an

alternative sensing means. A Hall sensor is a type of sensor which is very well known for this purpose to the skilled person and it follows that its selection must be considered obvious. Corroboration for this statement can be seen for example in line 20 on page 8 of document D1, which recites "...instead of search coils any other appropriate flux measuring device, such as a Hall-effect device, may be used..." The board further observes in this connection that even had it have interpreted claim 1 of the main request generously as being limited to some kind of "Hall effect" type sensor and excluding a sensing coil, a similar negative conclusion as to inventive step would have been reached. Moreover, as far as submissions relating to disadvantages of a coil in relation to greater field intensities and thus closer positioning indicating inventive step are concerned, the board observes that quite apart from field intensity not being quantified in the claim, the submission is not persuasive as this type of information is part of the basic knowledge of the skilled person so that any problem of positioning sensing means to detect a particular field strength is solved in an obvious way by the skilled person, who simply positions the sensing means concerned where it will function properly.

4.2 Accordingly, the subject matter of claim 1 of the main request, even if read narrowly as novel, and the first auxiliary request is considered obvious to the skilled person having regard to the teaching of document D2.

4.3 The appellant main line of argument in support of the Hall sensor rather than a coil was that it solved the problem of flutter, since only by detecting out of balance of the field components themselves without

involving the first time derivative thereof can a fault be differentiated from belt flutter. However, the submissions of the appellant failed to establish any definite link between use of the Hall sensor and avoidance of flutter. On the contrary, it was in fact undisputed that movement towards and away from the Hall sensor affects its response. The Hall sensor is thus, just like a sensing coil, subject to error resulting from belt flutter, belt flutter amounting to no more than a vertical movement of a horizontally running belt. The application itself explicitly refers to and confirms this situation. For example, column 8, lines 53 to 57 of the published specification recite "one possible source of error in using a Hall effect sensor in connection with a moving conveyor belt is that there may be some degree of flutter in the belt where the vertical location of the belt would change. Thus, if the belt 10 moves closer to the Hall effect sensors 26, this makes the air gaps shorter and would thus cause a change in the magnetic fields sensed by the Hall effect sensors 26." A similar disclosure occurs in lines 32 to 37 of column 14. Furthermore, the submission that an anomaly in a stationary belt can be detected also failed to persuade the board because in such a case there is firstly no flutter and secondly the claim makes reference to the anomaly at a first and then second location, i.e. it was not stationary, it moved.

The board therefore reached the conclusion that as the subject matter actually claimed did not solve the problem of belt flutter, the arguments of the appellant relating to the solution were not relevant to inventive step.

4.4 Accordingly, the arguments of the appellant fails to convince the board and the subject matter of claim 1 of the main request, even if read narrowly as novel, and of the first auxiliary request is not considered to involve an inventive step within the meaning of Article 56 EPC.

5. *Second Auxiliary Request*

5.1 Admissibility of amendments (Article 123(2) EPC)

5.2 The second embodiment described in the documents as filed forms the support for the amendments made to the description and claims. Compared to claim 1 as filed, claim 1 contains further features deriving from this embodiment. The dependent claims and description have been amended consequentially and to take account of Rules 27(1)(b) and (c) EPC.

6. *Novelty (Article 54 EPC)*

6.1 The features of the characterising part of claim 1 of the second auxiliary request are novel having regard to the disclosure of document D1.

6.2 All the features in claim 1 of the second auxiliary request which are not present in claim 1 of the main request are novel having regard to document D2 (i.e. first and second sensing portions responsive to respective field components and the features from the "field coil frequency control means" to the end of the claim).

6.3 No other available document comes closer than document D1 or D2 to the subject matter of claim 1.

6.4 Accordingly, the requirements of Article 54 EPC are satisfied.

7. *Inventive Step (Article 56 EPC)*

7.1 Since sensing portions responsive to modifications in respective longitudinally spaced field components are specified in claim 1, and as document D2 employs only one sensing coil along the axis of the rope, document D1 has been taken as the closest prior art. The novel features of claim 1 with respect to document D1 enable the problem of belt flutter, which is detected at both sensing portions at the same time, to be differentiated from an anomaly, which is detected first at one sensing portion and then at a subsequent belt speed dependent time later at the other.

Belt flutter is not addressed at all in document D1, where wheels guide the rope to ensure positioning, nor is there any reason to modify the permanent magnetic stacks and provide a field coil frequency control means. General hints in this document to measuring rope speed also offer no guidance towards relating the alternating field frequency to movement between the sensing positions. Consequently, the board is convinced that the subject matter of claim 1 cannot be considered obvious in the light of the disclosure of document D1.

7.2 Document D2 has only one sensor arranged along a wire rope path and so cannot offer a solution to the flutter problem involving movement from one position to the other in accordance with the speed of the rope, nor fill in any gap in the teaching of document D2 in this direction. Accordingly, neither document D2 alone nor even its combination with document D1, for which the

board sees no particular reason, can call the inventive step of the subject matter of claim 1 into question.

7.3 Accordingly the subject matter of claim 1 of the second auxiliary request is considered as involving an inventive step and therefore to satisfy Article 56 EPC. The same conclusion applies to claims 2 to 5 in view of their dependence from claim 1.

7.4 No other available document comes closer to the invention than document D1 or D2 so that the inventive step of the subject matter of claim 1 is not called into question thereby.

Procedure

8. In view of the positive conclusion reached by the board with respect to the second auxiliary request, consideration of the third auxiliary request in this decision is not necessary.

9. Having convinced itself that the patent application satisfies the requirements of the Convention, the board, in accordance with Article 111(1) EPC, considers it appropriate to exercise the power within the competence of the examining division to order grant of a patent.

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: 1 and 5 filed as second auxiliary request, and

Description: as filed during the oral proceedings {pages 1 to 4, 8 to 31},

Drawings: as originally filed {Sheets 1/5 to 5/5}.

The Registrar:

The Chairman:

A. Townend

E. Turrini