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(54) A METHOD FOR MONITORING THE OPERATING AND DETERMINATION OF A MALFUNCTION OF AN ELEVATOR BRAKING SYSTEM

(57) A method for monitoring the operating and determination of a malfunction of an elevator braking system,
the braking system is adapted to brake an elevator car, where the elevator car is adapted to travel within an elevator shaft;
the brake is adapted to selectively reduce the speed of the elevator car and/or to keep the elevator car in a stop condition;
the method comprises the following steps:
- receive an actual braking current data from the elevator braking assembly;
- determine a derivative curve of the actual braking current data;
- analyze the derivative curve with the help of a predetermined algorithm,
- based on the result of the analyzing step, determine, whether the braking system is operating properly or not.

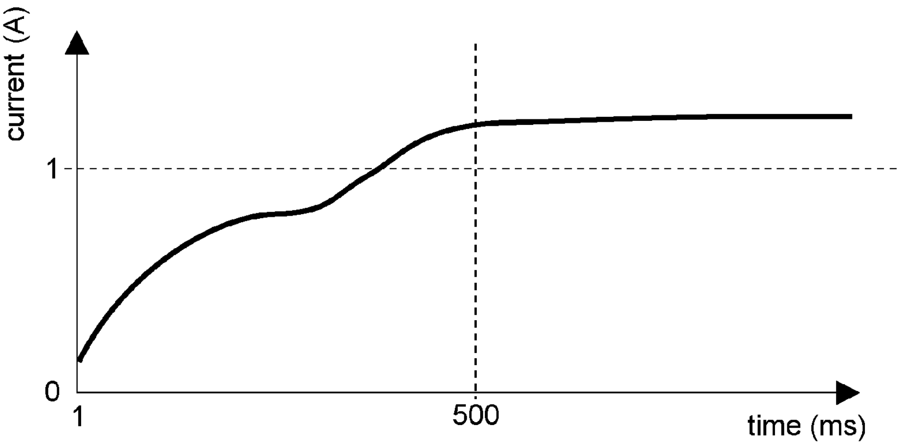

Fig. 1

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Description

[0001] The invention refers to a method for monitoring the operating and determination of a malfunction of an elevator braking system.

[0002] The present invention starts from the disclosure of US patent application 18,101/819 (filed 26. January 2023) titled "SYSTEMS AND METHODS FOR MONITORING ELEVATOR DUAL COIL ELECTROMECHANICAL BRAKES" (in the following "US'819"). The content of the above application is completely incorporated into the present description and forms with the following description one unitary disclosure.

[0003] The following idea is applicable to an elevator installation, which is described in US'819, e.g. figures 1A, 1B, 2B and related description, having in principle a brake according to figure 2B or figure 3 and related description.

[0004] Accordingly, a detection of the proper function of the brake is performed by analyzing the current of the coils for (see e.g. US'819, figures 6 and [0052]). Thereby it is detected if the mobile plate moves from the closed state to the released state or vice versa (in general: moving between the states) as a reaction of applying (power on") / switching off ("power off") a voltage to the magnet coils. In a faulty condition, a mobile plate does not move as intended. US'819 describes in detail a method for analyzing the current (see US'819, starting at [0089]).

[0005] In the installation disclosed in US'819, a brake has two magnetic coils and for redundancy reasons two separate mobile brake plates, each of the mobile plates is operated by a dedicated magnetic coil. For determining the proper function each pair of magnetic coils and mobile plate can be analyzed independently from each other.

[0006] It is the object of the present invention to provide improvements to the above method. The object is solved by a method according to the main claims. Embodiments are subject to subclaims and the description.

[0007] Accordingly, the present invention now deals with a slightly different configuration. Here one magnetic coil is used for operating two separate mobile plates. In such a configuration it may happen, that a first one of the mobile plates is properly moved between the states as intended, where a second of the mobile plates is not properly moved between the states as intended. Here the mathematic analysis of the currents as disclosed in US'819 does not provide a reliable result for the case that merely one of the both mobile plates does not move as intended.

[0008] In the following and with the help of the figures a method according to the inventions is described to detect that merely one of the both plates are moved, where on single coil is used to operate both plates, herein show

[0009] figures 1 to 7 different curves of a brake current and a derivatives thereof.

[0010] The curve according to figure 1 shows a current through the coil when power is turned on ("power on") for releasing the brake.

[0011] The curve according to figure 2 shows a derivate of the current according to figure 1 generated with a frequency of 10 Hz.

[0012] The curve according to figure 3 shows the current through the coil when power is turned off ("power off") for activating the brake.

[0013] The curve according to figure 4 shows a derivate of the above current generated with a frequency of 20 Hz.

[0014] For determining any abnormality, there are three different algorithms proposed.

1. <u>Area algorithm:</u> during "power on" to detect engage fault of both parts, e.g. brake plates of the brake.

2. <u>Variation algorithm:</u> during "power on" to detect disengage fault of one or both parts, e.g. brake plates of brake.

3. <u>Range algorithm:</u> during "power off" to detect engage and disengage faults of one or both parts, e.g. brake plates of brake.

[0015] Once a brake activation or deactivation order is detected, the system start one of the algorithms when the following conditions are fulfilled:

- For "power on": current greater than 0.1A and derivative greater than 1.
- For "power off": current is greater than 0.1A, current decreased by 10% since the start of the order and derivative is less than -1.

<u>1. Area algorithm</u>

[0016] The Area algorithm comprises the following steps (see figure 5):

1. Calculate derivative of the current.
2. After power on the brake, calculate the derivative area from first minimum until the derivative is stable.
3. If there is no minimum, then Area A is set to zero.
4. If minimum is below zero, then also negative values are considered.
5. The brake operates properly if Area A > Aok. The brake does not operate properly if Area A < Aok.

[0017] Thereby "Aok" is a threshold (limit value) that is set during the tunning or training phase to validate the calculated Area. By comparing said calculated area A with the preset Aok value, the proper operation of the brake can be determined.

[0018] Thereby P0 depicts the start of the algorithm, when a brake order is issued and the current is large r than 0,1A and the derivative is larger than 1; P1 depicts a first detected maximum; P2 depicts a first minimum; P3 depicts the end of the algorithm, where the derivative has reached a stable value.

2. Variation algorithm

[0019] The Variation algorithm comprises the following steps (see figure 6):

1. Calculate derivative of the current.
2. After power on the brake, take the value at 100ms and 150ms after the power is turned on.
3. Measure the variation V between the both values in percentage.
4. The brake operates properly if the variation V is larger than 15%.

[0020] The brake does not operate properly if the variation V is smaller than 15%.

3. Range algorithm

[0021] The range algorithm comprises the following steps (see figure 7):

1. Calculate the derivative of the current.
2. After power off the brake P0, measure the derivate of the current (after the first minimum P1) and take the time Range R between first zero crossing P2 the last zero crossing P3.
3. The brake operates properly if the time Range R is within a predetermined threshold:

$$\text{Range} - 20\% < \text{time R} < \text{Range} + 20\%$$

[0022] P4 depicts the end of the algorithm, where the current is smaller than 0,1A.

[0023] In summary the above description shows, that also for the particular case (one coil operates two brake plates) a determination of the proper / unproper operation of the brake is possible by analysing the current. The above presented algorithms are merely to be understood as examples, which are suitable for the particular brake system embodiment, which was used for the analysis. Any other embodiment of a brake system may require a different way of analysing the current. In this case the other embodiment needs to be analysed for any reoccurring pattern. These reoccurring patterns can be used to check the proper operation of the brake.

Claims

1. A method for monitoring the operating and determination of a malfunction of an elevator braking system,

the braking system is adapted to brake an elevator car, where the elevator car is adapted to travel within an elevator shaft;
the brake is adapted to selectively reduce the speed of the elevator car and/or to keep the elevator car in a stop condition;
the method comprises the following steps:

- receive an actual braking current data;
- determine a derivative curve of the actual braking current data;
- analyze the derivative curve with the help of a predetermined algorithm,
- based on the result of the analyzing step, determine, whether the braking system is operating properly or not.

2. Method according to the preceding claim,

wherein the brake is coupled to a traction sheave that moves an elevator car along the elevator shaft;
or
the brake is coupled to the elevator car and comprises or interacts with a brake rail fixedly located in the shaft.

3. Method according to any of the preceding claims,

wherein the elevator braking system has two mobile plates and one coil,
wherein the one coil, is adapted to move the two mobile plates from a braking state into a non-braking state and/or vice versa.

4. Elevator braking system, comprising:

- an elevator controller configured to control movement of the elevator car;
- a processing device communicatively coupled to the elevator controller, and
- a non-transitory, processor-readable storage medium in communication with the processing device, the non-transitory, processor-readable storage medium comprising one or more programming instructions for performing the method according to any of the preceding claims.

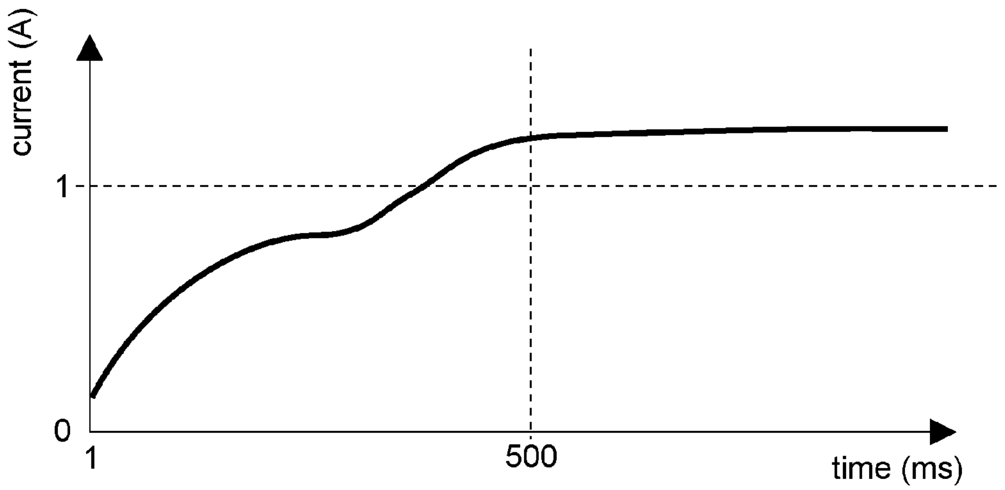

Fig. 1

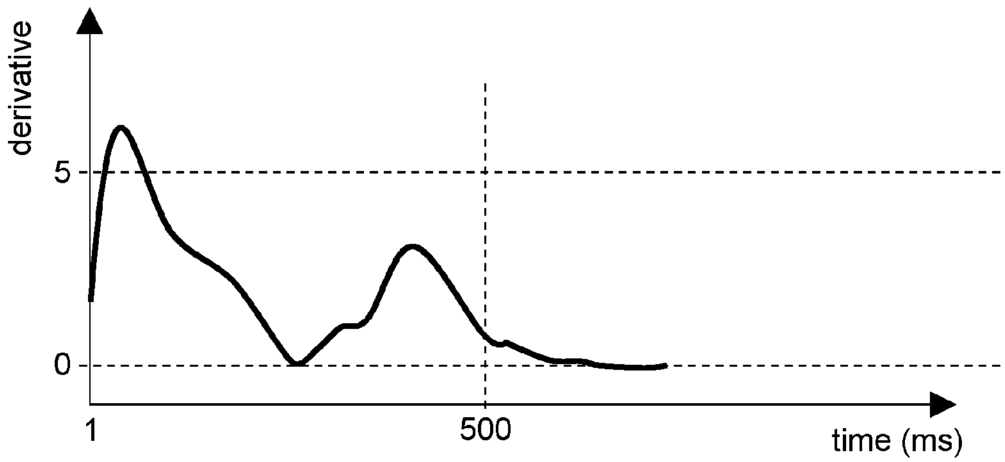

Fig. 2

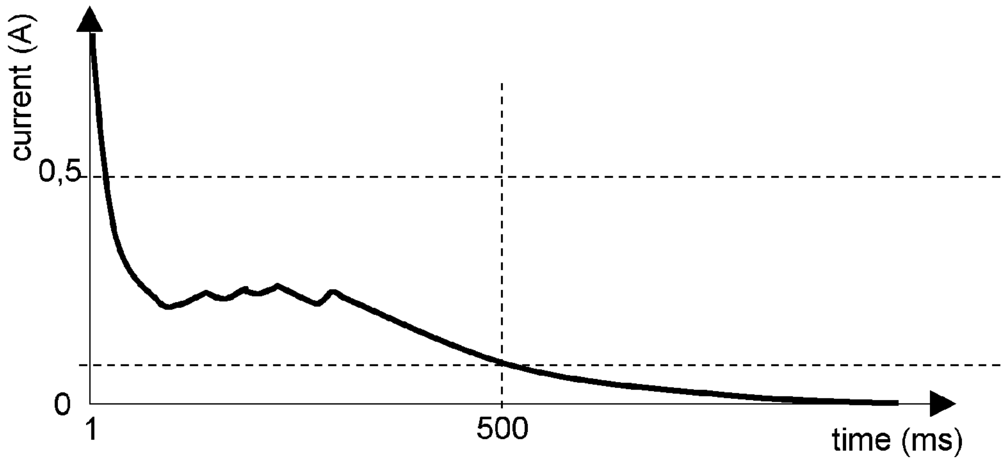

Fig. 3

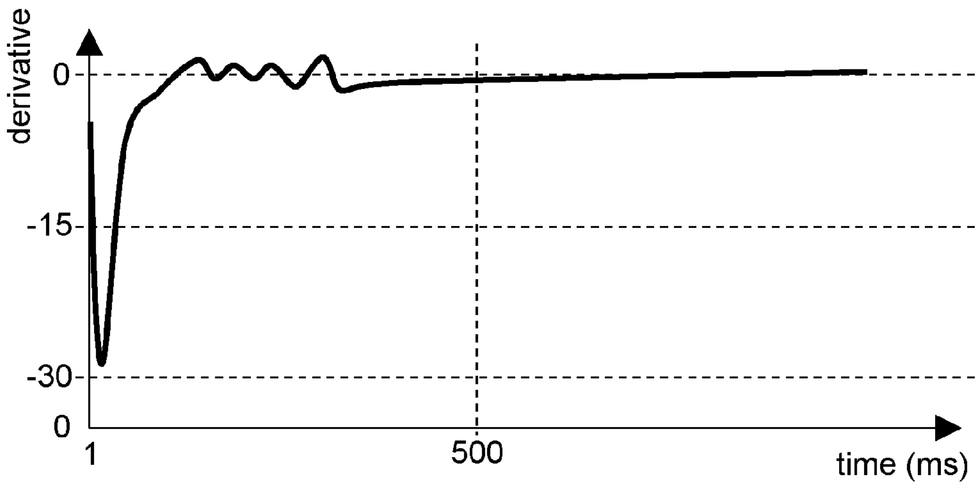

Fig. 4

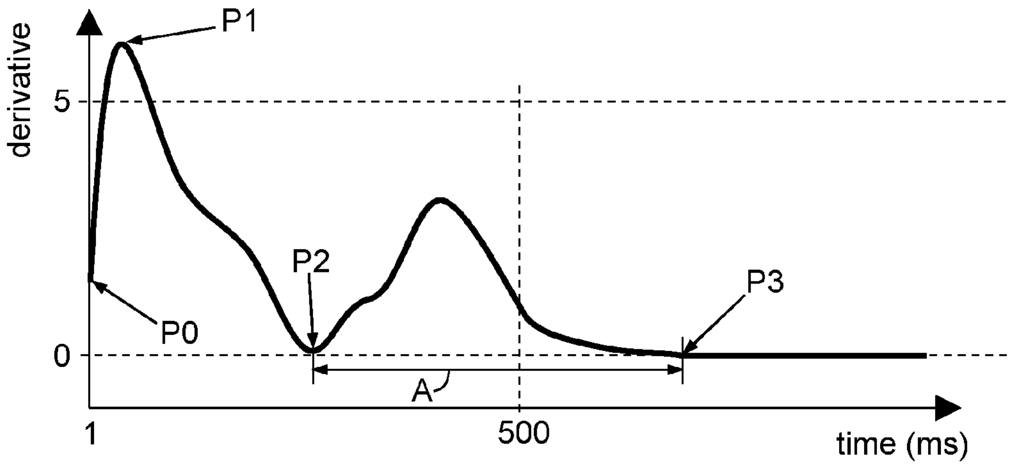

Fig. 5

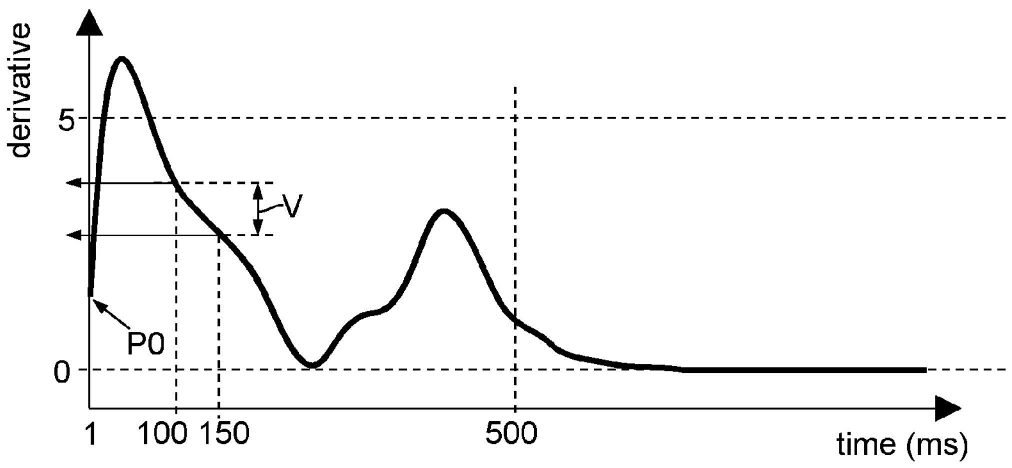

Fig. 6

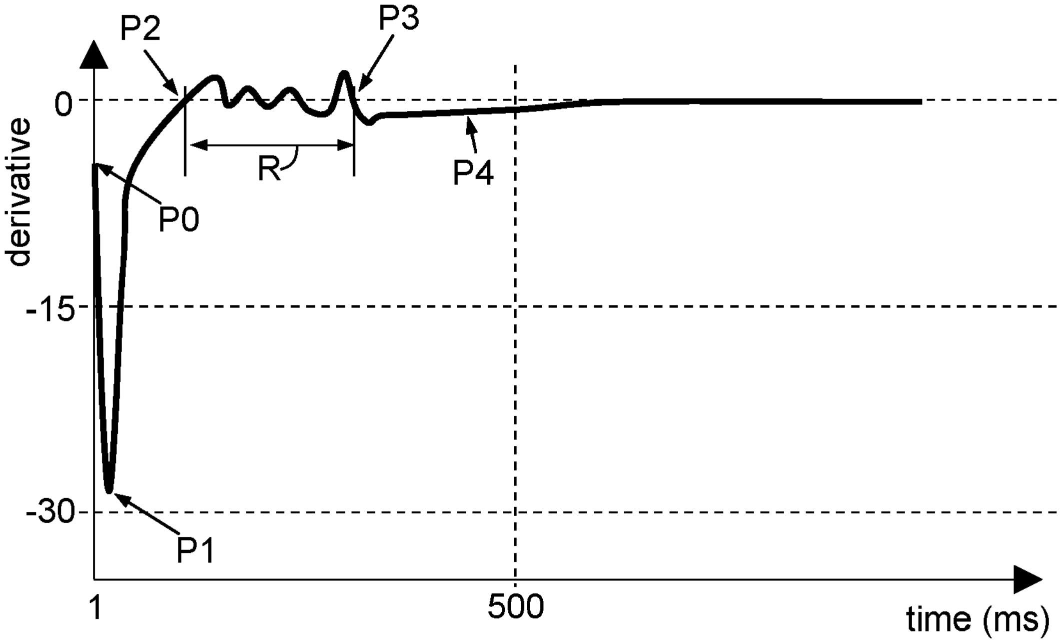

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 4608

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2023/249942 A1 (GALLE LEOCI RUDI [BR]) 10 August 2023 (2023-08-10) * paragraphs [0006], [0007], [0038], [0050]; figures 4, 11, 13 * -----	1-4	INV. B66B5/00
X	EP 3 798 176 A1 (ZIEHL ABEGG SE [DE]) 31 March 2021 (2021-03-31) * paragraph [0023]; figure 4 * -----	1-4	
A	WO 03/032479 A1 (PINTSCH BAMAG GMGH [DE]; CHMELA HEINZ [DE]) 17 April 2003 (2003-04-17) * figure 7 * -----	1,4	
			TECHNICAL FIELDS SEARCHED (IPC)
			B66B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 February 2024	Severens, Gert

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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