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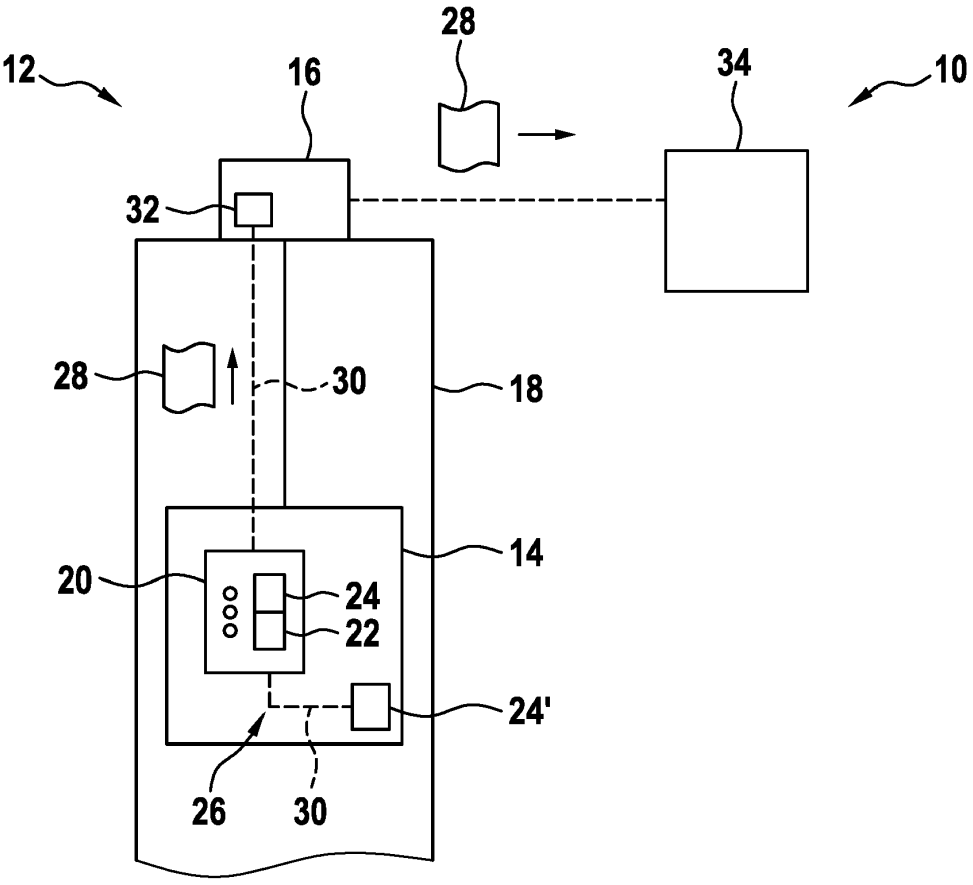
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(54) NOISE BASED ELEVATOR MALFUNCTION DETECTION

(57) A method for determining a malfunction of an elevator (12) comprises: detecting a vibration signal (26) within an elevator car (14); determining a vibration level (36) from the vibration signal (26); comparing the vibration level (36) with a threshold value (38); and, when the vibration level (36) exceeds the threshold value (38), generating an alert message (28).

Fig. 1



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Description

[0001] The present invention relates to a method for determining a malfunction of an elevator and to an elevator system.

[0002] During operation, elevator systems may develop malfunctions that may not completely prohibit an operation of the elevator but that may cause disturbing noises and/or vibrations in the elevator car. For example, such noises and/or vibrations are generated, when a belt or rope slips partially from a pulley or when the pulley becomes misaligned. Such a malfunction may become more serious and a fast maintenance of the elevator system may be beneficial. Furthermore, disturbing noises and/or vibrations may bother persons inside the elevator car and the cause should be removed as soon as possible.

[0003] JP 2009 274 805 A shows an elevator malfunction detecting device with a plurality of sound collecting microphones in an elevator shaft.

[0004] There may be a need for a fast and reliable method for detecting a changed noise and/or vibration situation in an elevator car.

[0005] Such a need may be met with the subject-matter of the independent claims. Advantageous embodiments are defined in the dependent claims.

[0006] Ideas underlying embodiments of the present invention may be interpreted as being based, inter alia, on the following observations and recognitions.

[0007] A first aspect of the invention relates to a method for determining a malfunction of an elevator. The elevator may comprise an elevator car in a shaft and a drive which moves the elevator car vertically in the shaft. The elevator furthermore may comprise a controller or control system, which automatically performs the method.

[0008] According to an embodiment of the invention, the method comprises: detecting a vibration signal within an elevator car; determining a vibration level from the vibration signal; comparing the vibration level with a threshold value; and, when the vibration level exceeds the threshold value, generating an alert message.

[0009] A sensor installed in the elevator car may detect noise and/or vibrations inside the elevator car. As noise may be seen vibrations within an audible frequency range, in the following the term "vibration" also always will refer to noise. In particular, these vibrations may be generated from equipment outside of the elevator car. For example, the vibrations may be caused by a jumping or jumped belt or rope running on flanged pulleys.

[0010] In particular, the vibration signal may be generated by continuously measuring vibrations at the same spot in the elevator car during its travel. For example, sample values of the vibrations may be generated and, as vibration signal, further processed by a controller.

[0011] The vibration signal may be processed to generate a vibration level. The vibration level is may be a value indicating specific features of the vibrations inside the elevator car. For example, the vibration level may be based on a maximal amplitude of the vibrations and/or an energy of the vibrations.

[0012] In the end, the vibration level is compared with a threshold value, and an alert message may be generated, when the vibration level is outside a range defined by the threshold value. For example, an alert message may be data or a data package sent from the controller to a further device, which data or data package indicates that the threshold value has been exceeded.

[0013] The threshold value may be taught and/or set during commissioning of the elevator. The threshold value may be set for the elevator car, the elevator shaft, and/or the elevator system individually. This, for example, may be done during a final commissioning of the elevator system.

[0014] The method may be seen as an early warning system for monitoring an operative elevator system and/or for triggering an alarm message or alert message. Based on the alert message, a service technician may be informed and/or the elevator may be taken out of service.

[0015] According to an embodiment of the invention, the vibration signal is detected with a vibration sensor and/or a microphone. A vibration sensor may measure vibrations that are guided through equipment of the elevator car. A microphone may detect vibrations and/or noise transported through air.

[0016] According to an embodiment of the invention, the vibration signal comprises a noise signal. In the case, when the frequency of the vibrations is within 10 Hz to 20 kHz, a vibration signal also may be seen as a noise signal.

[0017] According to an embodiment of the invention, the vibration sensor and/or microphone is installed within a control panel of the elevator car. The microphone and control circuit may be embedded into a control panel of the elevator car. The vibration sensor and/or microphone may be placed on an existing circuit board, for example in a control panel inside the elevator car. Also, an already present sensor may be used.

[0018] According to an embodiment of the invention, the microphone is additionally used for acquiring a voice signal of a person in the elevator car. For example, a microphone may be used that is used for communication of persons inside the elevator car to the outside.

[0019] According to an embodiment of the invention, the vibration signal is filtered before determining the vibration level. This filtering may be performed (analogue or digital) to eliminate misinterpretations caused by irrelevant surrounding noise, such as traffic, people, etc.

[0020] For example, the vibration signal may be frequency filtered. It may be that frequencies are filtered out that usually are generated by an environment, such as a frequency range of human voice, etc.

[0021] Furthermore, the vibration signal may be content filtered. For example, an algorithm may determine, whether the vibrational signal was caused by environmental noise. This may be done by discarding vibration

signals with a continuous to high amplitude. It also may be possible that vibration signals are discarded, when persons are inside the elevator car, which may be detected with a weight detection of the elevator car.

[0022] There are several possibilities, how the vibration signal is transformed into the vibration level. In general, an algorithm may process a digitized vibration signal that was recorded for a specific time period to calculate the vibration level.

[0023] According to an embodiment of the invention, the vibration level is a maximal amplitude of the vibration signal during a time period. For example, the vibration level may be the maximal value of the amplitude of the vibration signal, which is determined for a moving time window, such as the last second.

[0024] According to an embodiment of the invention, the vibration level is an energy of the vibration signal. Usually, the energy of the vibration signal during a time period may be determined by integrating the vibration signal during the time period. The vibration level is based on an integral over the vibration signal. Such an integral may be calculated by summing up amplitudes of the vibration signal over time.

[0025] According to an embodiment of the invention, the vibration signal is Fourier transformed and the vibration level is determined from the Fourier transformed vibration signal. The vibration signal within a time period may be discrete Fourier transformed generating a frequency spectrum of the vibration signal during this time period.

[0026] According to an embodiment of the invention, the vibration level is a maximal level of the Fourier transformed vibration signal at least in a frequency range. For example, the threshold value may be compared with a maximal frequency level in a frequency range. Specific malfunctions create specific vibration signals with specific frequencies. When limiting to these frequencies, for example by only evaluating the Fourier transformed vibration signal in a corresponding frequency range, the generation of alert messages may be limited to specific malfunctions. Furthermore, frequencies generated by the environment may be suppressed.

[0027] According to an embodiment of the invention, the vibration level is based on an integral over at least a frequency range of the Fourier transformed vibration signal. In such a way, only frequency specific energies of the vibration signal may be taken into account.

[0028] According to an embodiment of the invention, the alert message is generated in a controller within the elevator car and sent to a central controller of the elevator. It may be that the evaluation of the vibration signal is performed directly in the elevator car. After that, the alert message may be sent to a central controller, which is also responsible for controlling other parts of the elevator system, such as the drive.

[0029] According to an embodiment of the invention, the alert message is sent to a maintenance server, to which a plurality of elevators is communicatively connected. The alert message also may be sent to a server remote from the elevator, which, for example, is responsible to coordinate maintenance operations for a plurality of elevators. For example, the alert message may be sent via a telephone line and/or the Internet.

[0030] A further aspect of the invention relates to an elevator system, comprising an elevator with an elevator car in an elevator shaft and a controller with a noise and/or vibration sensor inside the elevator car, wherein the controller is adapted for performing the method as described in the above and in the following. For example, the method may be performed by a computer program that is executed in the controller.

[0031] In the following, advantageous embodiments of the invention will be described with reference to the enclosed drawings. However, neither the drawings nor the description shall be interpreted as limiting the invention.

Fig. 1 schematically shows an elevator system according to an embodiment of the invention.

Fig. 2 shows a flow diagram for a method according to an embodiment of the invention.

Fig. 3A shows a diagram with a vibration signal detected in the system of Fig. 1.

Fig. 3B shows a diagram with the Fourier transformed vibration signal of Fig. 3A.

Fig. 4A shows a diagram with a vibration signal detected in the system of Fig. 1.

Fig. 4B shows a diagram with the Fourier transformed vibration signal of Fig. 4A.

[0032] The figures are only schematic and not to scale. Same reference signs refer to same or similar features.

[0033] Fig. 1 shows an elevator system 10 with an elevator 12 comprising an elevator car 14 that is movable by a drive 16 in an elevator shaft 18. The elevator car comprises a control panel 20, which, for example, may comprise buttons for selecting a floor. The control panel 20 furthermore comprises a controller or control logic 22 and a vibration sensor 24 that may be directly installed to a circuit board of the control panel 20. Additionally or alternatively, a vibration sensor 24' may be installed inside the elevator car 14 remote from the control panel 20.

[0034] It may be that both or at least one of the vibration sensors 24, 24' are microphones. For example, a microphone 24 may be a microphone used for communication of persons inside the elevator car 14 with the outside.

[0035] The microphone 24, 24' measures vibrations and generates a vibration signal 26, which, for example, may be sent via a CAN bus 30 to the controller 22. The controller 22 evaluates the vibration signal and depending on a vibration level may generate an alert message 28. This alert message 28 may be sent to a central con-

troller 32 of the elevator 12, for example also via CAN bus 30. The central controller 32 may be situated near the drive 16 and/or may be adapted for controlling the drive 16 and or further equipment, such as elevator doors, etc.

[0036] The alert message 28 may be sent to a monitoring infrastructure, such as a maintenance server 34. The central controller 32 and the maintenance server 34 may be interconnected via a telephone line and/or via Internet.

[0037] Fig. 2 shows a flow diagram for a method for determining a malfunction of the elevator 12, which may be performed by the elevator system 10.

[0038] In step S10, a vibration signal 26 is detected within the elevator car 14. For example, the vibration signal may be detected with the vibration sensor 24' and/or the microphone 24.

[0039] Fig. 3A and 4A show vibration signals 26 that have been detected with two microphones 24 inside an elevator car 14. Both diagrams show the amplitude or sound pressure of the detected noise during a time period of the time. Fig. 3A shows the vibration signals 26, when the elevator 12 is operating properly. There is some noise present, which stays substantially in the same amplitude range. Fig. 4A shows the corresponding vibration signals during a malfunction. In particular, a flanged pulley, which guides a traction belt and which was properly aligned during the measurements of Fig. 3A, has become misaligned. During the measurements of Fig. 4A, the axis of the pulley was moved out about 1.5° of an orthogonal direction. As can be seen in Fig. 4A, the noise amplitude in general becomes higher and there are larger deviations from an average noise amplitude.

[0040] It may be that the one or more vibration signals 26 are filtered in step S10. For example, a vibration signal 26 may be frequency filtered with an analogue filter, such that very high or very low frequencies or frequencies within a specific range are filtered out. For example, frequencies in a range, where human speech or outside traffic is usually present, may be filtered out.

[0041] It also may be possible that the one or more vibration signals 26 are digitally Fourier transformed. Fig. 3B and Fig. 4B show a Fourier transformed vibration signal 40 corresponding to a vibration signal 26 of Fig. 3A and Fig. 4B, respectively. One can see, that during a proper operation of the elevator 12 (Fig. 3B), mainly low frequencies are present with higher amplitudes. Thus, it may be possible that frequencies below a threshold value are filtered out (either analogue or after the Fourier transformation digitally) and the following steps are only performed based on the filtered signal.

[0042] Furthermore, it may be possible that the vibration signal 26 is content filtered.

[0043] In a simple case, it may be determined that too much ambient noise from an environment of the elevator 12 is present and the vibration signals measured during such time periods may be discarded. For example, such determinations may be made by determining a maximal amplitude in a specific frequency range and discarding the signals, when the maximal amplitude is above a threshold value. For example, passing traffic may cause very low frequencies with very high amplitudes.

[0044] Another option is to detect patterns in the vibration signal that indicate a specific environmental noise. For example, passing traffic results in a raising and then falling overall maximal averaged amplitude, independently of the movement of the elevator car.

[0045] A further option is to correlate the vibration signal 26 with a movement of the elevator car 14. Only vibration signals 26 may be used in the following steps, which have been measured during a continuous movement of the elevator car 14.

[0046] In step S12, a vibration level 36 from one or more of the vibration signals 26 is determined. In general, the vibration level is a value or number indicating specific features of the vibration signal 26 during a time period.

[0047] For example, the vibration level 36 may be a maximal amplitude of the vibration signal 26 during a time period, as indicated in Fig. 3A and 4B. In this case, the controller 22 may determine the maximal value of the amplitude during a time period as the vibration level.

[0048] It also may be possible that the vibration level is based on an energy of the vibration signal 26. In this case, the corresponding vibration signal 26 may be integrated over a time period.

[0049] It also may be possible that the vibration level is determined from the Fourier transformed vibration signal 40 as shown in Fig. 3B and Fig. 4B. In this case, the vibration level 36 may be a maximal level of the Fourier transformed vibration signal 40 at least in a frequency range 42.

[0050] However, the vibration level also may be based on an energy of the vibration signal 26 within a frequency range. In this case, the Fourier transformed vibration signal 40 may be integrated over the frequency range 42 to determine the vibration level.

[0051] In step S14, the vibration level 36 is compared with a threshold value 38, and when the vibration level 36 exceeds the threshold value 38, an alert message 28 is generated.

[0052] Such threshold values 38 are shown in Fig. 3A to 4B. The one or more threshold values may be set during commissioning of the elevator 12. For example, a service technician may move the newly installed elevator car 14 and may determine the vibration level 36 during this movement. This vibration level 36 with an added offset then may be set as threshold value.

[0053] In general, it has to be noted that more than one vibration level 36 may be determined with different methods. The alert message 28 may be generated on a combination of the outcomes of the comparison of the different vibration levels 36 with their threshold.

[0054] All the above steps may be performed by the controller 22. Also, the alert message 28 may be generated in the controller 22 and may be sent to the central controller 32 of the elevator 12. The central controller 32

then may use the alert message 28 to stop the operation of the elevator 12. This, for example, may be the case, when the threshold value 38 is set very high and an exceedance of the threshold value indicates a severe malfunction.

[0055] It also may be that the alert message 28 is sent to a maintenance server 34, to which a plurality of elevators is communicatively connected. The server 34 may collect the alert messages 28, for example for several elevators 12 in the same building, and, based upon the number of alert messages 28 from these elevators 12, may inform a service technician.

[0056] Finally, it should be noted that the term "comprising" does not exclude other elements or steps and the "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

List of reference signs

[0057]

10	elevator system
12	elevator
14	elevator car
16	drive
18	elevator shaft
20	control panel
22	controller
24	vibration sensor, microphone
24'	vibration sensor
26	vibration signal
28	alert message
30	CAN bus
32	central controller
34	maintenance server
36	vibration level
38	threshold value
40	Fourier transformed vibration signal
42	frequency range

Claims

1. A method for determining a malfunction of an elevator (12), the method comprising:

detecting a vibration signal (26) within an elevator car (14);
determining a vibration level (36) from the vibration signal (26);
comparing the vibration level (36) with a threshold value (38);
when the vibration level (36) exceeds the threshold value (38), generating an alert message (28).

2. The method of claim 1,
wherein the vibration signal (26) is detected with a vibration sensor (24') and/or a microphone (24).

3. The method of claim 2,
wherein the vibration signal (26) comprises a noise signal.

4. The method of claim 2 or 3,
wherein the vibration sensor (24') and/or microphone (24) is installed within a control panel (20) of the elevator car (14).

5. The method of one of claims 2 to 4,
wherein the microphone (24) is additionally used for acquiring a voice signal of a person in the elevator car (14).

6. The method of one of the preceding claims,
wherein the vibration signal (26) is filtered before determining the vibration level (36).

7. The method of claim 6,
wherein the vibration signal (26) is frequency filtered; and/or
wherein the vibration signal (26) is content filtered.

8. The method of one of the preceding claims,
wherein the vibration level (36) is a maximal amplitude of the vibration signal (26) during a time period.

9. The method of one of the preceding claims,
wherein the vibration level (36) is an energy of the vibration signal (26); and/or
wherein the vibration level (36) is based on an integral over the vibration signal (26).

10. The method of one of the preceding claims,
wherein the vibration signal (26) is Fourier transformed and the vibration level (36) is determined from the Fourier transformed vibration signal (40).

11. The method of claim 10,
wherein the vibration level (36) is a maximal level of the Fourier transformed vibration signal (40) at least in a frequency range (42).

12. The method of claim 10 or 11,
wherein the vibration level (36) is based on an integral over at least a frequency range (42) of the Fourier transformed vibration signal (40).

13. The method of one of the preceding claims,
wherein the alert message (28) is generated in a controller (22) within the elevator car (14) and sent to a central controller (32) of the elevator (12); and/or
wherein the alert message (28) is sent to a maintenance server (34), to which a plurality of elevators

are communicatively connected.

14. The method of one of the preceding claims,
wherein the vibration signal (26) is detected with a vibration sensor (24') and/or a microphone (24) installed within a control panel (20) of the elevator car (14); and
wherein the vibration level (36) is based on an integral over at least a frequency range (42) of the Fourier transformed vibration signal (40).

15. An elevator system (10), comprising:

an elevator (12) with an elevator car (14) in an elevator shaft (18);
a controller (22) with a microphone (24) and/or vibration sensor (24') inside the elevator car (14);
wherein the controller (22) and/or the elevator (12) is adapted for performing the method according to one of the previous claims.

Fig. 1

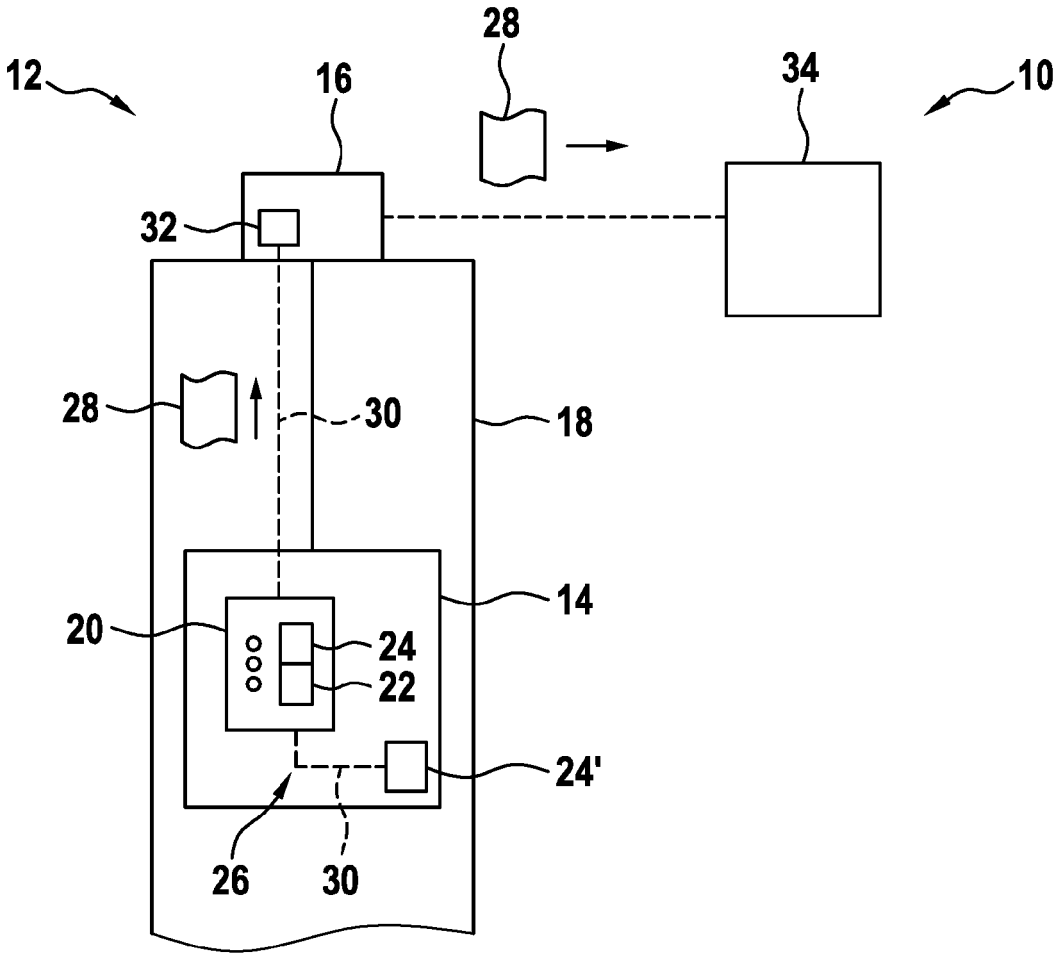


Fig. 2

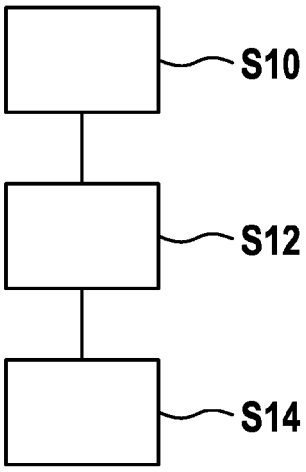


Fig. 3A

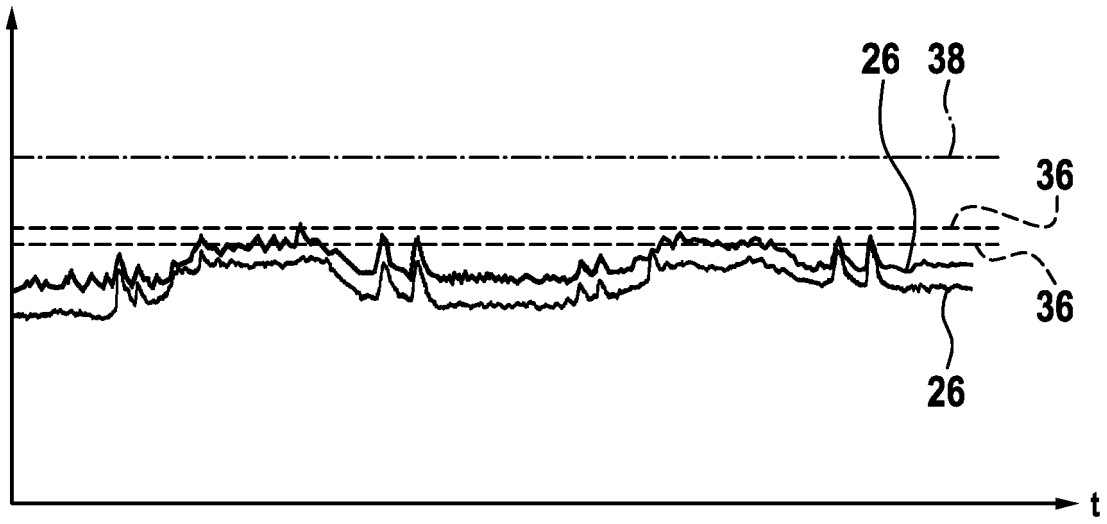


Fig. 3B

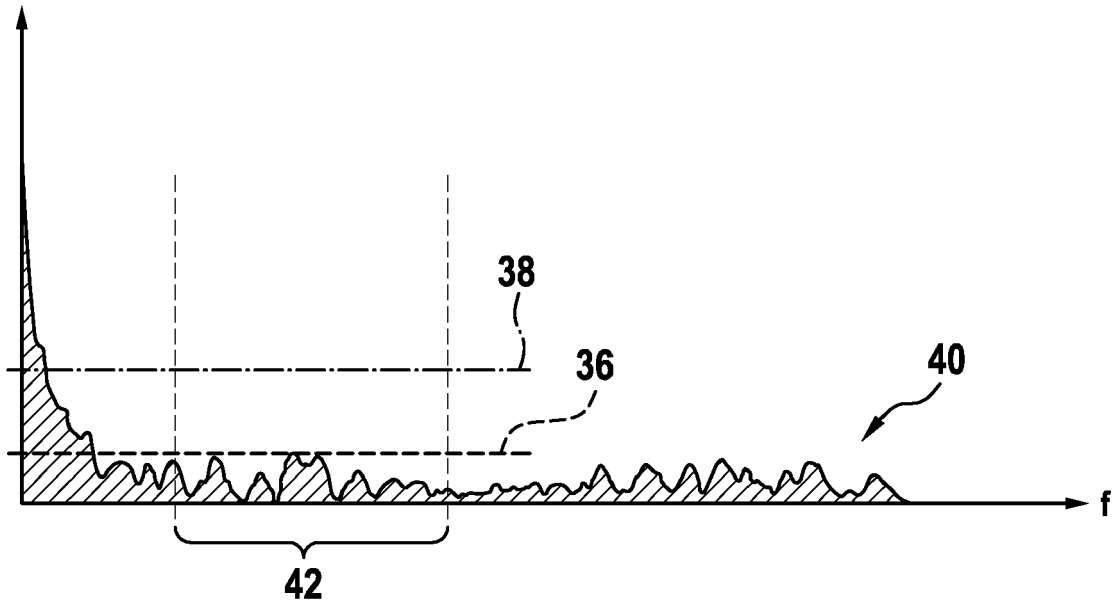


Fig. 4A

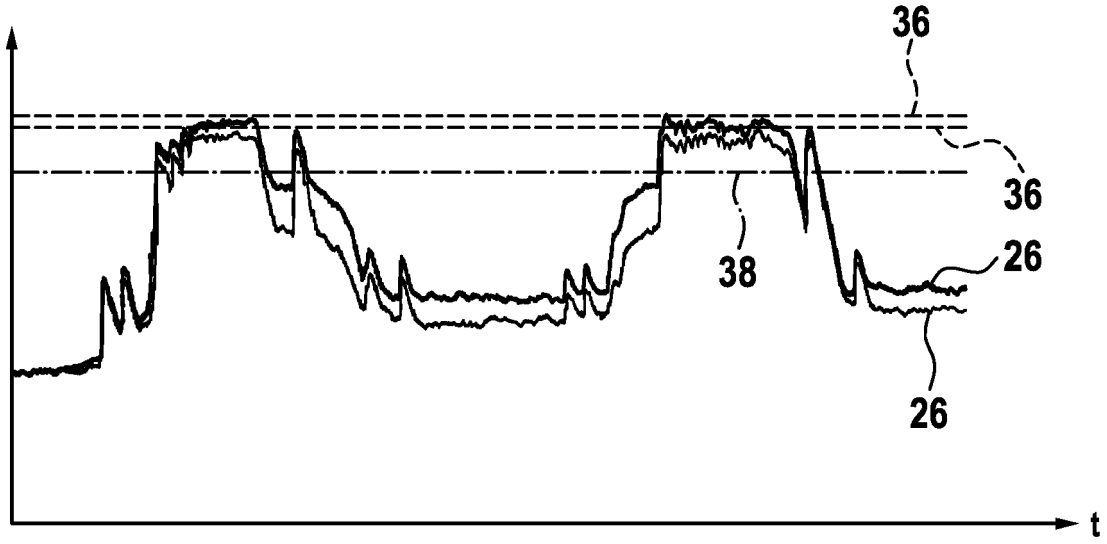
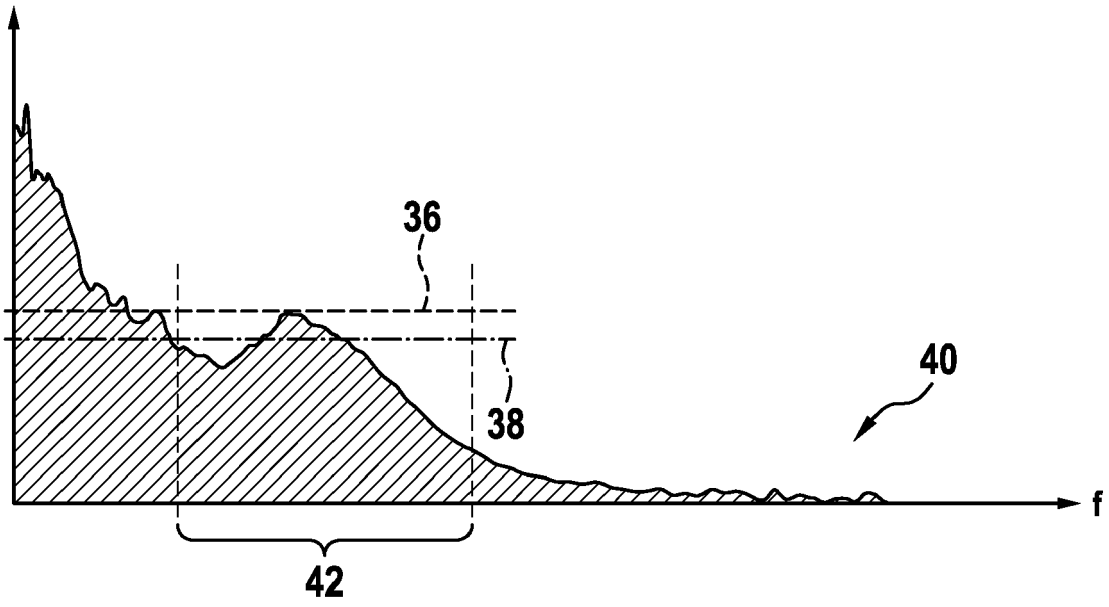


Fig. 4B



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EUROPEAN SEARCH REPORT

Application Number
EP 16 18 5160

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	JP 2010 180011 A (MITSUBISHI ELECTRIC CORP) 19 August 2010 (2010-08-19) * abstract; figures 1-3 * * paragraphs [0009] - [0015] *	1-15	INV. B66B5/00
X	SG 188 710 A1 (HITACHI LTD [JP]) 30 April 2013 (2013-04-30) * abstract; figures 1-8 * * page 7, line 11 - page 13, line 4 * * page 19, line 13 - page 21, line 9 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

B66B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 March 2017	Bleys, Philip

CATEGORY OF CITED DOCUMENTS

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06-03-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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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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