

(19) **DANMARK**

(10) **DK/EP 3281840 T3**



(12)

Oversættelse af europæisk patentskrift

Patent- og
Varemærkestyrelsen

-
- (51) Int.Cl.: **B 61 L 1/06 (2006.01)** **B 61 L 27/00 (2006.01)** **B 61 L 25/02 (2006.01)**
- (45) Oversættelsen bekendtgjort den: **2021-08-02**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2021-07-07**
- (86) Europæisk ansøgning nr.: **17186360.8**
- (86) Europæisk indleveringsdag: **2010-09-03**
- (87) Den europæiske ansøgnings publiceringsdag: **2018-02-14**
- (30) Prioritet: **2009-09-03 GB 0915322**
- (62) Stamansøgningsnr: **10752138.7**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR**
- (73) Patenthaver: **Siemens Mobility Limited, Euston House , 24 Eversholt Street, London, NW1 1AD, Storbritannien**
- (72) Opfinder: **Chadwick, Simon, Plum Tree Cottages, Etchilhampton, Devizes, SN10 3JP, Storbritannien**
Chapman, Mike, P.O. Box 79, Pew Hill, Chippenham, SN15 1JD, Storbritannien
Glover, Mark, P.O. Box 79, Pew Hill, Chippenham, SN151jd, Storbritannien
McQuillan, James, P.O. Box 79, Pew Hill, Chippenahm, SN15 1JD, Storbritannien
Priest, Ian, P.O. Box 79, Pew Hill, Chippenham, SN15 1JD, Storbritannien
- (74) Fuldmægtig i Danmark: **Zacco Denmark A/S, Arne Jacobsens Allé 15, 2300 København S, Danmark**
- (54) Benævnelse: **Fremgangsmåde til overvågning af komponenter af et jernbanesystem**
- (56) Fremdragne publikationer:
CA-A1- 2 212 063
DE-A1- 4 214 271
DE-A1- 19 913 057
US-A- 580 304
US-A- 5 493 390
US-A1- 2009 001 226
US-B1- 6 216 985
D.R. Anderson: "Detecting flat wheels with a fiber-optic sensor", Rail Conference, 2006. Proceedings of the 2006 IEEE/ASME Joint, 1 January 2006 (2006-01-01), pages 25-30, XP055220534, DOI: 10.1109/RRCON.2006.215289 ISBN: 978-0-7918-4203-4

DESCRIPTION

[0001] The present invention relates to a method of monitoring components of a railway system.

[0002] Recent development in fibre optic sensing technology offers opportunity for a number of advances that can be made in the field of railway sensing and control.

[0003] As background art may be mentioned DE-A1-10 2007 006833, which discloses acoustic monitoring at a single point on a railway.

[0004] It is an aim of the present invention to provide improved systems and methodologies for train and railway control, operation and security. This aim is achieved by the method of monitoring components of a railway system according to claim 1, which provides 'listening' to the trackside environment and allow information to be derived for a number of uses. This 'listening' makes use of an acoustic transducer comprising an optical fibre.

[0005] CA2212063A discloses a combination of existing computer sound recognition technology, listening devices and railway communication appliances that, when combined with the sound or vibration transmission properties of a railways' rail, will aid in the immediate detection and location of rockslides, washouts, railway rolling stock anomalies, like shelled or flatspotted wheels or derailed cars.

[0006] In accordance with the present invention there is provided a method of monitoring components of a railway system which includes a track and at least one train that is operable to run on said track, comprising the steps of: a) providing an acoustic transducer proximate the railway for picking up acoustic signals; b) receiving signals from the transducer; and c) analysing the received signals, the method further comprising identifying a signature associated with fixed railway assets wherein the fixed assets comprises at least one asset selected from the group including: points, point machines, level crossings, cables, switches, track; characterised in that the acoustic transducer comprises an optical fibre; and in that the method includes picking up the vibration caused by the moving parts of a fixed railway asset and comparing with the signature for the fixed railway asset.

[0007] As is well understood, acoustic waves emitted from a source act to cause incident objects to vibrate. Vibrations on the outer surface of a fibre optic cable cause changes in the refractive properties experienced by light passing through the cable, which may for example be analysed using computer algorithms in order to determine where on the cable such vibration is being experienced, and additionally the frequency and amplitude of such disturbance. This is analogous to turning the cable into one or a series of microphones. The systems described below all use the same basic principle of 'listening' to the trackside environment or train vehicles as they pass an acoustic transducer comprising an optical fibre. In all cases computer-based analysis of the vibration vs time signature (or a frequency domain version of the same)

may be used in order to identify a particular case.

[0008] It should be noted that existing rail tracks are often already provided with at least one fibre optic cable positioned adjacent to the track, so that communications signals may be transmitted therethrough. Typically, a bundle of fibres are provided, of which some will be "dark", i.e. unused in normal operation. Advantageously, such dark fibres may be used as the acoustic transducers in accordance with the present invention. It is not essential to use dark fibres however, for example "light" communications carrying fibres may be used, in which case it is necessary to distinguish between the communications and acoustic signals, which can be achieved using electronic filters for example. As a further alternative, new optical fibre may be laid at or adjacent to the track for the purpose of hydrophony.

[0009] The invention will now be described with reference to the accompanying figures, of which:

Fig. 1 schematically shows a theoretical train signature in the amplitude vs time domain,

Fig. 2 schematically shows a first possible optical fibre arrangement,

Fig. 3 schematically shows a second possible optical fibre arrangement,

Fig. 4 schematically shows a third possible optical fibre arrangement;

Fig. 5 schematically shows a conventional level crossing predictor; and

Fig. 6 schematically shows a level crossing predictor in accordance with a first embodiment of the present invention.

[0010] The signature of a train will be characterised by a series of frequencies at various amplitudes caused by the passage of the wheel along the rail, in particular there will be specific peaks as an axle passes a given point. It is therefore possible to determine not only that a train has passed a particular location on the railway, but also to determine further information such as train length, the number of axles of the train, the condition of equipment on that train, and the condition of fixed equipment such as the track itself or trackside equipment.

[0011] Fig. 1 schematically shows a theoretical signature in the amplitude vs time domain for a train operating normally. For simplicity, the train is assumed to be simple, for example a "two-car sprinter" lightweight vehicle with substantially evenly-distributed weight along the length of the train. The signature shown reflects the acoustic signal measured by a trackside transducer over time at a set region, located away from, and out of the influence of, "noisy" equipment, and shows the approach, passage and departure of a train. At a first region A of the signature, the acoustic signal corresponds to ambient or background noise only. At region B, a train approaches the transducer, and as it approaches the noise level increases. Region C occurs as the train passes the transducer. Since the train is assumed to be simple and with evenly

distributed weight, this region generally takes the form of a plateau, i.e. there is a similar noise level experienced throughout passage of the train. However, there are points D of raised signal, which occur when individual wheels of the train pass by the transducer. Region E occurs after the passage of the train, and shows a gradually diminishing noise level as the train moves away. Finally, region F shows a return to ambient or background noise only.

[0012] Although not shown in Fig. 1, the signature will have a characteristic spectral response in the frequency domain, which advantageously is also monitored.

[0013] It can be seen from Fig. 1 that various types of information may be collated from the transducer's output. These include:

1. i) The train signature is unique for each train. Therefore comparison of detected signatures can be used to identify and differentiate trains. Furthermore trains may be tracked by means of the signature, as described below. It must be remembered though that the signature will be "squeezed" or "stretched" along the time axis depending on the speed of the train as it passes a transducer, and so compensation is necessary when identifying or tracking trains.
2. ii) The number of points D corresponds to the number of axles of the train. Therefore, the transducer may be used as an axle-counter.
3. iii) The profile of points D contains information as to the condition of the wheels and the condition of track where the wheels pass. If all such points D share a common unusual feature, then this implies that the track has a certain characteristic (e.g. a fault). If on the other hand a feature is only shown in one point D, then it may be implied that a particular wheel has a characteristic (e.g. a region of flattening). Furthermore the wheel affected may be determined.
4. iv) Other conditions of the train may be identified. For example, a signature including a high response at certain frequencies may imply "squealing" due to a fault. An unusual profile in region E may imply that an object is dragging along behind the train for example.
5. v) The signal outside the signature, i.e. the ambient noise in regions A, F, provides information on fixed equipment proximate the transducer, as will be described further below.

[0014] It should be noted that a single such signature cannot be used alone to determine either the length of the train or its speed. In order to enable these determinations, it is necessary to acquire at least one additional signature, i.e. from second transducer region.

[0015] There are various alternatives for providing fibre optic hydrophony proximate a track. These include:

1. i) providing a "long" fibre, i.e. one which is longer than the desired resolution of the system, alongside the track. The location of the source of acoustic signals may be

determined by using signal processing, as is known in the art. This type of arrangement is schematically shown in Fig. 2, where a single length of optical fibre 1 is provided alongside a track 2. Signal detection is performed by a receiver 3 located at an end of the fibre 1. Receiver 3 is in connection with a signal processor 4. This outputs data to the main train control system (not shown). Alternatively, receiver 3 and signal processor 4 may be integrally formed.

2. ii) Providing a series of discrete fibres along the track, with each fibre having a length approximately equal to the desired resolution of the system. This arrangement is schematically shown in Fig. 3, where a number of fibres 1a are provided alongside track 2, each fibre being connected to a receiver 3. This arrangement may reduce processing load. It is possible to apply signal processing to the signal received from each fibre 1a, in order to further improve localisation of the acoustic signal source.
3. iii) Providing a "point" measurement with a short section of fibre to provide accurate determination of the acoustic signal source location without requiring the signal processing of i) above. This arrangement is shown in Fig. 4, with a number of short fibre sections 1b positioned proximate a track 2, each section 1b being connected to a receiver 3. This arrangement may be of particular use for monitoring fixed / trackside equipment such as points, crossings etc.

[0016] As mentioned above, the present invention provides various improvements over conventional systems. Some of these are now described for illustration.

[0017] In this embodiment, a fibre optic cable laid close to the trackside may be used to determine the status of fixed railway assets such as point machines, level crossing barriers and so on.

[0018] The vibration caused by the moving parts of the equipment will cause the outer layer of the fibre optic cable to vibrate, and this is picked up by the sensing equipment. Measurements of the signature of healthy equipment are made and recorded, in particular characteristics such as time of operation, and peaks of amplitude or vibration as areas of high friction are encountered.

[0019] By detecting vibrations on the outer surface of the fibre, and in particular in comparison with a prerecorded 'signature' for the particular object, it is possible to reveal fixed asset faults including:

■ Track deformation, for example torsion of the rail or gauge corner cracking. As the train moves along the rail, the signature detected will be different to the 'normal' signature, for all axles, thus allowing detection with some surety that that rail is not as expected and that further inspection is required.

- Switch and crossings suffering increased friction or slower operational times.
- Point machines where condition is not optimal.

[0020] By using computer algorithms to determine trends in such characteristics, the system can determine at which point maintenance is required.

[0021] By adopting such a technique, no routine maintenance may be required, all maintenance can be based entirely upon the condition and operational status of the device being monitored.

[0022] Furthermore, this technique may be used to monitor vandalism, trespassing or theft at railside locations. If the noise expected to be created by an item disappears from a received signal, then this implies that the item has been physically removed, e.g. by theft. Abnormal signals received from an item may indicate vandalism of that item. In addition, the acoustic monitoring may be able to detect items not associated with the railway, e.g. monitoring intruders directly, for example footsteps, talking, or vehicles.

[0023] Various alternatives and modifications within the scope of the invention as defined by the claims will be apparent to those skilled in the art.

[0024] Preferably, the acoustic signals are monitored continuously, however this may not be necessary for all applications.

[0025] In the event of ambiguity in the interpretation of the received signal, it may be played to a human operator, who may be able to identify the noise picked up.

[0026] The methodology described above may be used in combination, e.g. the same received signals may be used both for train location and for monitoring of fixed assets.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE102007006833A1 [0003]
- CA2212063A [0005]

P a t e n t k r a v

5 **1.** Fremgangsmåde til overvågning af komponenter i et jernbanesystem, som omfatter et spor (2) og mindst et tog, som kan betjenes til køre på sporet (2), omfattende de følgende trin:

a) at tilvejebringe en akustisk transducer (1) i nærheden af banelinjen til at opfange akustiske signaler;

b) at modtage signaler fra transducere (1); og

c) at analysere de modtagne signaler,

10 hvor fremgangsmåden endvidere omfatter at identificere en signatur, der er forbundet med faste jernbaneaktiver, hvor de faste aktiver omfatter mindst et aktiv udvalgt fra gruppen, der indbefatter: sporskifter, sporskiftmaskiner, jernbaneoverskæringer, kabler, omskiftere, spor;

kendetegnet ved at:

15 den akustiske transducer (1) omfatter en optisk fiber;

og **ved at** fremgangsmåden indbefatter at opfange den vibration, der forårsages af de bevægelige dele af et fast jernbaneaktiv, og at sammenligne med signaturen for det faste jernbaneaktiv.

20 **2.** Fremgangsmåde ifølge krav 1, hvor det at opfange vibrationen omfatter detektering af vibrationer på den udvendige overflade af den optiske fiber (1).

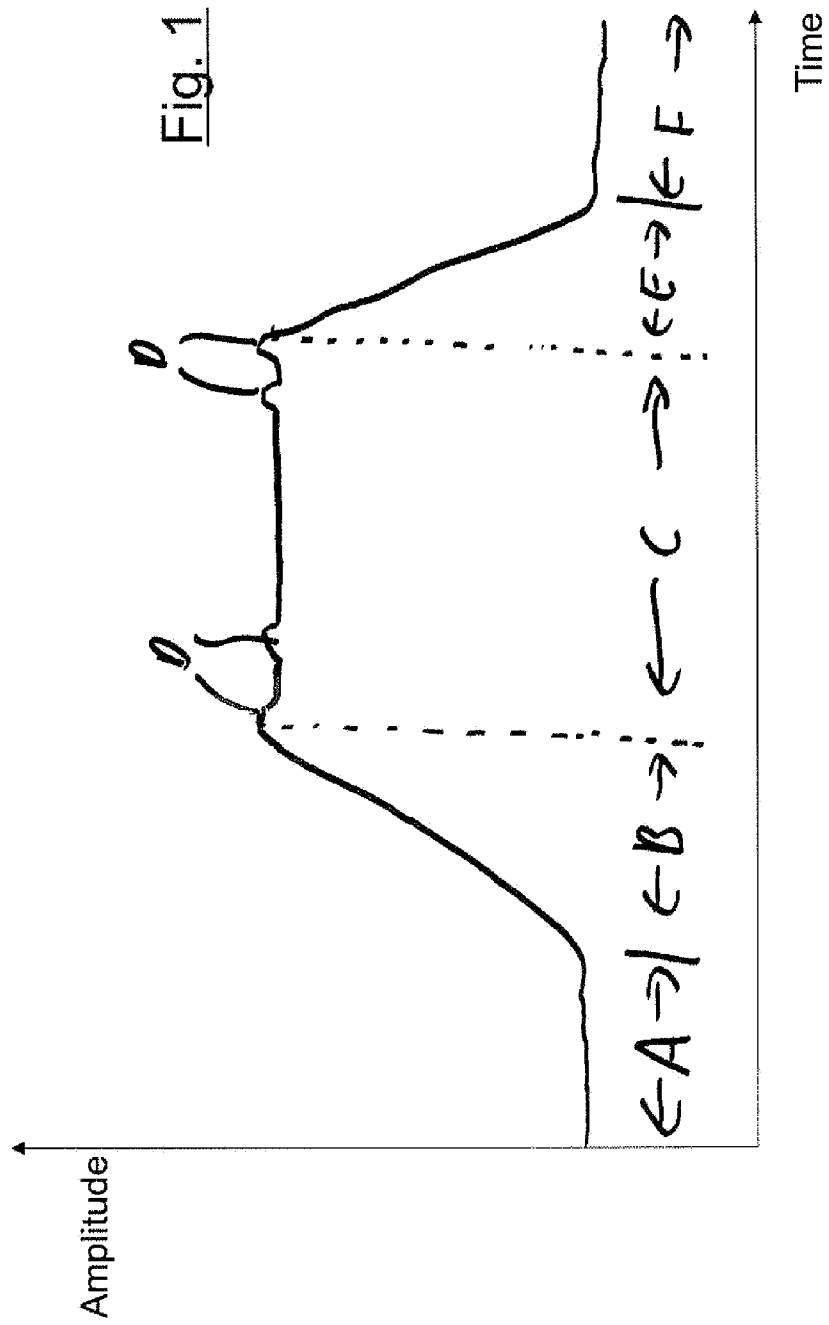
3. Fremgangsmåde ifølge krav 1 eller 2, hvor det at analysere de modtagne signaler indbefatter identificering af driftstid eller amplitude-toppe.

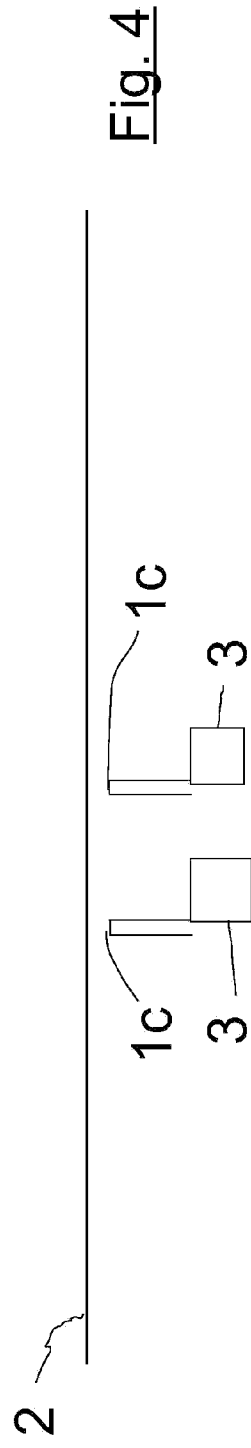
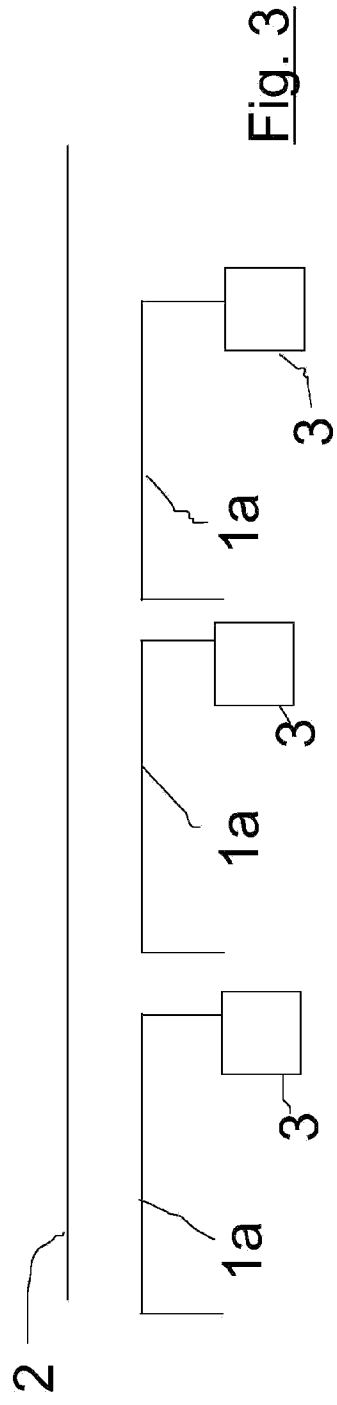
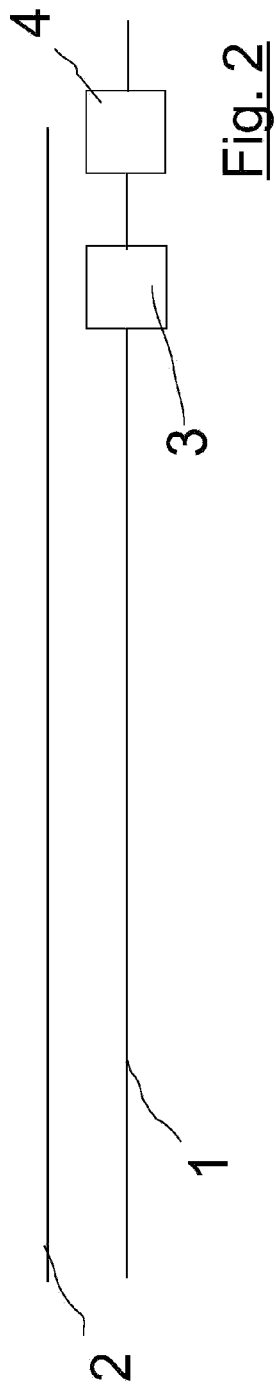
25

4. Fremgangsmåde ifølge et hvilket som helst af de foregående krav, hvor de modtagne signaler analyseres i et frekvensdomæne.

30 **5.** Fremgangsmåde ifølge et hvilket som helst af kravene 1 til 3, hvor de modtagne signaler analyseres som en vibration-versus-tid-signatur.

DRAWINGS





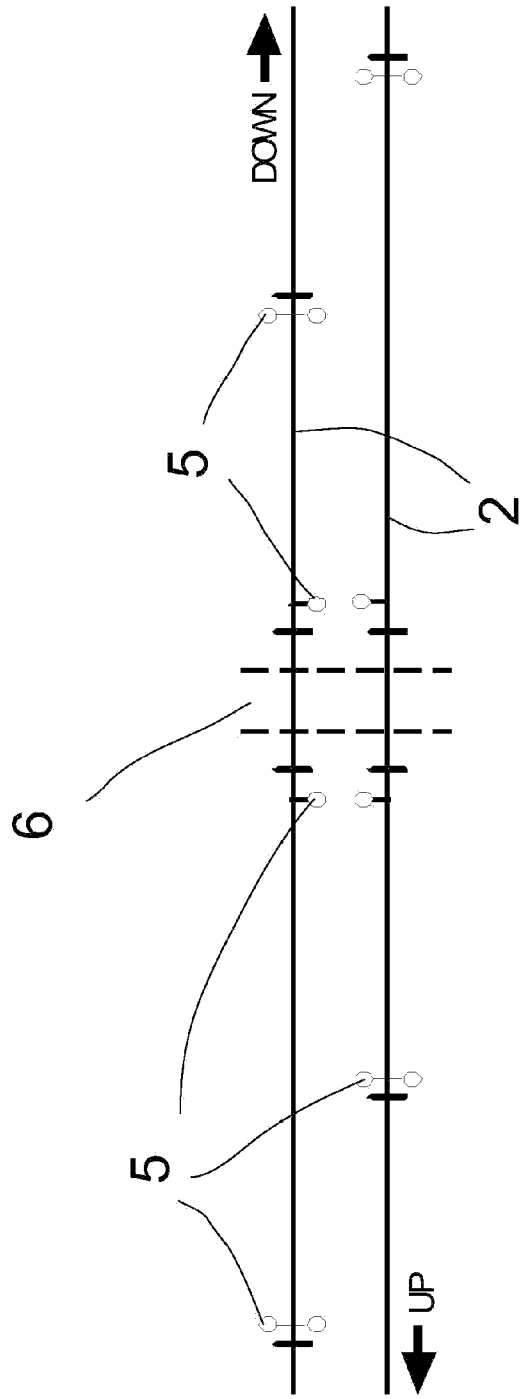


Fig. 5

