(12) UK Patent Application (19) GB (11) 2479900 (13) A

(43) Date of A Publication 02.11.2011

(21) Application No: 1007073.8

(22) Date of Filing: 28.04.2010

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(51) INT CL:
B61L 25/02 (2006.01) ***B61L 27/00*** (2006.01)

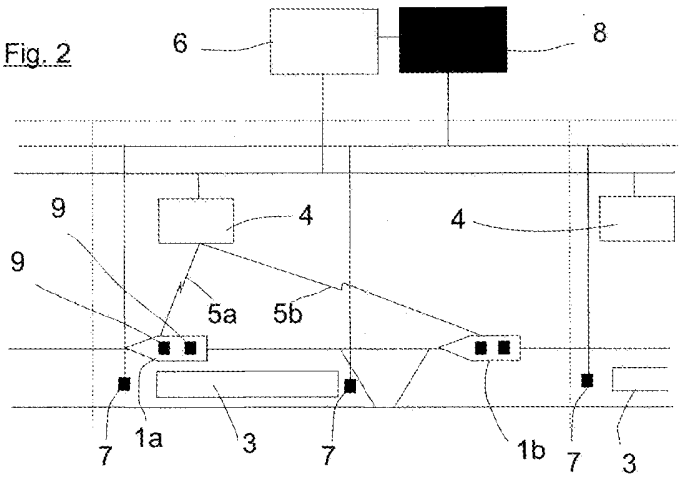
(56) Documents Cited:
EP 0638469 A
JP 2002187552 A
US 20050192720 A
US 20020062181 A
JP 2004338520 A
US 5950966 B
US 20050133673 A

(58) Field of Search:
INT CL **B61L**
Other: **EPODOC, WPI.**

(54) Title of the Invention: **Initialisation of a signalling system**
Abstract Title: **Block by block initialisation of a rail signalling system for a rail network.**

(57) Disclosed is a method of initialising a rail signalling system for a rail network which has trains on it. The signalling system having signalling equipment, signalling communication equipment located on each train for enabling train location information to be sent from the train to the signalling equipment and a controller, in communication with the signalling equipment, for controlling the signalling equipment. The method has the steps of dividing the network into a plurality of blocks, providing a train location detection system, with a train database for storing the location of each train within the network at a block level. The train database able to send train location information to the controller. Next, the controller is set to treat any blocks with at least one train located on it as occupied, and then causing a train to move if the block ahead of that train in the direction of travel is not occupied.

Fig. 2



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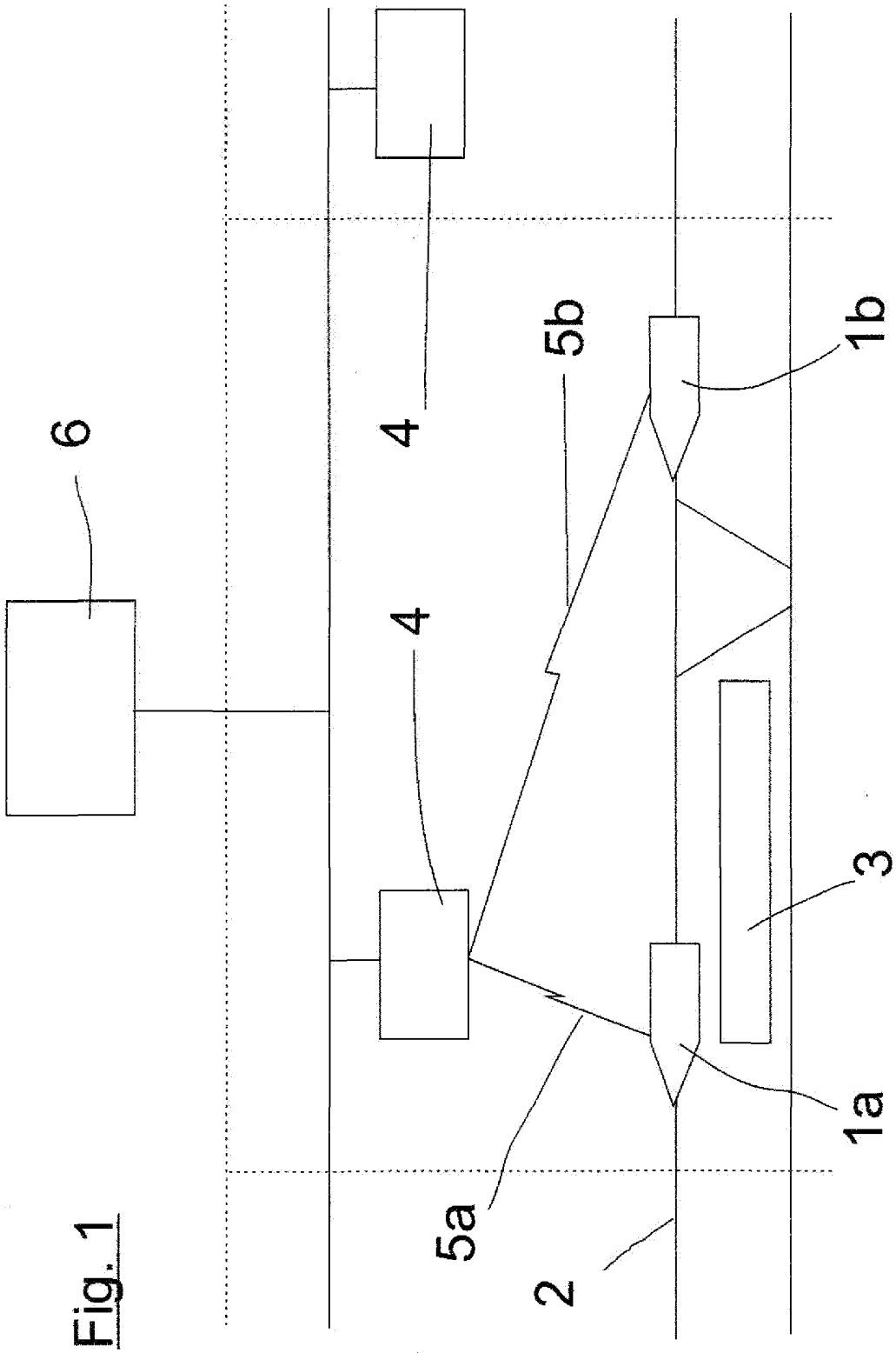

Fig. 1

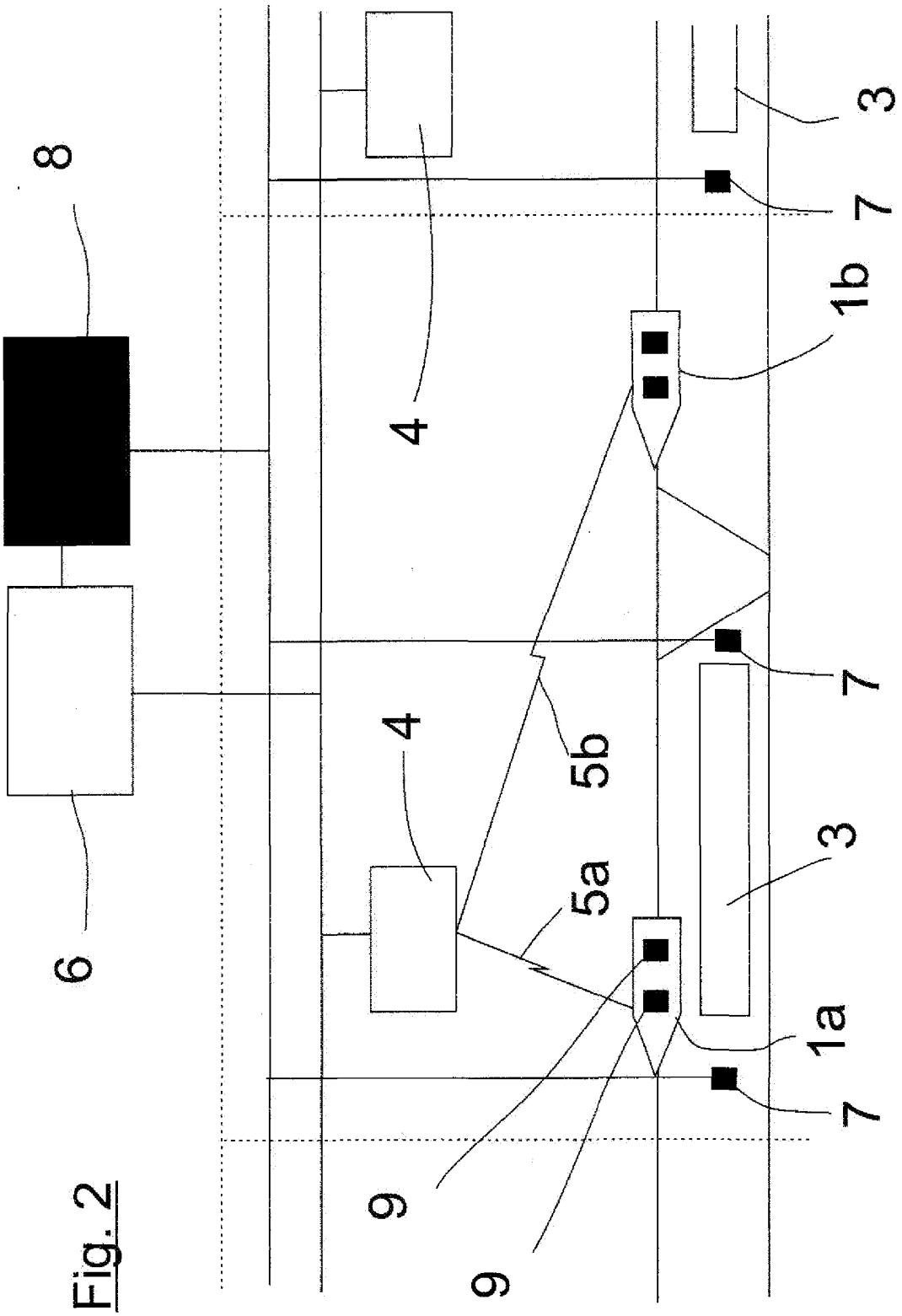

Fig. 2

Initialisation of a Signalling System

This invention relates to a method of initialising a rail signalling system for a rail network with a plurality of trains located therein and a rail signalling system for controlling the movement of one or more trains on a rail network.

Fig. 1 schematically shows a typical computer-based train control system, such as could be used, for example, with an unmanned metro or underground rail network. Two trains 1a, 1b are shown on a line 2. A platform 3 is shown near train 1a's location. The network is divided into signalling sections, shown by the dotted lines, with one signalling equipment hub 4 in each section. In this example, both trains 1a, 1b are within the same section. The trains are in bi-directional radio communication 5a, 5b with signalling equipment 4 within the section. Each signalling equipment hub 3 is connected to a central control system 6 allowing bi-directional communication therebetween.

When the system is fully operational, train location is detected on the train 1a, 1b, for example via absolute position references ("APR"s), for example where the train passes a unique identifiable marker (not shown in Fig. 1), or derived via odometry and / or via a tachometer. With these methods, the train location may only be determined if the train is moving. The trains report their location to the signalling equipment 4 by radio. The signalling equipment 4 uses the train location reports and requests from the control system 6 to compute the signalling data sent to trains 1a, 1b.

There are systems where train location may be determined while stationary, for example by using GPS positioning techniques or by the use of track circuits. However, such techniques are not appropriate for all rail systems, for example metro or underground rail systems.

Such systems, while generally working well in normal use, may have problems associated with them, which are generally associated with one or more failures within the system. These include:

- Communications failures, such that the signalling system is not able to receive train locations;
- Failure of individual trains;
- Partial trackside signalling system failure; and
- Complete signalling system failure.

In the event of a partial or complete signalling system failure, for safety any trains located on the route in question are stopped. This may lead to problems following rectification of the signalling failure. In particular, and as mentioned previously, train locations may generally only be determined if the trains are moving. Therefore there is a problem re-starting the system, as some or all of the train locations may not be known. In addition, certain trains may have been moved since the system failed, for example under manual supervision to allow egress of passengers.

The nature of the system demands that, as described above, trains need to move in order to determine their position. However, if the train positions are not all known, it is difficult to know which trains can move.

With a manned system, voice protocols can be used to report locations of "lost" trains, and verbal authorities can be given to move trains at slow speeds.

With an unmanned system however, this solution is not available.

It is an aim of the present invention to overcome these problems, such that the locations of trains can be determined sufficiently accurately to enable a timely return to operation following a system failure. The invention is considered to be particularly advantageous in relation to metro / underground rail systems and unmanned systems. In practice, unmanned systems are often also metro / underground systems.

This aim is achieved by providing a diverse, coarse train detection system in a centralised, overseeing capacity, together with a train database, which monitors the locations of all trains within the railway (or area) under consideration.

Such a system provides for initialisation of a signalling system which does not have continuous trackside train detection, such as that provided by track circuits.

In accordance with a first aspect of the present invention there is provided a method of initialising a rail signalling system for a rail network with a plurality of trains located therein, the signalling system having a signalling architecture comprising signalling equipment, signalling communication equipment located on each train for enabling train location information to be sent from the train to the signalling equipment; and a controller, in communication with the signalling equipment, for controlling the signalling equipment;

the method comprising the steps of:

a) dividing the network into a plurality of blocks;

b) providing a train location detection system, diverse to the signalling architecture, comprising a train database for storing the location of each train within the network at a block level, the train database being in communication with the controller for sending train location information thereto;

c) setting the controller to treat any blocks with at least one train located therein as occupied;

d) causing one train to move if the block ahead of that train in the direction of travel is not occupied; and

e) repeating the previous step for each of the plurality of trains.

In accordance with a second aspect of the present invention there is provided a rail signalling system for controlling the movement of one or more trains on a rail network, the system having a signalling architecture comprising: signalling equipment, signalling communication equipment located on each train for enabling train location information to be sent from the train to the signalling equipment; and a controller in communication with the signalling equipment, for controlling the signalling equipment;

wherein the rail signalling system further comprises:

a train location detection system comprising:

a train database for storing the location of each train at a block level within the network, the train database being in communication with the controller for sending train location information thereto;

a plurality of beacons, defining the blocks, located at spaced locations within the network;

means for detecting that a train passes a beacon; and

communications means for enabling information confirming that a train has passed a beacon to be sent to the train database;

the signalling architecture and train location detection system being diverse such that in the event of failure of the signalling architecture, train locations remain available from the train database.

The present invention is therefore capable of providing, inter alia, the following advantages:

- the restarting of a railway without continuous trackside train detection, following a partial or complete signalling system failure;
- a means of providing "occupied areas" for individual trains which have failed, until those trains have been repaired or removed from the system, including over difficult border and transition areas;
- the ability to take into consideration any train moves which may have taken place under verbal controls, whilst the signalling system is failed;
- the potential to control trolleys and other track-mounted equipment during possessions for maintenance work.

The invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 schematically shows a typical computer-based train control ("CBTC") system; and

Fig. 2 schematically shows a computer-based train control system in accordance with the present invention.

An embodiment of the invention is schematically shown in Fig. 2. As for as possible, the numbering system used in Fig. 1 has been retained for like items.

As mentioned previously, the present invention can be directly applied to "closed" railway, with captive stock, such as a metro system or to an "open" railway, by

transitioning trains into and out of the area. The embodiment shown and described with reference to Fig. 2 is for a typical computer-based train control ("CBTC") system.

As in Fig. 1, a portion of a rail network is shown having two trains, 1a and 1b. Platforms are shown at 3, signalling equipment at 4 and a controller at 6. Bi-directional communications between signalling equipment 4 and trains 1a and 1b are shown as 5a and 5b respectively. The combination of signalling equipment 4, controller 6 and train-carried signalling communication apparatus constitutes a signalling architecture.

In this embodiment, the network is divided into a plurality of relatively coarse train location blocks by trackside-located beacons 7. As shown, one beacon 7 is provided at each end of a platform 3. There need not be many of these beacons/sensors, as only coarse train detection is required. As will be described below, the provision of these beacons 7 enables each train 1 to be located within a block, each block being delimited by two beacons 7. The location definition provided is relatively coarse compared to that available through the signalling architecture in fault-free operation. Each block can contain more than one train.

Each beacon 7 has a unique identifier or ID, and furthermore is in communication with a train database 8, which maintains a record of the location of each train on a block level. Train database 8 is connected to controller 6 for communication therewith. In this embodiment, beacons 7 are capable of both transmitting their unique identifiers to train-carried beacon detection means in the form of transceivers 9 when they pass, and of receiving train identifiers from the transceivers 9. The transceivers are also able to detect movement of the train using inertial navigation sensors. The transceivers are fitted externally to the trains, and be battery-backed. The beacons 7 send the received train identifiers, with their own unique identifiers, to train database 8. In addition, transceivers 9 are operable to send the beacon identifiers received via the train-carried signalling communication equipment using bi-directional communication 5, to signalling equipment 4, to controller 6 and then to train database 8. Therefore, whenever a train passes a beacon 7, the train identifier and beacon identifier are sent to the train database 8 so that the block location of the

train is recorded. Having this information sent by both the beacon 7 and train 1 provides the security of a back-up transmission path for redundancy.

Fig. 2 shows that each train 1 carries two transceivers 9, typically one proximate the front of the train, and one proximate the rear. Such an arrangement is useful to confirm that the entirety of the train has passed into one block, or conversely that the train straddles two adjacent blocks. Having two transceivers also provides redundancy if one transceiver should fail.

The beacon to train database communications system is wholly diverse to the signalling architecture. Therefore, if one system should fail, the other will be unaffected.

The controller 6 has a processor which receives train reports from all valid sources, including from the train database 8. During failure conditions, it is possible that only this coarse train location may be received in certain areas.

Train Database

The following summarises the functions in the train database:

1. Maintain the location of all trains in the system against the railway layout, using all train location data available. Where possible maintain a fine level of train location, but a coarse level must always be maintained. Algorithms using time-dependent "train-growing" variables may need to be used. Note that there may be more than one train per section. The time of entry of a train into a section should also be recorded.

2. Continually process train location reports from trackside beacons and train-carried sensors. There is redundant information in this, which needs to be resolved to both fine level and simple coarse block level occupancy.

3. Process addition / removal of trains to / from the network. In a "closed" railway, this should not happen very often. Joining and splitting of trains will also need to be catered for.

4. Publish the coarse train locations to the signalling system. Also indicate whether there are any "lost" trains in the system.

System operation under initialisation conditions

The following summarises the required operation of the signalling system, when recovering from a system failure:

1. Check if all trains are accounted for, by using the data published by the train database. If there are trains for which the location is not known, then manual intervention will be required.

2. Treat any coarse train location blocks containing one or more trains as occupied in the signalling system.

3. Start trains moving one by one, in accordance with the order of entry into the block. This may be via an automated algorithm, or via the intervention of a single central controller.

4. As each train moves, it will report location again. This information can be correlated with the train database information, until such time as the coarse train location blocks can be regarded as "clear".

The following summarises the required operation of the signalling system, when recovering from the failure of a single train:

5. Check which trains are in the same coarse section, and permit those in front of the failed or "lost" train to proceed, whilst sending stop messages to those behind the failed or "lost" train.

6. After the failed or "lost" train has been removed via manual procedures, permit those which were behind the failed or "lost" train to proceed.

7. Alternatively, if it is required to reverse the trains behind the failed or "lost" train, in order to permit egress of passengers at a station, the trains can be given permission to move in the reverse order to that which they entered the coarse section.

8. Once all trains have been removed from the coarse section, including the failed or "lost" train, normal operation can be resumed.

The above-described embodiments are exemplary only, and other possibilities and alternatives within the scope of the invention will be apparent to those skilled in the art. For example, while the embodiment shown in Fig. 2 enables the train and beacon identifiers to be transmitted to the train database via two diverse communications routes, for simplicity only one such route could be used. In this case, it is preferable to rely upon the beacon - train database route so that this communication will not be affected by failure of the signalling architecture.

In addition, other modifications / alternative arrangements are possible within the scope of the invention:

1. Train locations may be passed from the signalling system to the train database, in order to enable clearing of the "coarse blocks".

2. The communications system could be "mesh" based, with limited use of fixed communications.

3. In a system with visibility to the skies, i.e. not entirely within tunnels, the train location in these areas could be determined via GPS, rather than via trackside beacons.

4. The system could be extended to include other equipment, for example trolleys etc. used during possessions. This would require different types of

trains in the train database, and then an output from the train database to indicate whether or not such items were still on the railway.

Claims

1. A method of initialising a rail signalling system for a rail network with a plurality of trains located therein, the signalling system having a signalling architecture comprising signalling equipment, signalling communication equipment located on each train for enabling train location information to be sent from the train to the signalling equipment; and a controller, in communication with the signalling equipment, for controlling the signalling equipment;

the method comprising the steps of:

a) dividing the network into a plurality of blocks;

b) providing a train location detection system, diverse to the signalling architecture, comprising a train database for storing the location of each train within the network at a block level, the train database being in communication with the controller for sending train location information thereto;

c) setting the controller to treat any blocks with at least one train located therein as occupied;

d) causing one train to move if the block ahead of that train in the direction of travel is not occupied; and

e) repeating the previous step for each of the plurality of trains.

2. A method according to claim 1, further comprising the step of:

f) determining the location of each train at a higher resolution than at the block level once the train is moving, using the signalling architecture.

3. A method according to either of claims 1 and 2, wherein step c) includes the initial step of consultation of the location information stored by the train database to check that the location of all trains on the network is known at the block level.

4. A method according to any preceding claim, wherein the train location detection system further comprises a plurality of beacons, defining the blocks, located at spaced locations within the network, and communications means for enabling information confirming that a train has passed a beacon to be sent to the train database.

5. A method according to claim 4, wherein the train location detection system comprises beacon detection means located on each train for detecting when the train passes a beacon.

6. A method according to claim 5, wherein each beacon has a unique identifier, and the communications means comprises communication equipment located on each train for sending the received identifier information to the train database via the signalling equipment.

7. A method according to any of claims 4 to 6, wherein the train location detection system comprises train detection means located on each beacon for detecting when the train passes a beacon.

8. A method according to claim 7, wherein the communications means comprises beacon communication equipment for enabling communication between each beacon and the train database.

9. A method according to any preceding claim, comprising the step of updating the train database with train location information from the signalling architecture.

10. A rail signalling system for controlling the movement of one or more trains on a rail network, the system having a signalling architecture comprising: signalling equipment, signalling communication equipment located on each train for enabling train location information to be sent from the train to the signalling equipment; and a controller in communication with the signalling equipment, for controlling the signalling equipment;

wherein the rail signalling system further comprises:

a train location detection system comprising:

a train database for storing the location of each train at a block level within the network, the train database being in communication with the controller for sending train location information thereto;

a plurality of beacons, defining the blocks, located at spaced locations within the network;

means for detecting that a train passes a beacon; and

communications means for enabling information confirming that a train has passed a beacon to be sent to the train database;

the signalling architecture and train location detection system being diverse such that in the event of failure of the signalling architecture, train locations remain available from the train database.

11. A system according to claim 10, wherein each beacon has a unique identifier.

12. A system according to claim 11, wherein the detecting means comprises beacon detection means located on each train, and means for receiving the identifier from that beacon.

13. A system according to claim 12, wherein the communications means comprises communication equipment located on each train for sending the received identifier information to the train database via the signalling equipment.

14. A system according to either of claims 12 and 13, comprising a first beacon detection means located substantially at the front of each train and a second beacon detection means located substantially at the rear of each train.

15. A system according to any of claims 10 to 14, wherein the detecting means comprises train detection means located at each beacon.

16. A system according to claim 15, wherein the communications means comprises beacon communication equipment for enabling communication between each beacon and the train database.

17. A system according to any of claims 10 to 16, wherein the controller is adapted to send train location information to the train database.

18. A method substantially as herein described with reference to the accompanying Fig. 2.

19. A system substantially as herein described with reference to the accompanying Fig. 2.

Application No:	GB1007073.8	**Examiner:**	Mr David Maskery
Claims searched:	1 - 17	**Date of search:**	16 August 2010

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1 - 17	US 2005/0192720 A (CHRISTIE et AL) See paragraphs 16 - 27 and 41 - 51.
Y	1 - 17	US 2005/0133673 A (SUGITA et AL) See paragraphs 45 - 67.
Y	1 - 17	US 5950966 B (HUNGATE et AL) See columns 3 - 6.
Y	1 - 17	US 2002/0062181 A (POLIVKA et AL) See paragraphs 13 - 15 and 19 - 29.
Y	1 - 17	EP 0638469 A (UNION SWITCH AND SIGNAL) See columns 6 - 9 and 11 - 13.
Y	1 - 17	JP 2004338520 A (NISHNIPPION RYOKAKU TETSUDO) See JPO abstract.
Y	1 - 17	JP 2002187552 A (HITACHI) See JPO abstract.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B61L

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI.

International Classification:

Subclass	Subgroup	Valid From
B61L	0025/02	01/01/2006
B61L	0027/00	01/01/2006