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(71) Applicant: **Westinghouse Brake and Signal Holdings Limited**
London
Greater London SW1X 7AW (GB)

(72) Inventor: **Chadwick, Simon**
Devizes, Wiltshire SN10 3JP (GB)

(74) Representative: **Emerson, Peter James et al**
Page Hargrave
Whitefriars
Lewins Mead
Bristol BS1 2NT (GB)

(54) Train location system

(57) Train location apparatus comprises:
means for providing information relating to the state of points within the railway region;
dynamic map creation means for creating a dynamic map of a railway region using said points information;
GNSS means for determining the location of the train from a GNSS system; and
processing means for combining the dynamic map and the GNSS location to determine the location of the train.

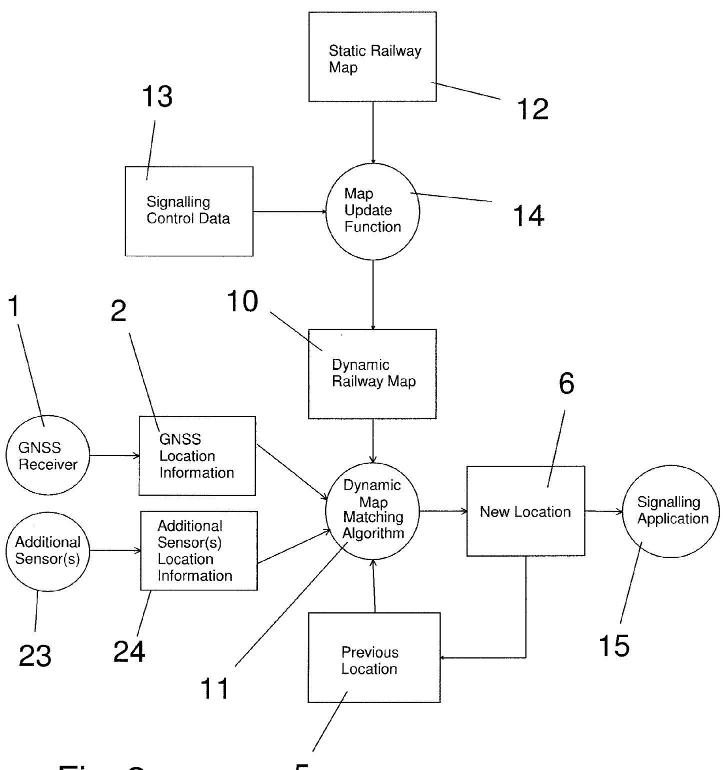

Fig. 3

EP 2 386 459 A2

Description

[0001] This invention relates to a method for creating a dynamic railway map, a method for determining the location of a train, and train location apparatus.

[0002] It is a desire within the field of railway signalling systems to use a global navigation satellite system (GNSS) to provide train location. Such technology has been developed for the automotive industry (for example "sat nav") already, however it is also seen as beneficial within the rail industry, due to the high availability and relatively low cost of such systems. However, such a system would require sufficient accuracy to resolve between two adjacent tracks on a railway with high levels of dependability, this level of accuracy being required for railway signalling, and this has hitherto been difficult to achieve.

Conventional Map Matching

[0003] Within the automotive industry, the use of global position systems (GPS - a form of GNSS) for navigation is widespread. Within such systems, there is a "map matching" algorithm, which aims to ensure that vehicles are placed on roads within a static map of the area. Such an algorithm is schematically shown in Fig. 1.

[0004] As shown, a map matching algorithm 4 has a number of data inputs, e.g. a GNSS location 2 received from a GNSS receiver 1, a static map 3 which contains e.g. road layout information, and a "previous location" 5. The algorithm 4 correlates as far as possible the GNSS location with the static map, checked against the previous location 5, to determine the location 6 of the vehicle. This location 6 is used to provide the "previous location" input 5 for the next running of the algorithm. The new location 6 is passed to the "Sat. Nav." application 7, for example an in-car device.

[0005] In practice, such map matching algorithms in use take account of current and previous speed, and current and previous heading.

[0006] Of course, roads are generally quite widely spaced, and so such methods generally provide sufficient accuracy for their needs. In contrast, railway tracks may be very closely spaced together, especially near stations for example, and such methods are not usable.

[0007] As prior art in related fields may be mentioned EP 0407875, GB 1532638, US 2003/0236598, WO 2006/136783 and JP 2005247024.

[0008] It is an aim of the present invention to provide a method and system for achieving train location via GNSS systems with sufficient accuracy for rail signalling systems. This aim is achieved by combining GNSS data with additional information from within the railway signalling systems. In this way, the use of standard low cost GNSS systems within the rail industry is permitted.

[0009] In accordance with a first aspect of the present invention there is provided a method for creating a dynamic railway map of a region of a railway system, comprising the steps of:

a) providing a static map of said region, showing railway lines present in that region;
b) providing information relating to the state of points within the railway region; and
c) combining said static map and said points information to create the dynamic map.

[0010] In accordance with a second aspect of the present invention there is provided a method of determining a location of a train within a region of a railway system, comprising the steps of providing a dynamic railway map of said region and providing GNSS information relating to the location of said train, and combining the map and the GNSS information.

[0011] In accordance with a third aspect of the present invention there is provided train location apparatus comprising:

means for providing information relating to the state of points within the railway region;
dynamic map creation means for creating a dynamic map of a railway region using said points information;
GNSS means for determining the location of the train from a GNSS system; and processing means for combining the dynamic map and the GNSS location to determine the location of the train.

[0012] The invention will now be described with reference to the accompanying drawings, in which:

Fig. 1 schematically shows a conventional static map matching system;
Figs. 2a-d schematically show a rail network plan at various stages of a dynamic mapping technique in accordance with an embodiment of the present invention;
Fig. 3 schematically shows a dynamic map matching algorithm in accordance with an embodiment of the present invention;
Figs. 4a, b schematically show a rail network plan at various stages of a location determination technique in accordance with an embodiment of the present invention;
Fig. 5 schematically shows a train-carried dynamic map matching arrangement in accordance with an embodiment of the present invention; and
Fig. 6 schematically shows a trackside dynamic map matching arrangement in accordance with an alternative embodiment of the present invention.

[0013] A first embodiment of the invention is schematically shown in Figs. 2a-e, in which a static rail map is converted to create a dynamic railway map.

[0014] A static railway map is shown in Fig. 2a, which here represents an area in the proximity of a station, with various tracks shown at 8. It can be seen that there are two main tracks 8a, 8b running in the left-right direction, each of these tracks having a "loop" section 8c, 8d respectively. In addition, the main tracks are interconnected by four small lengths of track, 8e-8h. Points (known as "switches" in the US for example) are located where the lines interconnect. Fig. 2a is a straight line drawing - in practice the lines will be within a geographical context, and will therefore probably be curved in three dimensions.

[0015] A dynamic map is created by implementing additional dynamic rules. Trains on a railway do not have as many degrees of freedom as automotive vehicles on a road. Essentially, a train can move forwards or backwards only, along a path determined for the train by the signalling system. The signalling system controls the points, which in turn determine the paths for trains.

[0016] For any one point, at any one time, the signalling system will determine whether the point is:

"Normal" - i.e. controlled and detected to be in the "normal" sense for this point;
"Reverse" - i.e. controlled and detected to be in the "reverse" sense for this point; or
"Out of Correspondence" - essentially this is neither "Normal" nor "Reverse". This could be because the point is moving between "Normal" and "Reverse", or because there has been some failure.

[0017] Fig. 2b shows one possible dynamic state for the railway of Fig. 2a, i.e. where the topmost main track 8a has its points set to divert along the loop section 8c, and where the lower main track 8b has its points set to maintain a straight-through path.

[0018] For a facing point, i.e. in the direction of divergence, it is a reasonable assumption that a train will follow the direction on the railway determined by the signalling system, so long as the point is controlled and detected in a particular position. This may be termed "Assumption 1" for the sake of example.

[0019] Fig. 2c shows the system once Assumption 1 has been applied, resulting in the bold lines as being possible paths for trains, given the states of the points.

[0020] For a trailing point, i.e. in the direction of convergence, it is a reasonable assumption that a train will follow the sense of convergence. This may be termed "Assumption 2" for the sake of example.

[0021] Given these two assumptions, the current sense of the points can be used to refine the railway map. If the state of the points is changed by the signalling control system, then this map will change. This map therefore represents a "dynamic railway map".

[0022] The signalling system should prevent trains approaching points which are "out of correspondence". However, for safety the dynamic railway map must be able to handle such "out of correspondence" points, i.e. points which are not "normal" or "reverse".

[0023] The safest assumption to make for points which are "out of correspondence" is that trains could follow either path at a divergence. This may be termed "Assumption 3" for the sake of example. Fig. 2d illustrates the system once Assumption 3 has been applied, and where "9" designates an out of correspondence point.

[0024] The next step is to provide dynamic map matching, by using the dynamic railway map with a map matching algorithm, as shown in Fig. 3, to determine train location. As far as possible, items similar to those in Fig. 1 have retained the same numbering in Fig. 3.

[0025] As explained above, the dynamic railway map 10 is produced from a static railway map 12 in conjunction or combination with signalling control data 13, providing information about the status of points in the region, used to update (at 14) the map. As such, the dynamic map 10 contains a representation of the railway with the dynamic point states, "Normal", "Reverse" or "Out of Correspondence". This is then used by the dynamic map matching algorithm 11 to determine the new location 6 for a train, based on the previous location 5. The new location 6 is then fed to a signalling application 15. The GNSS receiver 1, which provides a GNSS location 2 is generally similar to that shown in Fig. 1. Additional sensors or information sources 23 may also be used to input train location information 24 to the map matching algorithm 11. Examples of suitable additional sensors 23 include train-carried tachometers, Doppler measurement devices, trackside balises etc. These sensors and their basic operation are well-known in the art. Combining this additional information with the GNSS information and dynamic map may further improve positional accuracy, or be used to cross-check the GNSS information for safety.

[0026] An exemplary system is shown in Fig. 4, where Fig. 4a shows a track layout similar to that of Fig. 2, with a train 16 having entered the region. Fig. 4a in effect shows the "previous location" 5 (see Fig. 3) of the train 16. A new "raw" GNSS location (corresponding to item 2 in Fig. 3) is shown at 17, which indicates that the train location is somewhere near the loop, but between two adjacent tracks. It can be seen that if this information were used with a simple static map algorithm, the location of the train could not be determined sufficiently accurately to place the train on the correct track.

[0027] Here, the new location 6 (see Fig. 3) of the train 16 can be calculated via the dynamic map matching algorithm 11 (see Fig. 3) to be on the track within the loop, as shown in Fig. 4b.

[0028] There are of course temporal aspects to be considered. The dynamic map matching algorithm will need to take account of the time at which that raw GNSS location was determined, and also the time at which the dynamic railway map was last updated.

[0029] If these are not within a threshold time of each other, then the train location should be recorded as "not determined".

Physical Arrangements

[0030] The dynamic map matching algorithm can be applied within a train, or, in an alternative embodiment, within a trackside system, or with the processing shared between the two, or at an alternative location.

[0031] A train-carried dynamic map matching system is schematically shown in Fig. 5. Here, the status of points is transmitted, e.g. wirelessly, either from trackside-located equipment 19, which may for example comprise the points equipment (i.e. the points status information is obtained from the points themselves, these being driven by the signalling system), or components of the signalling system (i.e. such that the points status information is obtained directly from the signalling system) to a train 18. The train 18 stores a static map of the railway, which may for example be updated automatically as it enters a new locality. The dynamic railway map is created on the train, by onboard processing means. The dynamic map matching algorithm is implemented on the train, by onboard processing means. The train location may then be transmitted from the train to an external signalling application as required.

[0032] With this embodiment, any one train only needs to know about the status of points in front of the train.

[0033] An alternative embodiment, utilising trackside dynamic map matching is schematically shown in Fig. 6. Here, a train 20 reports its GNSS location to signalling system 22, with the system's processing means located either at a trackside location 21 as shown, or elsewhere. As shown, the static map is stored trackside (21), and the dynamic map is created trackside (21). The map matching algorithm is also implemented trackside (21). With this embodiment, the signalling system will need to be able to process GNSS data from multiple trains at any one time.

[0034] 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, in alternative embodiments, the dynamic map matching algorithm 11 can also take account of current and previous speeds, and current and previous headings of the train.

[0035] Additionally, the dynamic map may be created, and indeed updated, using information gathered by a train as it moves around the rail network. For example, information directly obtained by the train from points machines allows a greater accuracy of train position at diverging junctions.

Claims

1. A method for creating a dynamic railway map of a region of a railway system, comprising the steps of:

   a) providing a static map of said region, showing railway lines present in that region;
   b) providing information relating to the state of points within the railway region; and
   c) combining said static map and said points information to create the dynamic map.

2. A method according to claim 1, wherein the points information is obtained from a signalling system.

3. A method according to claim 2, comprising step of obtaining said points information from the signalling system.

4. A method of determining a location of a train within a region of a railway system, comprising the steps of providing a dynamic railway map of said region and providing GNSS information relating to the location of said train, and combining the map and the GNSS information.

5. A method according to claim 4, comprising the initial step of creating the dynamic railway map using a method in accordance with any of claims 1 to 3.

6. A method according to either of claim 4 and 5, comprising the step of providing at least one of: a current speed of the train, a previous speed of the train, a current heading of the train, and a previous heading of the train.

7. A method according to any of claims 4 to 6, comprising the step of providing train location information from at least one additional source and combining this with the map and GNSS information.

8. A method according to any of claims 4 to 7, wherein the step of combining the dynamic map and the GNSS information comprises comparing the time at which the GNSS information was compiled with the time at which the dynamic map was created.

9. A method according to any preceding claim, wherein step c) is performed on a train.

10. A method according to any of claims 1-8, wherein step c) is performed at a trackside location.

11. Train location apparatus comprising:

    means for providing information relating to the state of points within the railway region;
    dynamic map creation means for creating a dynamic map of a railway region using said points information;
    GNSS means for determining the location of the train from a GNSS system; and
    processing means for combining the dynamic map and the GNSS location to determine the location of the train.

12. Apparatus according to claim 11, wherein the map creation means is provided on the train.

13. Apparatus according to claim 11, wherein the map creation means is provided at a trackside location.

14. Apparatus according to any of claims 11 to 13, wherein the processing means is provided on the train.

15. Apparatus according to any of claims 11 to 13, wherein the processing means is provided at a trackside location.

16. Apparatus according to any of claims 11-15, wherein the means for providing information relating to the state of the points comprises a signalling system.

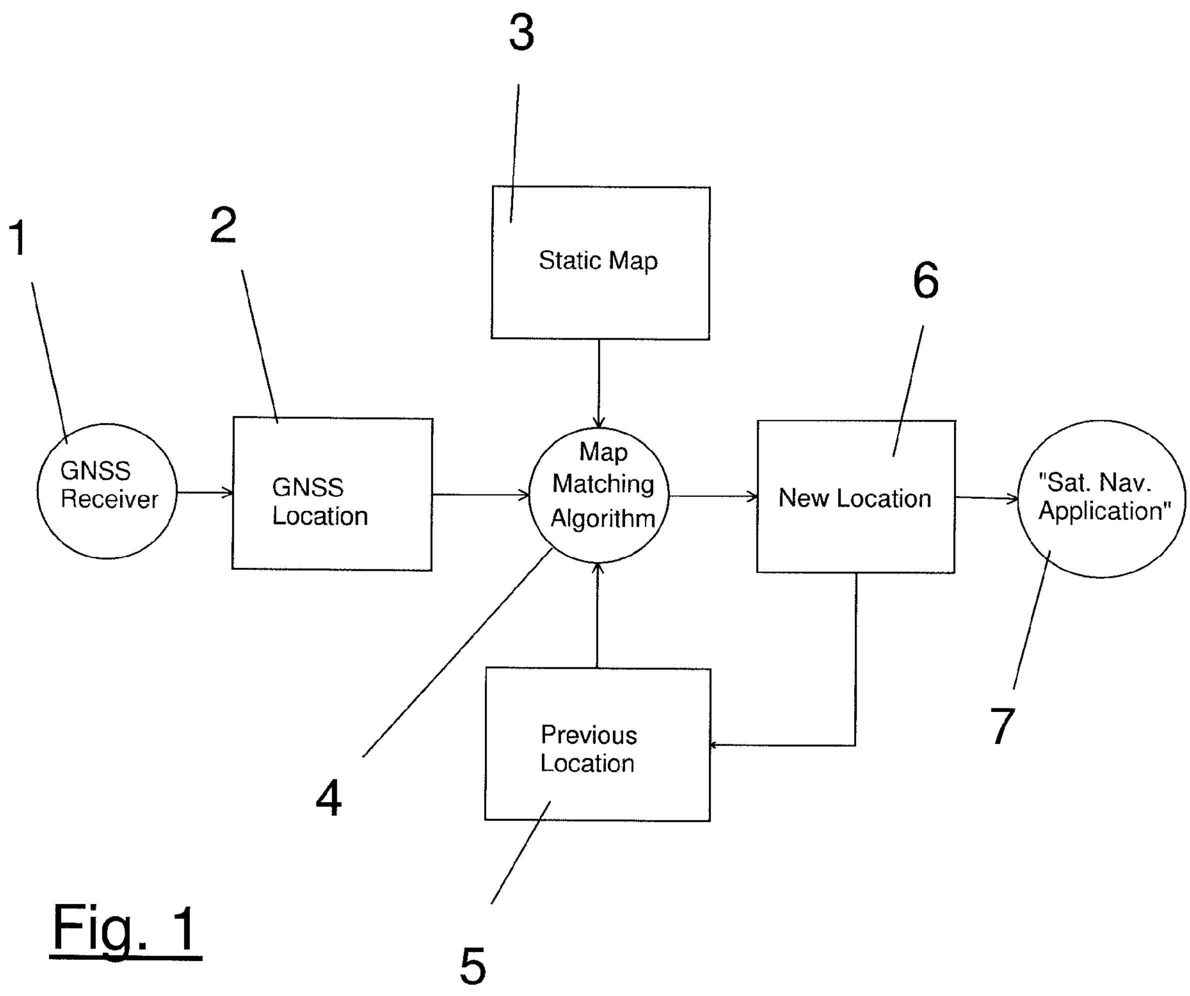
3
1
2
Static Map
6
GNSS Receiver
GNSS Location
Map Matching Algorithm
New Location
"Sat. Nav. Application"
Previous Location
4
7
5

Fig. 1

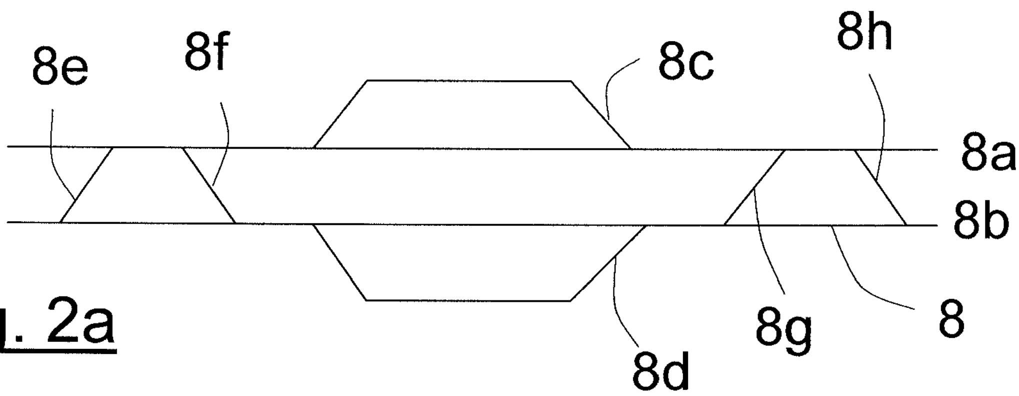

Fig. 2a

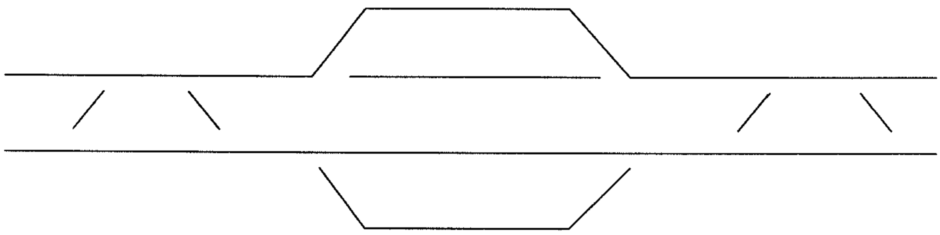

Fig. 2b

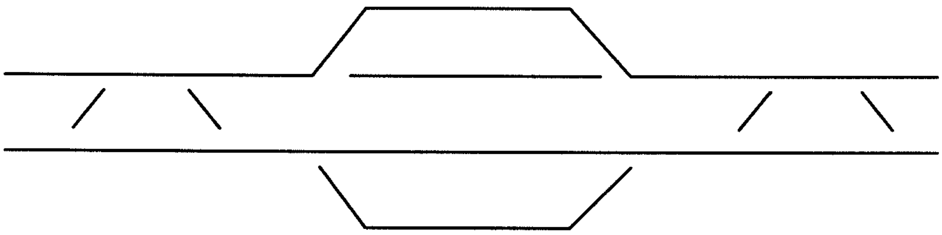

Fig. 2c

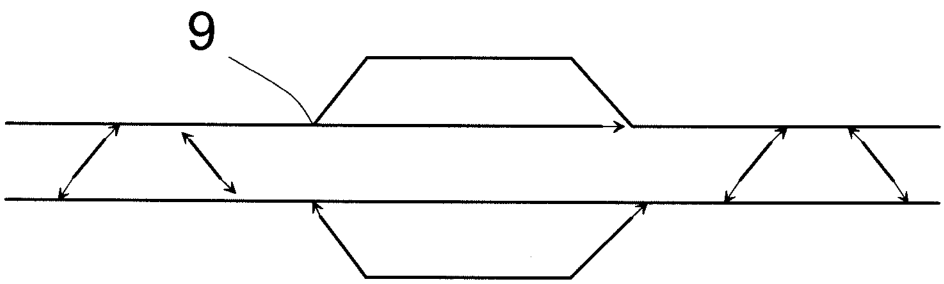

Fig. 2d

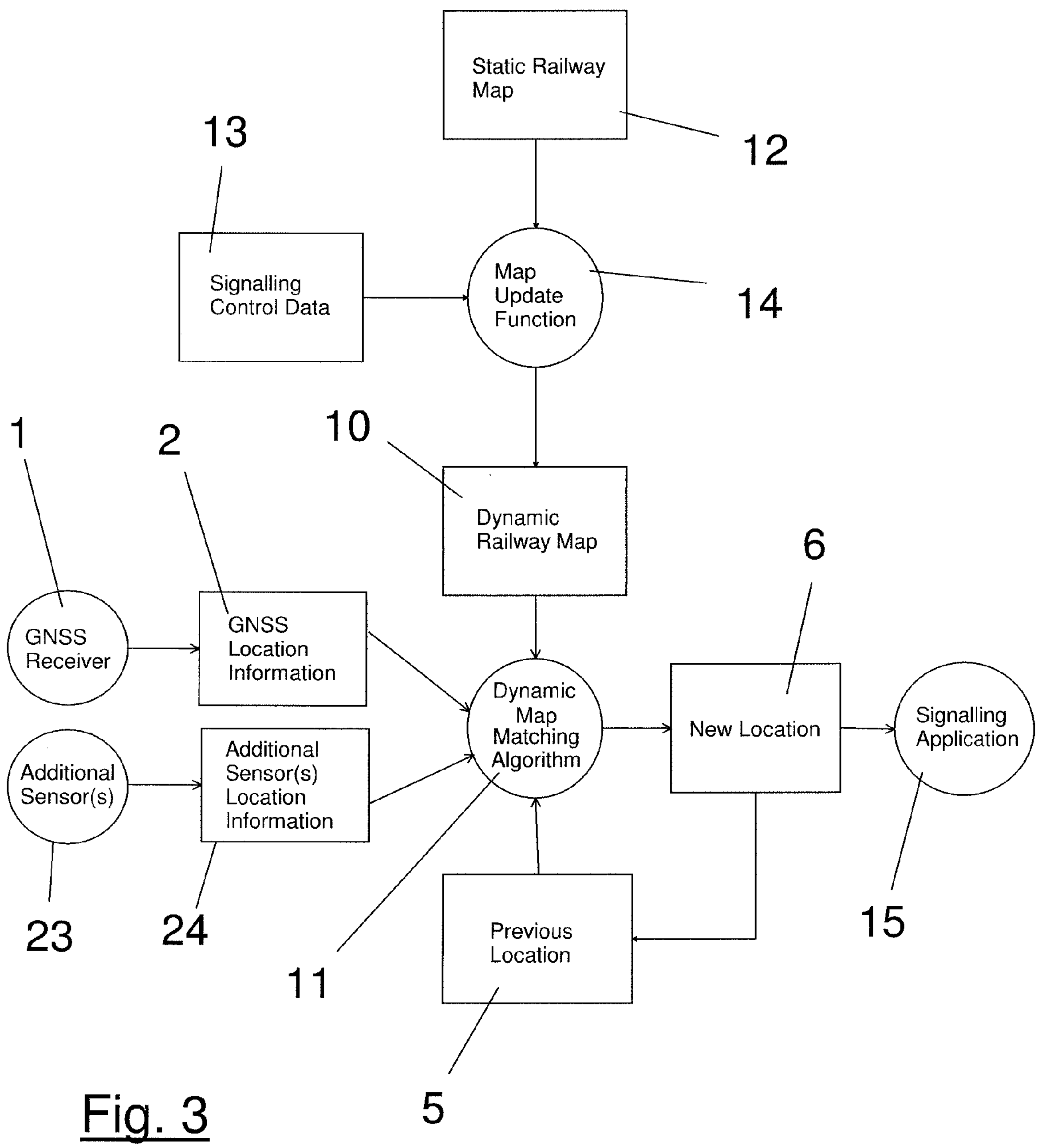
Static Railway Map
12
13
Signalling Control Data
Map Update Function
14
1
2
10
Dynamic Railway Map
6
GNSS Receiver
GNSS Location Information
Dynamic Map Matching Algorithm
New Location
Signalling Application
Additional Sensor(s)
Additional Sensor(s) Location Information
23
24
11
Previous Location
15
5

Fig. 3

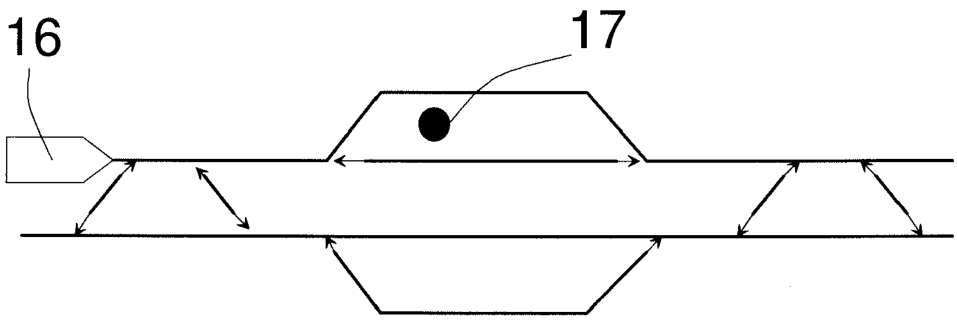

Fig. 4a

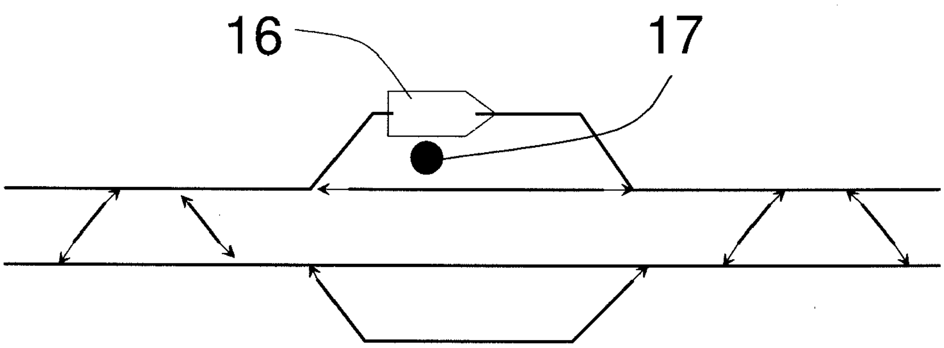

Fig. 4b

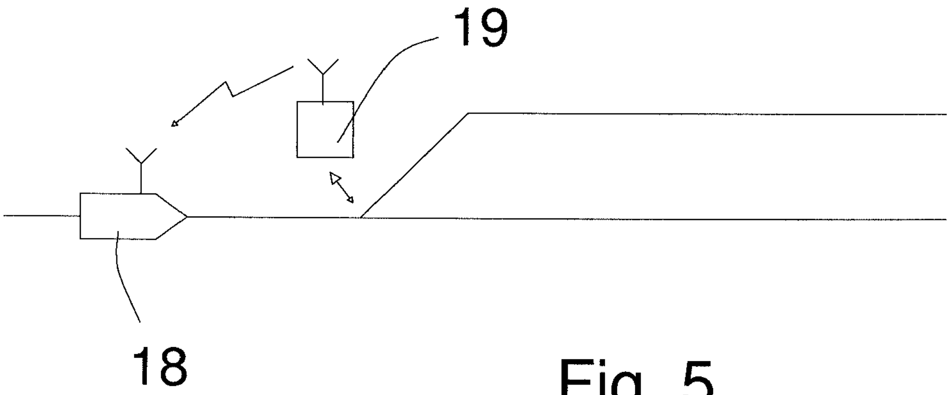

Fig. 5

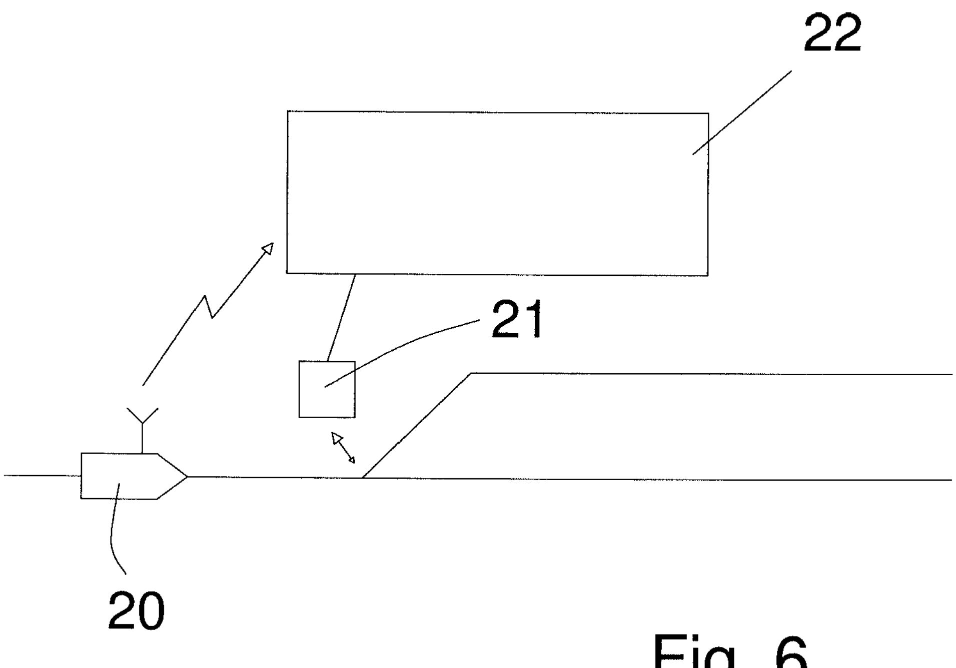

Fig. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0407875 A **[0007]**
- GB 1532638 A **[0007]**
- US 20030236598 A **[0007]**
- WO 2006136783 A **[0007]**
- JP 2005247024 B **[0007]**