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(71) Applicant: **Siemens Mobility Limited**
London, NW1 2PL (GB)

(72) Inventor: **Stringer, Andrew**
Birmingham, B4 6TB (GB)

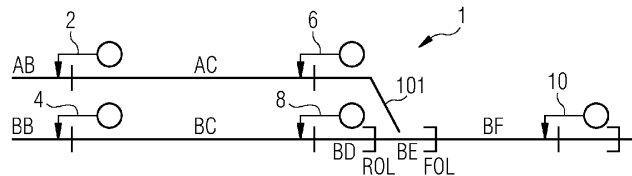
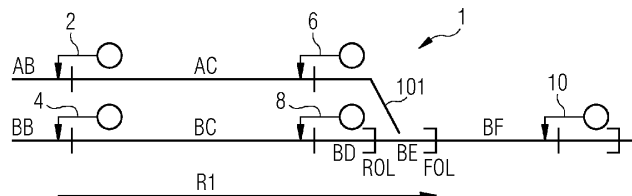
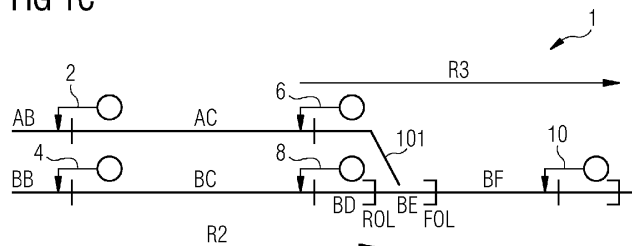
(74) Representative: **Siemens Patent Attorneys**
Postfach 22 16 34
80506 München (DE)

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(54) METHOD OF REDUCING AN OVERLAP IN A RAILWAY SIGNALLING SYSTEM

(57) A method of stepping down between routes in a railway signalling system is described. The method involves comparing the speed of a train to a given first

threshold to determine whether a full overlap (FOL) may be reduced to a restricted overlap (ROL) safely, even in complex signalling systems.

FIG 1A**FIG 1B****FIG 1C**

Description

[0001] The present invention relates to a method of reducing an overlap in a railway signalling system.

[0002] Railway signalling systems set routes for trains between entrance signals and destination signals along a railway line. However, should the train fail to stop at the destination signal, a safe space needs to be reserved for the train to run into in order to prevent accidents. This safe space is known as an overlap, and is reserved for the destination signal at the same time as a route up to the destination signal. A "full overlap" (FOL) for a signalling system incorporating train protection typically comprises three sections: a release distance, to provide a train driver with sufficient distance to bring a train to a halt at a Safe Supervised Stopping Point (SSSP); an Odometry Overrun Distance (OOD), to provide a flexibility to accommodate errors in the odometer on the train; and a buffer zone, provided to cater for overhang of a preceding train. A conventional signalling systems without train protection still effectively requires the three sections, although they are considered to be all included within the single concept of an overlap. Once the overlap is reserved, no other route can be set that would require the railway line the overlap covers. This reduces the risk of any collision between trains on conflicting routes. Whilst from a health and safety perspective this is clearly a necessity, from an operational perspective the reservation of full overlaps may be restrictive in busy and complex areas, such as junctions and stations.

[0003] An overlap is only released once it is confirmed that the train has come to rest at the destination signal, which is determined by various methods such as timing the occupation of the track section of the railway line immediately prior to the destination signal. Since no other route can be set until the overlap is clear, the movement of trains in complex regions is effectively limited based on the number of conflicts with required overlaps. It is possible to set a "restricted overlap", which is where the length of the overlap is shortened based on a reduced approach speed. Stepping up from a restricted overlap (ROL) to a full overlap (FOL) is usually done by setting a forward route from the destination signal. Stepping down, or reducing the overlap, from the full overlap (FOL) to the restricted overlap (ROL) is generally not possible as the speed of the approaching train is unknown. A method of achieving this, which is dependent on a train based signalling system, is described in EP2983960B1. Here a route is configured up to a signal where an overlap is to be released, with a separate route then configured for the overlap itself. A proceed indication for the overlap route is provided by an interlocking to trackside processing equipment whenever the overlap route is available for use by an approaching train but no forward route is set from the signal. If the train receives and accepts a shortened movement authority (for only the route up to the signal, with an End of Authority, or EoA approximately at the signal) then the overlap route can be released. This would also allow a train to exit a station and cross over onto the railway line forward of the signal, for example. However, this requires a specific route configuration in order to be used and relies on the acceptance of a modified movement authority, which may therefore not improve the operational capacity of a rail network in all circumstances. This is also reliant on the interlocking having direct communication with the train to confirm its speed, at a suitable level of safety integrity. Conventional signalling systems therefore cannot reduce the length of an overlap where the speed of the train is not known by the interlocking system.

[0004] It would therefore be desirable to find a way in which a full overlap (FOL) could be reduced to a restricted overlap (ROL) safely in complex signalling designs to improve operational capacity of a railway network without creating a risk to health and safety, or relying on specific configurations of routes, track to train communications, or changes to movement authorities.

[0005] The present invention aims to address these issues by providing, in a first instance, a method of reducing an overlap in a railway signalling system, the railway signalling system comprising a first railway line (A) having a first signal (2) and a second signal (6), a second railway line (B) also having a first signal (4) and a second signal (8), a set of points (101) adapted to be set to enable train to cross from the first railway line (A) onto the second railway line (B) and travel towards a destination signal (10) on the second railway line (B), the method comprising the steps of: maintaining the first signal (2) on the first railway line (A) at a red aspect; setting a first route (R1) along the second railway line (B) up to the second signal (8) whilst maintaining a full overlap (FOL) at the second signal (8) that extends beyond the set of points (101); determining the speed of a first train (T1) as it travels along the first route (R1) and approaches the second signal (8) on the second railway line (B); if the speed of the first train (T1) is below a predetermined first threshold, then reducing the full overlap (FOL) to a restricted overlap (ROL) on the second railway line (B) that extends from the second signal (8) and stops short of the set of points (101), setting a second route (R2) on the second railway line (B) and setting a third route (R3) on the first railway line (A) from the second signal (6) past the set of points (101) to the destination signal (10) on the second railway line (B); or if the speed of the first train (T1) exceeds the predetermined first threshold, maintaining the full overlap (FOL) and maintaining both the second signal (8) on the second railway line (B) and the first signal (2) on the first railway line (A) at a red aspect.

[0006] By measuring the speed of the train in a preceding track section rather than relying on either specially configured routes or agreement to changes in movement authorities, it is possible to reduce overlaps reliably and safely in even complex railway signalling systems.

[0007] Preferably, the speed of the first train (T1) is determined using a trackside system.

[0008] The trackside system may be a wheel sensing device positioned at a point (X) located between the first signal (4)

and the second signal (8) on the second railway line (B). Preferably, the wheel sensing device is an axle-counter head.

[0009] Alternatively, the trackside system may be a radar or LiDAR speed measurement system.

[0010] Alternatively, the trackside system may be an overspeed sensor positioned at a point (X) located between the first signal (4) and the second signal (8) on the second railway line (B).

[0011] Alternatively, the track section (BC) between the first signal (4) and the second signal (8) on the second railway line (B) is divided into first (BC1) and second (BC2) sub-sections, and wherein the time of occupation of the first sub-section (BC1) is used to calculate the speed of approach of the first train (T1).

[0012] The pre-determined first threshold may be a speed corresponding to the length of a restricted overlap associated with the second signal (8) on the second railway line (B) from which the train (T1) can safely come to a halt within the length of the restricted overlap. In this situation, the full overlap (10) may be removed.

[0013] When the speed of the first train (T1) is below a pre-determined second threshold, the full overlap (FOL) may be released completely. In this case, the pre-determined second threshold is a lower speed than the pre-determined first threshold.

[0014] The method may further comprise the steps of varying the speed of the first train (T1) as it approaches the second signal (8) on the second railway line (B); and

varying the length of a corresponding restricted overlap (ROL) in response to the speed of the first train (T1); wherein the length of the restricted overlap (ROL) is proportional to the speed of the first train (T1).

first threshold The invention will now be described by way of example only, and with reference to the accompanying drawings, in which:

Figure 1a illustrates a conventional railway signalling system layout for two railway lines;

Figure 1b illustrates a first route (R1) along the second railway line (B);

Figure 1c illustrates a second route (R2) along the first railway line (B);

Figure 2 is a flow chart of a method in accordance with the embodiments of the present invention; and

Figure 3 illustrates the division of a track section into two sub-sections.

[0015] The embodiments of the present invention take the approach of using trackside infrastructure to monitor the speed of an approaching train in order to determine whether or not a full overlap (FOL) can be released or reduced in length to a restricted overlap. This enables the reduction of a full overlap (FOL) in a railway signalling system to take place safely, and increases the operational capacity of the railway network. The railway signalling system comprises a first railway line (A) having a first signal (2) and a second signal (6), a second railway line (B) also having a first signal (4) and a second signal (8), a set of points (101) adapted to be set to enable train to cross from the first railway line (A) onto the second railway line (B) and travel towards a destination signal (10) on the second railway line (B). Initially, the first signal (2) on the first railway line (A) is maintained at a red aspect. Then, a first route (R1) is set along the second railway line (B) up to the second signal (8) whilst maintaining a full overlap (FOL) at the second signal (8) that extends beyond the set of points (101). The speed of a first train (T1) is determined as it travels the first route (R1) and approaches the second signal (8) on the second railway line (B). If the speed of the first train (T1) is below a predetermined first threshold, then the full overlap (FOL) is reduced to a restricted overlap (ROL) on the second railway line (B) that extends from the second signal (8) and stops short of the set of points (101), and a second route (R2) is set on the second railway line (B). A third route (R3) can then be set on the first railway line (A) from the second signal (6) past the set of points (101) to the destination signal (10) on the second railway line (B). However, if the speed of the first train (T1) exceeds the predetermined first threshold, the full overlap (FOL) must be maintained, and both the second signal (8) on the second railway line (B) and the first signal (2) on the first railway line (A) are maintained at a red aspect. The methods of the embodiments of the present invention will now be described in more detail.

[0016] Figure 1a illustrates a conventional railway signalling system layout for two railway lines. Conventional United Kingdom practice is used for the nomenclature of the signals, railway lines and points, and is used throughout this description and in the accompanying drawings. The railway signalling system 1 comprises a first railway line (A) having a first signal (2) and a second signal (6), a second railway line (B) also having a first signal (4) and a second signal (8). A set of points (101) is adapted to be set to enable train to cross from the first railway line (A) onto the second railway line (B). A destination signal (10) is also provided on the second railway line (B), up to which trains from each of the first (A) and second (B) can approach. Each region of a railway line (A, B) is divided into track sections or blocks, based upon the signals. These are as follows:

Table 1: Track sections in Figure 1a

Line	Section	Location
A	AB	Up to the first signal (2)
	AC	Between the first signal (2) and the second signal (6)
B	BB	Up to the first signal (4)
	BC	Between the first signal (4) and the second signal (8)
	BD	Between the second signal (8) and a reduced overlap (ROL) for the second signal (8)
	BE	Between the reduced overlap (ROL) and the full overlap (FOL) for the second signal (8)
	BF	Between the full overlap (FOL) for the second signal (8) and the destination signal (10)

[0017] Figure 1b illustrates a first route along the second railway line (B). This first route (R1) is set from a main signal, along which the driver of a train may proceed at the main signal's aspect (either green or yellow). In Figure 1b, the first route (R1) is set up to the second signal (8) on the second railway line (B). A full overlap (FOL) is set at the second signal (8), and is protected from a train exceeding the safe overrun distance using TPWS (Train Protection and Warning System) loops or ETCS (European Train Control System) balises on the approach to the second signal (8), such as an Over Speed Sensor (OSS), or at the second signal (8), such as a Train Stop Sensor (TSS). The full overlap (FOL) requires that the track sections BD and BE are clear, and that the set of points (101) are set to normal. In this configuration, a route from the second signal (6) on the first railway line (A) to the destination signal (10) on the second railway line (B) cannot be set. However, a route from the second signal (8) on the second railway line (B) to the destination signal (10) on the second railway line (B) can be set over the top of the full overlap (FOL) as it is safe to do so.

[0018] Figure 1c illustrates a second route along the first railway line (B). This second route (R1) is one where a restricted overlap (ROL) may be set at the second signal (8) on the second railway line (B). This is due to the first route (R1) being set on the first railway line (A) up to the destination signal (10) on the second railway line (B). However, since the restricted overlap (ROL) length is not sufficient to stop a train overrunning the second signal (8) on the second railway line (B), the first signal (4) on the second railway line (B) must be held at a red aspect until the track section BB is occupied for a sufficient time to confirm that the approach speed of the train is slow enough to be able to stop within the reduced overlap (ROL) length at the second signal (8) on the second railway line (B). If this is the case, a third route (R1) can be set from the second signal (6) on the first railway line (A) past the set of points (101) to the destination signal (10) on the second railway line (B).

[0019] In order to improve the operational capacity of the railway network, the embodiments of the present invention enable the release of a full overlap (FOL) on one railway line to allow the setting of another route crossing onto the railway line from a second railway line that would ordinarily not be possible. Figure 2 is a flow chart of a method in accordance with the embodiments of the present invention. As an example, the signalling system configuration shown in Figures 1a, 1b and 1c is used to illustrate how an embodiment of the present invention functions. However, it should be borne in mind that the embodiments of the present invention may be applied to any situation where an overlap requires release, such as when entering and exiting a station and crossing onto and across sections of track (such as between main and relief lines).

[0020] The method 200 begins, at step 202, with maintaining the first signal (2) on the first railway line (A) at a red aspect. This prevents any trains from moving from the track section AB into the track section AC and approaching the second signal (6) on the first railway line (A), since no overlap has been set. At step 204, a first route is set along the second railway line (B) up to the second signal (8) whilst maintaining a full overlap (FOL) at the second signal (8) that extends beyond the set of points (101). This is possible as no overlap is set for the second signal (6) on the first railway line (A) as the previous signal shows a red aspect. Next, at step 206, the speed of a first train (T1) is determined as it travels the first route (R1) and approaches the second signal (8) on the second railway line (B). Determining the speed of the first train (T1) as it travels along the track section BC reveals whether or not the first train (T1) can stop safely within the full overlap (FOL). At step 208, if the speed of the first train (T1) is determined to be below a predetermined first threshold, then the full overlap (FOL) is reduced to a restricted overlap (ROL) on the second railway line (B) that extends from the second signal (8) and stops short of the set of points (101) and a second route (R2) is set on the second railway line (B) at step 212 up to the second signal (8) on the second railway line (B). If the speed of the train (T1) is low enough, then the full overlap (FOL) may be released completely. Then, at step 214, a third route (R3) is set, this time on the first railway line (A), which may be from the first signal (2) to the second signal (6), the second signal (6) past the set of points (101) to the destination signal (10) on the second railway line (B) or both. However, if at step 208, the speed of the first train (T1) is determined to exceed the predetermined first threshold, then at step 212 the full overlap (FOL) is maintained, as are both the second signal (8) on the second railway line (B) and the first signal (2) on the first railway line (A) at a red aspect.

[0021] The speed of the first train (T1) is determined using a trackside system. This may be based on existing trackside infrastructure, such as loops or balises, or separate infrastructure provided purely to determine train speed. A simple form

of separate infrastructure is wheel sensing device, such as an axle counter head. An axle counter head comprises two separated magnetic fields that may be used to sense the direction of a train (T1). However, the distance between the magnetic fields and the time a wheel spends between them (measured using the time the fields are impinged by the axle) may be used to calculate the speed of the train (T1). Given that the distance between two such magnets is typically an order of magnitude less than the distance separating the rails of the railway track, effects from the acceleration or deceleration of the train (T1) may be ignored, and speed determined simply using the equation:

$$s = d/t \quad (\text{Equation 1})$$

$s = d/t$ (Equation 1) where s is the speed of the train (T1), d is the distance between the magnets and t is the time the wheel spends traversing the distance between the magnets. The time t may be found by sensing the perturbations of the magnetic fields as the wheel passes through each individual field, for example. The axle counter head needs to be located in the track section BC. This allows enough time for the train (T1) speed to become constant after passing the first signal (4) on the second railway line (B) whilst balancing any speed effects from the driver of the train (T1) seeing the aspect of the second signal (8) on the second railway line (B). This is illustrated in Figure 3, which illustrates the division of a track section into two sub-sections. A point, X, is positioned at the halfway point between the first signal (4) and second signal (8) on the second railway line (B), dividing the track section BC into two track sub-sections BC1, BC2 of equal length. However, the track-sub-sections do not need to be of equal length, but may be of any known desired length.

[0022] In an alternative embodiment of the present invention, an over speed sensor (OSS) is placed between the first signal (4) and second signal (8) on the second railway line (B). Preferably, this is also located at the point X illustrated in Figure 3. The over speed sensor (OSS) is used to detect the speed of the train (T1) at point X. In a further alternative embodiment of the present invention, the time taken for the train (T1) to traverse the first track sub-section BC1 is used, along with the length of the track section BC1, to determine the speed of the train (T1). This may be by either a simple calculation, as in Equation 1 above, with any contributions from acceleration or deceleration ignored, or by setting a minimum dwell time within the track sub-section BC1, which corresponds to a maximum speed at which the train (T1) can stop safely in the full overlap (T1). In yet a further embodiment of the present invention, additional infrastructure may be provided trackside to directly measure the speed of the train. This may be a radar system, for example, or a LiDAR (Light Detection And Ranging) system, both of which use the principle of timing the return of a reflected beam of electromagnetic radiation to determine the speed of an approaching object. The positioning of such a system should be wherever is convenient next to the railway line. Preferably, this may also be in the region of the point X at the boundary of the track sub-sections BC1, BC2.

[0023] The first threshold against which the speed of the train (T1) is compared to is a speed that corresponds to the length of certain distances associated with a signal in which the train could come to a halt safely. For example, for removal of the full overlap (FOL) the pre-determined first threshold is a speed corresponding to the length of the restricted overlap associated with the second signal (8) on the second railway line (B) from which the train (T1) can safely come to a halt within the length of the restricted overlap. For the stepping down from the full overlap (FOL) to the restricted overlap (ROL), then the pre-determined first threshold is a speed corresponding to the length of a buffer zone and safe supervised stopping point (SSSP) associated with the second signal (8) on the second railway line (B) from which the train (T1) can safely come to a halt within the length of the restricted overlap and safe supervised stopping point. If the speed of the first train (T1) is below a pre-determined second threshold, where the pre-determined second threshold is a low enough speed, the full overlap (FOL) can be released completely. The pre-determined second threshold is a lower speed than the pre-determined first threshold.

[0024] The length of the restricted overlap (ROL) may also be determined by the speed of an approaching train (T1). For example, if an approaching train (T1) travels at a speed of 50km/h, then a restricted overlap (ROL) having a first length ROL_1 is set. However, if an approaching train is travelling at a speed of 25km/h, then a restricted overlap (ROL) having a second length ROL_2 is set, where ROL_2 is shorter than ROL_1 . It is possible therefore that by varying the speed of a train (T1) as it approaches a signal to vary the length of the restricted overlap (ROL) according to the speed of the train. Therefore, the length of the restricted overlap (ROL) may be static (set until the train (T1) reaches a specific signal) or dynamic.

[0025] 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.

Claims

1. A method of reducing an overlap in a railway signalling system, the railway signalling system comprising a first railway line (A) having a first signal (2) and a second signal (6), a second railway line (B) also having a first signal (4) and a second signal (8), a set of points (101) adapted to be set to enable train to cross from the first railway line (A) onto the

second railway line (B) and travel towards a destination signal (10) on the second railway line (B), the method comprising the steps of:

- a) maintaining the first signal (2) on the first railway line (A) at a red aspect;
- b) setting a first route (R1) along the second railway line (B) up to the second signal (8) whilst maintaining a full overlap (FOL) at the second signal (8) that extends beyond the set of points (101);
- c) determining the speed of a first train (T1) as it travels along the first route (R1) and approaches the second signal (8) on the second railway line (B);
- d) if the speed of the first train (T1) is below a predetermined first threshold, then reducing the full overlap (FOL) to a restricted overlap (ROL) on the second railway line (B) that extends from the second signal (8) and stops short of the set of points (101), setting a second route (R2) on the second railway line (B) and setting a third route (R3) on the first railway line (A) from the second signal (6) past the set of points (101) to the destination signal (10) on the second railway line (B);
- or
- e) if the speed of the first train (T1) exceeds the predetermined first threshold, maintaining the full overlap (FOL) and maintaining both the second signal (8) on the second railway line (B) and the first signal (2) on the first railway line (A) at a red aspect.

2. Method as claimed in claim 1, wherein the speed of the first train (T1) is determined using a trackside system.

3. Method as claimed in claim 2, wherein the trackside system is a wheel sensing device positioned at a point (X) located between the first signal (4) and the second signal (8) on the second railway line (B).

4. Method as claimed in claim 3, wherein the wheel sensing device is an axle-counter head.

5. Method as claimed in claim 2, wherein the trackside system is a Radar or LiDAR speed measurement system.

6. Method as claimed in claim 2, wherein the trackside system is an overspeed sensor positioned at a point (X) located between the first signal (4) and the second signal (8) on the second railway line (B).

7. Method as claimed in claim 1, wherein the track section (BC) between the first signal (4) and the second signal (8) on the second railway line (B) is divided into first (BC1) and second (BC2) sub-sections, and wherein the time of occupation of the first sub-section (BC1) is used to calculate the speed of approach of the first train (T1).

8. Method as claimed in either claim 3 or claim 6, wherein the point (X) is located halfway between the first signal (4) and the second signal (8) on the second railway line (B).

9. Method as claimed in any preceding claim, wherein the pre-determined first threshold is a speed corresponding to the length of a buffer zone associated with the second signal (8) on the second railway line (B) from which the train (T1) can safely come to a halt within the length of the buffer zone.

10. Method as claimed in claim 9, wherein when the pre-determined first threshold is a speed corresponding to the length of a restricted overlap associated with the second signal (8) on the second railway line (B) from which the train (T1) can safely come to a halt within the length of the restricted overlap, then for a speed below the pre-determined first threshold, the full overlap (10) is removed.

11. Method as claimed in any of claims 1 to 8, wherein the pre-determined first threshold is a speed corresponding to the length of a restricted overlap and safe supervised stopping point (SSSP) associated with the second signal (8) on the second railway line (B) from which the train (T1) can safely come to a halt within the length of the restricted overlap and safe supervised stopping point.

12. Method as claimed as in any preceding claim, wherein when the speed of the first train (T1) is below a pre-determined second threshold, the full overlap (FOL) can be released completely.

13. Method as claimed in claim 12, wherein the pre-determined second threshold is a lower speed than the pre-determined first threshold.

14. Method as claimed in any preceding claim, further comprising the steps of:

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varying the speed of the first train (T1) as it approaches the second signal (8) on the second railway line (B); and varying the length of a corresponding restricted overlap (ROL) in response to the speed of the first train (T1); wherein the length of the restricted overlap (ROL) is proportional to the speed of the first train (T1).

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FIG 1A

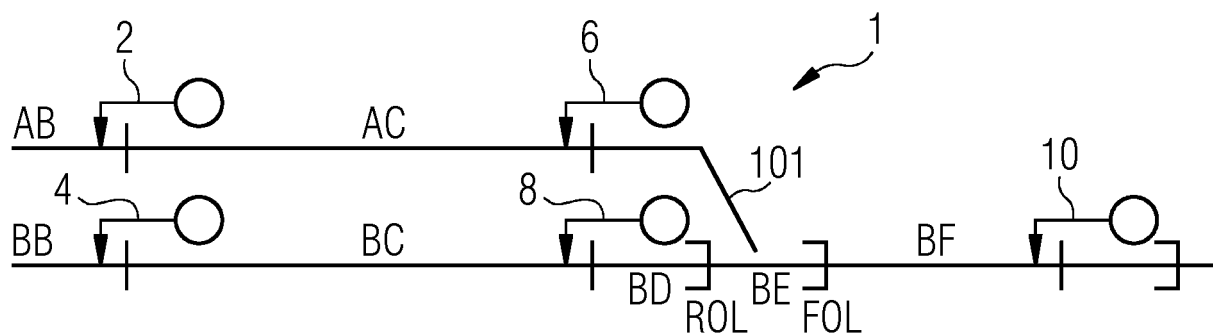


FIG 1B

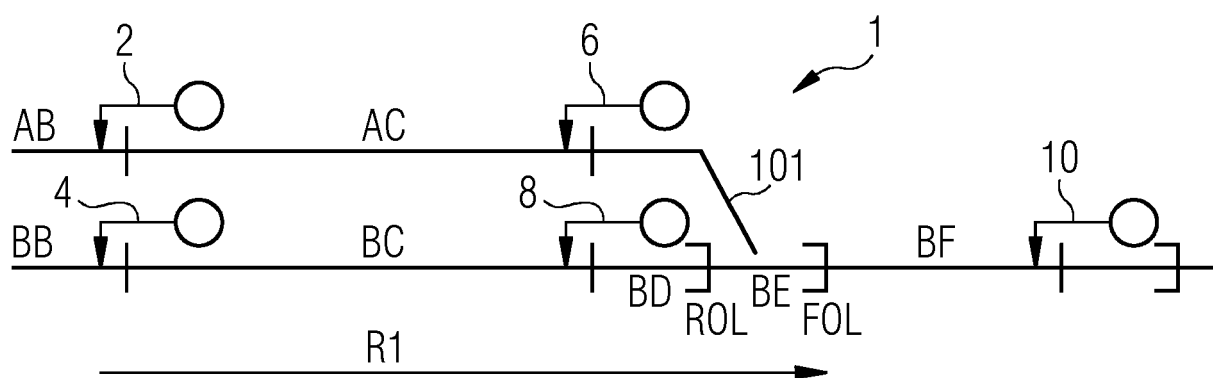


FIG 1C

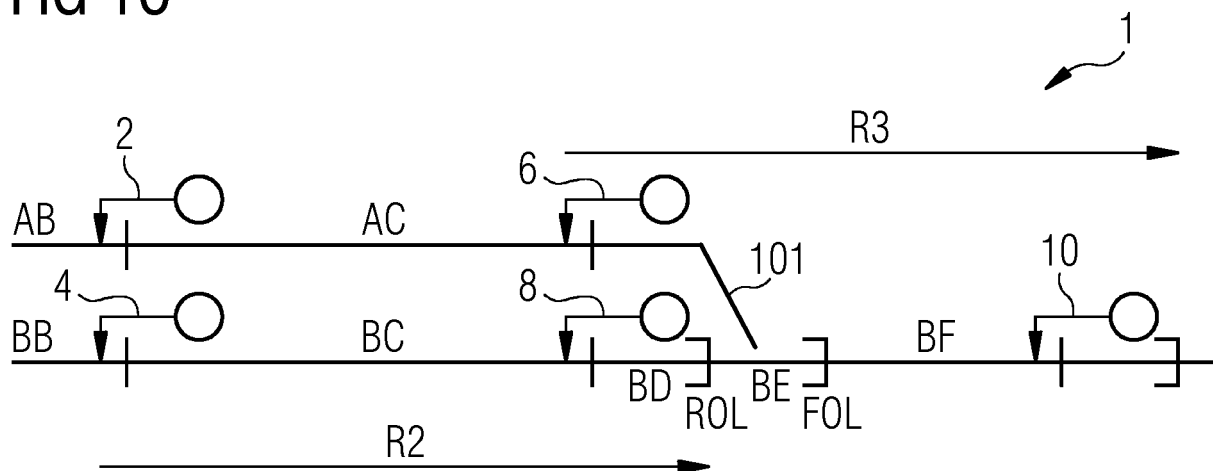


FIG 2

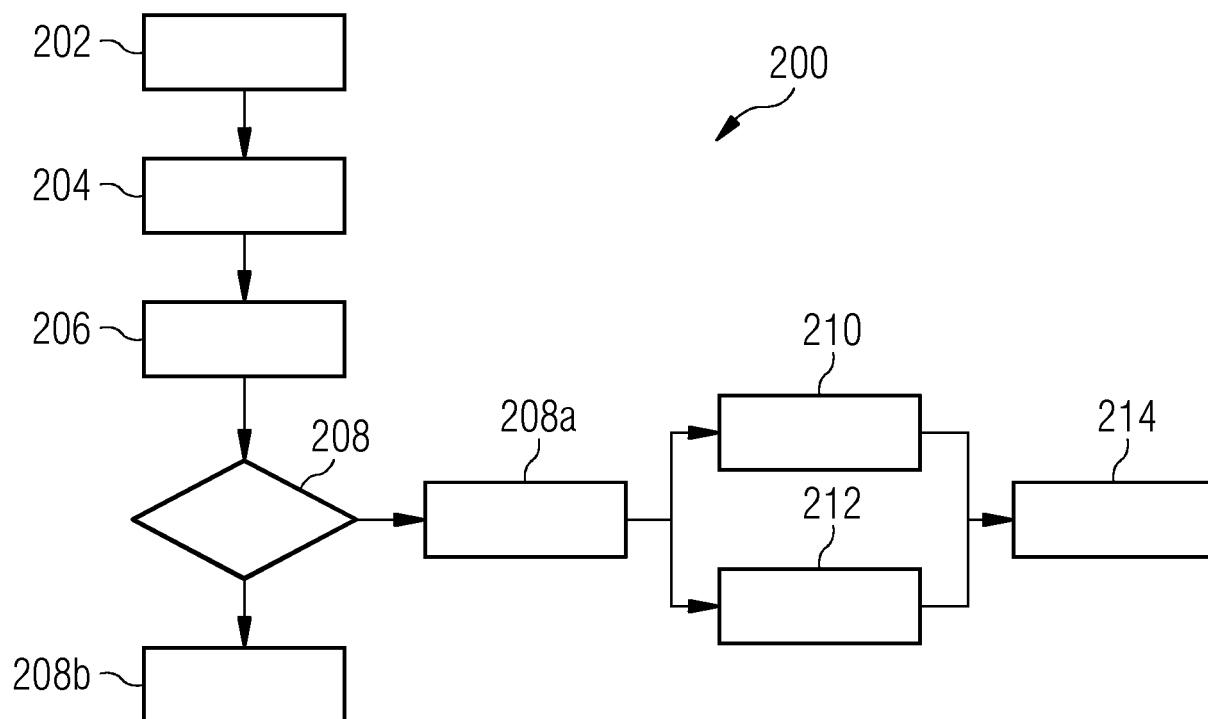
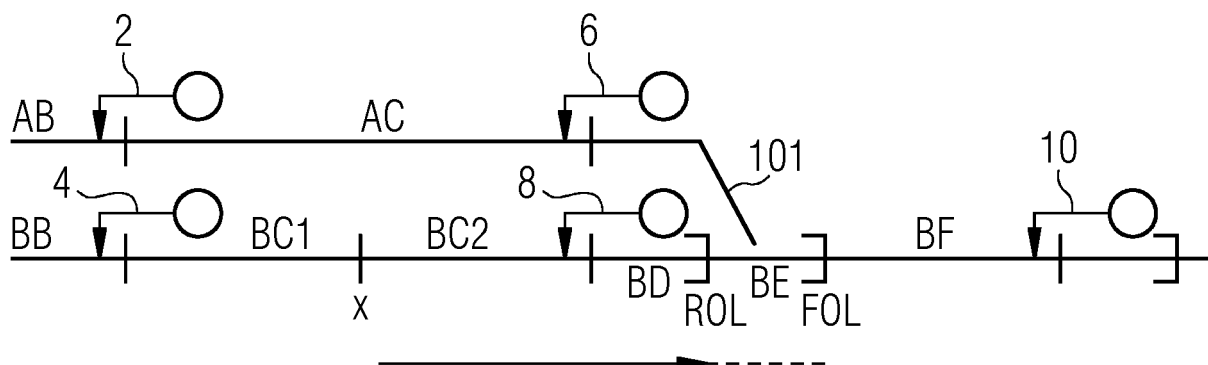


FIG 3





EUROPEAN SEARCH REPORT

Application Number

EP 24 18 9072

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 983 960 B1 (SIEMENS MOBILITY LTD [GB]) 24 February 2021 (2021-02-24) * figures 1-6 * * paragraphs [0008] - [0014] * * paragraphs [0022] - [0028] *	1-14	INV. B61L25/02 B61L27/20 B61L27/40
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