

PATENT SPECIFICATION

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(19)



(54) IMPROVEMENT IN OR RELATING TO RAILWAY SIGNALLING ARRANGEMENTS

(71) We, WESTINGHOUSE BRAKE AND SIGNAL COMPANY LIMITED, a Company incorporated under the Laws of Great Britain, of 3 John Street, London, WC1N 2ES, England, do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention relates to railway signalling arrangements.

In the field of railway signalling, particularly where automatic train control is applied, the rails are customarily divided into mutually electrically insulated sections, by means of electrically non-conductive rail joints. Although necessary in prior art systems, electrically non-conductive rail joints are undesirable from the point of view of cost, maintenance, and deleterious effect on rolling stock. There have been proposals for electrically dividing the track into sections without the use of joints, for example, by utilising resonant circuits, but generally such proposed arrangements lack the precision of separation of track sections that is available with electrically insulating joints.

It is known to feed an electrically isolated section of railway with an electric signal whose frequency designates a desired train speed, there being train-mounted equipment for detecting the signal and controlling the speed of the train according to the perceived frequency. In such arrangements, the number of mutually electrically insulated rail sections tends to be large because of the corresponding number of different train speeds desired, this being especially so at approaches to stations where the train has to be controlled to conform to a descending speed and eventual halt.

According to the invention there is provided a railway signalling arrangement for a length of railway track section electrically isolated from adjacent track sections comprising a.c. signal transmitter means the signal output of which is coupled to the rails adjacent one end of said section, the normal direction of travel of trains being through the section towards the transmitter, and a plurality of train responsive means located at spaced intervals along the section and responsive to the passage of a train to indicate such passage to the transmitter means which, in turn, is responsive to the indication to change the transmitted output according to a selected train-position-related signal sequence.

Preferably there is provided in combination with the train responsive means adjacent to the end of the section remote from the transmitter track circuit signal receiver means coupled to the rails and responsive to the signals from the transmitter to indicate the absence or presence of the signals, the signals from the transmitter to the receiver being interrupted by the presence of a train in the section whose axles shunt the section's rails, and the receiver responding to the absence of signals from the transmitter to fail-safely indicate the presence of a train in the section whereby a track-circuiting function is performed.

In place of a track circuit signal receiver located and functioning as aforesaid, there may be a further train responsive means located adjacent the end of the section remote from the transmitter and responsive to the passage of a train to perform a track-circuiting function without being dependent on reception of signals from the transmitter.

Preferably the transmitter transmits train speed control signals when in operation, and may be responsive to the signal from the train responsive means to transmit a lower speed command signal or a stop signal should the succeeding track section be occupied by another train, or to maintain the train speed control signal should the succeeding track section be

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clear, or to transmit a lower speed command signal should the succeeding track section be clear but subject to a speed restriction.

5 Preferably there is a plurality of train responsive means located at spaced intervals along the section, each being responsive to the passage of a train to transmit a signal to the track section transmitter whereby effectively to divide the section into a plurality of relatively short sub-sections equivalent to a like plurality of short mutually electrically isolated track sections. 5

10 The track may, as is customary, be divided into a number of mutually electrically isolated sections along its length, and according to the invention one, several, or all of such sections may be provided with one or more train responsive means, so effectively dividing the track into a correspondingly greater number of sections. 10

15 The train responsive means may take any suitable form. For example, there may be an active device or arrangement on the train interacting with a passive trackside device or arrangement or vice versa, or active devices or arrangements on both train and trackside. The train responsive means may respond to the passage of a train by a temporary inductive link therewith, or by physical contact. Inductive linkage may, for example, be by means of the signalling system known under the trade name "Identra". Physical contact means could, for example, comprise a known wheel-operated treadle. ("Trackside" means a location adjacent the rails on the outside thereof, or between the rails). 15

20 In order that the invention may be more clearly understood and readily put into effect, preferred embodiments of the same will now be described firstly by way of an unillustrated example, and further by reference to the accompanying drawing wherein:- 20

Figure 1 is a schematic diagram illustrating a prior art signalling arrangement;

25 Figure 2 illustrates an embodiment of the present invention; and Figures 3 to 8 illustrate successive stages in the operation of the embodiment of Figure 2. 25

30 Referring to an unillustrated example, the running rails of an underground metro line are divided into 500 yard long sections by means of electrically insulating rail joints. At the further end (in the direction of travel) of each section in the direction of travel is located a variable frequency transmitter coupled between the rails. At the near end of each section is located a track signal receiver coupled to the rails to receive the signals from the transmitter, when the rails are not shunted by the axles of a train, in well known manner. 30

35 Located at 100 yard intervals between the transmitters and receivers are train responsive means (four to each 500 yard section). The train responsive means are such as to respond in any suitable manner to the passage of a train, and are coupled to the respective transmitter of that section to signal the passage to the transmitter. 35

40 Consider now the special case of a 500 yard track section leading up to a station platform, with a train approaching at 25 m.p.h. The transmitter for that section will initially be transmitting a 20 m.p.h. speed control signal to the automatic driver on the train as the train enters the track section. The train will commence to brake towards the new target speed of 20 m.p.h. At the same time, the rails will be shunted by the train axles, and the transmitter signal can no longer be received by the receiver for that section, consequently indicating that the section is occupied. (This is the standard track circuit function and need not be described further). 40

45 After progressing 100 yards into the section, the train reaches the first train responsive means, and a signal passes to the transmitter which now transmits a 15 m.p.h. target speed command signal. The train consequently brakes further. At the next train responsive means, another signal passes to the transmitter which now transmits a 10 m.p.h. target speed command signal. 45

50 As the train passes the third train responsive means, a further signal passes to the transmitter and a 5 m.p.h. command signal is issued. As the fourth train responsive means is passed, the transmitter receives a signal therefrom and transmits a zero speed signal which brings the train to a halt alongside the platform. 50

55 Thus it will be seen that a railway signalling arrangement according to the invention can perform the same function as a multiplicity of relatively short track circuits. The provision of short track circuits in station areas keeps headway to a minimum when a train is approaching a station from which another train is departing. By utilising the invention, the equivalent of relatively short track circuits can be achieved without a transmitter and receiver for each section, but merely requiring one or several train responsive means mounted on or adjacent to the track. 55

60 As well as being applicable to station approaches, the invention can be applied to junctions, crossovers, and sidings, as well as longer stretches of track between stations or other locations. 60

65 Referring now to Figure 1, this illustrates a prior art railway signalling system of the type which is suited for automatic control of train speed, starting and stopping, such as on London Transport's Victoria Line. The line 10 represents a duo-rail track which is 65

electrically divided into eleven track sections 11 - 21 by electrically insulated block joints 22 - 31. Each track section 11 - 21 requires its own track circuit transmitter and receiver (not shown). The large number of block joints 22 - 31 limits the possible length of jointless rails, and has a deleterious effect on rolling stock due to the mechanical shock produced when a wheel passes over a block joint.

In accordance with the invention and as shown in Figure 2, a large number of the block joints are eliminated and replaced with train passage detectors functioning as train responsive means. The block joints 22, 23, 24, 25 and 27 are replaced by front-of-train detectors 32, 33, 34, 35 and 36 respectively. The block joints 29, 30 and 31 are replaced by rear-of-train detectors 37, 38 and 39 respectively. The block joints 26 and 28 are retained to isolate the track sections 16 and 17 which lie alongside a station platform 40.

The front-of-train detectors can take any suitable form. For example, the known "Identra" equipment may be employed, or a wheel-actuated treadle of known form, or a magnetic detector responsive to the presence of the large mass of ferromagnetic material present in a train wheel. A magnetic detector could take the form of a permanent magnet and one or more reed relays all mounted in proximity to a rail, the linkage of flux from the magnet to the relays being radically changed by the proximity of a train wheel and so switching the relays. Alternatively a magnetic detector could take the form of a transmitter of high-frequency (100kHz) radiation mounted on one side of the rail and a suitable receiver mounted on the other side of the rail. In the absence of a train wheel, the transmitter and receiver are inductively linked and transmitted radiation is picked-up by the receiver, while the presence of a train wheel diverts transmitted radiation into the rail and the receiver no longer picks up radiation. If the receiver controls the power supply for the transmitter, and the absence of received radiation switches off the power supply, this provides a detector which is latched in an "off" condition by the passage of a train wheel. Resetting of the power supply to cause the transmitter to again transmit radiation to the receiver can be controlled by a track circuit relay responding to the departure of the train from the track section in which the detector is located.

Rear-of-train detectors can take any suitable form. Since a train equipped with "Identra" apparatus will normally have one such apparatus mounted at each end of the train to suit bi-directional travel of the train, the normally temporarily redundant apparatus at the rear of the train can be utilised to signal passage of the end of the train, while the front apparatus, which will be on the opposite side of the train from the rear apparatus, continues its normal function of signalling the identity of the train. Similarly, a train equipped at either end with a coil or coils mounted ahead of the leading axles for picking up train speed control signals produced by a signal current passing down one rail, through the leading axle and back along the other rail may employ the temporarily redundant coil or coils at the rear of the train as electromagnetic radiation transmitters, the transmissions being picked up by a track-mounted coil and an associated filter and amplifier (preferably operating on fail-safe principles) forming a train responsive means, thereby to respond to the passage of the rear of the train carrying the actively transmitting coil or coils. Alternatively, a rear-of-train detector could take the form of a projection on the rear of the train operating in use to actuate a lineside treadle or electrical switch by physical contact therewith.

Since the arrangement shown in Figure 2 combines the track sections 11 - 15 into a single section, the sections 16 and 17 into another single section, and the sections 18 - 21 into a further single section, the number of track circuit transmitters required is reduced from eleven in the Figure 1 arrangement to three in the Figure 2 arrangement, and likewise the number of track circuit receivers is reduced from eleven to three, leading to a substantial saving in cost and complexity. These transmitters and receivers are omitted from the drawings for the sake of clarity.

Referring again to Figure 2, there are shown coupled to the rails 10 two automatic train protection (A.T.P.) transmitters 41 and 42. The A.T.P. transmitters serve to transmit signals along the rails to be inductively detected at the front of the train, the signals indicating the instantaneous maximum permissible speed of the train and serving to over-ride the train controller and reduce the speed of the train should the speed limit be exceeded. The A.T.P. transmitter 41 serves the track sections 11 - 15 and is coupled to the rails 10 adjacent the forward end of the track section 15. The A.T.P. transmitter 42 serves the track section 16 and 17 and is coupled to the rails adjacent the forward end of the track section 17. A further A.T.P. transmitter (not shown) will serve the track sections 18 - 21, but this further transmitter is not shown because it does not take part in the operation of the illustrated embodiment insofar as the description goes.

For a description of the operation of the embodiment of the invention, refer first to Figure 3 wherein a first train 43 (whose direction of travel is from left to right) is stopped alongside the platform 40. The transmitter 41 will in consequence of the occupation of the track sections 16 and 17 transmit the following speed limit signals to a second train (not

shown) following the first train 43. If the second train is in the track section 11, a 90 kilometres per hour signal is transmitted. As the second train passes the detector 32, the detector 32 will respond thereto and signal to the transmitter 41 that the second train has passed the detector 32 and entered the track section 12. The transmitter 41 will in consequence transmit a 70 kilometre per hour speed limit signal. As the second train passes the next detector 33, the detector 33 signals the transmitter 41 and a 40 kilometre per hour (with traction motors "on") speed limit signal is now transmitted. Upon the second train passing the detector 34, the transmitter 41 is again signalled, and in return transmits a 40 kilometre per hour speed signal (with traction "off" and the train coasting). As the detector 35 is passed, the transmitter 41 is again signalled and this time transmits a zero speed limit signal to halt the second train in the track section preceding the first train 43.

Let it now be assumed that an A.T.C. (automatic train control) transmitter (not shown) signals the first train 43 to depart from the station (in a rightwards direction as viewed in the drawing), it being assumed that this is permitted by the A.T.P. transmitter 42 transmitting a 70 or 90 kilometre per hour speed signal. The progression of the first train 43 through the successive track sections 18 - 21 is shown in Figures 4 - 8. The passage of the train past each of the back-of-train detectors 37, 38 and 39 will alter the signals transmitted by the transmitters 41 and 42 as the headway available to the second train increases. The speed limit signals from the transmitters 41 and 42 will now be tabulated for the succeeding positions of the first train 43, bearing in mind that each time a train passes a detector, the respective transmitter will be appropriately signalled. (The connections of the detectors to the transmitters have been omitted from the drawing for the sake of clarity).

Position of First Train 43	Position of Second Train	Speed Limit Signal Transmitted by Transmitter 41	Speed Limit Signal Transmitted by Transmitter 41
	(before detector 32)	90 k.p.h.	-
	(past detector 32)	70 k.p.h.	-
	(past detector 33)	40 k.p.h. (motoring)	-
	(past detector 34)	40 k.p.h. (motoring)	-
	(past detector 35)	40 k.p.h. (motoring)	-
	(past block-joint 26)	-	40 k.p.h. (coasting)
	(past detector 36)	-	0
	(before detector 32)	90 k.p.h.	-
	(past detector 32)	70 k.p.h.	-
	(past detector 33)	70 k.p.h.	-
	(past detector 34)	70 k.p.h.	-

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	Position of First Train 43	Position of Second Train	Speed Limit Signal Transmitted by Transmitter 41	Speed Limit Signal Transmitted by Transmitter 41	
5	(Figure 5)	(past detector 35	70 k.p.h.		5
10		(past block- joint 26	-	40 k.p.h. (motoring)	10
15		(past detector 36	-	40 k.p.h. (coasting)	15
	past detector 38 - (Figure 6)	(before detector 32	90 k.p.h.	-	
20	(continued on next page).....	(past detector 32	90 k.p.h.	-	20
25		(past detector 33	90 k.p.h.	-	25
	past detector 38 - (Figure 6)	(past detector 34	90 k.p.h.	-	
30		(past detector 35	70 k.p.h.	-	30
		(past block- joint 26	-	70 k.p.h.	
35		(past detector 36	-	40 k.p.h. (coasting)	35
40		(before detector 32	90 k.p.h.	-	40
		(past detector 32	90 k.p.h.	-	
45		(past detector 33	90 k.p.h.	-	45
	past detector 39 -	(past detector 34	90 k.p.h.	-	
50		(			50

5	Position of First Train 43	Position of Second Train	Speed Limit Signal Transmitted by Transmitter 41	Speed Limit Signal Transmitted by Transmitter 41	5
	(Figure 7)	(past detector 35	90 k.p.h.	-	
10		(past block-joint 26	-	70 k.p.h.	10
15		(past detector 36	-	40 k.p.h. (coasting)	15
		(before detector 32	90 k.p.h.	-	
20		(past detector 32	90 k.p.h.	-	20
		(past detector 33	90 k.p.h.	-	
25		(past detector 34	90 k.p.h.	-	25
	out of track - section 21	(past detector 35	90 k.p.h.	-	
30	(Figure 8)	(past block-joint 26	-	90 k.p.h.	30
35		(past detector 36	-	90 k.p.h.	35

The above speed limits were derived on the basis that the distance from the detector 32 to the block-joint 26 is the 90 k.p.h. overlap distance, the distance from the detector 33 to the block-joint 26 is the 70 k.p.h. overlap distance, the distance from the detector 35 to the block-joint 26 is the 40 k.p.h. overlap distance, the distance from the block-joint 26 to the detector 39 is the 90 k.p.h. overlap distance, the distance from the detector 36 to the detector 38 is the 70 k.p.h. overlap distance, and the distance from the block-joint 28 to the detector 37 is the 40 k.p.h. overlap distance.

It should also be borne in mind that the above speed limits are maximum permitted speeds in accordance with the headway and taking into account the overlap distances. In the event that the second train was required to stop at the platform 40, A.T.C. train speed control signals (as distinct from the above-described train speed limit signals) would be on a descending scale from section to section along the approach to the platform 40. The A.T.C. signal transmitters are omitted from the drawing for the sake of clarity.

It will thus be seen from the above description of the embodiments of the invention schematically illustrated in Figures 2 - 8, how the use of train-responsive detectors coupled to the respective track section speed limit control transmitters can take the place of a plurality of electrically-insulating rail block-joints, especially in station approaches. This is clear from a comparison of Figure 1 with Figure 2.

The detectors may also be coupled to the train speed control signal transmitters (not shown) for automatic train control with a minimal number of block-joints.

While the signal transmitters described above produce a.c. signals, the term "a.c." is deemed to include pulsating or otherwise varying direct current.

WHAT WE CLAIM IS:-

1. A railway signalling arrangement for a length of railway track section electrically isolated from adjacent track sections comprising a.c. signal transmitter means the signal output of which is coupled to the rails adjacent one end of said section, the normal direction of travel of trains being towards the transmitter means, and a plurality of train responsive means located at spaced intervals along the section and responsive to the passage therepast

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	Position of First Train 43	Position of Second Train	Speed Limit Signal Transmitted by Transmitter 41	Speed Limit Signal Transmitted by Transmitter 41	
5					5
	(Figure 7)	(past detector 35	90 k.p.h.	-	
10		(past block-joint 26	-	70 k.p.h.	10
		(past detector 36	-	40 k.p.h. (coasting)	
15		(before detector 32	90 k.p.h.	-	15
		(past detector 32	90 k.p.h.	-	
20		(past detector 33	90 k.p.h.	-	20
		(past detector 34	90 k.p.h.	-	
25	out of track - section 21	(past detector 35	90 k.p.h.	-	25
	(Figure 8)	(past block-joint 26	-	90 k.p.h.	
30		(past detector 36	-	90 k.p.h.	30
35					35

40 The above speed limits were derived on the basis that the distance from the detector 32 to the block-joint 26 is the 90 k.p.h. overlap distance, the distance from the detector 33 to the block-joint 26 is the 70 k.p.h. overlap distance, the distance from the detector 35 to the block-joint 26 is the 40 k.p.h. overlap distance, the distance from the block-joint 26 to the detector 39 is the 90 k.p.h. overlap distance, the distance from the detector 36 to the detector 38 is the 70 k.p.h. overlap distance, and the distance from the block-joint 28 to the detector 37 is the 40 k.p.h. overlap distance.

45 It should also be borne in mind that the above speed limits are maximum permitted speeds in accordance with the headway and taking into account the overlap distances. In the event that the second train was required to stop at the platform 40, A.T.C. train speed control signals (as distinct from the above-described train speed limit signals) would be on a descending scale from section to section along the approach to the platform 40. The A.T.C. signal transmitters are omitted from the drawing for the sake of clarity.

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60 WHAT WE CLAIM IS:-

1. A railway signalling arrangement for a length of railway track section electrically isolated from adjacent track sections comprising a.c. signal transmitter means the signal output of which is coupled to the rails adjacent one end of said section, the normal direction of travel of trains being towards the transmitter means, and a plurality of train responsive means located at spaced intervals along the section and responsive to the passage therepast



of a train to indicate such passage to the transmitter means which, in turn, is responsive to the indication to change the transmitted output according to a selected train-position-related signal sequence.

2. An arrangement according to Claim 1, wherein there is included, in combination with the train responsive means, track circuit signal receiver means coupled to the rails adjacent to the end of the section remote from the transmitter and responsive to the signals from the transmitter to indicate the presence or absence of the signals, the signals from the transmitter to the receiver being interrupted by the presence of a train in the section whose axles shunt the section's rails, the receiver being responsive to the absence of signals from the transmitter to fail-safely indicate the presence of a train in the section whereby a track-circuiting function is performed. 5
3. An arrangement according to Claim 1, wherein there is a further train responsive means located adjacent the end of the section remote from the transmitter and responsive to the passage of a train to perform a track-circuiting function without being dependent on reception of signals from the transmitter. 10
4. An arrangement according to any preceding claim wherein the signals transmitted by the a.c. signal transmitter means represent, in operation, train speed control signals. 15
5. An arrangement according to Claim 4, wherein the train-position-related signal sequence comprises progressively lower speed command signals and a stop signal should the next succeeding track section be occupied by another train, or to maintain the train speed control signal should the succeeding track section be clear, or to transmit a lower speed command signal should the succeeding track section be clear but subject to a speed restriction. 20
6. An arrangement according to any preceding claim, wherein there is a plurality of train responsive means located at spaced intervals along the section, each being responsive to the passage of a train to transmit a signal to the track section transmitter, whereby effectively to divide the section into a plurality of relatively short sub-sections equivalent to a like plurality of short mutually electrically isolated track sections. 25
7. An arrangement according to any preceding claim, wherein the train responsive means comprises a passive trackside device or arrangement interacting in operation with an active device or arrangement on a passing train. 30
8. An arrangement according to any of Claims 1 - 6, wherein the train responsive means comprises an active trackside device or arrangement interacting in operation with a passive device or arrangement on a passing train. 35
9. An arrangement according to any of Claims 1 - 6, wherein the train responsive means comprises an active trackside device or arrangement interacting in operation with an active device or arrangement on a passing train. 40
10. An arrangement according to any of Claims 1 - 6, wherein the train responsive means responds to the passage of a train by a temporary inductive link therewith. 45
11. An arrangement according to Claim 10, wherein there is an electromagnetic alternating field transmitter located adjacent a rail on the side thereof, and a field responsive receiver located adjacent said rail on the other side thereof, the receiver receiving transmissions from the transmitter before a train passes, the passage of a ferromagnetic train wheel shunting the field into the rail and shielding the receiver whereby the receiver is enabled to sense the presence of a passing train. 50
12. An arrangement according to Claim 11, wherein the receiver controls a power supply or an enabling signal from the transmitter such as to cause transmissions during reception and before the passage of a train, but to switch off or disable the transmitter in the absence of reception whereby when a train passes, the transmitter is latched in an inactive state until reset. 55
13. An arrangement according to Claim 12, wherein the transmitter is reset to again cause transmissions to the receiver by a track circuit relay responding to the departure of the train that caused the latching from the track section in which the transmitter and receiver are located. 60
14. An arrangement according to any of Claims 1 - 6, wherein the train responsive means responds to the passage of a train by physical contact therewith. 55
15. An arrangement according to Claim 14, wherein the train responsive means comprises a treadle switch. 60
16. A railway signalling arrangement substantially as hereinbefore described with reference to the un-illustrated example. 60



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17. A railway signalling arrangement substantially as hereinbefore described with reference to Figures 2 to 8 of the accompanying drawing.

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