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Cochran et al.

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[54] **LOGIC BACKUP FOR A TRAIN DETECTION SYSTEM IN AN AUTOMATIC BLOCK SYSTEM**

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[52] **U.S. Cl.** .... **246/34 R**; 246/28 R; 340/38 R

[51] **Int. Cl.²** **B61L 21/06**

[58] **Field of Search** ...... 246/34 R, 34 CT, 62, 28 R; 340/31 R, 38 R

[56] **References Cited**

UNITED STATES PATENTS

2,811,634 10/1957 Hufnagel .... 246/34 R

3,662,330 5/1972 Meredith .... 340/38 R

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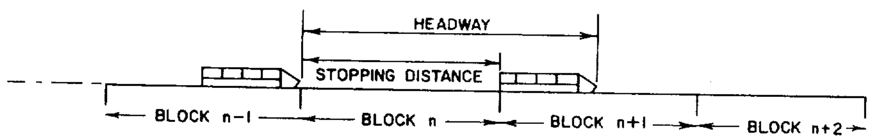
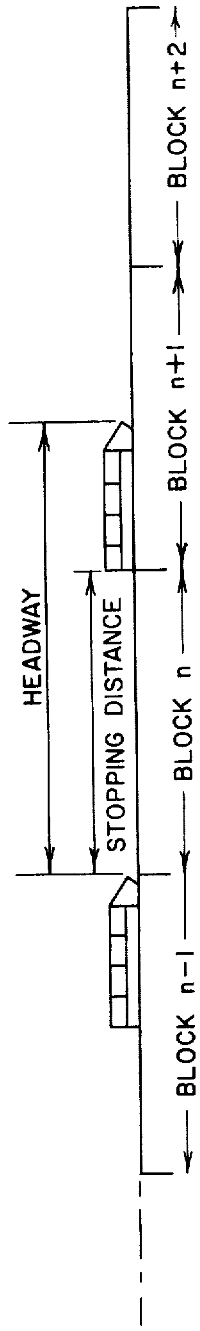
[57] **ABSTRACT**

The backup train detection system described herein distinguishes false from true block occupancies and recursively decides whether to set a true or a false occupancy latch whenever an occupancy indication from the primary detection system occurs. The decision to set a true occupancy latch somewhere in the system is a decision not to set the false occupancy latch in the block in which the indication occurs and is made on the basis of the states of all the true and false occupancy latches and occupancy situations throughout the system. The true occupancy latch in one block is reset if and only if the true occupancy latch in the next block is set. The false occupancy latch is reset by the absence of the occupancy indication in that block.

5 Claims, 3 Drawing Figures



ZERO SPEED COMMAND



ZERO SPEED COMMAND

FIGURE 1

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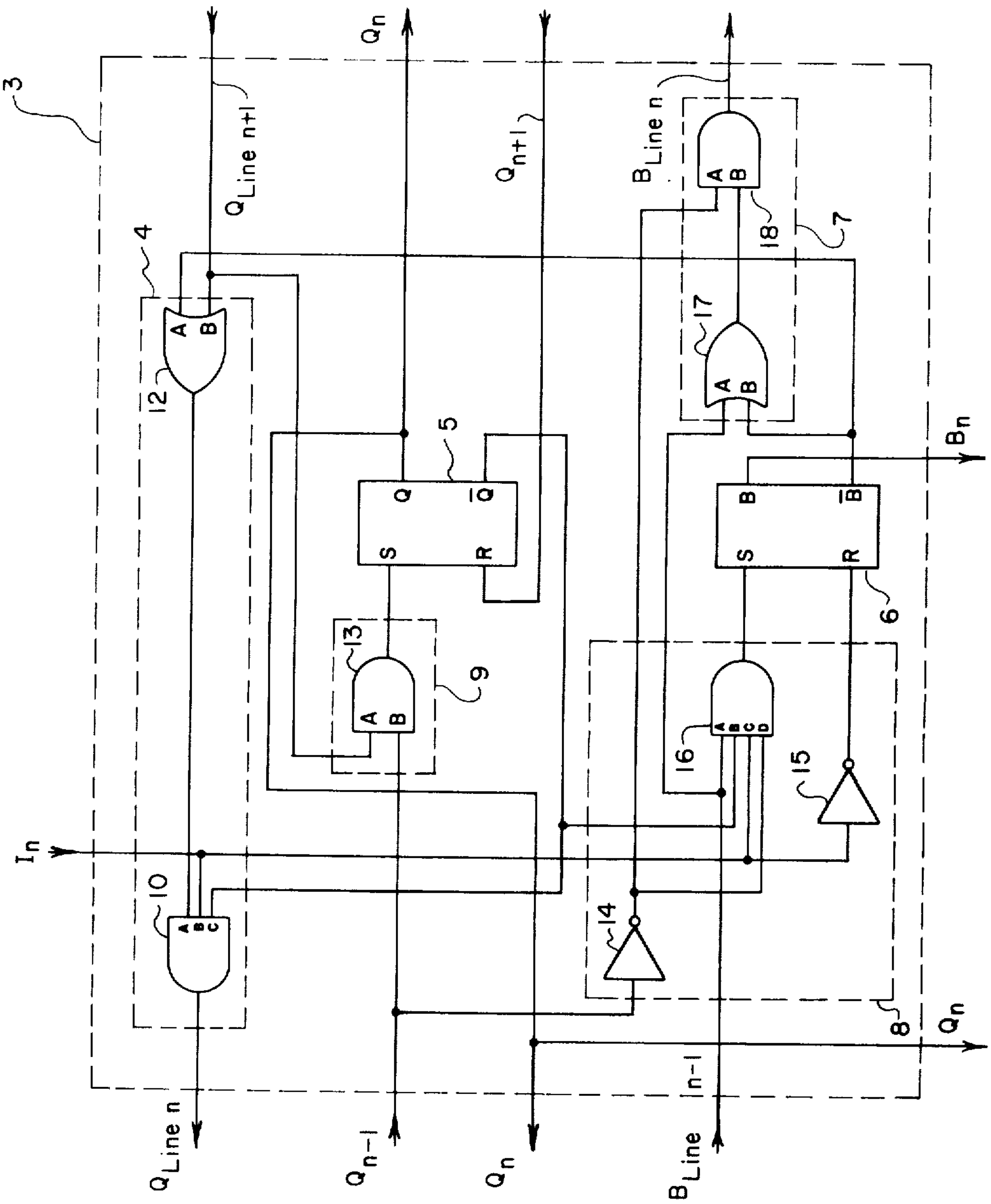
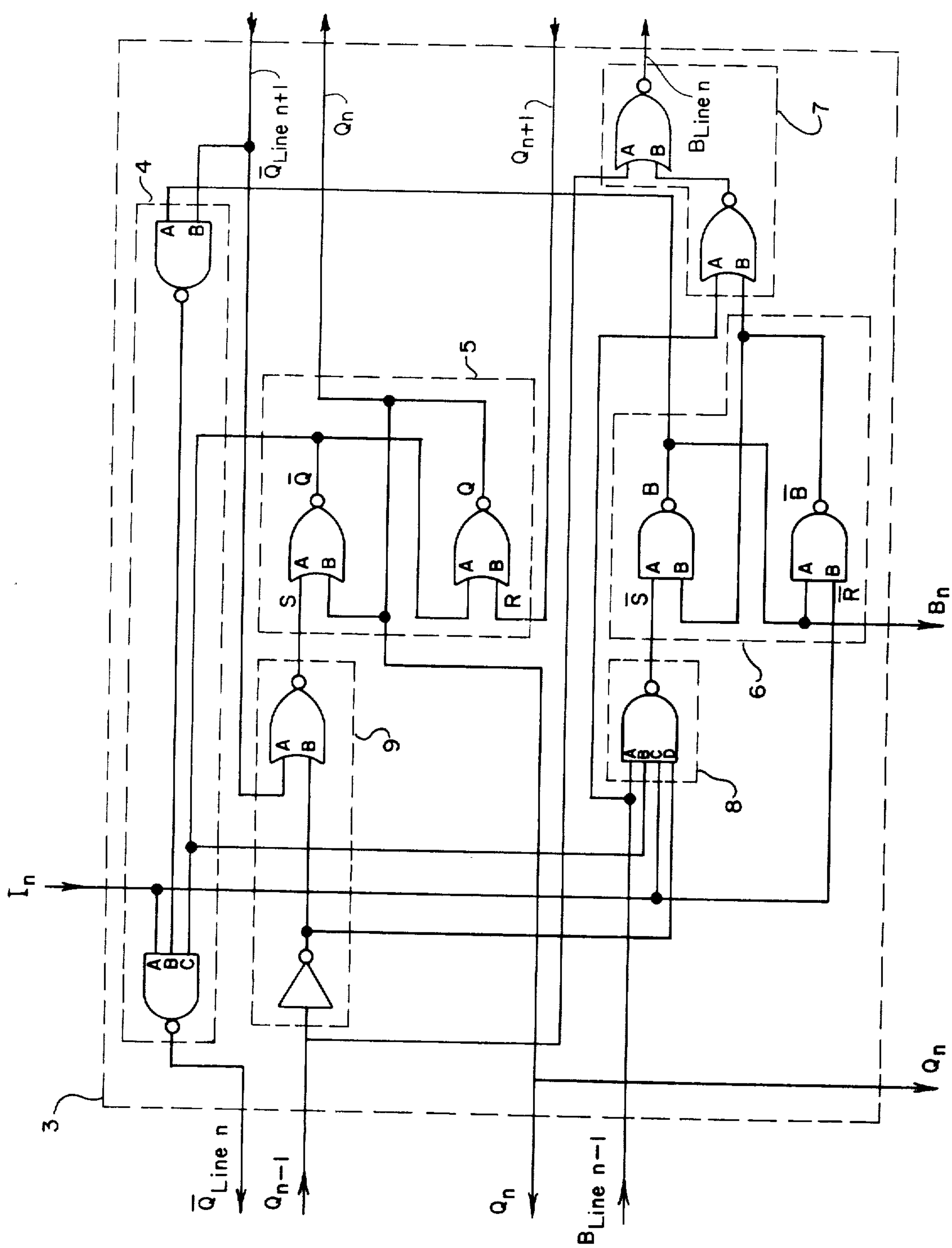


FIGURE 2


$\bar{Q}_{Line\ n+1}$
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Q_n
$B_{Line\ n-1}$
Q_n
3
4
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FIGURE 3

LOGIC BACKUP FOR A TRAIN DETECTION SYSTEM IN AN AUTOMATIC BLOCK SYSTEM

BACKGROUND OF THE INVENTION

An essential element of train safety, especially in an automatic multi-train system, is knowing with relative certainty whether there is another train immediately ahead or behind each train in the system. While train safety is paramount in such a system, cost and efficiency considerations are closely related. This invention, therefore, relates generally to train safety and more particularly to train detection in an automatic train control system.

In automatic block systems, train positions are usually determined by dividing the route into segments or defined lengths of track referred to as "blocks," and continuously updating the control system with information indicating whether or not each block is occupied. FIG. 1 illustrates such a system wherein the standard block length is at least the maximum stopping distance of a following train and is usually longer than the longest train of the system. For safety, the one or more blocks immediately behind a train operating in such a system always has a zero speed command for the following train thereby providing the maximum stopping distance between trains. For efficiency, the protective spacing between trains, or "headway," which is generally the length of one block plus the length of a train and measured in units of time, is kept to a minimum. For economy, block length is maximized in order to limit the amount of equipment required.

In systems using conventional track signalling, the steel rails of track are used as the transmission line for detection signals and speed commands. Each block has a signal loop to detect the presence or absence of a train in the block. The signal loop contains a transmitter at one end of the block and a receiver at the other. Transmission of the signal between transmitter and receiver is usually undisturbed until a train enters the block. When a train enters a block, its wheels shunt the tracks and a relay is released. The relay contacts then may be used to enable a series of signals for following trains, including "proceed," "slow," and "stop." However, the problem of an occupancy signal being transmitted from a block in which no train exists, i.e. a false occupancy indication, occurs in systems employing either type of communication scheme.

Train safety standards require that any system, subsystem or component must incorporate failsafe design characteristics which ensures that any malfunction affecting safety will cause the system to revert to a state known to be safe. Thus, if a false occupancy signal is transmitted, the system will transmit a zero speed command to following trains because stopping is safer than proceeding at the risk of colliding with an obstruction ahead. False occupancy signals can be generated in a number of ways, including dampness from rain or snow, foreign objects such as wires falling across the tracks, a broken rail or simply any component failure causing the transmitter or receiver to fail. In all primary detection systems, such false occupancy signals have the same effect on the control system as true occupancy signals.

Many primary train detection systems have backup systems augmenting the detection capability of the primary system. Frequently these are logic systems and

are required because detection by the primary system can be intermittent.

Prior art backup systems usually comprise a single latch per block which is set by an occupancy indication in the block from the primary system. The latch is usually reset by an occupancy indication two blocks ahead. This latch is used in conjunction with the primary detection system to assure protection for the rear of trains. However, the latch at the rear of the train will be reset by the train encountering a falsely occupied block or the latch set by the rear of a leading train. Therefore a logic backup system must distinguish between true and false occupancies to avoid endangering the rear of a train by a false occupancy advancing the set latch in the logic backup system.

SUMMARY OF THE INVENTION

The present invention always employs at least two latches per block to distinguish between true and false occupancies. One preferred embodiment of the invention comprises two flip-flops used as latches and logic consisting of two OR-gates, four AND-gates and two inverters for each block in the track system. The true output of one flip-flop (latch) indicates true occupancy in the block while the true output of the second latch indicates a false occupany. Whenever an occupancy indication from the primary train detection equipment occurs, the logic decides whether to set a true or false occupancy latch, but not both (exclusive OR). The decision is made on the basis of the present state of the entire system, consisting only of the states of all the true and false occupancy latches and the occupancy situations. Another embodiment comprises only NAND and NOR gates which results in the same backup control states.

A train in a system utilizing the preferred embodiment of this invention leaves a sequential pattern of set true occupancy latches in its wake along the track. One of the conditions for setting a true occupancy latch is that the true occupancy latch in the preceding block is set. Premature resets can also occur in prior art backup systems when one train follows another too closely wherein the true occupancy latch at the end of the following train is reset by the set latch at the rear of the leading train. In this circumstance the following train is unprotected as would be a train moving into an already falsely occupied block. Thus, in addition to the set condition of the true occupancy latch in the preceding block, all true occupancy latches in the preferred embodiment of the invention are set only upon receipt of an occupancy indication via the primary detection system from the first non-falsely occupied block ahead and, furthermore, when no true occupancy latches are set in blocks ahead, up to and including the one supplying said occupancy indication.

The primary object of the present invention is to provide a logic backup train detection system in which occupancy of a block is registered by setting a latch (flip-flop or relay) which is not reset until a similar latch is set in the next block ahead. Another feature of the system is that the occupancy latches and associated speed profile remain locked up behind the last block in which detection occurred, even in the presence of intermittent detection or in the event of a derailment. This feature also provides protection when the primary system fails to detect a train for an entire block or more for any reason.

Another objective of the present invention is to provide a logic backup system which can be coupled to a primary system in a failsafe manner so that if a circuit malfunction occurs in the backup system degradation of overall system safety or the primary detection system is precluded.

A further objective of the present invention is to provide means for identifying and recording false occupancies automatically, and to use this information to delay the advance of the set true occupancy latches when a train encounters falsely occupied region until the train is detected coming out of that region. A false occupancy that suddenly appears in the block immediately ahead of a train is undistinguishable from the true occupancy that results from advance of the train itself, but will be registered as false when the train moves on.

A still further objective of the present invention is to provide a backup system for detecting trains as they move along a track system in which the speed profile may be extended into as many blocks as required for safety to correspond to the flexibility of the primary train detection system.

Still another objective of this invention is to provide means for safely hostling trains through a region of contiguous false occupancies while assuring adequate train separation for safety. A record of train operator performance is provided in the event procedural rules for hostling of trains are violated.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram of an automatic block system.

FIG. **2** is a logic diagram of the preferred embodiment of the invention.

FIG. **3** is a logic diagram of the invention of FIG. **1** in which alternative components are used in common logic elements.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring again to FIG. **1**, blocks have been numbered sequentially $n-1$, n, $n+1$ . . . . Block number increases in the direction of train travel. Under this convention, block n refers to the block being observed, block $n-1$ refers to the preceding block and block n+1 refers to the succeeding block.

FIG. **2** shows the backup logic system **3** of the preferred embodiment of the invention for block n of a railroad employing an automatic block system for train control. The set input, S, of logic element (LE) **5** of the true occupancy latch and comprising an RS flip-flop in this embodiment, is coupled to the true output of the equivalent element in block $n-1$ through LE 9 (B input). Logic element 9 comprises an AND-gate with two inputs, the A input of which is connected to the B input of gate 12 of LE 4. Logic element 4 comprises two gates, OR gate 12 and AND gate 10. The output of gate 12 is connected to input A of gate 10 while input A thereof is connected to the not true output, $\overline{B}$, of LE 6, the false occupancy latch. Input B of gate 12 is connected to the output of an equivalent of LE 4 in block $n+1$. Input B of gate 10 is connected to the occupancy indicator signal from the primary train detection system and the C input thereof is connected to the not true output, $\overline{Q}$, of LE 5.

True output Q of LE **5** is connected to both adjacent blocks, and, in addition to providing true occupancy indication to the system for block n, becomes a set input for the true occupancy latch in block $n+1$ and the reset input for true occupancy latch in block $n-1$. Reset input R of LE **5** is connected to Q of the true occupancy latch in block $n+1$. Not true output, $\overline{Q}$, of LE 5 is coupled to the S input of LE 6 through gate 16 (B input) of LE 8, LE 6 being a false occupancy latch comprising another RS flip-flop. As mentioned above, $\overline{Q}$ of LE 5 is also coupled to the C input of gate 10 in LE 4.

The true output of LE **6**, B, provides the false occupancy indication to the system for block n. $\overline{B}$ is connected to OR gate **17**, the first of two gates comprising LE **7**. The output of gate **17** is coupled to the input of an equivalent of LE **8** in block $n+1$ through AND gate 18 at input B, the second gate of LE 7. Input A of gate 18 is coupled to the true output of the true occupancy latch in block $n-1$ through inverting amplifier 14 of LE 8. Input A of gate 17 is connected to the output of an equivalent to LE 7 in block $n-1$.

The set input, S, of LE **6** is connected to the output of AND gate **16** of LE **8.** Input A of gate **16** is connected to the output of an equivalent of LE **7** in block $n-1$ with, as described above, the A input of gate 17; input B of gate 16 connected to $\overline{Q}$ of LE 5 as also described above; input C of gate 16 is connected to the occupancy indication signal, I_n, from the primary train detection system; and input D is connected to the output of inverting amplifier **14.** R input of LE **6** is coupled to I_n through inverting amplifier **15.**

In operation, as a train enters block n, LE 5 will be set if and only if the true occupancy latch of block $n-1$ is set and I_n is present and the true and false occupancy latches in block $n+1$ are not set. LE 5 will be reset if and only if the true occupancy latch in block $n+1$ is set. In accordance with the preferred embodiment of this invention the setting of the true or false occupancy latch is an exclusive OR decision. A decision to set the true occupancy latch in a preceding block in response to the occurrence of the indication of train occupancy from the primary system in block n is also a decision not to set the false occupancy latch in block n. Thus, the reset condition for the false occupancy latch in block n is the absence of I_n, which allows it to reset immediately.

FIG. **3** shows another embodiment of the present invention in which LE **5** comprises a cross-coupled latch circuit consisting of **2** NOR gates used for the RS flipflop as in the embodiment shown in FIG. **2.** Similarly, LE **6** consists of cross-coupled NAND gates. LE **4** comprises two NAND gates instead of one each AND and OR gate, LE **9** comprises a NOR gate with one input connected to an inverting amplifier, replacing an AND gate; a single NAND gate replaces the components in LE **8** shown in FIG. **2**; and two NOR gates replace the OR gate and AND gate of LE **7.** The operation of the logic backup system **3** of FIG. **3** is equivalent to that of the system shown in FIG. **2.**

In order for the backup system to operate normally, a moving train must be detected by the primary system, even intermittently, at least once in every block. Unless a true occupancy latch is force set when a train is first dispatched, a train first entering the system will be interpreted as a false occupancy by the backup system. If a train passes through a block undetected it will leave a true occupancy latch set in the preceding block and the train will then be interpreted as a traveling false occupancy. By such interpretation, the preferred embodiment of this invention provides a very useful indication that a serious detection problem has occurred.

An important feature of the present invention is that the true occupancy of a given block in the system is determined recursively from the occupancy states and occupancy indications of succeeding blocks. Any combination of trains may pass through any combination of false occupancies without confusing the logic unless the trains follow too closely. For example, in the absence of false occupancies, the setting of a true occupancy latch by a following train can occur no closer than two blocks behind the setting of the latch by a leading train. However, the following train could leave its set occupancy latch behind by moving up so that it and the leading train are entirely contained within one block. By so closing the headway, the system will now interpret the following train as a false occupancy as the leading train moves ahead since the following train is unable to set the true occupancy latch in the block immediately ahead of the last block in which a true occupancy latch was set. This problem can be avoided by observing the minimum headway standard or fixing block lengths shorter than the length of two trains.

In the presence of false occupancies, the backup system is free from premature resets except when a false occupancy occurs in the block just ahead of the leading block in which a train has first been detected or when a false occupancy occurs in the block immediately ahead of one or more falsely occupied blocks that a train has entered or about to enter. As mentioned above, these false occupancies are undistinguishable from a true occupancy initiated by the advance of the train, and cause premature resets of the true occupancy latches behind the train. This type of premature reset can be prevented and the rear of the train protected by using the reset signal for the true occupancy latch as well as the absence of occupancy indication, I_n, to reset the false occupancy latch instead of I_n alone. However, a momentary false occupancy would remain latched until a train came through to reset the latch, causing reduced system efficiency particularly if there are very many momentary false occupancies. Even so, such a modification for resetting false occupancy latches could serve as an indicator that some service to the system is needed and where inasmuch as false occupancies would be detected unambiguously, and the outputs of the false occupancy latches are available for display or recording. The set conditions for the true occupancy latch must also be modified slightly in this case.

Where track configuration, location of switch, and other similar constraints require, blocks may be shorter than the maximum train length. In this situation, the reset condition for true occupancy latches are changed so that they are not reset until the true occupancy latch in a block several blocks ahead is set to insure that a true occupancy latch remains set at the rear of the train. It should be noted also that overall system performance can be enhanced by introducing time delays in the transmission of occupancy indications. It should be further noted that the principles of this invention can be implemented by an appropriately programmed computer.

We claim:

1. In a train detection backup system for providing supplemental detection of train occupancy in a block system which provides a primary indication of train occupancy, the apparatus for each block comprising:

first input means having an output port and two input ports coupled to receive a first electrical signal representing the true occupancy status of the preceding block at one input port, and to receive a second electrical signal representing the logical combination of the true and false occupancy statuses and the primary indications of train occupancy from the block system for succeeding blocks at the other input port for providing an electrical signal at the output port in response to the occurrence of said signals at the input ports thereof;

true occupancy latching means having a first and a second output port and having a first input port coupled to receive the output signal from the first input means and having a second input port coupled to receive an electrical signal representing the true occupancy status of at least one of the succeeding blocks for providing an electrical signal at the first output port representing true occupancy of the block in response to the occurrence of said signal at the first input port and an electrical signal at the second output port representing the complement of true occupancy of the block in response to the occurrence of said signal at the second input port;

second input means having three output ports and having four input ports coupled to receive electrical signals from the block system, the block and preceding blocks for providing electrical signals at the output ports in response to the occurrence of said signals at the input ports;

false occupancy latching means having a first and a second output port and a first and second output port coupled to receive electrical signals from the second input means for providing electrical signals at the output ports in response to the occurrence of said signals at the input ports;

output means having one output port and three input ports coupled to the second input means and the false occupancy latching means for providing an electrical signal representing the logical combination of true and false occupancy status of the block and preceding blocks at the output port for succeeding blocks in response to the occurrence of said signals at the input ports; and

transmission means having one output port and four input ports coupled to the block system, the first input means and the true and false occupancy latching means of the block for providing an electrical signal representing the logical combination of true and false occupancy status of the block and succeeding blocks at the output port for preceding blocks in response to the occurrence of said signals at the input ports.

2. The train detection backup system as in claim 1 wherein:

the input ports of the second input means include a first input port for receiving an electrical signal representing the logical combination of true and false occupancy status for preceding blocks, a second input port for receiving an electrical signal representing the true occupancy of the preceding block, a third input port for receiving an electrical signal representing the primary indication of train occupancy from the block system and a fourth input port for receiving the complement of true occupancy of the block;

the output ports of the second input means include a first output port for providing an electrical signal to the output means in response to the electrical signal received at the second input port, a second output port for providing an electrical signal to the first input port of the false occupancy latching means in response to the electrical signals received at the first, second, third and fourth input ports and a third output port for providing an electrical signal to the second input of the false occupancy latching means in response to the electrical signal received at the third input port; and

the false occupancy latching means provide an electrical signal at the first output port representing false occupancy of the block in response to the electrical signal received at the first input port and an electrical signal at the second output port representing the complement of false occupancy of the block in response to the electrical signal received at the second input port.

3. The train detection backup system as in claim **1** wherein:

the input ports of the output means include a first input port for receiving an electrical signal representing the logical combination of true and false occupancy status for preceding blocks, a second input port for receiving the electrical signal provided at the second output port of the false occupancy latch, and a third input port for receiving the electrical signal provided at the first output port of the second output means; and

the input ports of the transmission means include a first input port for receiving an electrical signal representing the primary indication of train occupancy from the block system, a second input port for receiving the electrical signal provided at the second output port of the true occupancy latching means, a third input port for receiving the electrical signal provided at the second output port of the false occupancy latching means and a fourth input port for receiving an electrical signal representing the logical combination of the true and false occupancy status for succeeding blocks from the succeeding block.

4. In a train detection backup system for providing supplemental detection of train occupancy in a block system which provides a primary indication of train occupancy, a method for each block comprising the steps of:

providing a first signal representing the true occupancy of the preceding block;

providing a second signal representing the logical combination of the true and false occupancy status of the succeeding blocks and the primary indication of train occupancy from the block system for the succeeding block;

providing a signal representing the true occupancy of the block to the block system and to the preceding and succeeding blocks in response to the occurrence of the first and second signals; and

maintaining the signals representing the true occupancy of the block and its complement as long as no signal representing true occupancy of at least one of the succeeding blocks appears.

5. The method as in claim **4** further comprising the steps of:

providing a first signal representing the logical combination of the true and false occupancy statuses for preceding blocks;

providing a second signal representing the true occupancy of the preceding block;

providing a third signal representing the primary indication of train occupancy from the block system;

providing a fourth signal representing the complement of the true occupancy of the block;

providing a signal representing false occupancy of the block to the block system in response to the occurrence of the first, second, third and fourth signals;

providing a signal representing the logical combination of the complements of the true and false occupancy of the block and the primary indication of train occupancy from the block system and the logical combination of the true and false occupancy statuses and primary indications of train occupancy from the block system for succeeding blocks to the preceding blocks;

providing a signal representing the logical combination of the complement of false occupancy for the block and the complement of true occupancy for the preceding block and the logical combination of the true and false occupancy statuses for preceding blocks to succeeding blocks; and

maintaining the signals representing the false occupancy of the block and its complement as long as the signal representing the primary indication of train occupancy appears.

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