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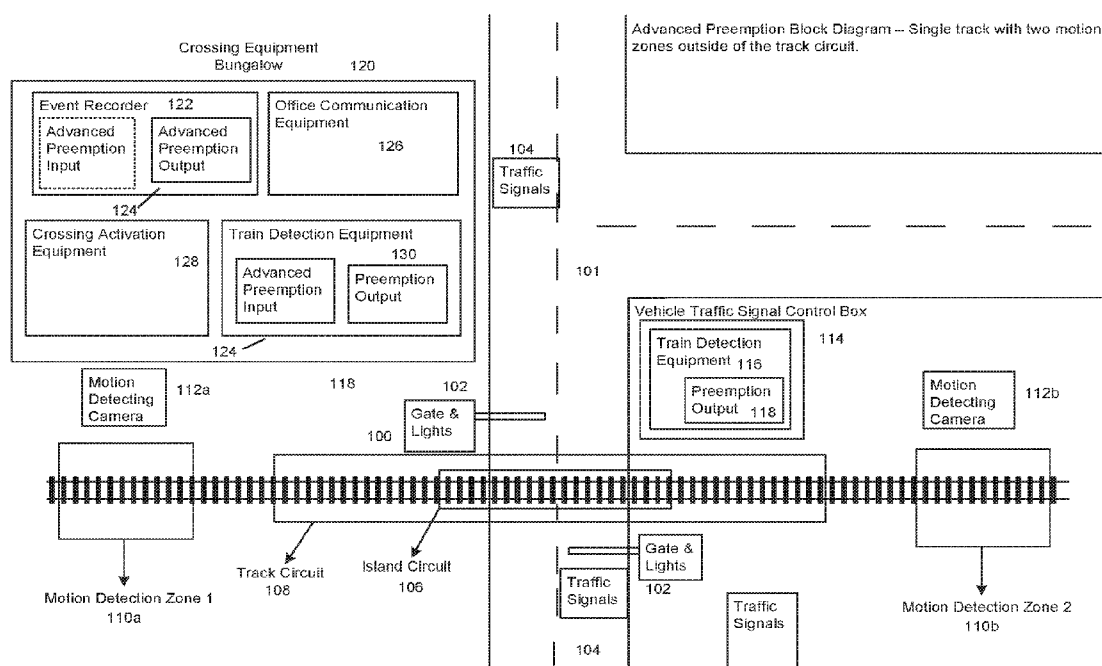


FIG. 1

(57) Abstract: An advanced preemption system may comprise at least one motion detector and at least one advanced preemption processing system in communication with the at least one motion detector. The at least one motion detector may be configured to detect motion within at least one motion detection zone, the at least one motion detection zone containing a section of railroad track outside of a track circuit containing a railroad crossing where a thoroughfare crosses the railroad track. The at least one advanced preemption processing system may be configured to receive, from the at least one motion detector, an indication that motion has been detected within the at least one motion detection zone and activate at least one traffic control element for the thoroughfare before a train enters the track circuit.

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TITLE

ADVANCED PREEMPTION

BACKGROUND

Railroad tracks cross other paths, such as roads and walkways, at railroad crossings. As a train approaches a railroad crossing, train detection systems detect the train and prepare the railroad crossing. For example, traffic signals on either side of the crossing can indicate the approach of the train (e.g., by turning red), crossing gates and lights can be activated (e.g., gates are lowered and warning lights flash), and/or audible alarms (e.g., bells) can sound. Generally, the train is detected by a track circuit, which detects the train by detecting a short between parallel rails caused by a conductive train axle on the rails. For example, a track circuit can be arranged to extend some distance beyond a railroad crossing in either direction of the track, and when the track circuit detects a train on that portion of the track, crossing signals and gates activate. This is known as preemption.

SUMMARY OF THE DISCLOSURE

Systems and methods described herein may provide advanced preemption by detecting a train before it reaches a track circuit associated with a railroad crossing. For example, some embodiments described herein may deploy sensors such as motion-sensing cameras beyond the ends of the track circuit. These sensors may detect a train as it approaches the track circuit area, detecting the train before it enters the track circuit. Advanced preemption may improve railroad crossing safety through earlier and more reliable train detection, allowing crossing signals and gates to activate earlier and/or allowing additional warnings such as traffic signals positioned at a distance from the railroad crossing. Advanced preemption systems and methods described herein may be inexpensive, compact, and more easily set up compared with installing additional track circuits in series with the track circuit at the railroad crossing, for example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a railroad crossing according to an embodiment of the invention.

FIG. 2 is a block diagram of an advanced preemption element architecture according to an embodiment of the invention.

FIGS. 3-5 are advanced preemption processes according to an embodiment of the invention.

DETAILED DESCRIPTION OF SEVERAL EMBODIMENTS

Systems and methods described herein may combine camera technology with train predictors and/or event recorders to provide an advanced preemption indication to traffic signaling equipment. For example, motion detecting cameras may be set up past the boundaries of railroad crossing track circuit(s) in order to detect train motion and send an advanced preemption indication to railroad crossing and/or traffic signaling equipment.

FIG. 1 is a block diagram of a railroad crossing 100 according to an embodiment of the invention. Railroad crossing 100 may be an area where the railroad crosses another thoroughfare such as a road 101. Crossing access control equipment 102 may be installed at railroad crossing 100 to prevent collisions between traffic on the railroad and traffic on the road 101. For example, crossing access control equipment 102 may include gates that close and lights that flash when a train is approaching and/or crossing at railroad crossing 100. Traffic signals 104, such as traffic lights, may be disposed along the road 101 at a distance further removed from the railroad crossing 100 than the crossing access control equipment 102. The advanced preemption systems and methods described herein may enable control of traffic signals 104 when a train is approaching and/or crossing at railroad crossing 100, as described below.

Railroad crossing 100 may include one or more track circuits configured to detect the presence of a train and perform preemption. The track circuits may include island circuit 106 configured to detect the train in the immediate vicinity of the road 101 (e.g., on the portion of the track that crosses the road 101 itself) and track circuit 108 configured to detect the train in the area of the track extending out from railroad crossing 100. Island circuit 106 and track circuit 108 may each be communicatively coupled to crossing access control equipment 102, for example by wires (not shown). Island circuit 106 and/or track circuit 108 may detect a train by detecting a short between parallel rails caused by a conductive train axle on the rails. When a train is detected, island circuit 106 and/or track circuit 108 may send a signal to crossing access control equipment 102 causing crossing access control equipment 102 to activate (e.g., causing gates to close and/or lights to flash). In some embodiments, island circuit 106 and/or track circuit 108 may send a signal to equipment in crossing equipment bungalow 120, as discussed below, which in turn may control crossing access control equipment 102.

Railroad crossing 100 may benefit from advanced preemption in addition to the basic preemption provided by island circuit 106, track circuit 108, and crossing access control equipment 102. Advanced preemption equipment may include one or more motion detecting cameras 112 (in this example, two cameras 112a and 112b) configured to monitor one or more motion detection zones 110 (in this example, two zones 110a and 110b). Motion detecting cameras 112 are discussed in the examples herein, but any other motion detecting technology (e.g., radar, etc.) may be used. Motion detecting cameras 112 may be configured to monitor multiple motion detection zones 110. In some embodiments, each motion detecting cameras 112 may be configured to monitor up to ten motion detection zones 110 (e.g., for areas wherein multiple tracks are in use). This feature may reduce cost and complexity by allowing for the installation of fewer cameras.

Motion detecting cameras 112 may be configured to detect motion and generate an output in response to detecting motion. For example, motion detecting cameras 112 may capture images in response to detecting motion and/or output a signal indicating the presence of motion within motion detection zones 110. In some embodiments, motion detecting cameras 112 may transmit outputs to external equipment (e.g., equipment in crossing equipment bungalow 120) using various protocols (e.g., SNMP, HTTP, HTTPS, etc.) through integrated and/or separate wireless devices or buried Ethernet cable. In some embodiments, motion detecting cameras 112 may transmit outputs to external equipment (e.g., equipment in crossing equipment bungalow 120) using a direct wire connection (e.g., supplying a high voltage in response to detecting motion and a low voltage otherwise, or supplying a low voltage in response to detecting motion and a high voltage otherwise). Motion detecting cameras 112 may utilize onboard digital relay outputs with buried cable in some embodiments. Motion detecting cameras 112 may be powered locally with power over Ethernet or using integrated and/or separate solar, battery, or other power sources. Motion detecting cameras 112 may be non-vital systems in some embodiments, because the track circuit 108 and island circuit 106 provide a vital system for closing railroad crossing 100 that is installed in conjunction with motion detecting cameras 112.

Motion detecting cameras 112 may transmit outputs to equipment in crossing equipment bungalow 120. Crossing equipment bungalow 120 may contain equipment used to control and monitor crossing access control equipment 102 and, in some embodiments, traffic signals 104. For example, crossing equipment bungalow 120 may include event recorder 122, office communication equipment 126, crossing activation equipment 128, and/or train detection equipment 130. Each of these elements may be embodied as one or more dedicated

circuits or processors and/or one or more software modules contained in a memory and executed by a processor.

Vehicle traffic signal control box 114 may contain equipment used to control and monitor traffic signals 104, such as traffic signal control equipment 116. For example, traffic signal control equipment 116 may be in communication with equipment in crossing equipment bungalow 120, and the respective elements may work together to control traffic signals 104 in response to motion detected by one or more motion detecting cameras 112. These elements may communicate with one another using various protocols (e.g., SNMP, HTTP, HTTPS, etc.) through integrated and/or separate wireless devices or buried Ethernet cable, or through direct wire connections sending a high or low voltage signal, for example. In some embodiments, each traffic signal 104 may be controlled by a separate vehicle traffic signal control box 114. Vehicle traffic signal control box 114 may be coupled to and/or integrated with traffic signals 104, for example. In some embodiments, vehicle traffic signal control box 114 may control multiple traffic signals 104. Vehicle traffic signal control box 114 may be in communication with multiple traffic signals 104 from a single location, and may be collocated with crossing equipment bungalow 120 in some cases.

The equipment in crossing equipment bungalow 120 and/or vehicle traffic signal control box 114 may control crossing access control equipment 102 and/or traffic signals 104 when a train is in the vicinity of the railroad crossing 100. For example, when motion detecting camera 112 detects motion, it may send output (e.g., a message using a protocol or a voltage on a direct wire) to event recorder 122. Event recorder 122 may perform further processing and output advanced preemption data 124. Event recorder 122 may perform other functions, such as logging each motion detection event and/or logging track circuit 108 and/or island circuit 106 events. Train detection equipment 130 may receive advanced preemption data 124, perform further processing, and generate preemption data 118. Train detection equipment 130 may also receive signals from island circuit 106 and/or track circuit 108 (e.g., signals indicating the presence of a train) and control crossing access control equipment 102 based on these signals. Train detection equipment 130 may generate preemption data 118 based on the signals from island circuit 106 and/or track circuit 108 as well in some embodiments. Traffic signal control equipment 116 may receive preemption data 118 and control traffic signals 104. Example embodiments of this process is described in detail in FIGS. 3-5 below.

In some embodiments, crossing equipment bungalow 120 can include office communication equipment 126. Office communication equipment 126 may be configured to

communicate status of other equipment in crossing equipment bungalow 120 and/or vehicle traffic signal control box 114 to a central office. For example, office communication equipment 126 may report on the status of the equipment periodically and/or report in the event of failure of any of the equipment.

FIG. 2 is a block diagram of an advanced preemption element architecture 200 according to an embodiment of the invention. In some embodiments, one or more of traffic signal control equipment 116, event recorder 122, office communication equipment 126, crossing activation equipment 128, and train detection equipment 130 may be implemented partially or entirely by one or more computer systems. FIG. 2 shows an example computer architecture 200 that may provide any of these elements or a combination thereof.

Architecture 200 may be implemented on any electronic device that runs software applications derived from compiled instructions. In some implementations, architecture 200 may include one or more processors 202, one or more input devices 204, one or more power supplies 206, one or more network interfaces 208, and one or more computer-readable mediums 210. Each of these components may be coupled by bus 212.

Power supply 206 may be any power supply technology, including connection to a power grid, renewable source, battery, or combination thereof. Input device 204 may be any input device technology, including but not limited to a human interface such as a keyboard, mouse, touchpad, etc. and/or a device interface such as a direct connection to equipment (e.g., a connection to motion detecting camera 112). Bus 212 may be any internal or external bus technology, including but not limited to ISA, EISA, PCI, PCI Express, NuBus, USB, Serial ATA or FireWire. Computer-readable medium 210 may be any medium that participates in providing instructions to processor(s) 202 for execution, including without limitation, non-volatile storage media (e.g., optical disks, magnetic disks, flash drives, etc.), or volatile media (e.g., SDRAM, ROM, etc.).

Computer-readable medium 210 may include various instructions 214 for implementing an operating system (e.g., Mac OS®, Windows®, Linux). The operating system may be multi-user, multiprocessing, multitasking, multithreading, real-time, and the like. The operating system may perform basic tasks, including but not limited to: recognizing input from input device 204; keeping track of files and directories on computer-readable medium 210; controlling peripheral devices (e.g., crossing access control equipment 102, traffic signals 104, etc.) which can be controlled directly or through an I/O controller; and managing traffic on bus 212. Network communications instructions 216 may establish and

maintain network connections (e.g., software for implementing communication protocols, such as TCP/IP, HTTP, Ethernet, etc.).

Preemption system equipment instructions 218 can include instructions that may implement one or more of traffic signal control equipment 116, event recorder 122, office communication equipment 126, crossing activation equipment 128, and train detection equipment 130. For example, preemption system equipment instructions 218 may be used to perform some or all parts of the process of FIG. 3 discussed below.

Application(s) 220 may be an application that uses or implements the processes described herein or other processes. The processes may also be implemented in operating system 214.

The described features may be implemented in one or more computer programs that may be executable on a programmable system including at least one programmable processor coupled to receive data and instructions from, and to transmit data and instructions to, a data storage system, at least one input device, and at least one output device. A computer program is a set of instructions that can be used, directly or indirectly, in a computer to perform a certain activity or bring about a certain result. A computer program may be written in any form of programming language (e.g., Objective-C, Java), including compiled or interpreted languages, and it may be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment.

Suitable processors for the execution of a program of instructions may include, by way of example, both general and special purpose microprocessors, and the sole processor or one of multiple processors or cores, of any kind of computer. Generally, a processor may receive instructions and data from a read-only memory or a random access memory or both. The essential elements of a computer may include a processor for executing instructions and one or more memories for storing instructions and data. Generally, a computer may also include, or be operatively coupled to communicate with, one or more mass storage devices for storing data files; such devices include magnetic disks, such as internal hard disks and removable disks; magneto-optical disks; and optical disks. Storage devices suitable for tangibly embodying computer program instructions and data may include all forms of non-volatile memory, including by way of example semiconductor memory devices, such as EPROM, EEPROM, and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in, ASICs (application-specific integrated circuits).

FIG. 3 is an advanced preemption process 300 according to an embodiment of the invention. Advanced preemption system elements of FIG. 1 may work together to perform this process 300 to help prevent accidents at railroad crossing 100. This example process 300 is for a single track with two motion detection zones 110 outside the boundaries of track circuit 108, as shown in FIG. 1, although it may be applied to railroad crossings 100 with different configurations as well. Process 300 may begin when there is no train on track circuit 108.

At 302, track circuit 108 may deactivate. As those of ordinary skill in the art understand, track circuit 108 may be configured to detect a train by detecting a short between parallel rails of the track. The short is caused by a train's conductive axle contacting both rails. When the rails are shorted, track circuit 108 may be regarded as active (e.g., having a train thereon). Accordingly, track circuit 108 deactivation may indicate a transition from an active state, where there is a short between the rails, to an inactive state where the rails are not electrically coupled. Track circuit 108 may communicate its state to event recorder 122. When track circuit 108 deactivates, event recorder 122 may start a track circuit inactive timer. The track circuit inactive timer may expire after a certain period of time. The period of time may be customized based on the properties of each individual track (e.g., track speeds, distances between motion detection zones 110 and track circuit 108, size of track circuit 108, customer preference, etc.).

At 304, railroad crossing 100 may be inactive. Railroad crossing 100 may be inactive when no preemption equipment (e.g., island circuit 106, track circuit 108, and/or motion detecting camera(s) 112) is detecting the presence of a train.

At 306, one or more motion detecting cameras 112 may detect motion. For example, motion detecting camera 112a may detect motion within its associated motion detection zone 110a, and/or motion detecting camera 112b may detect motion within its associated motion detection zone 110b. It will be appreciated from FIG. 1 that motion detecting cameras 112 may detect motion caused by a train entering motion detection zones 110 before the train shorts parallel rails in track circuit 108.

At 308, event recorder 122 may receive data indicating motion detection from at least one motion detecting camera 112. For example, as noted above, motion detecting cameras 112 may be connected wirelessly or by wire to equipment in crossing equipment bungalow 120, including event recorder 112. Event recorder 122 may receive messages from motion detecting cameras 112 indicating motion in associated motion detection zones 110.

At 310, event recorder 122 may start an advanced preemption timer if the track circuit inactive timer has expired. As noted above, the track circuit inactive timer starts when a train first moves off track circuit 108. The train may need time to travel beyond track circuit 108, through motion detection zone 110, and beyond. Accordingly, while the train circuit inactive timer is running, the advanced preemption system may be expecting motion in motion detection zone 110 from the known train passing through motion detection zone 110. Thus, event recorder 112 may start the advanced preemption timer only after the track circuit inactive timer has expired.

At 312, event recorder 122 may activate its advanced preemption output 124. Train detection equipment 130 may detect this advanced preemption output 124 from event recorder 112.

At 314, in response to detecting advanced preemption output 124, train detection equipment 130 may activate its preemption output 118. Traffic signal control equipment 116 may detect this preemption output 118 from train detection equipment 130.

At 316, traffic signal control equipment 116 may adjust traffic signals 104 in response to receiving preemption output 118. For example, traffic signal control equipment 116 may hold traffic signals 104 at red while preemption output 118 is active to prevent traffic from moving into railroad crossing 100. In some embodiments, crossing activation equipment 128 may also receive preemption output 118 and control crossing access control equipment 102 in response to receiving preemption output 118. However, in other embodiments, because preemption output 118 may be based on input from a non-vital system (e.g., motion detecting cameras 112), crossing activation equipment 128 may control crossing access control equipment 102 only in response to track circuit 108 and/or island circuit 106 detecting the presence of a train.

In the example of FIG. 3, traffic signal control equipment 116 receives preemption output 118 from train detection equipment 130, which in turn receives advanced preemption output 124 from event recorder 122. As noted above, train detection equipment 130 may also control crossing access control equipment 102 in response to detecting a train on track circuit 108 and/or island circuit 106. Routing preemption data through train detection equipment 130 to traffic signal control equipment 116 may allow the advanced preemption system to be installed at railroad crossings 100 where train detection equipment 130 and track circuit 108/island circuit 106 systems are already in place, using the same train detection equipment 130 to perform basic track circuit-based preemption and advanced preemption. Routing preemption data through train detection equipment 130 to traffic signal control equipment

116 may also coordinate control of traffic signals 104 and crossing access control equipment 102. However, in some embodiments, step 314 may be skipped, and traffic signal control equipment 116 may receive advanced preemption output 124 directly from event recorder 122 at step 316.

At 318, track circuit 108 may activate as the train moves past motion detection zone 110 and onto track circuit 108.

At 320, island circuit 106 may activate as the train moves onto island circuit 106.

At 322, island circuit 106 may deactivate as the train moves off island circuit 106. At this point, the train may be clear of railroad crossing 110.

At 324, in response to deactivation of island circuit 106, all preemption signals (e.g., advanced preemption output 124, preemption output 118) may deactivate, indicating that railroad crossing 100 is now safe to cross.

At 326, in response to deactivation of preemption signals, crossing access control equipment 102 and traffic signals 104 may resume normal operation, allowing traffic from the thoroughfare to enter railroad crossing 100.

Returning to 310, the advanced preemption timer may expire if track circuit 108 does not activate within a certain period of time. The period of time may be customized based on the properties of each individual track (e.g., track speeds, distances between motion detection zones 110 and track circuit 108, size of track circuit 108, customer preference, etc.). The advanced preemption timer may expire without track circuit 108 activating in cases where a train enters motion detection zone 110 and stops before reaching track circuit 108. Event recorder 122 may not activate its advanced preemption output 124 when the advanced preemption timer is not active (e.g., after it expires). This may prevent unnecessary activation of crossing access control equipment 102 and/or traffic signals 104 when the train does not reach railroad crossing 100.

FIG. 4 is an advanced preemption process 400 according to an embodiment of the invention. Advanced preemption system elements of FIG. 1 may work together to perform this process 400 to help prevent accidents at railroad crossing 100. This example process 400 is for a single track with two motion detection zones 110 outside the boundaries of track circuit 108, as shown in FIG. 1, although it may be applied to railroad crossings 100 with different configurations as well. Process 400 may begin when there is no train on track circuit 108.

At 402, track circuit 108 may deactivate. As those of ordinary skill in the art understand, track circuit 108 may be configured to detect a train by detecting a short between

parallel rails of the track. The short is caused by a train's conductive axle contacting both rails. When the rails are shorted, track circuit 108 may be regarded as active (e.g., having a train thereon). Accordingly, track circuit 108 deactivation may indicate a transition from an active state, where there is a short between the rails, to an inactive state where the rails are not electrically coupled. Track circuit 108 may communicate its state to train detection equipment 130. When track circuit 108 deactivates, train detection equipment 130 may start a track circuit inactive timer. The track circuit inactive timer may expire after a certain period of time. The period of time may be customized based on the properties of each individual track (e.g., track speeds, distances between motion detection zones 110 and track circuit 108, size of track circuit 108, customer preference, etc.).

At 404, railroad crossing 100 may be inactive. Railroad crossing 100 may be inactive when no preemption equipment (e.g., island circuit 106, track circuit 108, and/or motion detecting camera(s) 112) is detecting the presence of a train.

At 406, one or more motion detecting cameras 112 may detect motion. For example, motion detecting camera 112a may detect motion within its associated motion detection zone 110a, and/or motion detecting camera 112b may detect motion within its associated motion detection zone 110b. It will be appreciated from FIG. 1 that motion detecting cameras 112 may detect motion caused by a train entering motion detection zones 110 before the train shorts parallel rails in track circuit 108.

At 408, train detection equipment 130 may receive data indicating motion detection from at least one motion detecting camera 112. For example, as noted above, motion detecting cameras 112 may be connected wirelessly or by wire to equipment in crossing equipment bungalow 120, including train detection equipment 130. Train detection equipment 130 may receive messages from motion detecting cameras 112 indicating motion in associated motion detection zones 110. Train detection equipment 130 may communicate with event recorder 122 so event recorder 122 can record the motion detection event.

At 410, train detection equipment 130 may start an advanced preemption timer if the track circuit inactive timer has expired. As noted above, the track circuit inactive timer starts when a train first moves off track circuit 108. The train may need time to travel beyond track circuit 108, through motion detection zone 110, and beyond. Accordingly, while the track circuit inactive timer is running, the advanced preemption system may be expecting motion in motion detection zone 110 from the known train passing through motion detection zone 110. Thus, train detection equipment 130 may start the advanced preemption timer only after the track circuit inactive timer has expired.

At 412, train detection equipment 130 may activate its preemption output 118. Traffic signal control equipment 116 may detect this preemption output 118 from train detection equipment 130.

At 414, traffic signal control equipment 116 may adjust traffic signals 104 in response to receiving preemption output 118. For example, traffic signal control equipment 116 may hold traffic signals 104 at red while preemption output 118 is active to prevent traffic from moving into railroad crossing 100. In some embodiments, crossing activation equipment 128 may also receive preemption output 118 and control crossing access control equipment 102 in response to receiving preemption output 118. However, in other embodiments, because preemption output 118 may be based on input from a non-vital system (e.g., motion detecting cameras 112), crossing activation equipment 128 may control crossing access control equipment 102 only in response to track circuit 108 and/or island circuit 106 detecting the presence of a train.

In the example of FIG. 4, traffic signal control equipment 116 receives preemption output 118 from train detection equipment 130. As noted above, train detection equipment 130 may also control crossing access control equipment 102 in response to detecting a train on track circuit 108 and/or island circuit 106. Routing preemption data through train detection equipment 130 to traffic signal control equipment 116 may allow the advanced preemption system to be installed at railroad crossings 100 where train detection equipment 130 and track circuit 108/island circuit 106 systems are already in place, using the same train detection equipment 130 to perform basic track circuit-based preemption and advanced preemption. Routing preemption data through train detection equipment 130 to traffic signal control equipment 116 may also coordinate control of traffic signals 104 and crossing access control equipment 102.

At 416, track circuit 108 may activate as the train moves past motion detection zone 110 and onto track circuit 108.

At 418, island circuit 106 may activate as the train moves onto island circuit 106.

At 420, island circuit 106 may deactivate as the train moves off island circuit 106. At this point, the train may be clear of railroad crossing 110.

At 422, in response to deactivation of island circuit 106, all preemption signals (e.g., preemption output 118) may deactivate, indicating that railroad crossing 100 is now safe to cross.

At 424, in response to deactivation of preemption signals, crossing access control equipment 102 and traffic signals 104 may resume normal operation, allowing traffic from the thoroughfare to enter railroad crossing 100.

Returning to 410, the advanced preemption timer may expire if track circuit 108 does not activate within a certain period of time. The period of time may be customized based on the properties of each individual track (e.g., track speeds, distances between motion detection zones 110 and track circuit 108, size of track circuit 108, customer preference, etc.). The advanced preemption timer may expire without track circuit 108 activating in cases where a train enters motion detection zone 110 and stops before reaching track circuit 108. Train detection equipment 130 may not activate its advanced preemption output 124 when the advanced preemption timer is not active (e.g., after it expires). This may prevent unnecessary activation of crossing access control equipment 102 and/or traffic signals 104 when the train does not reach railroad crossing 100.

FIG. 5 is an advanced preemption process 400 according to an embodiment of the invention. Advanced preemption system elements of FIG. 1 may work together to perform this process 500 to help prevent accidents at railroad crossing 100. This example process 500 is for a single track with two motion detection zones 110 outside the boundaries of track circuit 108, as shown in FIG. 1, although it may be applied to railroad crossings 100 with different configurations as well. Process 500 may begin when there is no train on track circuit 108.

At 502, one or more motion detecting cameras 112 may detect motion. For example, motion detecting camera 112a may detect motion within its associated motion detection zone 110a, and/or motion detecting camera 112b may detect motion within its associated motion detection zone 110b. It will be appreciated from FIG. 1 that motion detecting cameras 112 may detect motion caused by a train entering motion detection zones 110 before the train shorts parallel rails in track circuit 108.

At 504, traffic signal control equipment 116 may receive data indicating motion detection from at least one motion detecting camera 112. For example, motion detecting cameras 112 may be connected wirelessly or by wire to equipment in vehicle traffic signal control box 114, including traffic signal control equipment 116. Traffic signal control equipment 116 may receive messages from motion detecting cameras 112 indicating motion in associated motion detection zones 110.

At 506, traffic signal control equipment 116 may adjust traffic signals 104. For example, traffic signal control equipment 116 may hold traffic signals 104 at red while traffic

signal control equipment 116 is receiving messages from motion detecting cameras 112 indicating motion in associated motion detection zones 110 to prevent traffic from moving into railroad crossing 100.

At 508, traffic signal control equipment may maintain traffic signals 104 at red to prevent traffic from moving into railroad crossing 100 until traffic signal control equipment 116 is no longer receiving messages from motion detecting cameras 112 indicating motion in associated motion detection zones 110. Additionally, traffic signal control equipment may further require indication that track circuit 108 and/or island circuit 106 are no longer detecting a train to switch traffic signals 104 from red.

As mentioned above, motion detecting cameras 112 may be non-vital. This may be possible because if no motion is detected by motion detecting cameras 112 prior to track circuit 108 becoming active, train detection equipment 130 will activate its preemption output 118 in response to track circuit 108 activity. Traffic signal control equipment 116 may detect preemption output 118 and control traffic signals 104. This is backup logic used in case a motion detecting camera 112 experiences a malfunction.

The above-described systems may require less setup and may have a smaller footprint than other train detection systems. The above-described systems may provide a relatively low cost and low maintenance approach while also getting the railroads more familiar with camera technology that may be used in future applications. Pairing camera technology with event recorders and other crossing equipment may have many future uses such as crossing light out detection, crossing gate level detection, the monitoring of movements within train yards, intrusion detection, automated inspections, and more. The above-described systems may be set up completely isolated from the railroad if desired, pushing more of the advanced preemption burden back on the municipalities over time. For example, the advanced preemption systems described above may be installed and maintained by the same entities that install and maintain municipal traffic signals in some embodiments.

While various embodiments have been described above, it should be understood that they have been presented by way of example and not limitation. It will be apparent to persons skilled in the relevant art(s) that various changes in form and detail can be made therein without departing from the spirit and scope. In fact, after reading the above description, it will be apparent to one skilled in the relevant art(s) how to implement alternative embodiments. Other steps may be provided, or steps may be eliminated, from the described flows, and other components may be added to, or removed from, the described systems. Accordingly, other implementations are within the scope of the following claims.

In addition, it should be understood that any figures which highlight the functionality and advantages are presented for example purposes only. The disclosed methodology and system are each sufficiently flexible and configurable such that they may be utilized in ways other than that shown.

Although the term “at least one” may often be used in the specification, claims and drawings, the terms “a”, “an”, “the”, “said”, etc. also signify “at least one” or “the at least one” in the specification, claims and drawings.

Finally, it is the applicant’s intent that only claims that include the express language “means for” or “step for” be interpreted under 35 U.S.C. 112(f). Claims that do not expressly include the phrase “means for” or “step for” are not to be interpreted under 35 U.S.C. 112(f).

CLAIMS

What is claimed is:

1. An advanced preemption system comprising:
 - at least one motion detector configured to detect motion within at least one motion detection zone, the at least one motion detection zone containing a section of railroad track outside of a track circuit containing a railroad crossing where a thoroughfare crosses the railroad track; and
 - at least one advanced preemption processing system in communication with the at least one motion detector and configured to:
 - receive, from the at least one motion detector, an indication that motion has been detected within the at least one motion detection zone; and
 - activate at least one traffic control element for the thoroughfare before a train enters the track circuit.
2. The system of claim 1, wherein the at least one motion detector comprises at least one camera.
3. The system of claim 1, wherein the at least one advanced preemption processing system comprises an event recorder configured to receive the indication and generate an advanced preemption output in response to the indication.
4. The system of claim 3, wherein the event recorder is further configured to log the indication in a memory.
5. The system of claim 1, wherein the at least one advanced preemption processing system comprises train detection equipment configured to generate a preemption output in response to the indication.
6. The system of claim 5, wherein the train detection equipment is further configured to generate the preemption output in response to the track circuit detecting a train on the track circuit.
7. The system of claim 1, wherein the at least one traffic control element comprises crossing access control equipment configured to selectively control access to the

railroad crossing from the thoroughfare, the system further comprising crossing activation equipment configured to activate the crossing access control equipment in response to the indication.

8. The system of claim 1, wherein the at least one traffic control element comprises at least one traffic signal for the thoroughfare, the system further comprising traffic signal control equipment configured to control the at least one traffic signal in response to the indication.
9. The system of claim 1, wherein:
 - the least one advanced preemption processing system is further configured to start a timer in response to a train leaving the track circuit; and
 - activate the at least one traffic control element in response to both the indication and an expiration of the timer.
10. The system of claim 1, wherein:
 - the least one advanced preemption processing system is further configured to start a timer in response to the indication; and
 - activate the at least one traffic control element in response to both the indication and an expiration of the timer.
11. The system of claim 1, further comprising the track circuit, the at least one traffic control element, or a combination thereof.
12. An advanced preemption method comprising:
 - detecting, by at least one motion detector, motion within at least one motion detection zone, the at least one motion detection zone containing a section of railroad track outside of a track circuit containing a railroad crossing where a thoroughfare crosses the railroad track;
 - receiving, by at least one advanced preemption processing system in communication with the at least one motion detector, an indication from the at least one motion detector that motion has been detected within the at least one motion detection zone; and

activating, by the at least one advanced preemption processing system, at least one traffic control element for the thoroughfare before a train enters the track circuit.

13. The method of claim 12, further comprising:

receiving, by an event recorder of the at least one advanced preemption processing system, the indication; and

generating, by the event recorder, an advanced preemption output in response to the indication.

14. The method of claim 13, further comprising logging, by the event recorder, the indication in a memory.

15. The method of claim 12, further comprising:

generating, by train detection equipment of the at least one advanced preemption processing system, a preemption output in response to the indication.

16. The method of claim 15, further comprising generating, by the train detection equipment, the preemption output in response to the track circuit detecting a train on the track circuit.

17. The method of claim 12, wherein the at least one traffic control element comprises crossing access control equipment configured to selectively control access to the railroad crossing from the thoroughfare, the method further comprising activating, by crossing activation equipment of the at least one advanced preemption processing system, the crossing access control equipment in response to the indication.

18. The method of claim 12, wherein the at least one traffic control element comprises at least one traffic signal for the thoroughfare, the method further comprising controlling, by crossing activation equipment of the at least one advanced preemption processing system, the at least one traffic signal in response to the indication.

19. The method of claim 12, further comprising:

starting, by the least one advanced preemption processing system, a timer in response to a train leaving the track circuit; and

activating, by the least one advanced preemption processing system, the at least one traffic control element in response to both the indication and an expiration of the timer.

20. The method of claim 12, further comprising:

starting, by the least one advanced preemption processing system, a timer in response to the indication; and

activating, by the least one advanced preemption processing system, the at least one traffic control element in response to both the indication and an expiration of the timer.

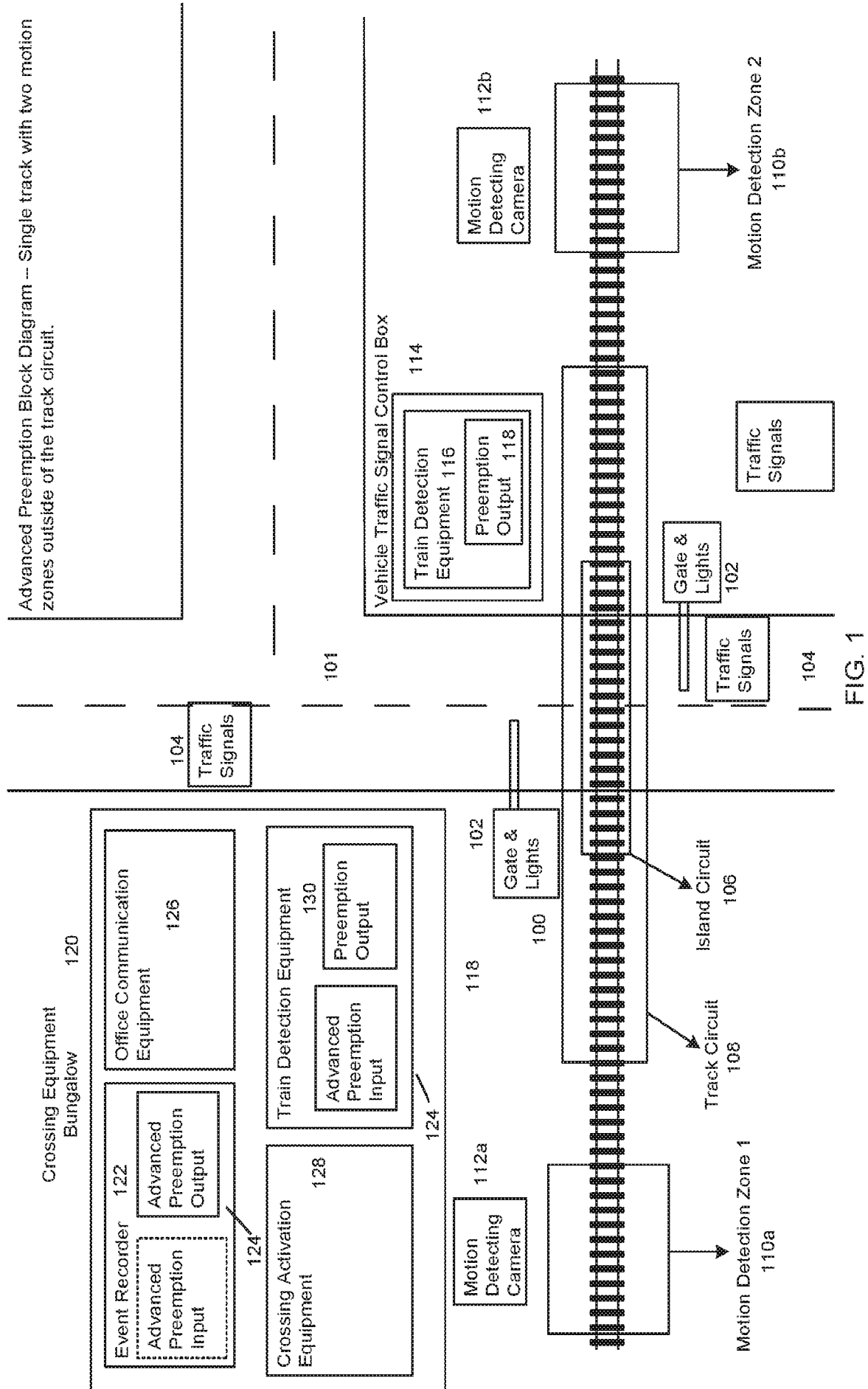


FIG. 1

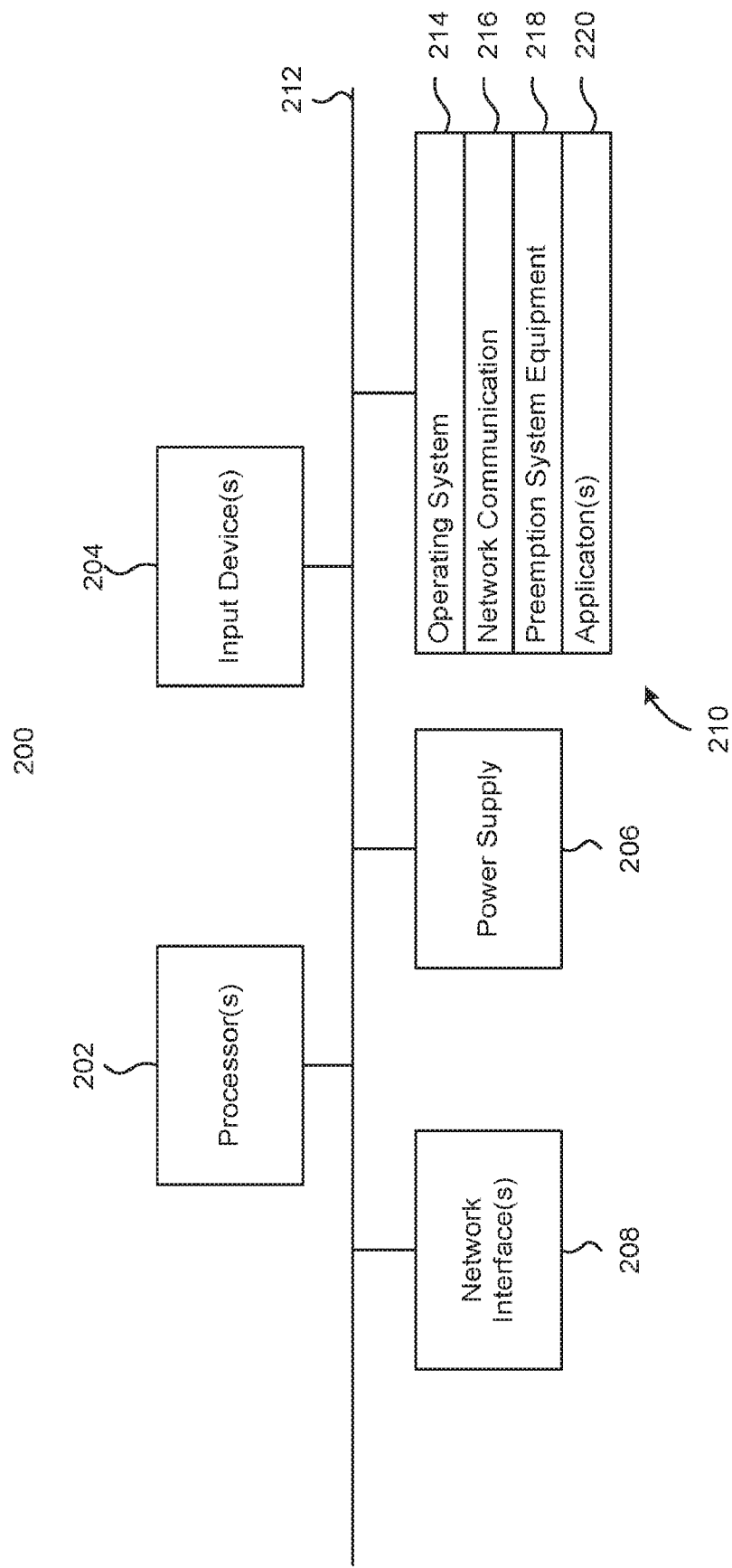


FIG. 2

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300

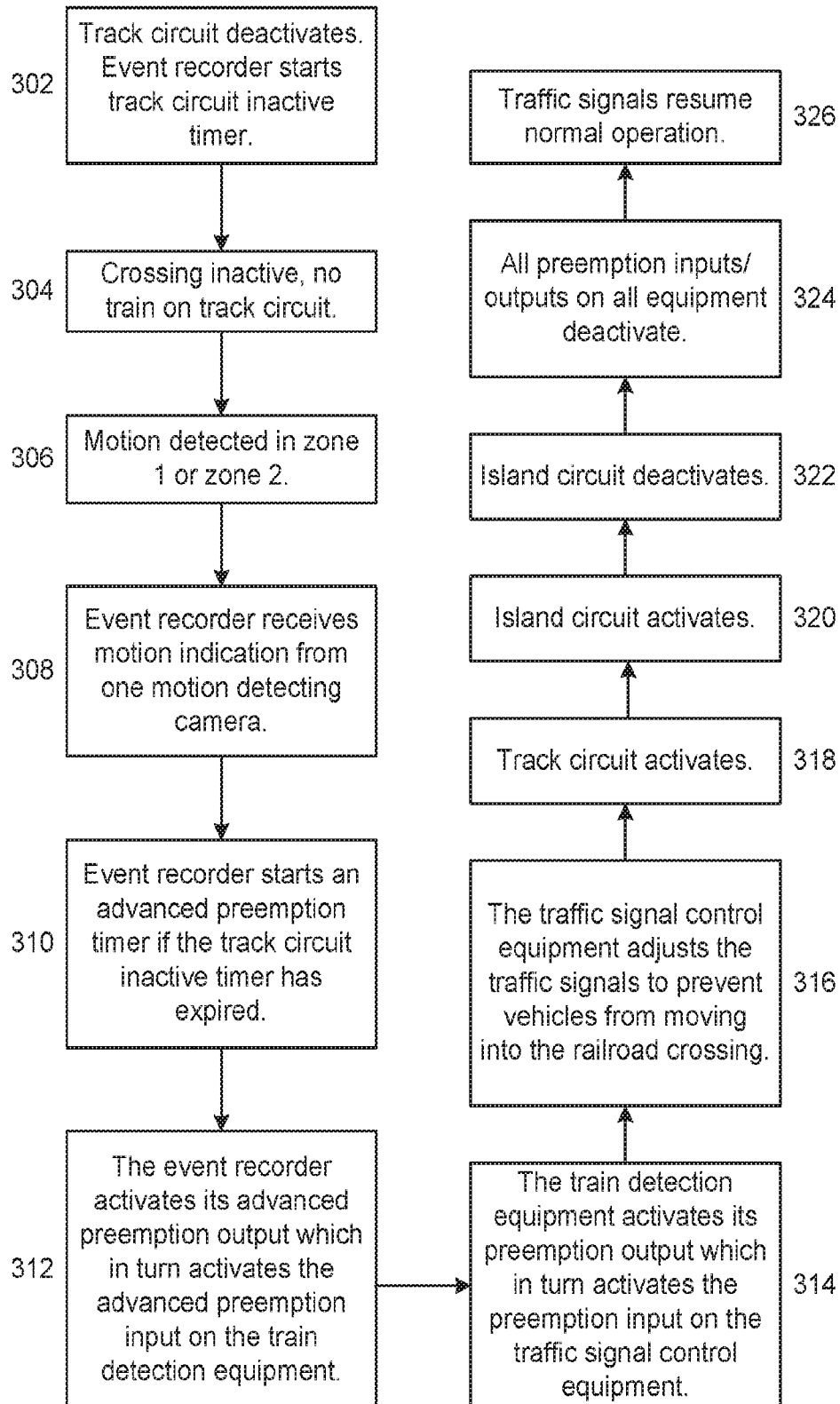


FIG. 3

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400

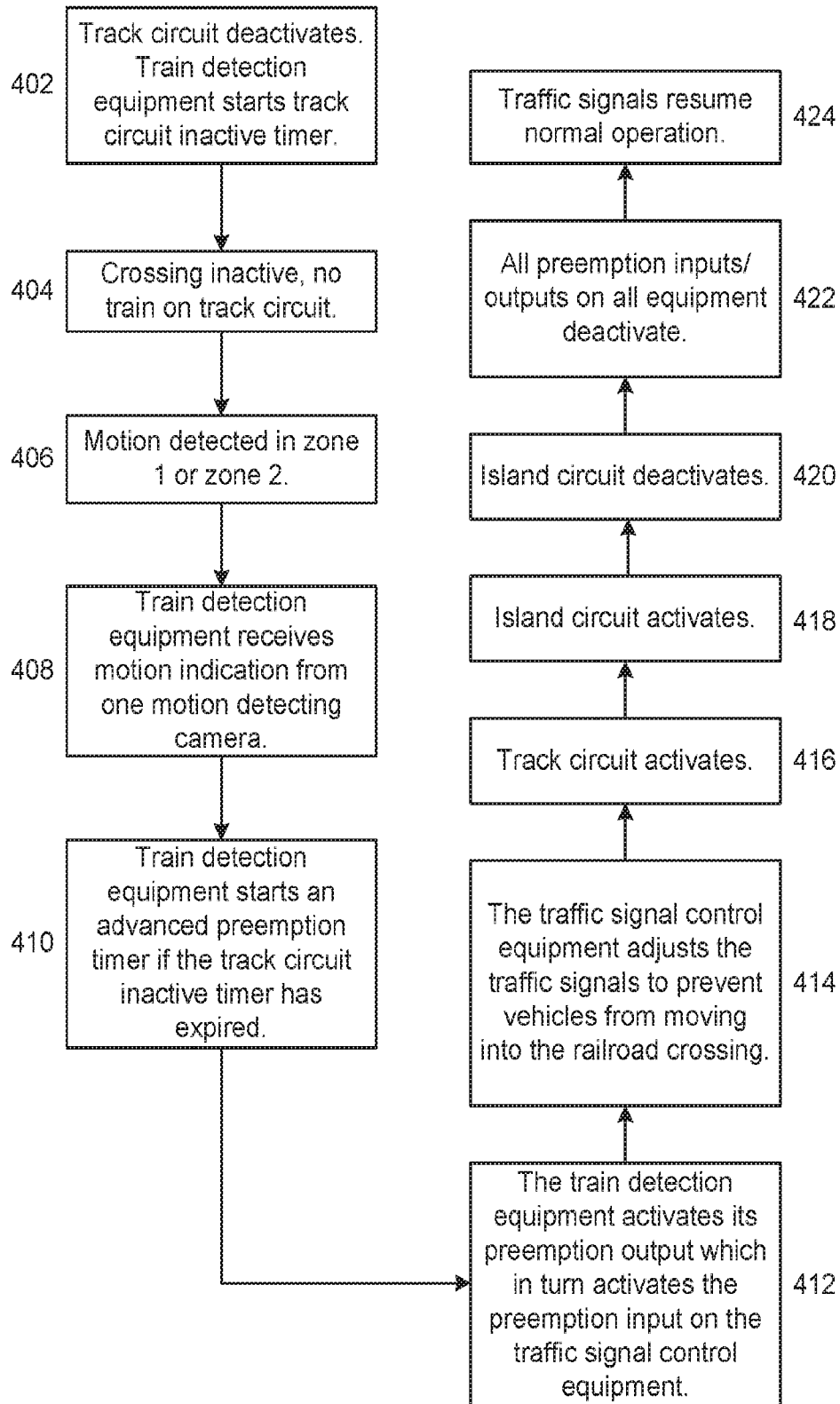


FIG. 4

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500

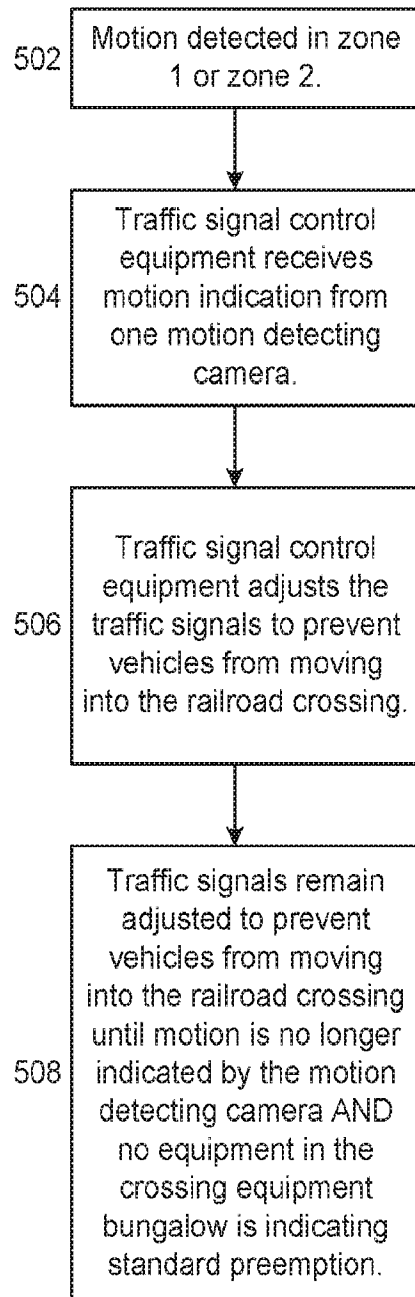


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/035579

A. CLASSIFICATION OF SUBJECT MATTER

INV. B61L29/32 B61L29/28 B61L29/30 B61L29/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2008/169939 A1 (DICKENS CHARLES E [US] ET AL) 17 July 2008 (2008-07-17) paragraph [0010] - paragraph [0071]; figures 1-9	1,3-8, 10-18,20 2
X	----- US 5 098 044 A (PETIT WILLIAM A [US] ET AL) 24 March 1992 (1992-03-24) column 3, line 3 - column 8, line 36	1,5-9, 11,12, 15-19
X	----- US 2005/184883 A1 (GRAHAM KEVIN M [US]) 25 August 2005 (2005-08-25) paragraph [0011] - paragraph [0025]; figures 1-5 ----- -/-	1,5,7,8, 12,15, 17,18



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

22 January 2018

Date of mailing of the international search report

30/01/2018

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/035579

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	WO 2011/153114 A2 (CENTRAL SIGNAL LLC [US]; BALDWIN DAVID E [US]; ASHRAF AHTASHAM [US]) 8 December 2011 (2011-12-08) page 8, lines 23-27 -----	2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/035579

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			WO 2011153114 A2 08-12-2011
			WO 2011153115 A2 08-12-2011