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(71) Applicant: WESTINGHOUSE AIR BRAKE COMPANY [US/US]; Air Brake Avenue, Wilmerding, PA 15148 (US).

(71)(72) Applicant and Inventor: HUNGATE, Joe, B. [US/US]; 700 33rd Avenue, Marion, IA 52302 (US).

(74) Agents: SEXTON, Forest, C. et al.; James Ray & Associates, 2640 Pitcairn Road, Monroeville, PA 15146 (US).

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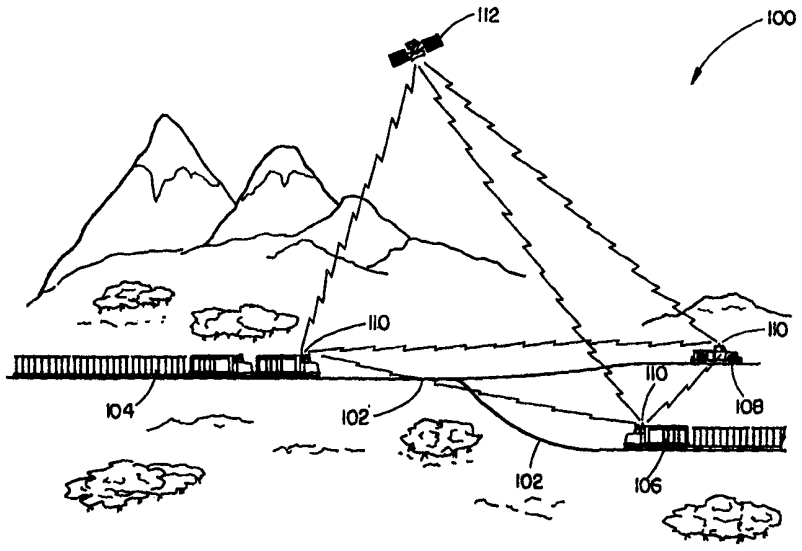

(57) Abstract

A system for alerting the crew of a rail vehicle (104, 106, 108) of the proximity of one or more other rail vehicles (104, 106, 108) is disclosed. The system includes a receiver (202) for receiving a signal from which the position of the rail vehicle (104, 106, 108) may be determined and a communication device (206) for receiving position information transmitted by other rail vehicles (104, 106, 108) operating in the area. The communication device (206) also transmits the vehicle's position to other equipped rail vehicles (104, 106, 108) operating in the area. A computer (210), operatively coupled to the receiver (202) and the communication device (206), determines the proximity and movement of other rail traffic in a selectable area based on the position of the rail vehicle determined by the receiver (202) and the position information received by the communication device (206). The computer (210) may then communicate this information to the crew via a user interface (212).

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TRAIN PROXIMITY ALERTING SYSTEM

BACKGROUND OF THE INVENTION

The present invention generally relates to railroad collision avoidance systems, and more particularly to a system for alerting the crew of a rail vehicle such as a train, maintenance-of-way vehicle, or the like of the proximity and movement of other rail traffic in the area so that the crew may take appropriate action if necessary.

In railroad operating environments, safe movement of rail vehicles such as trains, locomotives, maintenance-of-way vehicles, or the like is typically based on the concept of maintaining a safe separation distance between each vehicle. Safe separation distance is usually maintained by assigning each rail vehicle a limited authority of movement along a given section of track. This authority is communicated to the train crew via wayside equipment comprising a series of signals and switches placed along the track and controlled by a dispatcher centrally located in a control center or office. Preferably, the dispatcher monitors the movement of trains along the track and controls the signals and switches accordingly to ensure each train does not exceed its authority limit. Authority limits may further be communicated to the train crew by means of a two way radio link between a dispatcher and the crew.

Safe train separation is based on the assumption that all train movement authorities have been issued and are being acted upon with no errors and that the wayside signal system is functioning flawlessly. Due to human error, equipment malfunction, or the like, however, a rail vehicle may at times inadvertently exceed its authority limit. When this happens, the possibility exists for collision between two or more trains or a train and a maintenance-of-way vehicle. Further, the crew of a given train is not

usually aware of other rail vehicles in close proximity to their train. Consequently, the crew often can not be aware of a human or equipment error which may place them on a collision course with another vehicle.

True train collision avoidance (or global authority enforcement) requires vital on-board knowledge of authority limits, switch position, current location and train make-up. However, such a system may be extremely costly and difficult to develop and implement. Therefore, it is desirable to improve the safety of railroad operations by raising the awareness of a train crew or the operator of a maintenance-of-way vehicle of the proximity and movement of other rail traffic so that appropriate action may be taken if necessary to prevent a collision. It is also highly desirable to automatically stop a train if the train crew has not confirmed the physical separation of other rail traffic from their train within a given distance from that traffic.

SUMMARY OF THE INVENTION

Accordingly, the present invention provides a novel system for alerting the crew of a rail vehicle such as a train, locomotive, maintenance-of-way vehicle, or the like, of the proximity of other rail vehicles in the surrounding area. The system comprises a receiver for receiving a signal from which a position of the rail vehicle may be determined and a communication device, such as a radio frequency transceiver, for example, for receiving position information transmitted from other rail vehicles in the area. A computer is operatively coupled to the receiver and the communication device for determining the proximity and movement of other rail vehicles utilizing the position determined by the receiver and the position information received by the communication device. A user interface is operatively coupled to the computer for communicating the proximity and movement of other rail vehicles within a selectable area to the crew. Wherein the rail vehicle is a train, the system may be operatively coupled to the train's brake system for automatically stopping the train if the train crew has not confirmed the physical separation of other rail traffic from their train within a given distance from that traffic.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention claimed.

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention and together with the general description, serve to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The numerous objects and advantages of the present invention may be better understood by those skilled in the art by reference to the accompanying figures in which:

FIG. 1 illustrates a typical railroad operating environment wherein the rail vehicles operating in the environment are each equipped with the proximity alerting system according to an exemplary embodiment of the present invention;

FIG. 2 is a block diagram depicting apparatus for implementing the system shown in FIG. 1 in the locomotive of a train;

FIG. 3 is a block diagram depicting apparatus for implementing the system shown in FIG. 1 in a maintenance-of-way vehicle;

FIG. 4 is an overhead view illustrating the relative position of trains operating within a railroad operating environment;

FIG. 5 illustrates a display employed by the present system to communicate train proximity information to the crew of a rail vehicle;

FIG. 6 illustrates a display employed by the present system to communicate train proximity information to the crew of a rail vehicle; and

FIG. 7 is a block diagram depicting apparatus for modifying a train control system to provide the train proximity alerting system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the presently preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

Referring now to FIG. 1, a typical railroad operating environment is shown wherein rail vehicles operating in the environment are equipped with a proximity alerting system according to an exemplary embodiment of the present invention. The railroad operating environment 100 preferably comprises one or more sections of railed track 102 on which one or more rail vehicles may operate at any given time. Such rail vehicles may include all on-track and off-track equipment typically associated with the operation and maintenance of a railroad such as, for example, trains 104 & 106 and maintenance-of-way or hy-rail vehicles 108. The proximity alerting system of the present invention provides a method and apparatus for alerting the crew of each rail vehicle 104, 106 & 108 of the proximity of other rail traffic within a selectable area surrounding the rail vehicle so that the crew may take appropriate action if necessary.

Each rail vehicle 104, 106 & 108 may receive a signal from which the rail vehicle's position, velocity, and direction of travel may be determined. Preferably, each rail vehicle 104, 106 & 108 periodically transmits its determined position, velocity, and direction of travel along with its vehicle identification to all other rail vehicles operating within range of transmission. Each rail vehicle 104, 106 & 108 may also receive position information periodically transmitted from other rail vehicles operating within the railroad operating environment 100. This position information may include the other rail vehicles' identification, location,

velocity, and heading or direction of travel. For example, as shown in FIG. 1, train 104 may receive position information transmitted by train 106 and maintenance-of-way vehicle 108, train 106 may receive position information transmitted by train 104 and maintenance-of-way vehicle 108, and maintenance-of-way vehicle 108 may receive position information transmitted by trains 104 and 106. Each rail vehicle 104, 106 & 108 may then calculate the straight line distance between it and the other rail vehicles from which position information has been received. For example, as shown in FIG. 1, train 104 may calculate the distance between train 104 and train 106 and between train 104 and maintenance-of-way vehicle 108, train 106 may calculate the distance between train 106 and train 104 and between train 106 and maintenance-of-way vehicle 108, and maintenance-of-way vehicle 108 may calculate the distance between maintenance-of-way vehicle 108 and trains 104 & 106.

Wherein the rail vehicle is a train 104 & 106, an emergency brake application message may also be transmitted along with the position information in the event that train has an emergency brake application. In an emergency brake application, it is possible for a train to have some of its cars derail. Other rail vehicles that are approaching from the front or rear of the train or are currently passing the train may be alerted to this situation upon receiving the emergency message so that their crews may take appropriate action to avoid a possible collision.

Each rail vehicle 104, 106 & 108 may include a user interface (see FIGS. 2, 3, 5 and 6) for alerting its crew of the proximity and movement of other rail vehicles operating within a selectable area surrounding that rail vehicle so that the crew may take appropriate action if necessary. The

user interface may provide information such as, for example, the identification of other rail vehicles within the selectable area, the distance of other rail vehicles from the crew's vehicle, the velocity of each rail vehicle, the heading or direction of travel of each rail vehicle, and the location of other rail vehicles with respect to the crew's vehicle.

The crew of each rail vehicle 104, 106 & 108 may periodically be required to acknowledge that their respective rail vehicle 104, 106 & 108 is not on a collision course with another rail vehicle in the area. If the crew fails to provide this acknowledgment within a predetermined time of receiving an alert of the proximity of the other vehicle, the system may automatically take appropriate action until such acknowledgment is received. For example, wherein the rail vehicle is a train 104 & 106, the system may apply brakes to slow or stop the train if the system determines that the train is approaching another rail vehicle and is within a predetermined range. Similarly, wherein the rail vehicle is a maintenance-of-way vehicle 108, the system may sound the vehicle's horn if the system determines that other rail vehicles are within a predetermined distance of the maintenance-of-way vehicle, thereby alerting the vehicle's crew of the proximity of other rail traffic and allowing the crew to take appropriate action. The horn may be sounded in short bursts for a predetermined period of time, for example 15 seconds, to provide a distinguishable alert to the crew.

Each rail vehicle 104, 106 & 108 is preferably equipped with a receiver 110 for receiving a signal from which a position of the rail vehicle may be determined. Preferably, the receivers are capable of receiving a geo-referencing signal from a global positioning system in order to

accurately geo-reference the positions of each rail vehicle 104, 106 & 108. The global positioning system is preferably the Global Positioning System (GPS), a space-based radio-navigation system managed by the U.S. Air Force for the Government of the United States. The Government provides civilian access to the Global Positioning System which is called the Standard Positioning Service (SPS). The Standard Positioning Service is intentionally designed to provide a positioning capability which is less accurate than the positioning service provided to military operators, however various techniques have been developed to improve the accuracy of the civilian positioning service wherein position accuracy of one to five meters may be achieved.

The system of the present invention may be utilized in conjunction with the Global Positioning System (GPS) to accurately geo-reference the position of each rail vehicle in the railroad operating environment 100. The receivers 110 may receive a reference signal from a satellite 112 operating as part of the GPS satellite constellation. Typically, the signals from at least three satellites are required to derive a coordinate position solution. Further reference signals which are not part of the government operated GPS system may also be used in order to compensate for the degraded civilian GPS signal (which may be transmitted as an FM carrier sublink by land based or space based locations or by an RS-232 data bus, for example). Such correcting signals may be provided by a third-party differential correction service provider. Other ways of correcting the degraded civilian signal may also be utilized which do not require an independent correcting signal to be transmitted. For example, signal processing techniques such as cross correlation of the military signal and

the civilian signal may be utilized to improve the accuracy of the civilian signal.

Turning now to FIG. 2, a block diagram depicting apparatus for implementing the proximity alerting system in the locomotive of a train is shown. The system 200 preferably comprises a receiver 202 and antenna 204 for receiving a signal from which the train's position may be determined. The receiver may be a Global Positioning System (GPS) receiver capable of receiving a geo-referencing signal from a global positioning system from which a geo-referenced coordinate position (e.g., latitude and longitude) may be determined. A communication device 206, such as a low powered UHF, VHF, or spread spectrum radio frequency (RF) transceiver and antenna 208 may receive position information from one or more other rail vehicles operating within a limited area surrounding the communication device 206, for example 10 square miles. The received position information may include, for example, the other rail vehicles' identification, coordinate position (e.g., latitude and longitude), velocity, heading (i.e., direction of travel), and for a train, an emergency brake application message if necessary. The communication device 206 and antenna 208 may also communicate the train's identification, position, velocity, and heading to other rail vehicles operating within range of transmission. A computer 210 may be operatively coupled to the receiver 202 and the communication device 206. The computer 210 may calculate the train's velocity and heading (i.e., direction of travel) utilizing the position information from the receiver 202. The computer 210 may then determine the proximity of (i.e., distance to) other rail vehicles based on the train's position, velocity and heading and the position information

received from the other rail vehicles via the communication device 206.

The computer 210 may further provide an event recorder which comprises a memory for electronically storing a historical record of the movement of the train and other rail traffic detected by the system 200. Preferably, the crew may recall this history to assist in determining if their train may be on a collision course with another rail vehicle. The historical record may also be periodically downloaded from the computer 210 and stored, or, alternatively, analyzed by railroad officials to, for example, facilitate an accident investigation or to improve the flow of rail traffic along a particular section of track.

A user interface 212 may be operatively coupled to the computer 210 to alert the train's crew of the proximity of other rail vehicles so that the crew may take appropriate action if necessary. Preferably, the user interface 212 includes a display such as a cathode ray tube (CRT) display, liquid crystal display (LCD) or the like for displaying information to the crew of the train. This information may include, for example, the velocity and heading of the train, the identification of other rail vehicles within a selectable area surrounding the train, the distance of other rail vehicles from the train, the velocity and heading of other rail vehicles, and the location of other rail vehicles with respect to the train (see FIGS. 5 and 6). The user interface 212 may further include crew input apparatus 214 such as a keyboard, keypad, touch panel overlay, or the like for accepting input from the crew, such as acknowledgment of the proximity of other rail vehicles and input of the train's identification. Vehicle identification 216 may also be directly provided by the train itself via connection to other lead locomotive systems. An audible alert apparatus 218 such as a horn,

siren, beeper, loudspeaker, or the like may be operationally coupled to the computer 210 to provide an audible alert to the train's crew of the proximity of another rail vehicle.

The system 200 may be operatively coupled to the brake system of the train via a brake system interface 220. The train's crew may periodically be required to acknowledge via the crew input apparatus 214 that the train is not on a collision course with other rail traffic in the area. If the crew fails to provide this acknowledgment within a predetermined time of receiving an alert of the proximity of another rail vehicle, the system may automatically stop the train if the system determines that the train is approaching another rail vehicle and is within a predetermined distance, for example, 2 miles of that vehicle. Further, the system 200 may be disabled by the crew or operator when the maintenance-of-way vehicle is in yard areas where the vehicle density will be too high for the proximity alerting system to be of benefit, or if the system 200 experiences a failure preventing it from functioning properly.

Referring now to FIG. 3, a block diagram depicting apparatus for implementing the proximity alerting system in a maintenance-of-way vehicle is shown. The system 300 preferably comprises a receiver 302 and antenna 304 for receiving a signal from which the maintenance-of-way vehicle's position may be determined. The receiver may be a Global Positioning System (GPS) receiver capable of receiving a geo-referencing signal from a global positioning system from which a geo-referenced coordinate position (e.g., latitude and longitude) may be determined. A communication device 306, such as a low powered UHF, VHF, or spread spectrum radio frequency (RF) transceiver and antenna 308 may receive

position information from one or more other rail vehicles operating within a limited area surrounding the communication device 306, for example a 10 mile radius. The received position information may include, for example, the other rail vehicles' identification, position, velocity, direction of travel, and for a train, an emergency brake application message. The communication device 306 and antenna 308 may also communicate the maintenance-of-way vehicle's identification, position, velocity, and direction of travel to other rail vehicles operating within range of transmission. Preferably, both the receiver 302 and communication device 306 comprise portable units mountable within the cab of the maintenance-of-way vehicle. Similarly, the antennas 304 & 308 may be integral to the receiver 302 and communication device 306 or, alternatively, may be mounted to an exterior surface of the maintenance-of-way vehicle.

A computer 310, such as a portable, laptop, or notebook computer, for example, may be operatively coupled to the receiver 302 and the communication device 306. The computer 310 may calculate the maintenance-of-way vehicle's velocity and heading (i.e., direction of travel) utilizing the position information from the receiver 302. The computer 310 may then determine the proximity of (i.e., distance to) other rail vehicles based on the maintenance-of-way vehicle's position, velocity and heading and the position information received from the other rail vehicles via the communication device 306.

The computer 310 may provide a user interface to alert the maintenance-of-way vehicle's crew or operator of the proximity of other rail vehicles so that the crew or operator may take appropriate action if

necessary. For example, the computer 310 may include a display such as a liquid crystal display (LCD) for displaying information to the crew or operator of the maintenance-of-way vehicle. This information may include, for example, the identification of other rail vehicles within a selectable area surrounding the maintenance-of-way vehicle, the distance of other rail vehicles from the maintenance-of-way vehicle, the velocity of each rail vehicle, the heading of each rail vehicle, and the location of all other rail vehicles with respect to the maintenance-of-way vehicle (see FIGS. 5 and 6). The computer 310 may further include a keyboard, keypad, touch panel overlay, or the like for accepting input from the crew or operator of the maintenance-of-way vehicle such as, for example, acknowledgment of the proximity of other rail vehicles and input of the vehicle identification into the computer 310. Vehicle identification 312 may also be directly provided by the maintenance-of-way vehicle itself via connection to other onboard systems.

The computer 310 may be operatively coupled to the horn 314 of the maintenance-of-way vehicle. Preferably, the computer 310 automatically sounds the horn 314 if it determines that the maintenance-of-way vehicle is approaching or being approached by another rail vehicle and is within a predetermined distance, for example, 2 miles, of that vehicle. Further, the system 300 may be disabled by the crew or operator when the maintenance-of-way vehicle is in yard areas where the vehicle density will be too high for the proximity alerting system to be of benefit, or if the system 300 experiences a failure preventing it from functioning properly.

Turning now to FIG. 4, a typical railroad operating environment

having one or more rail vehicles operating therein is shown. The railroad operating environment 400 may include a main track 402 on which rail vehicles may operate. For illustration purposes, the track 402 has been broken into straight segments in FIG. 4. However, the track 402, as shown in FIG. 4, is intended to represent a single continuous length of track which may have both straight and curved sections therein. Additionally, although a single track 402 is shown, it will be appreciated that two or more parallel tracks may be laid adjacent to each other to allow rail traffic to travel in either direction. The track 402 may have interconnected therewith sidings or passing tacks 404 which comprise shortened sections of track generally running parallel to the main track 402. Rail vehicles such as trains 406, 408, 410, 412, 414 & 416 may travel along the main track 402 or may be moved off the main track 402 onto the sidings 404 to allow other trains to pass.

Typically, safe operation of all rail vehicles in the railroad operating environment may be accomplished by assigning each train 406, 408, 410, 412, 414 & 416 a limited authority of movement along the track 402. This authority is communicated to the train crews via wayside equipment such as signals and switches placed along the track and controlled by a dispatcher who is preferably centrally located in a control center or office. The dispatcher monitors the movement of trains along the track and controls the signals and switches accordingly to ensure each train does not exceed its authority limit. Authority limits may further be communicated to the train crews by means of a two way voice radio link between a dispatcher and the train crew.

Due to human error, equipment malfunction, or the like, a train may

at times inadvertently exceed its authority limit. When this happens, the possibility exists for a collision between two or more trains or a train and a maintenance-of-way vehicle. The present system provides a proximity alerting system for alerting the crew of the locomotive of a train (or a maintenance-of-way vehicle) of the proximity and movement of other rail vehicles which may have exceeded their authority limit. In this manner, the system improves the safety of railroad operations by raising the awareness of the crew of a train (or maintenance-of-way vehicle) so they may ascertain if their train (or maintenance-of-way vehicle) is on a collision course with another rail vehicle and take appropriate action.

As shown in FIGS. 4, 5 and 6, each train 406, 408, 410, 412, 414 & 416 may be assigned an identification number which may be, for example, an identification number given to its lead locomotive. This is illustrated in FIG. 4, wherein train 406 is assigned its lead locomotive identification number "9999", train 408 is assigned its lead locomotive identification number "7200", train 410 is assigned its lead locomotive identification number "8759", train 412 is assigned its lead locomotive identification number "7800", train 414 is assigned its lead locomotive identification number "9249", and train 416 is assigned its lead locomotive identification number "6903". As shown in FIG. 4, each train 406, 408, 410, 412, 414 & 416 may be traveling in the direction indicated by the arrow next to its lead locomotive identification number.

Rail vehicles utilizing the present system may each have a user interface which may include a display for visually displaying the proximity and movement of other rail vehicles that are within a user selectable range. The system computer may include software for displaying

information in both graphical and list type formats on the display. The display may also allow the crew to recall a historical record of the movement of their rail vehicle and other rail traffic to assist them in determining if their vehicle may be on a collision course with another rail vehicle. FIGS. 5 and 6 depict, for illustration purposes, exemplary display screens 500 & 600 which may be displayed by the user interface of train "9999" 406 shown in FIG. 4. These display screens 500 & 600 may display proximity and movement information for the other trains 408, 410, 412, 414 & 418 operating within the area surrounding train "9999" 406.

Referring now to FIG. 5, a display screen having a graphical format for displaying rail vehicle proximity information is shown. The screen 500 may include a "bulls-eye" type range graphic 502 which may be segmented into radially distributed circular bands to show rail vehicles that are within a certain range. Each rail vehicle may be represented within the range graphic 502 by its identification number along with an "x" indicating its position. A tabular or list graphic 504 may be displayed adjacent to the range graphic 502. The list graphic 504 preferably provides specific information for each rail vehicle displayed by the range graphic 502. A rail vehicle information graphic 506 may be displayed, for example, above the range graphic 502 and list graphic 504 to provide selected information about the crew's vehicle such as its identification number, heading, and velocity or speed.

The range graphic 502 may be segmented into a plurality of circular bands each representing a range of radial distances surrounding the rail vehicle. For example, the range graphic 502 may be segmented into a circular outer band 508 representing a 4-6 mile range, an

intermediate band 510 representing a 2-4 mile range, and an inner band 512 representing a 2 mile range immediately surrounding the vehicle. The rail vehicle may be represented by an arrow and its identification number (e.g., "9999") 514 positioned at the center of the graphic 502. The arrow preferably indicates the rail vehicle's heading. Each rail vehicle detected by the system may be represented by its identification number displayed at a position within the band corresponding that vehicle's distance away from the crew's vehicle.

The list graphic 504 may include an entry 518 for each rail vehicle displayed by the range graphic 502. Each entry 518 may provide information, such as, for example, the vehicle identification number, the heading or direction of travel, and the speed or velocity for a specific rail vehicle displayed by the range graphic 502. The list graphic information is preferably keyed to the range graphic 502 via vehicle identification number.

According to an exemplary embodiment of the invention, the crew of the rail vehicle must manually acknowledge each train (or maintenance-of-way vehicle) shown on the display 500 as it moves into the outer band 508 or progressively moves from a band into the next innermost band (e.g., when the train moves from the outer band (4-6 mile range) 508 into the intermediate band (2-4 mile range) 510, and again when the train moves from the intermediate band (2-4 mile range) 510 into the inner band (2 mile range) 512. By forcing the crew to acknowledge changes in the position of surrounding rail vehicles, the crew's awareness of the movement of those vehicles may be enhanced so that those vehicles may be contacted via voice radio to determine if they are in fact on a collision

course.

Preferably, when a train (or maintenance-of-way vehicle) moves from one band into another, the representation of that train displayed by the range graphic 502 may be highlighted by the user interface. Similarly, the entry 516 on the list graphic 504 corresponding to the train may be highlighted and a pointer or cursor 524 may automatically be positioned next to that entry. Additionally, an audible alert may be sounded to draw the crew's attention to the display (see FIGS. 2, 3, and 7). A member of the crew, for example the engineer of the train must then acknowledge the change in position of the train (or maintenance of way vehicle) by, for example, touching an acknowledgment ("ACK") button 520 displayed on the screen (if the display includes a touch sensitive panel overlay), or alternatively depressing a separate pushbutton disposed near the display (not shown). Up and down scroll arrow buttons 522 may be provided to scroll the cursor 524 to other highlighted areas of the list graphic 504 in case more than one rail vehicle must be acknowledged by the crew. Preferably, the crew is not required to acknowledge the movement of a rail vehicle from an inner band to an outer band, since such movement is away from the crew's vehicle and reduces the threat of a collision. Similarly, when a rail vehicle moves out of the displayed area altogether, that vehicle will automatically be dropped from the display and the crew will not be required to acknowledge its removal.

The range graphic 502 shown in FIG. 5 indicates that there are two trains (lead locomotive identification numbers "7200" and "9429") within 2 miles, two trains (lead locomotive identification numbers "8759" and "6903") within 2-4 miles, and one train (lead locomotive identification

number "7800") within 4-6 miles of the crew's train (lead locomotive identification number "9999"). From the list graphic 504, the crew may determine that train "7200" is traveling east at 15 miles per hour, trains "8759" and "7800" are each traveling west at 10 miles per hour, and trains "9429" and "6903" are each traveling east at 35 miles per hour and 15 miles per hour respectively. Train "7200" has just moved into the inner band (2 mile range) 512 from the intermediate band (2-4 mile range) 510. The crew of train "9999" must acknowledge that they are aware of the position and movement of train "7200". The entry for train "7200" 516 is highlighted and the cursor 524 is moved automatically to that entry. Additionally, an audible alert may be sounded. A member of the crew, such as the engineer, may now acknowledge the position and movement of train "7200" to the system by pressing the "ACK" button 520. If the crew fails to acknowledge the position and movement of train "7200" within a predetermined time period, for example within 6 to 10 seconds, the system may automatically apply the train's brakes since train "7200" is within the inner band (2 mile range). The engineer may then confirm that train "7200" is not on a collision course with train "9999" via voice radio, for example.

Turning now to FIG. 6, the crew of the rail vehicle may also choose to display rail vehicle proximity information in a list format. The list format screen 600 segregates rail traffic according to the distance that traffic is away from the rail vehicle. For example, the list format screen 600 may be segmented to show rail vehicles that are within a 4-6 mile range 602, a 2-4 mile range 604, and a 2 mile range 606 in front of the vehicle, as well as a 4 mile range 608 to the rear of the vehicle. Rail traffic to the side of

the crew's vehicle may be similarly represented on a separate screen or by scrolling downward on the present screen utilizing the up and down arrow keys 618. The list screen 600 may display each rail vehicle's identification, velocity, and heading or direction of travel as separate columns of a table or list.

The crew of the rail vehicle may be required to manually acknowledge each train (or maintenance-of-way vehicle) shown on the display 600 as it progressively moves from one range into the next provided the next range is closer to the vehicle (e.g., when it moves from the 4-6 mile range in front of the train 602 into the 2-4 mile range in front of the train 604 and when it moves from the 4-6 mile range in front of the vehicle 604 into the 2 mile range 606). Preferably, when a train (or maintenance-of-way vehicle) moves from one range into another, the entry 612 corresponding to the train may be highlighted and a pointer or cursor 614 may automatically be positioned next to that entry. Additionally, an audible alert may be sounded to draw the crew's attention to the display (see FIGS. 2, 3, and 7). A member of the crew, for example the engineer of the train, must then acknowledge the change in proximity of the train (or maintenance-of-way vehicle) by depressing an acknowledgment ("ACK") pushbutton 616 disposed near the display, or, alternatively, by touching an acknowledgment ("ACK") button displayed on the screen if the display includes a touch sensitive panel overlay (see FIG. 5). Up and down scroll arrow pushbuttons 618 may be provided to scroll the cursor 614 to another highlighted area of the list in case more than one rail vehicle must be acknowledged by the crew at once. Preferably, when a rail vehicle moves out of the displayed area altogether, that

vehicle will automatically be dropped from the display and the crew will not be required to acknowledge its removal.

The list screen 600, shown in FIG. 6, indicates that there is one train (lead locomotive identification number "7200") within 2 miles traveling east at 15 miles per hour, one train (lead locomotive identification number "8759") within 2-4 miles traveling west at 10 miles per hour, one train (lead locomotive identification number "7800") within 4-6 miles traveling west at 10 miles per hour, and two trains (lead locomotive identification numbers "9429" and "6903") within 4 miles to the rear traveling east at 35 miles per hour and 15 miles per hour respectively. Train "7200" has just moved into the 2 mile range 606 from the 2-4 mile range 604. The crew of train "9999" must acknowledge that they are aware of the position and movement of train "7200". Preferably, the entry for train "7200" 612 is highlighted and the cursor 614 is moved automatically to that entry. Additionally, an audible alert may be sounded. A member of the crew, such as the engineer, may now acknowledge the position and movement of train "7200" to the system by pressing the "ACK" pushbutton 616. If the crew fails to acknowledge the position and movement of train "7200" within a predetermined time period, for example, within 6 to 10 seconds, the system may automatically apply the train's brakes since train "7200" is within the 2 mile range. The engineer may then confirm that train "7200" is not on a collision course with train "9999" via voice radio, for example.

Referring now to FIG. 7, a block diagram depicting apparatus for modifying a train control system to provide the train proximity alerting system of the present invention is shown. The proximity alerting system 700 of the present invention may be implemented as a non-vital overlay to

an existing train control system 702, such as, for example, the Integrated Cab Electronics (ICE) system manufactured by Rockwell International, a distributed power system, a distributed braking system, or an end-of-train (EOT) system. Preferably, the system 700 may be incorporated in the locomotive by modifying the train control system 702 to include a receiver 704 and antenna 706 for receiving a signal from which the train's position may be determined. The receiver 704 may be, for example, a Global Positioning System (GPS) receiver capable of receiving a geo-referencing signal from a global positioning system from which a geo-referenced coordinate position (e.g., latitude and longitude) may be determined.

Similarly, the train control system 702 may be modified to include a communication device 708 and antenna 710 for receiving position information from other rail vehicles operating within the railroad operating environment. The communication device 708 may be a low powered UHF, VHF, or spread spectrum radio frequency (RF) transceiver capable of short range data transmission. Alternatively, the train control system 702 may have an existing communication device which may be modified to transmit and receive position information. For example, an automatic train control system data radio (ATCP MCP) operated at reduced power and having a limited transmission range may be utilized. Transmission rates may be every 10-15 seconds. The receiver 704 and communication device 708 may be operatively coupled to a computer 712 of the train control system 702. The computer 712 may be modified to include software for calculating the train's velocity and direction of travel utilizing the position information received from the receiver 704 and for determining the proximity of (i.e., distance to) other rail vehicles in the

railroad operating environment based on the train's position, velocity and direction of travel and the position information received from the other rail vehicles via the communication device 708.

The train control system 702 may also provide a user interface 714 for alerting the train's crew of the proximity of other rail vehicles operating within the area surrounding the train so that the crew may take appropriate action if necessary. Preferably, the user interface 714 includes a display such as a cathode ray tube (CRT) display, liquid crystal display (LCD), or the like for displaying information to the crew of the train (see FIGS. 5 and 6). The user interface 714 may further include a keyboard, keypad, touch panel overlay, or the like for accepting input from the crew, such as acknowledgment the proximity of other rail vehicles and input of the vehicle identification. Vehicle identification 716 may also be directly provided by rail vehicle itself via connection to other systems of the locomotive. An audible alert apparatus 718 such as a horn, siren, beeper, loudspeaker, or the like may be operationally coupled to the computer 712 to provide an audible alert to the train's crew of the proximity of another rail vehicle.

Preferably the computer 712 of the train control system 702 is operatively coupled to the brake system of the train via a brake system interface 720. The train's crew may periodically be required to acknowledge via the user interface 714 that the train is not on a collision course with other rail traffic in the area. If the crew fails to provide this acknowledgment within a predetermined time of receiving an alert of the proximity of the other rail vehicle, the system may automatically stop the train if the system determines that the train is approaching another rail

vehicle and is within a predetermined distance, for example, 2 miles of that vehicle. The computer may further provide an event recorder. The event recorder provides the ability to show an historical record of the movement of rail traffic detected by the system 700 and the movement of the rail vehicle itself to the crew via the user interface 714. This information may assist the crew in determining if the rail vehicle may be on a collision course with other rail traffic. The event recorder may also provide a historical record of movement of the train and other rail traffic detected by the system for future use by the railroad, to for example, facility an accident investigation or improve the flow of rail traffic along a section of track.

The system 700 may be disabled by the crew or operator when the maintenance-of-way vehicle is in yard areas where the vehicle density will be too high for the proximity alerting system to be of benefit, or if the system 300 experiences a system failure. Preferably, the proximity alerting components of the system 700 may be disabled without affecting the existing functions of the train control system 702

It is believed that the system of the present invention and many of its attendant advantages will be understood by the foregoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the components thereof without departing from the scope and spirit of the invention or without sacrificing all of its material advantages. The form herein before described being merely an explanatory embodiment thereof, it is the intention of the following claims to encompass and include such changes.

CLAIMS

What is claimed is:

1. A system for alerting the crew of a rail vehicle of the proximity of one or more other rail vehicles, said system comprising:

a receiver disposed in said rail vehicle, said receiver for receiving a signal from which a position of said rail vehicle may be determined;

a communication device disposed in said rail vehicle, said communication device for receiving position information from said one or more other rail vehicles;

a computer operatively coupled to said receiver and said communication device, said computer for determining the proximity of said one or more other rail vehicles from the position information received from said one or more other rail vehicles and the position of said rail vehicle; and

a user interface operatively coupled to said computer, said user interface for communicating the proximity of said one or more other rail vehicles to said crew.

2. The system of claim 1, wherein said rail vehicle is the locomotive of a train.

3. The system of claim 2, wherein said computer is operatively coupled to a braking system for automatically stopping said train.

4. The system of claim 1, wherein said rail vehicle is a

maintenance of way vehicle.

5. The system of claim 1, wherein the signal from which the position of said rail vehicle may be determined is provided by a global positioning system.

6. The system of claim 1, wherein said communication device is adapted to communicate the position of said rail vehicle to at least one of said one or more other rail vehicles.

7. The system of claim 1, wherein said communication device comprises a radio frequency transceiver.

8. The system of claim 1, wherein said user interface comprises a display.

9. The system of claim 8, wherein said display provides an alphanumeric listing of said one or more other rail vehicles to said crew.

10. The system of claim 8, wherein said display provides a graphical display for informing said crew of the proximity of said one or more other rail vehicles.

11. The system of claim 1, wherein said user interface comprises an audible warning apparatus.

12. The system of claim 1, wherein said user interface comprises apparatus for receiving an acknowledgment from said crew.

13. A system for warning the crew of a rail vehicle of the proximity of one or more other rail vehicles, said system comprising:

means for receiving a signal from which a position of said rail vehicle may be determined;

means for receiving position information from said one or more other rail vehicles;

means for determining the proximity of said one or more other rail vehicles from the position information received from said one or more other rail vehicles and the position of said rail vehicle; and

means for communicating the proximity of said one or more other rail vehicles to said crew.

14. The system of claim 13, further comprising means for communicating the position of said rail vehicle to at least one of said one or more other rail vehicles.

15. The system of claim 13, wherein said communicating means comprises a means for displaying the proximity of said one or more other rail vehicles to said crew.

16. The system of claim 13, further comprising means for receiving acknowledgment from the crew of the proximity of said one or more other rail vehicles.

The system of claim 13, further comprising means for automatically stopping said rail vehicle.

18. A method for warning the crew of a rail vehicle of the proximity of one or more other rail vehicles, said method comprising the steps of:

receiving a signal from which a position of said rail vehicle may be determined;

receiving position information from said one or more other rail vehicles;

determining the proximity of said one or more other rail vehicles from the position information received from said one or more other rail vehicles and the position of said rail vehicle; and

communicating the proximity of said one or more other rail vehicles to said crew.

19. A method according to claim 18, further comprising the step of communicating the position of said rail vehicle to at least one of said one or more other rail vehicles.

20. A method according to claim 18, further comprising the step of receiving acknowledgment from the crew of the proximity of said one or more other rail vehicles.

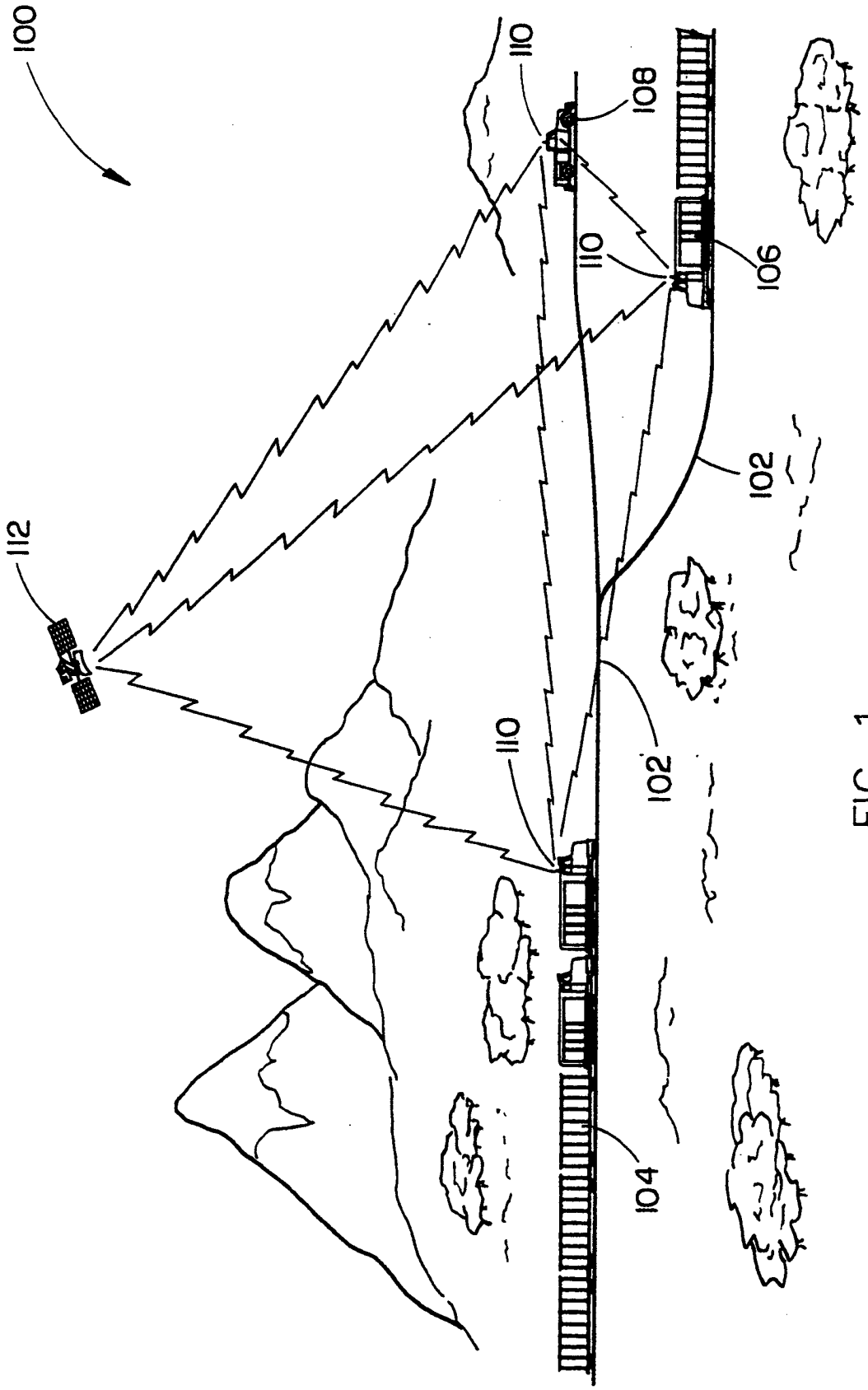

FIG. 1

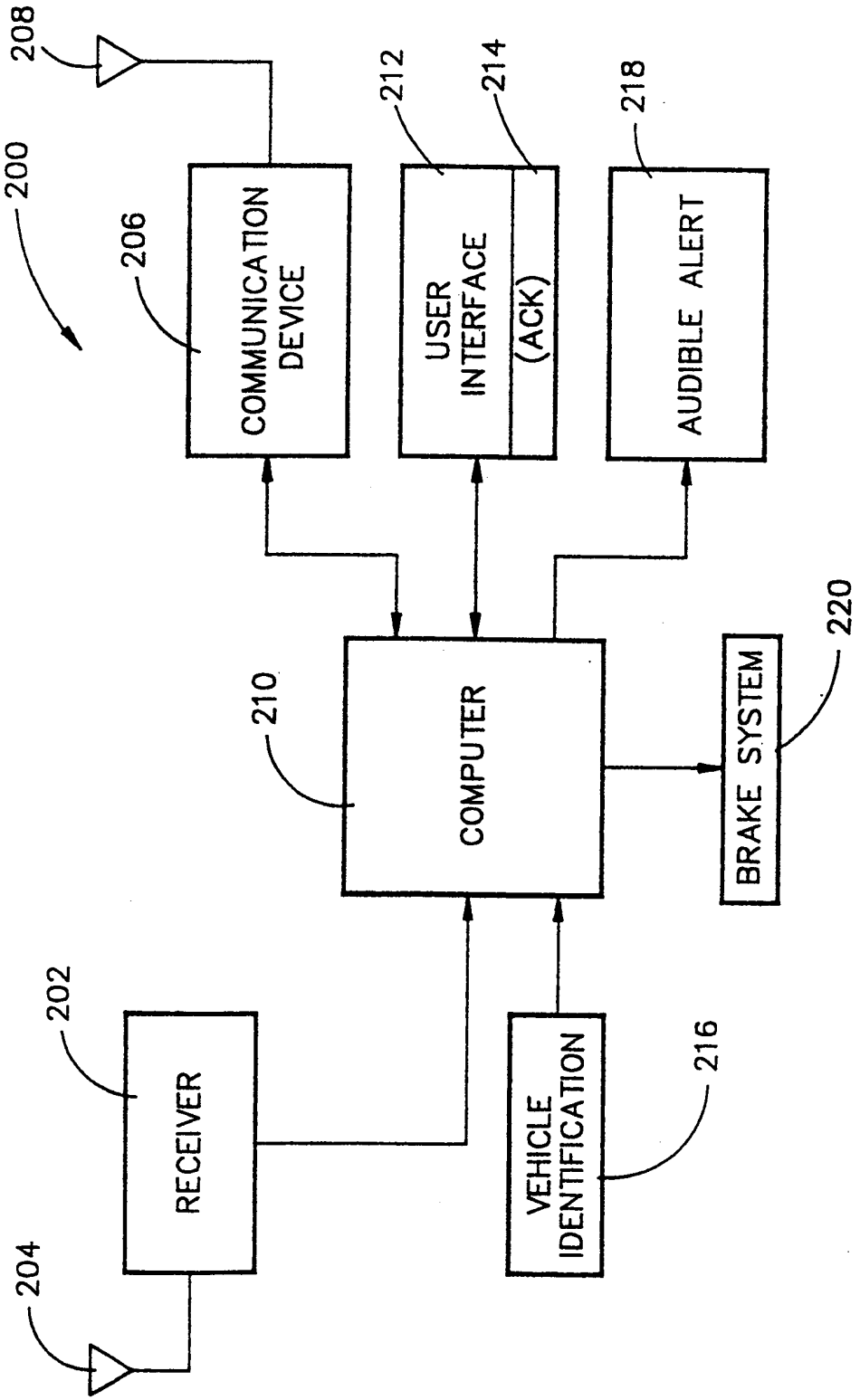
208
200
206
COMMUNICATION DEVICE
212
214
USER INTERFACE
(ACK)
218
AUDIBLE ALERT
210
COMPUTER
220
BRAKE SYSTEM
202
RECEIVER
216
VEHICLE IDENTIFICATION
204

FIG. 2

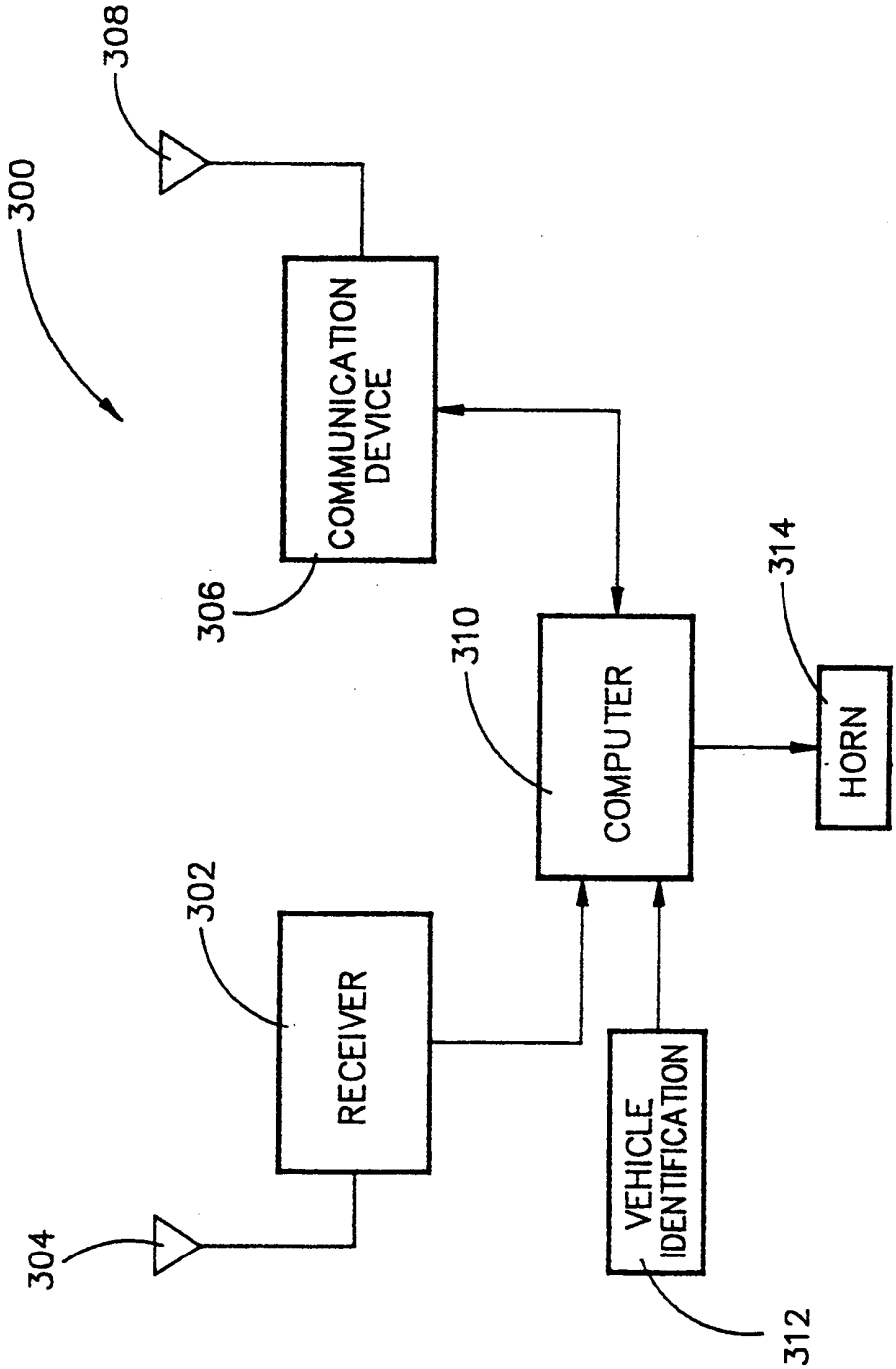
300
308
COMMUNICATION DEVICE
306
310
COMPUTER
314
HORN
302
RECEIVER
304
VEHICLE IDENTIFICATION
312

FIG. 3

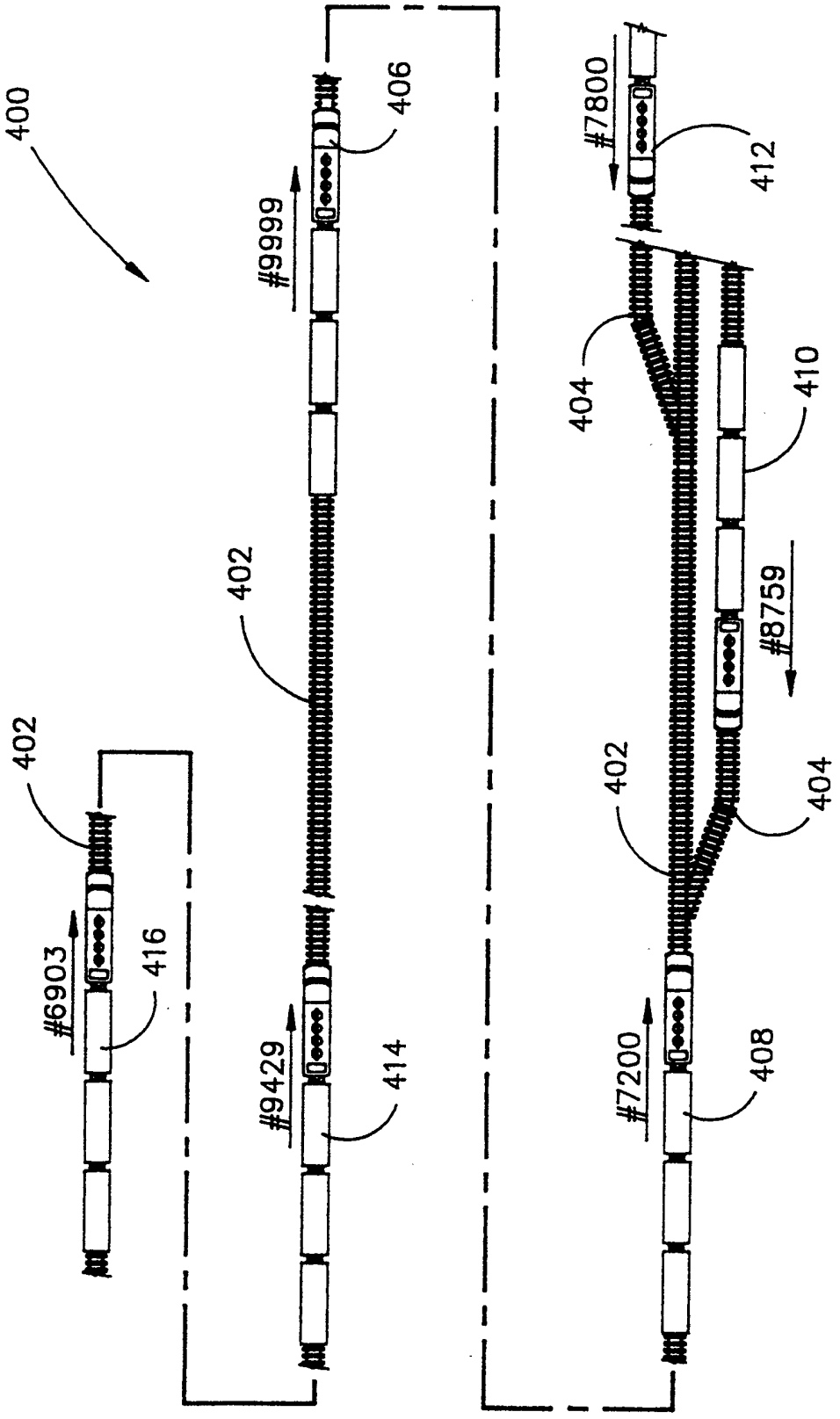
400
402
#6903
416
#9429
414
402
#9999
406
402
#7800
412
404
410
#8759
402
404
#7200
408

FIG. 4

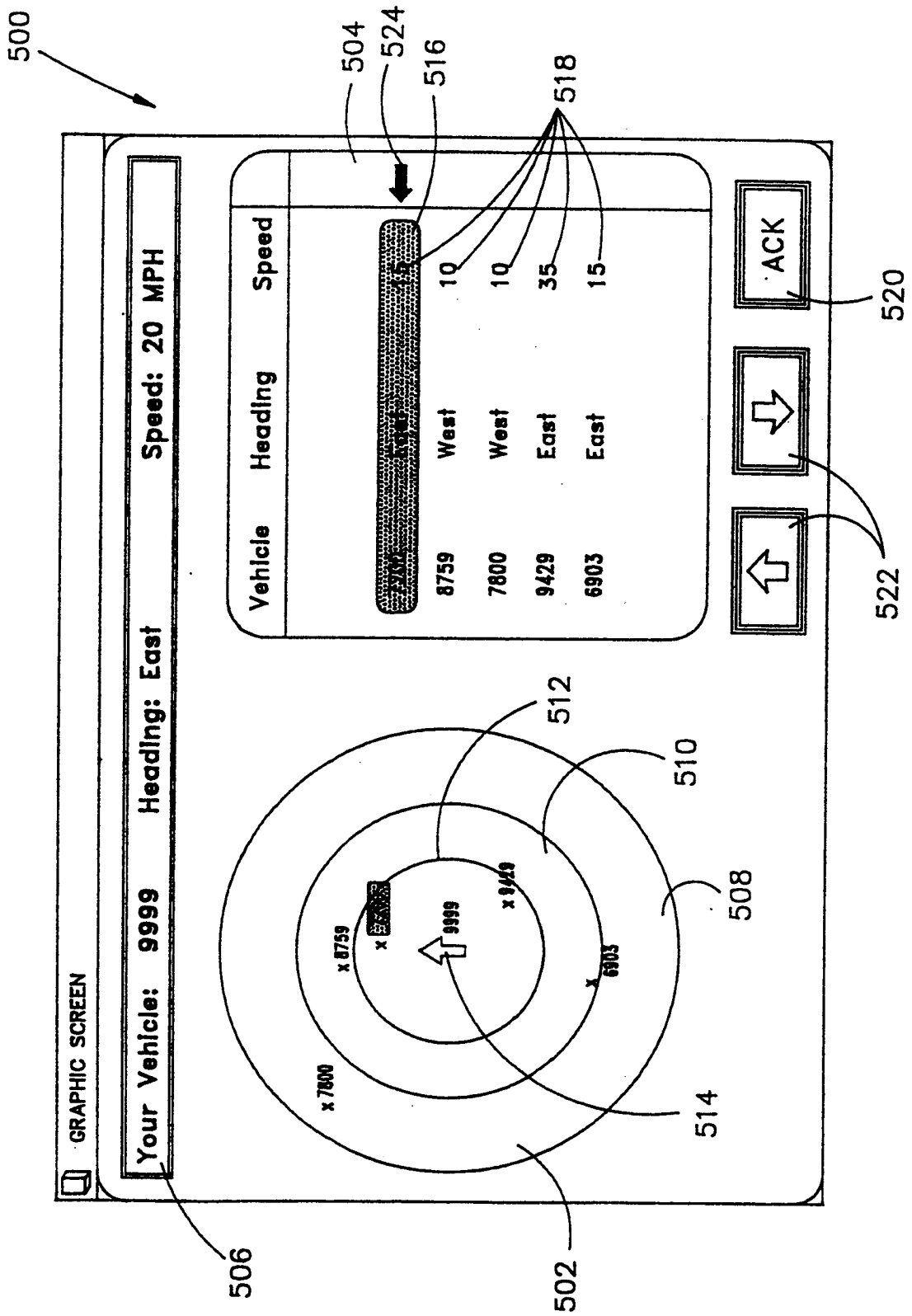
500
504
524
516
518
GRAPHIC SCREEN
Your Vehicle: 9999 Heading: East Speed: 20 MPH
Vehicle Heading Speed
8759 West 10
7800 West 10
9429 East 35
6903 East 15
ACK
520
522
512
510
508
514
502
506
x 8759
x 7800
x 6903
9999

FIG. 5

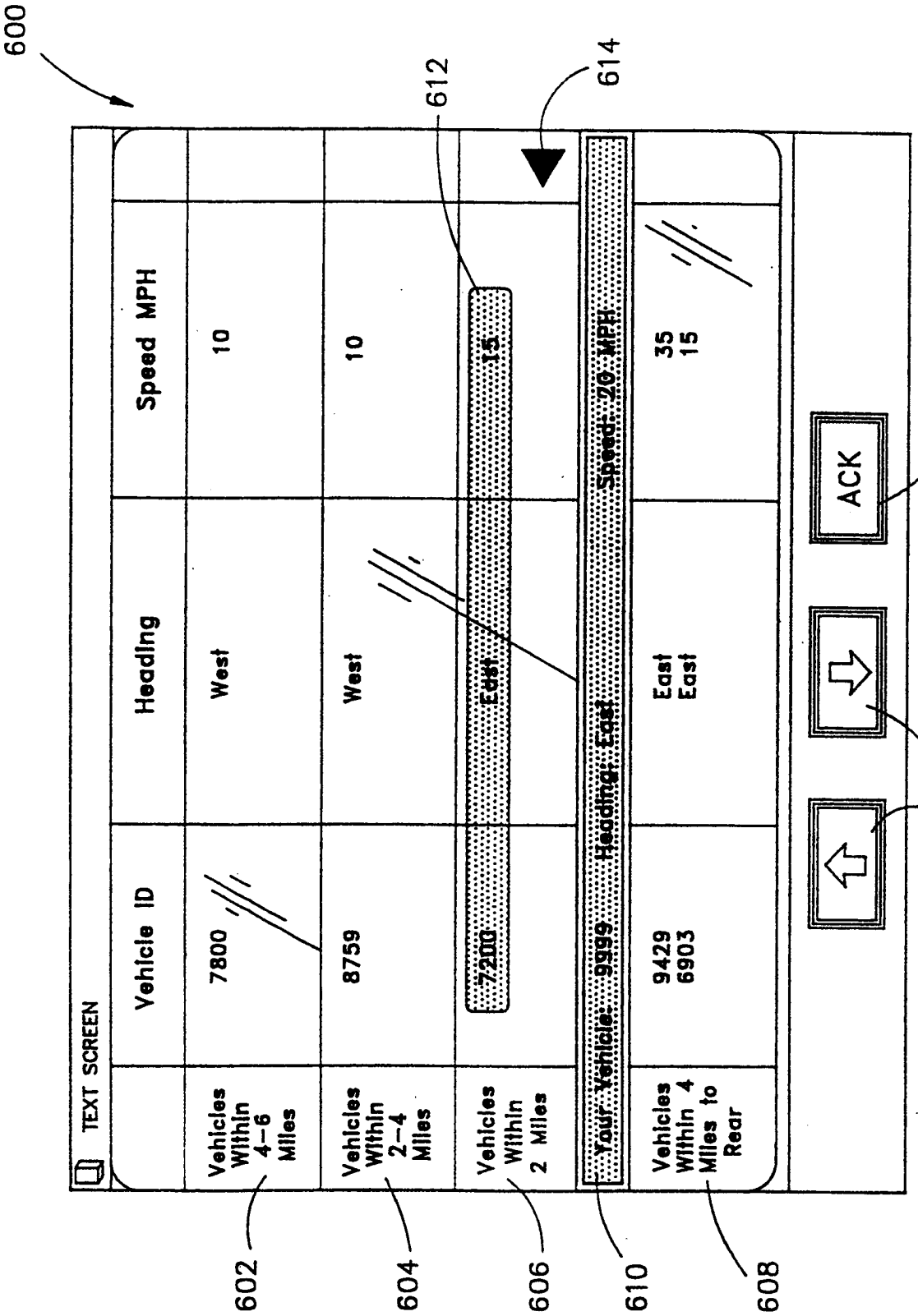
600
612
614
TEXT SCREEN
Vehicle ID
Heading
Speed MPH
Vehicles Within 4–6 Miles
7800
West
10
Vehicles Within 2–4 Miles
8759
West
10
Vehicles Within 2 Miles
7200
East
15
Your Vehicle: 9999 Heading: East Speed: 20 MPH
Vehicles Within 4 Miles to Rear
9429
6903
East
East
35
15
ACK
616
618
602
604
606
610
608

FIG. 6

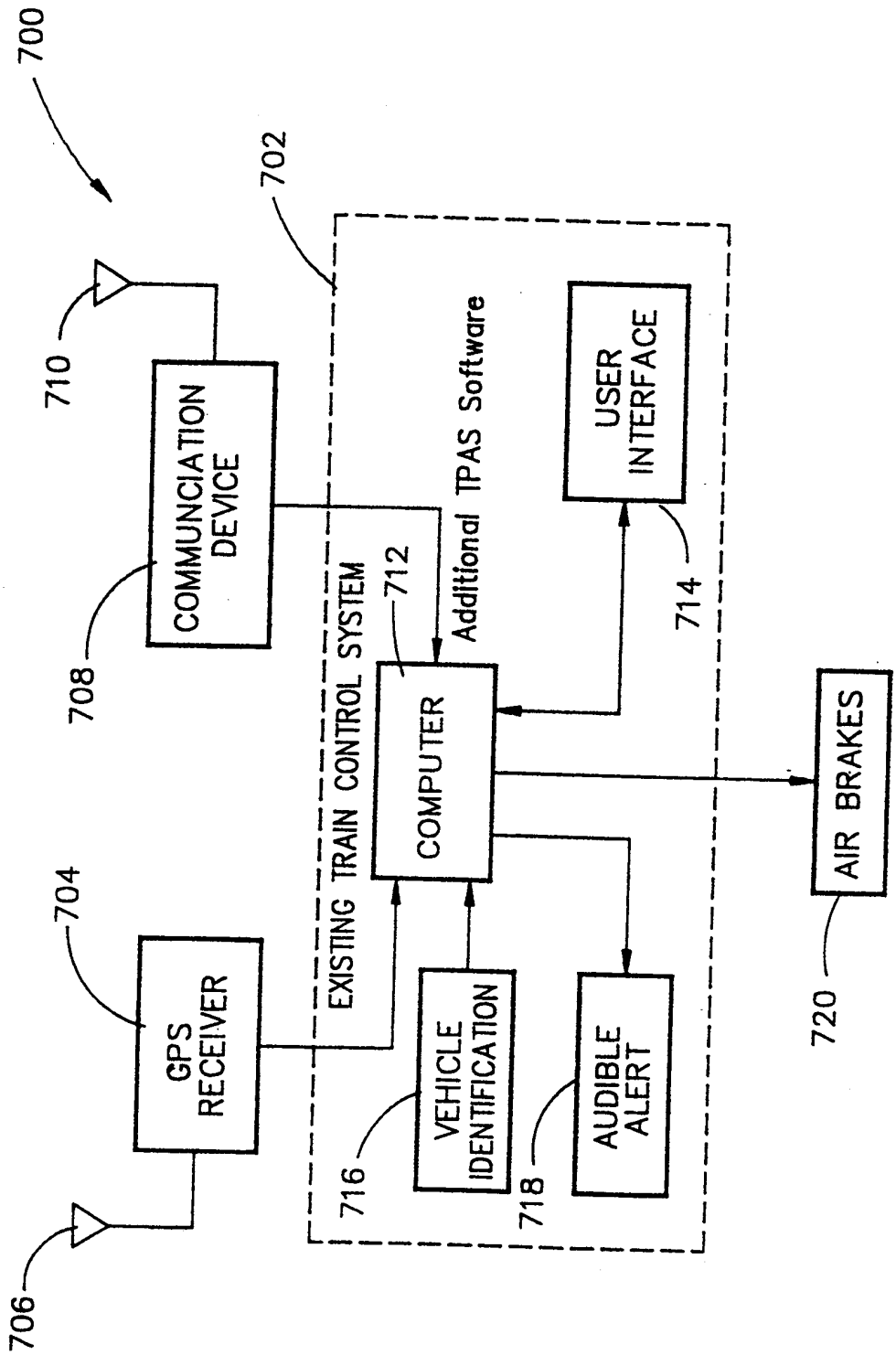
700
702
710
COMMUNCIATION DEVICE
708
712
Additional TPAS Software
USER INTERFACE
714
EXISTING TRAIN CONTROL SYSTEM
COMPUTER
AIR BRAKES
720
704
GPS RECEIVER
VEHICLE IDENTIFICATION
716
AUDIBLE ALERT
718
706

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/07503

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G08G 1/123
US CL :340/988, 989, 990, 991; 246/122R; 342/455
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)

U.S. : 340/988, 989, 990, 991, 992, 901, 902, 903; 246/122R; 342/455, 357; 701/19, 301

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)

APS, IPSS, WEST

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 5,574,469 A (HSU) 12, November 1996, col. 4, lines 62-67; col. 5, lines 1-67; col. 6, lines 1-41; col. 7, lines 15-23; Figs. 1-3.	1-9, 11-20 ---------- 10
Y	US 5,381,338 A (WYSOCKI et al) 10 January 1995, col. 11, lines 25-57.	10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 02 JULY 1999	Date of mailing of the international search report 17 AUG 1999
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer JEFFERY A. HOFSASS Joni Hill Telephone No. (703) 305-4700

Form PCT/ISA/210 (second sheet)(July 1992)★