in which the first line section formed in a loop illustrated in FIG. 2 is one-dimensionally expressed. FIG. 4 is a diagram illustrating an example of a case where the side that includes the virtual block is a designated section. FIGS. 2 and 3 illustrate a virtual block VB and multiple divided blocks [B1001] to [B1010] that are set in the loop line section L1. Information on such blocks [B1001] to [B1010] and the virtual block VB is stored, for example, in the track database 8. In FIG. 2, numerals in balloons attached to reference points of the blocks [B1001] to [B1010] on the loop line section L1 indicate kilometrage at the reference points of the blocks [B1001] to [B1010]. The position information on the first end point P1 and the second end point P2 is expressed, for example, by a block number and an intra-block position. For example, as illustrated in FIG. 4, the position information (kilometrage) on the first end point P1 is expressed as 240 obtained by adding 40 that is a coordinate value at the intra-block position in the block [B1003] to 200 that is kilometrage (coordinate value) at a reference point of the block [B1003]. The position information (kilometrage) on the second end point P2 is expressed as 800 obtained by adding 0 that is a coordinate value at the intra-block position in the block [B1009] to 800 that is a coordinate value at a reference point of the block [B1009]. FIG. 2 illustrates an example in which a coordinate value is set such that it decreases when the train 20 travels in a clockwise direction and increases when the train 20 travels in a counterclockwise direction. Since all the blocks [B1001] to [B1010] have a length of "100" in FIG. 2, the block [B1001] has a coordinate value of 0 to 100, the block [B1002] has a coordinate value of 100 to 200, the block [B1003] has a coordinate value of 200 to 300, the block

train 20c is not approaching the designated section A1 (S108), and ends the presence detection process performed by the train presence detection apparatus 1.

[0029] In the present embodiment described above, the train presence detection apparatus 1 (ground apparatus 10) includes a processor, a storage circuit, a receiver, and a transmitter, and each operation can be implemented by software. FIG. 9 is a diagram illustrating an example of a hardware configuration that implements the train presence detection apparatus 1 illustrated in FIG. 1. The train presence detection apparatus 1 illustrated in FIG. 9 includes a processor 101, a storage circuit 102, a receiver 103, a transmitter 104, and an input unit 105. The processor 101 uses received information to perform calculation and control by software, and the storage circuit 102 stores received information or information and software necessary for the processor 101 to perform calculation and control. The receiver 103 is an interface for receiving information from the outside. The transmitter 104 is an interface for transmitting information to the outside. The input unit 105 is an input interface for receiving input of various types of information. A plurality of individual processors 101, storage circuits 102, receivers 103, transmitters 104, and input units 105 may be provided. The input reception unit 2 illustrated in FIG. 1 is realized by the input unit 105. The information acquisition unit 3 is implemented by the processor 101 and the receiver 103. The designated section determination unit 4, the presence determination unit 5, and the approach determination unit 6 are implemented by the processor 101. The train control unit 7 is implemented by the processor 101 and the transmitter 104. The track database 8 is implemented by the storage circuit 102.

coil by the pickup coil information, uses an absolute position of the ground coil as a reference position, calculates a travel distance from the reference position, for example, on the basis of speed information detected by a rate generator attached to an axle, and obtains an intra-block position that is a position of the train 20 in a block, thereby calculating presence position information on the train 20 to which the presence position calculation unit 11 belongs. The presence position calculation unit 11 outputs the calculated presence position information on the train 20 to the information acquisition unit 3.

[0037] Although not illustrated in detail, the train presence detection apparatus 1 may be configured as a train control system including the ground apparatus 10 and the on-board apparatus 21. When the train presence detection apparatus 1 is configured as the train control system including the ground apparatus 10 and the on-board apparatus 21, a configuration may be employed in which, for example, the ground apparatus 10 has functions of the input reception unit 2, the information acquisition unit 3, and the designated section determination unit 4, and the on-board apparatus 21 has functions of the presence determination unit 5, the approach determination unit 6, the train control unit 7, the track database 8, and the presence position calculation unit 11. In such a case, in the train presence detection apparatus 1, the input reception unit 2 of the ground apparatus 10 receives input of the position information on the first end point P1 and the second end point P2 located at both ends of the designated section and the virtual block presence/absence information that indicates whether the virtual block VB indicating a specific position in the loop line section is included in the designated section, and outputs the above

information on the first end point of P1 and the second end point P2 and the virtual block presence/absence information. When any sensor 12 detects a specific state, the information acquisition unit 3 acquires the position information on the first end point P1 and the second end point P2 and the virtual block presence/absence information from the sensor information database 13 on the basis of the ID the sensor 12 has. Consequently, it is possible to determine the designated section efficiently in accordance with a state in the loop line section L1 or around the loop line section L1 detected by the sensor 12.

[0042] FIG. 13 is a block diagram illustrating another example of the configuration of the train presence detection apparatus according to the second embodiment of the present invention. Similarly to the train presence detection apparatus 1 according to the first embodiment, the train presence detection apparatus 1a according to the second embodiment may also be configured to include the sensor information database 13 in the on-board apparatus 21 included in the train, as illustrated in FIG. 13, in addition to the information acquisition unit 3, the designated section determination unit 4, the presence determination unit 5, the approach determination unit 6, the train control unit 7, the track database 8, and the presence position calculation unit 11. In the train presence detection apparatus 1a illustrated in FIG. 13, when the sensor 12 detects a specific state for which travel control of the train 20 needs to be performed, the sensor 12 transmits its own sensor ID the sensor 12 has to the on-board wireless apparatus 22 via the ground wireless apparatus 9, and the on-board wireless apparatus 22 transmits the sensor ID to the information acquisition unit 3. Then, the information acquisition unit 3 accesses

the first end point P1 and the second end point P2 and the virtual block presence/absence information.

[0044] FIG. 15 is a diagram illustrating an example of a virtual block in a case where a loop line section L2, which is a second line section formed in a loop, is connected adjacent to the loop line section L1. Although FIG. 2 illustrates the example in which the virtual block VB is set in one loop line section L1, for example, as illustrated in FIG. 15, when the loop line sections L1 and L2 different from each other are adjacently connected, the virtual block VB may be set at a connection point where the loop line sections L1 and L2 are connected. Thus, the loop line section L1 and the loop line section L2 can share and use the virtual block VB, and thereby the number of virtual blocks VB can be reduced by one as compared with a case where the virtual block VB is provided in each of the loop line section L1 and the loop line section L2, which is efficient.

[0045] Third Embodiment.

Next, a train presence detection apparatus 1b according to a third embodiment of the present invention will be described. FIG. 16 is a block diagram illustrating an example of a configuration of the train presence detection apparatus according to the third embodiment of the present invention. FIG. 17 is a diagram illustrating examples of blocks set in the first line section formed in a loop and direction information. In the train presence detection apparatus 1b according to the third embodiment of the present invention, as illustrated in FIGS. 16 and 17, the input reception unit 2 receives input of the position information on the first end point P1 and the second end point P2 located in the loop line section L1, and input of the direction information for indicating in which direction

detection apparatus 1b.

[0052] On the other hand, for example, when the train 20c is present in the block [B1006] as in illustrated in FIG. 17, the route information in accordance with which the train 20c travels is the route R1017 and indicates a travel route from the kilometrage (700) at the position of the terminating end of the block [B1007] to the kilometrage (400) at the position of the starting end of the block [B1005] in the clockwise direction, and therefore, the approach determination unit 6 determines that the first end point P1 (kilometrage is 240) that is the starting end point of the designated section A1 is not included in the route R1017 of the train 20c (S206: No). Then, the approach determination unit 6 determines that the train 20c is not approaching the designated section A1 (S108), and ends the presence detection process performed by the train presence detection apparatus 1b. The train presence detection apparatus 1b according to the third embodiment described above can also be implemented by a hardware configuration similar to that of the train presence detection apparatus 1.

[0053] The train presence detection apparatus 1b according to the third embodiment of the present invention includes the information acquisition unit 3 that acquires position information on the first end point P1 and the second end point P2 located in the loop line section L1 and direction information for indicating in which direction from the first end point P1 to the second end point P2 the designated section that is any of the first section A1 and the second section A2 in which the first end point P1 and the second end point P2 are located at both ends is located; the designated section determination unit 4 that determines which of the first section A1 and the second

Thus, in the train presence detection apparatus 1c illustrated in FIG. 23, although the ground apparatus 10 does not include the sensor information database 13, the information acquisition unit 3 can acquire the position information on the first end point P1 and the second end point P2 and the direction information.

[0061] Fifth Embodiment.

Next, a train presence detection apparatus 1d according to a fifth embodiment of the present invention will be described. FIG. 24 is a block diagram illustrating an example of a configuration of the train presence detection apparatus according to the fifth embodiment of the present invention. FIG. 25 is a diagram illustrating an example of a configuration in which a third line section L3, through which a train can enter the first line section L1 formed in a loop, is connected to the first line section L1. As illustrated in FIG. 24, the train presence detection apparatus 1d according to the fifth embodiment of the present invention further includes a connection point presence/absence determination unit 14 in addition to the configuration included in the train presence detection apparatus 1 illustrated in FIG. 1 according to the first embodiment. Regarding configurations and the like similar to those of the train presence detection apparatus 1 according to the first embodiment of the present invention, same reference numerals are given thereto, and detailed descriptions thereof will be omitted.

[0062] In the train presence detection apparatus 1d, the track database 8 stores connection point position information in advance, in addition to the route information. The connection point position information is information that indicates, as illustrated in FIG. 25, the position of a connection point P3 where the loop line

the designated section determination unit 4 determines that the first section A1 is the designated section, the connection point presence/absence determination unit 14 determines that the connection point P3 is not located in the designated section A1 because kilometrage (580) at the position of the connection point P3 is not included in the block sequence of less than or equal to the kilometrage (240) at the position of the first end point P1 of the designated section A1 illustrated in FIG. 4 or greater than or equal to the kilometrage (800) at the position of the second end point P2 thereof. Alternatively, when the designated section determination unit 4 determines that the second section A2 that does not include the virtual block VB is the designated section, the connection point presence/absence determination unit 14 determines that the connection point P3 is located in the designated section A2 because the kilometrage (580) at the position of the connection point P3 is included in the block sequence from the kilometrage (240) at the position of the first end point P1 of the designated section A2 illustrated in FIG. 5 to the kilometrage (800) at the position of the second end point P2 thereof.

[0064] An approach determination unit 6a determines whether the train 20 is approaching a designated section. When the connection point presence/absence determination unit 14 determines that the connection point P3 is located in the designated section, the approach determination unit 6a determines whether a distance D from the train 20 traveling from the third line section L3 toward the loop line section L1 to the connection point P3 is within a specific range. Even in a case where the train 20 is not traveling in the loop line section L1 but traveling in the third line section L3, when the connection point P3 to the

designated section (S303: Yes), for example, the presence determination unit 5 determines that the train 20 is present in the designated section (S304), and ends the presence detection process performed by the train presence detection apparatus 1d.

[0070] When the presence determination unit 5 determines that neither the kilometrage at the front end position of the train 20 nor that at the rear end position thereof is included in the designated section (S303: No), the presence determination unit 5 determines that the train 20 is not present in the designated section (S305).

[0071] When the presence determination unit 5 determines that the train 20 is not present in the designated section, next, the connection point presence/absence determination unit 14 determines whether the connection point P3 is located in the designated section (S306). When the connection point presence/absence determination unit 14 determines that the connection point P3 is located in the designated section (S306: Yes), the approach determination unit 6a determines whether the distance D from the train 20 traveling from the third line section L3 toward the loop line section L1 to the connection point P3 is within a specific range (S307).

[0072] When the approach determination unit 6a determines that the distance D from the train 20 to the connection point P3 is within the specific range (S307: Yes), the approach determination unit 6a determines that the train 20 is approaching the designated section (S308), and ends the presence detection process performed by the train presence detection apparatus 1d.

[0073] On the other hand, when the approach determination unit 6a determines that the distance D from the train 20 to the connection point P3 is not within the

ground apparatus 10 and the on-board apparatus 21, a configuration may be employed in which, for example, the ground apparatus 10 has functions of the input reception unit 2, the information acquisition unit 3, and the designated section determination unit 4, and the on-board apparatus 21 has functions of the presence determination unit 5, the approach determination unit 6a, the train control unit 7, the track database 8, and the presence position calculation unit 11.

[0077] Regarding the train presence detection apparatus 1d, the example is indicated in which the input reception unit 2 receives the input of the position information on the first end point P1 and the second end point P2 and the virtual block presence/absence information. However, similarly to the train presence detection apparatus 1a according to the second embodiment, the train presence detection apparatus 1d may include, instead of the input reception unit 2, the sensor 12 that detects a state in the loop line section L or around the loop line section L, and the sensor information database 13. Alternatively, similarly to the train presence detection apparatus 1a illustrated in FIG. 14, a configuration may be employed in which the sensor 12 stores the position information on the first end point P1, the position information on the second end point P2, and the virtual block presence/absence information in advance, and the position information on the first end point P1 and the second end point P2 and the virtual block presence/absence information are transmitted to the information acquisition unit 3 via the ground wireless apparatus 9 when a specific state is detected.

[0078] The present invention is not limited to the above embodiments, and each embodiment can be appropriately modified or omitted without departing from the scope of the