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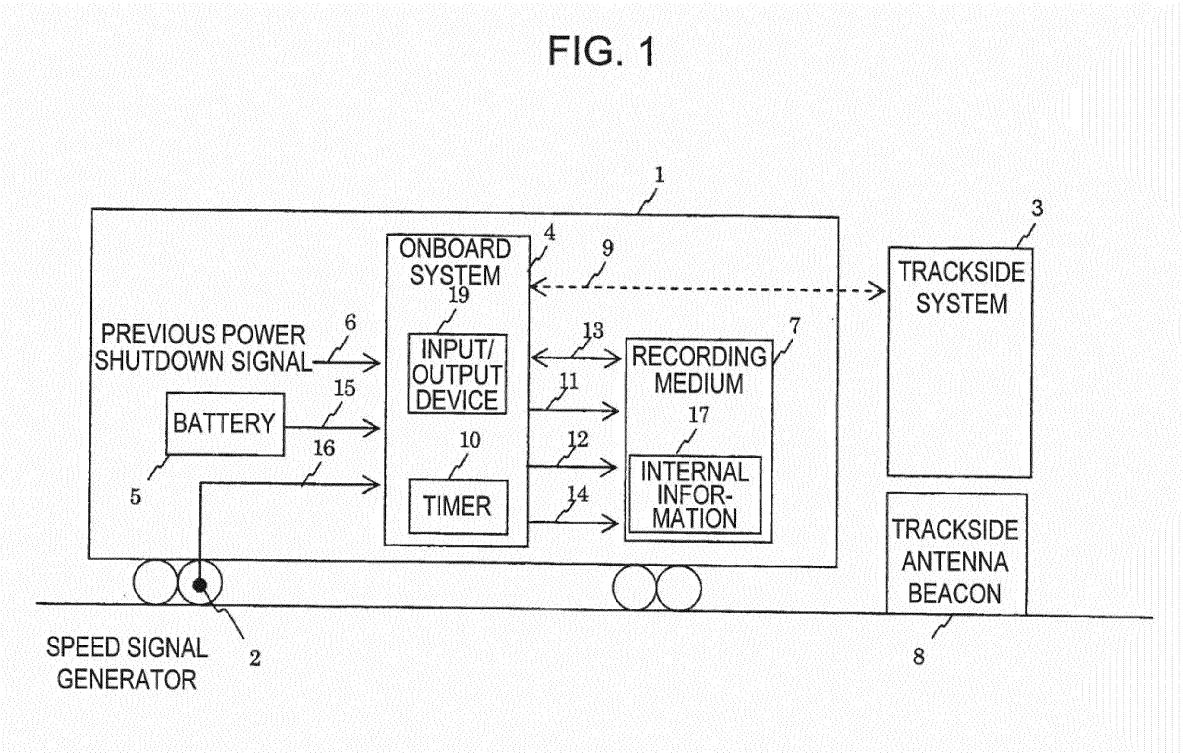
(54) Automatic train protection system

(57) There is provided an automatic train protection system that prevents wrong train position information from being transmitted from onboard system in a train to trackside system to impair the safety of train operation. When running or movement of the train is detected while internal information such as train position information and train control information are recorded on a recording medium in the train, onboard system deletes the internal information recorded on the recording medium. The onboard system does not record internal information such as train position information and train control information on the recording medium while the train is running.

FIG. 1



EP 2 769 897 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an automatic train protection system that improves safety of running of trains.

Description of the Related Art

[0002] Train detection using track circuits have been performed in order to control trains by using "block systems" which permit only one train to run in one track section. In these years, however, there is a drive to introduce a wireless communication system for train-trackside transmission to implement train detection using position report transmitted from a train in order to reduce the costs of railway communication systems.

[0003] In the United States and China, the CBTC (Communication Based Train Control) system, which controls trains by wireless communication, is being introduced. In Europe, on the other hand, a system called the ERTMS (European Rail Traffic Management System)/ETCS (European Train Control System) has been developed and is being introduced with the aim of improving interoperability by standardization of different signaling systems in different nations. The ERTMS/ETCS uses GSM-R (GSM-Railway) which is based on the GSM (Global System for Mobile Communication) (registered trademark) network for wireless communication systems.

[0004] Railway protection systems as in the CBTC and the ERTMS/ETCS include onboard system inside trains and trackside system external to the trains. The onboard system and the trackside system wirelessly communicate with each other. The train detects a trackside antenna beacon installed on the track to enable the onboard system to obtain train position information on the current point. Based on the train position information, train speed information, moving authority received from the trackside system, and other information, the onboard system performs speed supervision and, if the speed of the train exceeds a speed limit, outputs a braking command to reduce the speed of the train to the speed limit or lower. In this way, the onboard system controls the whole train.

[0005] To accomplish the control, the onboard system transmits information such as train position information of the train to the trackside system and the trackside system uses information such as information received from track circuits in a block and the train position information received from the onboard system to calculate information such as moving authority for each train and transmits these control informations to the onboard system.

[0006] Furthermore, upon power-on, onboard system in a wireless-based train control system reads train position information recorded at the power shutdown on an internal recording medium and provides the train position information to trackside system to allow the trackside system to detect the position of the train while the train is at the position at which the train is powered on, without the need for the train to run until the onboard system detects a trackside antenna beacon in order to determine the position.

[0007] To accomplish this, the onboard system needs to record and hold internal information such as train position information on the recording medium before power shutdown. For that purpose, a mechanism is provided in the train in which onboard system is installed that outputs a signal that gives an advance notice of power shutdown from the train a predetermined amount of time in advance of power shutdown of the train, and the onboard system receives the previous power shutdown signal and records on an internal recording medium various kinds of internal information to be used for train control upon the next power-on of the train.

[0008] Techniques of the related art for detecting the position of a train and storing detected train position information include the techniques described in Japanese Patent Laid-Open Publications No. Hei 9-301176 and No. 2008-238888.

[0009] According to the prior arts, when a train stops operation and power to onboard system is shut off, the onboard system receives a previous power shutdown signal from the train a predetermined amount of time in advance of power shutdown of the train so that the onboard system records internal information on a recording medium. When the onboard system is powered on, the onboard system reads the internal information about the train recorded in the previous operation from the recording medium and reports train position information to trackside system.

[0010] In the configuration described above, if the onboard system receives a previous power shutdown signal from the train but accidentally the train is not powered off and moves, a difference arises between the train position information (on-track position information) recorded on the recording medium and the position at which the train is actually located. Moreover, the different data is internally recorded in the onboard system and, if the different data is read and determined to be valid at the next power-on, the onboard system provides a wrong position report to the trackside system.

[0011] Furthermore, in a situation where the train is operated and the position of the train moves after internal information about the train is recorded on the recording medium in response to a previous power shutdown signal and the internal information is reported to trackside system at the next power-on of the onboard system, if the onboard system is powered off without an input of a previous power shutdown signal, internal information recorded before the movement remains stored on the recording medium and the onboard system reports information indicating a position different from the position at which the train is actually located to the trackside system

upon the next power-on of the onboard system.

[0012] Moreover, if a previous power shutdown signal is accidentally input while the train is running, the onboard system records internal information, which is to be recorded at power shutdown, at that unintended timing. If that is the case, since the train is running and the position of the train is changing, train position information recorded in response to the accidental input of the previous power shutdown signal during running is unusable as a position report at the next power-on.

SUMMARY OF THE INVENTION

[0013] An object of the present invention is to provide an automatic train protection system that prevents wrong train position information from being transmitted from onboard system in a train to trackside system to impair the safety of train operation.

[0014] In a first aspect, the present invention provides an automatic train protection system detecting a position of a train at trackside system on the basis of train control information including train position information,
the train comprising:

an onboard system controlling the whole train and communicating with the trackside system;
a power supply device supplying power to the whole train and generating a previous power shutdown signal providing an advance notice of shut-off of power supply to the onboard system;
a storage device storing position information of the train; and
a speed measuring device for measuring the speed of the train;
wherein the train control information is stored on the storage device in response to occurrence of the previous power shutdown signal;
the train position information recorded on the storage device is transmitted to the trackside system when power supply to the onboard system is started; and
the train control information stored on the storage device is deleted when a predetermined condition is satisfied.

In another aspect, the present invention provides an automatic train protection system detecting a position of a train at trackside system on the basis of train control information including train position information,
the train comprising:

an onboard system controlling the whole train and communicating with the trackside system;
a power supply device supplying power to the whole train and generating a previous power shutdown signal providing an advance notice of shut-off of power supply to the onboard system;
a storage device storing position information of the train; and
a speed measuring device for measuring the speed of the train;
wherein the train control information is stored on the storage device in response to occurrence of the previous power shutdown signal;
the train position information recorded on the storage device is transmitted to the trackside system when power supply to the onboard system is started;
wherein the train control information is prevented from being stored on the storage device while the speed measuring device is detecting running of the train.

[0015] Generally, an automatic train protection system of the present invention deletes internal information recorded on a recording medium when the automatic train protection system detects running or movement of a train while internal information about the train is recorded on a recording medium in the train. Alternatively, or moreover, the automatic train protection system does not record internal information about the train on the recording medium while the train is running.

[0016] According to the present invention, train control information such as train position information can be accurately recorded on a recording device provided inside the train and therefore can prevent a difference between stored train position information and train position information indicating the position at which the train is actually located, thereby improving safety of train operation. Problems, configurations and effects other than descried above will be apparent from the following description of embodiments.

[0017] Optional features of the invention set out below are applicable singly or in any combination with any aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is a diagram illustrating a configuration of an automatic train protection system of the present invention;
FIG. 2 is a diagram illustrating a conventional method for recording on a recording medium;
FIG. 3 is a diagram illustrating the relationship between the timing of recording on a recording medium and the position of a train;
FIG. 4 is a diagram illustrating a state of a train that has moved after reception of a previous power shutdown signal;
FIG. 5 is a diagram illustrating a conventional recording operation 1 for recording internal information on a recording medium;
FIG. 6 is a diagram illustrating a state of a train that has moved after reception of a previous power shutdown signal in a first embodiment of the present in-

vention;

FIG. 7 is a diagram illustrating a recording operation 1 for recording internal information on a recording medium in the first embodiment of the present invention;

FIG. 8 is a diagram illustrating a state of a train where the train has run while internal information is held on a recording medium;

FIG. 9 is a diagram illustrating a conventional recording operation 2 for recording internal information on a recording medium;

FIG. 10 is a diagram illustrating a state of a train where the train has moved after reception of a previous power shutdown signal in a second embodiment of the present invention;

FIG. 11 is a diagram illustrating a recording operation 2 for recording internal information on a recording medium in the second embodiment of the present invention;

FIG. 12 is a diagram illustrating a conventional recording operation 3 for recording internal information on a recording medium; and

FIG. 13 is a diagram illustrating a recording operation 3 for recording internal information on a recording medium in a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Embodiments of the present invention will be described below with reference to drawings.

[First Embodiment]

<System Configuration>

[0020] FIG. 1 is a diagram illustrating a configuration of an automatic train protection system of the present invention.

[0021] A train 1 includes a speed signal generator 2 outputting a wheel rotation speed from a wheel of the train 1, onboard system 4 having functions such as the function of speed supervision from a signal from a trackside system 3 and a train speed output from the speed signal generator 2, a battery 5 supplying power to devices installed in the train 1, a previous power shutdown signal 6 for giving advance notice of power shutdown from the train 1 to the onboard system 4 a predetermined amount of time in advance of shut-off of power output from the battery 5, a recording medium 7 storing internal information such as train position information indicating the position of the train 1 and information indicating an internal state of the train 1, and a communication channel 9 for performing communication between the trackside system 3 and the onboard system 4. Trackside antenna beacons 8 for the onboard system 4 to detect the position of the train 1 are provided on a track on which the train 1 runs.

[0022] The onboard system 4 stores, in addition to position information of the train 1, control information such as a control level before power shutdown and channel information, a phone number and an ID of the trackside system 3 with which it communicates, which are used for establishing a wireless link or a wired link at the position indicated by the train position information on the recording medium 7 before the train is powered off. The onboard system 4 reads the train position information and the control information stored on the recording medium 7 at power-on of the train 1 to enable train-trackside communication to be automatically established.

[0023] Additionally, the onboard system 4 takes power input 15 from the battery 5 and an input of speed signal 16 from the speed signal generator 2. The onboard system 4 further includes a timer 10 measuring time interval information and input/output devices 19 for inputting settings of various kinds of information, displaying internal information 17 such as train position information, and providing an audible alarm when an anomaly occurs.

[0024] Provided between the onboard system 4 and the recording medium 7 is a data bus 13 for transmitting and receiving data to be recorded on the recording medium 7 and data read from the recording medium 7, and a write signal 11 and a read signal 12 for controlling the data transmission and reception. Furthermore, provided between the onboard system 4 and the recording medium 7 is the delete signal 14 which is a feature of the present invention.

[0025] A basic operation in the automatic train protection system by wireless communication will be described first with reference to FIG. 1. As the train 1 passes over a trackside antenna beacon 8 installed on the track, the onboard system 4 detects the trackside antenna beacon 8 and receives train position information of the point from the trackside antenna beacon 8. The onboard system 4 performs speed supervision on the basis of control information such as the train position information from the trackside antenna beacon 8, speed information from the speed signal generator 2, and a moving authority obtained from the trackside system 3 and, if the train speed exceeds a speed limit, issues a braking output command. In addition, the onboard system 4 transmits internal information 17 such as the train position information of the train 1 to the trackside system 3 through the communication channel 9.

[0026] The trackside system 3 calculates information such as a moving authority for a train 1 in a track section by using train position information received from a track circuit in the track section and the onboard system 4 and transmits these control informations to the onboard system 4 through the communication channel 9. The communication channel 9 is not limited to a wireless link; a wired transmission line can also be used as the communication channel.

[0027] Train position information in the onboard system 4 is unknown immediately after power-on of the on-

board system 4 and the trackside system 3 cannot detect the on-track position of the train 1 until the train position is determined by the onboard system 4 detecting a trackside antenna beacon 8. To solve the problem, the train 1 is provided with the previous power shutdown signal 6. When the train 1 is powered off, the train 1 outputs the previous power shutdown signal 6 to the onboard system 4 and the onboard system 4 receives the previous power shutdown signal 6 and records internal information 17 such as train position information of the train 1 on the recording medium 7.

[0028] Upon the next power-on of the train 1, the onboard system 4 reads the internal information 17 recorded on the recording medium 7 and transmits and reports train position information included in the internal information 17 to the trackside system 3. The trackside system 3 detects the on-track position of the train 1 on the basis of the train position information from the onboard system 4.

[0029] In this way, the onboard system 4 reports the internal information 17 before power shutdown to the trackside system 3. In this configuration, however, due to movement of the train 1, the onboard system 4 can report train position information of the train 1 recorded on the recording medium 7 at a position other than the position where the train position information has been recorded or the onboard system 4 can record on the recording medium 7 train position information obtained at a wrong position. To address this problem, the present invention proposes a system and a method for preventing occurrence of such anomalies.

<Problem 1>

[0030] Referring to FIGS. 2 to 4, Problem 1 with a conventional train internal information recording method will be described in detail. FIG. 2 is a diagram illustrating a conventional method for recording on a recording medium 7. In the case of Problem 1, a train 1 runs after the onboard system 4 has recorded internal information 17 such as train position information on the recording medium 7 in response to a previous power shutdown signal 6, and consequently the onboard system 4 reports train position information different from actual train position information to the trackside system 3 in a report of internal information 17 including the train position information.

[0031] The onboard system 4 receives the previous power shutdown signal 6 from the train 1 a predetermined amount of time in advance of power shutdown and records the internal information 17 on the recording medium 7. When the onboard system 4 is powered on again, the onboard system 4 reads the internal information 17 that has been stored at the end of operation of the train 1 from the recording medium 7 and reports the train position information of the train 1 to the trackside system 3.

[0032] As illustrated in FIG. 2, after the operation of the train 1 ends, power input 15 from the battery 5 to the onboard system 4 is shut off by an operation by the driver (reference number 401: power input 15 changes from ON to OFF).

[0033] The train 1 sends a previous power shutdown signal 6 (a pulse signal labeled with reference number 402) to the onboard system 4 a predetermined amount of time in advance of the shut-off of the power input 15. The onboard system 4, which has taken the input of the previous power shutdown signal 6, starts writing internal information 17 on the recording medium 7 at the rising edge of the previous power shutdown signal 6 (reference number 403). The onboard system 4 sends internal information data to be written through a data bus 13 and records the data as the internal information 17 on the recording medium 7 by using a write signal 11.

[0034] When the onboard system 4 is powered on again (reference number 405: power input 15 changes from OFF to ON), the onboard system 4 reads from the recording medium 7 the internal information 17 (reference number 404) stored before the previous power shutdown on the recording medium 7 by using a read signal 12 and the data bus 13 (reference number 406). The onboard system 4 then transmits the read internal information 17 to the trackside system 3 through a communication channel 9, thereby reporting train position information of the train 1 to the trackside system 3 (reference number 407).

[0035] According to the configuration described above, if the train 1 moves without being powered off after the onboard system 4 has received the previous power shutdown signal 6 from the train 1, a difference arises between the train position information recorded on the recording medium 7 and the position at which the train 1 actually is located. If the onboard system 4 reads the different data upon the next power-on, the onboard system 4 will report wrong train position information to the trackside system 3.

[0036] FIG. 3 is a diagram illustrating the relationship between the timing of recording on the recording medium 7 and the position of the train 1. As described above, the onboard system 4 records internal information 17 on the recording medium 7 in response to the previous power shutdown signal 6 from the train 1. In FIG. 3, the position information of the train 1 recognized by the onboard system 4 is that at point A. When the previous power shutdown signal 6 is input from the train 1 into the onboard system 4, the onboard system 4 records the train position information "Point A" at point A on the recording medium 7 as internal information 17 by using a write signal 11 and the data bus 13.

[0037] FIG. 4 is a diagram illustrating a state of the train where the train has moved after reception of a previous power shutdown signal 6. In this case, train movement 103 has occurred and the train position has moved from point A to point B. However, if the train 1 in this state is powered off and the onboard system 4 is powered on the next time, the onboard system 4 reads the train position information indicating point A from the recording medium 7 by using a read signal 12 and the data bus 13

because the train position information in the internal information 17 stored in the recording medium 7 remains Point A.

[0038] The onboard system 4 then reports the read train position information indicating point A to the trackside system 3 through the communication channel 9. Accordingly, the trackside system 3 misidentifies the on-track position of the train 1 as point A, instead of point B, which is the correct position.

[0039] The operation described above will be described with reference to the timing chart in Fig. 5. Fig. 5 is a diagram illustrating a conventional recording operation 1 for recording internal information 17 on a recording medium 7. First, when the onboard system 4 receives a previous power shutdown signal 6 from the train 1 (reference number 21), the onboard system 4 performs a write process 11/13 for writing internal information 17 on the recording medium 7 (reference number 22). As a result, train position information "Point A" is recorded in the internal information 17 on the recording medium 7.

[0040] Then, when a speed signal 16 of the train 1 is input (reference number 24) while the power input 15 in the train 1 remains ON without being shut off, and the train 1 moves from point A to point B as indicated by reference number 103 in FIG. 4, the information "Point A" remains held in the internal information 17 on the recording medium 7 (reference number 22).

[0041] When the power input into the train 1 in this state is shut off without an input of the previous power shutdown signal 6 (reference number 25), the information "Point A" remains held in the internal information 17 on the recording medium 7 (reference number 22). Consequently, at the next power-up of the train 1 (reference number 26), the onboard system 4 reads the internal information 17, namely the train position information "Point A" (reference number 23), from the recording medium 7 (reference number 27) and reports the train position information "Point A" to the trackside system 3 (reference number 28). While normally the onboard system 4 has to report "Point B" as the train position information to the trackside system 3, the onboard system 4 reports "Point A" and therefore the trackside system 3 obtains the wrong train position information of the train 1, which adversely affects the railway traffic control system that controls the traffic of the train 1 and other trains.

<Solution 1>

[0042] One embodiment of a solution to Problem 1 described above will be described below with reference to FIGS. 6 and 7.

[0043] FIG. 6 is a diagram illustrating a state of the train 1 where the train 1 has moved after reception of a previous power shutdown signal 6 in a first embodiment of the present invention. FIG. 7 is a diagram illustrating a recording operation 1 for writing internal information 17 on the recording medium 7 in the first embodiment of the present invention.

[0044] The solution in the first embodiment is to delete train position information recorded as internal information 17 on the recording medium 7 when the onboard system 4 receives a speed signal 16 from the speed signal generator 2 to detect that the train 1 is running while the internal information 17 is held on the recording medium 7.

[0045] As illustrated in FIG. 6, when the train 1 stops at point A and the previous power shutdown signal 6 is input into the onboard system 4, the onboard system 4 records train position information at point A as internal information 17 on the recording medium 7. When the train 1 subsequently moves as indicated by reference number 203, the onboard system 4 detects the movement of the train 1 from a speed signal 16 from the speed signal generator 2 and uses a delete signal 14 to delete the internal information 17 "Point A" recorded on the recording medium 7. The delete process alters the internal information 17 on the recording medium 7 to "indeterminate", thereby preventing the wrong information from being held on the recording medium 7.

[0046] This process can prevent the onboard system 4 from reporting wrong train position information to the trackside system 3 when a difference arises between train position information recorded by the onboard system 4 and the on-track position at which the train 1 is actually located.

[0047] Specifically, when the onboard system 4 reads information from the recording medium 7 from which the internal information 17 has been deleted at the next power-up of the onboard system 4, the information "indeterminate" is read from the recording medium 7. Accordingly, the onboard system 4 determines that train position information and internal information relating to the train position information are "indeterminate" and reports that the train position information is "indeterminate" to the trackside system 3 through the communication channel 9.

[0048] While the train position information of the train 1 recognized by the trackside system 3 in this situation is "indeterminate", safe operation of the train 1 can be achieved by the trackside system 3 confirming the safety of the track on which the train 1 and other trains run and then issuing a control command indicting whether the safety has been ensured to the onboard system 4.

[0049] The operation described above will be described with reference to the timing chart in FIG. 7. As illustrated in FIG. 7, when the onboard system 4 receives a previous power shutdown signal 6 from the train 1 (reference number 501), the onboard system 4 performs a write process 11/13 (write signal 11/data bus 13) for writing internal information 17 on the recording medium 7 (reference number 502). In this state, train position information "Point A" has been recorded in the internal information 17 on the recording medium 7 (reference number 503).

[0050] When a speed signal 16 is input into the onboard system 4 without the power to the train 1 being shut off and the onboard system 4 detects that the train 1 is run-

ning (reference number 504) after the train position information has been recorded on the recording medium 7, the onboard system 4 deletes the internal information 17 recorded on the recording medium 7 (reference number 503) with the delete signal 14 (reference number 505).

[0051] In this way, when the power to the onboard system 4 is not shut off and the train 1 runs after the previous power shutdown signal 6 has been output, the onboard system 4 can detect that the train 1 is running (reference number 504) to delete the internal information 17 recorded on the recording medium 7.

[0052] Even if the onboard system 4 is powered off without taking an input of the previous power shutdown signal 6 again (reference number 506), the onboard system 4 performs a process 12/13 (read signal 12/data bus 13) for reading (reference number 509) the internal information 17 (reference number 508) on the recording medium 7 at the next power on (reference number 507).

[0053] However, the onboard system 4 determines that the internal information 17 is "indeterminate" (reference number 508) because the onboard system 4 has deleted the internal information 17 from the recording medium 7 previously. Accordingly, the onboard system 4 reports the train position information of the train 1 as "indeterminate" to the trackside system 3 (reference number 510).

[0054] In this way, if a previous power shutdown signal 6 is input and then the train 1 runs again (reference number 24) before the power input 15 is turned OFF as in Problem 1 illustrated from FIG. 3 to FIG. 5, train position information that differs from the current train position information is deleted and is not held on the recording medium 7. Accordingly, the onboard system 4 can be prevented from reporting the wrong train position information to the trackside system 3 at the next power-on (reference number 26).

[Second Embodiment]

<Problem 2>

[0055] Problem 2 with the conventional method for recording train internal information will be described next with reference to FIGS. 8 and 9. Problem 2 is that when power to a train 1 is shut off, a previous power shutdown signal 6 is not input into onboard system 4 due to some failure, therefore the current train position information cannot be correctly recorded on a recording medium 7, and train position information recorded at the previous power shutdown remains held on the recording medium 7 and is reported to the trackside system 3 at the next power shutdown. This phenomenon will be described with reference to FIGS. 8 and 9.

[0056] FIG. 8 is a diagram illustrating a state of the train 1 where the train 1 has run while internal information 17 is held on the recording medium 7. As illustrated in FIG. 8, when a previous power shutdown signal 6 is input from the train 1 into the onboard system 4 at point C, the onboard system 4 performs a write process 11/13 (write signal 11/data bus 13) for recording train position information "Point C" on the recording medium 7 as internal information 17.

[0057] When the onboard system 4 is powered on again after the train position information has been recorded, the onboard system 4 performs a read process 12/13 (read signal 12/data bus 13) for reading the train position information "Point C" from the recording medium 7. The onboard system 4 then reports the train position information "Point C" read from the recording medium 7 to the trackside system 3 through the communication channel 9.

[0058] After the report of the train position information, the train 1 runs to point D (reference number 110) while holding the train position information at point C on the recording medium 7 as internal information 17. If the onboard system 4 cannot obtain a previous power shutdown signal 6 from the train 1 when the train 1 is powered off at point D, the onboard system 4 cannot record train position information "Point D" on the recording medium 7 as internal information 17. Accordingly, the train position information "Point C" remains held in the internal information 17 on the recording medium 7.

[0059] Accordingly, at power-on at point D, the onboard system 4 reads the train position information "Point C" which has been reported to the trackside system 3 at the previous power-on from the recording medium 7 and reports the wrong train position information "Point C" to the trackside system 3.

[0060] The operation described above will be described with reference to the timing chart in FIG. 9. FIG. 9 is a diagram illustrating a conventional recording operation 2 for recording internal information 17 on a recording medium 7.

[0061] The onboard system 4 receives a previous power shutdown signal 6 from the train 1 a predetermined amount of time in advance of shut-off (reference number 30) of power input 15 to the train 1 as indicated by reference number 31 and performs a write process (reference number 32) for writing internal information 17 including train position information at point C on the recording medium 7. "Point C" is stored on the recording medium 7 as the internal information 17. On the next power-on (reference number 34), the onboard system 4 performs a read process (reference number 35) for reading the internal information 17 (reference number 33) on the recording medium 7 and reports the train position information "Point C" to the trackside system 3 (reference number 36).

[0062] If the onboard system 4 is powered off (reference number 38) without an input of the previous power shutdown signal 6 after the train position information "Point C" has been reported and then the train 1 has moved to point D (reference number 37), the process for writing on the recording medium 7 is not performed and the internal information 17 is still the train position information "Point C" at point C instead of train position infor-

mation "Point D" at point D.

[0063] Normally, a previous power shutdown signal 6 would be input into the onboard system 4 as indicated by a dashed line 31-2 (reference number 31-2) and a write process for writing the train position information "Point D" at Point D would be performed. However, the write process is not performed because the previous power shutdown signal 6 is not input into the onboard system 4. Consequently, upon the next power-on (reference number 39), the onboard system 4 reads (reference number 40) the previous train position information "Point C" (reference number 33) from the recording medium 7 and reports the train position information "Point C" to the trackside system 3 (reference number 41).

[0064] In this way, the trackside system 3 obtains wrong train position information of the train 1 in Problem 2 as in Problem 1, which adversely affects the railway traffic control system that controls the traffic of the train 1 and other trains.

<Solution 2>

[0065] One embodiment of a solution to Problem 2 described above will be described below with reference to FIGS. 10 and 11. FIG. 10 is a diagram illustrating a state of the train 1 where movement occurs after reception of a previous power shutdown signal 6 in a second embodiment of the present invention. FIG. 11 is a diagram illustrating a recording operation 2 for recording internal information 17 on the recording medium 7 in the second embodiment of the present invention.

[0066] A feature of the solution to Problem 2 is that the onboard system 4 deletes internal information 17 recorded on the recording medium 7 after the onboard system 4 has reported internal information 17 recorded on the recording medium 7 to the trackside system 3, as illustrated in FIG. 10.

[0067] In FIG. 10, when the train 1 stops at point C and the previous power shutdown signal 6 is input into the onboard system 4, the onboard system 4 performs a process for writing train position information at point C onto the recording medium 7 as internal information 17.

[0068] When the onboard system 4 is powered on in this situation, the onboard system 4 reads the internal information at point C from the recording medium 7 and reports the internal information to the trackside system 3. After the report, the onboard system 4 deletes the internal information 17, which is the train position information at point C, recorded on the recording medium 7. As a result of the delete process 14, the internal information 17 on the recording medium 7 changes from "Point C" to "indeterminate".

[0069] The train 1 is operated again and the on-track position moves from point C to point D. After the completion of the movement, if the onboard system 4 cannot receive the previous power shutdown signal 6 from the train 1 at power shutdown at point D as in the example in FIG. 9, the onboard system 4 does not record train position information at point D on the recording medium 7.

[0070] When the onboard system 4 is powered on again and reads the internal information 17 from the recording medium 7 in this situation, the onboard system 4 determines that the train position information and the internal information 17 relating to the train position information are "indeterminate" and reports to the trackside system 3 that train position information is "indeterminate".

[0071] With the configuration described above, unlike in FIG. 9, the recording medium 7 does not continue holding internal information 17 at point C, thereby preventing the onboard system 4 from reporting wrong train position information, "Point C", to the trackside system 3 as the train position information of the train 1 located at point D.

[0072] Moreover, if the onboard system 4 cannot obtain the previous power shutdown signal 6 after deleting the information recorded on the recording medium 7, the onboard system 4 reports information "indeterminate" to the trackside system 3 as described above. In this case, the trackside system 3 issues a control command indicating whether the safety has been ensured to the onboard system 4, therefore safety operation of the train 1 is not impaired.

[0073] The operation described above will be described with reference to the timing chart in FIG. 11. The onboard system 4 receives a previous power shutdown signal 6 (reference number 602) from the train 1 a predetermined amount of time in advance of power shutdown of the train 1 (reference number 601) and performs a write process (reference number 603) for writing internal information 17 on the recording medium 7.

[0074] At the next power-on (reference number 605), the onboard system 4 performs a read process (reference number 606) for reading the internal information 17 (reference number 604) from the recording medium 7 and reports the train position information to the trackside system 3 (reference number 608). After completion of the report of train position information "Point C" to the trackside system 3, the onboard system 4 deletes the internal information 17 recorded on the recording medium 7 with a delete signal 14 (alternatively referred to as a delete process 14) (reference number 607).

[0075] In this situation the train 1 moves again and reaches point D (reference number 600) and, if the previous power shutdown signal 6 is not input before power input to the onboard system 4 is shut off again (reference number 610), train position information at point D is not recorded on the recording medium 7 as the internal information 17, therefore the internal information 17 on the recording medium 7 indicates "indeterminate".

[0076] Then, on the next power-up (reference number 611), the onboard system 4 reads the internal information 17 on the recording medium 7 (reference number 612). However, since the internal information 17 has been deleted and is "indeterminate" (reference number 614), the onboard system 4 reports to the trackside system 3 that train position information is "indeterminate" (reference

number 613).

[0077] The delete process 14 for deleting the internal information 17 prevents previously reported train position information from being left on the recording medium 7 when the previous power shutdown signal 6 is not input into the onboard system 4 between the completion of running of the train 1 and shut-off of power input to the onboard system 4 as illustrated in FIG. 9 and can prevent wrong train position information from being reported to the trackside system 3.

[Third Embodiment]

<Problem 3>

[0078] A case where a previous power shutdown signal 6 is accidentally input will be described with reference to FIG. 12. Fig. 12 is a diagram illustrating a conventional operation 3 for recording internal information 17 on a recording medium 7.

[0079] When a previous power shutdown signal 6 is accidentally input while the train 1 is running, onboard system 4 records in the recording medium 7 internal information 17 that is to be recorded at power shutdown at a wrong timing at which the internal information 17 is not to be recorded. In such a situation, the train 1 is running and the position of the train 1 is continuously changing. Therefore, train position information recorded in response to the previous power shutdown signal 6 accidentally input while the train 1 is running is invalid and cannot be used as a train position report at the next power-on.

[0080] FIG. 12 illustrates a situation where train position information is recorded when the previous power shutdown signal is input at an unintended timing such as while the train is running. Normally, internal information 17 needs to be recorded in a situation where the power to the train 1 is shut off. However, the onboard system 4 records the internal information 17 on the recording medium 7 (reference number 703) when the onboard system 4 receives (reference number 702) a false previous power shutdown signal 6 from the train 1 while the train 1 is running (reference number 701). Then the recording medium 7 continues holding the recorded train position information at point E (reference number 704) while the position of the train 1 is changing.

<Solution 3>

[0081] One embodiment of a solution to Problem 3 described above will be described below with reference to FIG. 13. FIG. 13 is a diagram illustrating an operation 3 for recording internal information 17 on a recording medium 7 in a third embodiment of the present invention.

[0082] An operation for recording on the recording medium 7 performed when a previous power shutdown signal 6 is input while the train 1 is running will be described with reference to the timing chart in FIG. 13. In this embodiment, the process for writing internal information 17 on the recording medium 7 is performed only when both of the following two conditions are satisfied:

(1) the speed of the train 1 is 0 km/h, and
(2) a previous power shutdown signal 6 is input into the onboard system 4. This prevents the onboard system 4 from writing incorrect information on the recording medium 7 while the train 1 is running.

[0083] As illustrated in FIG. 13, when a previous power shutdown signal 6 is input into the onboard system 4 (reference number 802) while the speed of the train 1 is higher than 0 km/h (reference number 801), the onboard system 4 does not write on the recording medium 7 (reference number 803). When the previous power shutdown signal 6 is input (reference number 806) before power input 15 is shut off (reference number 805) while the train 1 is at rest with a speed of 0 km/h (reference number 804), the onboard system 4 writes train position information and train control information on the recording medium 7 as internal information 17 (reference number 807). In the example in FIG. 13, train position information "Point G" is recorded in the internal information 17 on the recording medium 7 (reference number 808).

[0084] In this way, if the onboard system 4 receives a previous power shutdown signal 6 (reference number 702) while the train 1 is running (reference number 701), the onboard system 4 can be prevented from recording internal information 17 on the recording medium 7 (reference number 703) and the recording medium 7 can be prevented from consistently holding incorrect train position information (Point E).

[0085] Moreover, since the onboard system 4 does not write train position information on the recording medium 7 every time the previous power shutdown signal 6 is input, the amount of processing by the onboard system 4 and load on the onboard system 4 can be reduced. Furthermore, since the number of writes on the recording medium 7 can be reduced, the life of the recording medium 7 implemented by a nonvolatile memory such as a flash memory, which has a limited number of write cycles, can be increased.

[0086] For the previous power shutdown signal 6, the timer 10 may start measuring time when the train stops and the speed signal 16 indicates 0. After the expiration of a predetermined amount of time, a previous power shutdown signal (reference number 802-2) may be generated inside the onboard system 4. If a previous power shutdown signal 6 is not input from an external source, the internally generated previous power shutdown signal may trigger execution of the process for writing train position information on the recording medium 7 as the internal information 17 (reference number 803-2).

[0087] The present invention is not limited to the embodiments describe above but instead includes various variations.

[0088] While the embodiments have been described

in detail above for better understanding of the present invention, the present invention is not limited to embodiments that include all of the components described. Some of the components of any one of the embodiments may be replaced with components of another embodiment. Furthermore, some of components of each embodiment may be added to another embodiment or may be omitted, or replaced with components of another embodiment.

[0089] Any or all of the elements such as the components, functions, processing units, and processing means described above may be implemented by hardware, for example by designing them as integrated circuits. Furthermore, any of all of the elements such as the component and functions described above may be implemented by software, where a processor interprets and executes a program that implements each of the functions.

[0090] The programs and information such as tables and files that implement the functions and the processes may be recorded on a recording device such as a memory, a hard disk, or an SSD (Solid State Drive) or a recording medium such as an IC card, an SD card, or a DVD.

[0091] Only control lines and information lines that are considered to be required for explanation are depicted and not all control lines and information lines are depicted. In practice, it may be considered that almost all of the components are interconnected.

Claims

1. An automatic train protection system detecting a position of a train at trackside system on the basis of train control information including train position information,
the train comprising:

an onboard system controlling the whole train and communicating with the trackside system;
a power supply device supplying power to the whole train and generating a previous power shutdown signal providing an advance notice of shut-off of power supply to the onboard system;
a storage device storing position information of the train; and
a speed measuring device for measuring the speed of the train;
wherein the train control information is stored on the storage device in response to occurrence of the previous power shutdown signal;
the train position information recorded on the storage device is transmitted to the trackside system when power supply to the onboard system is started; and
the train control information stored on the storage device is deleted when a predetermined condition is satisfied.

2. The automatic train protection system according to claim 1,
wherein the predetermined condition is that while the train control information is stored on the storage device, the speed measuring device detects running of the train before the power supply is shut off.

3. The automatic train protection system according to claim 1 or 2,
wherein the predetermined condition is that while the train control information is stored on the storage device, power supply to the train is resumed and the train control information is read from the storage device.

4. The automatic train protection system according to any one of claims 1 to 3,
wherein the predetermined condition is that while the train control information is stored on the storage device, power supply to the train is resumed and the stored train control information is read from the storage device and transmitted to the trackside system.

5. The automatic train protection system according to any one of claims 1 to 4,
wherein the onboard system and the trackside system communicate with each other wirelessly or via a wire.

6. The automatic train protection system according to any one of claims 1 to 5,
wherein the train control information comprises a control level before power shutdown, channel information, a phone number, and identification information of the trackside system that are used for establishing a wireless link or a wired link at a position at which the train is located, in addition to the train position information.

7. The automatic train protection system according to any one of claims 1 to 6,
wherein the train further comprises an input device for setting information for controlling the train and an output device for displaying information stored on the storage device.

8. The automatic train protection system according to any one of claims 1 to 7,
wherein the train control information is prevented from being stored on the storage device while the speed measuring device is detecting running of the train.

9. The automatic train protection system according to claim 8,
wherein the train control information is prevented

from being stored on the storage device while the speed measuring device is detecting running of the train, even when the previous power shutdown signal occurs.

10. The automatic train protection system according to claim 8 or 9,
wherein the train control information is allowed to be stored on the storage device while the speed measuring device is not detecting running of the train.

11. The automatic train protection system according to any one of claims 8 to 10,
wherein the train further comprises an input device for setting information for controlling the train and an output device for displaying information stored on the storage device.

FIG. 1

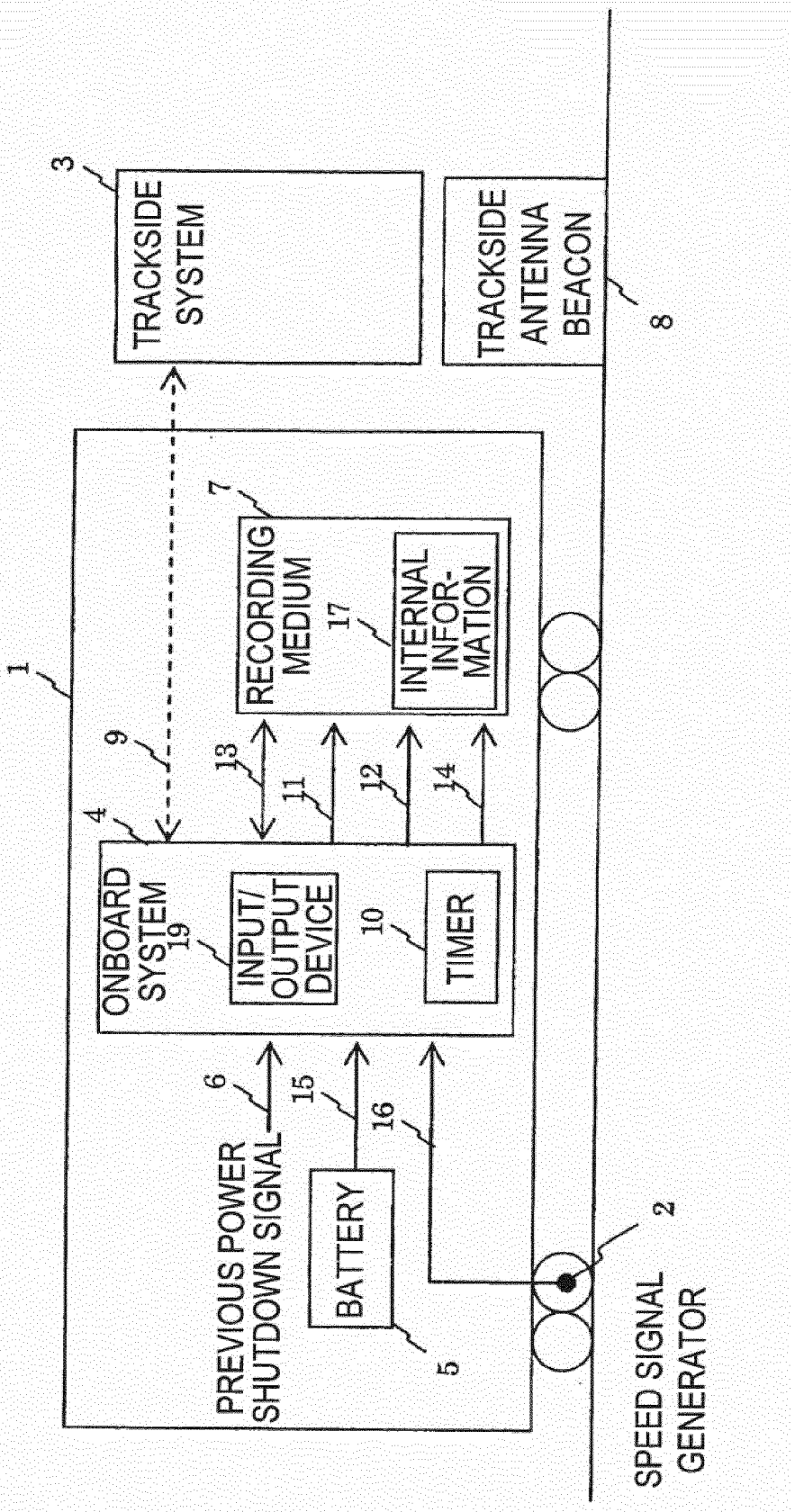

3
TRACKSIDE SYSTEM
TRACKSIDE ANTENNA BEACON
8
1
9
7
RECORDING MEDIUM
17
INTERNAL INFOR-MATION
13
11
12
14
4
ONBOARD SYSTEM
19
INPUT/ OUTPUT DEVICE
10
TIMER
6
PREVIOUS POWER SHUTDOWN SIGNAL
15
16
BATTERY
5
2
SPEED SIGNAL GENERATOR

FIG. 2

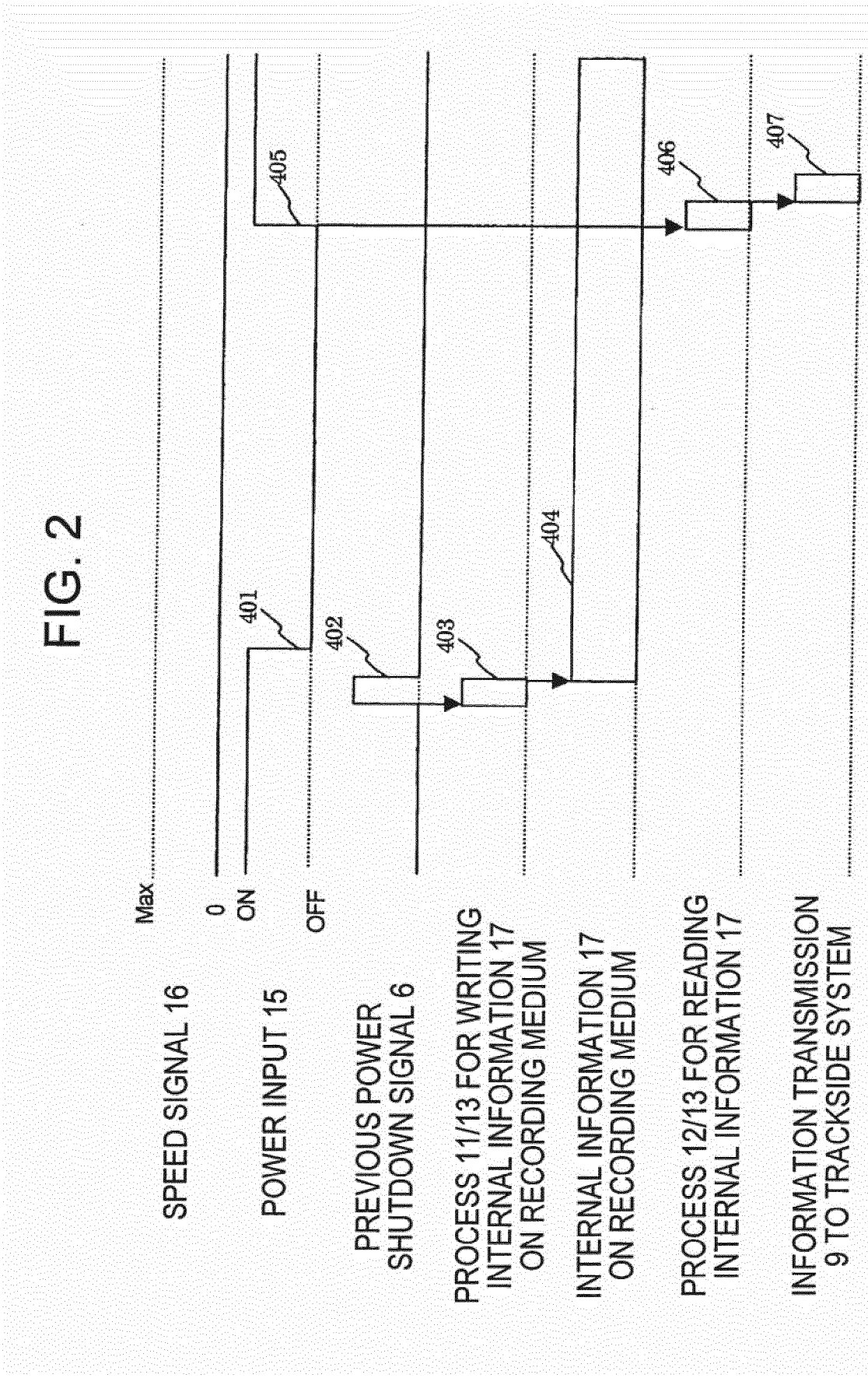

SPEED SIGNAL 16
Max
0
POWER INPUT 15
ON
OFF
PREVIOUS POWER SHUTDOWN SIGNAL 6
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 12/13 FOR READING INTERNAL INFORMATION 17
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM
401
402
403
404
405
406
407

FIG. 3

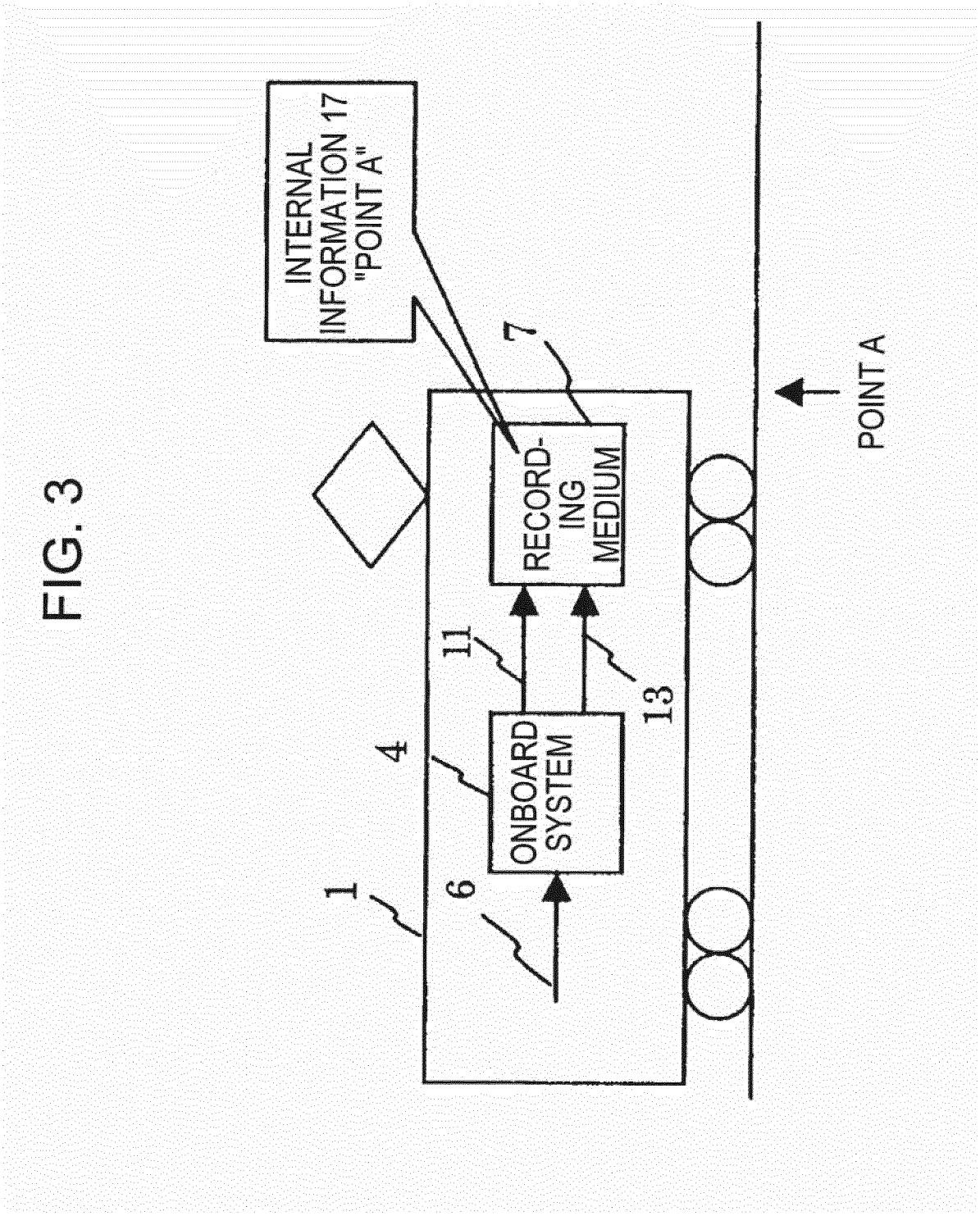

INTERNAL INFORMATION 17 "POINT A"
7
RECORD-ING MEDIUM
11
13
4
ONBOARD SYSTEM
6
1
POINT A

FIG. 4

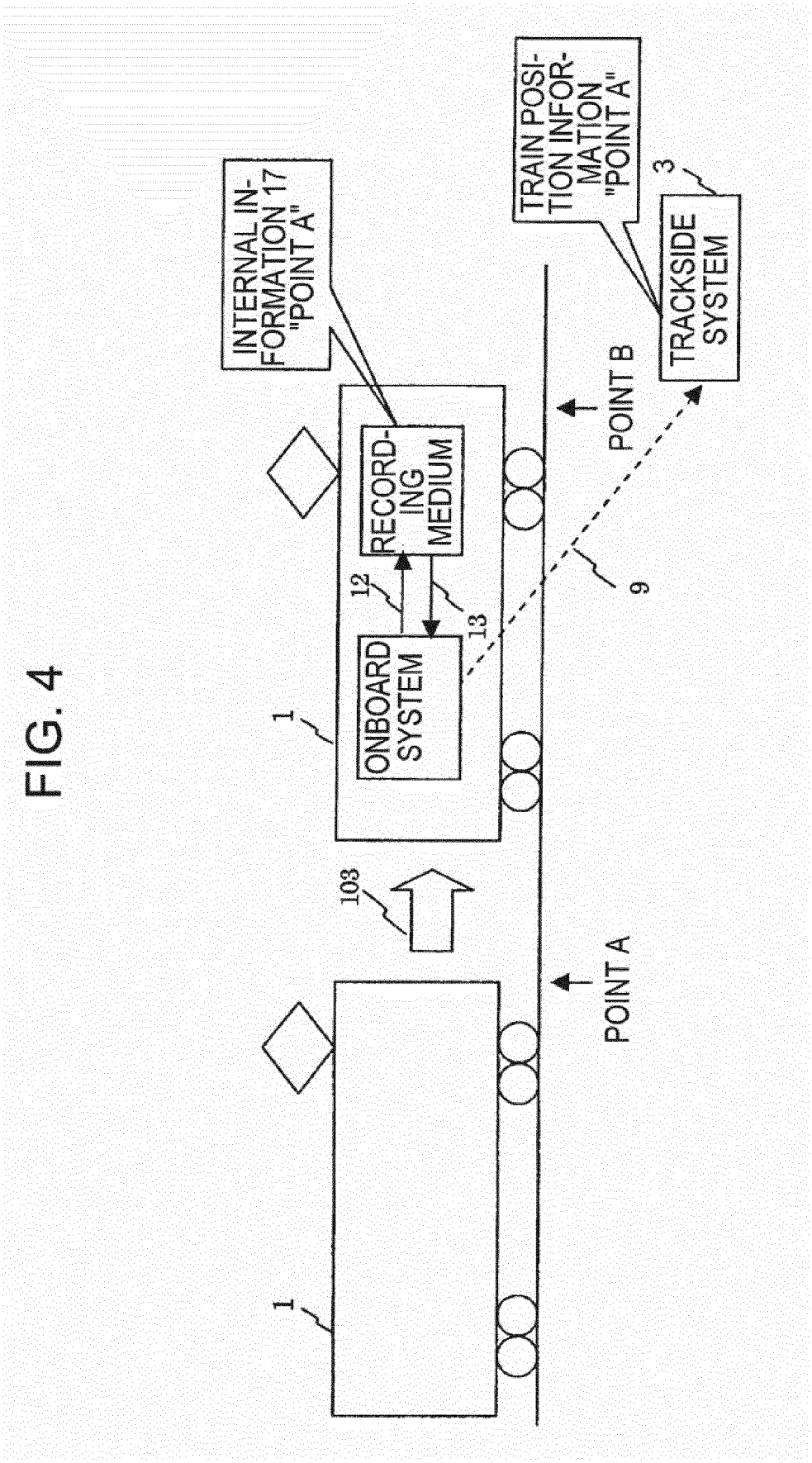

INTERNAL IN-FORMATION 17 "POINT A"
TRAIN POSI-TION INFOR-MATION "POINT A"
3
TRACKSIDE SYSTEM
POINT B
RECORD-ING MEDIUM
12
13
9
ONBOARD SYSTEM
1
103
POINT A
1

FIG. 5

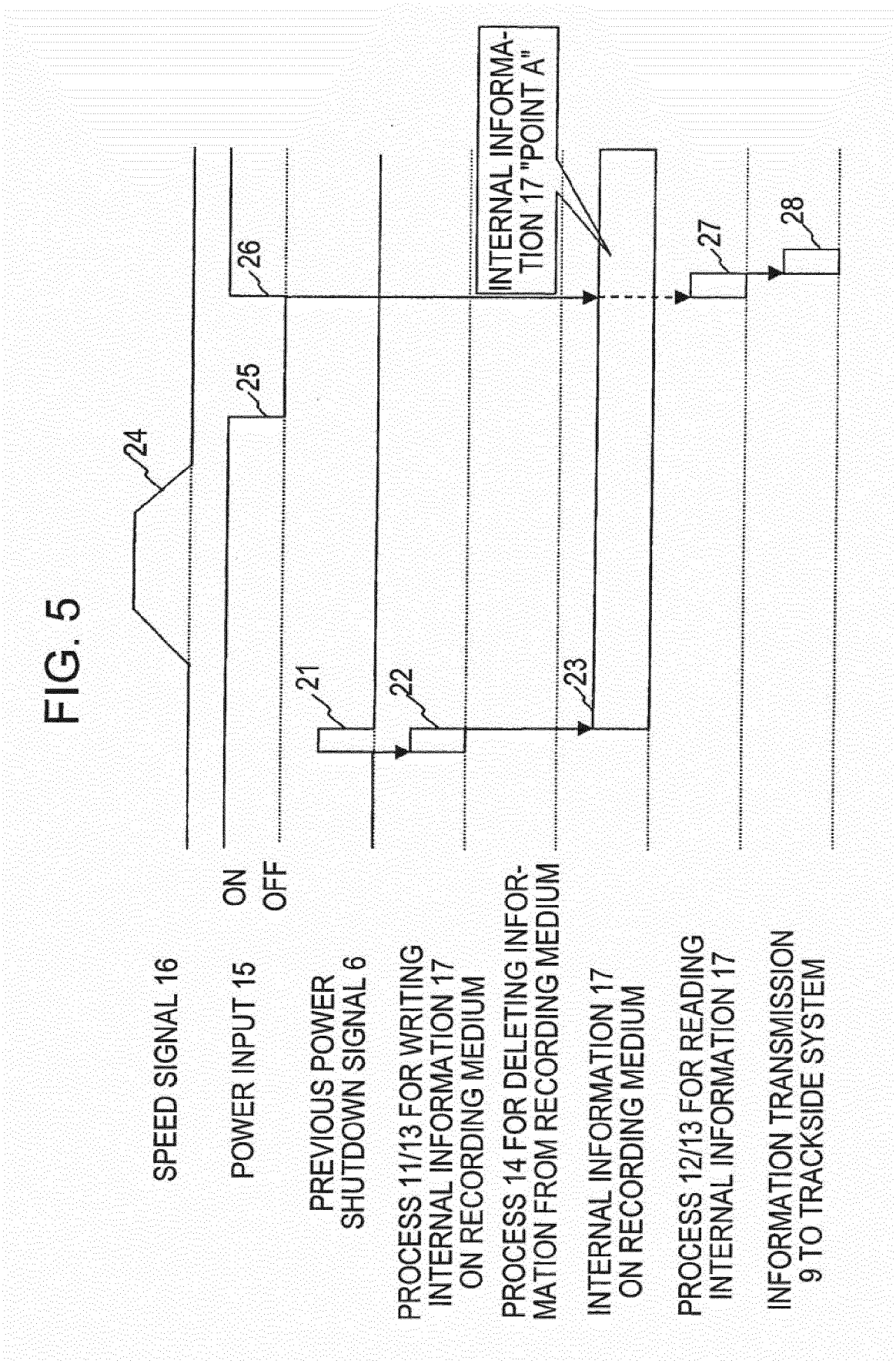

SPEED SIGNAL 16
POWER INPUT 15
ON
OFF
PREVIOUS POWER SHUTDOWN SIGNAL 6
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 14 FOR DELETING INFORMATION FROM RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 12/13 FOR READING INTERNAL INFORMATION 17
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM
INTERNAL INFORMATION 17 "POINT A"
21
22
23
24
25
26
27
28

FIG. 6

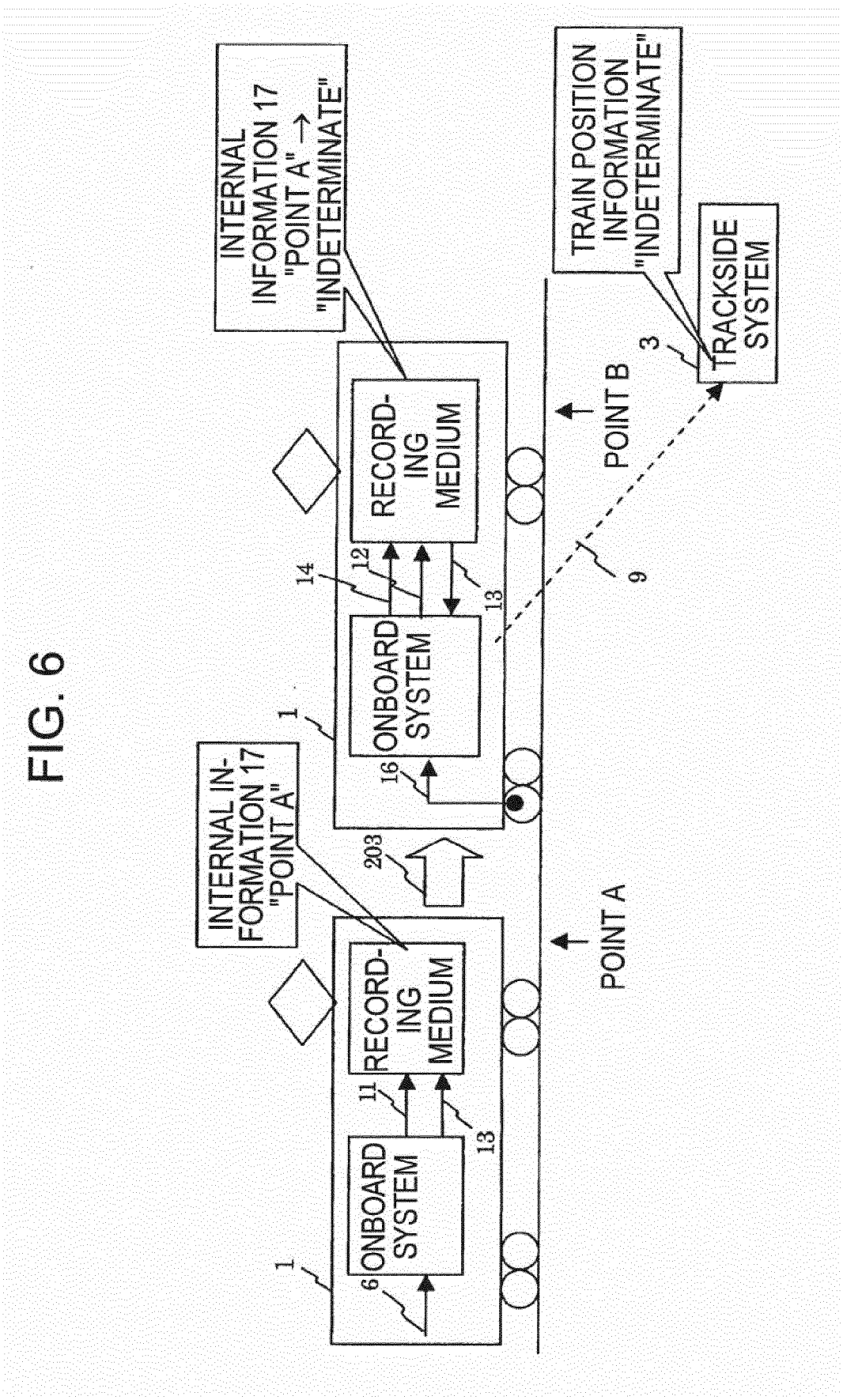

INTERNAL INFORMATION 17 "POINT A" → "INDETERMINATE"
TRAIN POSITION INFORMATION "INDETERMINATE"
TRACKSIDE SYSTEM
3
POINT B
9
RECORD-ING MEDIUM
12
14
13
ONBOARD SYSTEM
16
1
INTERNAL IN-FORMATION 17 "POINT A"
203
RECORD-ING MEDIUM
11
13
ONBOARD SYSTEM
6
1
POINT A

FIG. 7

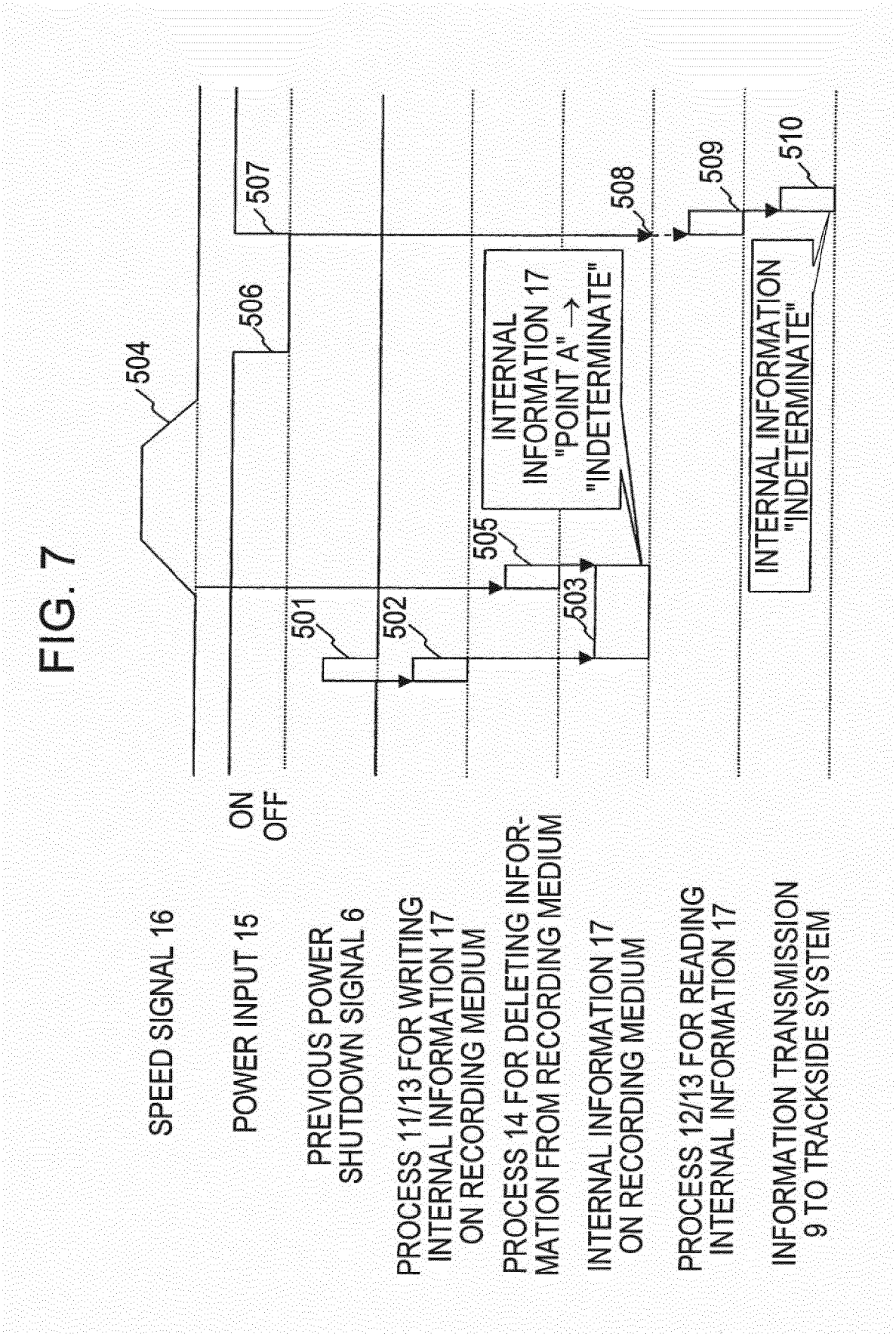

SPEED SIGNAL 16
POWER INPUT 15
ON
OFF
PREVIOUS POWER SHUTDOWN SIGNAL 6
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 14 FOR DELETING INFORMATION FROM RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 12/13 FOR READING INTERNAL INFORMATION 17
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM
504
506
507
501
502
505
503
INTERNAL INFORMATION 17 "POINT A" → "INDETERMINATE"
508
509
510
INTERNAL INFORMATION "INDETERMINATE"

FIG. 8

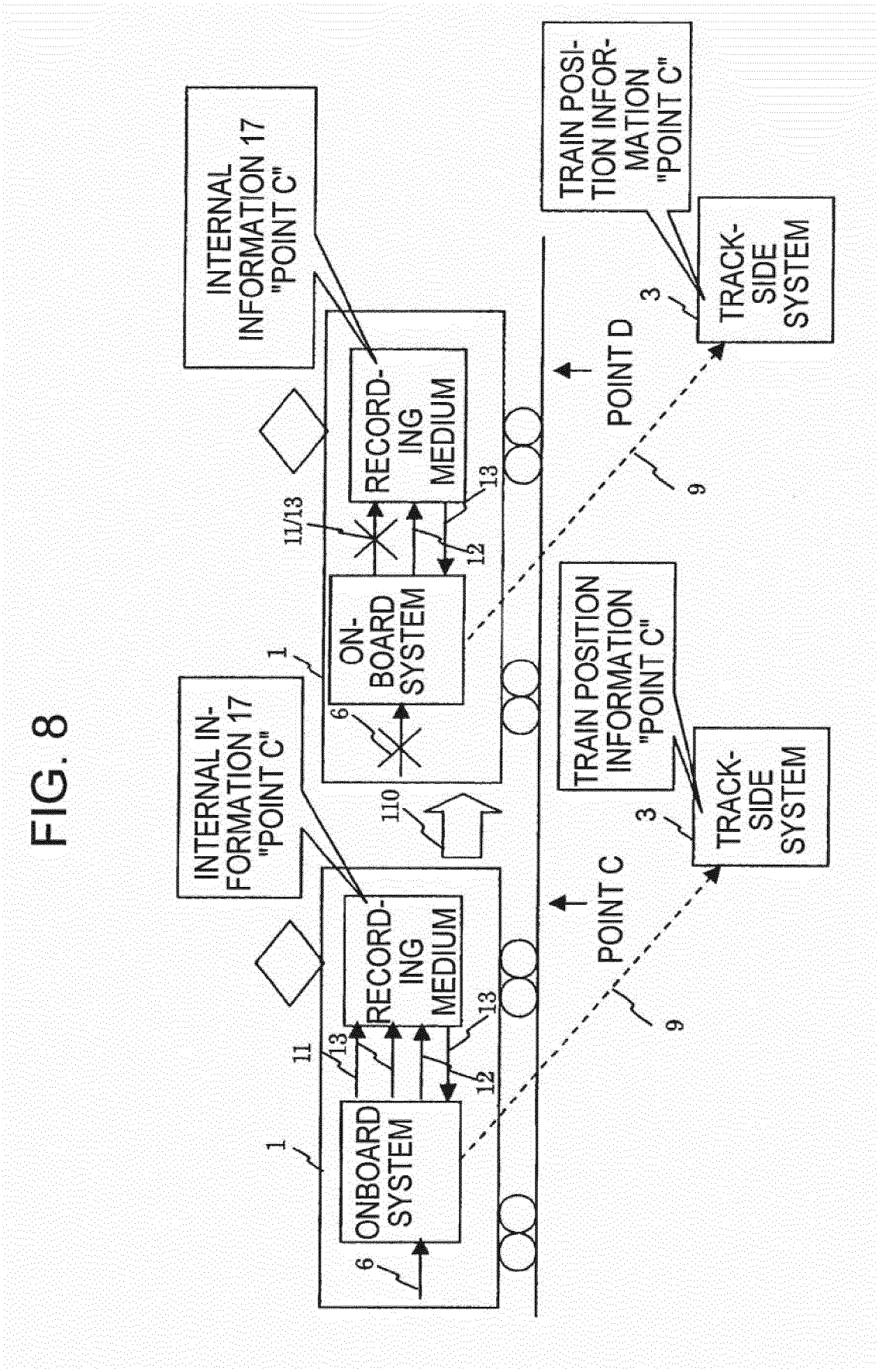

INTERNAL INFORMATION 17 "POINT C"
INTERNAL IN-FORMATION 17 "POINT C"
TRAIN POSI-TION INFOR-MATION "POINT C"
TRAIN POSITION INFORMATION "POINT C"
RECORD-ING MEDIUM
RECORD-ING MEDIUM
ON-BOARD SYSTEM
ONBOARD SYSTEM
TRACK-SIDE SYSTEM
TRACK-SIDE SYSTEM
POINT D
POINT C
1
1
3
3
6
6
9
9
11
11/13
12
12
13
13
110

FIG. 9

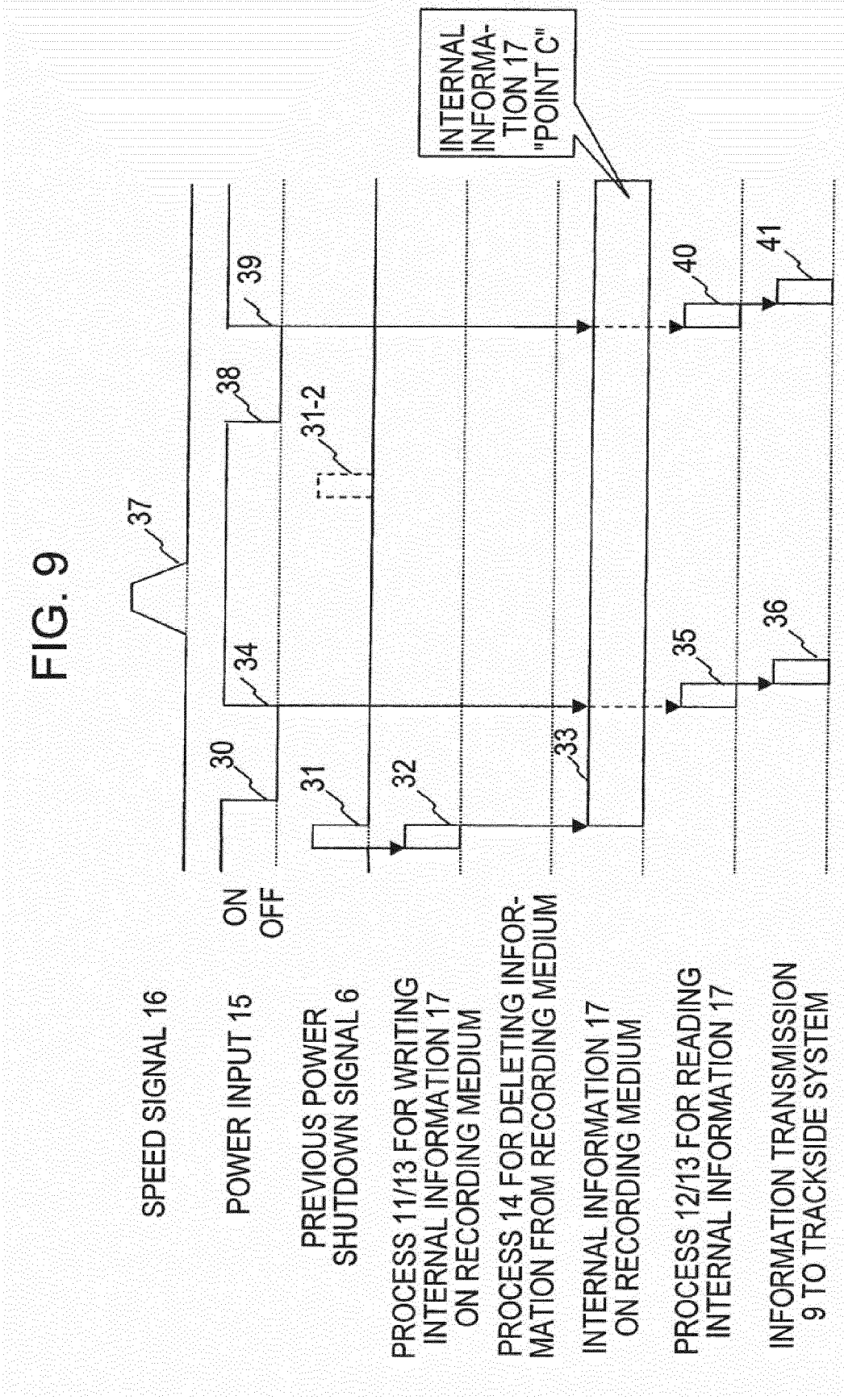

SPEED SIGNAL 16
POWER INPUT 15
ON
OFF
PREVIOUS POWER SHUTDOWN SIGNAL 6
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 14 FOR DELETING INFORMATION FROM RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 12/13 FOR READING INTERNAL INFORMATION 17
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM
INTERNAL INFORMATION 17 "POINT C"
30
31
31-2
32
33
34
35
36
37
38
39
40
41

FIG. 10

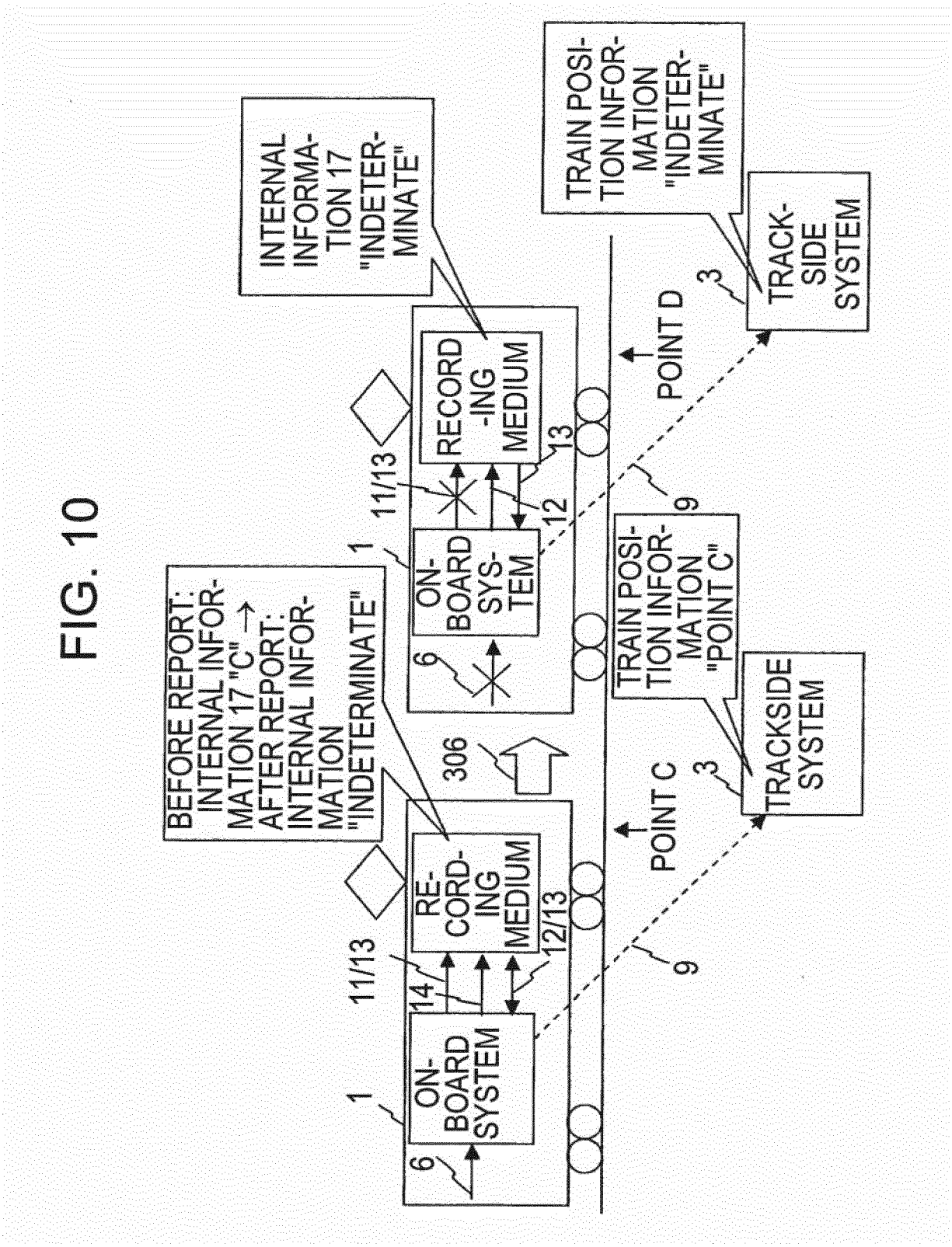

BEFORE REPORT: INTERNAL INFORMATION 17 "C" → AFTER REPORT: INTERNAL INFORMATION "INDETERMINATE"
INTERNAL INFORMATION 17 "INDETERMINATE"
TRAIN POSITION INFORMATION "INDETERMINATE"
TRAIN POSITION INFORMATION "POINT C"
ON-BOARD SYSTEM
RECORDING MEDIUM
TRACK-SIDE SYSTEM
TRACKSIDE SYSTEM
POINT C
POINT D
306
1
3
6
9
11/13
12/13
12
13
14

FIG. 11

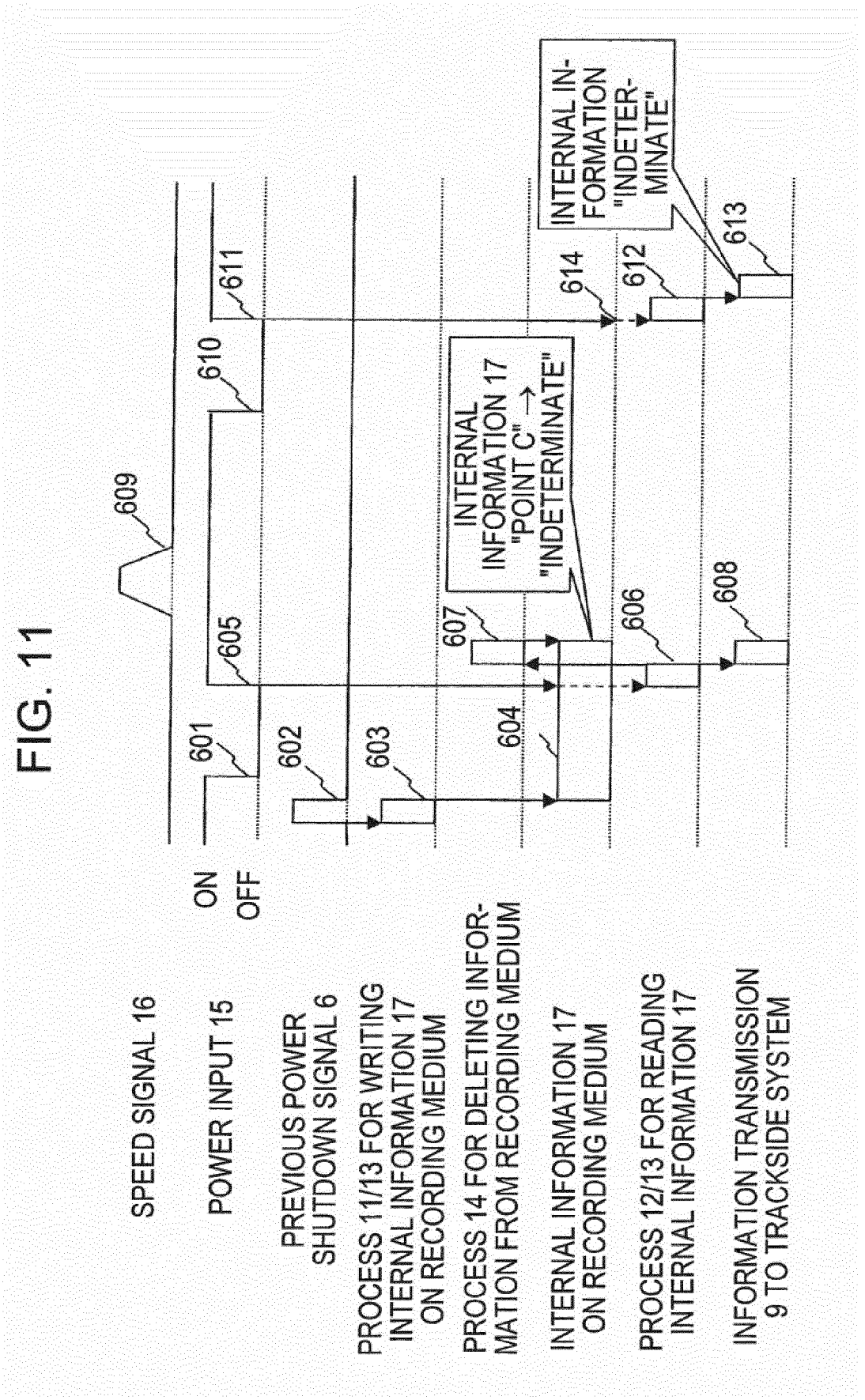

SPEED SIGNAL 16
POWER INPUT 15
ON
OFF
PREVIOUS POWER SHUTDOWN SIGNAL 6
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 14 FOR DELETING INFORMATION FROM RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 12/13 FOR READING INTERNAL INFORMATION 17
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM
INTERNAL INFORMATION 17 "POINT C" → "INDETERMINATE"
INTERNAL INFORMATION "INDETERMINATE"
601
602
603
604
605
606
607
608
609
610
611
612
613
614

FIG. 12

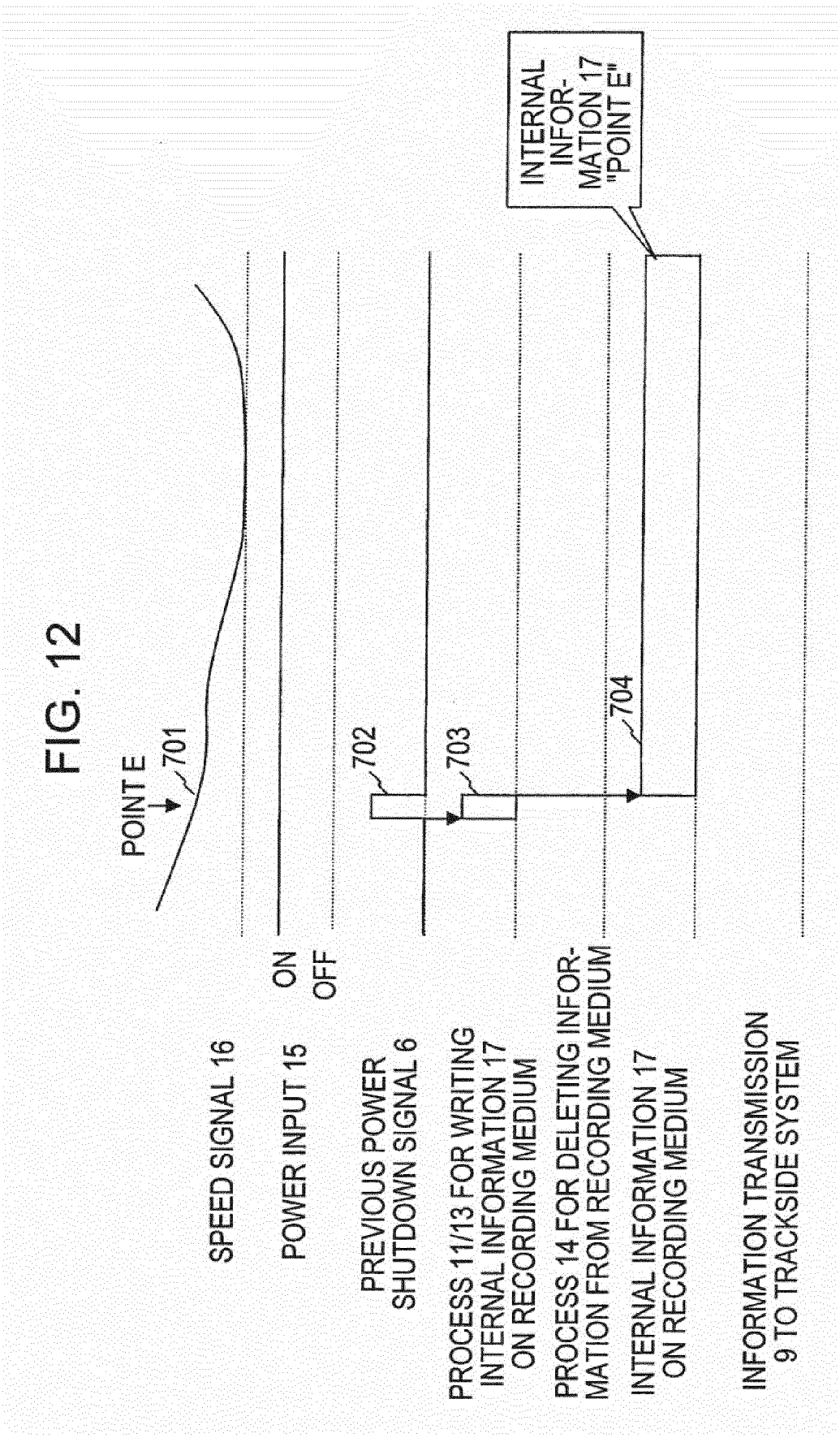
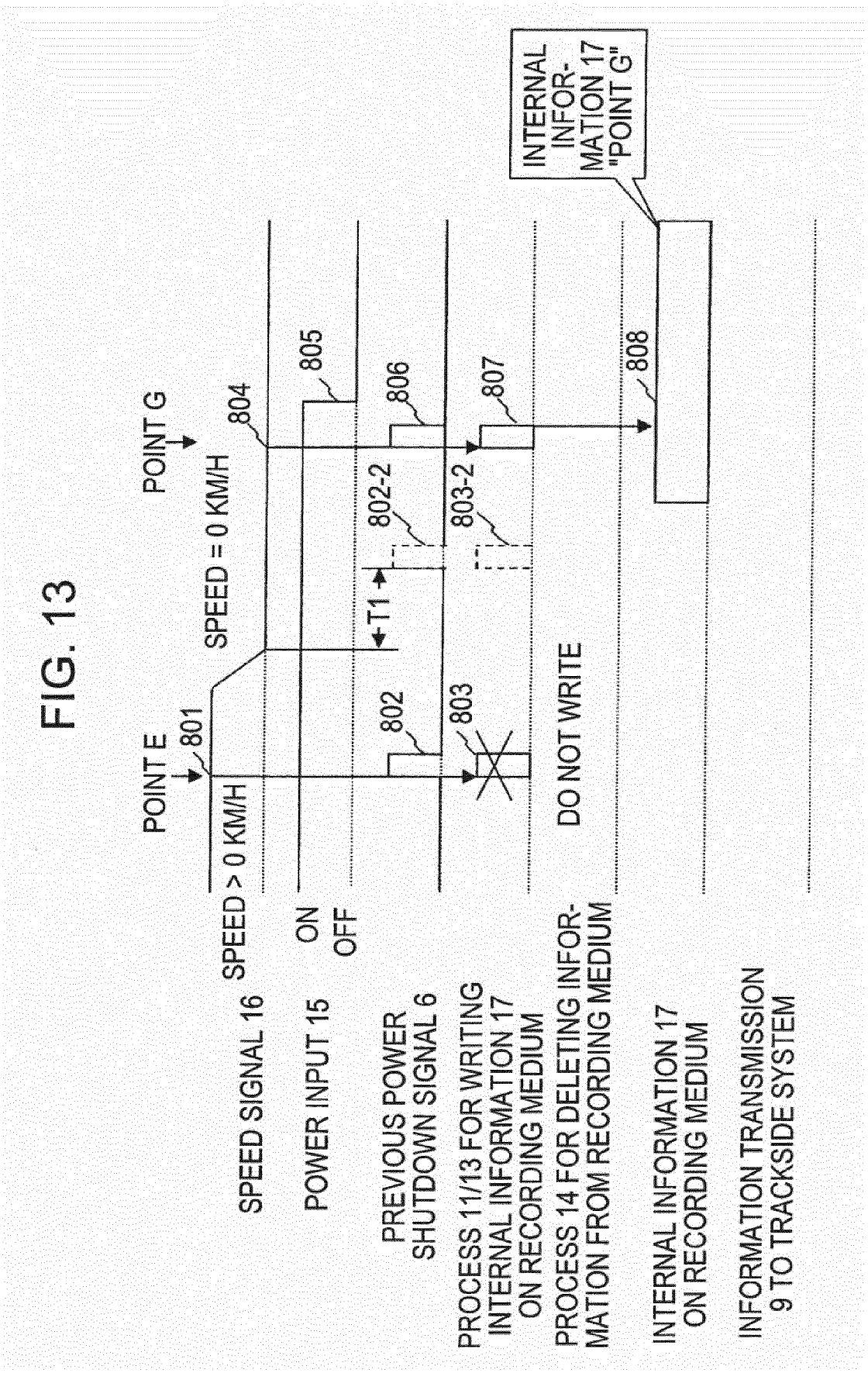

POINT E
701
SPEED SIGNAL 16
POWER INPUT 15
ON
OFF
PREVIOUS POWER SHUTDOWN SIGNAL 6
702
703
704
INTERNAL INFOR-MATION 17 "POINT E"
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
PROCESS 14 FOR DELETING INFOR-MATION FROM RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM

FIG. 13


POINT E
801
SPEED > 0 KM/H
SPEED SIGNAL 16
POINT G
SPEED = 0 KM/H
804
805
806
807
808
ON
OFF
POWER INPUT 15
802
803
802-2
803-2
T1
PREVIOUS POWER SHUTDOWN SIGNAL 6
PROCESS 11/13 FOR WRITING INTERNAL INFORMATION 17 ON RECORDING MEDIUM
DO NOT WRITE
PROCESS 14 FOR DELETING INFORMATION FROM RECORDING MEDIUM
INTERNAL INFORMATION 17 ON RECORDING MEDIUM
INTERNAL INFORMATION 17 "POINT G"
INFORMATION TRANSMISSION 9 TO TRACKSIDE SYSTEM

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP HEI9301176 B **[0008]**
- JP 2008238888 A **[0008]**