

Description

[0001] The present invention relates to a receiving apparatus mounted on a mobile body, such as a vehicle, and more particularly, to a radio receiver which is capable of receiving a broadcast signal into which data is multiplexed.

[0002] In Europe and other areas, a radio data system (RDS) (hereinafter referred to as "RDS") in which various items of data are multiplexed into a radio broadcast signal is in actual use. Examples of data items to be multiplexed into a radio broadcast signal are information for identifying a program (program identification (PI)), information for identifying a genre of a program (program type (PTY)), information concerning alternative broadcast stations, and traffic information using traffic message channel (TMC) services. In a radio receiver, on the basis of received data, a broadcast program name is displayed on a display, or a list of alternative broadcast stations is created, and when a vehicle is moved out of a reception area, automatic switching or retuning to an alternative broadcast station is implemented (see JP 2990187 B1 and JP 3271869 B2). An RDS receiver which can speedily receive traffic information provided by RDS broadcasts is also disclosed (see JP 4578413 B2).

[0003] Broadcast stations which transmit RDS broadcasts transmit various items of data to be multiplexed into broadcast signals in accordance with transmission standards, and radio receivers receive such items of data in accordance with the transmission standards. However, some broadcast stations transmit data without complying with the transmission standards. If a radio receiver receives an RDS broadcast including such data, it is wrongly determined that data has not been correctly received, on the basis of determination conditions which comply with the transmission standards. In such a case, it is necessary to take time to analyze a data fault and to further check whether the received data can be handled as normal data. If it takes too much time to receive and check traffic information, it is not possible for a navigation device to provide traffic information at appropriate times. If it takes too much time to perform reception processing for traffic information, the time to process other items of data multiplexed into the same broadcast signal as the traffic information is reduced, thereby failing to perform processing appropriately.

[0004] Accordingly, it may be an object of the present invention to provide a receiving apparatus and a receiving method in which it is possible to speedily receive data superposed on a broadcast signal.

[0005] The object is solved by the features of the independent claims. Further embodiments and developments are defined in the respective dependent claims.

[0006] A receiving apparatus according to a first aspect of the present invention is capable of receiving a broadcast signal into which data is multiplexed. The receiving apparatus includes: receiving means for receiving the broadcast signal; identifying means for identifying data

included in the broadcast signal received by the receiving means; extracting means for extracting a specific item of data from the identified data; determining means for determining whether the specific item of data has been correctly received, on the basis of a determination condition corresponding to transmission standards of the specific item of data; storage means for storing therein a first deviation table in which relationships between contents of deviation from the transmission standards and associated deviation determination conditions are defined; searching means for searching for a deviation determination condition from the first deviation table; and changing means for changing the determination condition corresponding to the transmission standards of the specific item of data to the deviation determination condition searched by the searching means. The determining means is able to determine on the basis of the deviation determination condition whether the specific item of data has been correctly received.

[0007] Preferably, the receiving apparatus may further include: extracting means for extracting broadcast station identification information for identifying a broadcast station which has transmitted the broadcast signal received by the receiving means; and storage means for storing therein a second deviation table in which relationships between contents of deviation when broadcast stations have transmitted the specific item of data by deviating from the transmission standards and associated items of broadcast station identification information are defined. The searching means may search for a content of deviation corresponding to the extracted broadcast station identification information by referring to the second deviation table, and may also search for a deviation determination condition corresponding to the searched content of deviation by referring to the first deviation table.

[0008] Preferably, when the determining means determines that the specific item of data has not been correctly received, on the basis of the determination condition corresponding to the transmission standards of the specific item of data, the searching means may search for a deviation determination condition.

[0009] Preferably, the receiving apparatus may further include updating means for updating the contents of the second deviation table. The updating means may register the content of deviation searched from the first deviation table in the second deviation table.

[0010] Preferably, when the determining means determines that the specific item of data has not been correctly received, on the basis of the deviation determination condition corresponding to the content of deviation stored in the second deviation table, the updating means may change the content of deviation stored in the second deviation table to another content of deviation.

[0011] Preferably, when the searching means has failed to search for the extracted broadcast station identification information from the second deviation table, the determining means may determine whether the specific item of data has been correctly received on the basis of

the determination condition corresponding to the transmission standards.

[0012] Preferably, the receiving apparatus may further include output means for outputting the specific item of data when the determining means determines that the specific item of data has been correctly received.

[0013] Preferably, the receiving apparatus may further include: control means for controlling the receiving means; audio output means; and signal processing means. The receiving means may include first and second tuners. The control means may cause the signal processing means to extract an audio signal from a signal received by the first tuner and may cause the audio output means to output the audio signal. The control means may cause the signal processing means to extract items of data from a signal received by the second tuner and to execute processing on the items of data other than the specific item of data while the specific item of data is being extracted.

[0014] Preferably, the receiving means may receive an radio data system (RDS) broadcast signal, and the specific item of data may be traffic message channel (TMC) data included in RDS data in the RDS broadcast signal.

[0015] A system according to a second aspect of the present invention includes: the receiving apparatus of the first aspect having none or at least one of the above-described preferred features; and a navigation device which is capable of communicating with the receiving apparatus. The receiving apparatus may provide traffic information multiplexed into a broadcast signal to the navigation device.

[0016] A receiving method according to a third aspect of the present invention is used for a receiving apparatus which is capable of receiving a broadcast signal into which data is multiplexed.

[0017] The receiving method includes: a receiving step of receiving the broadcast signal; an identifying step of identifying data included in the received broadcast signal; a first extracting step of extracting a specific item of data from the identified data; a determining step of determining whether the specific item of data has been correctly received, on the basis of a determination condition corresponding to transmission standards of the specific item of data; a first searching step of searching for a deviation determination condition from a first deviation table in which relationships between contents of deviation from the transmission standards and associated deviation determination conditions are defined; a changing step of changing the determination condition corresponding to the transmission standards of the specific item of data to the searched deviation determination condition; and a re-determining step of re-determining whether the specific item of data has been correctly received, on the basis of the deviation determination condition.

[0018] Preferably, the receiving method may further include: a second extracting step of extracting broadcast station identification information for identifying a broadcast station which has transmitted the received broadcast

signal; a second searching step of searching for a content of deviation corresponding to the extracted broadcast station identification information by referring to a second deviation table in which relationships between contents of deviation when broadcast stations have transmitted the specific item of data by deviating from the transmission standards and associated items of broadcast station identification information are defined; and a third searching step of searching for a deviation determination condition corresponding to the searched content of deviation by referring to the first deviation table.

[0019] Preferably, when the determining step determines that the specific item of data has not been correctly received, on the basis of the determination condition corresponding to transmission standards of the specific item of data, the first searching step searches for a deviation determination condition.

[0020] Preferably, the method may further include: an updating step of updating the contents of the second deviation table, wherein the updating step registers the content of deviation searched from the first deviation table in the second deviation table. Preferably, when the determining step determines that the specific item of data has not been correctly received, on the basis of the deviation determination condition corresponding to the content of deviation stored in the second deviation table, the updating step changes the content of deviation stored in the second deviation table to another content of deviation.

[0021] Preferably, the receiving method may include: an outputting step of outputting the specific item of data when the determining step or the re-determining step determines that the specific item of data has been correctly received.

[0022] According to one basic idea of the invention, it is possible to search for the content of deviation by referring to the first deviation table, thereby making it possible to speedily check whether a specific item of data has been correctly received. According to another basic idea of the invention, by referring to the second deviation table in which relationships between the contents of deviation and associated receiving broadcast stations are defined, it is possible to speedily search for the content of deviation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

Fig. 1A is a block diagram illustrating an example of a vehicle-mounted electronic system according to a first embodiment of the invention;

Fig. 1B is a block diagram illustrating the configuration of a radio receiver of the first embodiment;

Fig. 2 is a block diagram illustrating some functions of a signal processor and a controller of the radio receiver shown in Fig. 1B;

Fig. 3A illustrates an example in which TMC data is

transmitted in accordance with GAP3 standards;
Fig. 3B illustrates an example in which TMC data is transmitted by deviating from transmission standards;

Fig. 4 illustrates an example of a deviation processing table used in the first embodiment;

Fig. 5 is a flowchart illustrating a reception operation for TMC data in the radio receiver according to the first embodiment;

Fig. 6 is a block diagram illustrating some functions of a signal processor and a controller of a radio receiver according to a second embodiment;

Fig. 7 illustrates an example of a deviation code table used in the second embodiment;

Fig. 8 is a flowchart illustrating a reception operation for TMC data in the radio receiver according to the second embodiment; and

Fig. 9 illustrates an example in which TMC data is received according to the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] Embodiments of the present invention will be described below with reference to the accompanying drawings. In a preferred mode of an embodiment, a radio receiver mounted on a vehicle, which is a mobile body, will be described by way of example. A radio receiver is capable of receiving radio broadcasts into which data is multiplexed, and an example of such radio broadcasts is an RDS broadcast.

[0025] Fig. 1A illustrates the configuration of a vehicle-mounted electronic system 10 of a first embodiment. The vehicle-mounted electronic system 10 includes a radio receiver 20 and a navigation device 30 mounted on a vehicle. The radio receiver 20 receives a radio broadcast selected by a user, and traffic information contained in data superposed on the radio broadcast is provided to the navigation device 30. In RDS broadcasting, TMC services for providing traffic information by utilizing digital data (RDS data) which is superposed on an analog frequency-modulation (FM) broadcast signal are widely used. The traffic information is sorted by countries, areas, and roads. For the sake of convenience, traffic information provided by TMC services is referred to as "TMC data".

[0026] TMC data obtained by the radio receiver 20 is provided to the navigation device 30. Then, the navigation device 30 decrypts the TMC data and displays traffic information on a road map or provides it as audio guidance. For example, the navigation device 30 supplies position information concerning the position of a vehicle on which the radio receiver 20 and the navigation device 30 are mounted, and/or a destination, to the radio receiver 20, and then, the radio receiver 20 transmits TMC data corresponding to the position information to the navigation device 30. For example, the radio receiver 20 can select TMC data corresponding to the position information by referring to a PI code or a country code of the

RDS data. The configuration of the vehicle-mounted electronic system 10 shown in Fig. 1A is only an example, and may include a television receiver, a player for digital versatile discs (DVDs) and/or Blu-ray discs, a multifunction terminal (smartphone), etc.

[0027] Fig. 1B is a block diagram illustrating the configuration of the radio receiver 20 of the first embodiment. The radio receiver 20 includes first and second antennas 100A and 100B, first and second tuners 110A and 110B, a signal processor 120, an amplifier 130, a speaker 132, a display unit 140, a storage unit 150, an input unit 160, an interface (I/F) 170, and a controller 180. The first and second tuners 110A and 110B receive broadcast signals from broadcast stations (frequencies) selected via the first and second antennas 100A and 100B, respectively. The signal processor 120 receives broadcast signals from the first and second tuners 110A and 110B and performs required processing on the received broadcast signals. The amplifier 130 amplifies an audio signal processed by the signal processor 120. The speaker 132 outputs an audio signal amplified in the amplifier 130. The display unit 140 displays, for example, data decoded by the signal processor 120. The input unit 160 receives an input from a user. The I/F 170 enables the radio receiver 20 to connect to an external device, such as the navigation device 30. The controller 180 controls the first and second tuners 110A and 110B, the signal processor 120, the amplifier 130, etc.

[0028] The first tuner 110A includes, as is known, a radio frequency (RF) amplifier which receives an RF signal from the antenna 100A and amplifies the RF signal, a tuned circuit which selects a frequency signal of a station desired by a user from the amplified RF signal, a mixer which mixes a frequency signal output from a local oscillator with the RF signal to generate an intermediate frequency (IF) signal, and a signal strength (S) meter circuit which detects a direct current (DC) of the IF signal and extracts a reception field intensity signal (S meter signal). The first tuner 110A also converts the IF signal and the S meter signal to digital signals by using an analog-to-digital converter (ADC), and outputs the digital signals to the signal processor 120 and the controller 180. The second tuner 110B is formed similarly to the first tuner 110A. The first and second tuners 110A and 110B may select the same broadcast station or different broadcast stations in response to an instruction from the controller 180.

[0029] The signal processor 120 is constituted by, for example, a digital signal processor (DSP). The signal processor 120 can perform signal processing, such as fast Fourier transform (FFT), digital filtering, signal synchronization, time/frequency deinterleaving, audio decoding, data decoding, and phase diversity. The signal processing can be controlled by using software stored in a program memory within the signal processor 120. In a preferred mode of the first embodiment, the signal processor 120 includes a digital-to-analog converter (DAC). The DAC extracts an audio signal from a digital signal

received from the first tuner 110A, converts the audio signal into an analog signal, and outputs the analog audio signal to the amplifier 130. The signal processor 120 also extracts RDS data from a signal received from the second tuner 110B and executes various processing operations on the RDS data. For example, the signal processor 120 extracts TMC data from the RDS data and sends it to the navigation device 130, and creates a list of alternative broadcast stations from information concerning alternative broadcast stations, which is being transmitted between items of TMC data.

[0030] The controller 180 is constituted by, for example, a microcontroller, and controls the individual elements of the radio receiver 20 by executing a program stored in a memory. In a preferred mode of an operation, in order to obtain an audio signal of a radio broadcast by using the first tuner 110A, the controller 180 causes the signal processor 120 to extract an audio signal from a signal received by the first tuner 110A. Additionally, in order to obtain RDS data by using the second tuner 110B, the controller 180 causes the signal processor 120 to extract RDS data from a signal received by the second tuner 110B. The controller 180 then extracts TMC data from the extracted RDS data and outputs the TMC data to the navigation device 30. The controller 180 also extracts data concerning alternative broadcast stations of a broadcast station which is being received by the first tuner 110A, creates a list of alternative broadcast stations, and stores the list in the storage unit 150. The list of alternative broadcast stations is utilized, for example, when the sensitivity of the S meter signal received from the first tuner 110A or the second tuner 110B is decreased.

[0031] Fig. 2 is a block diagram illustrating the functional configurations of the signal processor 120 and the controller 180, and more specifically, the functional configuration in which TMC data is received. The signal processor 120 includes an RDS decoder 200, a data block identifying section 210, a TMC data extracting section 220, and a TMC data storage section 230. The RDS decoder 200 decodes a digital signal received from the second tuner 110B. The data block identifying section 210 identifies data blocks contained in an RDS data stream DS extracted by the RDS decoder 200. The TMC data extracting section 220 extracts TMC data from a data block including the TMC data on the basis of identification results obtained by the data block identifying section 210. The TMC data storage section 230 stores therein the extracted TMC data.

[0032] Preferably, the TMC data extracting section 220 and the TMC data storage section 230 are controlled on the basis of a determination signal S indicating a determination result output from a reception determining section 250 of the controller 180. The determination signal S indicates a logic state "1" when a determination is necessary. The determination signal S indicates a logic state "0" when a determination is not necessary. "When a determination is necessary" is, for example, when TMC data

is first received after a radio receiver is powered ON or when the channel of a broadcast station is changed. "When a determination is not necessary" is, for example, when the reception determining section 250 has already determined that data was correctly received. If the determination signal S indicates that a determination is not necessary, the TMC data extracting section 220 extracts TMC data from RDS data and the TMC data storage section 230 outputs the extracted TMC data to a TMC data output section 260 of the controller 180. The TMC data output section 260 then outputs the TMC data to the navigation device 30. In contrast, if the determination signal S indicates that a determination is necessary, the TMC data extracting section 220 extracts TMC data, an amount of which is sufficient to determine the transmission standards of the TMC data. For example, the TMC data extracting section 220 does not have to extract all items of TMC data, but extracts identification information added to the header of the TMC data without extracting traffic information contained in the body of the TMC data. The TMC data storage section 230 is constituted by, a first-in-first-out (FIFO) memory, and stores extracted items of TMC data for a certain period of time or for a certain amount and supplies the extracted items of TMC data to a TMC data comparing section 240 of the controller 180.

[0033] In addition to the TMC data comparing section 240, the reception determining section 250, and the TMC data output section 260 described above, the controller 180 includes a determination condition search section 270. The TMC data comparing section 240 receives extracted items of TMC data necessary for determining the transmission standards from the TMC data storage section 230, and then compares the extracted items of TMC data with each other. The reception determining section 250 determines, on the basis of the comparison results of the TMC data comparing section 240, whether the TMC data has been received such that it satisfies determination conditions corresponding to the transmission standards. The TMC data output section 260 outputs TMC data on the basis of the determination results of the reception determining section 250. If it is determined that the TMC data has been transmitted by deviating from the transmission standards, the determination condition search section 270 searches for a determination condition used when deviation from the transmission standards is determined by referring to a deviation processing table 280, and supplies the searched determination condition to the reception determining section 250. The functional configurations of the signal processor 120 and the controller 180 shown in Fig. 2 are only an example, and only one of the signal processor 120 and the controller 180 may be configured, as shown in Fig. 2.

[0034] A specific reception operation for TMC data will be described below. TMC data contained in RDS data superposed on an RDS broadcast is transmitted in accordance with transmission standards. That is, a broadcast station, which is a transmission side, transmits TMC

data in compliance with transmission standards, and the radio receiver 20, which is a reception side, is designed to determine whether the received TMC data has been correctly received, on the basis of determination conditions set for the transmission standards. Accordingly, in the first embodiment, if the reception of the TMC data does not satisfy the determination conditions, the radio receiver 20 assumes that the broadcast station has transmitted the TMC data without complying with the transmission standards (in other words, by deviating from the transmission standards), and determines whether the TMC data has been correctly received by using a determination condition corresponding to the content of deviation.

[0035] Figs. 3A and 3B illustrate an example of transmission standards of TMC data. Fig. 3A illustrates transmission standards of GAP3. An RDS data stream DS extracted by the RDS decoder 200 is a set of continuous multiple data groups or data blocks. In the RDS data stream DS, data groups having identification (ID) information called 8A are periodically contained. These 8A groups (hereinafter sometimes simply referred to as "8A") include TMC data. According to the GAP3 transmission standards, 8A including the same TMC data is transmitted three times, and three data groups are disposed between two 8A groups. As shown in Fig. 3A, the first three 8A groups include identical traffic information, and the next three 8A groups include identical traffic information which is different from the previous traffic information. Three 8A groups having the same TMC data are included in the RDS data stream DS intermittently at regular intervals.

[0036] If the transmission standards are GAP5, 8A having the same TMC data is transmitted three times, but unlike GAP3, five data groups are disposed between two 8A groups. In the case of GAP8, eight data groups are disposed between two 8A groups, and in the case of GAP11, eleven data groups are disposed between two 8A groups. Whichever transmission standards, i.e., GAP3, GAP5, GAP8, or GAP11, are employed, 8A including the same TMC data is transmitted three times, and information for identifying which transmission standards are used for transmitting TMC data is contained in another data group within the RDS data stream DS. When TMC data is transmitted according to such transmission standards, the radio receiver 20 of the first embodiment has the following determination conditions. If the first two sequentially received 8A groups have the same data, the radio receiver 20 determines that TMC data has been correctly received, and discards the third 8A group.

[0037] Referring back to Fig. 2, the RDS decoder 200 of the signal processor 120 extracts the RDS data stream DS shown in Fig. 3A, and the data block identifying section 210 decodes header information of a data block contained in the RDS data stream DS, thereby identifying the individual data blocks. The TMC data extracting section 220 extracts data blocks of 8A from the identified

data blocks, and the TMC data storage section 230 sequentially stores TMC data items of 8A.

[0038] The determination condition search section 270 can identify the transmission standards (e.g., GAP3 or GAP5) of TMC data from information concerning the 8A data groups identified by the data block identifying section 210, and supplies determination conditions associated with the transmission standards to the reception determining section 250. Alternatively, the reception determining section 250 may directly receive determination conditions associated with the transmission standards from the data block identifying section 210 without causing the determination condition search section 270 to search for the determination conditions. The TMC data comparing section 240 compares items of TMC data sequentially stored in the TMC data storage section 230 and informs the reception determining section 250 of the number of 8A groups having the same data, the number of times that 8A groups have been extracted, etc. The reception determining section 250 determines, in accordance with determination conditions corresponding to the transmission standards, whether 8A has been received three times and whether 8A having the same data has been received twice. If the determination conditions are satisfied, the reception determining section 250 determines that the TMC data has been correctly received, and outputs a determination signal S indicating the determination results to the TMC data extracting section 220, the TMC data storage section 230, and the TMC data output section 260. The TMC data output section 260 outputs the TMC data to the navigation device 30 on the basis of the determination results indicating that TMC data has been correctly received.

[0039] The signal processor 120 and the controller 180 know the timing at which TMC data is received, from the transmission standards (e.g., GAP3 or GAP5). During a period for which TMC data is not received, other processing operations, such as the extraction of alternative broadcast stations from RDS data and the creation of a list of alternative broadcast stations, can be performed. In other words, in order to secure a sufficient time for performing other data processing operations, reception processing for TMC data has to be performed for a certain period of time. Additionally, if a broadcast station has transmitted TMC data by deviating from transmission standards, the determination condition search section 270 refers to the deviation processing table 280 and checks the reception of TMC data by using a determination condition corresponding to the content of deviation. This will be discussed later.

[0040] Some RDS broadcast stations transmit TMC data by deviating from transmission standards. Particularly, RDS broadcast stations, which provide TMC services free of charge are likely to do so. As stated above, if an RDS broadcast station transmits TMC data by deviating from transmission standards, the reception determining section 250 determines that TMC data has not been correctly received since the determination condi-

tions set for the transmission standards are not satisfied, and a known radio receiver executes a routine for analyzing a data communication fault. This fault analysis requires a certain time, and while the fault analysis is being conducted, a navigation device is unable to receive TMC data, thereby decreasing the speed in updating traffic information. The time taken to conduct a fault analysis depends on the type of GAP. For example, in the case of GAP11, the time interval between two 8A groups is 1100 msec or longer, and it takes about thirty seconds at the maximum to determine that TMC data has been transmitted by deviating from transmission standards. If deviation from transmission standards has been detected, other processing operations which are supposed to be executed between two 8A groups are stopped for searching for the cause of the deviation.

[0041] In the first embodiment, the deviation processing table 280 is stored in the storage unit 150. In the deviation processing table 280, the relationships between the contents of deviation and associated processing operations which are to be performed (i.e., determination conditions used when deviation from transmission standards has been detected) are defined. By the provision of the deviation processing table 280, even if an RDS broadcast station transmits TMC data by deviating from transmission standards, it is possible to speedily check whether TMC data has been correctly received. Preferably, the deviation processing table 280 is stored in a rewritable non-volatile memory.

[0042] Fig. 4 illustrates an example of the deviation processing table 280. The deviation processing table 280 defines relationships among the content of deviation from transmission standards, deviation codes indicating the coded deviation contents, and associated processing operations to be performed (including determination conditions when deviation from transmission standard has been detected). For example, if the radio receiver 20 has failed to extract TMC data (8A shown in Figs. 3A and 3B) from RDS data received from an RDS broadcast station, the content of deviation is "no TMC data content", which is represented by deviation code "0". In this case, the controller 180 causes the second tuner 110B to receive a signal from a next candidate station. In the case of GAP3, if the deviation content indicates that a broadcast station has transmitted 8A once (the same TMC data has transmitted only once and the other two items of TMC data are different from the previous item of TMC data), the deviation code is represented by "1", and processing to be performed is "determine correct reception if 8A is read once". This is applicable to a determination condition when deviation from transmission standards has been detected. Thus, in this case, the determination condition search section 270 shown in Fig. 2 searches for a determination condition corresponding to the content of deviation and informs the reception determining section 250 of this determination condition. If the deviation content indicates that a broadcast station has transmitted 8A twice, it means that the same TMC data has been trans-

mitted twice and the remaining one item of TMC data is different from these previous items of TMC data, and the deviation code is represented by "2". If the deviation content indicates that a broadcast station has transmitted 8A four times or greater, the deviation code is represented by "3". In this case, it is determined that an abnormality has occurred during the transmission, and processing for switching to reception from another broadcast station is executed. If the deviation content indicates "preset GAP number deviated: 3", it means that the number of data groups between two 8A groups is three despite that the transmission standards are not GAP3 (e.g., the transmission standards are GAP5). In this case, the deviation code is "13", and processing to be performed is "correct GAP number to 3 and receive data". This is also applicable to a determination condition and is thus supplied to the reception determining section 250. At the same time, the signal processor 120 receives TMC data in accordance with the timing set for the GAP3 transmission standards, and allocates the other periods to other processing operations. The deviation processing table 280 has been set in a memory, and has reflected the deviation contents of an RDS broadcast station when a vehicle was actually running. However, the deviation contents shown in Fig. 4 are only an example.

[0043] A TMC data receiving operation performed by the radio receiver 20 of the first embodiment will be described below with reference to the flowchart of Fig. 5.

[0044] In step S101, the vehicle-mounted electronic system 10 shown in Fig. 1A is started. In a preferred mode, in step S102, a destination is set in the navigation device 30. The navigation device 30 supplies position information, such as the position of a vehicle in which the navigation device 30 is installed, a destination, a route position, and routing information, to the radio receiver 20. If a destination is not set, vehicle position information is supplied to the radio receiver 20.

[0045] In step S103, the radio receiver 20 receives an RDS broadcast of a station selected by a user. In the signal processor 120, a digital signal received by the first tuner 110A is decoded. A digital audio signal is extracted from the digital signal and is converted into an analog audio signal. The analog audio signal is then output from the speaker 132. In step S104, the RDS decoder 200 decodes a digital signal output from the second tuner 110B so as to generate an RDS data stream DS. The TMC data extracting section 220 extracts TMC data from the RDS data stream DS. In this case, the transmission standards of TMC data superposed on the RDS broadcast are not yet determined, and thus, a signal S indicating that a determination is necessary is supplied from the reception determining section 250 to the TMC data extracting section 220, the TMC data storage section 230 and the TMC data output section 260. Items of TMC data extracted by the TMC data extracting section 220 are sequentially stored in the TMC data storage section 230, and the TMC data comparing section 240 checks the number of times that TMC data has been transmitted and

the number of times that the same TMC data has been transmitted.

[0046] Then, in step S105, the reception determining section 250 receives comparison results from the TMC data comparing section 240 and makes a determination concerning reception of TMC data in accordance with determination conditions corresponding to the transmission standards of the TMC data. In step S106, the reception determining section 250 determines whether TMC data has been correctly received in accordance with the determination conditions. If the result of step S106 is YES, the process proceeds to step S107. If the result of step S106 is NO, the process proceeds to step S109. As stated above, if the transmission standards are GAP3 in which a set of three items of TMC data is transmitted, the determination conditions are as follows. If, among three items of TMC data, the same TMC data has been received twice, the reception of the TMC data is determined to be correct, and the third TMC data is discarded. If the same TMC data has not been received twice, or if the number of data items defined by GAP does not coincide with the number of data items contained between two TMC data items, it is not determined that the reception of the TMC data is correct, but is determined that the transmission of the TMC data deviates from the transmission standards.

[0047] If it is determined in step S106 that TMC data has been correctly received, the process proceeds to step S107. In step S107, the TMC data output section 260 transmits the TMC data to the navigation device 30. In step S108, the navigation device 30 displays traffic information (e.g., a traffic jam or the closure of a road in the form of an icon or a message) on a road map screen on the basis of the received TMC data, or outputs traffic information as sound.

[0048] In contrast, if it is determined in step S106 that TMC data has not been correctly received, i.e., that the transmission of the TMC data deviates from the transmission standards, the process proceeds to step S109. In step S109, the determination condition search section 270 obtains the transmission standards (e.g., GAP3 or GAP5) identified by the data block identifying section 210, the state in which TMC data has been extracted, and the determination results obtained from the reception determining section 250. The determination condition search section 270 then refers to these items of information and the deviation processing table 280 shown in Fig. 4 and determines the corresponding content of deviation. For example, if the radio receiver 20 has failed to receive TMC data "8A" even once, it is determined that the content of deviation is "no TMC data content" and the associated deviation code is "0". In the case of GAP3, if the same TMC data "8A" has been received only once, it is determined that the content of deviation is "8A transmitted once" and the associated deviation code is "1". That is, in the case of GAP3, three data groups are disposed between two 8A groups, and the same TMC data "8A" has been transmitted only once during a period for which

8A is transmitted three times. If the same TMC data "8A" has been received only twice, it is determined that the content of deviation is "8A transmitted twice" and the associated deviation code is "2". That is, the same TMC data "8A" has been transmitted only twice during a period for which 8A is transmitted three times. If the same TMC data "8A" has been received four times or greater, it is determined that the content of deviation is "terminate: shift to reception from another candidate station" and the associated deviation code is "3". That is, the same TMC data has been continuously received four times or greater. The other transmission standards, such as GAP5, GAP8, and GAP11 are handled similarly to the case of GAP3. If the number of data groups disposed between two 8A groups is three despite that the transmission standards are other than GAP3, it is determined that the content of deviation "preset GAP number deviated: 3" and the associated deviation code is "13". For other cases in which the GAP number of the transmission standards does not coincide with the number of data groups disposed between two 8A groups, it may be determined that the content of deviation is "preset GAP number deviated: 5", "preset GAP number deviated: 8", or "preset GAP number deviated: 11", and the associated deviation code "14", "15", or "16", respectively. If the content of deviation does not correspond to any one of the deviation codes "0" through "16", it is determined that the content of deviation is "deviation other than the above" and the associated deviation code is "17".

[0049] In this manner, the determination condition search section 270 searches for "processing to be performed" corresponding to the content of deviation by referring to the deviation processing table 280. This processing includes shifting to reception from another candidate station and changing of determination conditions. If "processing to be performed" concerns changing of determination conditions, in step S110, the determination condition search section 270 informs the reception determining section 250 of a new determination condition, and the reception determining section 250 changes the determination conditions set for the transmission standards to the informed determination condition used when deviation from the transmission standards has been detected. Then, in step S111, the controller 180 determines whether the content of deviation corresponds to shifting to reception from another candidate station, i.e., whether the content of deviation corresponds to the deviation code "0", "3", "6", "9", "12", or "17". If the result of step S111 is NO, the process returns to step S106 to determine on the basis of the new determination condition whether subsequent TMC data has been correctly received. If the result of step S111 is YES, the process proceeds to step S112. In step S112, the controller 180 causes the second tuner 110B to select another RDS broadcast station. Then, TMC data is extracted from RDS data received from the broadcast station, and reception of TMC data is determined similarly to that described above. When selecting another RDS broadcast station,

the second tuner 110B seeks an RDS broadcast station having high reception sensitivity or selects an RDS broadcast station contained in a list of alternative broadcast stations.

[0050] In a known radio receiver, if reception of TMC data does not satisfy determination conditions corresponding to transmission standards, it takes a long time to analyze a communication fault and to determine that the transmission of TMC data deviates from the transmission standards. If a communication fault is not solved, it also takes time before shifting to reception from another RDS broadcast station. As a result, the speed in updating traffic information in a navigation device is decreased. In contrast, in the first embodiment, the deviation processing table 280 is prepared, and if the reception of TMC data does not satisfy determination conditions corresponding to transmission standards, the content of deviation is determined by referring to the deviation processing table 280. Then, a determination condition corresponding to the content of deviation is searched for, and it is determined again by using the searched determination condition whether TMC data has been received correctly. Accordingly, even if the reception of TMC data deviates from transmission standards, unlike the related art, it is not necessary to take time to analyze a communication fault, thereby making it possible to speedily extract TMC data. Additionally, when data is first received from an RDS broadcast station, it is determined whether deviation from transmission standards has been detected. If deviation has been detected, a determination is made thereafter, on the basis of a determination condition corresponding to the content of deviation, whether TMC data has been correctly received, thereby accelerating and facilitating the extraction of TMC data. It is thus possible to speedily supply TMC data from the radio receiver 20 to the navigation device 30.

[0051] A second embodiment of the present invention will now be described below. A radio receiver 20 of the second embodiment has a learning function in order to make a speedy determination whether transmission from an RDS broadcast station deviates from transmission standards. The basic configuration of the radio receiver 20 is similar to that shown in Fig. 1B of the first embodiment. Fig. 6 is a block diagram illustrating the functional configurations of the signal processor 120 and the controller 180, and the same elements as those of the first embodiment are designated by like reference numerals. An RDS broadcast station transmits a PI code which is constituted by a country code and a broadcast station code. This PI code may be utilized, for example, when performing automatic tuning to a broadcast station broadcasting the same program as a program which is being received. In the second embodiment, the signal processor 120 includes a PI code extracting section 300 which extracts a PI code from an RDS data stream DS. An extracted PI code is supplied to the determination condition search section 270.

[0052] The determination condition search section 270

refers to a deviation code table 310 on the basis of the PI code and checks whether the PI code of a broadcast station which is being received deviates from transmission standards in the past. An example of the deviation code table 310 is shown in Fig. 7. The deviation code table 310 defines the relationships between PI codes and deviation codes, and may preferably be stored in a non-volatile memory of the storage unit 150. The controller 180 also includes a deviation code table updating section 320 which makes addition, correction, and modification to the content of the deviation code table 310.

[0053] In the initial state of the deviation code table 310 before the shipment, known deviation data (PI code/deviation code) is registered. When deviation from transmission standards is newly found while a vehicle is running, it is registered in the deviation code table 310. Alternatively, in the initial state, no deviation data is stored in the deviation code table 310, and thereafter, every time an RDS broadcast station which is being received deviates from transmission standards, a corresponding PI code may be registered in the deviation code table 310 and may be updated.

[0054] An operation performed in the second embodiment will be discussed below with reference to the flowchart of Fig. 8. In step S201, a selected RDS broadcast is received. Then, in step S202, a PI code is extracted. Then, in step S203, the determination condition search section 270 refers to the deviation code table 310. The determination condition search section 270 then checks in step S204 whether the PI code is registered in the deviation code table 310. If it is determined in step S204 that the PI code is registered, the process proceeds to step S205. In step S205, the deviation code corresponding to the PI code is extracted. Then, in step S206, the determination condition search section 270 searches for processing to be performed corresponding to the deviation code by referring to the deviation processing table 280. In step S207, the determination condition is changed in accordance with the processing to be performed. Then, in step S208, the reception determining section 250 determines on the basis of the new determination condition whether TMC data has been correctly received. If the result of step S208 is YES, the process proceeds to step S209. In step S209, TMC data is transmitted to the navigation device 30. In step S210, the navigation device 30 performs processing on the basis of the TMC data and displays traffic information on a road map.

[0055] If it is determined in step S204 that the PI code is not registered or if it is determined in step S208 that TMC data has not been correctly received, the process proceeds to step S211. In step S211, the reception determining section 250 makes a determination by using determination conditions associated with transmission standards. Then, in step S212, the reception determining section 250 determines whether TMC data has been correctly received. If the result of step S212 is YES, the process proceeds to step S209. If the result of step S212 is NO, the process proceeds to step S213. In step S213,

in a manner similar to the first embodiment, the determination condition search section 270 searches for the content of deviation by referring to the deviation processing table 280. In step S214, the determination condition is changed in accordance with the processing to be performed associated with the content of deviation. Then, in step S215, the reception determining section 250 determines again whether TMC data has been correctly received. If the result of step S215 is YES, the process proceeds to step S216. In step S216, the PI code and the deviation code are newly registered in the deviation code table 310. Then, steps S209 and S210 are executed. If the result of step S215 is NO, the process returns to step S213. In the second embodiment, by utilizing learning effects by using the deviation code table 310, it is possible to make a more speedy determination concerning the reception of TMC data in accordance with the content of deviation than the first embodiment.

[0056] Fig. 9 illustrates an example of learning effects of the second embodiment. In Fig. 9, it is assumed that a vehicle frequently runs in route R between city A and city B. In this case, the navigation device 30 requires traffic information concerning the traffic between city A and city B. As shown in Fig. 3A, in RDS data, TMC data "8A" of city A, TMC data "8A" of city B, and TMC data "8A" of other cities are transmitted sequentially. The navigation device 30 may supply position information concerning the positions of city A and city B to the radio receiver 20, and the radio receiver 20 may filter the TMC data and transmit items of TMC data concerning city A and city B to the navigation device 30. Alternatively, the navigation device 30 may filter TMC data received from the radio receiver 20 and extract items of TMC data concerning city A and city B.

[0057] It is assumed that city A, city B, and route R are positioned within a reception area of a broadcast station X and that the broadcast station X transmits TMC data by deviating from transmission standards. When a vehicle first runs from city A to city B, PI code (A221) of the broadcast station X or the associated deviation code is not registered in the deviation code table 310. Accordingly, the reception determining section 250 determines the content of deviation of the broadcast station X from the reception mode of TMC data by referring to the deviation processing table 280. Then, the PI code (A221) and the deviation code "2" indicating the content of deviation are registered in the deviation code table 310. When the vehicle runs in route R between city A and city B again, the PI code (A221) of the broadcast station X is already registered in the deviation code table 310. This makes it easy to search for the content of deviation and the associated processing to be performed from the deviation processing table 380 shown in Fig. 4, thereby speedily checking whether TMC data has been correctly received in accordance with the content of deviation.

[0058] While the present invention has been described with reference to preferred embodiments, it is to be understood that the invention is defined in the claims, i.e.

shall not be understood as limited to the disclosed embodiments.

[0059] In the above-described embodiments, a radio receiver that receives RDS broadcasts is illustrated by way of example. However, a broadcast to be received by a radio receiver is not restricted to an RDS broadcast but may be another radio broadcast as long as data can be multiplexed into such a broadcast.

[0060] Additionally, a broadcast to be received by a radio receiver is not restricted to an analog radio broadcast, but may be a digital radio broadcast.

[0061] Moreover, in the above-described embodiments, a radio receiver having two digital tuners is illustrated by way of example. However, tuners may output analog signals, and the number of tuners is not particularly restricted. A single tuner may be used for receiving a broadcast signal and for extracting data in a time division manner, or three or more tuners may be used, and one of them may be used for extracting an RDS signal.

Claims

1. A receiving apparatus (20) which is capable of receiving a broadcast signal into which data is multiplexed, comprising:

receiving means (20) configured to receive the broadcast signal;

identifying means (210) configured to identify data included in the broadcast signal received by the receiving means (20);

extracting means (220) configured to extract a specific item of data from the identified data;

determining means (250) configured to determine whether the specific item of data has been correctly received, on the basis of a determination condition corresponding to transmission standards of the specific item of data;

storage means (150) configured to store therein a first deviation table (280) in which relationships between contents of deviation from the transmission standards and associated deviation determination conditions are defined;

searching means (270) configured to search for a deviation determination condition from the first deviation table (280); and

changing means (250) configured to change the determination condition corresponding to the transmission standards of the specific item of data to the deviation determination condition searched by the searching means (270), wherein the determining means (250) is able to determine on the basis of the deviation determination condition whether the specific item of data has been correctly received.

2. The receiving apparatus (20) according to Claim 1,

further comprising:

extracting means (300) configured to extract broadcast station identification information for identifying a broadcast station which has transmitted the broadcast signal received by the receiving means (20); and
storage means (150) configured to store therein a second deviation table (310) in which relationships between contents of deviation when broadcast stations have transmitted the specific item of data by deviating from the transmission standards and associated items of broadcast station identification information are defined, wherein the searching means (270) is configured to search for a content of deviation corresponding to the extracted broadcast station identification information by referring to the second deviation table (310), and also to search for a deviation determination condition corresponding to the searched content of deviation by referring to the first deviation table (280).

3. The receiving apparatus (20) according to Claim 1 or 2, wherein, when the determining means (250) determines that the specific item of data has not been correctly received, on the basis of the determination condition corresponding to the transmission standards of the specific item of data, the searching means (270) is configured to search for a deviation determination condition.
4. The receiving apparatus (20) according to Claim 2, further comprising:
updating means (320) configured to update the contents of the second deviation table (310), wherein the updating means (320) is configured to register the content of deviation searched from the first deviation table (280) in the second deviation table (310).
5. The receiving apparatus (20) according to Claim 4, wherein, when the determining means (250) determines that the specific item of data has not been correctly received, on the basis of the deviation determination condition corresponding to the content of deviation stored in the second deviation table (310), the updating means (320) is configured to change the content of deviation stored in the second deviation table (310) to another content of deviation.
6. The receiving apparatus (20) according to Claim 2, wherein, when the searching means (270) has failed to search for the extracted broadcast station identification information from the second deviation table (310), the determining means (250) is configured to determine whether the specific item of data has been

correctly received on the basis of the determination condition corresponding to the transmission standards.

7. The receiving apparatus (20) according to one of Claims 1 to 6, further comprising:
output means (260) for outputting the specific item of data when the determining means (250) determines that the specific item of data has been correctly received.
8. The receiving apparatus (20) according to one of Claims 1 to 7, further comprising:
control means (180) configured to control the receiving means (20);
audio output means (132); and
signal processing means (120),
wherein:
the receiving means (20) includes first and second tuners (110A, 110B);
the control means (180) is configured to cause the signal processing means (120) to extract an audio signal from a signal received by the first tuner (110A) and causes the audio output means (132) to output the audio signal; and
the control means (180) is configured to cause the signal processing means (120) to extract items of data from a signal received by the second tuner (110B) and to execute processing on the items of data other than the specific item of data while the specific item of data is being extracted.
9. The receiving apparatus (20) according to one of Claims 1 to 8, wherein the receiving means (20) is configured to receive a radio data system broadcast signal, and wherein the specific item of data is traffic message channel data included in radio data system data in the radio data system broadcast signal.
10. A system (10) comprising:
the receiving apparatus (20) according to one of Claims 1 to 9; and
a navigation device (30) which is capable of communicating with the receiving apparatus (20),
wherein the receiving apparatus (20) is configured to provide traffic information multiplexed into a broadcast signal to the navigation device (30).
11. A receiving method for a receiving apparatus which is capable of receiving a broadcast signal into which

data is multiplexed, comprising:

a receiving step of receiving the broadcast signal;
 an identifying step of identifying data included 5
 in the received broadcast signal;
 a first extracting step of extracting a specific item
 of data from the identified data;
 a determining step of determining whether the
 specific item of data has been correctly received, 10
 on the basis of a determination condition corre-
 sponding to transmission standards of the spe-
 cific item of data;
 a first searching step of searching for a deviation
 determination condition from a first deviation ta- 15
 ble in which relationships between contents of
 deviation from the transmission standards and
 associated deviation determination conditions
 are defined;
 a changing step of changing the determination 20
 condition corresponding to the transmission
 standards of the specific item of data to the
 searched deviation determination condition;
 and
 a re-determining step of re-determining whether 25
 the specific item of data has been correctly re-
 ceived, on the basis of the deviation determina-
 tion condition.

12. The receiving method according to Claim 11, further 30
 comprising:

a second extracting step of extracting broadcast
 station identification information for identifying a
 broadcast station which has transmitted the re- 35
 ceived broadcast signal;
 a second searching step of searching for a con-
 tent of deviation corresponding to the extracted
 broadcast station identification information by
 referring to a second deviation table in which 40
 relationships between contents of deviation
 when broadcast stations have transmitted the
 specific item of data by deviating from the trans-
 mission standards and associated items of
 broadcast station identification information are 45
 defined; and
 a third searching step of searching for a devia-
 tion determination condition corresponding to
 the searched content of deviation by referring to
 the first deviation table. 50

13. The receiving method according to Claim 11, where-
 in, when the determining step determines that the
 specific item of data has not been correctly received,
 on the basis of the determination condition corre- 55
 sponding to transmission standards of the specific
 item of data, the first searching step searches for a
 deviation determination condition.

14. The receiving method according to Claim 12, further
 comprising:

an updating step of updating the contents of the
 second deviation table,
 wherein the updating step registers the content
 of deviation searched from the first deviation ta-
 ble in the second deviation table.

15. The receiving method according to Claim 14, where-
 in, when the determining step determines that the
 specific item of data has not been correctly received,
 on the basis of the deviation determination condition
 corresponding to the content of deviation stored in
 the second deviation table, the updating step chang-
 es the content of deviation stored in the second de-
 viation table to another content of deviation.

FIG. 1A

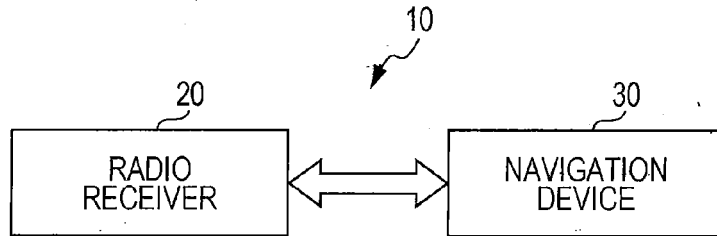


FIG. 1B

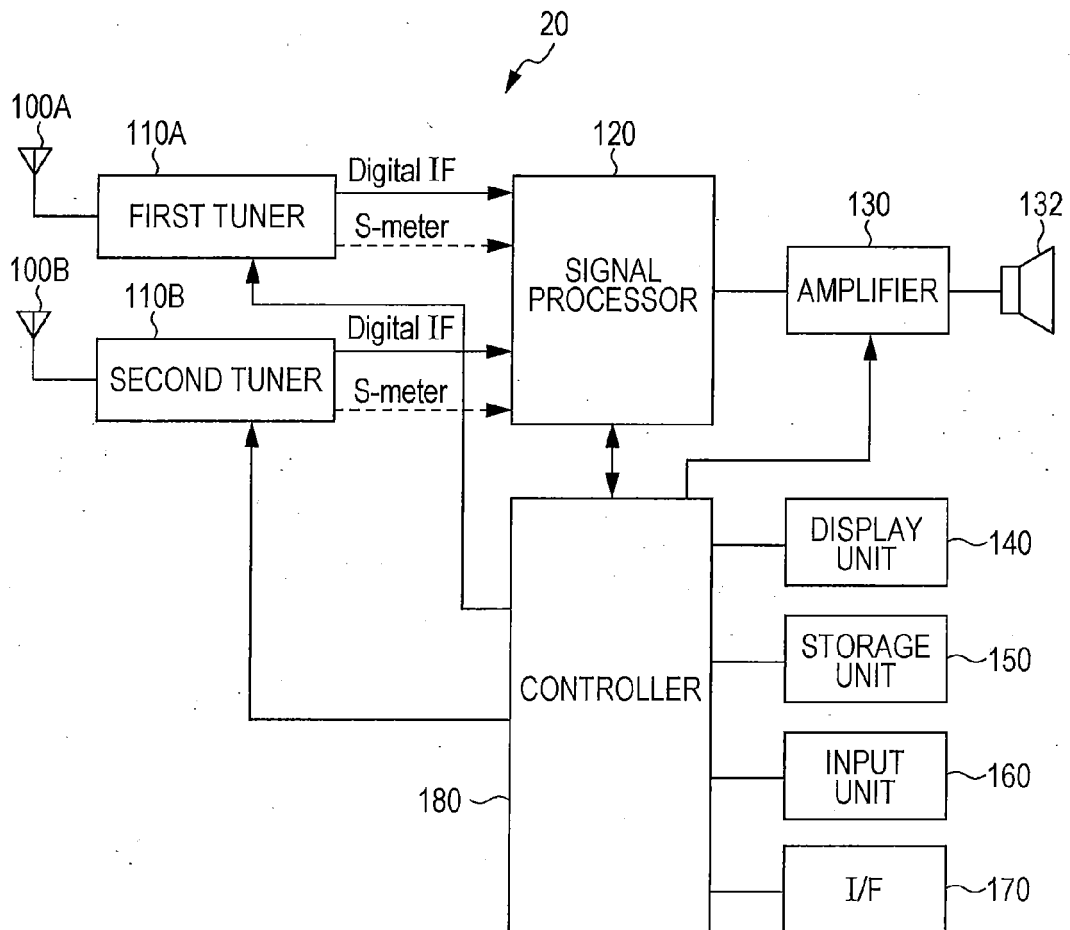


FIG. 2

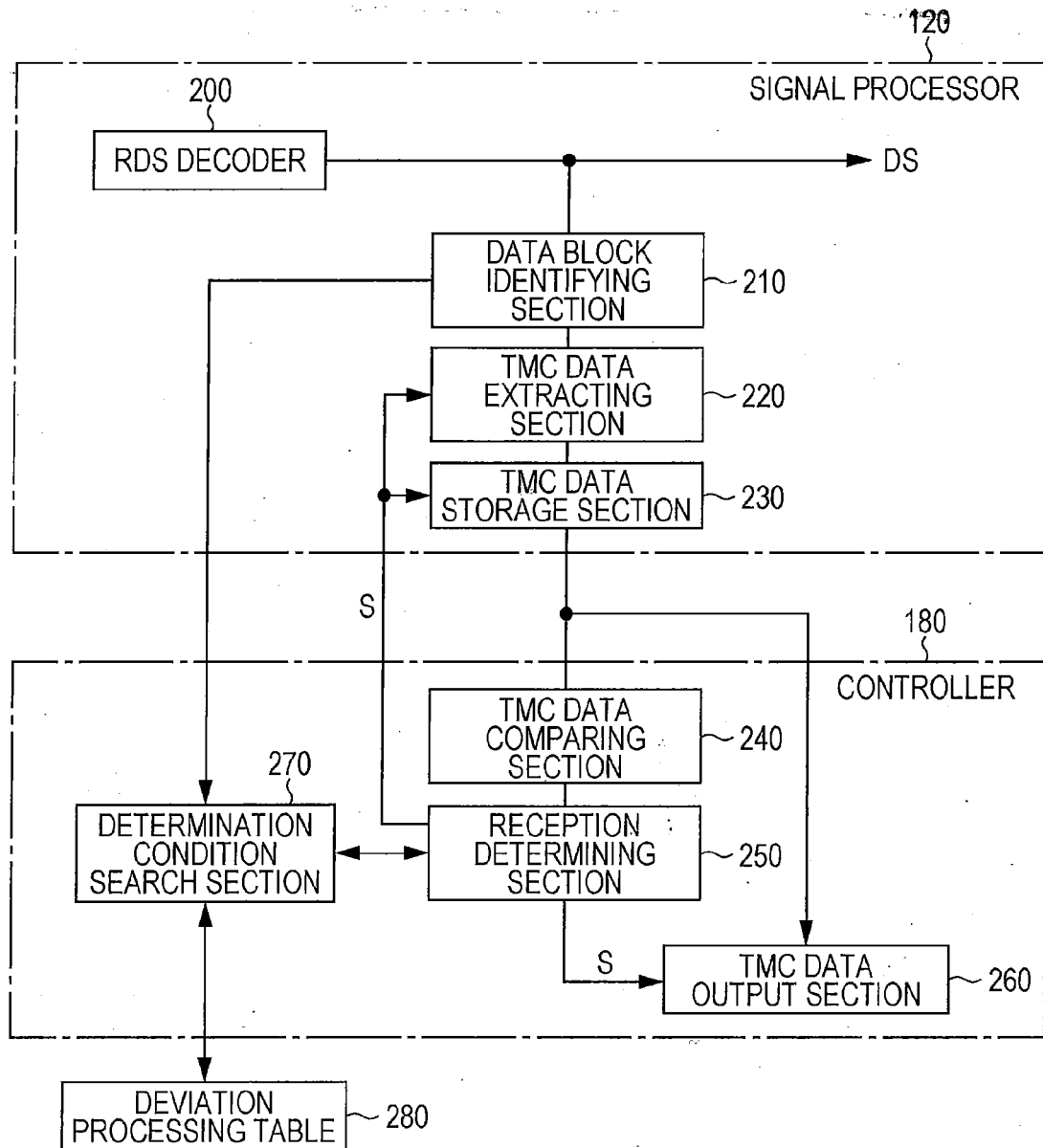


FIG. 3A

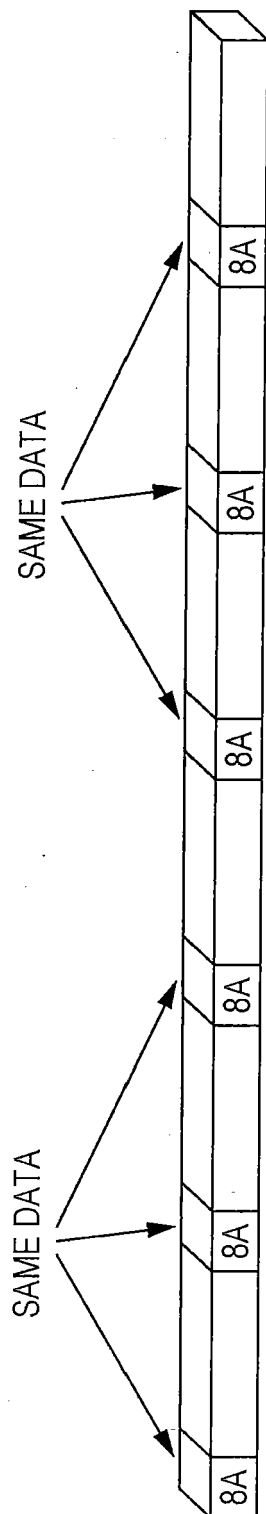


FIG. 3B

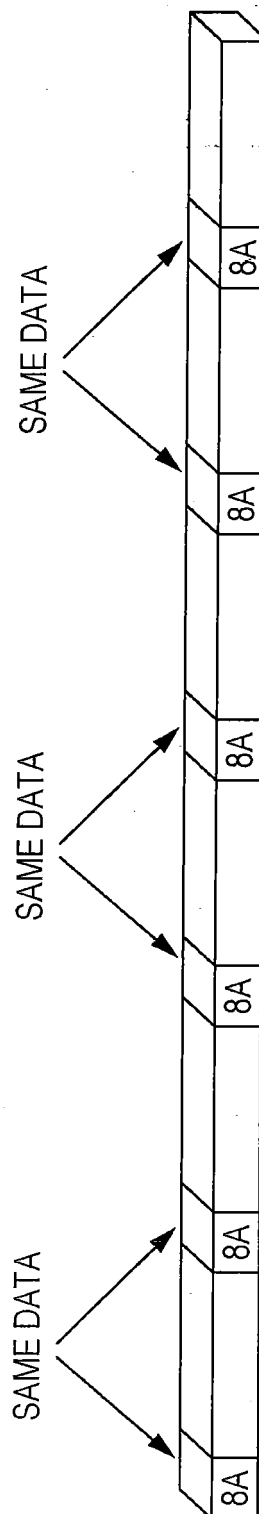


FIG. 4

CONTENT OF DEVIATION		DEVIATION CODE	PROCESSING TO BE PERFORMED
GAP3	NO TMC DATA CONTENT	0	TERMINATE: SHIFT TO RECEPTION FROM ANOTHER CANDIDATE STATION
	8A TRANSMITTED ONCE	1	DETERMINE CORRECT RECEPTION IF 8A IS READ ONCE
	8A TRANSMITTED TWICE	2	DETERMINE CORRECT RECEPTION IF 8A IS READ TWICE
GAP5	8A TRANSMITTED FOUR TIMES OR GREATER	3	TERMINATE: SHIFT TO RECEPTION FROM ANOTHER CANDIDATE STATION
	8A TRANSMITTED ONCE	4	DETERMINE CORRECT RECEPTION IF 8A IS READ ONCE
	8A TRANSMITTED TWICE	5	DETERMINE CORRECT RECEPTION IF 8A IS READ TWICE
GAP8	8A TRANSMITTED FOUR TIMES OR GREATER	6	TERMINATE: SHIFT TO RECEPTION FROM ANOTHER CANDIDATE STATION
	8A TRANSMITTED ONCE	7	DETERMINE CORRECT RECEPTION IF 8A IS READ ONCE
	8A TRANSMITTED TWICE	8	DETERMINE CORRECT RECEPTION IF 8A IS READ TWICE
GAP11	8A TRANSMITTED FOUR TIMES OR GREATER	9	TERMINATE: SHIFT TO RECEPTION FROM ANOTHER CANDIDATE STATION
	8A TRANSMITTED ONCE	10	DETERMINE CORRECT RECEPTION IF 8A IS READ ONCE
	8A TRANSMITTED TWICE	11	DETERMINE CORRECT RECEPTION IF 8A IS READ TWICE
PRESET GAP NUMBER DEVIATED: 3	8A TRANSMITTED FOUR TIMES OR GREATER	12	TERMINATE: SHIFT TO RECEPTION FROM ANOTHER CANDIDATE STATION
	PRESET GAP NUMBER DEVIATED: 3	13	CORRECT GAP NUMBER TO 3 AND RECEIVE DATA
	PRESET GAP NUMBER DEVIATED: 5	14	CORRECT GAP NUMBER TO 5 AND RECEIVE DATA
PRESET GAP NUMBER DEVIATED: 8	PRESET GAP NUMBER DEVIATED: 8	15	CORRECT GAP NUMBER TO 8 AND RECEIVE DATA
	PRESET GAP NUMBER DEVIATED: 11	16	CORRECT GAP NUMBER TO 11 AND RECEIVE DATA
	DEVIATION OTHER THAN THE ABOVE	17	TERMINATE: SHIFT TO RECEPTION FROM ANOTHER CANDIDATE STATION

FIG. 5

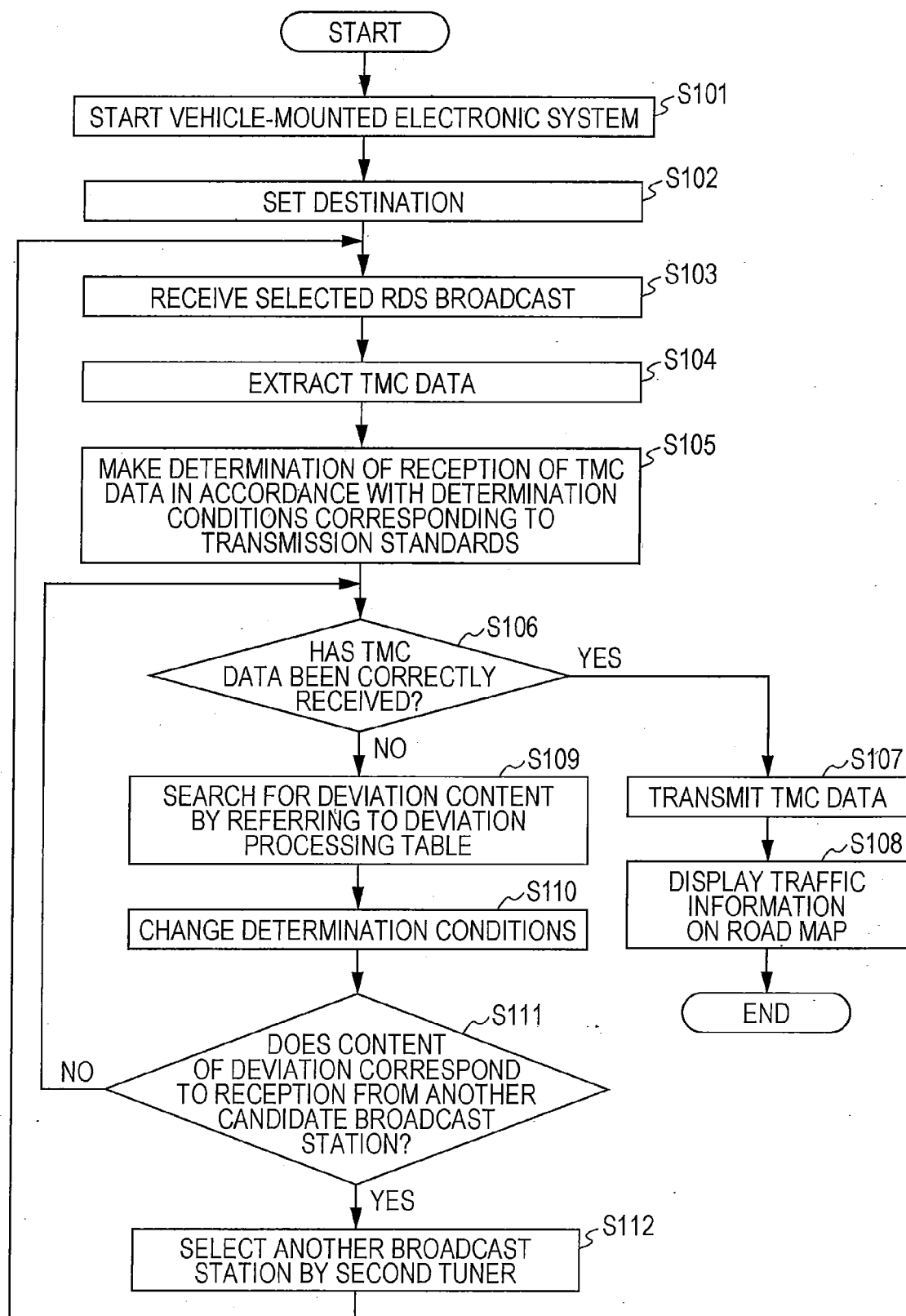


FIG. 6

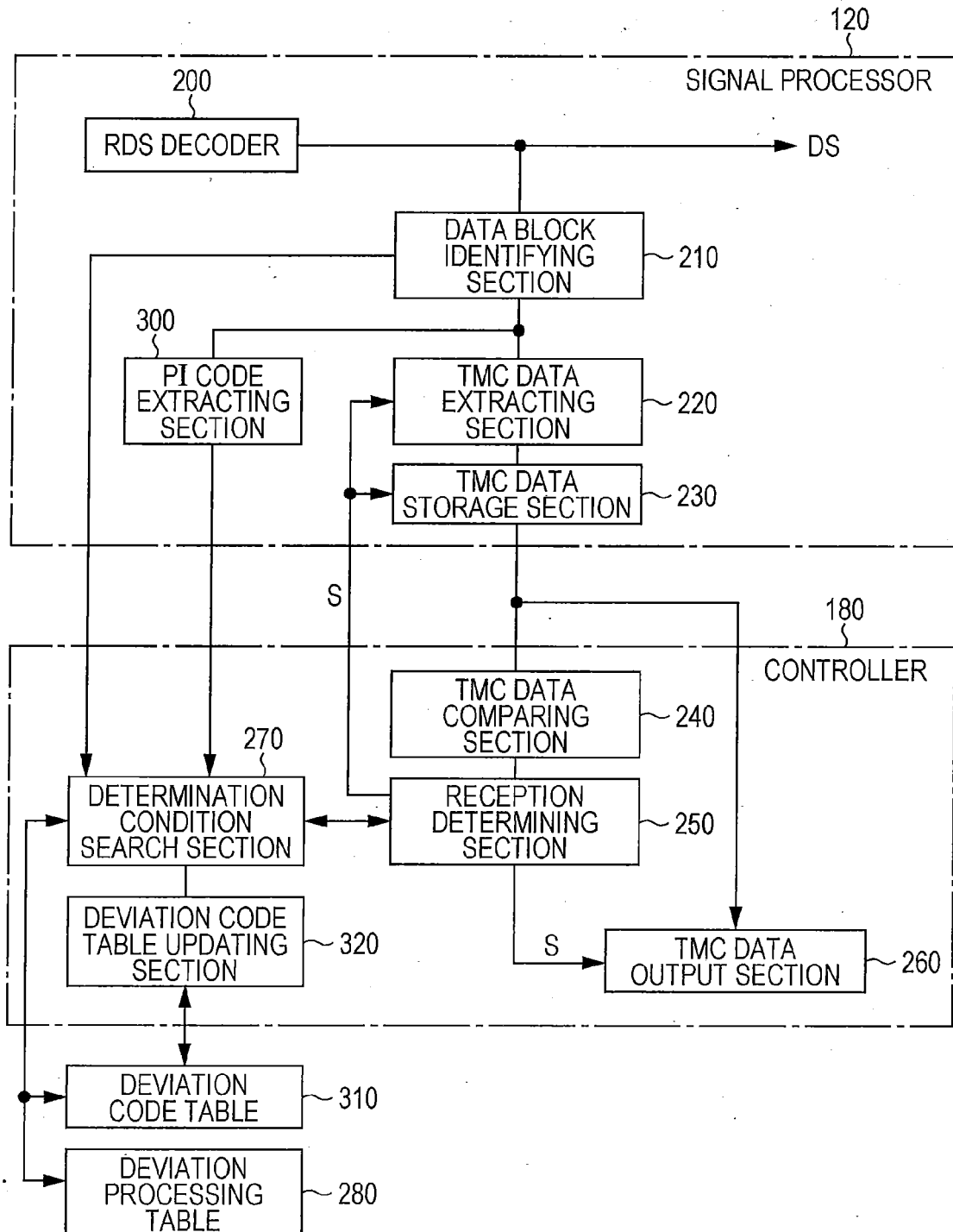


FIG. 7

310


PI CODE	DEVIATION CODE
5141	2
5322	3
5641	0
5911	5
A221	2
F201	14
F203	16

FIG. 8

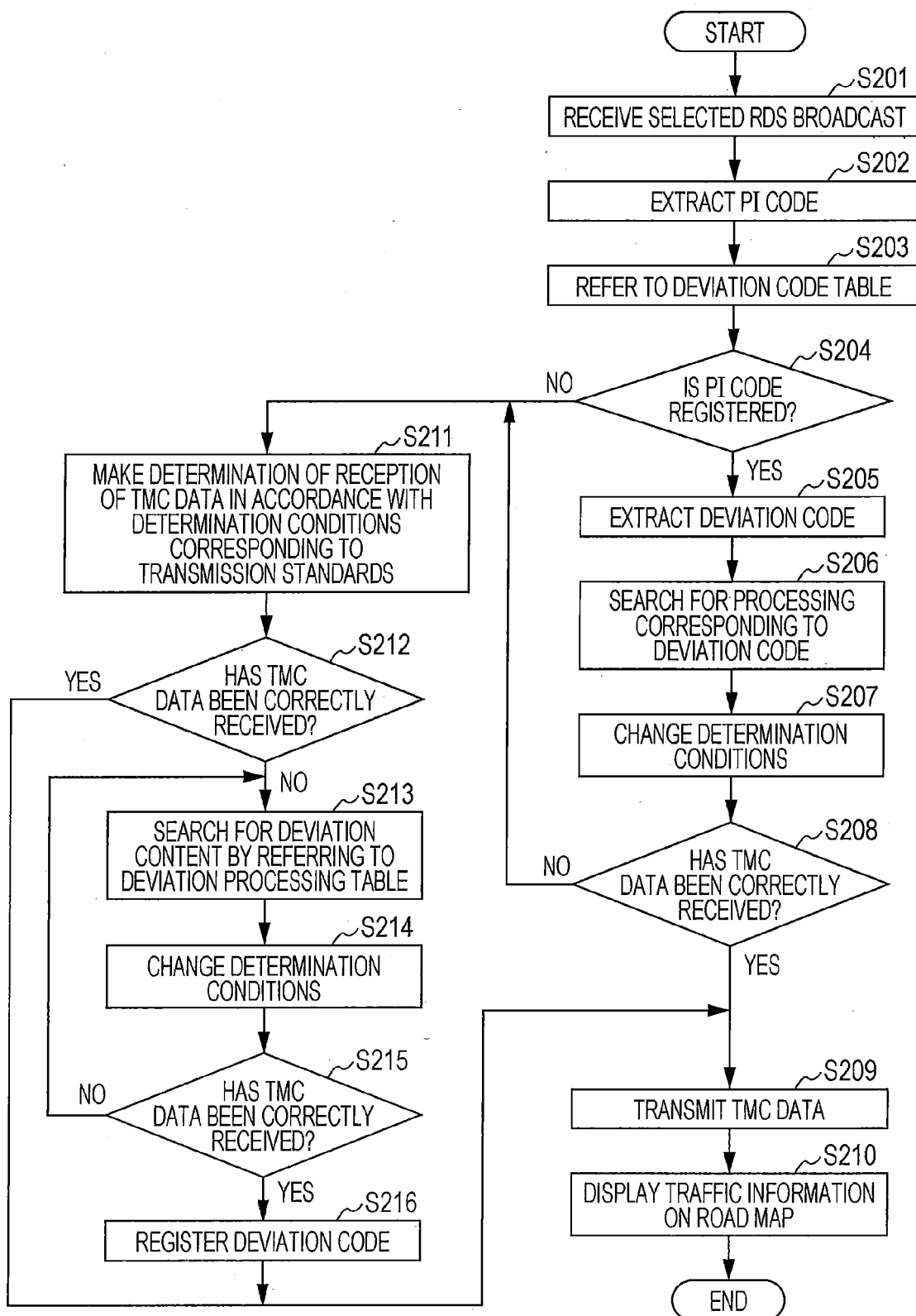
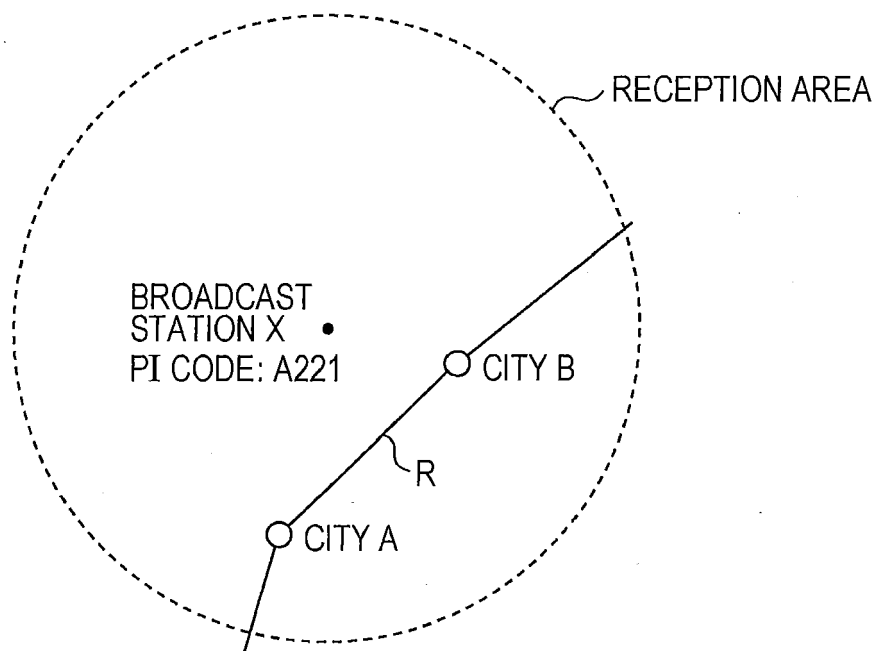


FIG. 9



REFERENCES CITED IN THE DESCRIPTION

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