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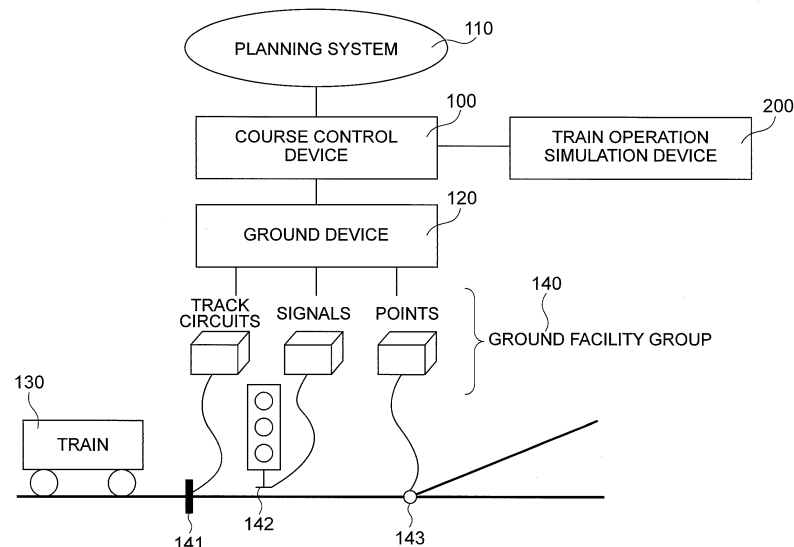
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(54) **Train operation control system, train operation simulation device, and train operation simulation method**

(57) A train operation simulator (200) avoids occurrence of deadlock while automatically setting train courses and sequence information by a step (510) of updating weather-disaster information (351) and human flow information (352), a step (520) of simulating a physical state, a step (530) of generating a train course and con-

ducting a train course change when an interrupted part has occurred due to a disaster, a step (570) of controlling a signal on the train course, and a step (580) of conducting state rewinding when deadlock has occurred and giving a sequence restriction to prevent reoccurrence of deadlock.

FIG. 1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a train operation control system, a train operation simulation device, and a train operation simulation method.

[0002] With the advance of computer control, train operation control has changed from conventional signal control exercised by a station employee to automatic signal control exercised by a railroad operation control system. In the railroad operation control system, signal control is exercised by a course control device. The root control device is a device that controls a signal on the basis of a state of ground facilities, on-rail position of a train, and a timetable which is a predetermined operation schedule of the train.

[0003] The railroad operation control system is a complicated method relating to a large number of trains and passengers, and cooperation among various elements such as an operation plan, a control method, and facility arrangement is indispensable. As a technique for implementing simulation of train traveling, there is a technique described in JP-A-2001-354139. In the technique described in JP-A-2001-354139, a simple station simulator conducts automatic recognition of a non-operating station and conducts automatically generation and elimination of a substitute simulator for simulating the station system. Correction of a difference between a plan timetable and an actual timetable in stationary traveling, an automatic adjustment of travel time based on a notifying result, and an on-rail position based on an operation arrangement journal in an operation arrangement input device and the actual timetable are reproduced on the simple station simulator.

SUMMARY OF THE INVENTION

[0004] According to the technique described in JP-A-2001-354139, however, the on-rail position based on an actual timetable is reproduced on the simple station simulator. Unless timetable information (info) is used, therefore, operation simulation of trains cannot be executed. In an upstream phase such as, for example, trial calculation of effects of new line opening and section through operation, a strict timetable is not determined in many cases. Especially in an area such as a city where railroad track networks are complicated and a large number of trains operate, creation of the timetable needs a long-term study mobilizing technical experts. Furthermore, when an unexpected situation such as a natural disaster has occurred, re-creation of the timetable is difficult and application to use such as making a substitute plan at the time of disaster is also restricted. In addition, since passengers are not included in the simulation target, the effect on human flow cannot be calculated.

[0005] Therefore, it is demanded to conduct operation simulation of trains without using timetable information.

[0006] A disclosed train operation control system includes a planning system, an external device, and a train operation simulation device. The planning system transmits facility information concerning train facilities and train information including on-rail positions of trains to the train operation simulation device. The external device transmits environmental information concerning environment of a train to the train operation simulation device. A facility information storage unit in the train operation simulation device stores the facility information acquired from the planning system. A train information storage unit stores the train information acquired from the planning system. An environmental information update unit updates the environmental information acquired from the external device. A train traveling course update unit updates the facility information and the train information on the basis of the environmental information and calculates a traveling course of a train.

[0007] According to the present embodiment, it becomes possible to conduct operation simulation of trains without using timetable information.

[0008] Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 shows a general configuration example of a railroad operation control system;

Fig. 2 shows a hardware configuration example of a train operation simulation device;

Fig. 3 shows a software configuration example of the train operation simulation device;

Fig. 4A shows an example of a weather-disaster information table;

Fig. 4B shows an example of a human flow information table;

Fig. 4C shows an example of a train information table;

Fig. 4D shows an example of a facility information table;

Fig. 4E shows an example of a route information table;

Fig. 4F shows an example of a topological information table;

Fig. 4G shows an example of a sequence information table;

Fig. 5A shows an example of a general processing flow;

Fig. 5B shows an example of a processing flow executed by a facility-train information update unit;

Fig. 5C shows an example of a processing flow executed by a train traveling course update unit;

Fig. 5D shows an example of a processing flow executed by the train traveling course update unit;

Fig. 5E shows an example of a processing flow executed by the train traveling course update unit;
 Fig. 5F shows an example of a processing flow executed by a train traveling situation evaluation unit;
 Fig. 5G shows an example of a processing flow executed by the train traveling situation evaluation unit;
 and
 Fig. 6 shows an example of a screen displayed by the train traveling situation evaluation unit.

DESCRIPTION OF THE EMBODIMENTS

[0010] Hereafter, an embodiment of the present invention will be described in detail with reference to Figs 1 to 6.

[0011] Fig. 1 shows a system general configuration of a railroad operation control system which controls operation of trains while monitoring a train operation plan, an on-rail position of a train, and states of facilities such as signals and points. The railroad operation control system includes a course control device 100, a planning system 110, a ground device 120, a train 130, and a ground facility group 140 (in Fig. 1, only a track circuit 141, a signal 142 and points 143 are shown).

[0012] The course control device 100 receives, via a network, train timetable information determined by the planning system 110 and states of the ground facility group 140 collected by the ground device 120. The course control device 100 retains the received information and states therein. The course control device 100 refers to an on-rail position of the train 130 obtained from the track circuit 141 and departure time and a planned route stated in the train timetable information, and controls the signal 142 and the points 143 installed on a route of the train 130 via the ground device 140.

[0013] The planning system 110 is a system that supports creation of train timetable and plans relating to operation of trains such as a vehicle operation plan and an inspection-maintenance plan. The planning system 110 is connected to the course control device 100 via a network.

[0014] The ground device 140 is connected to the course control device 100 via a network. The ground device 140 exercises reverse control of the signal 142 and the points 143 in response to a control request from the course control device 100. Furthermore, the ground device 140 monitors states (normal position/reverse position) of the signal 142 and the points 143 and a state (occupied/free) of the track circuit 141, and transmits the states to the course control device 100.

[0015] The train 130 includes therein onboard devices including a safety device which conducts automatic stop and automatic control of the train, such as an ATS (Automatic Train Stop) or an ATC (Automatic Train Control), and an information management system which collects, displays and records detailed onboard operation states and failure information. Furthermore, it is possible to transmit information retained by the onboard device to the ground device 120 via a digital radio. The course

control device 100 judges the on-rail position of the train 130 by using the state of the track circuit 141. Or the onboard device calculates or measures the position of the own train and transmits the position to the ground device via a digital radio, and thereby the course control device 100 judges the on-rail position of the train 130.

[0016] A train operation simulation device 200 which will be described later simulates states of the course control device 100, the planning system 110, the ground device 120, the train 130, and the ground facility group 140.

[0017] Fig. 2 shows a hardware configuration example of the train operation simulation device 200. Hardware of the train operation simulation device 200 includes a central processing unit 210, a main storage device 220, an internal bus 230, a bus interface 240, an external bus 250, an input/output (I/O) device 260, an input/output (I/O) interface (I/F) 261, a large capacity storage device 270, a large capacity storage device interface 271, and a communication device 280, and a communication device interface 281.

[0018] The central processing unit 210 is a processor for performing operation such as program execution. The main storage device 220 is used as a processing area at time of execution of a program and used as a temporary storage area of data used for transmission and reception with the planning system 110 and the ground device 120. The main storage device 220 stores a basic program, such as, for example, an OS (Operating System), and basic data. In addition, the main storage device 220 temporarily stores a program that implements an environmental information update unit 311, a train-facility state update unit 312, a train traveling course update unit 313, a signal control unit 314, a train traveling situation evaluation unit 315, a controller unit 320, a screen control unit 330, an input interface 341, and an output interface 342, at the time of execution of the program. The central processing unit 210 and the main storage device 220 are connected to each other by the internal bus 230. The internal bus 230 is connected to the external bus 250 via the bus interface 240.

[0019] The input/output device 260 includes an interface device for a user, such as a display, a keyboard, and a mouse, and a drive device capable of reading and writing on external media. The user can control program execution by using an input device such as a keyboard or a mouse.

[0020] The large capacity storage device 270 is a device such as, for example, an HDD (Hard Disk Drive). The large capacity storage device 270 can permanently store a basic program, a processing result, and the program that implements the environmental information update unit 311, the train-facility state update unit 312, the train traveling course update unit 313, the signal control unit 314, the train traveling situation evaluation unit 315, the controller unit 320, the screen control unit 330, the input interface 341, and the output interface 342. When executing each processing, the central processing unit 210 reads out the program into the main storage device

220, and executes the program. Furthermore, various data such as a weather-disaster information table 351, a human flow information table 352, a train information table 361, a facility information table 362, a route information table 363, a topological information table 364, a sequence information table 365, a train traveling actual result 371, and a simulation log 372 are stored in the train operation simulation device 200.

[0021] The communication device 280 is a device for connecting to an external server device such as, for example, Ethernet (registered trademark). It is possible to input and output information between the course control device 100 and the external server device via a network. It becomes possible to provide a computer connected via a network with, for example, the function of the course control device 100 as service, by using the communication device 280.

[0022] The input/output device 260, the large capacity storage device 270 and the communication device 280 are connected to the external bus 250 via the input/output device interface 261, the large capacity storage device interface 271 and the communication device interface 281, respectively. The train operation simulation device 200 may have a configuration including the input input/output device 260, the large capacity storage device 270 and the communication device 280.

[0023] Fig. 3 shows a software configuration example of the train operation simulation device 200. Software of the train operation simulation device 200 includes the environmental information update unit 311, the train-facility state update unit 312, the train traveling course update unit 313, the signal control unit 314, the train traveling situation evaluation unit 315, the controller unit 320, the screen control unit 330, the input interface 341, the output interface 342, the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363, the topological information table 364, the sequence information table 365, the train traveling actual result 371, and the simulation log 372.

[0024] The program that implements the environmental information update unit 311, the train-facility state update unit 312, the train traveling course update unit 313, the signal control unit 314, the train traveling situation evaluation unit 315, the controller unit 320, the screen control unit 330, the input interface 341, and the output interface 342 is developed from the large capacity storage device 270 into the main storage device 220 at the time of execution, and the central processing unit 210 performs operation. Furthermore, the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363, the topological information table 364, the sequence information table 365, the train traveling actual result 371, and the simulation log 372 generated by execution of the program are developed into the main storage device 220. The

user can control execution of the program by giving an instruction to the input interface 341 via the input/output device 260 such as a keyboard, a mouse and a display. Furthermore, the user can input and output data by using portable storage media that can be attached and detached as the input/output device 260. The user can also conduct inputting and outputting with another device via the communication device 280. The program that implements the function units may be previously stored in the large capacity storage device 270, or may be introduced from a different device into the large capacity storage device 270 or the main storage device 220 via available media. The media mean, for example, storage media that can be attached and detached, as the input/output device 260, and mean a network, or communication media such as a carrier wave or a digital signal propagating through a network as the communication device 280.

[0025] The environmental information update unit 311 is a part that updates the weather-disaster information table 351 and the human flow information table 352 from an external file via the input interface 341. Time changes of the weather-disaster information table 351 and the human flow information table 352 are previously recorded in the external file. The user may directly rewrite these tables from a GUI via the input interface 341. Here, environmental information is information concerning weather and a disaster and human flow information of passengers. In the present embodiment, operation simulation at the time of, for example, a disaster can be executed without conducting troublesome timetable changes, by conducting train operation simulation using environmental information. Furthermore, it is possible to easily execute maintenance capability measurement of train operation service, prediction of risk potentials, establishing countermeasures against a disaster, and measurement of countermeasure effects by conducting simulation including human flow information.

[0026] The train-facility state update unit 312 is a part that calculates changes of on-rail positions of trains, facility states, and human flow, and updates the train information table 361, the facility information table 362 and the human flow information table 352. Furthermore, the train-facility state update unit 312 is a part that stores actual traveling results of trains into the train traveling actual result 371, and stores current states of the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363 and the sequence information table 365 into the simulation log 372. Furthermore, the train-facility state update unit 312 is a part that displays contents of the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363, the topological information table 364, the sequence information table 365 and the train traveling actual result 371 on the GUI via the output interface 342.

[0027] The train traveling course update unit 313 is a

part that calculates a train route as regards a train that is not determined in route, and registers the train route into the train information table 361. Furthermore, the train traveling course update unit 313 is a part that determines an interrupted part of the railroad track on the basis of the weather-disaster information table 351, the facility information table 362 and the route information table 363, and executes course changes as for trains having the interrupted part on the route. A change result is registered in the train information table 361.

[0028] The signal control unit 314 is a part that controls signals by using the train information table 361, the facility information table 362 and the sequence information table 365, and updates the facility information table 362.

[0029] The train traveling situation evaluation unit 315 is a part that checks whether train deadlock occurs during simulation by using the route information table 363 and the topological information table 364. In a case where deadlock occurs, the train traveling situation evaluation unit 315 rewinds the simulation situation to before the occurrence of the deadlock by using the simulation log 372. In addition, the train traveling situation evaluation unit 315 determines travelling sequence of trains to avoid deadlock.

[0030] The weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363, the topological information table 364 and the sequence information table 365 will be described later by using configuration examples.

[0031] The train traveling actual result 371 stores traveling time of trains in each position on the railroad track. For example, the actual result is represented as a set of a position, a train and time.

[0032] The simulation log 372 stores contents of the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363, the sequence information table 365 and the train traveling actual result 371 in each section of internal time of the simulator. It is possible to restore a simulation state in each time section by extracting stored values in the table group in a specified time section from the simulation log 372 and developing the extracted values.

[0033] The controller unit 320 is a part that receives input information from the user via the screen control unit 330 and controls the environmental information update unit 311, the train-facility state update unit 312, the train traveling course update unit 313, the signal control unit 314 and the train traveling situation evaluation unit 315. The screen control unit 330 is a part that receives input information from the user via the input interface 341 and delivers the input information to the controller unit 320. Furthermore, the screen control unit 330 is a part that receives processing results in the environmental information update unit 311, the train-facility state update unit 312, the train traveling course update unit 313, the signal control unit 314 and the train traveling situation evalua-

tion unit 315, and delivers a screen output to the output interface 342. The input interface 341 is a part that receives input information from the user and delivers the input information to the screen control unit 330. The output interface 342 is a part that outputs the screen output received from the screen control unit 330 to a user interface such as a display.

[0034] Fig. 4A, Fig. 4B, Fig. 4C, Fig. 4D, Fig. 4E, Fig. 4F and Fig. 4G show examples of various tables used in the train operation simulation device 200.

[0035] Fig. 4A shows an example of the weather-disaster information table 351. The example of the weather-disaster information table 351 has "route ID" and weather-disaster information as elements. In the present example, the weather-disaster information has "wind velocity," "rainfall" and "fall of rock" as elements. In the "route ID," a key for uniquely identifying a route is stored. Here, "route" means one signal and a railroad track area protected by the signal. In the on-rail trail position detection method using a track circuit, the railroad track area is an area from a first signal protection area track circuit to a final signal protection area track circuit installed in a protection area of the signal. Or, for example, in a scheme an onboard device on the train 130 includes a positioning sensor such as a position calculation device or a GPS (Global Positioning System) and the on-rail position of a train is calculated by using a value in the sensor, the track area is an area where the signal instructs stop indication due to the train 130 on the rail. In the "wind velocity," for example, a maximum wind velocity during a determinate period immediately preceding current time is stored. The determinate period immediately preceding current time is set equal to, for example, 30 minutes. In the "rainfall," for example, a continuous rainfall is stored with mm taken as the unit.

[0036] Fig. 4B shows an example of the human flow information table 352. The example of the human flow information table 352 has "station name" and "passenger information" as elements. In the "station name," a key for uniquely identifying a station is stored. In the "passenger information," the number of passengers staying in the station is stated every destination. The example shown in Fig. 4B indicates that twelve passengers whose destination is Station_#2 and twenty-one passengers whose destination is Station_#3 are waiting for a train in Station_#1.

[0037] Fig. 4C shows an example of the train information table 361. The example of the train information table 361 has "train ID," "length," "train classification," "on-rail route," "on-rail position," "passenger information," "destination," "transit station," "transit route," and "course change target train" as elements. In the "train ID," a key for uniquely identifying a train is stored. In the "length," a length from a tip to an end of the train is stored. In the "on-rail route," a route ID of a route corresponding to a signal on which a train has confirmed clear indication in close vicinity and progressed in advance is stored. A tip part of the train exists on a railroad track area represented

by the route. In the "on-rail position," a length from a start end of the on-rail route to the tip part of the train is stored. In the example shown in Fig. 4C, it is represented that a tip part of Train_#1 exists in a position of 37 m from a start end of Block_#5. In the "passenger information," the number of passengers on the train is stored every passenger destination. In the example shown in Fig. 4C, it is represented that fifty-two passengers whose destination is Station_#1 and ninety-five passengers whose destination is Station_#2 are on Train_#1. In the "destination," a terminal station of the train is stored. In the "transit station," stations the train goes by way of are stored in the order the train goes by way of. In the "transit route," routes the train goes by way of as far as the destination are stored in the order the train goes by way of. The "course change target train" stores whether the train is a target of the traveling course change conducted by the train traveling course update unit 313.

[0038] Fig. 4D shows an example of the facility information table 362. The example of the facility information table 362 has "facility ID," "facility state" and "state duration" as elements. In the "facility ID," a key for uniquely identifying facilities is stored. In the "facility state," a state of the facilities is stored. For example, in the case of a signal, a state of "clear indication," "under progress control," "stop indication," "under stop control" or "in failure" is stored. In the case of a track circuit, a state of "occupied," "free," or "abnormal" is stored. In the "continuation time," time over which the same facility state continues is stored with a second taken as the unit.

[0039] Fig. 4E shows an example of the route information table 363. The example of the route information table 363 has "route ID," "station," "platform," "next route ID," "length," "signal," "track circuit," "priority," "passing possible," "under control trial," and "control train" as elements. In the "route ID," a key for uniquely identifying a route is stored. The "station" is set in a case where the route is in a place where passengers can get on and off. In the "station," a station where passengers get on and off is stored. The "platform" is set under the same condition as the "station." In the "platform," a platform where passengers get on an off is stored. In the "next route ID," all routes into which a train on the rail of the route can enter subsequently are stored. The example in Fig. 4E represents that a train on the rail of Block_#1 can enter Block_#2 or Block_#3 when exiting Block_#1. In the "length," a course length from a start end to a final end is stored. In the "signal," a signal corresponding to the route is stored. In the "track circuit," track circuits existing on a track area corresponding to the route and lengths of the track circuits in order from a start end of the route. The example shown in Fig. 4E represents that Block_#1 has TrackCircuit_#1, TrackCircuit_#2 and TrackCircuit_#3 in advance thereof in order from the start end, and their lengths are 200 m, 250 m and 175 m. In the "priority," two values, i.e., "preference" and "no preference" are stored. For example, in a situation in which a preference direction of the railroad track is previously

specified, "preference" is stored when a direction of the route coincides with a preference direction of a railroad track existing at a final end of the route. Otherwise, "no preference" is stored. In the "passing possible," it is represented whether the route is judged to be an interrupted part by the train traveling course update unit 313. In the example shown in Fig. 4E, "×" represents that the route is an interrupted part whereas "○" represents that the route is not an interrupted part. In the "under control trial," it is stored whether the route became a target of control exercised by the signal control unit 314 in the last period. In the example shown in Fig. 4E, it is represented that Block_#1 became a target of control exercised by the signal control unit 314 in the last period whereas Block_#2 did not become a target of the control. In the "control train," a train that has issued a control request to the route is stored. In the "control train," a value is stored when the "under control trial" is "Yes" or the state of the light of route is "clear indication" or "under progress control."

[0040] Fig. 4F shows an example of the topological information table 364. The example of the topological information table 364 has "topology ID," "topology classification," "route 1 ID," "route 2 ID" and "sequence competition" as elements. In the "topology ID," a key for uniquely identifying a topological relation is stored. In the "topology classification," a classification of the topological relation is stored. In the "route 1 ID" and "route 2 ID," two routes that are in the topological relation are stored. In the "sequence competition," "Yes" is stored in a case where the topological relation is a topological relation that needs a control logic of a sequence decision, and otherwise "No" is stored. Whether the topological relation needs a control logic of a sequence decision is determined according to WO2013/014989.

[0041] FIG 4G shows an example of the sequence information table 365. The example of the sequence information table 365 has "topology ID," "preference train" and "no preference train" as elements. In the "topology ID," a key for uniquely identifying a topological relation is stored. The "preference train" and "no preference train" represent that a train stated in the "no preference train" cannot enter either route in the topological relation until a train stated in the "preference train" passes through either one of the two routes in the topological relation. The sequence information table 365 has no records at the start time of the simulation.

[0042] FIG 5A shows a general flow of processing executed by the train operation simulation device 200. Processing 500 is started by taking depression of a simulation control button 613 as a trigger, and processing 501, 510, 520, 530, 570 and 580 is executed.

[0043] The processing 501 is processing that repeats the processing 510, 520, 530, 570 and 580. The repetition is executed periodically with a predetermined time interval. The repetition is executed with a period of, for example, one second. Furthermore, internal time of the simulator is advanced at the time of repetition. At this time,

apparent acceleration and deceleration of the simulation becomes possible by providing the repetition period and the advanced quantity of the internal time of the simulator with a difference. For example, in a case where the repetition interval of the processing 501 is set equal to one second and the advanced quantity of the internal time of the simulator is set equal to five seconds, the simulation looks like being executed with a speed of five times from the user. The ratio of the repetition interval of the processing 501 to the advanced quantity of the internal time of the simulator can be changed suitably if, for example, the user operates a simulation speed change window 612 shown in Fig. 6.

[0044] The processing 510 is processing executed by the environmental information update unit 311. The processing 510 updates the weather-disaster information table 351 and the human flow information table 352. Update of the tables is implemented by, for example, previously preparing external files that record time changes of the weather-disaster information table 351 and the human flow information table 352 and acquiring data pertinent to the present time period from the files via the input interface 341. Selection of a file is conducted using, for example, a dialogue box displayed by depressing a file setting button 602 shown in Fig. 6. Or the user may directly rewrite the table from a GUI via the input interface 341. In other words, the planning system 110 transmits train information including an on-rail position of a train to the train operation simulation device 200. An external device transmits environmental information concerning environment of the train to the train operation simulation device 200. The train operation simulation device 200 includes a facility information storage unit (the facility information table 362) which stores facility information acquired from the planning system 110 and a train information storage unit (the train information table 361) which stores train information acquired from the planning system 110.

[0045] The processing 520 is executed by the train-facility state update unit 312. The processing 520 is processing that simulates changes of on-rail positions of trains, facility states, and human flow, and updates the train information table 361, the facility information table 362 and the human flow information table 352. Furthermore, in the present processing, traveling actual results of trains and current states of various tables are stored in the train traveling actual result 371 and the simulation log 372.

[0046] A detailed flow of the processing 520 is shown in Fig. 5B. In the processing 520, processing 521, 522, 523 and 524 is executed successively.

[0047] The processing 521 is processing that calculates a moving distance of a train and stores a new on-rail position of the train into the train information table 361. The moving distance of the train is calculated, for example, as a product of the execution period and a predetermined reference speed of the train. Here, in a case where a reference speed differing from train to train is

used, it can be implemented by, for example, adding a train reference speed item to the train information table 362. Furthermore, a new on-rail position of a train is determined by adding the moving distance of the train calculated as described above to the on-rail position of the train before movement stored in the "on-rail position" in the train information table 362. Here, in a case where the new on-rail position of the train exceeds the length of a route where the train is on the rail, the train is moved into the next route. The route where the train is on the rail, the length of the route and the route of the movement destination are acquired from the facility information table 362 and the route information table 363. By the way, the route of the movement destination is a route that is included in routes stated in the "next route ID" of the on-rail route before movement and that is "clear indication" in the "facility state" of the signal. The on-rail position of the train in the route of the movement destination is set equal to an excess of the moving distance of the train over the length of the route of the movement source.

[0048] The processing 522 is processing that calculates changes of facility states such as track circuits and signal caused by movement of the on-rail position of the train and stores the changes into the facility information table 362. As for the track circuit state, a track circuit where a train is on the rail is in the occupied state. Otherwise, a track circuit is in the free state. The track circuit existing in the on-rail position of the train is determined by determining an on-rail range of the train on the basis of the "on-rail position" and "length" of the train in the train information table 361 and comparing track circuits stored in the "track circuit" in the route information table 363 corresponding to the "on-rail route" in the train information table 361 with the on-rail range of the train. Besides the signal state and the track circuit state, the user can input an abnormal state such as a facility failure from a GUI via the input interface 341. Or it is also possible to previously define a time change of an abnormal state of facilities in an external file and acquire data pertinent to the present time period from the external file via the input interface 341.

[0049] The processing 523 is conducted for a train stopping at a station. The processing 523 is processing that causes passengers whose destination or junction station is the station to get off the train and updates the train information table 361. The passengers whose destination is the station can be judged from the "passenger information" in the train information table 361. Getting off the train of passengers is implemented as an operation of removing data of passengers whose destination or junction station is the station from the "passenger information" in the train information table 361. Furthermore, at the same time, data of passengers who have got off the train is added to the "passenger information" of a station pertinent to the station where the passengers got off the train, in the human flow information table 352.

[0050] The processing 524 is conducted for a train stopping at a station. The processing 524 is processing

that causes passengers whose destination or junction station coincides with a transit station of the train to get on the train and updates the train information table 361. It can be determined whether the destination of a passenger is included in the transit stations of the train by comparing the human flow information table 352 with the train information table 361. Getting on the train of passengers is implemented as an operation of adding data of passengers to the "passenger information" in the train information table 361. Furthermore, at the same time, data of passengers who have got on the train is removed from the human flow information table 352.

[0051] The processing 525 is processing that displays a state of simulation on the screen. Prior to description of the processing 525, first, Fig. 6 will be described in detail.

[0052] Fig. 6 shows a screen which displays the operation state of the train operation simulation device 200. The screen includes an end button 601, a file setting button 602, a simulator operation control window 610, an information display window 620 and a simulation situation display window 630.

[0053] The end button 601 is a button that terminates a simulation program executed by the train operation simulation device 200. The user can terminate the program by depressing the end button 601.

[0054] The file setting button 602 is a button for specifying a file that becomes a reading source of the weather-disaster information table 351 or the human flow information table 352. For example, a dialogue box is displayed by depressing the file setting button 602. The user can specify a file by using the dialogue box.

[0055] The simulator operation control window 610 is a window for controlling the operation of the train operation simulation device 200. The simulator operation control window 610 includes a simulator internal time display window 611, a simulation speed change window 612 and a simulation control button 613.

[0056] The simulator internal time display window 611 is a window that displays the internal time of the train operation simulation device 200. The user can directly rewrite the internal time of the simulator from the window. The simulation speed change window 612 is a window for controlling the simulation speed. The user can accelerate or decelerate the simulation speed from the window. The simulation control button 613 is a window for controlling drawing on the screen. The user can conduct temporary stop or resumption of drawing and reproduction of a past simulation state by operating the window.

[0057] The information display window 620 is a window for displaying the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363, the topological information table 364, the sequence information table 365 and the train traveling actual result 371 on the screen. Furthermore, the user can directly edit contents of the tables from the window.

[0058] The simulation situation display window 630 is a window for graphically displaying contents such as on-rail positions of trains, control states of signals, atmospheric phenomenon information, and human flow information. Reference numerals 631 and 632 denote trains. A shade of color of a train represents a boarding rate. The user can grasp at a glance whether the boarding rate is large on the basis of the color of the train. Reference numeral 633 denotes a traveling course of a train #1. Reference numeral 634 denotes a signal, and 635 a route. Reference numeral 636 denotes a station where passengers can get on and off a train, and a shade of color represents a rate of crowdedness at the station.

[0059] Description with reference to Fig. 6 will be finished, and description of the processing 525 will be resumed. In the processing 525, information required for drawing of the simulator operation control window 610, the information display window 620 and the simulation display window 630 is transmitted to the screen control unit 330. The screen control unit 330 creates drawing information, and presents the screen shown in Fig. 6 to the user via the output interface 342.

[0060] The processing 520 is finished as described heretofore, and a shift to the processing 530 is conducted. The processing 530 is processing executed by the train traveling course update unit 313. The processing 530 is processing that stores a result obtained by calculating or changing a train course for each train into the train information table 361. In other words, the train operation simulation device 200 includes the environmental information update unit 311 which acquires environmental information acquired from an external device, and the train traveling course update unit 313 which updates facility information and train information on the basis of the environmental information and calculates a traveling course of a train.

[0061] A detailed flow of the processing 530 is shown in Fig. 5C. In the processing 530, processing 540, 550 and 560 is executed.

[0062] In the processing 540, for a train a traveling course of which is not registered in the train information table 361, a route group on the course is determined on the basis of a destination and transit stations of the train. Extraction of the course can be implemented by, for example, taking out route rows that go by way of all transit stations of the train from among route rows capable of arriving at a destination obtained by following the route information table 363 with a route where the train is on the rail taken as a base point. In a case where there are a plurality of extracted courses, the courses are narrowed down to one. For this purpose, the train operation simulation device 200 further includes a priority storage unit which previously determines a preference direction on a railroad track that is a preference traveling railroad track. And a course that is the shortest in sum total of lengths of routes each having a direction that does not coincide with a preference direction of a railroad track existing at an exit point of the route is selected.

[0063] In the processing 550, trains that become targets of traveling course change are determined on the basis of the weather-disaster information table 351, the train information table 361, the facility information table 362 and the route information table 363. A detailed flow of the processing 550 is shown in Fig. 5D. In the processing 550, processing 551, 552, 553 and 554 is executed successively.

[0064] In the processing 551, an interrupted part of the railroad track is determined on the basis of the weather-disaster information table 351 and the facility information table 362. Determination whether a railroad track is interrupted is conducted by, for example, determining whether the wind velocity or rainfall stored in the weather-disaster information table 351 exceeds a previously stipulated operation stop standard. For example, a route that exceeds 25 m/second in wind velocity or exceeds 100 mm in rainfall is determined to be an interrupted part. Furthermore, determination whether a railroad track is interrupted is conducted by determining whether the "fall of rock" information in the weather-disaster information table 351 or the "facility state" in the facility information table 362 indicates an abnormality. The interrupted part of the railroad track is linked to a route, and the determination result is stored in the route information table 363. Correspondence between facilities and a route can be determined by referring to the route information table 363.

[0065] In the processing 552, a railroad track interrupted range which becomes interrupted secondarily due to the interrupted part of the railroad track determined in the processing 551 is determined. The railroad track interrupted range which becomes interrupted secondarily is determined for each of routes in the route information table 363. Determination whether the route is included in the railroad track interrupted range which becomes interrupted secondarily is conducted, for example, in a case where a train is on the rail in the route, by determining whether it is inevitable for the train to pass through the interrupted part of the railroad track determined in the processing 551. Such a route can be extracted by repeating processing of adding a route for which all routes stored in the "next route ID" in the route information table 363 are interrupted to routes included in the railroad track interrupted range until routes newly included in the railroad track interrupted range do not increase.

[0066] In the processing 553, a train that becomes a target of traveling course change is determined by using the result of the processing 552. For example, among trains existing in the train information table 361, trains that include the interrupted range of the railroad track determined in the processing 552 in the "transit route" in the train information table 361 and that have expected time of arrival at the route within determinate minutes can be determined to be trains that become targets of traveling course change. The expected time of arrival at the route can be determined by, for example, calculating a distance up to arrival on the basis of the "transit route"

in the train information table 361 and the "length" in the route information table 363 and dividing the distance by a predetermined reference speed of the train. In a case where the reference speed of the train differs from train to train, an item of "train reference speed" may be added to the train information table 362. As for a train that has become a target of traveling course change, "Yes" is stored in the "route change target" in the train information table 362.

[0067] In the processing 554, in a case where there is a predetermined standard for determining a traveling course change train besides the processing 553, a train that satisfies the standard is added to trains of traveling course change target. The predetermined standard is, for example, arrival of the train at a specified station. A train that satisfies the reference is set to be a target of course change regardless of the traveling course. At this time, if the specified course change causes a destination change, a new destination is also specified at the same time.

[0068] The processing 550 is completed as described heretofore, and a shift to the processing 560 is conducted. In the processing 560, for a train registered in the train information table 361 as a course change target, a course change of the train is conducted by referring to the route information table 363 and a result is registered in the train information table 361. In other words, the train traveling course update unit 313 in the train operation simulation device 200 calculates a railroad track interrupted range in which the railroad track is interrupted, on the basis of environmental information and facility information, determines a train relating to the railroad interrupted range to be a train to be changed in traveling course, and updates the traveling course.

[0069] A detailed flow of the processing 560 is shown in Fig. 5E. In the processing 560, processing 561, 562, 563, 564, 565, 566 and 567 is executed.

[0070] In the processing 561, the processing 562, 563, 564, 565 and 566 is repeated for all trains of course change target determined in the processing 550.

[0071] In the processing 562, for a train that is currently the target of repetition, all courses leading from the on-rail position of the train to a destination are searched for. The courses obtained by the search are represented as rows of routes. The search for courses can be implemented by, for example, taking out route rows that go by way of all transit stations of the train from among route rows capable of arriving at a destination obtained by following the route information table 363 with a route where the train is on the rail taken as a base point.

[0072] In the processing 563, branching to the processing 564, 565 and 566 is conducted according to the number of courses obtained in the processing 562. When the number of courses is one, the processing 566 is executed. When the number of courses is at least two, the processing 565 is executed. If there are no courses, the processing 564 is executed.

[0073] The processing 564 is processing executed in

a case where a course is not obtained in the processing 562. In the processing 564, a destination of the train is newly set. For example, from among stations on a course of a posterior operation train of the target train, a station existing on the former course of the target train and located farthest from the current position of the target train is set to be a new destination. In this case, after the target train has arrived at the new destination, the target train is changed to a posterior operation train in operation.

[0074] The processing 565 is processing executed in a case where a plurality of courses are obtained in the processing 562. In the processing 565, one course is selected from among the plurality of obtained courses. For example, from among courses obtained as a result of the search in the processing 562, a course that goes by way of the most transit stations on the former course is selected. The transit stations on the former course can be determined by referring to the train information table 361. In a case where there are a plurality of courses satisfying the condition, the courses are narrowed down to one. As for a method therefor, for example, a preference direction is determined on the railroad track and a course that is the shortest in sum total of lengths of routes each having a direction that does not coincide with a preference direction of a railroad track existing at an exit point of the route is selected.

[0075] In the processing 566, the course obtained by narrowing down courses in the processing 562 or the processing 565 is stored in the train information table 361 as a new train traveling course.

[0076] The processing 560 and 530 is completed as described heretofore, and a shift to the processing 570 is conducted. The processing 570 is processing executed by the signal control unit 314. A signal to be controlled is determined on the basis of the train information table 361, the facility information table 362 and the sequence information table 365. Determination of the controllable signal is conducted by executing a control program used in the course control device 100. For example, a course control program generated by a device according to WO2013/014989 should be previously prepared. Here, the train information table 361 and the sequence information table 365 simulate the input to the course control device 100 from the planning system 110 and the on-rail position information of the train 130. And contents of the facility information table 362 simulate the input from the ground device 120. When previously generating a course control program, a control logic belonging to a course selection logic type is set to read and execute a train traveling course stored in the train information table 361, and a control logic belonging to a sequence decision logic type is set to read and execute the sequence information table 365. The state of the signal obtained by the course control device 100 is reflected to the facility state in the facility state table 362.

[0077] The processing 580 is processing executed by the train traveling situation evaluation unit 315. In the processing 580, it is checked whether deadlock of a train

has occurred during simulation by using the route information table 363 and the topological information table 364. In a case where deadlock has occurred, the simulation situation is rewound to before the occurrence of the deadlock by using the simulation log 372 and the traveling sequence of the train is determined to avoid deadlock.

[0078] A detailed flow of the processing 580 is shown in Fig. 5F. In the processing 580, processing 581, 582, 583, 584, 585 and 586 is executed.

[0079] In the processing 581, a deadlock occurrence place between trains is detected by using a result in the signal control unit 314. Detection of the deadlock occurrence place is conducted by using the route information table 363 and the topological information table 364. Detection of the deadlock occurrence place is conducted in accordance with, for example, the following procedure. First, in the route information table 363, a set (hereafter represented as B, where elements of B are B1, B2, ... Bn (n: natural number)) obtained by collecting all routes for which the "under control trial" is "Yes" is acquired. Subsequently, topological relations among elements of B are discriminated from the topological information table 364. Subsequently, as regards a partial set $B_p = (B_{p1}, B_{p2}, \dots, B_{pk})$ ($p1, p2, \dots, pk$: natural number, $k \leq n$) of B, it is determined whether a topological relation in which the i th route includes a entry point of the $(i+1)$ -st holds true, for all i in $1 \leq i \leq k-1$. In a case where B_p satisfying the condition for all i exists, it is determined that deadlock has occurred in B_p . At this time, a train (hereafter referred to as T_p) concerning deadlock is obtained by extracting a control train for all element routes of B_p from the route information table 363. By the way, when the number of elements of B_p is two, it may be determined that deadlock has occurred in B_p in a case where elements of B_p are in topological relation of (8) deadlock B, (14) reverse direction connection B, or (22) deadlock A.

[0080] The processing 582 is processing that repeats the processing 583, 584 and 585 for all B_p obtained in the processing 581.

[0081] In the processing 583, priority of T_p is determined. The processing 583 can be implemented by, for example, previously determining priority for train classification and destination and comparing values stored in the train information table 361 for each train of T_p .

[0082] In the processing 584, a train that is the lowest in priority determined in the processing 583 is determined from among T_p . Hereafter, the train determined in the present processing is referred to as T_d .

[0083] In other words, the train operation simulation device 200 includes the train traveling situation evaluation unit 315 which evaluates the calculated traveling course. The priority storage unit previously stores priority of the train. The train traveling situation evaluation unit 315 detects occurrence of deadlock for the calculated traveling course. In a case where deadlock is detected, the traveling sequence of the train is changed on the basis of the priority of the train.

[0084] A detailed flow of the processing 590 is shown in Fig. 5G. In the processing 590, processing 591, 592, 593, 594, 595, 596, 597 and 598 is executed.

[0085] In the processing 591, the processing 592, 593, 594, 595, 596, 597 and 598 is loop-executed. Here, processing loop is executed for routes obtained by sorting routes controlled by the train Td in order from a distant side of the traveling course of Td. Extraction and sort of routes can be implemented by referring to the "control train" and the "next route ID" in the route information table 363.

[0086] In the processing 592, from among topological relations held by a route that is the loop target in the processing 591, all topological relations that are "Yes" in the "sequence competition" in the topological information table 364 are extracted.

[0087] In a case where any topological relation is not obtained in the processing 592, processing is shifted in the processing 593 to the next loop. In a case where at least one topological relation is obtained, the processing 594 is executed.

[0088] In the processing 594, from among trains Tp concerned in deadlock, a train having at least one route that is in the topological relation obtained in the processing 592 to the route of loop target is acquired.

[0089] In a case where even one topological relation is not obtained in the processing 594, the processing is shifted to the next loop in the processing 595. In a case where at least one topological relation is obtained in the processing 594, the processing 596 is executed.

[0090] In the processing 596, new records are added to the sequence information table 365. As for added records, the topological relation obtained in the processing 593 is stored in the "topological ID," the train obtained in the processing 595 is stored in the "preference train," and Tb is stored in the "no reference train."

[0091] In the processing 597, it is determined whether records corresponding to all trains in Tp have been added to the sequence information table 365 in the processing 591. In a case where there is an unprocessed train, processing is shifted to the next loop. In a case where record addition has been conducted for all trains, the processing 598 is executed.

[0092] In the processing 598, time when Tb has controlled the route that is the target of the loop at the present time is acquired by referring to the simulation log 372. The obtained time is stored in a temporary area in a memory or the like. By the way, at the time obtained in the present processing, deadlock among the train group Tp has not yet occurred. In a case where records newly added to the sequence information table 365 in the processing 591 are used and simulation is re-executed from the time, deadlock among Tp does not occur.

[0093] The processing 590 is finished as described heretofore. Referring back to Fig. 5D, the processing 585 will now be described.

[0094] In the processing 585, the earliest time In the processing 585, the earliest time In the processing 585,

the earliest time is calculated from among time points obtained in the processing 598 in the repeated processing 582.

[0095] In the processing 586, stored values in various tables at the time calculated from the simulation log 372 in the processing 585 are reconstructed. Here, various tables are the weather-disaster information table 351, the human flow information table 352, the train information table 361, the facility information table 362, the route information table 363 and the train traveling actual result 371. The topological information table 364 is constants, and is not rewritten by simulation. Therefore, it is not necessary to reconstruct the topological information table 364. Furthermore, as for the sequence information table, reconstruction is not conducted and contents obtained in the processing 590 of the present time period are taken over intact.

[0096] According to the present embodiment, it becomes possible to cause trains to travel without causing deadlock even in a situation in which timetable information such as time and sequence of trains is not determined as described heretofore. Simple and rapid train operation simulation can be implemented. Furthermore, operation simulation at the time of, for example, a disaster can be executed without conducting troublesome timetable changes. Therefore, it is possible to easily execute maintenance capability measurement of train operation service, prediction of risk potentials, establishing countermeasures against a disaster, and measurement of countermeasure effects. In addition, train operation possibility at the time of disaster can be largely improved by connecting the present simulator to the planning system 110 and using the train traveling actual result generated by the present simulator as timetable when an unexpected situation has occurred.

[0097] By the way, the present invention is not restricted to the described embodiment. A change can be made suitably without departing from the spirit of the present invention.

[0098] It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

[0099] Embodiments of the invention are also specified in the following paragraphs.

1. A train operation simulation device (200) comprising:

a facility information storage unit (362) for storing facility information concerning train facilities;
a train information storage unit (361) for storing train information including on-rail positions of trains;
an environmental information update unit (311) for acquiring environmental information; and

a train traveling course update unit (313) for updating the facility information and the train information on the basis of the environmental information and calculating a traveling course of a train.

2. The train operation simulation device (200) according to paragraph 1, wherein the train traveling course update unit (313) calculates a railroad track interrupted range in which a railroad track is interrupted, on the basis of the environmental information and the facility information, determines trains relating to the railroad track interrupted range to be trains to be changed in traveling course, and updates traveling courses.

3. The train operation simulation device (200) according to paragraph 2, further comprising a priority storage unit for previously storing a traveling railroad track given priority, wherein

in a case where a plurality of the traveling courses are calculated, the train traveling course update unit (313) selects a course that is the shortest in sum total of lengths of routes each having a direction that does not coincide with a preference direction of a railroad track existing at an exit point of the route.

4. The train operation simulation device (200) according to paragraph 3, further comprising a train traveling situation evaluation unit (315) to evaluate the calculated traveling course, wherein

the priority storage unit previously stores priorities of trains as well, and

the train traveling situation evaluation unit detects occurrence of deadlock with respect to the calculated traveling course, and in a case where occurrence of the deadlock is detected, the train traveling situation evaluation unit changes traveling sequence of trains on the basis of the priorities of trains.

Claims

1. A train operation control system comprising:

a planning system (110) for transmitting facility information concerning train facilities and train information including on-rail positions of trains to a train operation simulation device;

an external device for transmitting environmental information concerning environment of a train to the train operation simulation device; and the train operation simulation device (200), the train operation simulation device (200) comprising:

a facility information storage unit (362) for storing the facility information acquired from

the planning system;

a train information storage unit (361) for storing the train information acquired from the planning system;

an environmental information update unit (311) for updating the environmental information acquired from the external device; and

a train traveling course update unit (313) for updating the facility information and the train information on the basis of the environmental information and calculating a traveling course of a train.

2. The train operation control system according to claim 1, wherein the train traveling course update unit (313) in the train operation simulation device (200) calculates a railroad track interrupted range in which a railroad track is interrupted, on the basis of the environmental information and the facility information, determines trains relating to the railroad track interrupted range to be trains to be changed in traveling course, and updates traveling courses.

3. The train operation control system according to claim 2, wherein the train operation simulation device (200) further comprises a priority storage unit for previously storing a traveling railroad track given priority, and in a case where a plurality of the traveling courses are calculated, the train traveling course update unit (313) selects a course that is the shortest in sum total of lengths of routes each having a direction that does not coincide with a preference direction of a railroad track existing at an exit point of the route.

4. The train operation control system according to claim 2, wherein the train operation simulation device (200) further includes a train traveling situation evaluation unit (315) to evaluate the calculated traveling course, the priority storage unit previously stores priorities of trains as well, and the train traveling situation evaluation unit detects occurrence of deadlock with respect to the calculated traveling course, and in a case where occurrence of the deadlock is detected, the train traveling situation evaluation unit changes traveling sequence of trains on the basis of the priorities of trains.

5. A train operation simulation method executed by a train operation simulation device (200), storing facility information concerning train facilities; storing train information including on-rail positions of trains; acquiring environmental information; and updating the facility information and the train information on the basis of the environmental information

and calculating a traveling course of a train.

6. The train operation simulation method according to claim 5, wherein the train operation simulation device (200) calculates a railroad track interrupted range in which a railroad track is interrupted, on the basis of the environmental information and the facility information, determines trains relating to the railroad track interrupted range to be trains to be changed in traveling course, and updates traveling courses.
7. The train operation simulation method according to claim 6, comprising:
- previously storing a traveling railroad track given priority; and
in a case where a plurality of the traveling courses are calculated, selecting a course that is the shortest in sum total of lengths of routes each having a direction that does not coincide with a preference direction of a railroad track existing at an exit point of the route.
8. The train operation simulation method according to claim 7, comprising:
- evaluating the calculated traveling course;
previously storing priorities of trains as well; and
detecting occurrence of deadlock with respect to the calculated traveling course, and in a case where occurrence of the deadlock is detected, changing traveling sequence of trains on the basis of the priorities of trains.

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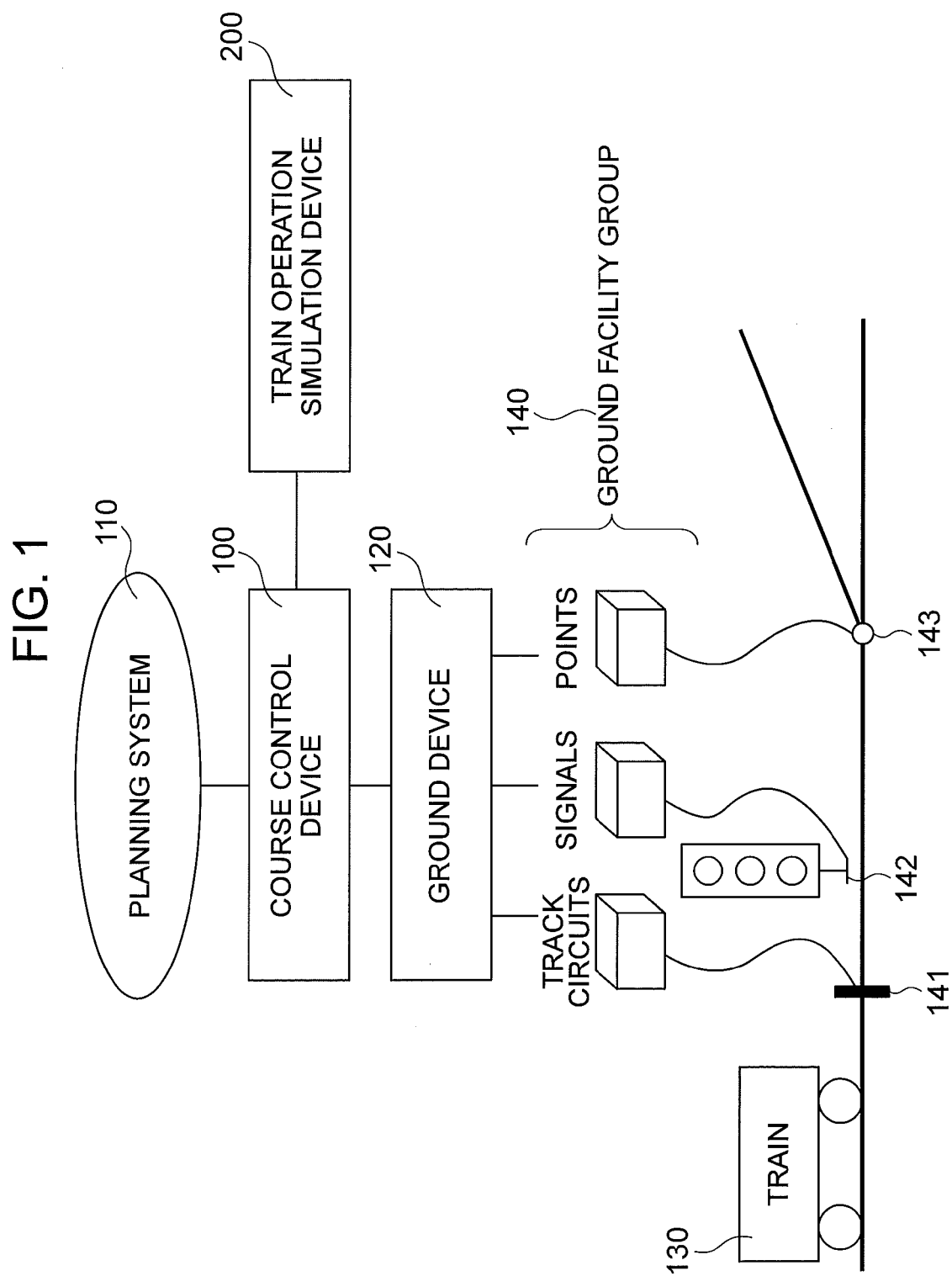


FIG. 2

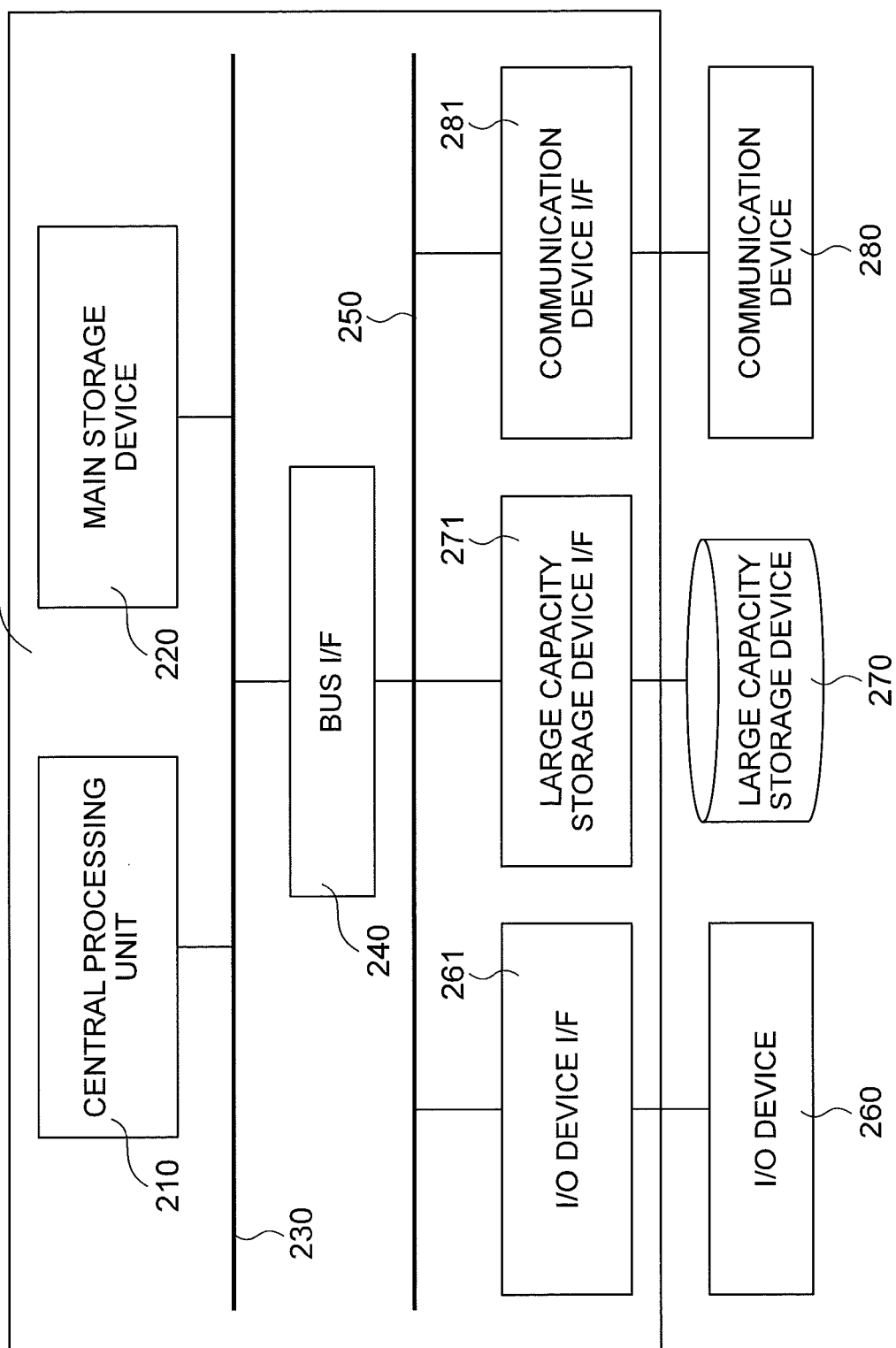


FIG. 3

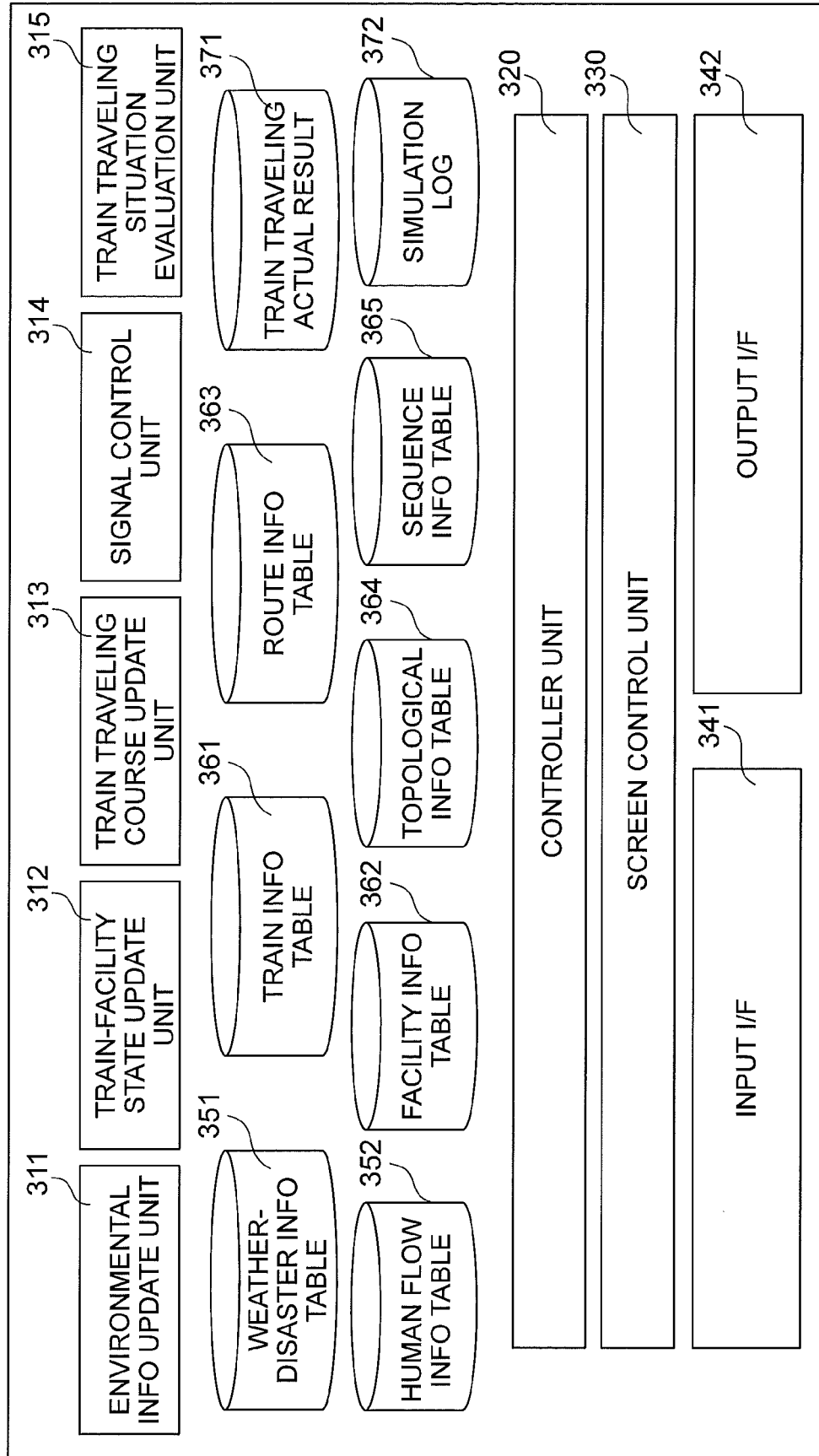


FIG. 4A

WEATHER-DISASTER INFO TABLE

351

ROUTE ID	WIND VELOCITY	RAINFALL	FALL OF ROCK
Block_#1	5.4m/s	0mm	NONE
Block_#2	15.2m/s	0mm	NONE
...	...	...	...

FIG. 4B

HUMAN FLOW INFO TABLE

352

STATION NAME	PASSENGER INFO
Station_#1	FOR Station_#2: 12 PERSONS FOR Station_#3: 21 PERSONS ...
Station_#2	FOR Station_#3: 15 PERSONS FOR Station_#4: 33 PERSONS ...
...	...

FIG. 4C

361

TRAIN ID	LENGTH	TRAIN CLASSIFICATION	ON-RAIL ROUTE	ON-RAIL POSITION	PASSENGER INFO	DESTINATION	TRANSIT STATION	TRANSIT ROUTE	COURSE CHANGE TARGET TRAIN
Train_#1	120m	LIMITED EXPRESS	Block_#5	37m	FOR Station_#1: 52 PERSONS FOR Station_#2: 95 PERSONS ...	Station_#10	Station_#1 Station_#2 ...	Block_#3 Block_#5 ...	No
Train_#2	80m	LOCAL TRAIN	Block_#6	120m	FOR Station_#2: 21 PERSONS FOR Station_#3: 44 PERSONS ...	Station_#5	Station_#2 Station_#3 ...	Block_#4 Block_#6 ...	Yes
...	...	...	...	...	...	...	...	...	...

FIG. 4D

FACILITY INFO TABLE

FACILITY ID	FACILITY STATE	STATE DURATION
Signal_#1	STOP INDICATION	15s
TrackCircuit_#1	OCCUPIED	4s
...	...	...

362

FIG. 4E

363

ROUTE INFO TABLE										
ROUTE ID	STATION	PLATFORM	NEXT ROUTE ID	LENGTH	SIGNAL	TRACK CIRCUIT	PRIORITY	PASSING POSSIBLE	UNDER CONTROL TRIAL	CONTROL TRAIN
Block_#1	-	-	Block_#2 Block_#3	625m	Signal_#1	TrackCircuit_#1:200m TrackCircuit_#2:250m TrackCircuit_#3:175m	PREFERENCE	O	Yes	Train_#1
Block_#2	Station_#1	Platform_#1	Block_#4	340m	Signal_#2	TrackCircuit_#4:340m	NO PREFERENCE	x	No	-
...			...	...		...	...	...	...	...

FIG. 4F

TOPOLOGICAL INFO TABLE

364

TOPOLOGY ID	TOPOLOGY CLASSIFICATION	ROUTE 1 ID	ROUTE 2 ID	SEQUENCE COMPETITION
Topology_#1	(6) END POINT SINGLE BLOCKADE B	Block_#1	Block_#2	Yes
Topology_#2	(19) END POINT BOTH BLOCKADE B	Block_#1	Block_#3	Yes
Topology_#3	(12): FORWARD CONNECTION	Block_#2	Block_#4	No
...	...	...	...	...

FIG. 4G

SEQUENCE INFO TABLE

365

TOPOLOGY ID	PREFERENCE TRAIN	NO PREFERENCE TRAIN
Topology_#1	Train_#5	Train_#6
Topology_#1	Train_#7	Train_#6
Topology_#2	Train_#8	Train_#9
...	...	...

FIG. 5A

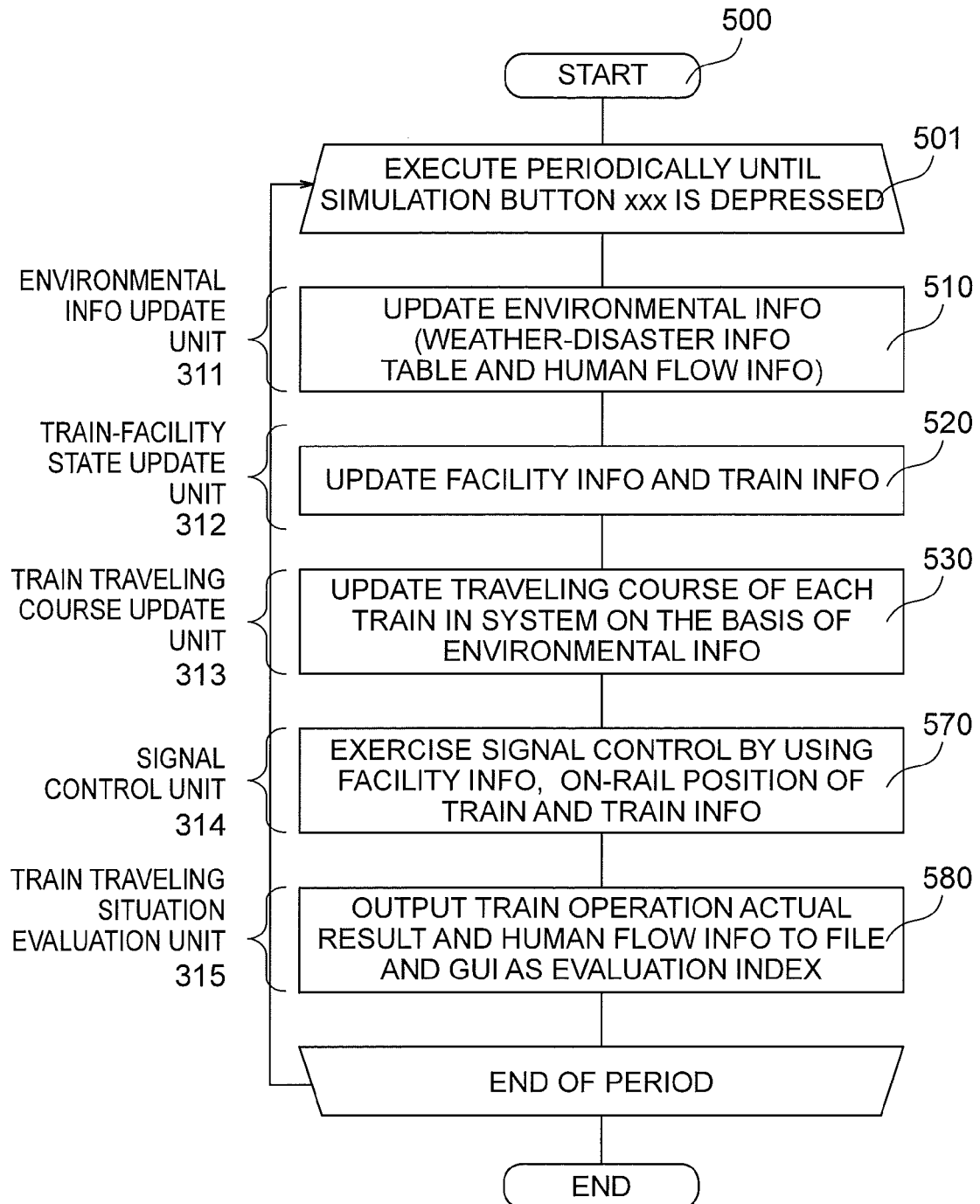


FIG. 5B

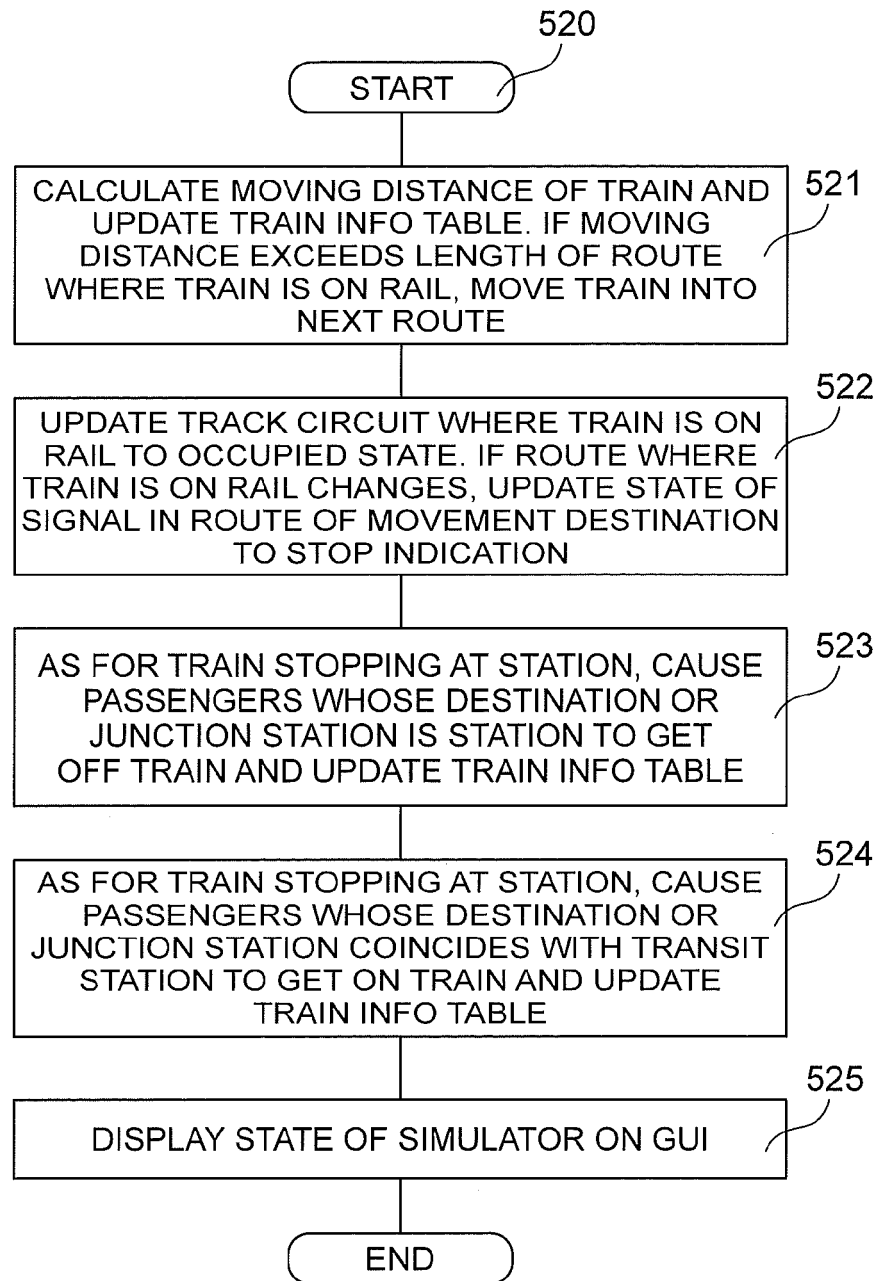


FIG. 5C

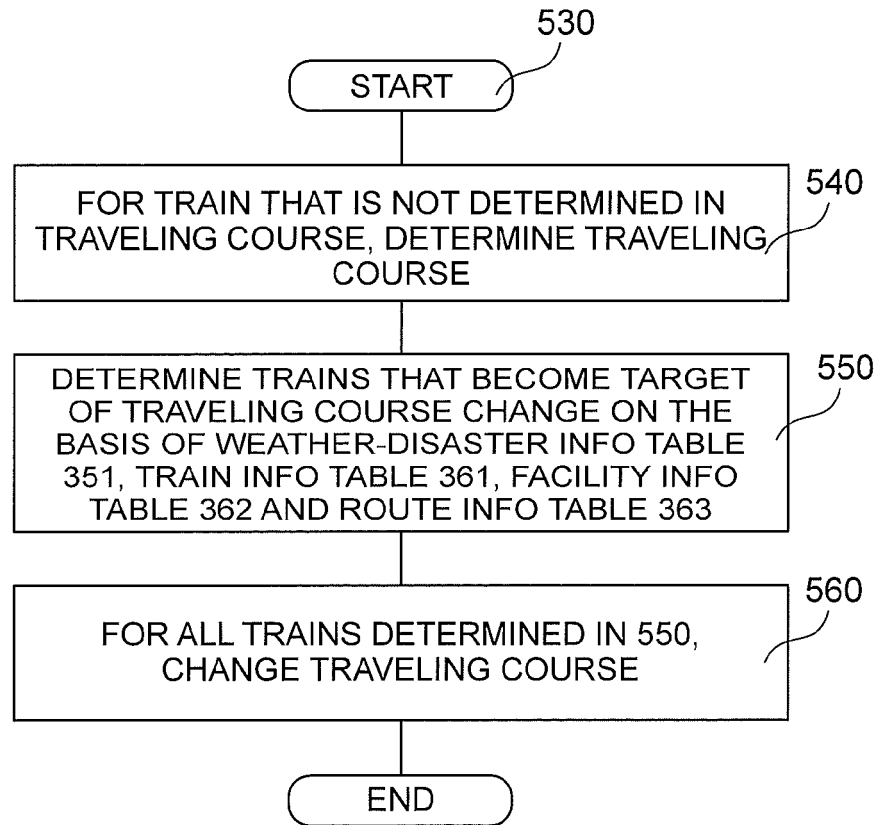


FIG. 5D

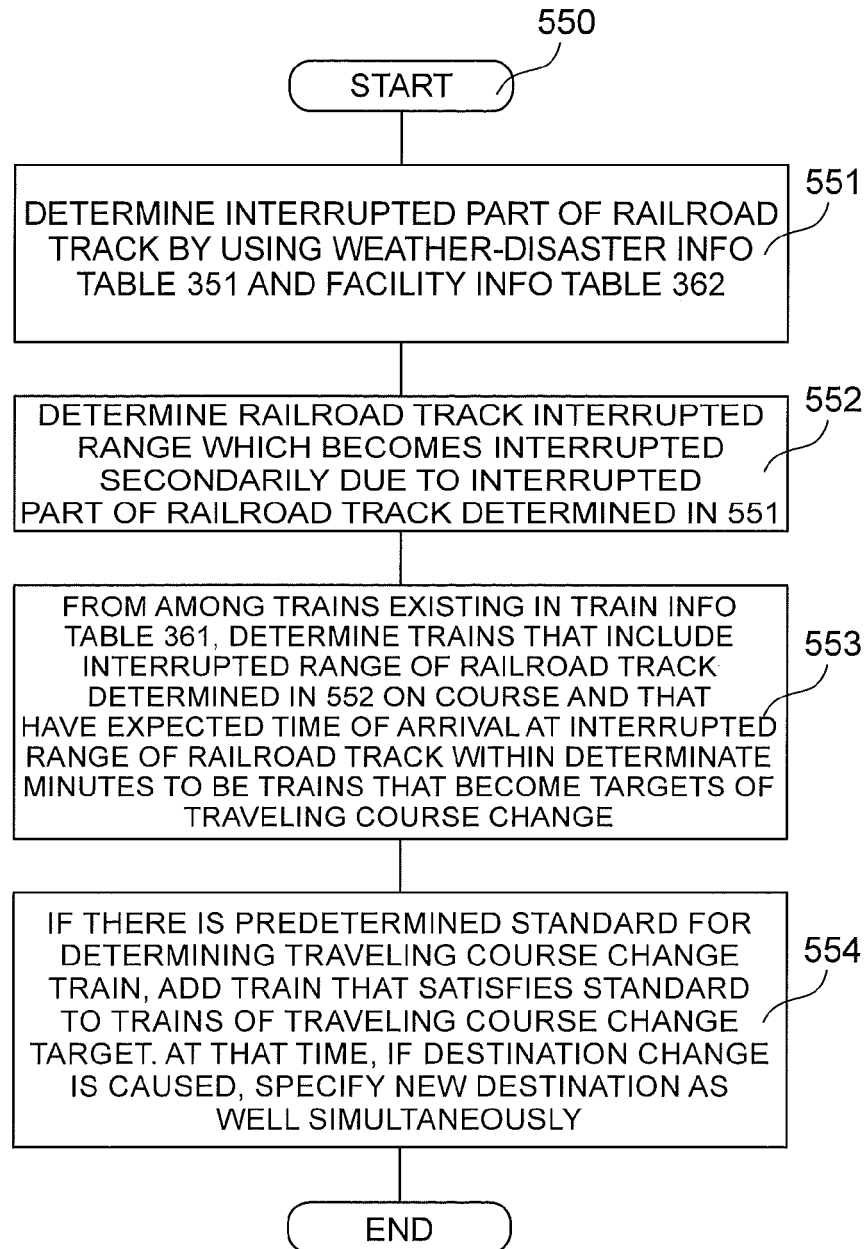


FIG. 5E

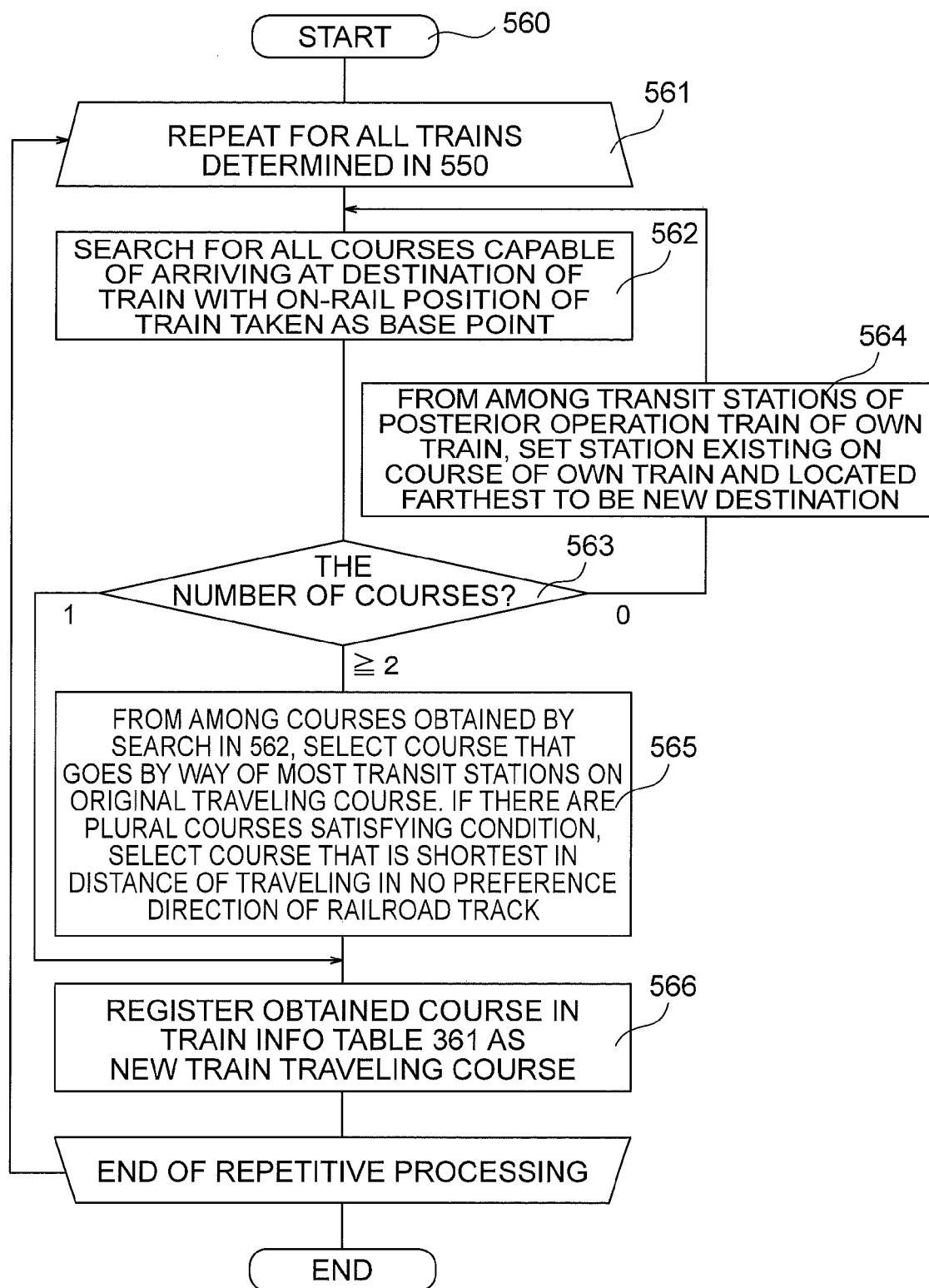


FIG. 5F

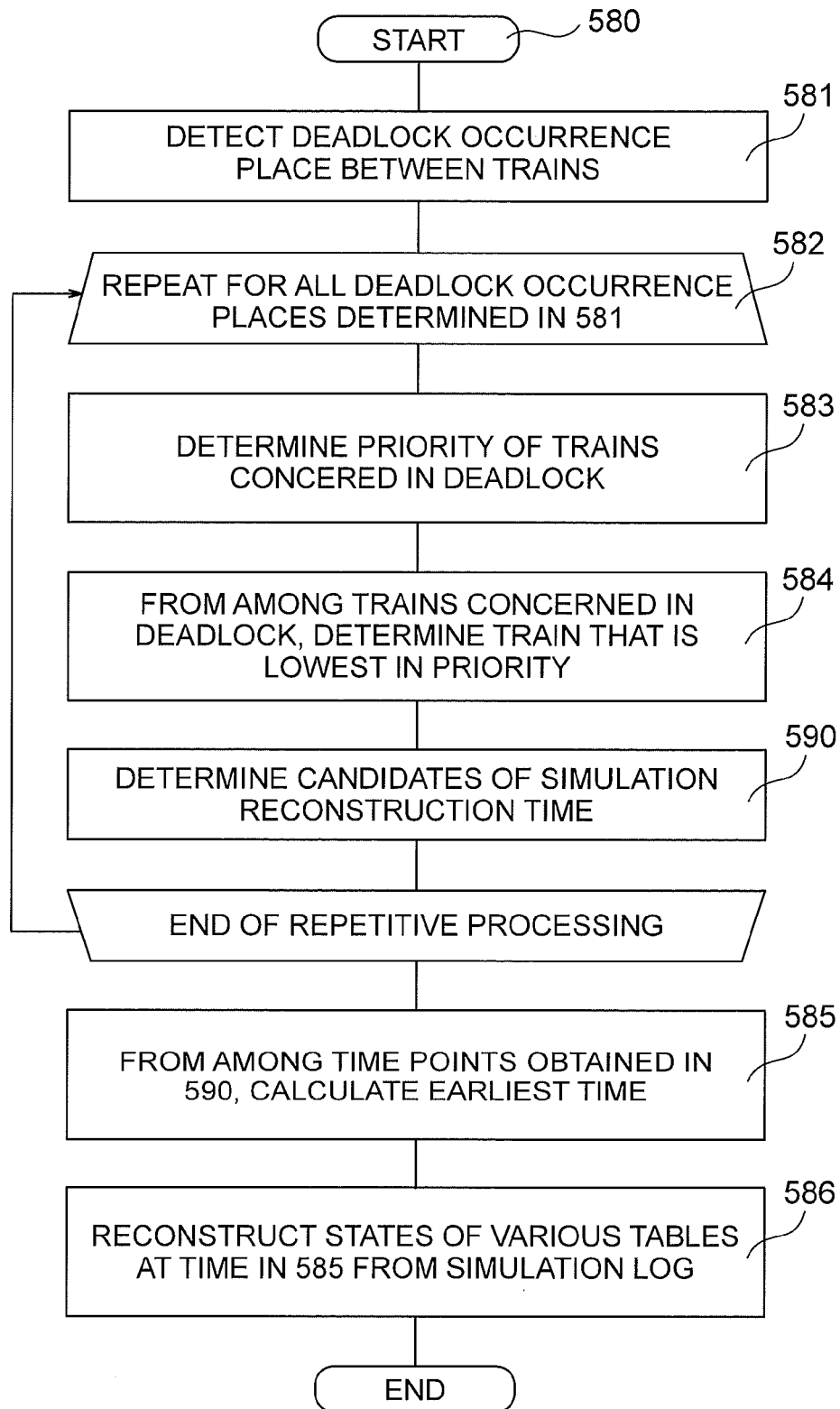


FIG. 5G

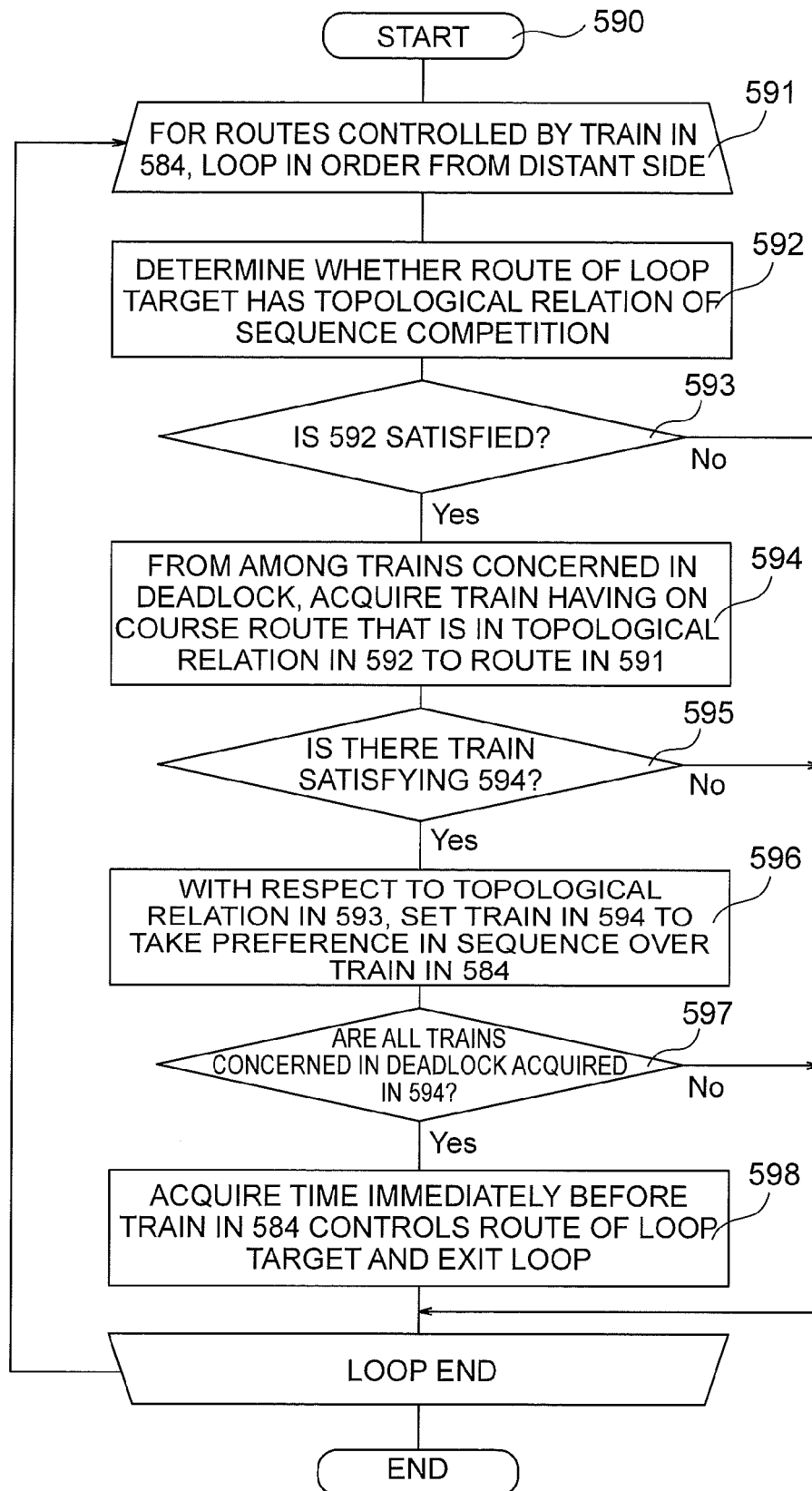
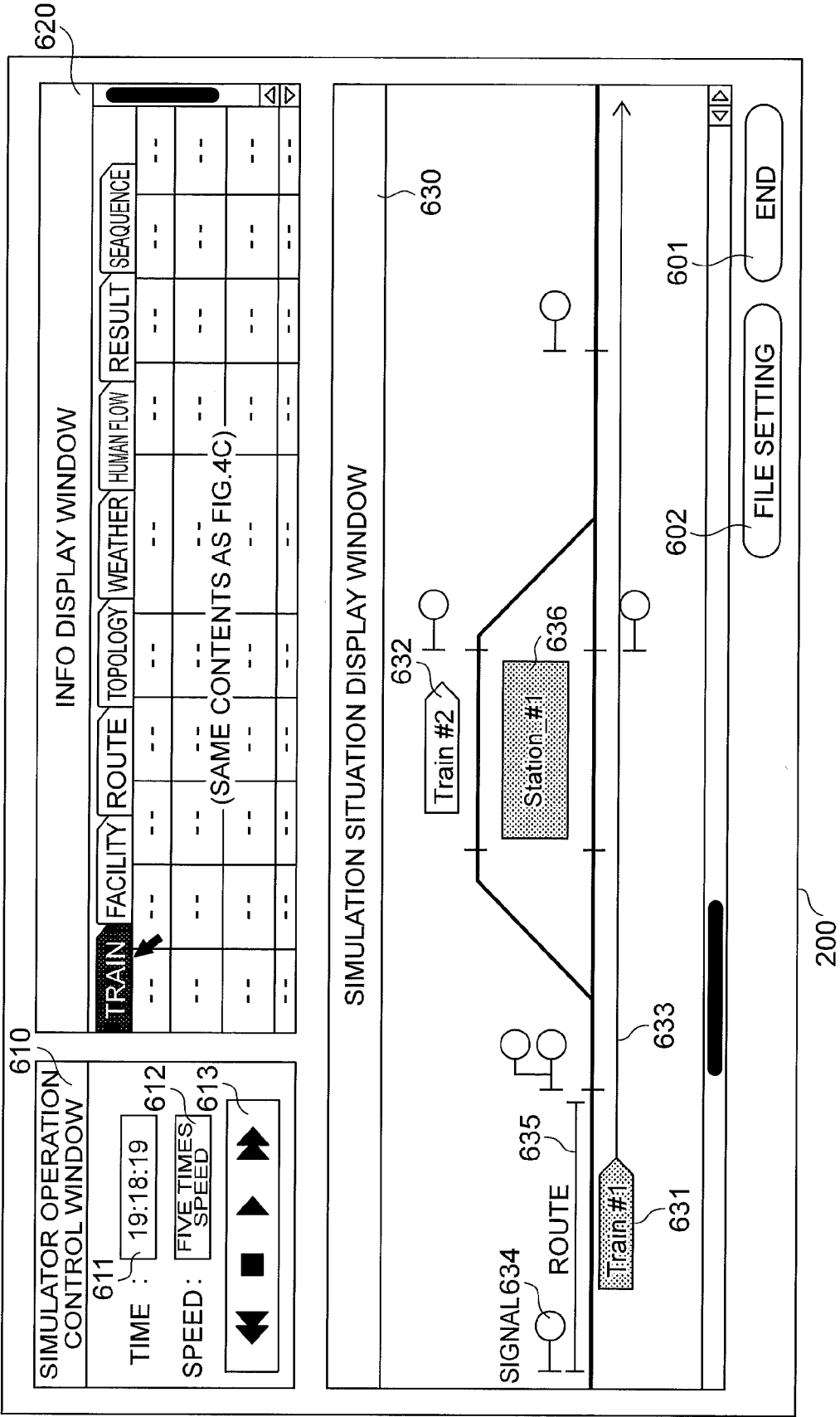


FIG. 6



REFERENCES CITED IN THE DESCRIPTION

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