



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.05.2014 Bulletin 2014/21

(51) Int Cl.:
B61L 15/00 (2006.01) **B61L 27/00** (2006.01)
B61L 3/00 (2006.01) **B61L 25/02** (2006.01)

(21) Application number: **13191851.8**

(22) Date of filing: **07.11.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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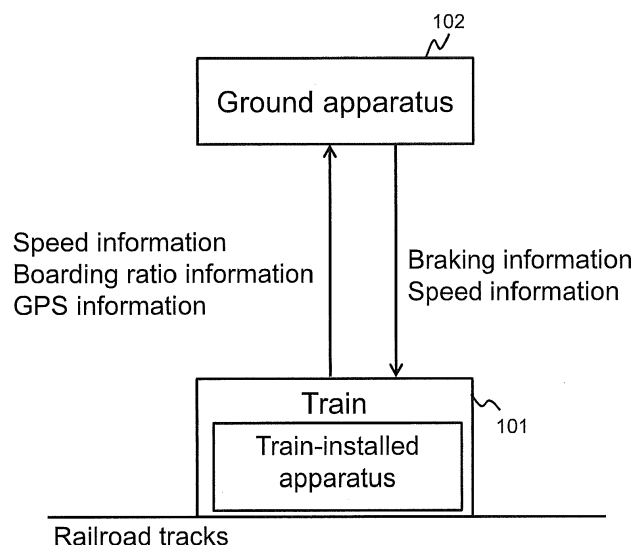
(30) Priority: **19.11.2012 JP 2012252853**

(54) **Operations-related information display system and method using real-time train traveling information**

(57) As a system for notifying a train operator of support information for operating a train 101 according to a schedule, there is technology for supporting train operations by displaying the location and speed of the train 101 on a running curve that accords with the operations schedule of the train 101. However, the prior art does not take into account displaying, in real-time, operations support information to the operator. Therefore, technology for processing ever-changing train traveling information,

and creating and displaying in real-time operations support information has not been disclosed. Hence, the present invention transmits onboard information in real-time from a train 101 to a ground apparatus 102. The ground apparatus 102 is configured to perform computations by merging the onboard information with ground information, to calculate optimum operating conditions, and to display this information on a monitor 113 for the operator via a network 105.

Fig. 1



Description

BACKGROUND

[0001] The present invention generally relates to an operations support system that makes use of real-time train traveling information, and more particularly, to a system for communicating the optimum operating method to a train operator using real-time information.

[0002] A railroad vehicle operator is not able to ascertain the passenger boarding ratio of the train carriages during operation or the relative positions of a preceding or following train while traveling. Thus, proper operation in compliance with a timetable depends in large part on the experience and skill of the operator. Japanese Patent Application Publication No. 2009-29234 discloses technology for using traveling information of a train. Japanese Patent Application Publication No. 2009-29234 discloses technology for supporting train operations by displaying the location and speed of one's own train on a running curve that accords with the train's operations schedule.

SUMMARY

[0003] However, Japanese Patent Application Publication No. 2009-29234 does not disclose the timing for calculating the traveling location and speed of one's own train. Thus, the display in real-time of operations support information to be communicated to the operator is not taken into account. Therefore, technology for processing ever-changing train traveling information, and creating and displaying in real-time operations support information is not disclosed.

[0004] Accordingly, the present invention first transmits onboard information from a railroad vehicle in real-time to the ground. Then, the ground side merges the onboard information with ground information, performs automatic computations, and displays the optimum operating conditions on an operator's seat monitor. The present invention makes good use of information available only onboard the train and information available only on the ground, and tailors this information to the traveling environment in order to communicate the optimum operating conditions to the operator in real-time via a wireless network. The present invention is also able to speed up processing and improve information communication performance by using the traveling conditions to perform determination processes and narrowing down appropriate operating conditions from an existing table.

[0005] According to the present invention, optimum operations that more closely adhere to the timetable are possible by operating in accordance with real-time instructions from the ground. Even when trains are running off schedule, operations that are closest to the original timetable are possible by making determinations in conjunction with the latest schedule information available only on the ground side. In addition, punctual operations that accord with the schedule enable the realization of

more precise operations by reducing extra time allotted for service disruptions.

[0006] According to the present invention an operations-related information display method can be provided for displaying information related to operations on the basis of train traveling information, the method can comprise:

a traveling information transmission step of transmitting sequentially train traveling information to a server, which is not installed in the train, via a network at a timing at which the traveling information is acquired;

an operations-related information creation step of creating, in the server, information related to train operations from the traveling information; and/or an operations-related information transmission step of transmitting the created operations-related information to the train.

According to the present invention an operations-related information display system can be provided for displaying information related to operations on the basis of train traveling information by using a train-installed apparatus and a ground apparatus,

the train-installed apparatus can comprise:

a traveling information transmission processor configured to sequentially transmit the traveling information to a server, which is not installed in the train, via a network at a timing at which the traveling information is acquired; and

a display unit configured to display support information transmitted from the ground apparatus, and

the ground apparatus can comprise:

a train information computation unit configured to create information related to the operations of the train from the traveling information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

FIG. 1 is a schematic diagram of an operations support system;

FIG. 2 is a drawing of the hardware configurations of a train-installed apparatus and a ground apparatus;

FIG. 3 is an example of a latest train schedule table;

FIG. 4 is an example of a boarding ratio table;

FIG. 5 is an example of a table of GPS information;

FIG. 6 is an example of a table of speed information;

FIG. 7 is an example of a table of optimum operating conditions;

FIG. 8 is a flowchart showing processing for the operations support system as a whole;

FIG. 9 is a flowchart showing computational processing for determining the distance between traveling trains;

FIG. 10 is a flowchart showing the processing for determining the optimum operating conditions when there are no changes to the timetable; and

FIG. 11 is a flowchart showing the processing for determining the optimum operating conditions when there has been a change to the timetable.

DETAILED DESCRIPTION

[Embodiment 1]

[0008] An aspect of this embodiment will be described hereinbelow using the drawings.

[0009] FIG. 1 is a schematic diagram of an operations support system. A traveling train 101 continuously transmits speed information, boarding ratio information, and GPS information in real-time to a ground apparatus 102. Here, real-time means sequentially transmitting information to the ground apparatus 102 at a timing at which the train-installed apparatus acquires the train traveling information from various devices of the train (sensors and the like).

[0010] The ground apparatus 102 is configured to perform determination processing by combining the onboard information with information available only on the ground side, calculating the optimum operating conditions (speed information, braking information) and returning this information to the train 101. It is supposed that the onboard information and the results of the ground determination are transmitted and received via an existing 3G network or wireless link. Furthermore, in this embodiment, it is assumed that the real-time communications are performed in units of hundreds of milliseconds, but the present invention is not limited thereto. According to this embodiment, optimum operating conditions in accordance with the latest traveling situation are instructed in real-time to the train, thereby making it possible for the operator to quickly ascertain the situation and implement an operation closer to the optimum operation. Each operator has his own operating habits, but continuously issuing operating instructions from the ground side makes it possible to achieve uniform operations.

[0011] FIG. 2 is an example of the hardware configurations of the equipment required in this embodiment. Simple configurations formed of the train-installed apparatus and the ground apparatus enable the rapid processing and communication of information. First, a description of the configuration of the train-installed apparatus 103 will be given. The train-installed apparatus 103 has a train information unit 104, and an operator's seat display device 113. The train information unit 104 is a device having a CPU, and comprises a train information collection function for collecting the train information, a train information packing unit for packing the train information, and a train information transmitting function for transmit-

ting the train information to the ground side. The processing involved in these functions will be described in detail using FIG. 8. The operator's seat display device 113 is configured to display operating instructions to the operator.

[0012] Next, the configuration of the ground apparatus 102 will be described. The ground apparatus 102 has a train information transceiving unit 106 for transmitting and receiving data to and from the train-installed apparatus 103, a DB group for storing information received from the train-installed apparatus 103 (a latest schedule DB 107, a boarding ratio DB 108, a GPS DB 109, a speed DB 110, and an optimum operating conditions DB 111), and a train information computation unit 112 for extracting information from the DBs and computing the optimum operating conditions. The train information computation unit 112 is a device having a CPU, and possesses a distance-between-vehicles computation function for using position information stored in the GPS DB 109 to compute the distance between trains, and an optimum speed computation function for using the latest schedule DB 107, the boarding ratio DB 108, the speed DB 110, and the optimum operating conditions DB 111 to calculate the optimum speed. Each method of computation will be described in detail using FIG. 8. Next, the flow of data will be described. The information collected by the train information unit 104 is transmitted to the train information transceiving unit 106 via a network apparatus 105 such as a 3G or a wireless LAN, and stored in the DB group (latest schedule DB 107, boarding ratio DB 108, GPS DB 109, speed DB 110). The results obtained by the train information computation unit 112 processing the stored information are once again transmitted to the train-installed apparatus 103 via the train information transceiving unit 106 and the network apparatus 105, and displayed on the operator's seat display device 113. Ground-onboard communications can be via a 3G or via a wireless LAN, and can be switched automatically depending on the traveling location and situation (inside a tunnel) of the train, making reliable communication possible under all sorts of situations and enabling operating instructions to be issued in a continuous manner. The optimum speed computation is calculated using a stored pattern table, and as such, processing is completed quickly without the need to perform a complicated computation process.

[0013] FIG. 3 is an example of the latest schedule table needed to compute the optimum operating conditions. The latest schedule information at the time of a schedule change due to an accident or a malfunction is stored in this table. This table comprises train number information, which is the train identifier, route information showing the route the train takes, identifier information on each station, and information on the arrival/departure times at these stations. Arrival times are not shown in the drawing for the intermediate stations, but arrival time information may be stored in the table. This table maintains the latest information by being updated each time the schedule

changes. The latest schedule information is not known on the train side, and therefore plays an important role in this embodiment.

[0014] FIG. 4 is an example of a boarding ratio table. Boarding ratio information obtained when each train stops at a station is stored in this table. Using the boarding ratio to change the way braking is performed makes it possible to achieve eco-operations that consume less energy. The boarding ratio calculation may be determined from the overall weight of the train including the passengers, or may be determined using various sensors disposed inside the train.

[0015] FIG. 5 is an example of a GPS information table. This example is one in which train position information is stored at fixed periods of time. However, because of the need for cautious control of the distances between trains during rush periods when headway becomes tight, the GPS device sequentially writes GPS information to the GPS table and sequentially transmits this information to the ground apparatus at the shortest cycle, thereby making it possible to react in real-time to instructed operating conditions. This enables operations support even when operations are being carried out under extremely tight conditions.

[0016] FIG. 6 is an example of a speed table. This example is one in which the train speed is stored at fixed periods of time. The speed information in this table prescribes the optimum speed at the time. The displaying of ever-changing speed information is essential to operations support.

[0017] FIG. 7 is an example of an optimum operating conditions table. This table associates various conditions with information for optimum operations under these conditions. Based on this table, it is possible to extract the optimum operating conditions by refining the conditions. In the optimum operating conditions column, S stands for speed and B stands for braking. In this table, braking is only ON or OFF, but when the brakes are applied in multiple stages, a record may be created in this table for each stage.

[0018] FIG. 8 is the overall processing of this embodiment. First, onboard real-time speed information, boarding ratio information, and GPS information is collected in accordance with an onboard information collection process (S0001). In a collected information packing process (S0002), the collected information is packed into a format for transmission to the ground side. Next, the packed information is transmitted to the ground side via a 3G or wireless network in accordance with a train information transmission process (S0003). A traveling train generates an enormous amount of information, and packing this information prior to transmitting the information to the ground enables more rapid processing. Packing is a process for minimizing data size and compressing the data into a transmittable format by extracting, from among an enormous amount of binary data, the portions of data needed for subsequent processing, and/or the portions in which data are actually contained or portions

for which the data has changed (and discarding the rest).

[0019] The processing up to this point is performed by the train information unit 104 in FIG. 2. The transmitted information is received by the train information transceiving unit 106 (S0004) in FIG. 2 and stored in the respective tables (S0005). Next, information required for performing a distance-between-trains computation, a schedule change determination, a static operating conditions computation, and a dynamic operating conditions computation, which are carried out by the train information computation unit 112 of FIG. 2, is extracted from the DB group (S0006). Using the extracted GPS information, first a distance-between-trains computation (S0007) is performed to calculate the distance to the preceding train.

[0020] Thereafter, a determination is made as to whether or not that schedule for that day has been changed due to an accident or a rolling stock malfunction (S0008). This process obtains information on a schedule change by linking up with an operations management system (not shown in the drawings) coupled to the ground apparatus. In a case where the schedule has not changed and train service is operating as usual, a static operating conditions computation process (S0009) is performed to calculate the optimum operating conditions. When the train schedule for the day in question has changed, a dynamic operating conditions computation process (S0010) is performed using the latest updated schedule information in the DB to calculate the optimum operating conditions. The distance-between-trains computation, the static operating conditions computation process, and the dynamic operating conditions computation process will be described in detail using FIGS. 9, 10, and 11, respectively. The processing can be speeded up by performing a computation using a table (optimum speed condition DB 111 of FIG. 2) prepared beforehand when schedule is normal as a separate computation for determining a special case (in this embodiment, the presence or absence of a train schedule change). Next, the optimum operating conditions calculated in accordance with the static operating conditions computation process and the dynamic operating conditions computation process are once again transmitted to the train-installed apparatus 103 from the train information transceiving unit 106 of FIG. 2 (S0011), and displayed on the display device 113 in the operator's seat (S0012).

[0021] FIG. 9 is the detailed processing of the distance-between-trains computation process in FIG. 8. First, GPS information on the vehicle n, which is transmitting the operating instructions, and the preceding railroad vehicle n-1 is acquired from the DB (S0101). The GPS information of the two vehicles is compared (S0102), and the distance between the vehicle and the preceding vehicle is calculated (S0103). Up until now, the distance between trains could not be ascertained in real-time, but this processing makes it possible, enabling even tighter operations during the rush periods.

[0022] FIG. 10 is the detailed processing of the static operating conditions computation process in FIG. 8. In

this process, an optimum operating conditions table like that shown in FIG. 7 is stored in advance to shorten the processing time, and refinements are made in accordance with the traveling conditions and environment to calculate the optimum operating conditions. Processing time can be shortened by starting the condition narrowing down process with railroad vehicle information for which selection conditions, such as type of vehicle and travel route, are limited, and shifting to unique information in each time period, such as the real-time boarding ratio and the traveling location.

[0023] Specifically, first a vehicle type determination process (S0201), a route determination process (S0202), and an inbound/outbound determination process (S0203) are performed. At this point, the current traveling location is determined from the GPS information, and the route situation in the direction of travel (inclines, extent of curves, and so forth) are calculated from the route and inbound/outbound determinations. Next, the processing shifts to real-time information, a distance-between-trains determination process (S0204), a process for determining a discrepancy between the timetable and the current traveling location (S0205), a boarding ratio determination process (S0206), and a traveling location determination process (S0207) are performed, and optimum operating conditions such as "accelerate to 'xxx' kilometers per hour; brakes OFF" are calculated (S0208) as shown in the table in Fig. 7.

[0024] FIG. 11 is the detailed processing of the dynamic operating conditions computation process in FIG. 5. When the train schedule is disrupted by an accident or a rolling stock malfunction, processing branches off to this dynamic optimum operating conditions computation process. First, the latest schedule information acquired from the DB is acquired (S0301), and a distance-between-trains determination process (S0302), a boarding ratio determination process (S0303), and a traveling location determination process (S0304) are performed using the results calculated from the real-time information, and the optimum operating conditions are calculated (S0305). When the schedule gets disrupted, a rapid service correction is required to quickly return operations to normal and not to cause passengers any inconvenience, and by incorporating the latest schedule information available only on the ground side into the computation process, it becomes possible to calculate operating conditions that enable a lag in operations to be alleviated rather quickly.

[0025] Features, components and specific details of the structures of the above-described embodiments may be exchanged or combined to form further embodiments optimized for the respective application. As far as those modifications are apparent for an expert skilled in the art they shall be disclosed implicitly by the above description without specifying explicitly every possible combination.

Claims

1. An operations-related information display method for displaying information related to operations on the basis of train traveling information, the method comprising:
 - a traveling information transmission step of transmitting sequentially train traveling information to a server, which is not installed in the train (101), via a network at a timing at which the traveling information is acquired;
 - an operations-related information creation step of creating, in the server, information related to train operations from the traveling information; and
 - an operations-related information transmission step of transmitting the created operations-related information to the train (101).
2. An operations-related information display method according to claim 1, **characterized in that** the server comprises an operating conditions table in which a traveling state of the train is associated with the information related to operations in the traveling state, and a support information creation step creates the operations-related information from the traveling information and the operating conditions table.
3. An operations-related information display method according to claim 2, **characterized in that** the traveling information includes position information on the train, and the support information creation step identifies a preceding train, which travels preceding to the train (101), from schedule information, calculates a distance between the train and the preceding train from the position information on the preceding train and the position information on/ the train, and creates the operations-related information from the distance between the trains (101) and the operating conditions table.
4. An operations-related information display method according to claim 3, further comprising a step of determining whether or not there has been a change in the schedule.
5. An operations-related information display method according to any of claims 1 through 4, **characterized in that**, in the traveling information transmission step, information acquired from a device of a train (101) is transmitted to the server, which is not installed in the train, after this information is subjected to packing.
6. An operations-related information display system for

displaying information related to operations on the basis of train traveling information by using a train-installed apparatus (103) and a ground apparatus (102),

the train-installed apparatus (103) comprising:

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a traveling information transmission processor configured to sequentially transmit the traveling information to a server, which is not installed in the train (101), via a network at a timing at which the traveling information is acquired; and
a display unit configured to display support information transmitted from the ground apparatus (102), and

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the ground apparatus (102) comprising:

a train information computation unit configured to create information related to the operations of the train (101) from the traveling information.

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7. An operations-related information display system according to claim 6, **characterized in that** the ground apparatus (102) comprises an operating conditions table in which a traveling state of the train (101) is associated with the information related to operations in the traveling state, and the train information computation unit is configured to create the operations-related information from the traveling information and the operating conditions table. 25 30
8. An operations-related information display system according to claim 7, **characterized in that** the traveling information includes position information on the train (101), and the train information computation unit is configured to identify a preceding train, which travels preceding to the train (101), from schedule information, calculate a distance between the train (101) and the preceding train from the position information on the preceding train and the position information on the train (101), and create the train operations-related information from the distance between the trains (101) and the operating conditions table. 35 40 45
9. An operations-related information display system according to claim 8, **characterized in that** the train information computation unit is also configured to perform a process for determining whether or not there has been a change in the schedule. 50
10. An operations-related information display system according to any of claims 6 through 9, **characterized in that** the traveling information transmission processor is configured to acquire the traveling information from a device of a train (101) and transmit the traveling 55

information to the server, which is not installed in the train (101), after subjecting the information to packing.

Fig. 1

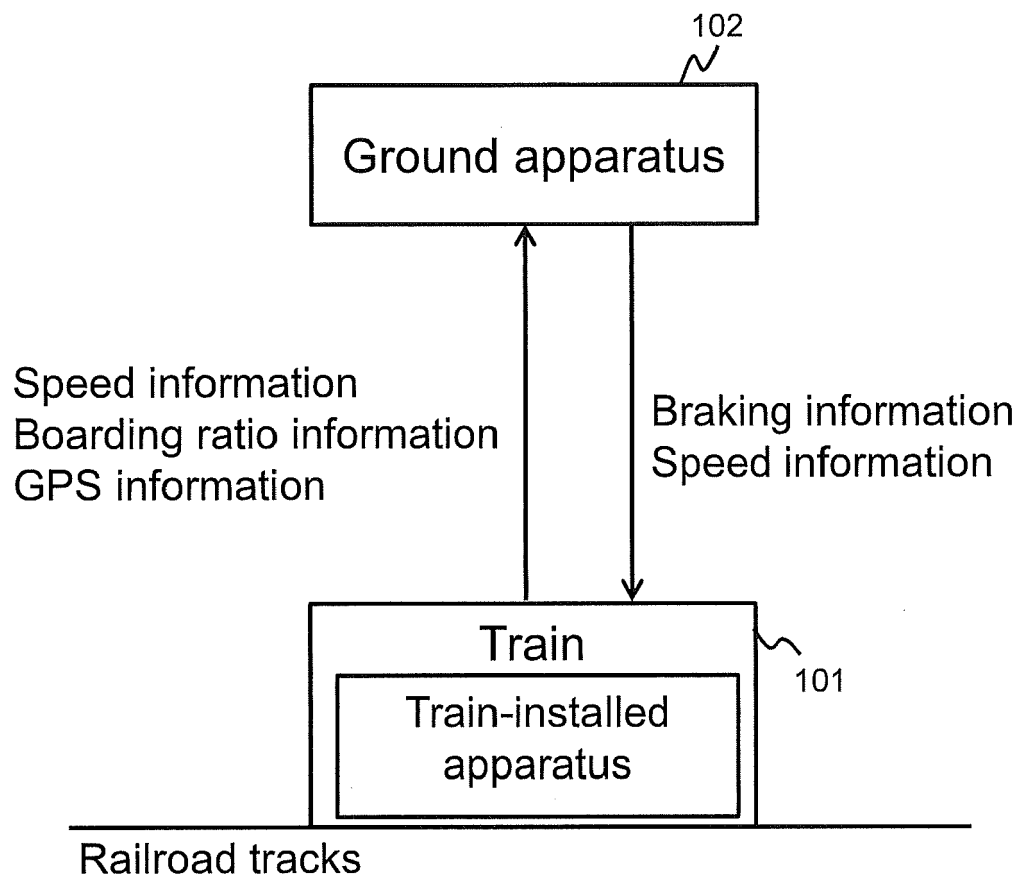


Fig. 2

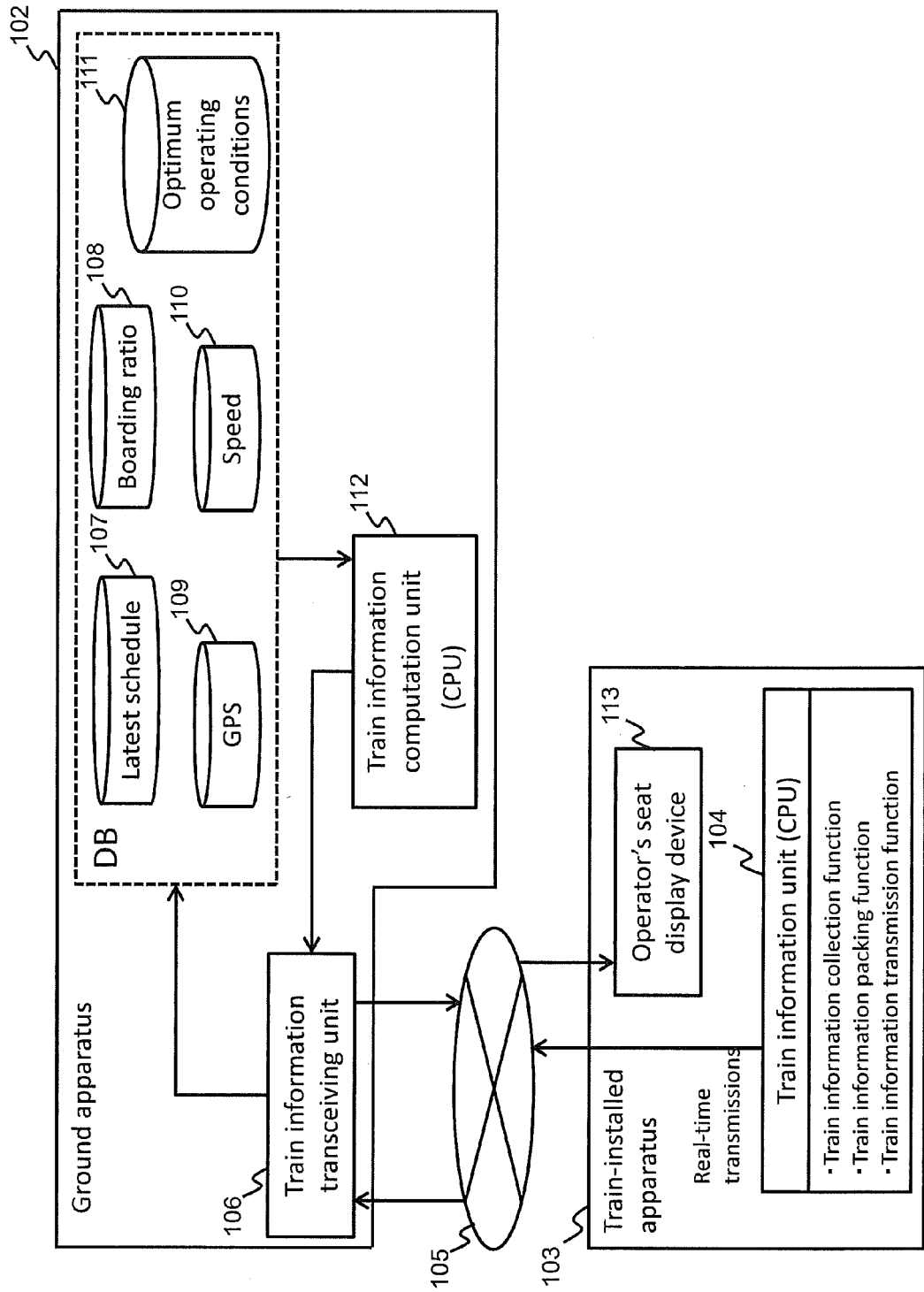


Fig. 3**Latest schedule table**

Train number	Route	Departure station	Departure time	Intermediate station	Departure time	...	Destination station	Arrival time
201	R01	AA	8:21	CC	8:30	...	ZZ	9:12
223	R02	CC	8:23	GG	8:38	...	FF	9:45
438	R03	AA	8:16	PP	8:19	...	KK	9:30
870	R02	ZZ	9:45	AA	9:57	...	QQ	11:20
930	R01	PP	10:24	JJ	10:45	...	LL	11:54

Fig. 4

Boarding ratio table

Train number	Time	Boarding ratio
201	8:12	40%
201	8:15	30%
201	8:35	80%
201	8:40	20%
201	8:48	10%

Fig. 5

GPS table

Train number	Time	Position information
201	8:12:00	36° 44' 55.3" 140° 18' 08.3"
201	8:12:30	38° 37' 50" 140° 45' 10.3"
201	8:13:00	40° 43' 22" 141° 20' 30"
201	8:13:30	38° 42' 45" 133° 24' 08"
201	8:14:00	36° 20' 44.2" 138° 43' 10.3"

Fig. 6

Speed table

Train number	Time	Speed
201	8:12:00	80km/H
201	8:12:30	83km/H
201	8:13:00	86km/H
201	8:13:30	80km/H
201	8:14:00	75km/H

Fig. 7

Optimum operating conditions table

Train type	Route	Inbound/ outbound	Distance between trains	Discrepancy	Boarding ratio	Position information	Optimum operating conditions
A	R01	Inbound	Equal to or less than 100 m	0	30%	Straight	S=120k, B=OFF
A	R01	Inbound	Equal to or less than 100 m	1	40%	Curve 1	S=100k, B=ON
A	R01	Inbound	Equal to or more than 100 m but equal to or less than 200 m	2	50%	Incline	S=80k, B=ON
A	R01	Outbound	Equal to or more than 100 m but equal to or less than 200 m	0	120%	Curve 2	S=120k, B=OFF
A	R01	Outbound	Equal to or less than 100 m	1	140%	Straight	S=50k, B=ON
A	R01	Outbound	Equal to or less than 100 m	2	30%	Curve 1	S=70k, B=OFF
A	R02	Inbound	Equal to or more than 100 m but equal to or less than 200 m	0	40%	Incline	S=160k, B=OFF
A	R02	Inbound	Equal to or more than 100 m but equal to or less than 200 m	1	50%	Curve 2	S=120k, B=ON
A	R02	Inbound	Equal to or less than 100 m	2	120%	Straight	S=40k, B=OFF
A	R02	Outbound	Equal to or less than 100 m	0	140%	Curve 1	S=100k, B=ON
A	R02	Outbound	Equal to or more than 100 m but equal to or less than 200 m	1	50%	Incline	S=70k, B=OFF
A	R02	Outbound	Equal to or more than 100 m but equal to or less than 200 m	2	120%	Curve 2	S=60k, B=ON
B	R01	Inbound	Equal to or less than 100 m	0	140%	Incline	S=80k, B=OFF

Fig. 8

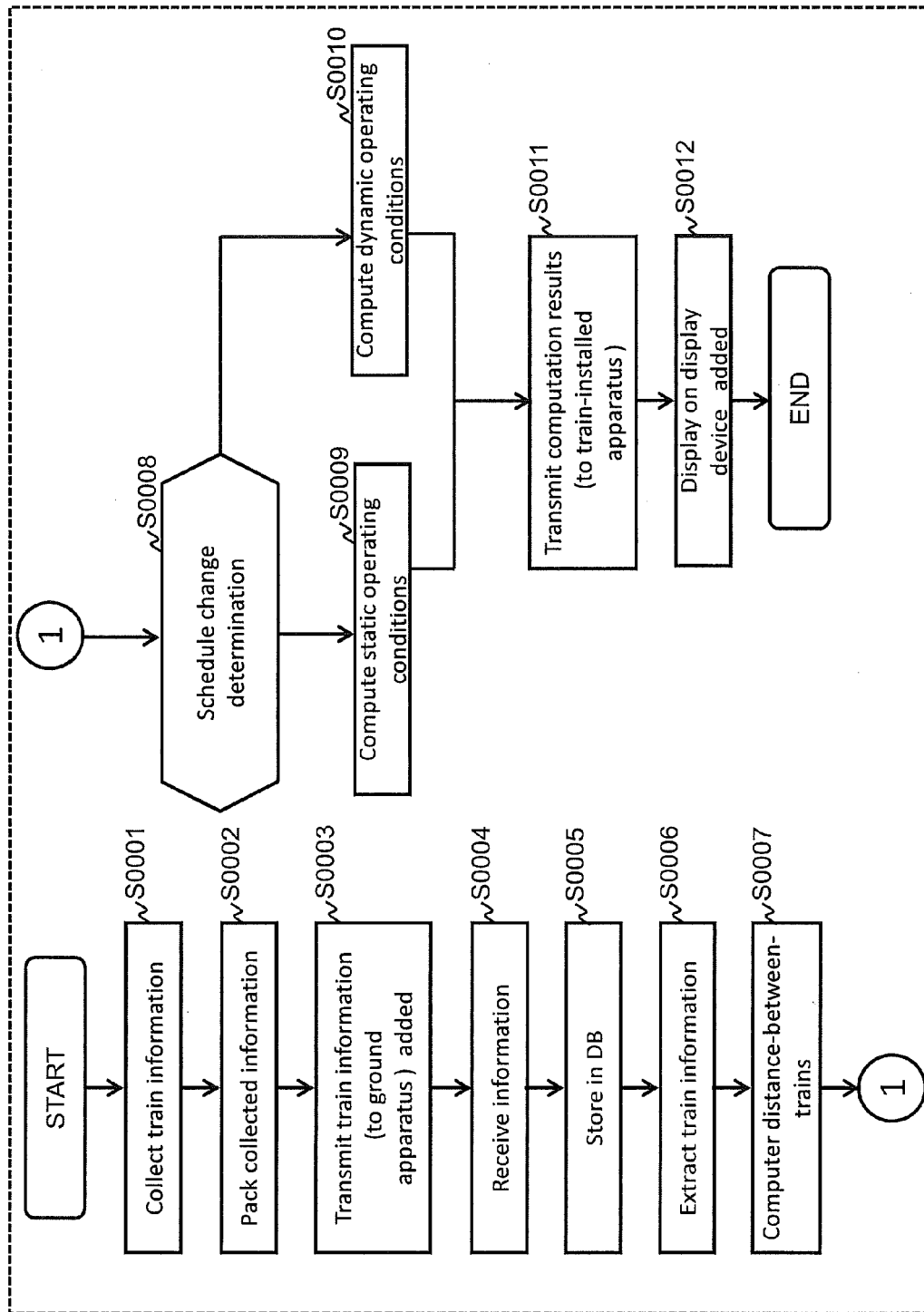


Fig. 9

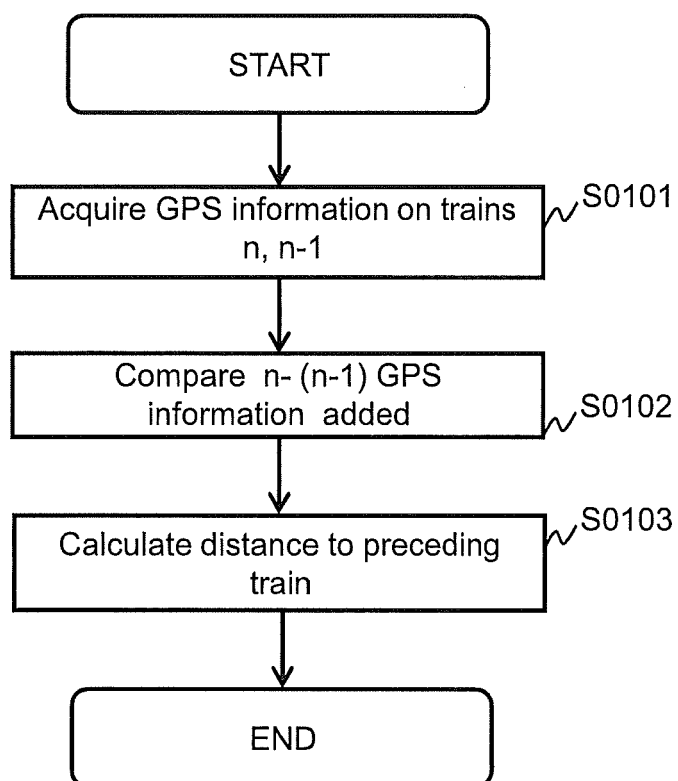


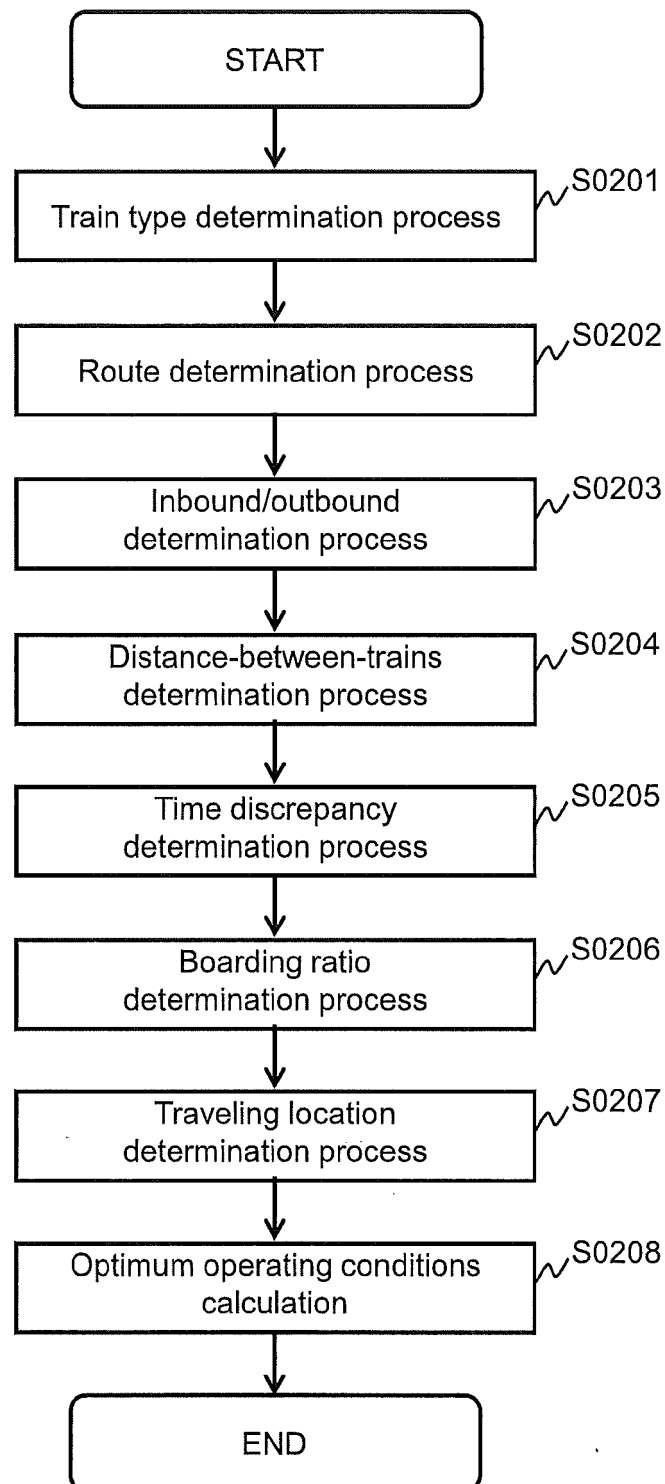
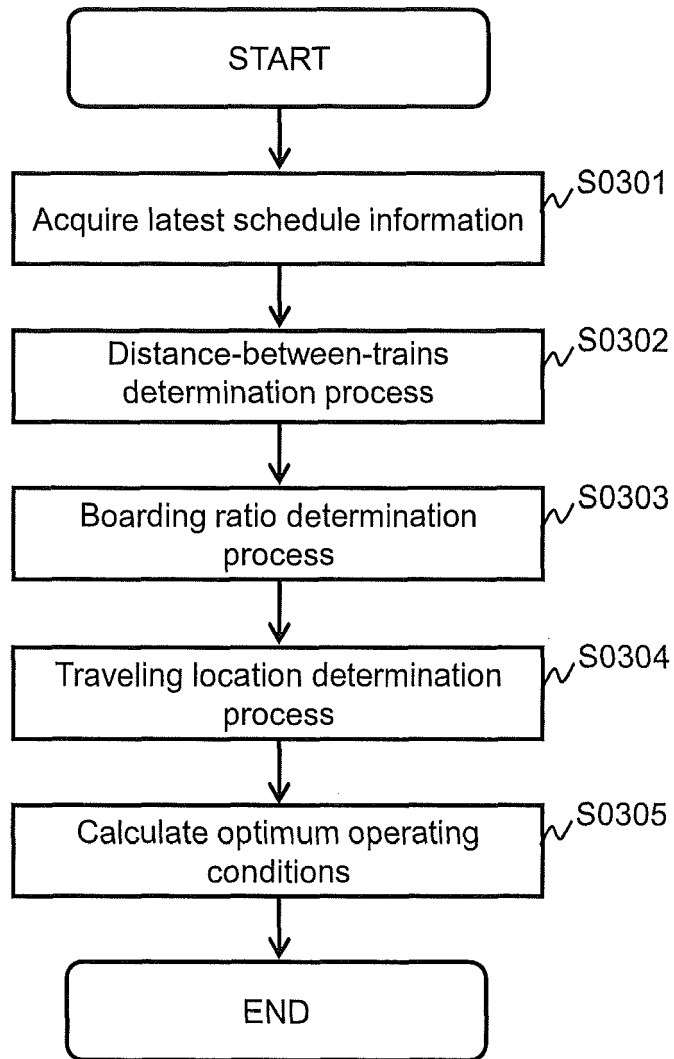
Fig. 10

Fig. 11

REFERENCES CITED IN THE DESCRIPTION

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