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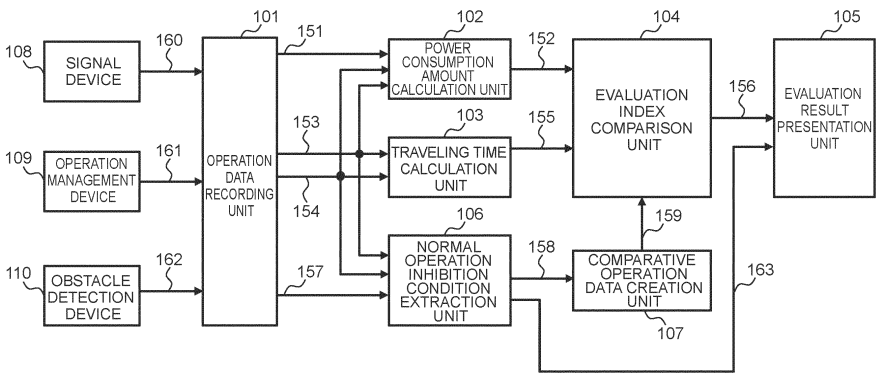
(54) DRIVING ASSISTANCE SYSTEM AND DRIVING ASSISTANCE METHOD

(57) A driving support system includes: an operation data recording unit; a power consumption amount calculation unit; a traveling time calculation unit; an evaluation index comparison unit configured to set a reference power consumption amount and a reference traveling time that are comparison targets, for a power consumption amount and a traveling time, and calculate a driving evaluation of a driver during the operation of the train based on a comparison result between the power consumption amount and the reference power consumption amount and a comparison result between the traveling time and the reference traveling time; a normal operation inhibition condition extraction unit configured to extract, based on data in the operation data recording unit, an inhibition condition for an normal operation that occurs during the operation of the train; and a comparative operation data creation unit configured to calculate, based on the inhibition condition, the reference power consumption amount and the reference traveling time.

FIG. 1



EP 4 494 972 A1

Description

Technical Field

[0001] The present invention relates to a driving support system and a driving support method.

Background Art

[0002] In order to cope with environmental problems and reduce operation costs, a railway operator faces a challenge of reducing a power consumption amount associated with a train operation. One method to reduce the power consumption amount associated with the train operation is to optimize a speed pattern of inter-station traveling. There are variations in speed patterns of the inter-station traveling due to drivers, which causes variations in a traveling time and the power consumption amount. Therefore, it is necessary to reduce the power consumption amount associated with the train operation by reducing the variation in the speed pattern and performing energy-saving driving in a traveling time in a range in which punctuality can be observed.

[0003] In order to reduce the variation in the speed pattern of the inter-station traveling aiming at energy-saving driving, it is effective to adopt an automatic train driving device for automating the driving, and to introduce a driving support system that provides training on energy-saving driving methods and advice on driving operations on the premise of manual driving. With regard to the introduction of the driving support system, a method on the premise of the manual driving is effective in reducing the variation of the speed pattern on the premise of the manual driving until the automatic driving becomes mainstream in the future because introduction cost is reduced as compared with the adoption of the automatic train driving device.

[0004] In addition, in a driving support system aiming at energy-saving driving, it is a major issue whether a train driver can maintain motivation for traveling in order to advance the reduction in variations in the speed pattern. For many drivers, there is considerable psychological resistance as it involves modifying the driving methods that the drivers are accustomed to. Therefore, in order to fix an energy-saving driving method, it is necessary that an energy-saving effect is visible to the driver and can be actually perceived. As one of methods corresponding to the problem, one example is the introduction of a driving support system that displays on a driver cab screen a power consumption amount and a traveling time associated with inter-station traveling, as well as evaluation of a driving skill. In this way, by checking a driving result and an evaluation for the driver for each inter-station traveling, it is possible to expect to maintain the motivation for devising the driving method.

[0005] For example, Patent Literature 1 discloses a configuration in which, in a driving simulator for training on a driving method, a power consumption amount, a traveling time, and the like are scored and presented to a driver as an evaluation result.

Citation List

Patent Literature

[0006] Patent Literature 1: JP2020-134757A

Summary of Invention

Technical Problem

[0007] The technique described in Patent Literature 1 is an evaluation method on the premise that there is no influence of a preceding train. However, since a punctual operation is important for railways, it is necessary to evaluate the power consumption amount in consideration of the traveling time, and depending on an operating situation, the traveling at a target traveling time may not be possible due to the influence of the preceding train. For this reason, since points will be deducted for late arrival due to the influence of the preceding train and energy consumption associated with additional acceleration and deceleration performed out of necessity, even when the best driving is performed within the given constraints, the evaluation result may be poor. In this way, when a situation in which it cannot be said that the driving skill evaluation is appropriate occurs, it is not desirable for the driver to maintain the motivation for devising the driving method.

[0008] In view of the above, the invention provides a driving support system and a driving support method capable of appropriately evaluating a traveling time and a power consumption amount and implementing energy saving of a train operation even when there is a condition for inhibiting a normal operation such as an influence of a preceding train.

Solution to Problem

[0009] A driving support system includes: an operation data recording unit configured to record operation data related to an operation record of a train; a power consumption amount calculation unit configured to calculate, based on the operation data recorded in the operation data recording unit, a power consumption amount between stations during an operation of the train; a traveling time calculation unit configured to calculate, based on the operation data recorded in the operation data recording unit, a traveling time between stations during the operation of the train; an evaluation index comparison unit configured to set a reference power consumption amount and a reference traveling time that are comparison targets, for the power consumption amount and the traveling time, and calculate a driving evaluation of a driver during the operation of the train based on a comparison result between the power consumption amount and the

reference power consumption amount and a comparison result between the traveling time and the reference traveling time; a normal operation inhibition condition extraction unit configured to extract, based on the operation data recorded in the operation data recording unit, an inhibition condition for an normal operation that occurs during the operation of the train; and a comparative operation data creation unit configured to calculate, based on the inhibition condition, the reference power consumption amount and the reference traveling time.

[0010] In addition, a driving support method includes: calculating, based on operation data related to an operation record of a train, a power consumption amount and a traveling time between stations during an operation of the train; extracting, based on the operation data, an inhibition condition for a normal operation that occurs during the operation of the train; calculating the reference power consumption amount and the reference traveling time based on the inhibition condition; and calculating a driving evaluation of a driver during the operation of the train by comparing the power consumption amount and the traveling time with the reference power consumption amount and the reference traveling time, respectively.

Advantageous Effects of Invention

[0011] According to the invention, it is possible to provide a driving support system and a driving support method capable of appropriately evaluating a traveling time and a power consumption amount and implementing energy saving of a train operation even when there is a condition for inhibiting a normal operation.

Brief Description of Drawings

[0012]

[FIG. 1] FIG. 1 is a diagram showing a functional configuration of a driving support system according to an embodiment of the invention.

[FIG. 2] FIG. 2 is a diagram showing an example of a normal operation inhibition condition and a main influence operation inhibition factor.

[FIG. 3] FIG. 3 is a diagram showing an example of the normal operation inhibition condition and the main influence operation inhibition factor.

[FIG. 4] FIG. 4 is a diagram showing an example of a normal operation inhibition condition and a main influence operation inhibition factor.

[FIG. 5] FIG. 5 is a diagram showing an example of comparative operation data.

[FIG. 6] FIG. 6 is a diagram showing an example of the comparative operation data.

[FIG. 7] FIG. 7 is a diagram showing an example of an evaluation result.

[FIG. 8] FIG. 8 is a diagram showing an example of the evaluation result.

[FIG. 9] FIG. 9 is a diagram showing an example of the evaluation result.

[FIG. 10] FIG. 10 is a diagram showing a display example of an evaluation result presentation unit.

[FIG. 11] FIG. 11 is a diagram showing an example of an evaluation method.

[FIG. 12] FIG. 12 is a diagram showing an example of the evaluation method.

[FIG. 13] FIG. 13 is a diagram showing a display example of the evaluation result presentation unit.

[FIG. 14] FIG. 14 is a diagram showing a display example of the evaluation result presentation unit.

Description of Embodiments

[0013] Hereinafter, an embodiment according to the invention will be described with reference to the drawings. The following description and drawings are examples for showing the invention, and are appropriately omitted and simplified for clarity of the description. The invention can be implemented in various other forms. Unless otherwise specified, each element may be single or plural.

[0014] In order to facilitate understanding of the invention, the position, size, shape, range, and the like of each element shown in the drawings may not represent the actual position, size, shape, range, and the like. Therefore, the invention is not necessarily limited to the positions, sizes, shapes, ranges, and the like disclosed in the drawings.

(Embodiment in Invention and Overall Configuration)

[0015] A driving support system according to the invention is a system that performs an evaluation related to a power consumption amount and a traveling time associated with an inter-station traveling at the end of inter-station traveling of a train and at subsequent timings, and presents an evaluation result for a driver of the train.

[0016] Reference values of the power consumption amount and the traveling time to be compared in the evaluation are determined in consideration of a condition that exists during the operation of the train and inhibits the normal operation. In the following description of the driving support system, as the condition that inhibits the normal operation of the train, a signal indication due to an influence of a preceding train acquired from a signal device, a temporary speed limit due to weather deterioration acquired from an operation management device, and obstacle risk acquired from an obstacle detection device are exemplified, and a speed limit corresponding thereto is indicated.

(FIG. 1)

[0017] The driving support system includes an operation data recording unit 101, a power consumption amount calculation unit 102, a traveling time calculation unit 103, an evaluation index comparison unit 104, an

evaluation result presentation unit 105, a normal operation inhibition condition extraction unit 106, a comparative operation data creation unit 107, a signal device 108, an operation management device 109, and an obstacle detection device 110.

[0018] The operation data recording unit 101 is a device that records operation data related to an operation record of a train. A specific example of the device is a driving condition recording device. The operation data recording unit 101 records data in time series for at least a train position, a train speed, information related to power consumption associated with an operation, information related to a speed limit, and a factor inhibiting the normal operation of the train. The operation data recording unit 101 is not limited to the driving condition recording device, and may be any device as long as the device can record the information in time series.

[0019] The operation data recording unit 101 is connected to the signal device 108, the operation management device 109, and the obstacle detection device 110 as an acquisition source of the condition that inhibits the normal operation. In FIG. 1, these devices are directly connected to the operation data recording unit 101, but may be indirectly connected via another device as long as necessary data can be received.

[0020] The signal device 108 is a device that manages a speed limit to be kept by its own train according to a track condition such as a curved line or a distance from a preceding train. Although the signal device 108 according to the embodiment is described as an on-board device, the signal device 108 is generally provided separately on the ground and on the vehicle. The operation data recording unit 101 receives a signal indication 160 indicating a speed limit at a current train position from the signal device 108 and constantly records the signal indication 160. Information of the signal indication 160 is notified to the driver of the train by a driver cab screen or the like. The driver who recognizes the information of the signal indication 160 controls the train speed to keep the signal indication 160.

[0021] The operation management device 109 is a ground device that controls the operation of each train in a route, and transmits temporary speed limit information corresponding to weather deterioration or the like. The operation data recording unit 101 receives and records a temporary speed limit 161 from the operation management device 109. The temporary speed limit 161 is defined by a target section and a speed limit value in relation to the speed limit in the route. The information of the temporary speed limit 161 is notified to the driver of the train by the driver cab screen or the like. The driver who recognizes the temporary speed limit 161 controls the train speed to keep the temporary speed limit 161.

[0022] The obstacle detection device 110 is a device that determines a risk of obstacles that impede the operation of the own train. A sensor such as a camera or a radar for recognizing the outside world is provided, and a type of the obstacle and the risk of operation hindrance due to the obstacle are determined according to a recognition result of the outside world. The operation data recording unit 101 receives and records an obstacle risk speed limit 162 from the obstacle detection device 110. The obstacle risk speed limit 162 is defined by a target section and a speed limit value in relation to the speed limit in the route. The information of the obstacle risk speed limit 162 is notified to the driver of the train by the driver cab screen or the like. The driver who recognizes the obstacle risk speed limit 162 controls the train speed to keep the obstacle risk speed limit 162.

[0023] The operation data recording unit 101 transmits power consumption information 151, a train position 153, and a train speed 154 to the power consumption amount calculation unit 102 at the end of the inter-station traveling and at subsequent timings. As an example of the power consumption information 151, an input voltage and an input current of each inverter in the train can be exemplified, and in this case, the power consumption amount calculation unit 102 calculates power consumption of the train for each instant by summing up products of the input voltage and the input current for all inverters mounted on the train, and calculates actual inter-station power consumption amount 152 by integrating the power consumption for each instant in a time range of the targeted inter-station traveling. The train position 153 and the train speed 154 in the power consumption amount calculation unit 102 are used to determine the time range of the targeted inter-station traveling. The time range of the inter-station traveling is a time range from a time point at which a speed of the train changes from zero to positive at a departure station position between the targeted stations to a time point at which the speed changes from positive to zero at a stop station position. As described above, the power consumption amount calculation unit 102 calculates, based on operation data recorded in the operation data recording unit 101, the power consumption amount 152 between stations during the operation of the train. The actual inter-station power consumption amount 152 calculated by the power consumption amount calculation unit 102 is transmitted to the evaluation index comparison unit 104.

[0024] In the calculation of the power consumption in the power consumption amount calculation unit 102, only a case in which the input current is positive, that is, only power running excluding the regeneration may be the target of the power consumption calculation. By doing so, it is possible to exclude an influence of an on-rail state and a braking or driving state of another train and set the power consumption amount of the own train alone as an evaluation target.

[0025] The operation data recording unit 101 transmits the train position 153 and the train speed 154 to the traveling time calculation unit 103. The traveling time calculation unit 103 calculates, as a traveling time 155, using a position at a departure station of the targeted inter-station traveling as the train position 153, a time from a time point at which the speed changes from zero to

positive to a time point at which the train position 153 is at the stop station position and the speed changes from positive to zero. As described above, the traveling time calculation unit 103 calculates, based on the operation data recorded in the operation data recording unit 101, the traveling time 155 between stations during the operation of the train. The traveling time 155 calculated by the traveling time calculation unit 103 is transmitted to the evaluation index comparison unit 104.

[0026] The operation data recording unit 101 transmits the train position 153 and additional speed limit information 157 to the normal operation inhibition condition extraction unit 106. The additional speed limit information 157 includes all contents of the signal indication 160, the temporary speed limit 161, and the obstacle risk speed limit 162 held by the operation data recording unit 101.

[0027] The normal operation inhibition condition extraction unit 106 extracts, based on recorded operation data information acquired from the operation data recording unit 101, an inhibition condition 158 for the normal operation occurring during the operation of the train. The normal operation inhibition condition 158 and a main influence operation inhibition factor 163 are generated. In this way, the normal operation inhibition condition 158 is transmitted to the comparative operation data creation unit 107 as information defined by a correspondence relationship between a position and a speed in the route. In addition, the main influence operation inhibition factor 163 is transmitted to the evaluation result presentation unit 105 as information indicating a factor substantially reflected in the normal operation inhibition condition 158 with low speed priority for a plurality of pieces of information related to the speed limit included in the additional speed limit information 157. A method for generating the normal operation inhibition condition 158 and the main influence operation inhibition factor 163 will be described later with reference to FIGS. 2 to 4.

[0028] The comparative operation data creation unit 107 creates comparative operation data to be compared with the latest driving record on the premise of the normal operation inhibition condition 158 received from the normal operation inhibition condition extraction unit 106, and generates an evaluation reference value 159 for evaluating the driving record. The comparative operation data is time-series driving data, and includes information on speed, position, notch operation, and power consumption associated therewith. A method for creating the comparative operation data will be described later. In addition, the evaluation reference value 159 is a power consumption amount between stations serving as a comparison criterion (hereinafter, referred to as a reference inter-station power consumption amount) and a traveling time between stations serving as a comparison criterion (hereinafter, referred to as a reference inter-station traveling time), which are generated from the comparative operation data based on the inhibition condition 158, and is transmitted to the evaluation index comparison unit 104.

[0029] The reference inter-station power consumption amount is calculated by integrating the power consumption included in the comparative operation data over the inter-station traveling. The reference inter-station traveling time is calculated by referring to position information and speed information included in the comparative operation data and as a time from the time point at which the train is at the departure station position and the speed changes from zero to positive to the time point at which the train is at the stop station position and the speed changes from positive to zero. The calculation method is the same as the calculation method in the traveling time calculation unit 103.

[0030] The evaluation index comparison unit 104 generates an evaluation result 156 by comparing the evaluation reference value 159 received from the comparative operation data creation unit 107, the actual inter-station power consumption amount 152 received from the power consumption amount calculation unit 102, and the actual inter-station traveling time 155 received from the traveling time calculation unit 103. Specifically, a reference power consumption amount and a reference traveling time included in the evaluation reference value 159 are set for the power consumption amount 152 and the traveling time 155, respectively, and the evaluation result 156, which is a driving evaluation for a driver during the operation of the train, is calculated based on a comparison result between the power consumption amount 152 and the reference power consumption amount and a comparison result between the traveling time 155 and the reference traveling time. The calculated evaluation result 156 is transmitted to the evaluation result presentation unit 105.

[0031] The evaluation result presentation unit 105 that receives the comparison result that is the driving evaluation calculated by the evaluation index comparison unit 104 presents information to the driver by displaying the information via a visible display device such as a driver cab screen of a vehicle information device. Details will be described later with reference to FIGS. 7 to 9.

[0032] Installation locations of the power consumption amount calculation unit 102, the traveling time calculation unit 103, the evaluation index comparison unit 104, the normal operation inhibition condition extraction unit 106, and the comparative operation data creation unit 107, which are the processing units described above, may be installed in either a ground device or an on-board device, and data is exchanged between the ground and the vehicle as necessary. In particular, since the comparative operation data creation unit 107 has many processes and uses a database of past operation data, by processing on a high-performance ground server, it is possible to reduce cost and make the on-board device more compact. The evaluation result presentation unit 105 is implemented on the driver cab screen or the like on the vehicle, and is assumed to be checked by the driver immediately after the end of the inter-station traveling, and alternatively, the evaluation result presentation unit 105 may be imple-

mented in a tablet terminal carried by the driver or a computer terminal used on the ground.

(FIGS. 2 to 4)

[0033] A method for generating the normal operation inhibition condition 158 and the main influence operation inhibition factor 163 in the normal operation inhibition condition extraction unit 106 will be described. In common with FIGS. 2 to 4, left drawings each show a permanent speed limit known as route information and speed limit information included in the additional speed limit information 157, which is information about the inhibition condition 158 that is not included in the permanent speed limit, in a relationship between the position and the speed. In the embodiment, there are three types of the additional speed limit information 157, that is, the signal indication 160, the temporary speed limit 161, and the obstacle risk speed limit 162, but in some cases, a part or all of the speed limit information may not be generated. In this case, the additional speed limit information 157 includes only the generated speed limit information. Right drawings show the normal operation inhibition condition 158 generated by the normal operation inhibition condition extraction unit 106 in a relationship between the position and the speed. In addition, at the bottom of the right drawings, the main influence operation inhibition factor 163 is shown as the speed limit information (of the main influence) that substantially influences the generation of the normal operation inhibition condition 158.

[0034] FIG. 2 shows an example in which the additional speed limit information 157 includes only the signal indication 160. The left drawing of FIG. 2 shows the permanent speed limit over the entire space between stations and the signal indication 160 present near an arrival station. In this case, with respect to the permanent speed limit and the signal indication 160, a speed pattern in the right drawing, which gives priority to lower speeds, becomes the normal operation inhibition condition 158. At this time, the main influence operation inhibition factor 163 is only the signal indication 160. That is, the additional speed limit information 157 is a speed limit set by the signal indication 160 by the signal device 108.

[0035] FIG. 3 shows an example in which the additional speed limit information 157 includes three types of information, that is, the signal indication 160, the temporary speed limit 161, and the obstacle risk speed limit 162. The left drawing of FIG. 3 shows the permanent speed limit over the entire space between stations and the three types of speed limit information, and positions of the three types of speed limits do not overlap. In this case, with respect to the permanent speed limit and the three types of speed limits, a speed pattern in the right drawing, which gives priority to lower speeds, becomes the normal operation inhibition condition 158. At this time, the main influence operation inhibition factor 163 includes all of the three types of the signal indication 160, the temporary speed limit 161, and the obstacle risk speed limit 162. That is, the additional speed limit information 157 is not only the signal indication 160 by the signal device 108, but also the temporary speed limit 161 set according to a situation such as a deterioration in weather conditions, or a speed limit set according to an obstacle existing in front of the train.

[0036] FIG. 4 shows an example in which the additional speed limit information 157 includes three types of the signal indication 160, the temporary speed limit 161, and the obstacle risk speed limit 162, but unlike FIG. 3, the positions of the inhibition factors that influence the speed limit partially overlap. The left drawing of FIG. 4 shows the permanent speed limit over the entire space between stations and three types of speed limit information. Among the three types of speed limits, the positions of the signal indication 160 and the temporary speed limit 161 overlap, and a section of the temporary speed limit 161 is included in a section of the signal indication 160. That is, since the speed limit value is lower in the signal indication 160 than that in the temporary speed limit 161, the speed limit is set in accordance with the lower signal indication 160. As a result, with respect to the permanent speed limit and the three types of speed limits, a speed pattern in the right drawing, which gives priority to lower speeds, becomes the normal operation inhibition condition 158. The temporary speed limit 161 does not substantially affect the normal operation inhibition condition 158. Therefore, there are two types of the main influence operation inhibition factors 163, that is, the signal indication 160 and the obstacle risk speed limit 162.

[0037] In consideration of the additional speed limit that does not exist on the permanent speed limit described above, the normal operation inhibition condition extraction unit 106 functions to enable new speed limit information, and therefore, the information is used to search for an optimal traveling pattern in consideration of energy saving.

[0038] Since the inhibition factor can be patterned in a certain degree of variation and is limited to, for example, a section with a bridge or a section with a river, it is also possible to search for the same condition in the past, acquire data related to a day in the form of the same speed limit, and set an optimal driving style in consideration of the energy saving, the traveling time, and the power consumption amount at that time as threshold values for final determination.

(FIG. 5)

[0039] An example will be shown in which the comparative operation data creation unit 107 uses the fastest pattern in consideration of the normal operation inhibition condition 158 as the comparative operation data. Under a condition that there is the additional speed limit in addition to the permanent speed limit, it is basically considered that the train is to travel in such a way as to minimize a delay. Therefore, the fastest pattern in consideration of

the normal operation inhibition condition 158 is the best traveling speed pattern, whereas if there are so many speed limits, the speed has to be greatly reduced with respect to the permanent speed limit, and thus becomes slower than the target, so that the fastest pattern is adopted as the most suitable comparative operation data with the actual operation even if it is later than the timetable. That is, the traveling time that is equal to or greater than the traveling time defined by the timetable is adopted as the comparative operation data. As described above, the reference traveling time is, in the presence of the inhibition condition 158, a time from a time point at which the train departs from a departure station to an earliest arrival time point at which the train can arrive at an arrival station after an arrival time point on the timetable.

(FIG. 6)

[0040] FIG. 6 shows an example in which an energy-saving traveling pattern (energy-saving pattern) is the comparative operation data in the comparative operation data creation unit 107. Since the fastest pattern is applied to the traveling speed pattern in consideration of the normal operation inhibition condition 158 of FIG. 5, a degree of freedom is not generated. However, when the traveling time of the fastest pattern in consideration of energy saving is shorter than the traveling time defined by the timetable, since the train cannot travel earlier than the timetable (since the traveling time shorter than the traveling time defined by the timetable is not possible), it is necessary to match the traveling time defined by the timetable. In this case, the optimal traveling time in consideration of energy saving can be made longer than the traveling time of the fastest pattern. By utilizing this margin, a degree of freedom is generated in the traveling speed pattern. That is, after traveling for the traveling time defined by the timetable, by lowering the maximum speed or increasing coasting based on the calculated fastest pattern, it is possible to generate an optimal speed pattern that performs the inter-station traveling in an energy-saving manner and within the traveling time defined by the timetable. In such a case, an energy-saving traveling pattern that is mathematically generated and with which the train travels at the traveling time defined by the timetable is adopted as the comparative operation data.

[0041] There are many existing studies on mathematically generating energy-saving patterns, such as methods using dynamic programming and hill-climbing methods, and these methods can be utilized.

(FIGS. 7 to 9)

[0042] A description will be given of a process in which the evaluation index comparison unit 104 calculates a reference power consumption amount based on an energy-saving pattern calculated using a past operation data search and an operation simulation (operation data for energy-saving traveling) or an average pattern calculated using the past operation data search (operation data for traveling with an average power consumption amount), and compares the reference power consumption amount with an actual value to calculate an evaluation value.

[0043] First, two methods, that is, a method based on the past operation data search and a method based on the operation simulation, will be described for the operation data for energy-saving traveling.

(Method for Creating Comparative Operation Data Using Past Operation Data Search)

[0044] The past operation data search is performed using an operation data group accumulated in the past between target stations. The accumulated operation data is time-series driving data, and includes information on speed, position, notch operation, power consumption, and speed limit information. The speed limit information is speed information with lower priority given to the signal indication 160, the temporary speed limit 161, the obstacle risk speed limit 162, and the permanent speed limit (see FIGS. 2 to 4). The accumulation of the operation data can be implemented by periodically acquiring data from the operation data recording unit 101 which is a driving condition recording device.

[0045] In the past operation data search, the search is performed based on a relationship between the position and the speed limit. Since the accumulated operation data includes the information on the position and the speed limit in time series, the relationship between the position and the speed limit can be created. The normal operation inhibition condition 158 described above is defined by the relationship between the position and the speed limit. Based on this, past operation data in which the relationship between the position and the speed limit matches the normal operation inhibition condition 158 in a traveling record is searched and extracted.

[0046] From the extracted past operation data, operation data in which the inter-station traveling is performed at the shortest traveling time within a range in which the train does not arrive earlier than the timetable is extracted again. The traveling time of the operation data is defined as the reference inter-station traveling time. In addition, among the re-extracted operation data, operation data with which the most energy-saving traveling is performed and operation data with which traveling is performed with an average power consumption amount are searched, and respective power amounts are defined as a reference inter-station power consumption amount (energy-saving) and a reference inter-station power consumption amount (average). When the power consumption amount calculation unit 102 adopts power consumption calculation that targets only running power, operation data search for energy-saving power amount and average power amount is also performed here from the viewpoint of a running power amount.

[0047] When the number of pieces of re-extracted operation data is small (for example, three pieces or less) when the reference inter-station traveling time is determined, in order to re-extract a plurality of pieces of operation data, the reference inter-station traveling time may be set to the shortest traveling time by providing a width of about 5 to 10 seconds to the traveling time within a range in which the train does not arrive earlier than the timetable.

[0048] As described above, the comparative operation data creation unit 107 calculates the reference traveling time and the reference power consumption amount by extracting the operation data when the inhibition condition 158 exists from the past operation data recorded in the operation data recording unit 101.

(Method for Creating Comparative Operation Data Using Operation Simulation)

[0049] As the condition settings necessary for the operation simulation, vehicle conditions (weight, traveling resistance characteristics, traction force and braking force and electric braking force characteristics), route conditions (station kilometer, route gradient and curvature, presence or absence of tunnels, speed limit), timetable conditions (inter-station traveling time), and driving method conditions are exemplified. Among these, the conditions other than the speed limit are held in advance in the comparative operation data creation unit 107. Then, the normal operation inhibition condition 158 is used as the condition of the speed limit.

[0050] In addition, since the weight included in the vehicle conditions is affected by fluctuations in an occupancy rate depending on a day of a week or a time zone, by additionally acquiring and using an occupancy rate value for the inter-station traveling to be simulated from the operation data recording unit 101, it is possible to perform the operation simulation with higher accuracy from the viewpoint of the speed pattern or the power consumption amount. In addition, since the traction force characteristics included in the vehicle conditions are affected by overhead wire voltage in electric railways, by additionally acquiring and using an overhead wire voltage value for the inter-station traveling to be simulated from the operation data recording unit 101, it is possible to perform the operation simulation with higher accuracy from the viewpoint of the speed pattern or the power consumption amount. In addition, since the electric braking force characteristics included in the vehicle conditions are affected by overhead wire voltage in electric railways, by additionally acquiring and using the overhead wire voltage value for the inter-station traveling to be simulated from the operation data recording unit 101, it is possible to perform the operation simulation with higher accuracy from the viewpoint of the power consumption amount. In addition, the driving method condition is a method for determining a traveling speed pattern during inter-station traveling, and is a strategy for handling a notch. Depending on the driving method condition, the traveling time and the power consumption amount change.

[0051] In the operation simulation in the comparative operation data creation, on the premise of the normal operation inhibition condition 158, first, a traveling speed pattern that enables traveling between stations in the shortest time is generated. The fastest pattern is a speed pattern in which the train travels by increasing the speed within a range not exceeding the speed limit by utilizing a maximum acceleration and a maximum deceleration allowed in consideration of safety and ride comfort.

[0052] As described above with reference to FIG. 5, the fastest pattern is set as the comparative operation data if the traveling time in the case of traveling between the stations in the fastest pattern is equal to or longer than the traveling time defined by the timetable. When there is the normal operation inhibition condition 158 in which the speed has to be greatly reduced in response to the permanent speed limit, as described above with reference to FIG. **6,** even when the train travels at the highest speed, the train cannot travel with a traveling time shorter than the traveling time defined by the timetable, and the fastest pattern is the comparative operation data.

[0053] As the reference inter-station traveling time, the longer one of the traveling time in the case of traveling between stations in the fastest pattern and the traveling time defined by the timetable is adopted. When the reference inter-station traveling time is the traveling time in the case of traveling between stations in the fastest pattern, the reference inter-station power consumption amount is defined as the inter-station power consumption amount in the case of traveling in the fastest pattern. In addition, when the reference inter-station traveling time is the traveling time defined by the timetable, the reference inter-station power consumption amount is defined as the inter-station power consumption amount in the case of traveling in the energy-saving pattern.

[0054] Here, the inter-station power consumption amount can be calculated by integrating, over the inter-station traveling, the power consumption for each instant, which is estimated and obtained from a magnitude of a traction force and an electric braking force required for traveling along the fastest pattern in consideration of equipment efficiency and the like. When the power consumption amount calculation unit 102 adopts the power consumption calculation that targets only the running power, an inter-station running power amount is also calculated by integrating only positive power consumption.

[0055] In the method according to the operation simulation, since it is difficult to express the variation of the traveling pattern in an actual operation, only the operation data for energy-saving traveling is generated as the comparative operation data without generating the operation data for traveling with the average power consumption amount.

[0056] As described above, the comparative operation

data creation unit 107 calculates the reference inter-station traveling time and the reference inter-station power consumption amount by the traveling simulation on a computer including the inhibition condition, uses the reference inter-station traveling time and the reference inter-station power consumption amount as threshold values to compare with actual values such as the actual inter-station power consumption amount 152 and the actual inter-station traveling time 155, and outputs the evaluation reference value 159 to the evaluation index comparison unit 104. Based on the above two methods, the evaluation results of FIGS. 7 to 9 will be described.

[0057] In the energy-saving patterns of FIGS. 7 and 9, the reference power consumption amount is a power amount consumed in a case in which the train travels between the stations in the reference traveling time and travels with the lowest power consumption.

[0058] In the average pattern of FIG. 8, the reference power consumption amount is an average power consumption amount in a case in which the train travels between stations in the reference traveling time. In order to obtain an index for the purpose of energy saving, the evaluation index comparison unit 104 calculates the driving evaluation so that when the power consumption amount 152 is less than the reference power consumption amount, the evaluation is higher than when the power consumption amount 152 is more than the reference power consumption amount.

(Calculation of Evaluation Results)

[0059] The calculation of the evaluation result 156 generated by the evaluation index comparison unit 104 will be described. With respect to numerical values of the evaluation result 156, first, numerical values of the traveling time and the power consumption amount are compared to calculate a difference. Hereinafter, as shown in FIGS. 7 to 9, the evaluation result 156 includes the calculated difference together with the numerical value of each comparison target. The difference is a value based on the evaluation reference value 159.

[0060] In FIG. 7, the reference inter-station traveling time included in the evaluation reference value 159 (result obtained by the past operation data search, energy saving) is compared with the actual inter-station traveling time 155. The reference inter-station power consumption amount included in the evaluation reference value 159 (result obtained by the past operation data search, energy saving) is compared with the actual inter-station power consumption amount 152.

[0061] In FIG. 8, the reference inter-station traveling time included in the evaluation reference value 159 (result obtained by the past operation data search, average) is compared with the actual inter-station traveling time 155. The reference inter-station power consumption amount included in the evaluation reference value 159 (result obtained by the past operation data search, average) is compared with the actual inter-station power consumption amount 152.

[0062] In FIG. 9, the reference inter-station traveling time included in the evaluation reference value 159 (result obtained by operation simulation) is compared with the actual inter-station traveling time 155. The reference inter-station power consumption amount included in the evaluation reference value 159 (result obtained by operation simulation) is compared with the actual inter-station power consumption amount 152.

[0063] Subsequently, based on the comparison numerical values of the traveling time and the power consumption amount, scores are given so that the closer the actual value is to an ideal value, the higher the score. As the ideal value of the traveling time, either the result obtained by the past operation data search or the result obtained by the operation simulation among the reference inter-station traveling time included in the evaluation reference value 159 is used.

[0064] Finally, the evaluation result (scoring result) based on the comparison of the numerical values of the traveling time and the power consumption amount is compared with a predetermined score reference value, and a pass and fail determination is performed which determines as pass when the score is more than the reference value. In addition, in relation to the power consumption amount, an average value obtained by the past operation data search among the reference inter-station power consumption amount included in the evaluation reference value 159 is compared with the actual inter-station power consumption amount, and the pass and fail determination is determined as pass when the latter is smaller than the former.

[0065] The information of FIGS. 7 to 9 evaluated as described above is displayed by the evaluation result presentation unit 105 by displaying numerical values in a table format or graphing the numerical values.

[0066] The evaluation result presentation unit 105 does not need to display all the information in FIGS. 7 to 9, and may extract and display only a part of the information. In addition, the evaluation result presentation unit 105 displays, in a display device, contents of the main influence operation inhibition factor 163 acquired from the normal operation inhibition condition extraction unit 106 (see FIGS. 10, 13, and 14). Accordingly, the driver can recognize the operating conditions under which the reference inter-station traveling time and reference inter-station power consumption amount, which are compared with their own driving records, are calculated, and can check validity of the result of the comparative evaluation.

(FIG. 10)

[0067] FIG. 10 shows a driving record screen that is a presentation example of the evaluation result 156 obtained by comparing numerical values of the traveling time and the power consumption amount and calculating a difference and the main influence operation inhibition

factor 163. As described above, the evaluation result presentation unit 105 displays, in a graph, at least one of the comparison result between the power consumption amount 152 and the reference power consumption amount and the comparison result between the traveling time 155 and the reference traveling time that are compared by the evaluation index comparison unit 104. The evaluation result presentation unit 105 further displays the presence or absence of the operation inhibition factor regarding the inhibition condition 158 related to the driving evaluation.

(FIG. 11)

[0068] FIG. 11 shows an example of a method for assigning scores related to the traveling time 155. As shown in the graph of the example, a time range is provided so that the driver has the highest score as the traveling time is closer to the reference inter-station traveling time, and the score decreases as away from the range. As described above, the evaluation index comparison unit 104 calculates the driving evaluation so that the driving evaluation becomes higher as the traveling time 155 is closer to the reference traveling time.

(FIG. 12)

[0069] FIG. 12 shows an example of a method for assigning scores related to the power consumption amount 152. In the example, a time range is provided so that the driver has the highest score near the reference inter-station power consumption amount, and the score decreases as the power amount is greater than the range. As described above, the evaluation index comparison unit 104 calculates the driving evaluation so that the driving evaluation becomes higher as the power consumption amount 152 is closer to the reference power consumption amount. As the ideal value of the power consumption amount, either an energy-saving value obtained by the result obtained by the past operation data search or the result obtained by the operation simulation among the reference inter-station power consumption amount included in the evaluation reference value 159 is used.

(FIG. 13)

[0070] FIG. 13 is a presentation example of the evaluation result 156 in the evaluation result presentation unit 105, and is a method in which, based on the comparison numerical values of the traveling time and the power consumption amount, scores are given so that the closer the actual value is to the ideal value, the higher the score. The evaluation result presentation unit 105 displays the scores on a display device that can be viewed by the driver, such as the driver cab screen of the vehicle information device. In view of the display, the score of the traveling time and the score of the power consumption amount may be individually displayed, or a value obtained by adding the score of the traveling time and the score of the power consumption amount after certain weighting may be displayed. It is desirable that the evaluation result presentation unit 105 displays, in a display device, contents of the main influence operation inhibition factor 163 acquired from the normal operation inhibition condition extraction unit 106.

(FIG. 14)

[0071] FIG. 14 is a presentation example of the evaluation result 156 in the evaluation result presentation unit 105, in which the evaluation result (scoring result) based on the comparison of the numerical values of the traveling time and the power consumption amount is compared with a predetermined score reference value, and a pass and fail determination is displayed which determines as pass when the score is more than the reference value. FIG. 14 shows an example in which the evaluation result 156 is pass. For example, as shown in the drawing, "appropriate" may be displayed in relation to the traveling time, and "ECO" may be displayed in relation to the power consumption amount.

[0072] In the invention described above, a driving support method includes: calculating, based on operation data related to an operation record of a train, the power consumption amount 152 and the traveling time 155 between stations during an operation of the train; extracting, based on the operation data, the inhibition condition 158 for a normal operation that occurs during the operation of the train; calculating the reference power consumption amount and the reference traveling time based on the inhibition condition; and calculating the driving evaluation 156 of a driver during the operation of the train by comparing the power consumption amount 152 and the traveling time 155 with the reference power consumption amount and the reference traveling time, respectively. According to such a driving support method, it is possible to provide a driving support system capable of presenting an appropriate evaluation result according to an operating situation.

[0073] According to the embodiment of the invention described above, the following effects are obtained.

(1) A driving support system includes: the operation data recording unit 101 configured to record operation data related to an operation record of a train; the power consumption amount calculation unit 102 configured to calculate, based on the operation data recorded in the operation data recording unit 101, the power consumption amount 152 between stations during an operation of the train; the traveling time calculation unit 103 configured to calculate, based on the operation data recorded in the operation data recording unit 101, the traveling time 155 between stations during the operation of the train; the evaluation index comparison unit 104 configured to set a

reference power consumption amount and a reference traveling time that are comparison targets, for the power consumption amount 152 and the traveling time 155, and calculate a driving evaluation 156 of a driver during the operation of the train based on a comparison result between the power consumption amount 152 and the reference power consumption amount and a comparison result between the traveling time 155 and the reference traveling time. In addition, the driving support system includes the normal operation inhibition condition extraction unit 106 configured to extract, based on the operation data recorded in the operation data recording unit 101, the inhibition condition 158 for a normal operation that occurs during the operation of the train; and the comparative operation data creation unit 107 configured to calculate, based on the inhibition condition 158, the reference power consumption amount and the reference traveling time. In this way, even when there is a condition to inhibit the normal operation, it is possible to appropriately evaluate the traveling time and the power consumption amount and implement energy saving of the train operation.

(2) The driving support system includes the evaluation result presentation unit 105 configured to present, to the driver, the driving evaluation calculated by the evaluation index comparison unit 104. In this way, the driver can maintain motivation to devise the driving method to save energy.

(3) The reference traveling time is, in presence of the inhibition condition 158, a time from a time point at which the train departs from a departure station to an earliest arrival time point at which the train can arrive at an arrival station after an arrival time point on a timetable. In this way, it is possible to create a target traveling time based on the inhibition condition 158.

(4) The evaluation index comparison unit 104 calculates the driving evaluation so that the driving evaluation is higher as the traveling time 155 is closer to the reference traveling time. In this way, the evaluation result 156 can be clarified.

(5) The reference power consumption amount is a power amount consumed when the train travels between the stations at the reference traveling time and travels with lowest power consumption. In this way, it is possible to create a reference of the power amount when the train travels in the energy-saving manner.

(6) The evaluation index comparison unit 104 calculates the driving evaluation so that the driving evaluation is higher as the power consumption amount is closer to the reference power consumption amount. In this way, the evaluation result 156 can be clarified.

(7) The reference power consumption amount is an average power consumption amount when the train travels between the stations at the reference traveling time. In this way, it is possible to create a reference of the power amount when the train travels in the energy-saving manner.

(8) The evaluation index comparison unit 104 calculates the driving evaluation 156 so that the driving evaluation is higher when the power consumption amount 152 is less than the reference power consumption amount than when the power consumption amount is more than the reference power consumption amount. In this way, it is possible to clarify the evaluation of the energy-saving traveling of the train based on the average power consumption amount.

(9) The comparative operation data creation unit 107 calculates the reference traveling time and the reference power consumption amount by extracting the operation data in a case in which the inhibition condition 158 exists among past operation data recorded in the operation data recording unit 101. In this way, even when there is a preceding train, it is possible to create an optimal standard for the energy-saving traveling of the train.

(10) The comparative operation data creation unit 107 calculates the reference traveling time and the reference power consumption amount by a traveling simulation on a computer including the inhibition condition 158. In this way, it is possible to create an evaluation standard even when there is no past operation data.

(11) The inhibition condition 158 is an additional speed limit that does not exist in a permanent speed limit. In this way, for example, it is possible to create a standard for the energy-saving traveling of the train when there is a preceding train.

(12) The additional speed limit is a speed limit set according to a signal indication by the signal device 108. In this way, it is possible to create the inhibition condition 158 including the speed limit information when there is the preceding train.

(13) The additional speed limit is a speed limit set according to a weather condition. In this way, it is possible to create the inhibition condition 158 including the speed limit information in case of bad weather.

(14) The additional speed limit is a speed limit set according to an obstacle existing in front of the train. In this way, for example, it is possible to create the inhibition condition 158 including speed limit information in consideration of an external obstacle that causes a risk to the traveling of the train.

(15) The evaluation result presentation unit 105 further displays the inhibition condition 158 related to the driving evaluation. In this way, the driver can clearly recognize the inhibition condition 158 and maintain the motivation to devise the driving method to save energy.

(16) The evaluation result presentation unit 105 further displays, in a graph, at least one of the comparison result of the power consumption amount 152 and the reference power consumption amount and

the comparison result of the traveling time 155 and the reference traveling time that are compared by the evaluation index comparison unit 104. In this way, the driver can recognize the traveling evaluation result 156 of his or her own train.

(17) A driving support method includes: calculating, based on operation data related to an operation record of a train, the power consumption amount 152 and the traveling time 155 between stations during an operation of the train; extracting, based on the operation data, the inhibition condition 158 for a normal operation that occurs during the operation of the train; calculating a reference power consumption amount and a reference traveling time based on the inhibition condition 158; and calculating the driving evaluation 156 of a driver during the operation of the train by comparing the power consumption amount 152 and the traveling time 158 with the reference power consumption amount and the reference traveling time, respectively. In this way, even when there is a condition to inhibit the normal operation, it is possible to appropriately evaluate the traveling time and the power consumption amount and implement energy saving of the train operation.

[0074] The invention is not limited to the embodiments described above, and various modifications and other configurations can be combined without departing from the gist of the invention. Further, the invention is not limited to the invention including all configurations described in the above embodiments, and includes a configuration in which a part of the configurations is deleted.

Reference Signs List

[0075]

101: operation data recording unit
102: power consumption amount calculation unit
103: traveling time calculation unit
104: evaluation index comparison unit
105: evaluation result presentation unit
106: normal operation inhibition condition extraction unit
107: comparative operation data creation unit
108: signal device
109: operation management device
110: obstacle detection device
151: power consumption information
152: actual inter-station power consumption amount
153: train position
154: train speed
155: actual inter-station traveling time
156: evaluation result
157: additional speed limit information
158: normal operation inhibition condition
159: evaluation reference value
160: signal indication
161: temporary speed limit
162: obstacle risk speed limit
163: main influence operation inhibition factor

Claims

1. A driving support system comprising:

an operation data recording unit configured to record operation data related to an operation record of a train;
a power consumption amount calculation unit configured to calculate, based on the operation data recorded in the operation data recording unit, a power consumption amount between stations during an operation of the train;
a traveling time calculation unit configured to calculate, based on the operation data recorded in the operation data recording unit, a traveling time between stations during the operation of the train;
an evaluation index comparison unit configured to set a reference power consumption amount and a reference traveling time that are comparison targets, for the power consumption amount and the traveling time, and calculate a driving evaluation of a driver during the operation of the train based on a comparison result between the power consumption amount and the reference power consumption amount and a comparison result between the traveling time and the reference traveling time;
a normal operation inhibition condition extraction unit configured to extract, based on the operation data recorded in the operation data recording unit, an inhibition condition for an normal operation that occurs during the operation of the train; and
a comparative operation data creation unit configured to calculate, based on the inhibition condition, the reference power consumption amount and the reference traveling time.

2. The driving support system according to claim 1, further comprising:
an evaluation result presentation unit configured to present, to the driver, the driving evaluation calculated by the evaluation index comparison unit.

3. The driving support system according to claim 1 or 2, wherein
the reference traveling time is, in presence of the inhibition condition, a time from a time point at which the train departs from a departure station to an earliest arrival time point at which the train can arrive at an arrival station after an arrival time point on a timetable.

4. The driving support system according to claim 3, wherein
the evaluation index comparison unit calculates the driving evaluation so that the driving evaluation is higher as the traveling time is closer to the reference traveling time.

5. The driving support system according to claim 1, wherein
the reference power consumption amount is a power amount consumed when the train travels between the stations at the reference traveling time and travels with lowest power consumption.

6. The driving support system according to claim 5, wherein
the evaluation index comparison unit calculates the driving evaluation so that the driving evaluation is higher as the power consumption amount is closer to the reference power consumption amount.

7. The driving support system according to claim 1, wherein
the reference power consumption amount is an average power consumption amount when the train travels between the stations at the reference traveling time.

8. The driving support system according to claim 7, wherein
the evaluation index comparison unit calculates the driving evaluation so that the driving evaluation is higher when the power consumption amount is less than the reference power consumption amount than when the power consumption amount is more than the reference power consumption amount.

9. The driving support system according to claim 1, wherein
the comparative operation data creation unit calculates the reference traveling time and the reference power consumption amount by extracting the operation data in a case in which the inhibition condition exists among past operation data recorded in the operation data recording unit.

10. The driving support system according to claim 1, wherein
the comparative operation data creation unit calculates the reference traveling time and the reference power consumption amount by a traveling simulation on a computer including the inhibition condition.

11. The driving support system according to claim 1, wherein
the inhibition condition is an additional speed limit that does not exist in a permanent speed limit.

12. The driving support system according to claim 11, wherein
the additional speed limit is a speed limit set according to a signal indication by a signal device.

13. The driving support system according to claim 11, wherein
the additional speed limit is a speed limit set according to a weather condition.

14. The driving support system according to claim 11, wherein
the additional speed limit is a speed limit set according to an obstacle existing in front of the train.

15. The driving support system according to claim 2, wherein
the evaluation result presentation unit further displays the inhibition condition related to the driving evaluation.

16. The driving support system according to claim 2, wherein
the evaluation result presentation unit further displays, in a graph, at least one of the comparison result of the power consumption amount and the reference power consumption amount and the comparison result of the traveling time and the reference traveling time that are compared by the evaluation index comparison unit.

17. A driving support method comprising:

calculating, based on operation data related to an operation record of a train, a power consumption amount and a traveling time between stations during an operation of the train;
extracting, based on the operation data, an inhibition condition for a normal operation that occurs during the operation of the train;
calculating the reference power consumption amount and the reference traveling time based on the inhibition condition; and
calculating a driving evaluation of a driver during the operation of the train by comparing the power consumption amount and the traveling time with the reference power consumption amount and the reference traveling time, respectively.

FIG. 1

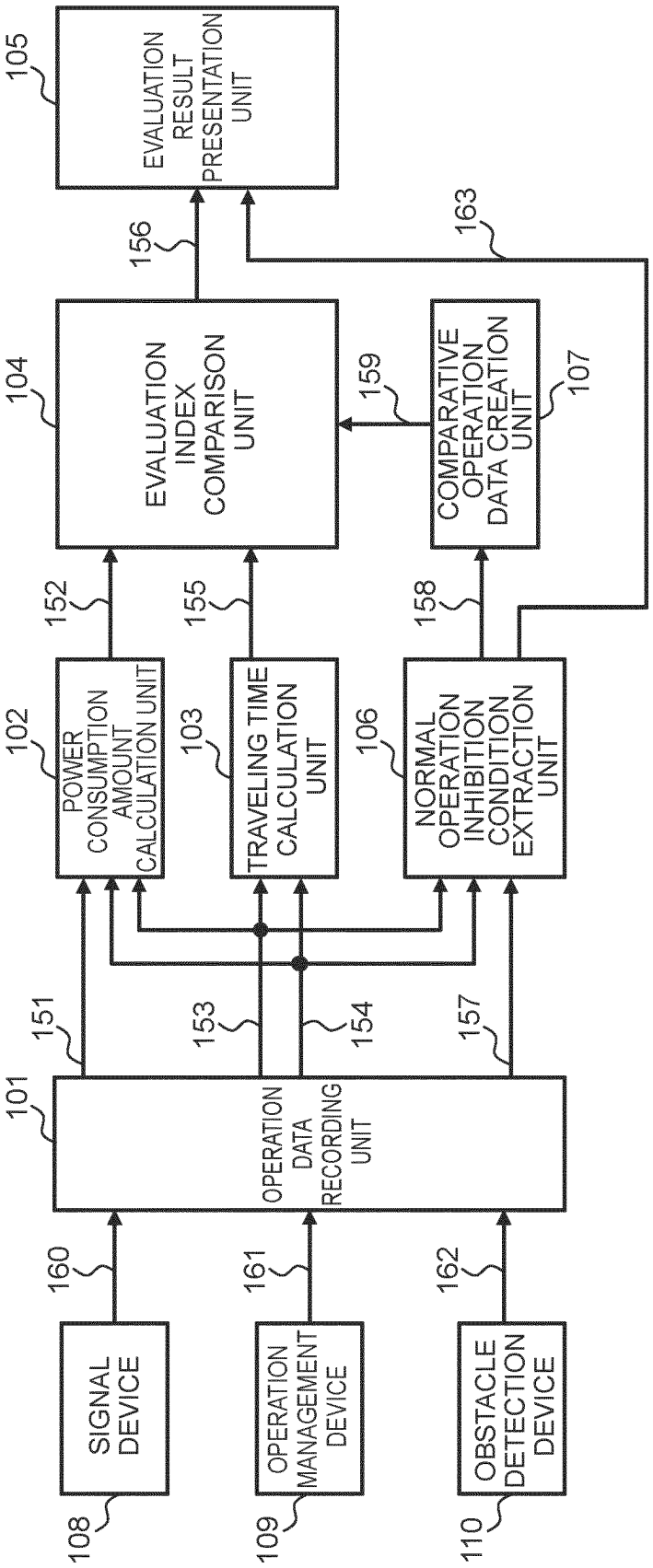

105
EVALUATION RESULT PRESENTATION UNIT
156
163
104
EVALUATION INDEX COMPARISON UNIT
159
COMPARATIVE OPERATION DATA CREATION UNIT
107
152
155
158
102
POWER CONSUMPTION AMOUNT CALCULATION UNIT
103
TRAVELING TIME CALCULATION UNIT
106
NORMAL OPERATION INHIBITION CONDITION EXTRACTION UNIT
151
153
154
157
101
OPERATION DATA RECORDING UNIT
160
161
162
SIGNAL DEVICE
OPERATION MANAGEMENT DEVICE
OBSTACLE DETECTION DEVICE
108
109
110

FIG. 2

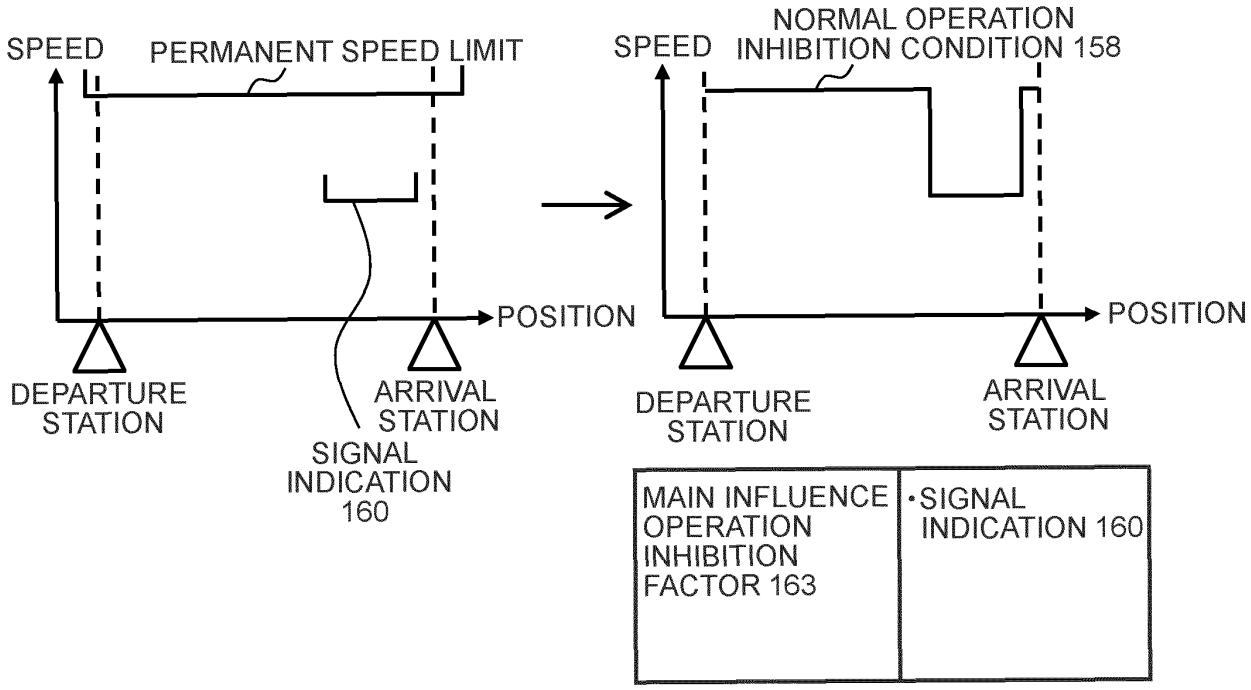

SPEED
PERMANENT SPEED LIMIT
POSITION
DEPARTURE STATION
ARRIVAL STATION
SIGNAL INDICATION 160
SPEED
NORMAL OPERATION INHIBITION CONDITION 158
POSITION
DEPARTURE STATION
ARRIVAL STATION
MAIN INFLUENCE OPERATION INHIBITION FACTOR 163
•SIGNAL INDICATION 160

FIG. 3

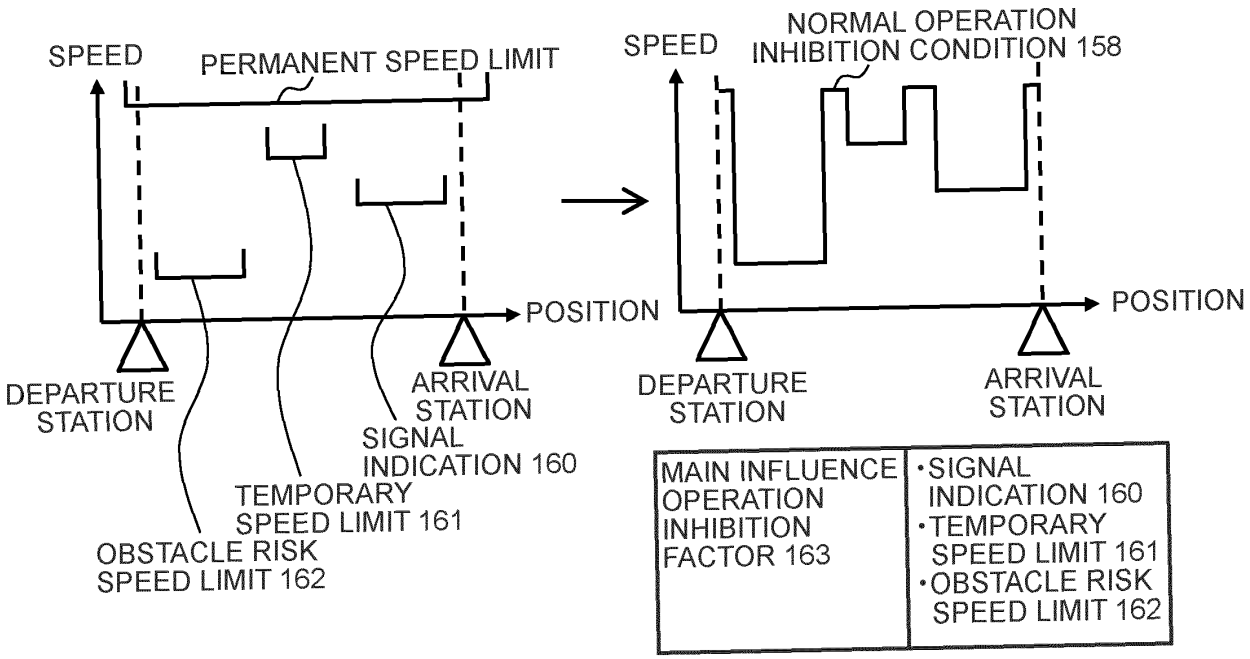

SPEED
PERMANENT SPEED LIMIT
POSITION
DEPARTURE STATION
ARRIVAL STATION
SIGNAL INDICATION 160
TEMPORARY SPEED LIMIT 161
OBSTACLE RISK SPEED LIMIT 162
SPEED
NORMAL OPERATION INHIBITION CONDITION 158
POSITION
DEPARTURE STATION
ARRIVAL STATION
MAIN INFLUENCE OPERATION INHIBITION FACTOR 163
•SIGNAL INDICATION 160
•TEMPORARY SPEED LIMIT 161
•OBSTACLE RISK SPEED LIMIT 162

FIG. 4

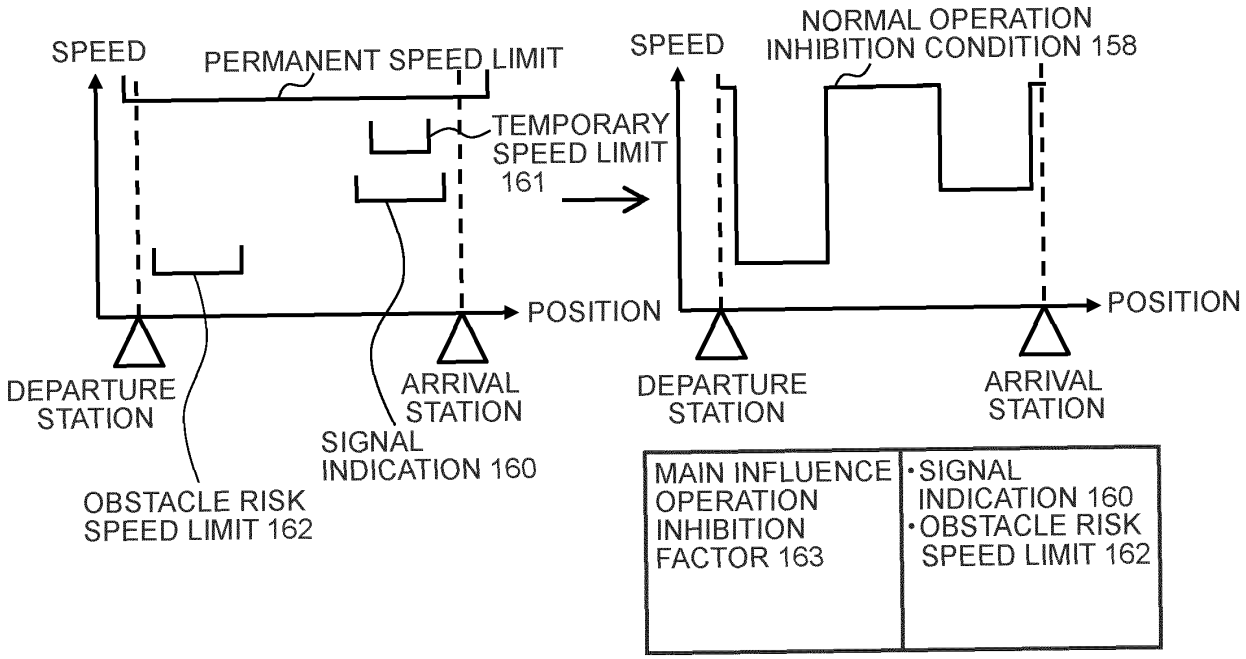

SPEED
PERMANENT SPEED LIMIT
TEMPORARY SPEED LIMIT 161
POSITION
DEPARTURE STATION
ARRIVAL STATION
SIGNAL INDICATION 160
OBSTACLE RISK SPEED LIMIT 162
SPEED
NORMAL OPERATION INHIBITION CONDITION 158
POSITION
DEPARTURE STATION
ARRIVAL STATION
MAIN INFLUENCE OPERATION INHIBITION FACTOR 163
• SIGNAL INDICATION 160
• OBSTACLE RISK SPEED LIMIT 162

FIG. 5

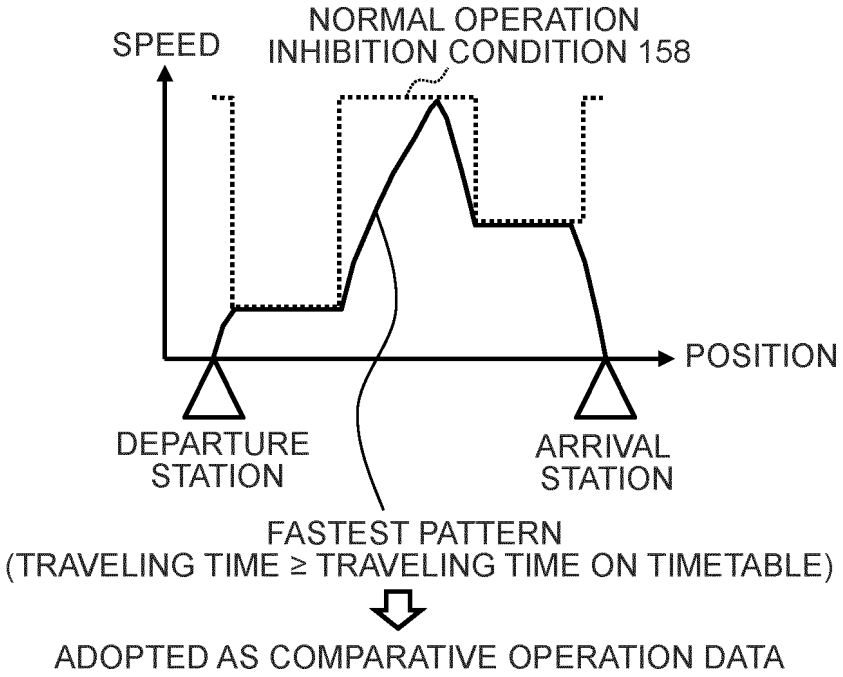

SPEED
NORMAL OPERATION
INHIBITION CONDITION 158
POSITION
DEPARTURE
STATION
ARRIVAL
STATION
FASTEST PATTERN
(TRAVELING TIME ≥ TRAVELING TIME ON TIMETABLE)
ADOPTED AS COMPARATIVE OPERATION DATA

FIG. 6

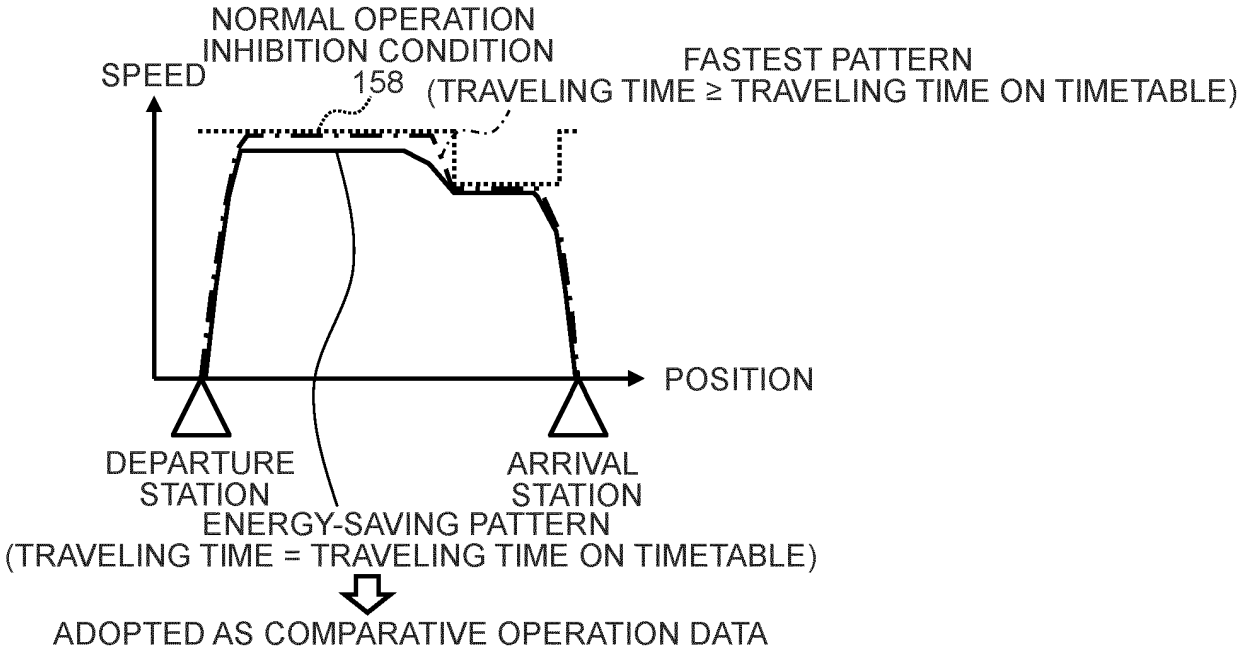

NORMAL OPERATION
INHIBITION CONDITION
158
SPEED
FASTEST PATTERN
(TRAVELING TIME ≥ TRAVELING TIME ON TIMETABLE)
POSITION
DEPARTURE STATION
ARRIVAL STATION
ENERGY-SAVING PATTERN
(TRAVELING TIME = TRAVELING TIME ON TIMETABLE)
ADOPTED AS COMPARATIVE OPERATION DATA

FIG. 7

	EVALUATION REFERENCE VALUE (PAST OPERATION DATA SEARCH, ENERGY SAVING)	ACTUAL VALUE	DIFFE-RENCE
INTER-STATION TRAVELING TIME [SEC]	155	158	+3
INTER-STATION POWER CONSUMPTION AMOUNT [kWh]	46	48	+2

FIG. 8

	EVALUATION REFERENCE VALUE (PAST OPERATION DATA SEARCH, AVERAGE)	ACTUAL VALUE	DIFFE-RENCE
INTER-STATION TRAVELING TIME [SEC]	155	158	+3
INTER-STATION POWER CONSUMPTION AMOUNT [kWh]	50	48	-2

FIG. 9

	EVALUATION REFERENCE VALUE (OPERATION SIMULATION)	ACTUAL VALUE	DIFFE-RENCE
INTER-STATION TRAVELING TIME [SEC]	150	158	+8
INTER-STATION POWER CONSUMPTION AMOUNT [kWh]	44	48	+4

FIG. 10

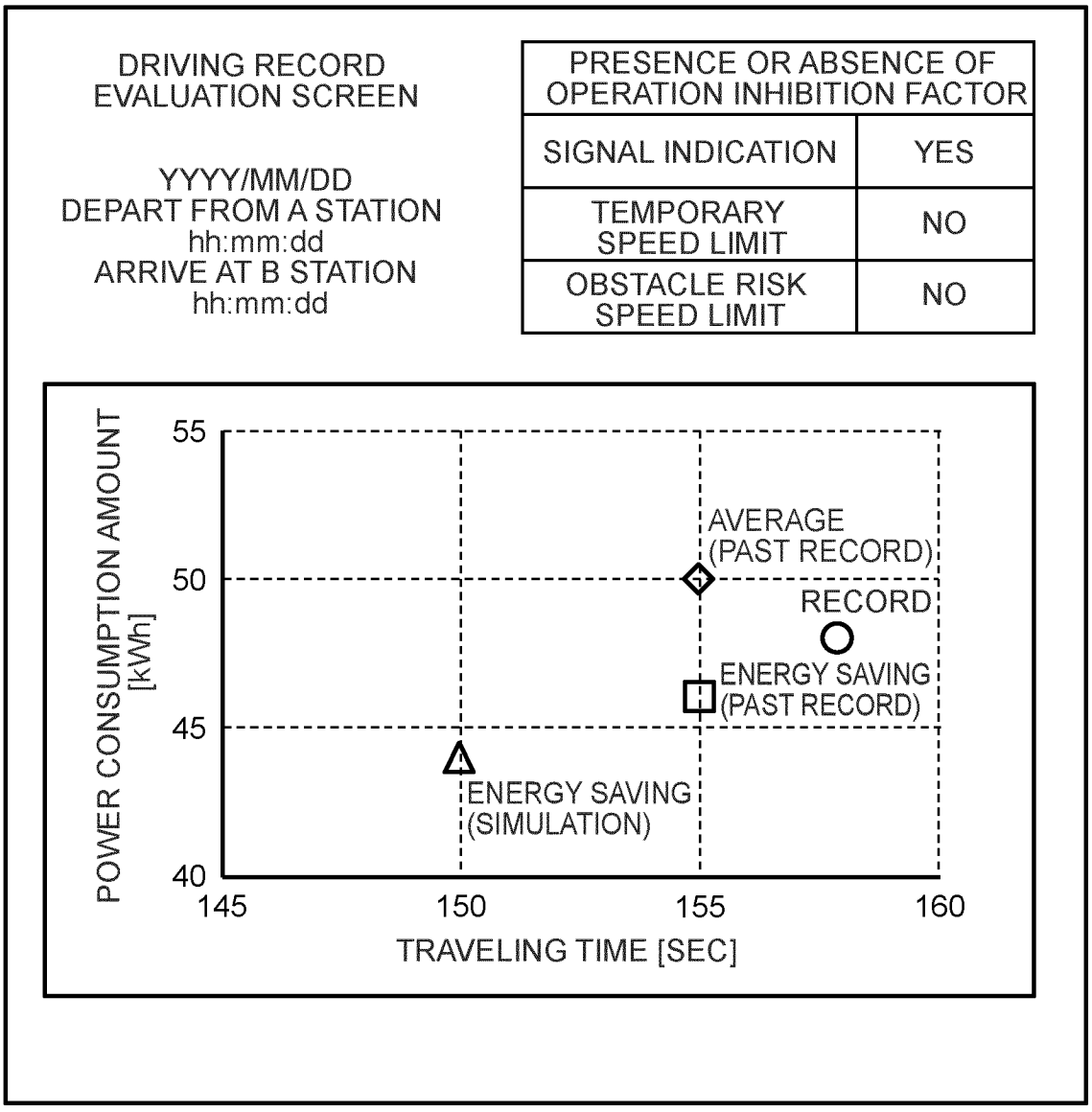

DRIVING RECORD EVALUATION SCREEN
YYYY/MM/DD
DEPART FROM A STATION
hh:mm:dd
ARRIVE AT B STATION
hh:mm:dd
PRESENCE OR ABSENCE OF OPERATION INHIBITION FACTOR
SIGNAL INDICATION
YES
TEMPORARY SPEED LIMIT
NO
OBSTACLE RISK SPEED LIMIT
NO
POWER CONSUMPTION AMOUNT [kWh]
55
50
45
40
145
150
155
160
TRAVELING TIME [SEC]
AVERAGE (PAST RECORD)
RECORD
ENERGY SAVING (PAST RECORD)
ENERGY SAVING (SIMULATION)

FIG. 11

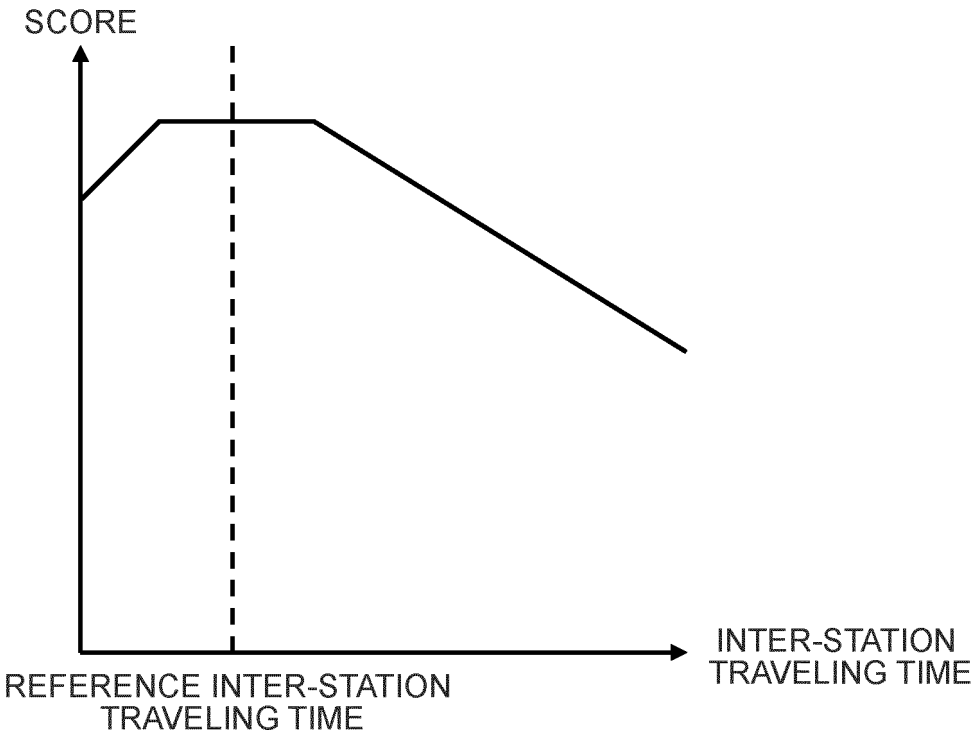

SCORE
INTER-STATION TRAVELING TIME
REFERENCE INTER-STATION TRAVELING TIME

FIG. 12

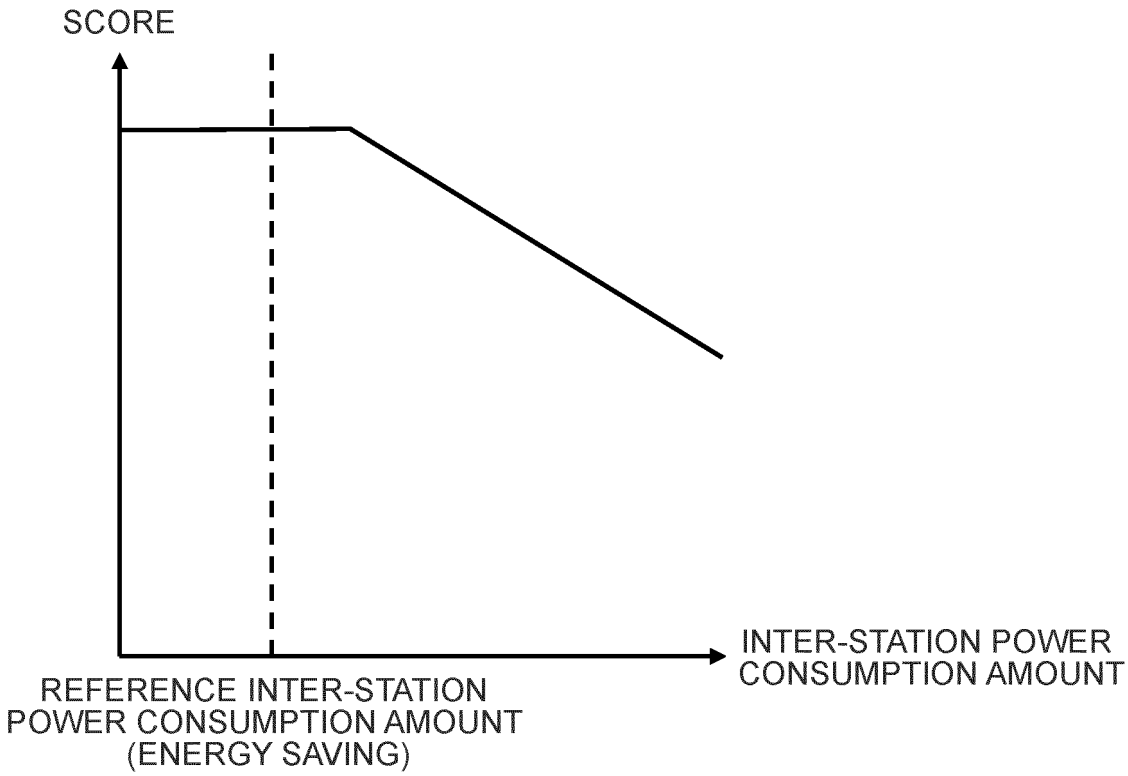

SCORE
INTER-STATION POWER CONSUMPTION AMOUNT
REFERENCE INTER-STATION POWER CONSUMPTION AMOUNT (ENERGY SAVING)

FIG. 13

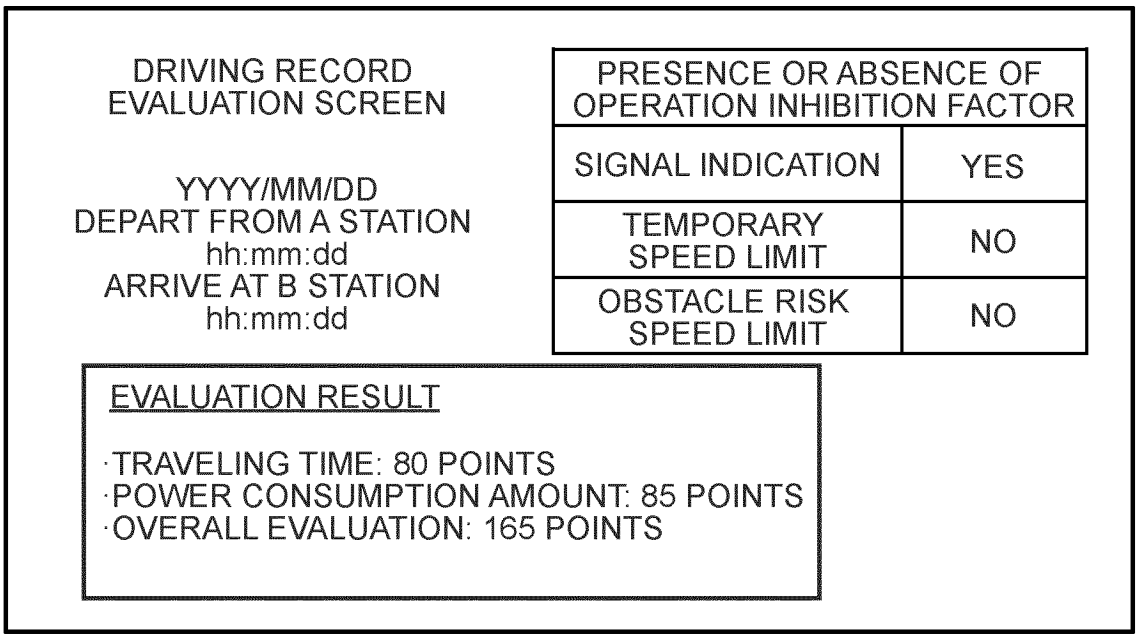
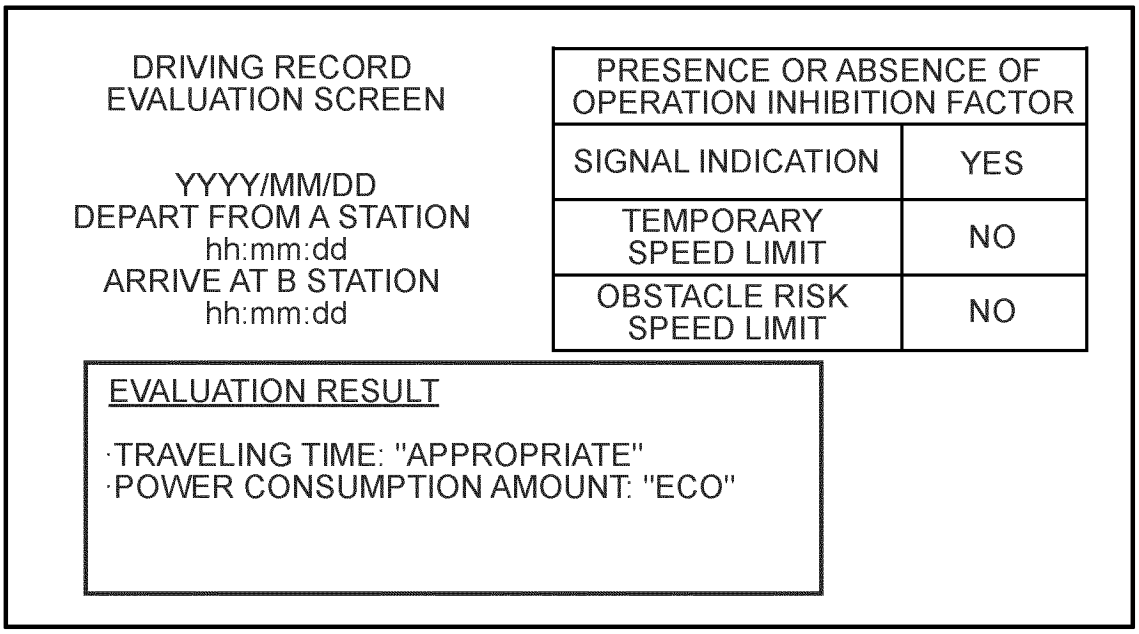

DRIVING RECORD EVALUATION SCREEN
YYYY/MM/DD
DEPART FROM A STATION
hh:mm:dd
ARRIVE AT B STATION
hh:mm:dd
PRESENCE OR ABSENCE OF OPERATION INHIBITION FACTOR
SIGNAL INDICATION
YES
TEMPORARY SPEED LIMIT
NO
OBSTACLE RISK SPEED LIMIT
NO
EVALUATION RESULT
·TRAVELING TIME: 80 POINTS
·POWER CONSUMPTION AMOUNT: 85 POINTS
·OVERALL EVALUATION: 165 POINTS

FIG. 14


DRIVING RECORD
EVALUATION SCREEN
YYYY/MM/DD
DEPART FROM A STATION
hh:mm:dd
ARRIVE AT B STATION
hh:mm:dd
PRESENCE OR ABSENCE OF OPERATION INHIBITION FACTOR
SIGNAL INDICATION
YES
TEMPORARY SPEED LIMIT
NO
OBSTACLE RISK SPEED LIMIT
NO
EVALUATION RESULT
·TRAVELING TIME: "APPROPRIATE"
·POWER CONSUMPTION AMOUNT: "ECO"

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/044958

A. CLASSIFICATION OF SUBJECT MATTER

B61L 27/12(2022.01)i
FI: B61L27/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61L27/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-184052 A (CENTRAL JAPAN RAILWAY CO) 14 August 2008 (2008-08-14) paragraphs [0028]-[0073], fig. 1-3	1-17
A	JP 2020-134757 A (RAILWAY TECHNICAL RES INST) 31 August 2020 (2020-08-31) paragraphs [0022]-[0114], fig. 1-18	1-17
A	JP 2015-182684 A (HITACHI LTD) 22 October 2015 (2015-10-22) paragraphs [0014]-[0267], fig. 1-17	1-17
A	JP 2009-190473 A (KOZO KEIKAKU ENGINEERING INC) 27 August 2009 (2009-08-27) paragraphs [0014]-[0028], fig. 1-4	1-17
A	JP 2015-77912 A (TOSHIBA CORP) 23 April 2015 (2015-04-23) paragraphs [0008]-[0058], fig. 1-10	1-17
A	JP 2016-155442 A (HITACHI LTD) 01 September 2016 (2016-09-01) paragraphs [0012]-[0092], fig. 1-11	1-17

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 January 2023	**31 January 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/044958

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2008-184052 A	14 August 2008	(Family: none)	
JP 2020-134757 A	31 August 2020	(Family: none)	
JP 2015-182684 A	22 October 2015	(Family: none)	
JP 2009-190473 A	27 August 2009	(Family: none)	
JP 2015-77912 A	23 April 2015	(Family: none)	
JP 2016-155442 A	01 September 2016	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2020134757 A **[0006]**