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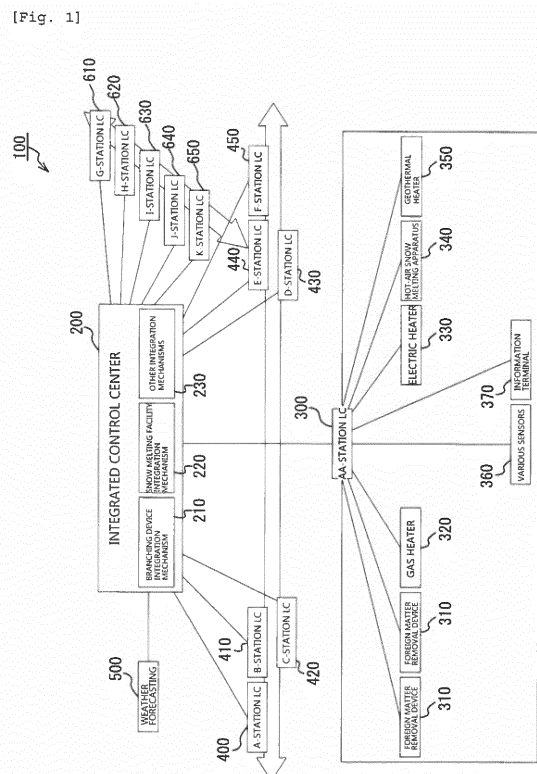
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(54) **FOREIGN MATTER REMOVAL SYSTEM FOR TRACK BRANCH PARTS AND FOREIGN MATTER REMOVAL DEVICE FOR TRACK BRANCH PART**

(57) To provide a foreign matter removal system for track branch parts and a foreign matter removal device for a track branch part, which can promote energy saving for the entire rail line in which the foreign matter removal apparatus is disposed without deteriorating foreign matter removal performance. In a foreign matter removal system 100 for track branch parts, an integrated control center 200 and an AA-station LC 300 can switch over a plurality of operation modes of a plurality of foreign matter removal devices 310 for track branch part based on the operation state of a train.



## Description

### Technical field

**[0001]** The present invention relates to a foreign matter removal system for track branch parts and a foreign matter removal device for a track branch part, which remove foreign matters in the vicinity of a track branch part of a railway with air injection.

### Background Art

**[0002]** Conventionally, snow or ice may be held between a base rail and a tongue rail of a track branch part as a result of snow and ice accreted to a car falling thereon due to vibration when the car passes the track branch part, or as a result of snow depositing thereon, thus causing a problem that non-shifting of the tongue rail occurs. For that reason, various foreign matter removal devices for track branch part have been developed.

**[0003]** For example, Patent Literature 1 (Japanese Patent Laid-Open No. 2005-344355) discloses a foreign matter removal device for a track branch part, which removes a foreign matter present between a base rail and a tongue rail at the time of retry operation which is performed when a point switching failure occurs.

**[0004]** The foreign matter removal device for a track branch part according to Patent Literature 1 (Japanese Patent Laid-Open No. 2005-344355) is a foreign matter removal device for a track branch part, which removes a foreign matter fallen between a base rail and a tongue rail of a track branch part by injecting compressed air into between the base rail and the tongue rail. The aforementioned device injects compressed air while the tongue rail is returning to a normal position or after it has been moved to the normal position in retry operation of a track branch part in which the tongue rail is reversed to return to the normal position and then is switched to a shifted position again upon occurrence of a point switching failure when the position of the tongue rail is switched from the normal position to the shifted position.

### Citation List

#### Patent Literature

**[0005]** Patent Literature 1: Japanese Patent Laid-Open No. 2005-344355

### Summary of Invention

#### Technical Problem

**[0006]** The foreign matter removal device for a track branch part according to Patent Literature 1 (Japanese Patent Laid-Open No. 2005-344355) can remove foreign matters present between the basic rail and the tongue

rail at the time of retry operation which is performed when point switching failure occurs. Since injection is performed only when a point switching failure is likely to happen, such a control scheme is desirable in the aspect of energy saving.

**[0007]** On the other hand, in the above described control scheme, since point switching failure will occur at least once, the total time for point switching will increase. Therefore, in the aspect of foreign matter removal performance, a control scheme in which injection is performed every time the track branch part is switched is more desirable.

**[0008]** From what described so far, it is an objective of the present invention to provide a foreign matter removal system for track branch parts, and a foreign matter removal device for a track branch part, which can promote energy saving for the entire rail line in which the foreign matter removal device is disposed, without deteriorating the foreign matter removal performance.

#### Solution to Problem

##### [0009]

(1) A foreign matter removal system for track branch parts according to one aspect of the present invention includes a plurality of foreign matter removal devices which are each disposed at a track branch part, and are switchable among a plurality of operation modes, and a control center which changes the operation modes of the plurality of foreign matter removal devices based on an operation state of a train.

**[0010]** In the foreign matter removal system for track branch parts relating to the present invention, the control center can switch over a plurality of operation modes of the plurality of foreign matter removal devices for track branch part based on the operation state of a train.

**[0011]** In this case, since the operation modes of the foreign matter removal devices can be switched individually or in unison, it is possible to select an optimum operation mode according to the operation state of a train. As a result of that, it is possible to promote energy saving for the entire rail line in which the foreign matter removal devices are disposed without deteriorating foreign matter removal performance. In particular, such effect is maximized by individually switching the operation mode in accordance with the location where the foreign matter removal device is installed.

##### [0012]

(2) In the foreign matter removal system for track branch parts according to the one aspect, a foreign matter removal system for track branch parts relating to a second invention may be configured such that the operation state of a train includes at least information on a quantity of snow accreted to the train.

**[0013]** In this case, the snow accreted to the train reflects a snowfall state or a snow cover state of a travelled rail line. For that reason, by reflecting the concerned state as information to the control operation of the foreign matter removal device of the travelled rail line, it is made possible to optimally operate the concerned foreign matter removal device.

**[0014]** Further, regarding the rail line on which the train is going to travel from now, since there is possibility that the snow accreted to the train falls onto a track branch part, it is possible to optimally operate the concerned foreign matter removal device by feed-forwarding the concerned state as information to the control of the foreign matter removal device which is disposed on the rail line on which the concerned train is going to travel.

**[0015]**

(3) In the foreign matter removal system relating to the second invention, a foreign matter removal system relating to a third invention may further include a communication terminal device for inputting information of the quantity of snow accreted to the train, wherein the information inputted by the communication terminal device may be transmitted to the control center.

**[0016]** In this case, such information can be notified to the control center by inputting the quantity of snow confirmed by a station staff with a communication terminal device when the train stops at a station, without using a special sensor, etc.

**[0017]**

(4) In the foreign matter removal system relating to the second invention, a foreign matter removal system relating to a fourth invention may further include an image sensor for picking up an image of the train, and transmitting a result of analysis of a quantity of snow accreted to the train from the image, or transmitting the image to the control center.

**[0018]** In this case, it is possible to grasp the quantity of accreted snow by only installing an image pickup device, even at a passing station at which the train does not stop, or any position between stations, and picking up an image of a snow accreting state of a train passing the concerned station, and transmitting information of the quantity of accreted snow with a communication sensor.

**[0019]**

(5) In the foreign matter removal system relating to any of the second to the fourth inventions, a foreign matter removal system relating to a fifth invention may further include a snow melting apparatus located in the track branch part and controlled by the control center, wherein the operation state of a train may further include a working state of the snow melting apparatus.

**[0020]** In this case, it is possible to change the operation mode of the foreign matter removal device, which is disposed in a same region as, or in a different region from that of the snow melting apparatus, in accordance with the working state of the snow melting apparatus. Further, it is possible to change the control of the snow melting apparatus in one control center. As a result of that, it is possible to promote energy saving for the entire rail line.

**[0021]**

(6) In the foreign matter removal system relating to any of the one aspect to the fifth invention, a foreign matter removal system relating to a sixth invention is preferably configured such that the foreign matter removal device is switchable among a retry injection operation mode, a preventive injection operation mode, a pre-shifting injection operation mode, an intermittent injection operation mode, or any combination of the each operation mode.

**[0022]** In this case, since the foreign matter removal device can be operated based on a plurality of operation modes, it is possible to more precisely balance the foreign matter removal performance with the energy saving thereof. Note that the retry injection operation mode is a control mode in which compressed air is injected prior to a shifting operation when performing the shifting operation again after shifting failure occurs; the preventive injection operation mode is a control mode in which compressed air is injected every time detecting a passage of train regardless of the shifting operation; the pre-shifting injection operation mode is a control mode in which compressed air is injected prior to the shifting operation; and the intermittent injection operation mode is a control mode in which compressed air is injected at a predetermined time interval regardless of the shifting operation.

**[0023]**

(7) In the foreign matter removal system relating to any of the one aspect to the sixth invention, a foreign matter removal system relating to a seventh invention may be configured such that the foreign matter removal device for a track branch part selects an operation mode which has the highest removing performance and automatically switches over thereto when communication with the control center becomes disabled.

**[0024]** In this case, since the foreign matter removal device for a track branch part automatically selects an operation mode having a high removing performance even when communication with the control center is disabled, it can ensure a foreign matter removal performance even when the situation changes and a high foreign matter removal performance becomes required.

**[0025]**

(8) A foreign matter removal device according to an-

other aspect is included in the foreign matter removal system relating to the one aspect, and is switchable among at least a retry injection operation mode, a preventive injection operation mode, a pre-shifting injection operation mode, or an intermittent injection operation mode.

**[0026]** In this case, since the foreign matter removal device can be operated based on a plurality of operation modes, it is possible to more precisely balance the foreign matter removal performance with the energy saving thereof.

#### Brief Description of Drawings

#### **[0027]**

[Figure 1] Figure 1 is a schematic diagram showing an example of a foreign matter removal system relating to the present embodiment.

[Figure 2] Figure 2 is a schematic diagram for explaining a configuration of a foreign matter removal device.

[Figure 3] Figure 3 is an explanatory diagram for explaining control ranks.

[Figure 4] Figure 4 is a flowchart of a retry injection mode.

[Figure 5] Figure 5 is a flowchart of a pre-shifting injection mode.

[Figure 6] Figure 6 is a flowchart of a preventive injection mode.

[Figure 7] Figure 7 is a flowchart of an intermittent injection mode.

[Figure 8] Figure 8 is a flowchart showing an example of the operation of an AA-station LC.

[Figure 9] Figure 9 is a flowchart of visual confirmation by a station staff, etc.

[Figure 10] Figure 10 is a flowchart for explaining an example of the perception of snow accretion state by a sensor.

[Figure 11] Figure 11 is a flowchart showing an example of changing of control rank of the foreign matter removal device.

[Figure 12] Figure 12 is a schematic diagram showing another example of the foreign matter removal system.

#### Reference Signs List

#### **[0028]**

100, 100a Foreign matter removal system for track branch parts  
 200, 200a Integrated control center  
 300 AA-station local control center  
 310 Foreign matter removal device for track branch part  
 320 Gas heater

330 Electric heater  
 340 Hot-air snow melting apparatus  
 350 Geothermal heater  
 360 Various sensors (image sensors, etc.)  
 370 Information terminal

#### Description of Embodiments

**[0029]** Hereinafter, embodiments relating to the present invention will be described by using the drawings. In the following description, like components are given like reference symbols. Their names and functions are identical as well. Therefore, detailed description thereof will not be repeated.

**[0030]** Note that in the present embodiment, an aspect in which a nozzle for a foreign matter removal device for a track branch part is applied to a track for a railway car. Note that the nozzle for the foreign matter removal device for a track branch part can be utilized not only for the track for a railway vehicle, but also in other tracks such as conventional lines.

#### (Configuration of Foreign Matter Removal Device for Track Branch Part)

**[0031]** Figure 1 is a schematic diagram showing an example of a foreign matter removal system 100 relating to the present embodiment.

**[0032]** The foreign matter removal system 100 shown in Figure 1 shows a case in which the foreign matter removal system 100 is applied to rail lines of a first railway car and a second railway car.

**[0033]** As shown in Figure 1, the foreign matter removal system 100 includes an integrated control center 200.

**[0034]** The integrated control center 200 includes a branching device integration mechanism 210, a snow melting facility integration mechanism 220, and other integration mechanisms 230. Moreover, the integrated control center 200 is connected with a weather forecasting 500 so that weather information is provided to the integrated control center 200.

**[0035]** In the rail line of the first railway car, various stations are respectively provided with an A-station local control center (hereinafter, abbreviated as LC) 400, a B-station LC 410, a C-station LC 420, an AA-station LC 300, a D-station LC 430, an E-station LC 440, and an F-station LC 450.

**[0036]** Further, in the rail line of the second railway car, various stations are respectively provided with a G-station LC 610, an H-station LC 620, an I-station LC 630, a J-station LC 640, and a K-station LC 650.

**[0037]** Here, the AA-station LC 300 will be described as an example. The AA-station LC 300 is connected with a plurality of foreign matter removal devices 310, various sensors 360, and an information terminal 370. Further, it is also connected with a gas heater 320, an electric heater 330, a hot-air snow melting apparatus 340, and a geothermal heater 350, which each are a snow melting

apparatus.

**[0038]** The various sensors 360 include a snowfall sensor by use of a photoelectric sensor, a train passage detection sensor by use of an ultrasonic sensor, an image sensor made up of an image pickup device, an infrared sensor, and any other sensors. The LC of each station is provided with various apparatuses as in the AA-station LC.

(Configuration of Foreign Matter Removal Device)

**[0039]** Next, Figure 2 is a schematic diagram for explaining a configuration of the foreign matter removal device 310.

**[0040]** As shown in Figure 2, the foreign matter removal device 310 includes a control device 311, a compressor 312, an air tank 313, an electromagnetic valve 314, an injection nozzle 315, and a buzzer 317.

**[0041]** The control device 311 of the foreign matter removal device 310 communicates with the AA-station LC 300.

**[0042]** Moreover, the control device 311 provides a control command to the compressor 312, and the compressor 312 accumulates compressed air in the air tank 313. Further, the control device 311 provides a control command to the electromagnetic valve 314. The electromagnetic valve 314 opens/closes based on the control command so that compressed air is injected from the injection nozzle 315.

**[0043]** Further, the control device 311 provides a control command to the buzzer 317. As a result of that, the buzzer sounds.

(Description of Operation Mode)

**[0044]** Next, examples of the operation mode of the foreign matter removal device 310 relating to the present invention include the following four major operation modes. Note that other than the four major operation modes, a forced injection in which injection is manually performed by an operator at a remote site, and the like can be named.

**[0045]** The first of the four operation modes is a retry injection mode in which compressed air is automatically injected prior to shifting operation when shifting operation is performed again upon occurrence of shifting failure of the point. This mode is performed any number of times until the shifting operation is completed. The second is a pre-shifting injection mode in which compressed air is injected immediately before the point is shifted. The third is a preventive injection mode in which compressed air is injected automatically in a preventive manner after passage of the train, for example, after 10 seconds from the passage, in preparation for the passage of a train coming next. The fourth is an intermittent injection mode in which compressed air is automatically injected at a predetermined time interval, for example, at one hour interval.

**[0046]** Moreover, in the present embodiment, a control

rank is set individually for the combinations of these operation modes. Hereinafter, the control rank will be described, and thereafter, each operation mode will be described.

(Description of Control Rank)

**[0047]** Figure 3 is an explanatory diagram for explaining the control rank.

**[0048]** As shown in Figure 3, rank 1 of the control rank indicates the retry injection mode alone; rank 2 of the control rank indicates a combination of the retry injection mode and the pre-shifting injection mode; rank 3 of the control rank indicates a combination of the retry injection mode, the pre-shifting injection mode, and the preventive injection mode; and rank 4 of the control rank indicates a combination of the retry injection mode, the pre-shifting injection mode, the preventive injection mode, and the intermittent injection mode.

**[0049]** Moreover, consumption energy is set to be low in rank 1, and consumption energy is set to be higher as approaching to rank 4.

**[0050]** That is, since in the retry injection mode, automatic injection will not occur unless shifting failure of the point occurs, it is possible to suppress energy consumption a low level when, for example, the snow coverage or the snow carried by the train is small in quantity.

(Retry Injection Mode)

**[0051]** Next, the retry injection mode will be described in detail. Figure 4 is a flowchart of a retry injection mode.

**[0052]** In the retry injection mode, it is determined whether or not non-shifting has occurred when the tongue rail has moved with respect to the base rail, and the tongue rail is not normally driven when 8 seconds have passed from the start of the movement (step S31).

**[0053]** On the other hand, when it is determined that non-shifting has not occurred (No in step S31), since shifting has been reliably performed, the retry injection mode will not be performed and the processing will be ended.

**[0054]** On the other hand, when it is determined that non-shifting has occurred (Yes in step S31), the retry injection mode is performed, and it is determined whether or not the residual quantity of the air tank 313 is not less than predetermined (step S32). For example, it is determined whether or not the residual quantity of the air tank 313 is not less than 0.78 MPa.

**[0055]** When the residual quantity of the air tank 313 is less than predetermined (No in step S32), the processing is ended.

**[0056]** When the residual quantity of the air tank 313 is not less than predetermined (Yes in step S32), detection of the retry operation of the point is performed (step S33). When the retry operation is not detected (No in step S33), the foreign matter removal device 310 stands by until the retry operation is detected.

**[0057]** On the other hand, when the retry operation is detected (Yes in step S34), performance of injection is announced by the buzzer 317 (step S34).

**[0058]** Next, the electromagnetic valve 314 is opened (step S35). Then, it is determined whether or not 2.5 seconds have passed after the electromagnetic valve 314 is opened (step S36). When it is determined that 2.5 seconds have not passed (No in step S36), the electromagnetic valve 314 is opened to inject compressed air.

**[0059]** On the other hand, when it is determined that 2.5 seconds have passed (Yes in step S36), the electromagnetic valve 314 is closed (step S37). After the electromagnetic valve 314 is closed, the process returns to the processing of step S31.

(Pre-Shifting Injection Mode)

**[0060]** Next, the pre-shifting injection mode will be described in detail. In the pre-shifting injection mode, injection is performed when switching the point of a track branch part. Figure 5 is a flowchart of a pre-shifting injection mode.

**[0061]** In the pre-shifting injection mode, first, it is determined whether or not a point shifting command is present (step S41). When it is determined that a point shifting command is not present (No in step S41), the processing is ended.

**[0062]** On the other hand, when it is determined that a point shifting command is present (Yes in step S41), it is determined whether or not the residual quantity of the air tank 313 is not less than predetermined (step S42). For example, it is determined if the residual quantity of the air tank 313 is not less than 0.78 MPa.

**[0063]** When the residual quantity of the air tank 313 is less than predetermined (No in step S42), the processing is ended.

**[0064]** When the residual quantity of the air tank 313 is not less than predetermined (Yes in step S42), performance of injection is announced by the buzzer 317 (step S43).

**[0065]** Next, the electromagnetic valve 314 is opened (step S44). Then, it is determined whether or not 2.5 seconds have passed after the electromagnetic valve 314 is opened (step S45). When it is determined that 2.5 seconds have not passed (No in step S45), the electromagnetic valve 314 is opened to inject compressed air.

**[0066]** On the other hand, when it is determined that 2.5 seconds have passed (Yes in step S45), the electromagnetic valve 314 is closed (step S46).

(Preventive Injection Mode)

**[0067]** Next, the preventive injection mode will be described in detail. In the preventive injection mode, injection is performed in advance of passage of a next train. Figure 6 is a flowchart of a preventive injection mode.

**[0068]** In the preventive injection mode, first, it is determined whether or not a train passage detection sensor

included in various sensors 360 has been turned on (step S51). When it is determined that the train passage detection sensor has not been turned on (No in step S51), the processing is ended.

5 **[0069]** On the other hand, when it is determined that the train passage detection sensor has been turned on (Yes in step S51), it is determined whether or not the residual quantity of the air tank 313 is not less than predetermined (step S52). For example, it is determined if the residual quantity of the air tank 313 is not less than 0.78 MPa.

10 **[0070]** When the residual quantity of the air tank 313 is less than predetermined (No in step S52), the processing is ended.

15 **[0071]** When the residual quantity of the air tank 313 is not less than predetermined (Yes in step S52), performance of injection is announced by the buzzer 317 (step S53).

20 **[0072]** Next, the electromagnetic valve 314 is opened (step S54). Then, it is determined whether or not 2.5 seconds have passed after the electromagnetic valve 314 is opened (step S55). When it is determined that 2.5 seconds have not passed (No in step S55), the electromagnetic valve 314 is opened to inject compressed air.

25 **[0073]** On the other hand, when it is determined that 2.5 seconds have passed (Yes in step S55), the electromagnetic valve 314 is closed (step S56).

(Outline of Intermittent Injection Mode)

30 **[0074]** Next, the intermittent injection mode will be described in detail. In the intermittent injection mode, injection is performed at intervals of constant period of time. Figure 7 is a flowchart of an intermittent injection mode.

35 **[0075]** In the intermittent injection mode, first, it is determined whether or not a predetermined time period has passed from the previous injection (step S61). When it is determined that the predetermined time period has not passed from the previous injection (No in step S61), the processing is ended.

40 **[0076]** On the other hand, when it is determined that the predetermined time period has passed (Yes in step S61), it is determined whether or not the residual quantity of the air tank 313 is not less than predetermined (step S62). For example, it is determined if the residual quantity of the air tank 313 is not less than 0.78 MPa.

45 **[0077]** When the residual quantity of the air tank 313 is less than predetermined (No in step S62), the processing is ended.

50 **[0078]** When the residual quantity of the air tank 313 is not less than predetermined (Yes in step S62), performance of injection is announced by the buzzer 317 (step S63).

55 **[0079]** Next, the electromagnetic valve 314 is opened (step S64). Then, it is determined whether or not 2.5 seconds have passed after the electromagnetic valve 314 is opened (step S65). When it is determined that 2.5 seconds have not passed (No in step S65), the electromag-

netic valve 314 is opened to inject compressed air.

**[0080]** On the other hand, when it is determined that 2.5 seconds have passed (Yes in step S65), the electromagnetic valve 314 is closed (step S66).

**[0081]** Thus, having a plurality of operation modes which have different foreign matter removal performances makes it possible to effectively utilize operation modes which exhibit different consumption energy. Moreover, by changing the use methods thereof, it is possible to efficiently ensure point switching of a track branch part.

(Flowchart of Local Control Center Side)

**[0082]** Next, the operation on the AA-station LC 300 side will be described. Figure 8 is a flowchart showing an example of the operation of the AA-station LC 300.

**[0083]** As shown in Figure 8, first, the AA-station LC 300 sets an initial value of the control rank (step S1).

**[0084]** Here, although it will be different depending on the season or weather information, for example, the retry injection mode is set as the initial value.

**[0085]** Moreover, the weather information includes, other than the information announced from the Meteorological agency, information from sensors such as a snowfall meter provided in a location where the foreign matter removal device 310 is installed. Note that the weather information may be determined by a time series.

**[0086]** For example, in a case in which there has been snowfall in the previous night, and the temperature at the present (at the time of initial setting) is not more than 0°, a combination of the retry injection mode, the pre-shifting injection mode, the preventive injection mode, and the intermittent injection mode is set as the initial value from a predetermined period of time before the first train, and after a predetermined period of time has passed, the setting is switched to that of the retry injection mode alone.

**[0087]** Next, it is determined whether or not the snow accretion state of the lower part of train is not less than a predetermined quantity (step S2).

**[0088]** Here, the predetermined quantity means the quantity of snow accretion which has accreted in a predetermined range in which the concerned train has passed from a station etc. where snow accretion is confirmed, to a track branch part which is the control target. Moreover, the concerned predetermined range indicates, for example, a range of at least 3 stations backward.

**[0089]** Note that an example of determination of snow accretion state of a train will be described later.

**[0090]** In step S2, when it is determined that the snow accretion state of the lower part of train corresponds to a predetermined quantity (the predetermined quantity in step S2), the control rank in an area is maintained at a predetermined stage (step S3). Here, the area refers to a same station yard or the vicinity of the station.

**[0091]** Note that the control rank may be changed by one rank, or changed by two or more ranks, for a single control. In the latter case, the changing width of rank can

be appropriately decided based on an information source, for example, information from a station staff and information of the kind of the sensor and the layout of the sensor, or the location of the station to which the system which is supposed to be the information source belongs. For example, the changing width of rank may be appropriately weighted based on such as difference between a place in the same station yard and a remote place such as another prefecture.

**[0092]** Note that the predetermined quantity may be any quantity within a predetermined range having an upper limit and a lower limit.

**[0093]** Moreover, in step S2, when it is determined that the snow accretion state of the lower part of train corresponds to less than the predetermined quantity (less than the predetermined quantity in step S2), the control rank in the area is reduced down to the predetermined stage (step S4).

**[0094]** Further, in step S2, when it is determined that the snow accretion state of the lower part of train corresponds to more than the predetermined quantity (exceeding the predetermined quantity in step S2), the control rank in the area is raised up to the predetermined stage (step S5).

**[0095]** Next, it is determined whether or not the working state of the snow melting apparatus corresponds to not less than a predetermined value (step S6).

**[0096]** Where, the snow melting apparatus includes a gas heater 320, an electric heater 330, a hot-air snow melting apparatus 340, a geothermal heater 350, and the like. Moreover, the working state includes the number of operations or the working time of various apparatuses.

**[0097]** Note that the predetermined value may be any value within a predetermined range having an upper limit and a lower limit.

**[0098]** In step S6, when it is determined that the working state of the snow melting apparatus corresponds to a predetermined value (normal in step S6), the control rank of the foreign matter removal device 310 in one station is maintained at a predetermined stage (step S7).

**[0099]** In step S6, when it is determined that the working state of the snow melting apparatus corresponds to less than a predetermined value (less than the predetermined quantity in step S6), the control rank of the foreign matter removal device 310 in one station is reduced down to a predetermined stage (step S8).

**[0100]** Next, in step S6, when it is determined that the working state of the snow melting apparatus corresponds to more than a predetermined value (more than the predetermined quantity in step S6), the control rank of the foreign matter removal device 310 in one station is raised up to a predetermined stage (step S9).

**[0101]** Further, although not shown in the drawings, it may be determined whether or not the various sensors 360 exhibit not less than a predetermined value, and the control rank of the foreign matter removal device 310 may be changed as with the judgment flow of the working state of the snow melting apparatus.

**[0102]** Finally, it is determined whether or not it is within a time period from after the last train to before the first train (step S10).

**[0103]** When it is determined that it is out of the time period from after the last train to before the first train (No in step S10), the control rank of the foreign matter removal device 310 whose control rank has been determined to be changed is changed, and the control rank of the foreign matter removal device 310 whose control rank has been determined to be maintained is maintained. Then, the process returns to step S2, and repeats the processing.

**[0104]** On the other hand, when it is determined that it is within the time period from after the last train to before the first train (Yes in step S10), the control of the foreign matter removal device 310 is stopped (step S12). Thereafter, the process returns to step S1, and repeats the processing.

(Confirmation by Station Staff, Operation of Tablet Terminal)

**[0105]** Next, description will be made on a case in which a station staff confirms snow accretion state at a stopping station or a terminal station. Figure 9 is a flowchart of visual confirmation by a station staff, etc.

**[0106]** First, as shown in Figure 9, the snow accretion state of the lower part of train is visually confirmed by a station staff, etc. in the concerned station (step S71).

**[0107]** Next, the station staff determines whether or not the snow accretion state of the lower part of train corresponds to not less than a reference quantity (step S72). When determined to correspond to not less than the reference quantity (Yes in step S72), the station staff inputs information through a smartphone or a tablet terminal which corresponds to the information terminal 370 (step S73). Then, the information is transmitted to the AA-station LC 300 or the integrated control center 200 (step S74).

**[0108]** On the other hand, when determined to correspond to less than the reference quantity (No in step S72), the processing is ended.

(Confirmation by Sensor)

**[0109]** Next, description will be made on a case in which the snow accretion state is confirmed by an image sensor included in the various sensors 360 at a stopping station, a terminal station, or a passing station. Figure 10 is a flowchart to explain an example of recognition of the snow accretion state by the concerned image sensor.

**[0110]** First, as shown in Figure 10, an image of the snow accretion state of the lower part of train is picked up by the concerned image sensor at a stopping station, a terminal station, or a passing station (step S81). Next, it is determined whether or not the snow accretion state of the lower part of train corresponds to not less than a reference quantity (step S82).

**[0111]** This determination is made such as based on the fact that a white portion is predominant in the color of the image pickup data picked up by the concerned image sensor. Moreover, although an image sensor targeted for a visible light range is to be used, this is not limiting, and it may be an image sensor targeted for an infrared light range. Moreover, the snow accretion state may be judged not by color, but by grasping the snow accretion state as a shape change.

**[0112]** Next, it is determined whether or not the snow accretion state of the lower part of train corresponds to not less than a reference quantity (step S82). When determined to correspond to not less than the reference quantity (Yes in step S82), information is transmitted to the AA-station LC 300 or the integrated control center 200 (step S83).

**[0113]** On the other hand, when determined to correspond to less than the reference quantity (No in step S82), the processing is ended.

**[0114]** These processings of Figures 9 and 10 make it possible to transmit a snow accretion state of a train to the AA-station LC 300 and the integrated control center 200.

(Control Mode of Foreign Matter Removal Device)

**[0115]** Next, changing of the control rank of the foreign matter removal device 310 of the AA-station LC 300 will be described. Figure 11 is a flowchart showing an example of changing of the control rank of the foreign matter removal device 310.

**[0116]** First, as shown in Figure 11, it is determined whether or not there is instruction for changing control rank (step S21). When it is determined that there is instruction for changing control rank (Yes in step S21), it is determined whether or not there is instruction for stopping control (step S22). When it is determined that there is no instruction for stopping control (No in step S22), the process moves to processing of step S25 to be described below.

**[0117]** On the other hand, when it is determined that there is instruction for stopping control (Yes in step S22), the control is stopped (step S23).

**[0118]** Next, it is determined whether or not there is instruction for changing control rank (step S24). When it is determined that there is instruction for changing control rank (Yes in step S24), the control rank is changed (step S25).

**[0119]** When it is determined that there is no instruction for changing control rank (No in step S24), the process returns to step S23 and repeats the processing.

**[0120]** Moreover, when it is determined that there is no instruction for changing control rank (No in step S21), it is determined whether or not communication is disabled (step S26). When it is determined that communication is disabled (Yes in step S26), the control rank is set to the highest (step S27), and the process moves to the processing of step S28.

**[0121]** Moreover, when it is determined that communication is not disabled (No in step S26), the process moves to the processing of step S28.

**[0122]** When the control rank is changed (step S25), and after the processing of steps S26 and S27, foreign matter removal operation is performed according to the control rank (step S28).

(Another Example)

**[0123]** Next, Figure 12 is a schematic diagram showing another example of the foreign matter removal system 100 of Figure 1.

**[0124]** As shown in Figure 12, a foreign matter removal system 100a may be directly controlled from an integrated control center 200a for the entire rail line, not from an LC of each station.

**[0125]** As so far described, since, in the present embodiment, the operation mode of the foreign matter removal device 310 can be switched between a plurality of control ranks, it is possible to select optimal one or more operation modes according to the operating state of a train. As a result of that, it is possible to promote energy saving for the entire rail line in which the foreign matter removal device 310 is disposed, without deteriorating the foreign matter removal performance.

**[0126]** Moreover, since the snow accreted to a train reflects the snowfall state or snow cover state of a travelled rail line, it is possible to optimally operate the concerned foreign matter removal device 310 by reflecting the concerned state to the control operation of the foreign matter removal device 310 of the travelled rail line.

**[0127]** For example, in the case of a train which travels from the G-station to the A-station passing the E-station, it acquires information on a J-station LC 640, a K-station LC 650, and an E-station LC 440, and predicts the snow accretion state at the AA-station LC 300 to select the operation mode of the foreign matter removal device 310.

**[0128]** Further, regarding a rail line to be travelled by the concerned train, since there is possibility that the snow accreted to the train falls onto a track branch part, it is possible to optimally operate the foreign matter removal device 310, which is disposed in the rail line to be travelled, based on the concerned state.

**[0129]** Moreover, it is possible to reliably and conveniently transmit information to the AA-station LC 300 by detecting the snow accretion state of a train with an image sensor, or confirming it by a station staff, and inputting it through an information terminal 370.

**[0130]** Moreover, in the AA-station LC 300, it is possible to change the operation mode of the foreign matter removal device 310 of the AA-station LC 300 in accordance with the control rank and operation mode information of the snow melting apparatus such as a gas heater 320, an electric heater 330, a hot-air snow melting apparatus 340, and a geothermal heater 350, and the foreign matter removal device 310 of the LC of another station. Further, as a result of that, it is possible to promote

energy saving for the entire rail line.

**[0131]** Further, since the foreign matter removal device 310 for track branch part itself automatically selects an operation mode of a high removal performance even when communication with the AA-station LC 300 or/and the integrated control center 200a is disabled, it can ensure a foreign matter removal performance.

**[0132]** In the present invention, the retry injection operation mode, the preventive injection operation mode, the pre-shifting injection operation mode, and the intermittent injection operation mode correspond to a plurality of operation modes; the foreign matter removal device 310 for track branch part corresponds to a plurality of foreign matter removal devices for track branch part; the AA-station LC 300 or the integrated control center 200, 200a corresponds to the control center; the foreign matter removal system 100, 100a for track branch parts corresponds to the foreign matter removal system 100 for track branch parts; the information terminal 370 corresponds to the communication terminal device; the image sensor included in the various sensors 360 corresponds to the image pickup device; and the gas heater 320, the electric heater 330, the hot-air snow melting apparatus 340, and the geothermal heater 350 correspond to the snow melting apparatus.

**[0133]** Although a preferred embodiment of the present invention is as described above, the present invention will not be limited to it alone. It will be understood that various other embodiments will be made without departing from the spirit and scope of the present invention. Further, although operations and effects according to the configuration of the present invention have been described in the present embodiment, these operations and effects are an example, and will not limit the present invention.

## Claims

1. A foreign matter removal system for track branch parts, comprising:
  - a plurality of foreign matter removal devices which are each disposed at a track branch part, and are switchable among a plurality of operation modes; and
  - a control center which changes the operation modes of the plurality of foreign matter removal devices based on an operation state of a train.
2. The foreign matter removal system for track branch parts according to claim 1, wherein the operation state of a train includes at least information on a quantity of snow accreted to the train.
3. The foreign matter removal system for track branch parts according to claim 2, further comprising:

a communication terminal device for inputting information of a quantity of snow accreted to the train, wherein the information of the quantity of snow inputted by the communication terminal device is transmitted to the control center. 5

- 4. The foreign matter removal system for track branch parts according to claim 2, further comprising: 10

an image sensor for picking up an image of the train, and transmitting a result of analyzing a quantity of snow accreted to the train from the image, or transmitting the image to the control center. 15

- 5. The foreign matter removal system for track branch parts according to any one of claims 2 to 4, further comprising: 20

a snow melting apparatus located in the track branch part and controlled by the control center, wherein the operation state of a train further includes a working state of the snow melting apparatus. 25

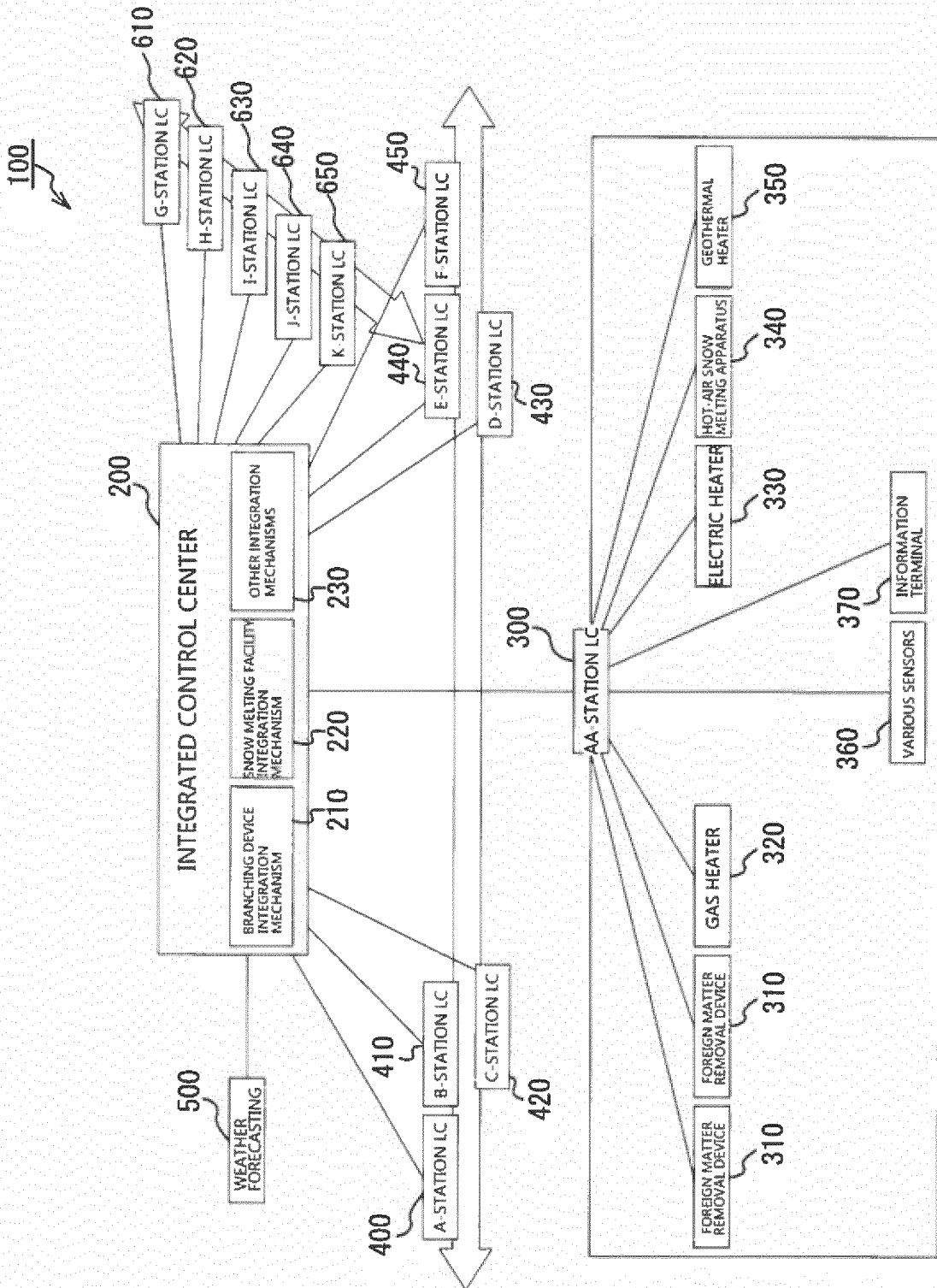
- 6. The foreign matter removal system for track branch parts according to any one of claims 1 to 5, wherein the foreign matter removal device is switchable among a retry injection operation mode, a preventive injection operation mode, a pre-shifting injection operation mode, an intermittent injection operation mode, or any combination of the each operation mode. 30 35

- 7. The foreign matter removal system for track branch parts according to any one of claims 1 to 6, wherein the foreign matter removal device for a track branch part selects an operation mode which has a highest removing performance and automatically switches over thereto when communication with the control center becomes disabled. 40

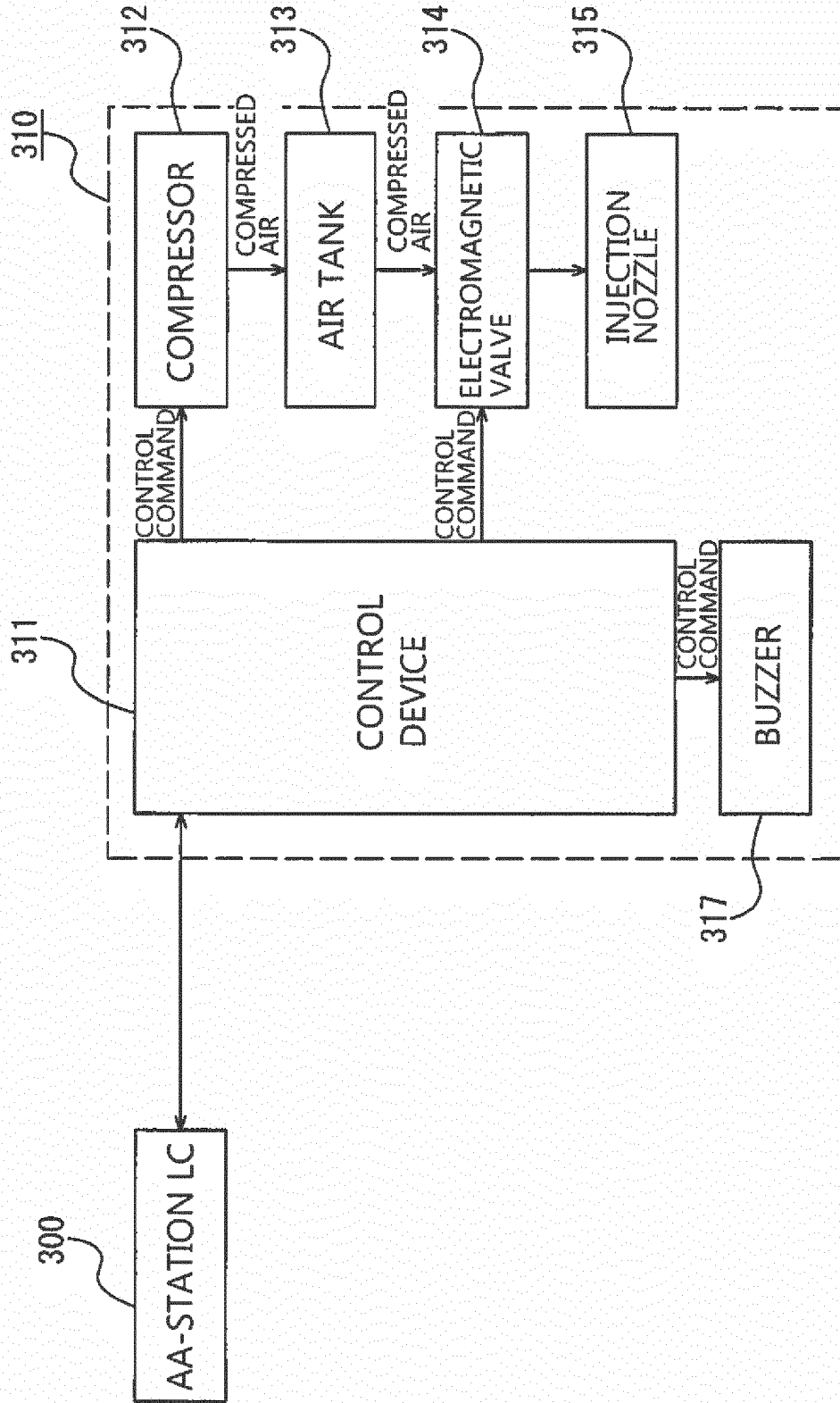
- 8. A foreign matter removal device for a track branch part, which is included in the foreign matter removal system according to claim 1, and is switchable among at least a retry injection operation mode, a preventive injection operation mode, a pre-shifting injection operation mode, or an intermittent injection operation mode. 45 50

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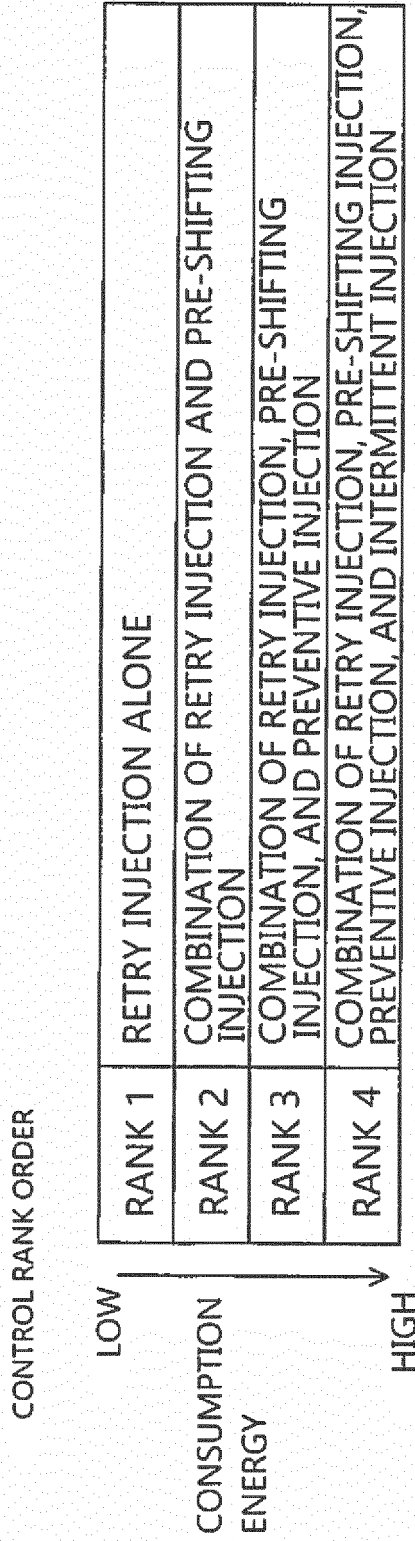
[Fig. 1]



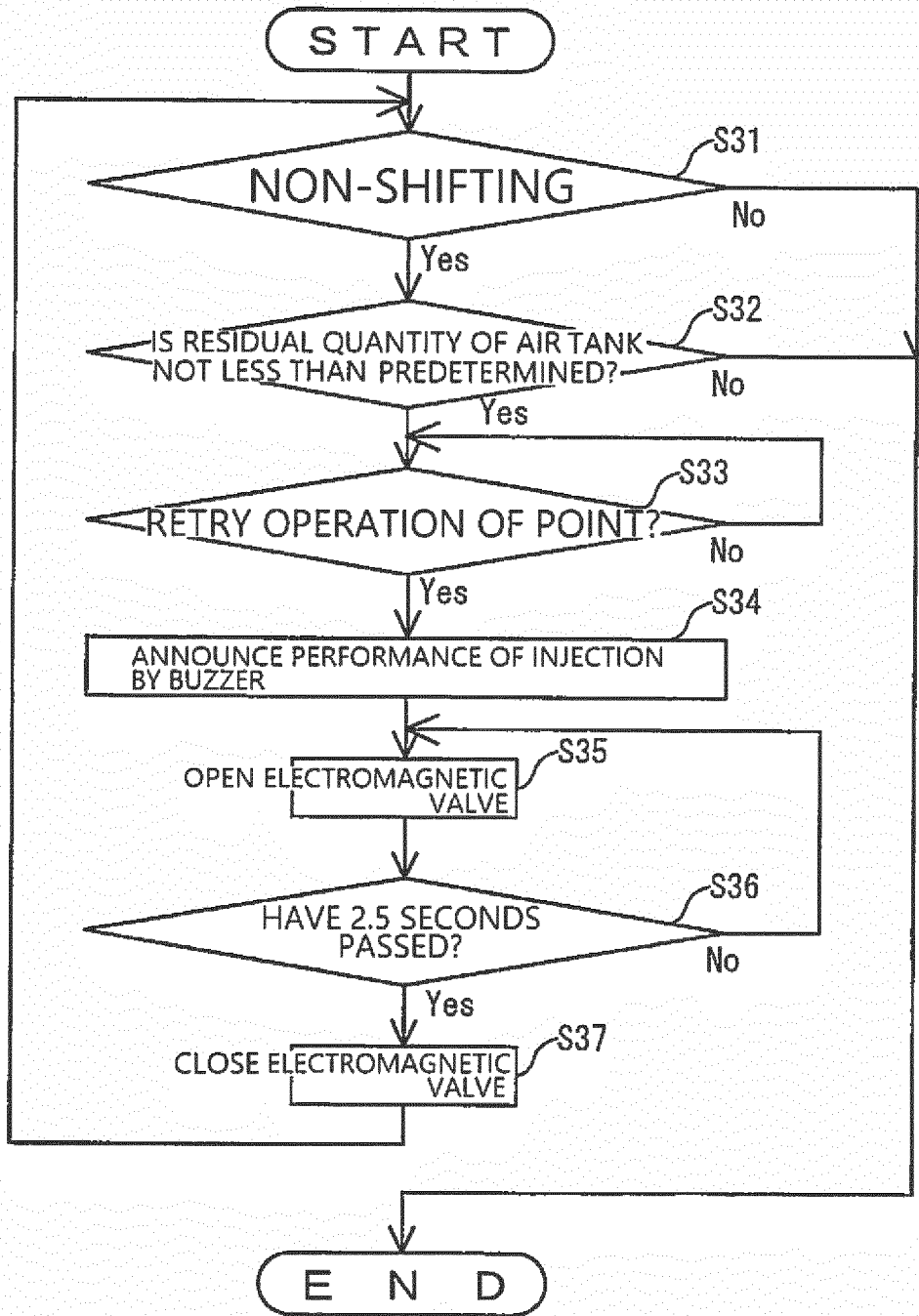
[Fig. 2]



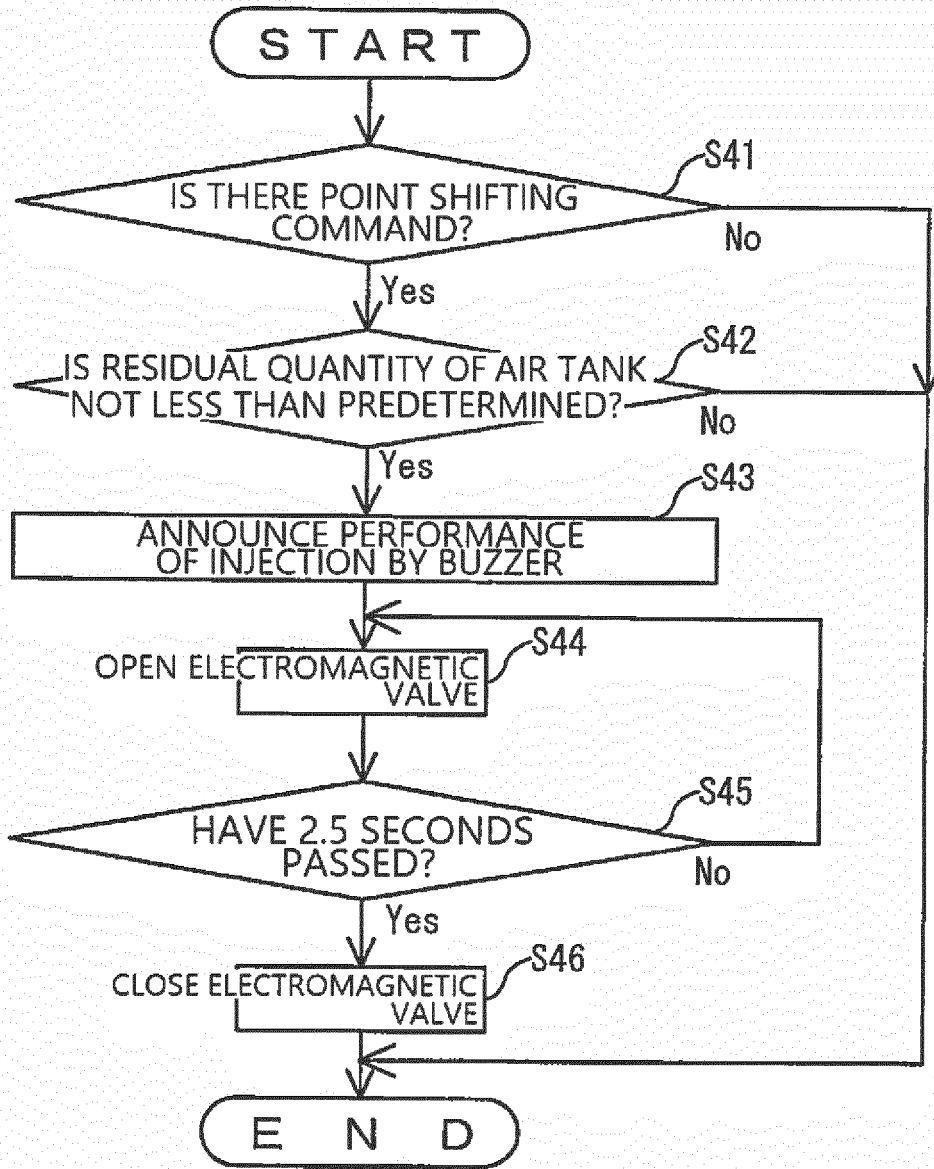
[Fig. 3]



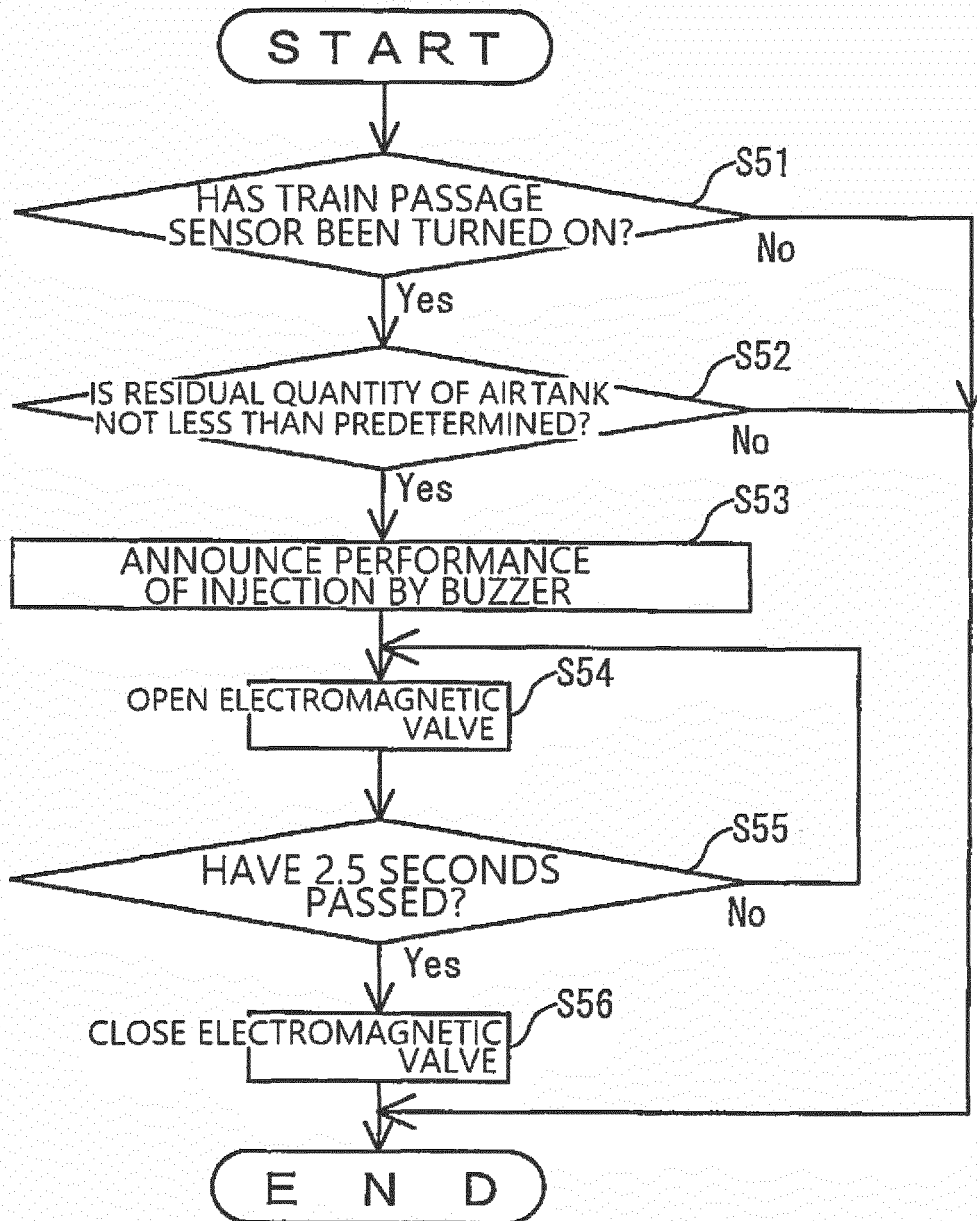
[Fig. 4]



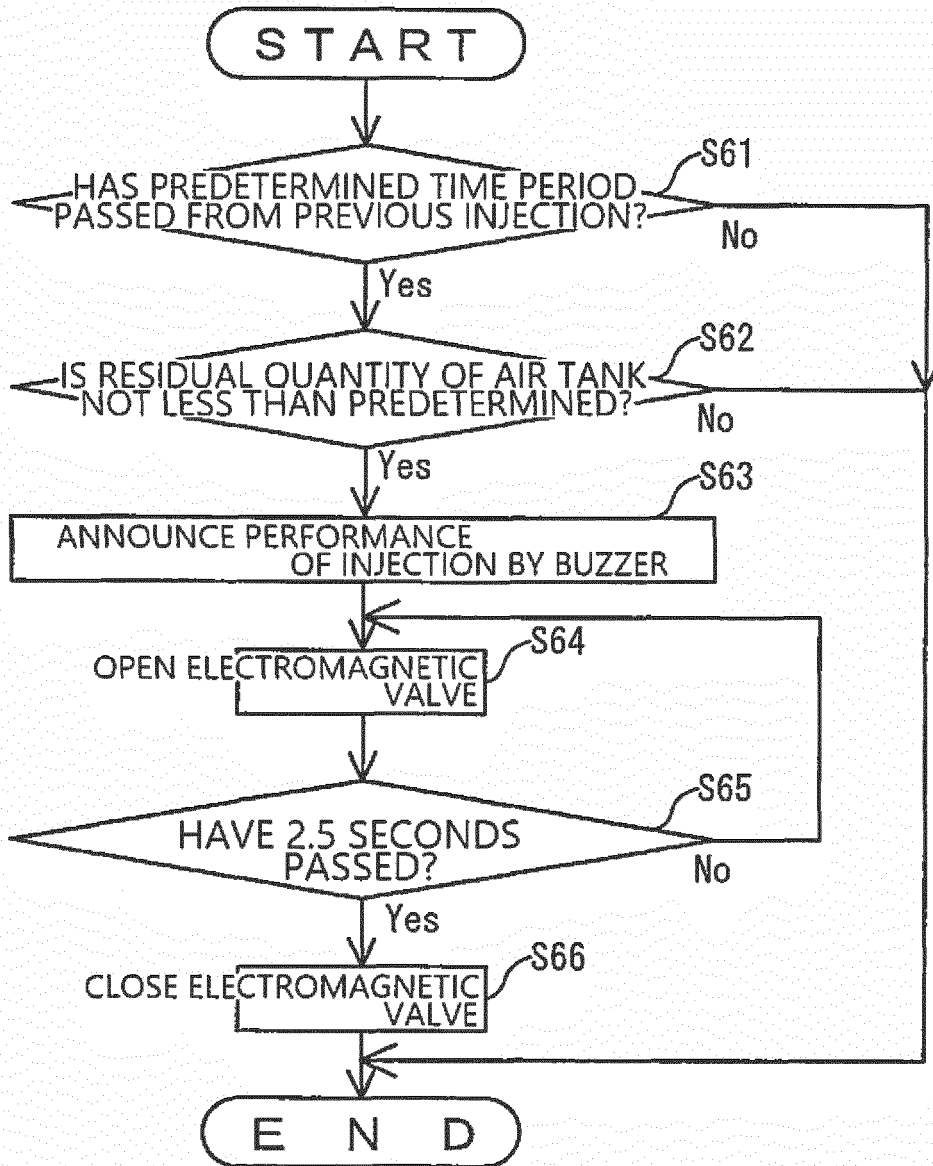
[Fig. 5]



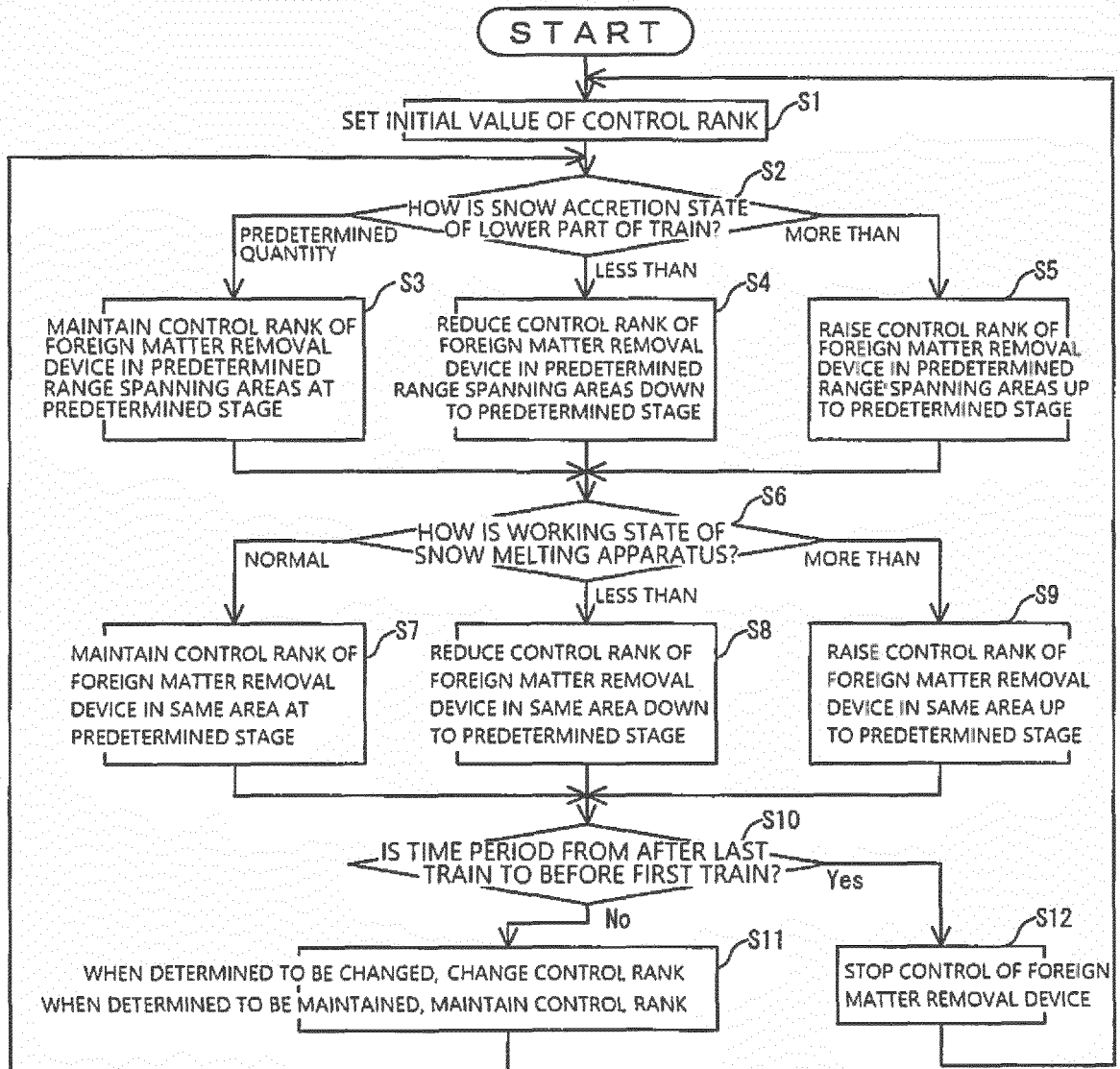
[Fig. 6]



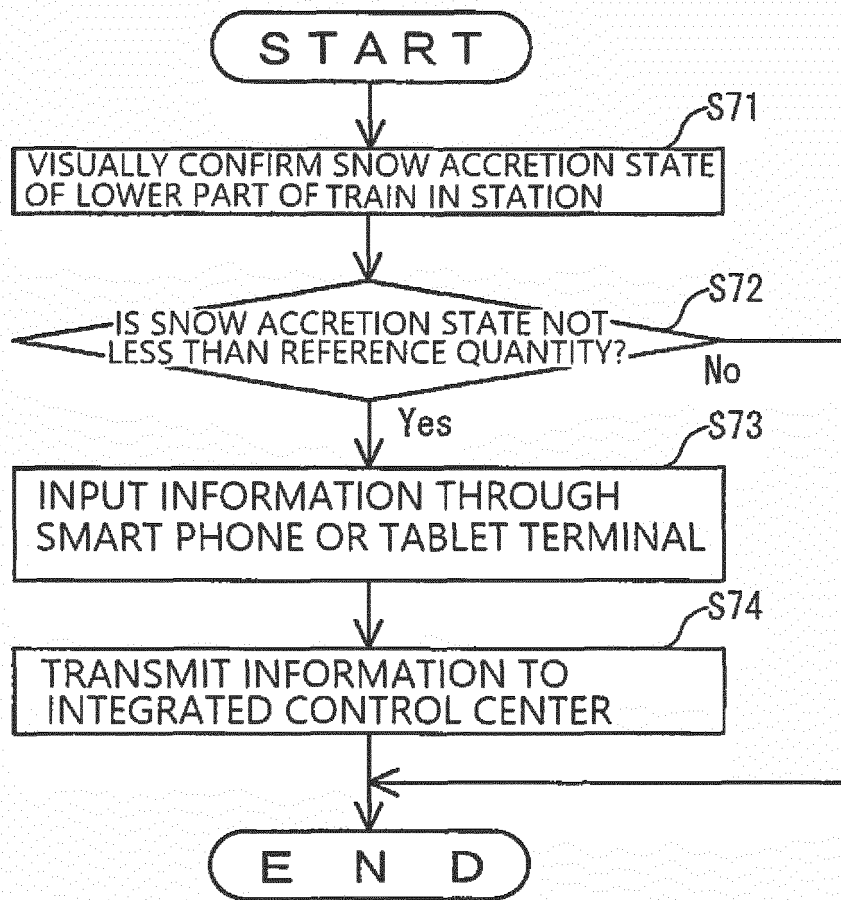
[Fig. 7]



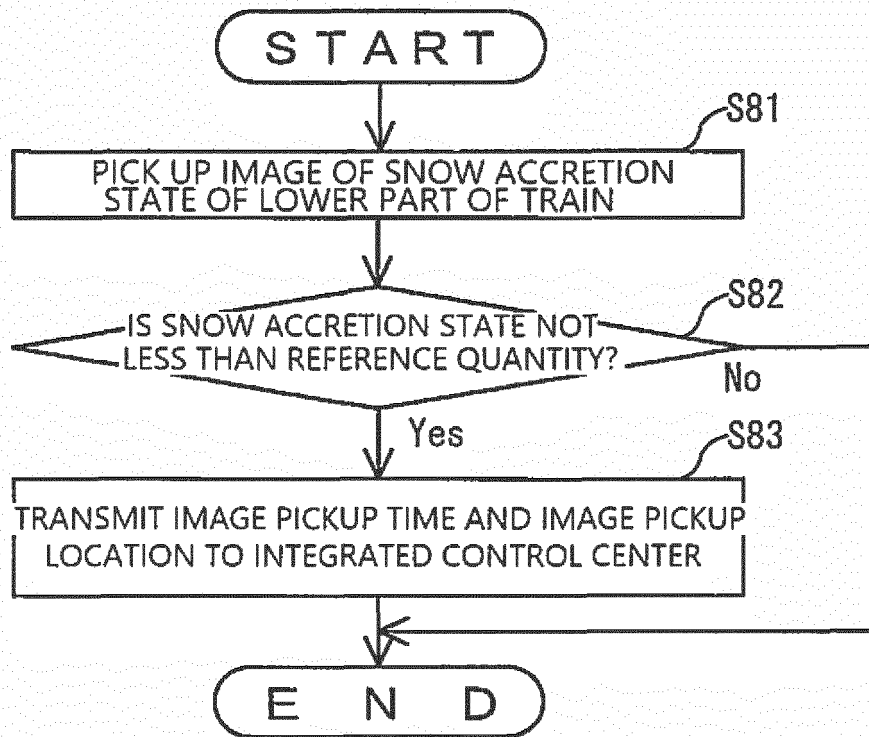
[Fig. 8]



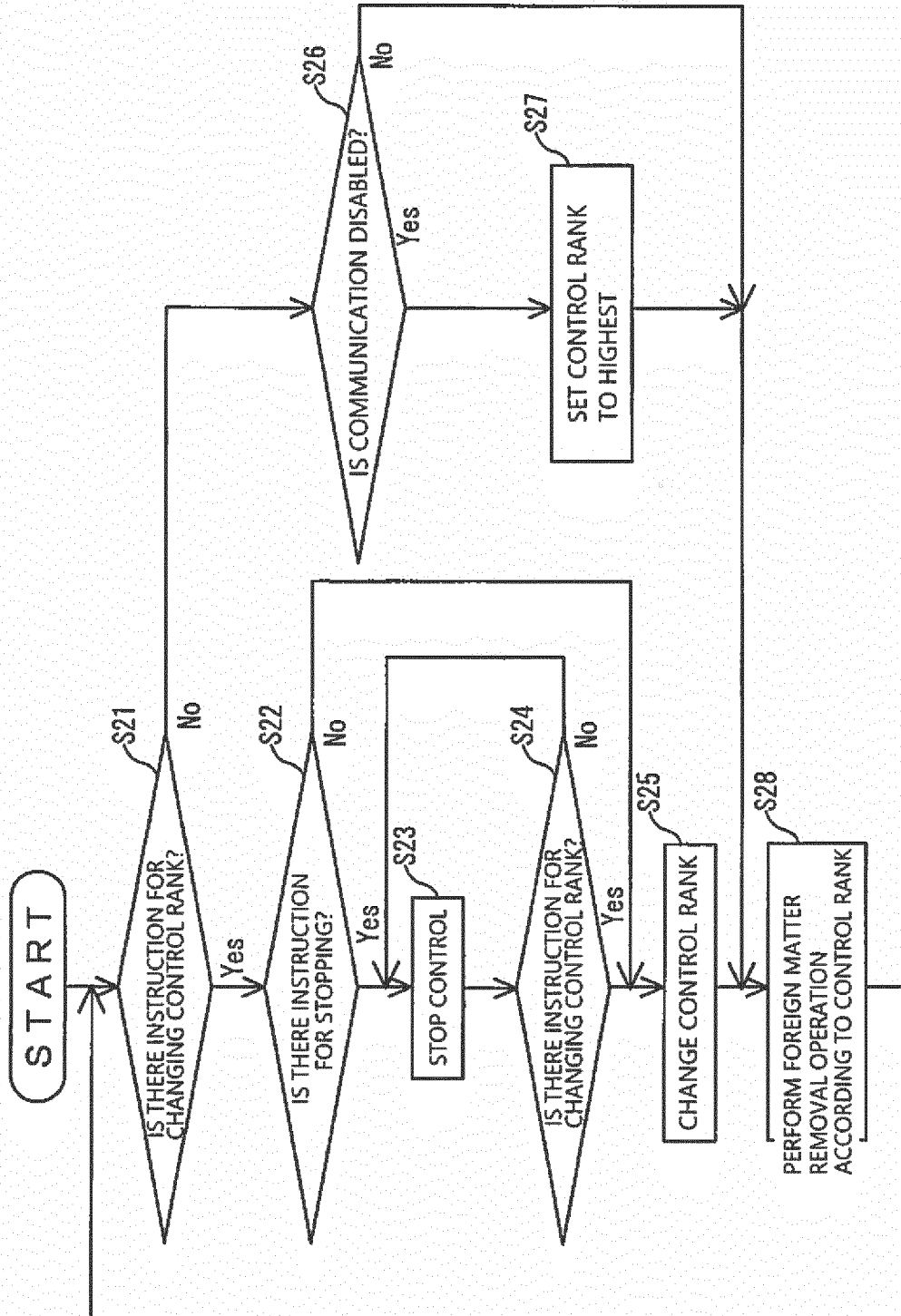
[Fig. 9]



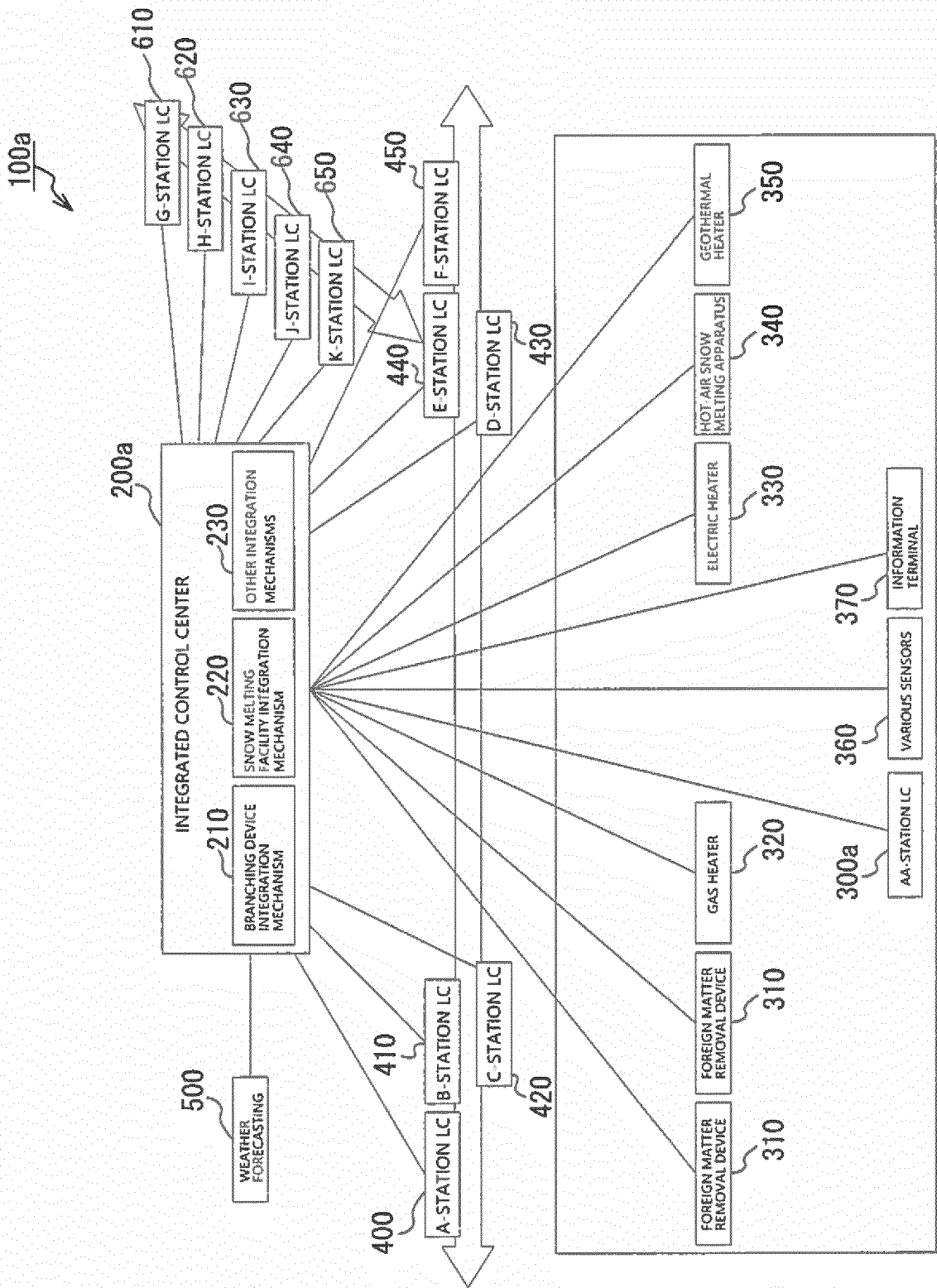
[Fig. 10]



[Fig. 11]



[Fig. 12]



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/005057

5	A. CLASSIFICATION OF SUBJECT MATTER <i>E01B19/00(2006.01)i, E01B7/20(2006.01)i, E01H8/10(2006.01)i</i>	
	According to International Patent Classification (IPC) or to both national classification and IPC	
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) <i>E01B19/00, E01B7/20, E01H8/10</i>	
15	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched <i>Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014</i> <i>Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014</i>	
	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
	Category*	Citation of document, with indication, where appropriate, of the relevant passages
25	A	WO 2013/038657 A1 (East Japan Railway Co. et al.), 21 March 2013 (21.03.2013), entire text; all drawings & EP 2765239 A1 & CA 2848310 A & CN 103946454 A
30	A	JP 2001-131935 A (Hokkaido Railway Co. et al.), 15 May 2001 (15.05.2001), entire text; all drawings (Family: none)
35	A	JP 2000-144602 A (Nabco Ltd. et al.), 26 May 2000 (26.05.2000), entire text; all drawings (Family: none)
40	<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.	
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "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
50	Date of the actual completion of the international search 24 December 2014 (24.12.14)	Date of mailing of the international search report 13 January 2015 (13.01.15)
55	Name and mailing address of the ISA/ Japan Patent Office	Authorized officer
	Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2005344355 A [0003] [0004] [0005] [0006]