(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 3 892 518 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
13.10.2021 Bulletin 2021/41

(21) Application number: **19892752.7**

(22) Date of filing: **11.11.2019**

(51) Int Cl.:
B61L 23/14 *(2006.01)*

(86) International application number:
PCT/CN2019/117092

(87) International publication number:
WO 2020/114204 (11.06.2020 Gazette 2020/24)

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

(30) Priority: **05.12.2018 CN 201811480041**

(71) Applicant: **CRRC Changchun Railway Vehicles Co., Ltd.**
Changchun, Jilin 130000 (CN)

(72) Inventors:
- **WANG, Huawei**
  Jilin 130000 (CN)
- **YAN, Weiwei**
  Jilin 130000 (CN)
- **MA, Xiaoming**
  Jilin 130000 (CN)
- **CHEN, Tianyu**
  Jilin 130000 (CN)
- **FAN, Jun**
  Jilin 130000 (CN)

(74) Representative: **Mewburn Ellis LLP**
Aurora Building
Counterslip
Bristol BS1 6BX (GB)

(54) **TRAIN SPEED LIMIT CONTROL METHOD AND DEVICE**

(57) A train speed limit control method and device. The train speed limit control method comprises: detecting whether instability occurs during travelling of a train (S201, S301, S401, S501); if it is detected that instability occurs during travelling of the train, braking the train to limit the train speed to a first speed for traveling (S202, S302, S402, S502). The train speed limit control method implements automatic speed limit control during travelling of a train. The application of the train speed limit control method to train travel control can reduce the labor intensity of the driver, and automatically and timely limit the train speed when instability occurs during traveling of the train, thereby effectively preventing train travel safety from being affected by the driver's negligence.

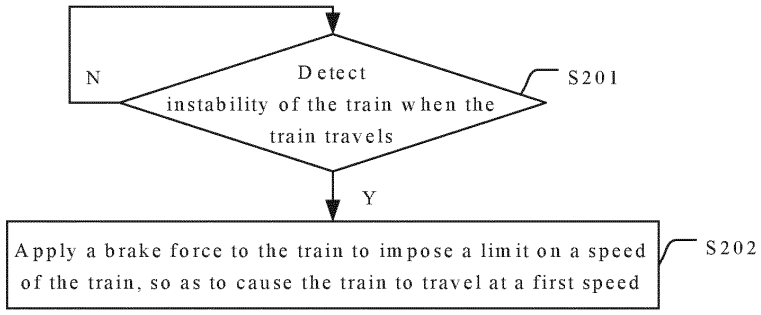

Figure 2

EP 3 892 518 A1

Description

[0001] The present application claims priority to Chinese Patent Application No. 201811480041.X, titled "TRAIN SPEED LIMIT CONTROL METHOD AND DEVICE", filed on December 5, 2018 with the Chinese Patent Office, which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates to the technical field of automatic train control, and in particular to a control method and a control device for limiting a speed of a train.

BACKGROUND

[0003] With the continuous development of high-speed train industry in China, the number of high-speed trains continuously grows, while the speed of high-speed trains continuously increases. Stable and safe operation of trains are the key factors that ensure the normal operation of high-speed train system.

[0004] Since the route condition and the weather change frequently during travelling of a train, which affects the operation of the train, instability of the train may occur. When instability of a train occurs, a instability warning should be provided timely, and the speed of the train should be limited timely to ensure the safe operation of the train. Currently, the instability of the train is managed by the driver imposing an appropriate speed limit according to experience, to ensure the safety of the train. The above process of limiting the speed of the train relies mainly on the experience of the driver, which requires the driver to always keep alert and operate carefully, and is also a tense work for the driver, which causes driving fatigue and easily affect the train driving safety due to the negligence of the driver.

SUMMARY

[0005] To address the above deficiencies in conventional technology, a control method and a control device for limiting a speed of a train are provided according to the present disclosure, to automatically control the speed of the train according to the instability of the train.

[0006] A control method for limiting a speed of a train is provided. The method includes:

detecting instability of the train when the train travels; and

applying a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed, if instability of the train is detected when the train travels.

[0007] Optionally, the method further includes:

determining whether instability of the train is detected again in a preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train; and

releasing the limit on the speed of the train if instability of the train is not detected again.

[0008] Optionally, the method further includes:

determining whether instability of the train is detected within a preset distance that the train travels since the limit on the speed of the train is released; and

applying a brake force to the train to impose a limit on the speed of the train, so as to cause the train to travel at the first speed, if instability of the train is detected.

[0009] Optionally, the method further includes:

determining whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels at the first speed since the limit is imposed on the speed of the train; and

limiting the speed of the train to cause the train to travel at a second speed, if it is determined that the number of times that instability of the train is detected when the train travels exceeds the preset number, wherein the second speed is less than the first speed.

[0010] Optionally, in a case that the speed of the train is limited to cause the train to travel at the second speed, the method further includes:

determining whether instability of the train is detected again when the train travels;

applying a brake force to the train until instability of the train is not detected if instability of the train is detected again when the train travels.

[0011] A control device for limiting a speed of a train is provided. The device includes a first detection unit and a first speed limit unit.

[0012] The first detection unit is configured to detect instability of the train when the train travels.

[0013] The first speed limit unit is configured to apply a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed, if instability of the train is detected by the first detection unit when the train travels.

[0014] Optionally, the device further includes a first determination unit and a speed limit releasing unit.

[0015] The first determination unit is configured to determine whether instability of the train is detected again in a preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train.

[0016] The speed limit releasing unit is configured to release the limit on the speed of the train if instability of the train is not detected again.

[0017] Optionally, the device further includes a second determination unit and a second speed limit unit.

[0018] The second determination unit is configured to determine whether instability of the train is detected within a preset distance that the train travels since the limit on the speed of the train is released.

[0019] The second speed limit unit is configured to apply a brake force to the train to impose a limit on the speed of the train, so as to cause the train to travel at the first speed, if instability of the train is detected.

[0020] Optionally, the device further includes a third determination unit and a third speed limit unit.

[0021] The third determination unit is configured to determine whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels at the first speed since the limit is imposed on the speed of the train.

[0022] The third speed limit unit is configured to limit the speed of the train to cause the train to travel at a second speed, if it is determined that the number of times that instability of the train is detected when the train travels exceeds the preset number, wherein the second speed is less than the first speed.

[0023] Optionally, the device further includes a fourth determination unit and a fifth speed limit unit.

[0024] The fourth determination unit is configured to determine whether instability of the train is detected again when the train travels, in a case that the speed of the train is limited to cause the train to travel at the second speed.

[0025] The fifth speed limit unit is configured to apply a brake force to the train until instability of the train is not detected if instability of the train is detected again when the train travels.

[0026] With the control method for limiting a speed of a train according to the present disclosure, instability of the train is automatically detected, and a brake force is automatically applied to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed if instability of the train is detected, so as to automatically reduce the travelling speed of the train. The above solution applies to train operation, to reduce the labor intensity of the driver. The speed of the train is automatically and timely limited in a case that instability occurs during travelling of the train, thereby effectively avoiding negligence of the driver compromising train travelling safety.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The drawings to be used in the description of the embodiments or the conventional technology will be described briefly as follows, so that the technical solutions according to the embodiments of the present disclosure or according to the conventional technology will become clearer. It is apparent that the drawings in the following description only illustrate some embodiments of the present disclosure. For those skilled in the art, other drawings may be obtained according to these drawings without any creative work.

Figure 1 is a schematic structural diagram of a system for controlling travelling of a train according to an embodiment of the present disclosure;

Figure 2 is a flow chart of a control method for limiting a speed of a train according to an embodiment of the present disclosure;

Figure 3 is a flow chart of a control method for limiting a speed of a train according to another embodiment of the present disclosure;

Figure 4 is a flow chart of a control method for limiting a speed of a train according to another embodiment of the present disclosure;

Figure 5 is a flow chart of a control method for limiting a speed of a train according to another embodiment of the present disclosure;

Figure 6 is a schematic structural diagram of a control device for limiting a speed of a train according to an embodiment of the present disclosure;

Figure 7 is a schematic structural diagram of a control device for limiting a speed of a train according to another embodiment of the present disclosure;

Figure 8 is a schematic structural diagram of a control device for limiting a speed of a train according to another embodiment of the present disclosure; and

Figure 9 is a schematic structural diagram of a control device for limiting a speed of a train according to another embodiment of the present disclosure.

DETAILED DESCRIPTION

[0028] The embodiments of the present disclosure is applicable to an application scenario of limiting a speed of a train in a case that instability of the train occurs. With the technical solutions according to the embodiments of the present disclosure, a speed of a train is limited according to instability of the train.

[0029] Figure 1 is a schematic structural diagram of a

system for controlling travelling of a train according to an embodiment of the present disclosure. A network control system of a train shown in Figure 1 is responsible for the centralized control of respective modules of the train, including a power system, a water supply system, a power supply system, and the like, of the train. The embodiments of the present disclosure focus on the above network control system controlling the power system of the train, including controlling the power system to perform braking, to control the speed of the train, and the like.

[0030] The power system shown in Figure 1 is mainly used for providing power to the train, performing braking, and providing power to the train according to a given speed such that the train travels at a certain speed, according to a control signal from the train network control system.

[0031] The instability warning apparatus in Figure 1 is configured to detect instability of the train, and send an instability signal to the network control system of the train if instability of the train is detected, to inform the network control system of the train that the instability occurs. The above instability includes lateral instability, longitudinal instability and undulating instability, and the like. In the embodiments of the present disclosure, the lateral instability is taken as an example to describe a control method for warning in a case that lateral instability of a train is detected, and limiting the speed of the train according to the lateral instability.

[0032] The technical solution according to the embodiments of the present disclosure is applied to the network control system shown in Figure 1. With the technical solution according to the embodiment of the present disclosure, the network control system sends the control signal to the power system of the train according to the instability warning signal outputted by the instability warning apparatus, to limit the speed of the train.

[0033] The technical solution according to the embodiment of the present disclosure is applicable to a hardware control processing device in the network control system, such as a central controller, a processor, and the like, or may alternatively exist as a control program in the network control system for implementing speed limitation of a train when executed, or as a control function module in a large control system to implement the speed limitation of the train. The present disclosure does not strictly limit the specific form of the execution subject of the technical solution according to the embodiment of the present disclosure. In theory, any software program or hardware device that capable of performing the technical solution according to the embodiment of the present disclosure is theoretically applicable to implement the technical solution according to the embodiments of the present disclosure, to implement the automatic speed limit of the train.

[0034] Technical solutions according to embodiments of the present disclosure are described clearly and completely hereinafter in conjunction with drawings used in the embodiments of the present disclosure. Apparently, the described embodiments are only some embodiments of the present disclosure rather than all the embodiments. Any other embodiments obtained by those skilled in the art based on the embodiments of the present disclosure without any creative work fall in the scope of protection of the present disclosure.

[0035] A control method for limiting a speed of a train is provided according to an embodiment of the present disclosure. Referring to Figure 2, the method includes the following steps S201 to S203.

[0036] In step S201, instability of the train is detected when the train travels.

[0037] Referring to Figure 1, the instability warning apparatus of the train monitors whether lateral instability of the train occurs in a real-time manner, and sends an instability warning signal to the network control system if the lateral instability of the train occurs. In this case, the network control system determines that instability of the train is detected when the train travels.

[0038] It should be noted that, since the instability warning apparatus monitors whether lateral instability of the train occurs in a real-time manner, and timely outputs the instability warning signal to the network control system if the lateral instability of the train is detected. Therefore, the network control system detects the instability of the train when the train travels by directly detecting whether the instability warning signal sent by the instability warning apparatus is received. If the instability warning signal sent by the instability warning apparatus is received, it may be determined that instability of the train is detected when the train travels. If the instability warning signal sent by the instability warning apparatus is not received, it may be determined that instability of the train is not detected when the train travels.

[0039] The above network control system periodically detects instability of the train when train the travels. That is, the network control system detects whether the instability warning signal sent by the instability warning apparatus is received at a certain time period. In order to ensure timely detection of the instability, the detection period may be set small enough to increase the detection frequency. Alternatively, the detection process may be a continuous detection process if the detection period is set small enough.

[0040] If instability is not detected, the detection is continued. If instability is detected, the subsequent speed limit operation is performed, and detection of instability is continued in a case that the speed limit operation is performed.

[0041] If instability of the train is detected when the train travels, step S202 is performed to apply a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed.

[0042] Specifically, on reception of the instability warning signal sent by the instability warning apparatus, that is, when determining that instability of the train is detected, the network control system sends a brake instruction to the power system of the train, to control the power

system to apply a brake force to the train, so as to reduce the speed of the train.

[0043] Furthermore, the network control system further sends a speed limit instruction to the power system of the train when sending the brake instruction to the power system. The speed limit instruction is used to instruct to limit the traveling speed of the train to a specified speed. In an embodiment of the present disclosure, the network control system sends the speed limit instruction to the power system of the train to impose a limit on a speed of the train, so as to cause the train to travel at the first speed, where the first speed is less than the travelling speed at which instability of the train occurs, so as to reduce the travelling speed of the train.

[0044] On reception of the above brake instruction and the above speed limit instruction, the power system of train applies an appropriate brake force to the train based the travelling speed specified in the speed limit instruction, to reduce the traveling speed of the train to the travelling speed specified in the speed limit instruction, and to cause the train to maintain the travelling speed.

[0045] It should be noted that, the first speed may be set according to train design, actual route conditions and train operation experiences. For example, instability of a high-speed train traveling at a speed of 350km/h may be eliminated when the speed is reduced to 280km/h according to the train test experience. In this case, the first speed is set to 280km/h. Based on the above setting, according to the technical solution of an embodiment of the present disclosure, if instability of a train occurs when the train travels at the speed of 350km/h, the network controller automatically sends an instruction to the power system of the train to apply a brake force to the train, to impose a limit on a speed of the train, so as to cause the train to travel at the first speed, that is, to limit the speed of the train, so as to cause the train to travel at the first speed 280km/h, so that instability of the train may be eliminated.

[0046] In an exemplary embodiment, the above brake instruction and the above speed limit instruction may be included in one control instruction, that is sent to the power system of the train. For example, one control instruction is used for instructing to apply a brake force to the train and to limit the travelling speed of the train to a certain speed. Alternatively, the above brake instruction and the above speed limit instruction may be sent to the power system successively or simultaneously as two separate instructions.

[0047] As can be seen from the above description, with the control method for limiting a speed of a train according to the present disclosure, instability of the train is automatically detected, and a brake force is automatically applied to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed if instability of the train is detected, so as to automatically reduce the travelling speed of the train. The above solution applies to train operation, to reduce the labor intensity of the driver. The speed of the train is automatically and timely limited in a case that instability occurs during travelling of the train, thereby effectively avoiding negligence of the driver compromising train travelling safety.

[0048] Referring to Figure 3, in another embodiment of the present disclosure, the above control method for limiting a speed of a train further includes the following step S303.

[0049] In step S303, it is determined whether instability of the train is detected again in a preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train.

[0050] In the preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train, the network control system determines whether instability of the train is detected again, that is, the network control system determines whether the instability warning signal sent by the instability warning apparatus is received again in the preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train.

[0051] If the instability warning signal sent by the instability warning apparatus is received again, that is, instability of the train is detected again, it is determined that the train is still in the state of instability. In this case, the speed of the train is continuously limited such that the train travels at the first speed.

[0052] If instability of the train is not detected again, step S304 is performed to release the limit on the speed of the train.

[0053] Specifically, if the instability warning signal sent by the instability warning apparatus is not received again, that is, if instability of the train is not detected again in the preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train, it is determined that the train travels stably or the train is pulled into a smooth rail section. In an embodiment of the present disclosure, the limit imposed on the speed of the train is released in this case, and the train gradually speeds up, that is, the travelling speed is increased.

[0054] For example, in a case that instability of the train occurs when the train travels at the speed of 350km/h, according to the technical solution of embodiment of the present disclosure, the network control system limits the speed of the train to 280km/h. In two minutes for which the train travels at the speed of 280km/h since the speed of the train is limited to 280km/h, the limit on the speed of the train is released if the network control system does not receive the instability warning signal sent by the instability warning apparatus again, and the train gradually speeds up until the speed reaches 350km/h. If the network control system receives the instability warning signal sent by the instability warning apparatus again in the two minutes, it is determined that instability of the train still occurs, the limit on the speed of the train is maintained such that the train travels at the speed of 280km/h.

[0055] Steps S301 and S302 in this embodiment of the present disclosure respectively correspond to steps S201 and S202 in the method embodiment shown in Fig-

ure 2. Reference may be made to the method embodiment shown in Figure 2 for contents of steps S301 and S302, which will not be repeated here.

[0056] Referring to Figure 4, according to another embodiment of the present disclosure, the above control method for limiting a speed of a train further includes the following step S405.

[0057] In step S405, it is determined whether instability of the train is detected within a preset distance that the train travels since the limit on the speed of the train is released.

[0058] Specifically, in a case that the speed of the train is limited, when it is determined that the train is pulled out of an unstable rail section and the limit on the speed of the train is released, the network control system determines whether instability of the train is detected, that is, whether the instability warning signal sent by the instability warning apparatus is received, in the predetermined distance that the train travels at a gradually increased speed.

[0059] If instability of the train is not detected within the above distance, the train may travel at a speed higher than the first speed, and the procedure returns to detecting instability of the train when the train travels.

[0060] If instability of the train is detected, step S402 is performed to apply a brake force to the train, to impose a limit on the speed of the train, so as to cause the train to travel at the first speed.

[0061] Specifically, if instability of the train is detected within the preset distance that the train travels since the limit on the speed of the train is released, it indicates that instability of the train occurs again after the previous occurrence of instability. In this case, the network control system applies a brake force to the train again to impose a limit on the speed of the train, so as to cause the train to travel at the first speed.

[0062] For example, within two minutes for which the train travels at the speed of 280km/h since the speed of 350km/h of the train is limited to 280km/h, if instability of the train does not occur again, the limit on the speed of the train is released, and the train gradually speeds up. Within 300km in which the train speeds up and travels since the limit on the speed of the train is released, if instability of the train does not occur, the train travels at a maximum allowable speed. If it is detected that instability of the train occurs within the above 300km, the network control system brake the train again to limit the speed of the train to 280km/h.

[0063] Steps S401 and S404 in this embodiment of the present disclosure respectively correspond to steps S301 and S304 in the method embodiment shown in Figure 3. Reference may be made to the method embodiment shown in Figure 3 for the contents of steps S401 to S404, which will not be repeated here.

[0064] Optionally, referring to Figure 5, in another embodiment of the present disclosure, the control method for limiting a speed of a train further includes the following steps S503 to S506.

[0065] In step S503, it is determined whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels at the first speed since the limit is imposed on the speed of the train.

[0066] Specifically, if instability occurs when the train travels, the speed of the train is limited to the first speed according to the technical solution of embodiment of the present disclosure, and the train travels at the first speed for the preset distance, the network control system continues detecting instability of the train, that is, detecting whether the instability warning signal sent by the instability warning apparatus is received again.

[0067] Within the preset distance that the train travels at the first speed, if instability of the train is not detected, or instability is detected but the number of times that instability is detected does not exceeds a preset number, the speed of the train is maintained at the first speed.

[0068] If the number of times that instability of the train is detected when the train travels exceeds a preset number, step S504 is performed to limit the speed of the train to cause the train to travel at a second speed, where the second speed is less than the first speed.

[0069] Specifically, in the preset distance in which the train travels at the first speed, if the number of times that instability of the train is detected exceeds the preset number, the network control system sends the brake command to the power system of the train to further brake the train, so as to limit the speed of the train to the second speed that is less than the first speed, so that safe traveling of the train is ensured.

[0070] For example, since the speed of 350km/h of the train at which instability occurs is limited to 280km/h, within a distance of 300km in which the train travels at 280km/h, the network control system receives the instability warning signal sent by the instability warning apparatus for two times, that is, the network control system detects instability of the train for two times within the distance of 300km that the train travels. It is indicated that the instability of the train is not eliminated when the train travels at the limited speed of 280km/h. In this case, the network control system further limits the speed of the train. The network control system sends the brake instruction to the power system of the train, to cause the power system of the train to apply a brake force to the train, so as to limit the speed of the train to 200km/h.

[0071] Furthermore, in a case that the speed of the train is limited to the second speed according to above technical solution, the network control system continues detecting instability of the train when the train travels, and continues to perform step S505, to determine whether instability of the train is detected again when the train travels.

[0072] Specifically, in a case that the network control system limits the speed of the train to the second speed, the network control system continues detecting instability of the train occurs when the train travels, that is, the network control system detects whether the instability warn-

ing signal sent by the instability warning apparatus is received again.

[0073] If instability of the train is not detected again when the train travels, the speed of the train is maintained at the second speed.

[0074] If instability of the train is detected again, step S506 is performed to apply a brake force to the train until instability of the train is not detected.

[0075] Specifically, in a case that the speed of the train is limited to the second speed, when the train travels at the second speed, the network control system detects instability of the train again, that is, the network control system receives the instability warning signal sent by the instability warning apparatus again, the network control system sends the brake instruction to the power system of the train again, to instruct the power system to apply a brake force to the train, so as to reduce the speed until instability of the train does not occur.

[0076] It should be noted that, the instability of the train not occurring indicates that instability of the train does not occur in a case that the brake force is applied to the train such that the speed of the train is further reduced, the train travels at the reduced speed for a preset time period or a preset distance.

[0077] If the brake force is applied to the train to further reduce the speed of the train, and instability of the train occurs again when the train travels at the reduced speed within the preset time period or the preset distance, the network control system applies a brake force to the train again to further reduce the speed until instability of the train does not occur.

[0078] Steps S501 and S502 in this embodiment of the present disclosure respectively correspond to steps S201 and S202 in the method embodiment shown in Figure 2. Reference may be made to the method embodiment shown in Figure 2 for the contents of steps S501 and 502, which will not be repeated here.

[0079] A control device for limiting a speed of a train is further provided according to another embodiment of the present disclosure. Referring to Figure 6, the device includes a first detection unit 100 and a first speed limit unit 110.

[0080] The first detection unit 100 is configured to detect instability of the train when the train travels.

[0081] The first speed limit unit 110 is configured to apply a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed, if instability of the train is detected by the first detection unit 100 when the train travels.

[0082] Optionally, in another embodiment of the present disclosure, the device further includes a first determination unit 120 and a speed limit releasing unit 130, as shown in Figure 7.

[0083] The first determination unit 120 is configured to determine whether instability of the train is detected again in a preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train.

[0084] The speed limit releasing unit 130 is configured to release the limit on the speed of the train if instability of the train is not detected again.

[0085] Optionally, in another embodiment of the present disclosure, the device further includes a second determination unit 140 and a second speed limit unit 150, as shown in Figure 8.

[0086] The second determination unit 140 is configured to determine whether instability of the train is detected within a preset distance that the train travels since the limit on the speed of the train is released.

[0087] The second speed limit unit 150 is configured to apply a brake force to the train to impose a limit on the speed of the train, so as to cause the train to travel at the first speed, if instability of the train is detected.

[0088] Optionally, in another embodiment of the present disclosure, the device further includes a third determination unit 160 and a third speed limit unit 170, as shown in Figure 9.

[0089] The third determination unit 160 is configured to determine whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels at the first speed since the limit is imposed on the speed of the train.

[0090] The third speed limit unit 170 is configured to limit the speed of the train to cause the train to travel at a second speed, if it is determined that the number of times that instability of the train is detected when the train travels exceeds the preset number, where the second speed is less than the first speed.

[0091] Optionally, in another embodiment of the present disclosure, the device further includes a fourth determination unit and a fifth speed limit unit.

[0092] The fourth determination unit is configured to determine whether instability of the train is detected again when the train travels, in a case that the speed of the train is limited to cause the train to travel at the second speed.

[0093] The fifth speed limit unit is configured to apply a brake force to the train until instability of the train is not detected if instability of the train is detected again when the train travels.

[0094] Specifically, one can refer to the content of the above method embodiment for the operations of respective units of the control device for limiting a speed of a train, which will not repeat here.

[0095] It should be noted that, in the present specification, the embodiments are described in progressive manner. Each embodiment mainly focuses on an aspect different from other embodiments, and reference can be made to these similar parts among the embodiments. The device disclosed in the embodiment corresponds to the method disclosed in the embodiment, and is described relatively simply. For detailed description of the device, reference may be made to the related description of the method

[0096] It may be known by those skilled in the art that,

units and steps in each method described in conjunction with the embodiments disclosed herein can be realized by electronic hardware, computer software or a combination thereof. In order to clearly illustrate interchangeability of the hardware and the software, steps and composition of each embodiment have been described generally in view of functions in the above specification. Whether the function is executed in a hardware way or in a software way depends on application of the technical solution and design constraint condition. Those skilled in the art can use different method for each application to realize the described function, and this is not considered to be beyond the scope of the application.

[0097] The method or algorithm steps described in embodiments of the present disclosure may be implemented directly with hardware, software units executed by processors, or a combination of the hardware and the software units. The software units may be stored in random access memory (RAM), memory, read-only memory (ROM), electrically programmable ROM, electrically erasable programmable ROM, register, hard disk, removable disk, CD-ROM, or any other form of storage medium well known in the technical field.

[0098] Finally, it should be further noted that the relationship terminologies such as "first", "second" and the like are only used herein to distinguish one entity or operation from another, rather than to necessitate or imply that the actual relationship or order exists between the entities or operations. Furthermore, terms of "include", "comprise" or any other variants are intended to be non-exclusive. Therefore, a process, method, article or device including a plurality of elements includes not only the elements but also other elements that are not enumerated, or also include the elements inherent for the process, method, article or device. Unless expressively limited otherwise, the statement "comprising (including) one..." does not exclude the case that other similar elements may exist in the process, method, article or device.

[0099] The above illustration of the disclosed embodiments enables those skilled in the art to implement or practice the present disclosure. Many changes to these embodiments are apparent for those skilled in the art, and general principles defined herein can be implemented in other embodiments without departing the spirit or scope of the present disclosure. Hence, the present disclosure is not limited to the embodiments disclosed herein, but is to conform to the widest scope consistent with principles and novel features disclosed herein.

Claims

1. A control method for limiting a speed of a train, comprising:

   detecting instability of the train when the train travels; and
   applying a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed, if instability of the train is detected when the train travels.

2. The method according to claim 1, further comprising:

   determining whether instability of the train is detected again in a preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train; and
   releasing the limit on the speed of the train if instability of the train is not detected again.

3. The method according to claim 2, further comprising:

   determining whether instability of the train is detected within a preset distance that the train travels since the limit on the speed of the train is released; and
   applying a brake force to the train to impose a limit on the speed of the train, so as to cause the train to travel at the first speed, if instability of the train is detected.

4. The method according to claim 1 or 3, further comprising:

   determining whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels at the first speed since the limit is imposed on the speed of the train; and
   limiting the speed of the train to cause the train to travel at a second speed, if it is determined that the number of times that instability of the train is detected when the train travels exceeds the preset number, wherein the second speed is less than the first speed.

5. The method according to claim 4, wherein in a case that the speed of the train is limited to cause the train to travel at the second speed, the method further comprises:

   determining whether instability of the train is detected again when the train travels;
   applying a brake force to the train until instability of the train is not detected if instability of the train is detected again when the train travels.

6. A control device for limiting a speed of a train, comprising:

   a first detection unit configured to detect instability of the train when the train travels; and
   a first speed limit unit configured to apply a brake force to the train to impose a limit on a speed of

the train, so as to cause the train to travel at a first speed, if instability of the train is detected by the first detection unit when the train travels.

7. The device according to claim 6, further comprising:

a first determination unit configured to determine whether instability of the train is detected again in a preset time period for which the train travels at the first speed since the limit is imposed on the speed of the train; and
a speed limit releasing unit configured to release the limit on the speed of the train if instability of the train is not detected again.

8. The device according to claim 7, further comprising:

a second determination unit configured to determine whether instability of the train is detected within a preset distance that the train travels since the limit on the speed of the train is released; and
a second speed limit unit configured to apply a brake force to the train to impose a limit on the speed of the train, so as to cause the train to travel at the first speed, if instability of the train is detected.

9. The device according to claim 6 or 8, further comprising:

a third determination unit configured to determine whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels at the first speed since the limit is imposed on the speed of the train; and
a third speed limit unit configured to limit the speed of the train to cause the train to travel at a second speed, if it is determined that the number of times that instability of the train is detected when the train travels exceeds the preset number, wherein the second speed is less than the first speed.

10. The apparatus according to claim 9, further comprising:

a fourth determination unit configured to determine whether instability of the train is detected again when the train travels, in a case that the limit is imposed on the speed of the train to cause the train to travel at the second speed;
a fifth speed limit unit configured to apply a brake force to the train until instability of the train is not detected if instability of the train is detected again when the train travels.

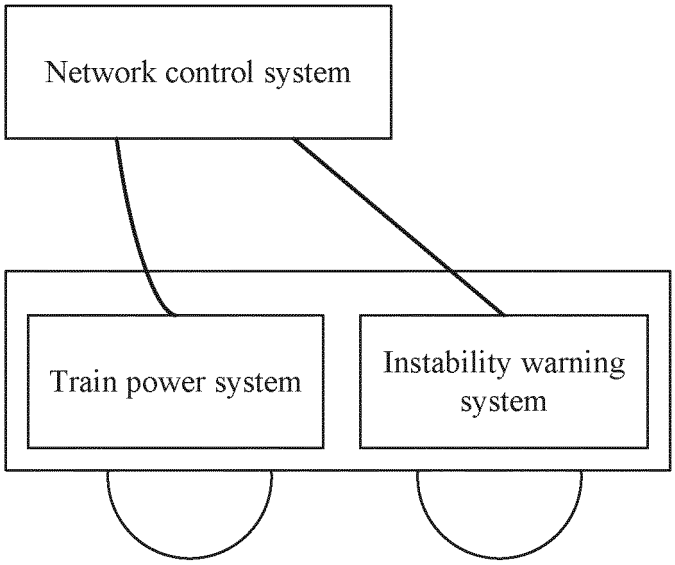

Figure 1

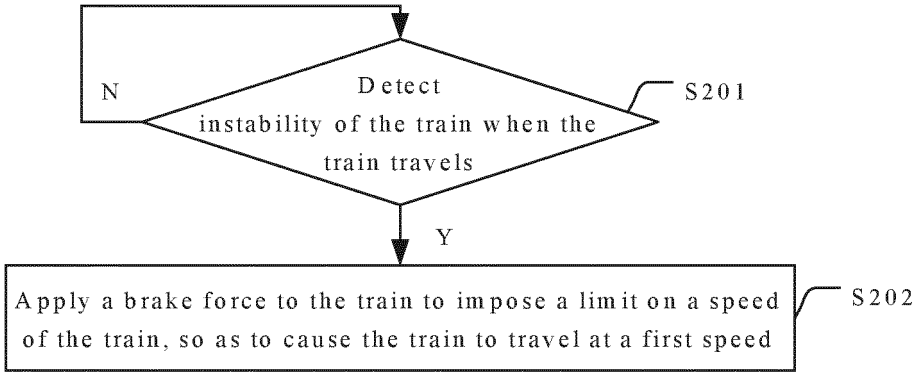

Figure 2

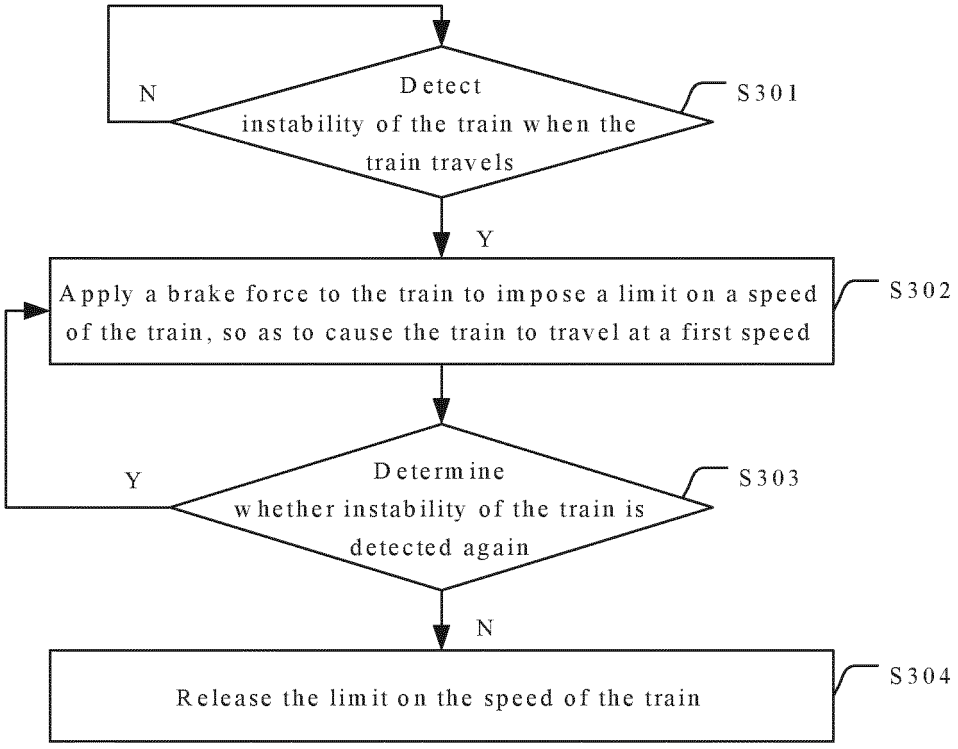
Detect instability of the train when the train travels
S301
N
Y
Apply a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed
S302
Determine whether instability of the train is detected again
S303
Y
N
Release the limit on the speed of the train
S304

Figure 3

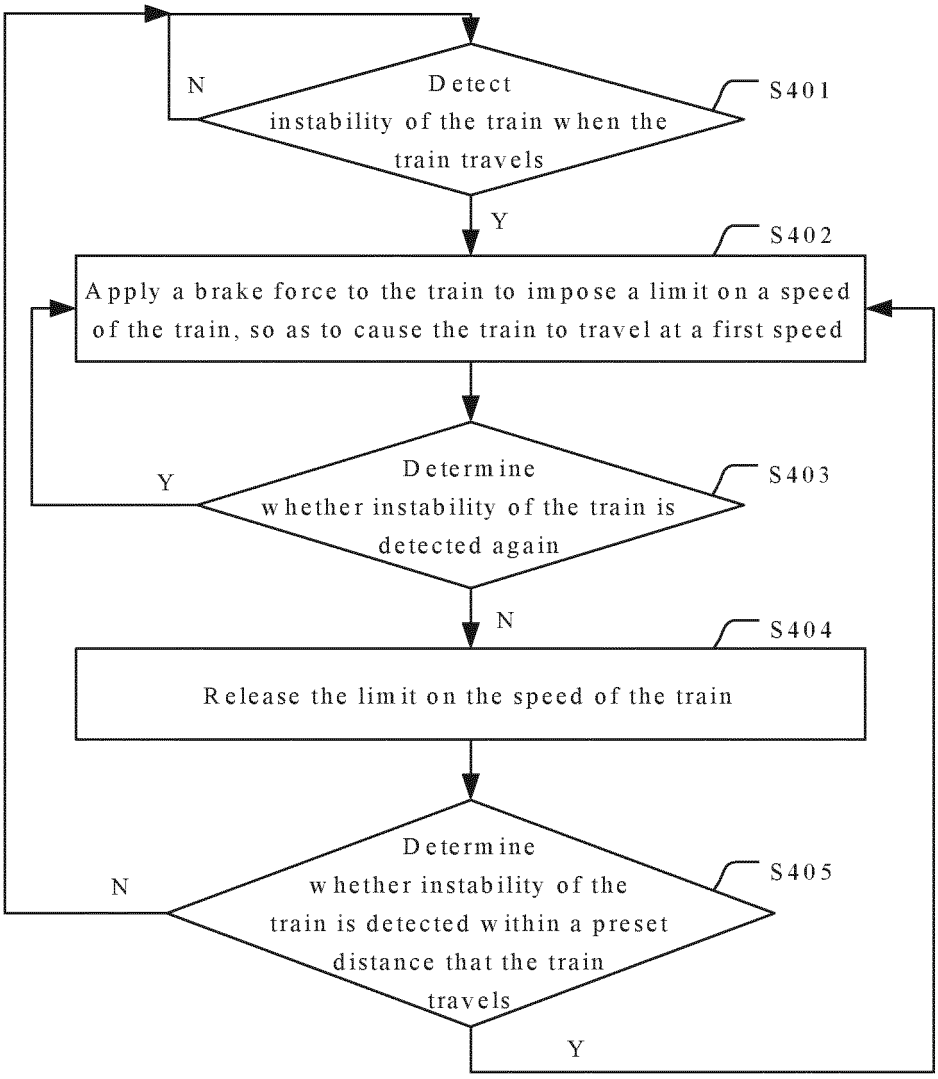
Detect instability of the train when the train travels
S401
N
Y
Apply a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed
S402
Determine whether instability of the train is detected again
S403
Y
N
Release the limit on the speed of the train
S404
Determine whether instability of the train is detected within a preset distance that the train travels
S405
N
Y

Figure 4

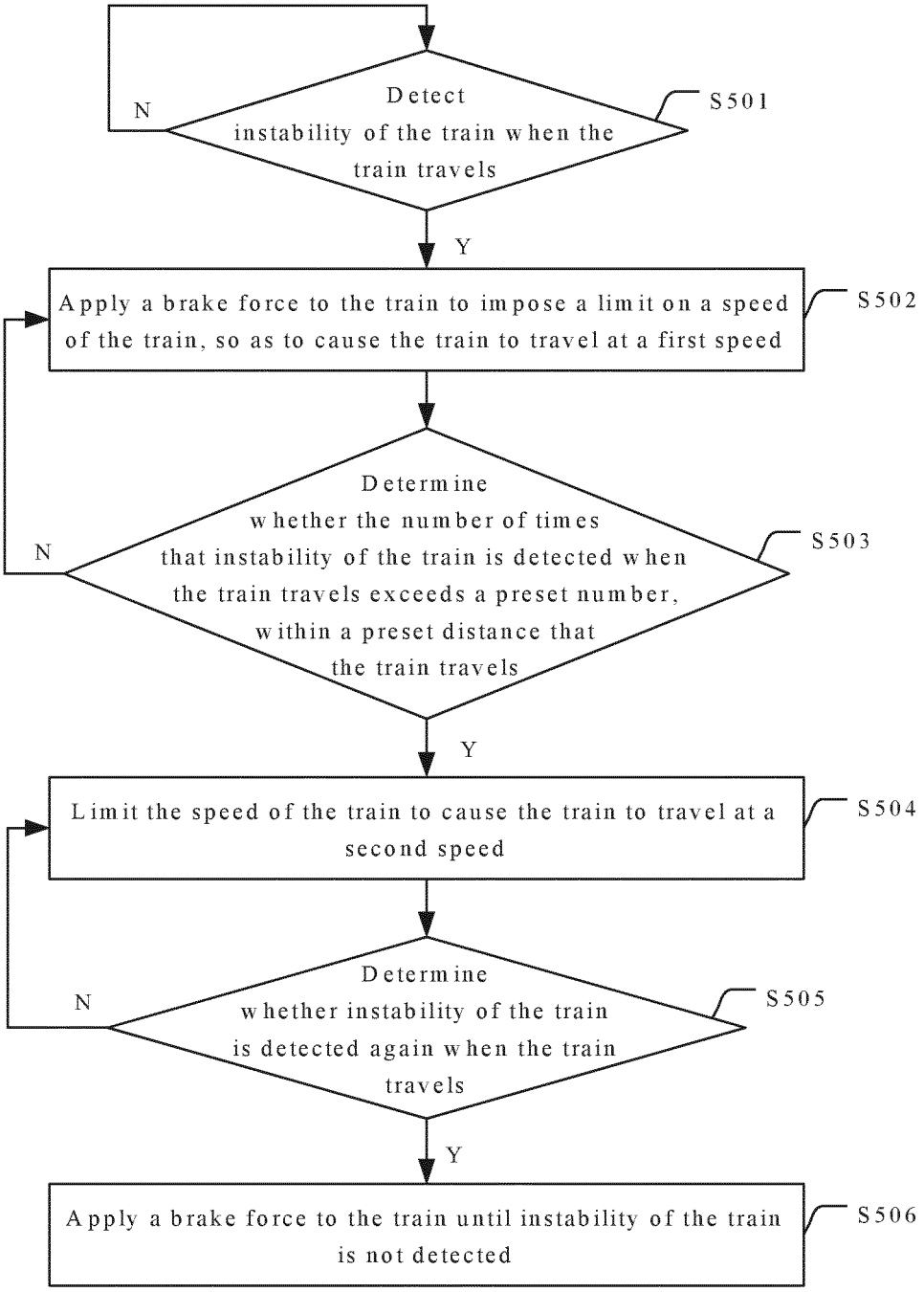
Detect instability of the train when the train travels
S501
N
Y
Apply a brake force to the train to impose a limit on a speed of the train, so as to cause the train to travel at a first speed
S502
Determine whether the number of times that instability of the train is detected when the train travels exceeds a preset number, within a preset distance that the train travels
S503
N
Y
Limit the speed of the train to cause the train to travel at a second speed
S504
Determine whether instability of the train is detected again when the train travels
S505
N
Y
Apply a brake force to the train until instability of the train is not detected
S506

Figure 5

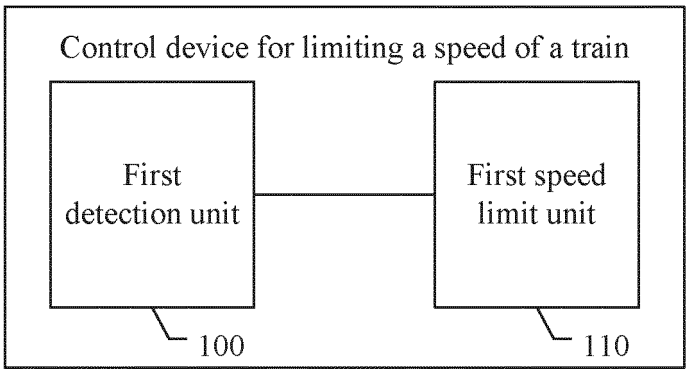

Figure 6

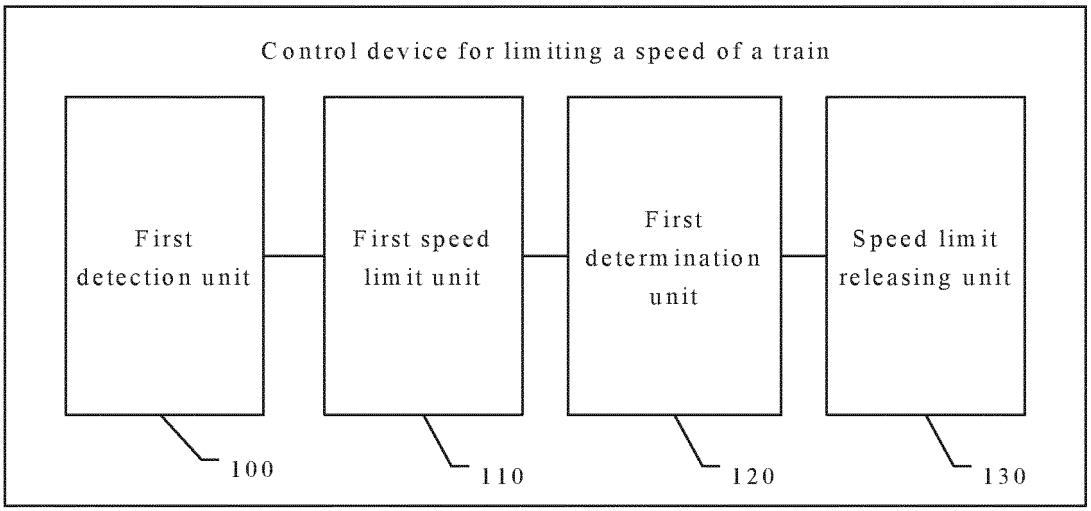

Figure 7

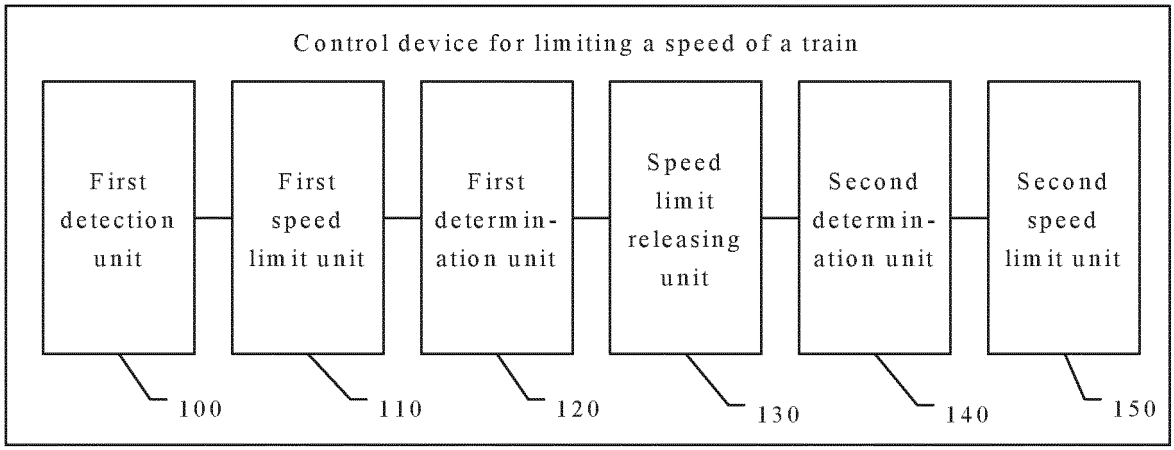

Figure 8

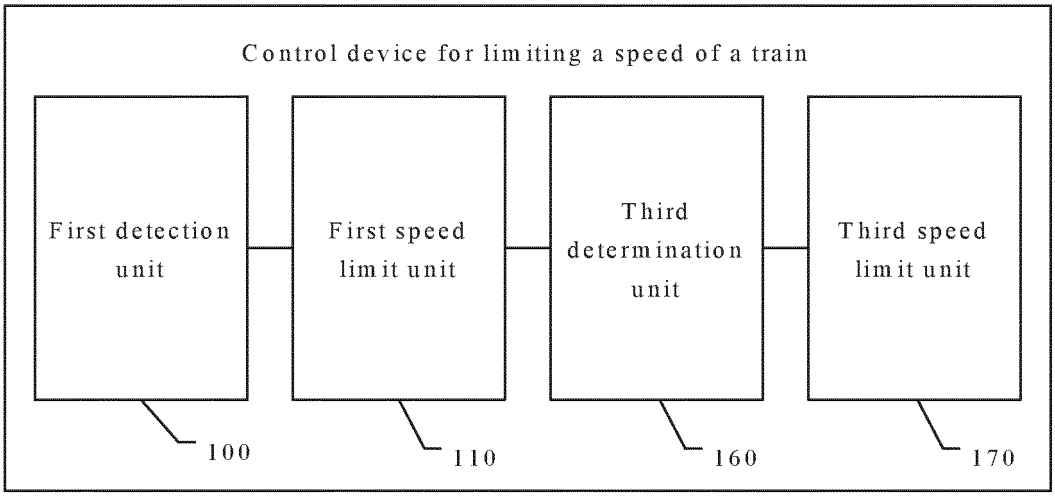

Figure 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/117092

A. CLASSIFICATION OF SUBJECT MATTER

B61L 23/14(2006.01)i

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)

B61L; B61C

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

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

CNPAT, CNKI, EPODOC, WPI: 列车, 火车, 失稳, 不稳, 限, 速, 制动, train, instability, limit+, speed, brake

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 105818820 A (ZHUZHOU CRRC TIMES ELECTRIC CO., LTD.) 03 August 2016 (2016-08-03) description, paragraphs [0019]-[0026], and figures 1 and 2	1-10
A	CN 105083251 A (CSR QINGDAO SIFANG CO., LTD.) 25 November 2015 (2015-11-25) entire document	1-10
A	CN 104071111 B (JILIN UNIVERSITY) 08 June 2016 (2016-06-08) entire document	1-10
A	CN 104890684 A (CHANGCHUN RAILWAY VEHICLES CO., LTD.) 09 September 2015 (2015-09-09) entire document	1-10
A	CN 102874280 A (CSR NANJING PUZHEN CO., LTD.) 16 January 2013 (2013-01-16) entire document	1-10
A	US 5758754 A (KIA MOTORS CORPORATION) 02 June 1998 (1998-06-02) entire document	1-10

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

* 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

Date of the actual completion of the international search	Date of mailing of the international search report
20 January 2020	**06 February 2020**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/117092

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	105818820	A	03 August 2016	CN	105818820	B	29 June 2018
CN	105083251	A	25 November 2015	CN	105083251	B	01 December 2017
CN	104071111	B	08 June 2016	CN	104071111	A	01 October 2014
CN	104890684	A	09 September 2015	CN	104890684	B	17 May 2017
CN	102874280	A	16 January 2013	CN	102874280	B	24 June 2015
US	5758754	A	02 June 1998	KR	970069708	A	07 November 1997

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- CN 201811480041X **[0001]**