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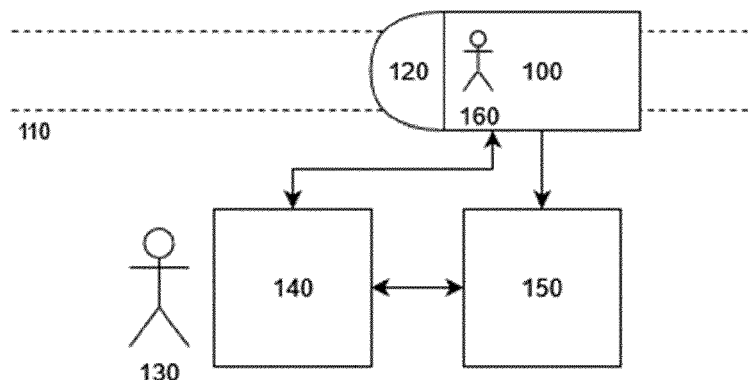
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APPARATUS FOR REMOTE SURVEILLANCE OF AT LEAST ONE AUTONOMOUSLY DRIVING RAIL VEHICLE

- (57)

Apparatus for remote control over at least one autonomously driving rail vehicle (100) containing sensors (120) and a communication device (160) in the vehicle (100) moving on a railway track (110) with possible occurrence of obstacles (200). The apparatus is provided with a surveillance device (140) located at a controller
- workstation (130) and a record device (150), wherein the record device (150) is interconnected with the surveillance device (140), and the surveillance device (140) is interconnected with the communication device (160) located in the rail vehicle (100).

Fig. 1



Description

Field of the Invention

[0001] The present invention relates to systems and processes determined for remote surveillance of an autonomously driving rail vehicle or a vehicle combination formed by such vehicles, for communication between the rail vehicle and the autonomous operation controller, and for taking control over a rail vehicle by a remote operator or an operator in the given rail vehicle.

Background of the Invention

[0002] Currently, the rail transport operates on the principle that the presence of an engine driver, who drives the rail vehicle, supervises its operation and reacts to any incidents that may occur, is requested in a rail vehicle.

[0003] In case of operation in Grade of Automation (hereinafter referred to as "GoA") 3 or GoA4 (defined by The International Association of Public Transport UITP: Union Internationale des Transports Publics), the rail vehicle is fully automatically controlled without the presence of the engine driver or an operator. In case of GoA3, train accompanying staff is present in the rail vehicle; in case of GoA4, no staff is present in the rail vehicle.

[0004] In both cases, it is convenient to provide supervision over an autonomously driving rail vehicle in a remote workplace using monitoring equipment in which the autonomous operation controller surveils assigned autonomous rail vehicles and/or autonomous rail vehicle combinations formed by such vehicles. If necessary, they must be able to assess arisen situations which can occur and perform corresponding actions, e.g. to hand-over the control over the train in the lower automation degree to an operator who can control the train using remote control equipment or using local control equipment. If necessary, the operator is also able to control shifting and coupling of the train using the remote control equipment or using the local control equipment.

[0005] The operator means a person assigned to an autonomously driving vehicle or a combination of such vehicles, which person is responsible for its drive and possesses necessary authorizations and training for the control of an autonomous rail vehicle at the given automation level.

[0006] A certain automation level exists also in other transport types. It is mainly the air transport, which uses the auto pilot function, and railway transport on special tracks, e.g. underground transport, which uses automatic train driving. However, contrary to these two mentioned transport types, the automation employment in the railway transport on conventional tracks is several times more demanding. Contrary to airplanes, which fly in the air, and underground trains in an enclosed environment, the train on a conventional track in an open environment must much more interact with the surrounding environ-

ment, and there is a several times higher probability of exceptional occurrences, which the autonomous train must cope with and solve. For this reason, it is necessary to present a comprehensive system of autonomous train operation and also a comprehensive controlling system for its correct operation and communication. Therefore, in this case, conventional tracks with the open environment cannot use current solutions from other transport fields. Except for the aspect of the open environment, it is necessary to count on the fact that in the conventional railway transport, contrary to the underground transport, a heterogeneous vehicle fleet with different train types - freight trains, passenger suburban, long-distance passenger, high-speed trains - are used, which trains have different demands for operation and surveillance, and this must be reflected in the controlling system.

[0007] Currently, in the field of the conventional railway transport, a system providing a supervisory activity over the autonomous railway operation is missing, which system would enable a constant supervision over individual trains and furthermore, it would enable staff intervention too. Existing solutions do not address the issue; these are either apparatuses working in close cooperation with the infrastructure only or signalling devices, or providing an overview of the railway operation from a purely transport-operational point of view. In order to supervise the autonomous train operation, the present solution has the capacity to combine sources from individual already existing systems, whether parts of security or transport-operational equipment are concerned, which parts are functionally extended and supplemented by data suitable and necessary directly for the autonomous operation on the railway track. The integration of such a functionality into existing systems would be expensive and would result in the necessity to maintain several versions of the given system both for railway with autonomous operation and standard conventional railway without autonomous operation. From the operational, economic and safety point of view, it is advisable to approach the issue in a modular way by forming a new system for surveillance and solution to events over the autonomous railway operation rather than by integrating it into several existing systems.

Summary of the Invention

[0008] According to this invention, the above stated deficiencies are largely eliminated by the apparatus for remote surveillance over at least one autonomously driving rail vehicle containing sensors and communication equipment in the vehicle moving on the railway track with possible occurrence of obstacles. Its essence is that it is provided with a surveillance device located in the controller's workstation and a recording device, wherein the recording device is interconnected with the surveillance device, and the surveillance device is interconnected with a personal communication device located in the rail vehicle.

[0009] The rail vehicle is preferably provided with op-

erator remote control.

[0010] In a preferred solution, the rail vehicle with the surveillance and record devices and the remote control are interconnected with another rail vehicle.

[0011] One aspect of the presented invention can provide a method of a remote surveillance over an autonomous rail vehicle or a combination of such vehicles. The method may comprise a surveillance device using which the controller of the autonomous operation monitors the current status and position of autonomous rail vehicles and autonomous train combinations. If necessary, they must be able to assess arisen situations which can occur and perform corresponding actions, e.g. to hand-over the train in the lower automation degree to an operator who can control the train using remote control equipment or using local control equipment. If necessary, the operator is also able to control shifting and coupling of the train using the remote control equipment or using the local control equipment.

[0012] Another aspect of the presented invention may provide a method of handing-over the control of the autonomous rail vehicle or a combination of such vehicles to an operator. This handing-over using the surveillance device is effectuated by the autonomous operation controller who also determines which controlling method and automation level will be transferred to the operator.

[0013] Contrary to other existing patents addressing the issue of an autonomous train and operation, this patent offers a comprehensive operation of the autonomous operation system, wherein it does not solely aims on the autonomous train itself but it also emphasizes the remote surveillance and control of trains and the communication between the train and other objects with which it interacts.

[0014] Due to an operating system of an autonomous train, controller's environment and operator activities, the railway transport can gain several new benefits. Due to sensors, which can monitor the train surroundings during its drive, and an advanced intelligent decision-making system, the train safety is increased also in situations of reduced visibility, when the engine driver faces poor weather conditions. For example, due to LIDAR and infrared camera, the autonomous train can detect obstacles in the fog at a greater distance than the engine driver, and thus can react more quickly to emerging circumstances and prevent a potentially dangerous situation. Dangerous situations occurring due to inattentiveness or fatigue of the engine driver, e.g. failing to notice the "Stop" signal, are also eliminated. A continuous controller surveillance over autonomous trains also increases the autonomous operation safety when the direct continuous communication connection with the autonomous train enables to respond quickly and efficiently to an emerging exceptional occurrence. This also increases the efficiency of the railway transport operation and can help even in the absence of qualified personnel. An operating autonomous operation system can result in an increase in the attractiveness and interest of passengers in the railway transport. A larger amount of transported persons

on the railway can then substantially decrease the total environmental burden since the railway transport is a very energy-efficient transport means.

[0015] The advantage of the solution is the integration of the data gained from respective autonomous train systems and the data specific to the autonomous operation into one system. The whole comprehensive system is composed of a surveillance terminal, a server data repository, an autonomous train mission planning device, a remote control application and a communication device.

[0016] The server data repository enables to store necessary information about surveilled trains, it safely stores operational data and operations related to the autonomous operation, provides authorization and authentication of users and operators, and manages individual trains between the surveillance workstation and the operators.

[0017] Remote control application - enables remote train driving, if necessary.

[0018] Service application - enables service interventions to autonomous train systems, their diagnostics, calibration, configuration, data and record reading.

[0019] Terminal - provides surveillance over individual trains in a certain area or a workstation. It enables displaying the train operational data, communication between the surveillance centre and the train operator, and enables to adapt the controlling system and transfer it safely to the operator. Furthermore, it enables to monitor the status of the newly built infrastructure for the autonomous operation - stationary camera systems, optical barriers, etc.

[0020] Mission planning equipment - provides management of individual tasks which the train is to execute, or associates the train mission with the train timetable, etc.

[0021] Connection to existing systems: GTN - timetables, operational information, ETCS, connection to conventional signalling devices, e.g. diagnostic data on signalling devices.

Explanation of Drawings

[0022] An apparatus for a remote surveillance over at least one autonomously driving rail vehicle according to this invention will be described in more detail on particular embodiment examples using attached drawings, where Fig. 1 is a basic scheme of an interconnection of an autonomous rail vehicle and a remote controlling workstation, and their mutual communication. Fig. 2 is a scheme of an interconnection of an autonomous rail vehicle, a remote controlling workstation and a remote controller, and their mutual communication, and of transferring authorities related to rail vehicle controlling, and Fig. 3 is a scheme of an interconnection of autonomous rail vehicles, a remote controlling workstation and a remote controller, and their mutual communication, and of transferring authorities related to rail vehicle shifting or coupling.

[0023] It is to be noted that for the sake of simplification and clarity of the illustrations, individual parts of the sketches may not be on the same scale. Descriptive numerals in respective sketches always have the same meaning if they denote the same or analogous elements.

Description of Embodiments

[0024] The following description specifies various aspects of the present invention. For the purpose of thorough understanding of the present invention, the description states all particular element configurations and specific details. A person skilled in the art will understand that the present invention can be practiced without the specific details given here. Moreover, well-known elements can be omitted or simplified in order not to overwhelm or obscure the present invention description. With reference to the attached sketches, it should be emphasized that the depicted data are only exemplary used for the purposes of an illustrative discussion about the present invention, and are stated for the purpose of provision of what is assumed to be the most useful and easily comprehensible description of principles and conceptual aspects of the invention. In this regard, no attempt is made to show specific details of the invention in more detail than is necessary for a basic understanding of the invention. The invention description, including sketches, corresponds with such level of understanding so that a person skilled in the art would understand how parts of the invention can be used in practice.

[0025] Before at least one example of the invention embodiment is explained in detail, it is to emphasize that the invention is not limited in its application to details of design and arrangement of components stated in the following description or depicted in the sketches. The invention is applicable in other embodiments which can be practiced in various methods as well as in combination of the described embodiments. It is also understood that the applied nomenclature and terminology are used for purposes of description and should not be construed as limiting.

[0026] Fig. 1 schematically depicts the interconnection of an autonomous rail vehicle and a remote controlling workstation, and their mutual communication.

[0027] It also shows a rail vehicle 100 located on a railway track 110. The rail vehicle 100 is fitted with sensors 120, which enable the rail vehicle 100 to drive autonomously without an engine driver or without an operator. These sensors 120 can be various camera types, e.g. a high-resolution camera, a thermal imaging camera, a stereo camera, but also other devices working on other principles, e.g. LIDAR, sonar, ultrasound. The rail vehicle 100 using sensors 120 monitors the situation on the railway track 110 and its surroundings, and then evaluates the situation. The rail vehicle 100 also sends information about its status to a controller workstation 130. This information is displayed using a surveillance device 140. The sent information may include current position of the

rail vehicle 100, current status and data from sensors 120, status of all systems in the rail vehicle 100, information related to the operation of the rail vehicle 100, etc. Moreover, the rail vehicle 100 sends important operational data to a record device 150, e.g. obstacle detection, vehicle stopping, which can be requested any time for display at the controller workstation 130 using the surveillance device 140.

[0028] Using the surveillance device 140 at the controller workstation 130, it can be communicated with the rail vehicle 100 or a personal communication device 160 of a person located in the given rail vehicle 100, and based on this communication, the status of the rail vehicle 100 and the operation status on the railway track 110 can be evaluated. The person is any personnel member of the provider of the rail vehicle 100 who meets set conditions of the provider for tasks requested by the controller. If necessary, the controller can e.g. stop the rail vehicle 100 using the surveillance device 140.

[0029] Fig. 2 schematically shows the interconnection of an autonomous rail vehicle, a remote controlling workstation and a remote controller, including their mutual communication, and transferring authorities over rail vehicle control.

[0030] If the rail vehicle 100 detects an obstacle 200 using sensors 120 on the railway track 110 and it is necessary to stop the vehicle, or if sensors 120 fail, or any other circumstances occur which require evaluation of the whole situation emerged both in the rail vehicle 100 or in its surroundings, the rail vehicle 100 immediately informs the controller at the controller workstation 130 about such situation using the surveillance device 140, and simultaneously the situation concerned is recorded in a record device 150. Subsequently, the controller evaluates the situation using the information from sensors 120 and other data sent by the rail vehicle 100, and decides if the rail vehicle 100 can continue its autonomous drive. The controller is able to view the current data for evaluation of the situation incurred or to request data retrospectively from the record device 150.

[0031] If the controller evaluates that the rail vehicle 100 cannot continue its autonomous drive, the controller must decide about transferring the control over the rail vehicle 100 to a remote operator 210. Based on the situation, the controller firstly selects the type of the remote control corresponding to the given automation level using the surveillance device 140. They may select the option when the remote operator 210 has full control over the rail vehicle 100, or they can grant only a simplified control over the rail vehicle 100 to the remote operator 210. In that case the rail vehicle 100 operates in a partial autonomous mode under a direct continuous surveillance of the remote operator 210.

[0032] After selecting the method of control using the surveillance device 140, they select an available remote operator 210 with corresponding authorization to control the rail vehicle 100 at the given automation level. After selecting a particular remote operator 210, the controller

requests the selected remoter operator 210 to take over the control over the rail vehicle 100 using the surveillance device 140. This take-over is possible only when the rail vehicle 100 is in a safe condition which is determined by applicable legislation and operational regulations of the provider of the rail vehicle 100. As soon as the remote operator 210 confirms taking control over the rail vehicle 100, they can start controlling the assigned rail vehicle 100 using the equipment for operator remote control 220. The rail vehicle 100 sends data necessary for the train control to the equipment for operator remote control 220 and it simultaneously sends such data to the surveillance device 140. The data sent to the equipment for operator remote control 220 correspond to the selected control method of the rail vehicle 100. The controller can withdraw the control over the rail vehicle 100 from the remote operator 210 using the surveillance device 140. This withdrawal is possible if circumstances leading to assigning the vehicle 100 to a remote operator 210 have ceased, and simultaneously the rail vehicle 100 is in a safe condition defined by the rules and regulations for authorization withdrawal. Subsequently, the controller transfers the train to the requested automation level using the surveillance device 140.

[0033] Fig. 3 schematically depicts the interconnection of autonomous rail vehicles, a remote controlling workstation and a remote controller and their mutual communication, and transferring authorities related to rail vehicle shifting or coupling.

[0034] As soon as it is necessary to interconnect the rail vehicle 100 fitted with sensors 120 with another rail vehicle 300, the controller at the controller workstation 130 assigns rail vehicles 100 and another rail vehicle 300 to a remote operator 210 using the surveillance device 140 in a specific mode designed for shifting or coupling rail vehicles.

[0035] Using the surveillance device 140, the controller selects an available remote operator 210 authorized for shifting or coupling. After selecting a particular remote operator 210, the controller requests taking the control over the rail vehicle 100 and the other rail vehicle 300 using the surveillance device 140. This takeover is possible only when the rail vehicle 100 and the other rail vehicle 300 are in safe conditions defined by operational rules and regulations. As soon as the remote operator 210 confirms taking control over the rail vehicle 100 and the other rail vehicle 300, the remote operator 210 can start shifting or coupling using the equipment for operator remote control 220. The rail vehicle 100 and the other rail vehicle 300 send data necessary for coupling or shifting to the equipment for operator remote control 220. After finishing shifting or coupling reported by the remote operator 210, the controller withdraws the control over the rail vehicle 100 and the other rail vehicle 300 from the remote operator 210 using the surveillance device 140. This withdrawal is possible only then when the rail vehicle 100 and the other rail vehicle 300 are in safe conditions. Subsequently, the controller transfers the

train to the requested automation level using the surveillance device 140.

Industrial Applicability

[0036] The present invention finds its use especially in railway transport during remote surveillance of an autonomously driving rail vehicle or a vehicle combination formed by such vehicles, during communication between the rail vehicle and the autonomous vehicle controller and during taking control over a rail vehicle by a remote operator or an operator in the said rail vehicle.

Claims

1. Apparatus for remote control over at least one autonomously driving rail vehicle (100) containing sensors (120) and a communication device (160) in the vehicle (100) moving on a railway track (110) with possible occurrence of obstacles (200) **characterized in that** the apparatus is provided with a surveillance device (140) located at a controller workstation (130) and a record device (150), wherein the record device (150) is interconnected with the surveillance device (140), and the surveillance device (140) is interconnected with the communication device (160) located in the rail vehicle (100).
2. The apparatus according to Claim 1 **characterized in that** the rail vehicle (100) is provided with an operator remote control (220).
3. The apparatus according to Claim 2 **characterized in that** the rail vehicle (100) with the surveillance device (140) and the record device (150) and the operator remote control (220) are interconnected with another rail vehicle (300).

Fig. 1

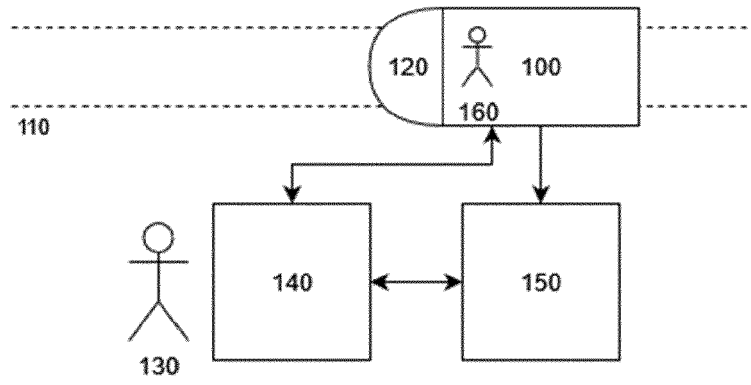


Fig. 2

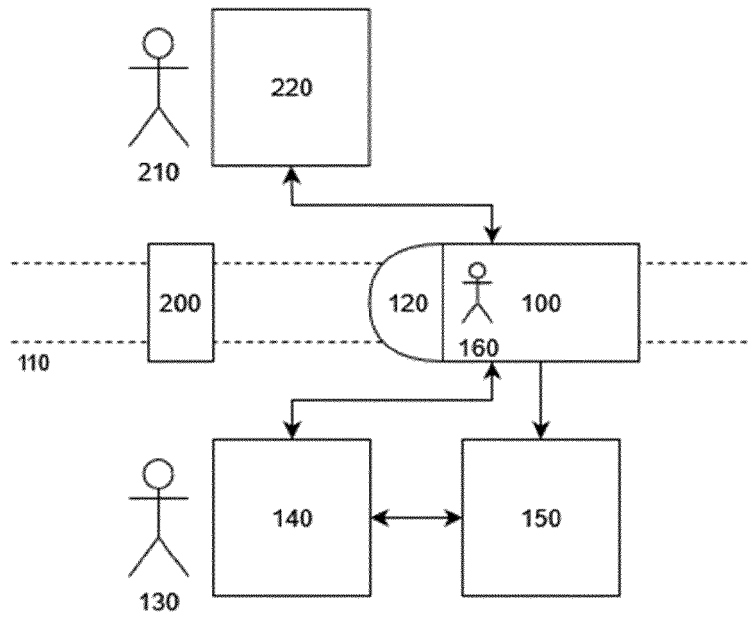
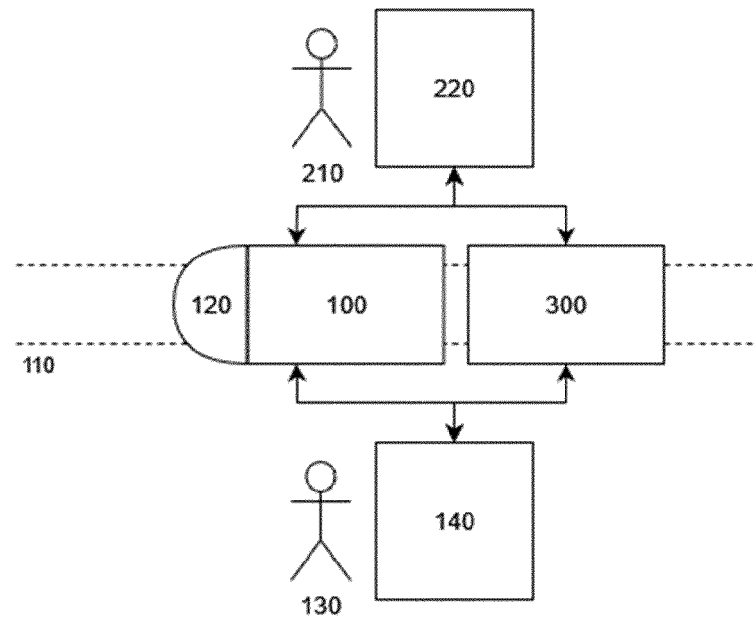


Fig. 3





EUROPEAN SEARCH REPORT

Application Number

EP 23 18 9029

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2020 102928 A1 (G ZWIEHOFF GMBH [DE]) 5 August 2021 (2021-08-05) * figure 8; paragraphs [0020], [0052] and [0053] *	1-3	INV. B61L23/04 B61L27/02
X,P	----- CZ 36 349 U1 (AZD PRAHA SRO [CZ]) 9 September 2022 (2022-09-09) * Figures 1 - 3 and corresponding parts of the description *	1-3	
			TECHNICAL FIELDS SEARCHED (IPC)
			B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 December 2023	Examiner Plützer, Stefan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 18 9029

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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22-12-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102020102928 A1	05-08-2021	NONE	

CZ 36349 U1	09-09-2022	CZ 36349 U1	09-09-2022
		SK 500832022 U1	22-02-2023
