A STEERING ARRANGEMENT FOR A VEHICLE WHICH IS MOVABLE ALONG A PREDEFINED PATH IN USE, BEING AUTOMATICALLY STEERED VIA AT LEAST ONE FIRST AXLE, AS WELL AS A VEHICLE PROVIDED WITH SUCH A STEERING ARRANGEMENT

The invention relates to a steering arrangement for a vehicle which is movable along a predefined path in use, being automatically steered via at least one first axle. The invention also relates to a steered vehicle provided with such a steering arrangement. It is an object of the invention to provide a steering arrangement as described in the introduction for use in a guided and steered vehicle, i.e. with a driver, which steering arrangement can continue to influence the steering of the vehicle for a minimum period of time in case of a malfunction, such that the risk of dangerous situations or accidents is minimised. In order further minimize an undesirable deviation from the path in case of a malfunction, for example at high speeds, the steering arrangement is according to the invention characterised in that it comprises further steering means designed to steer at least one further axle.
A steering arrangement for a vehicle which is movable along a predefined path in use, being automatically steered via at least one first axle, as well as a vehicle provided with such a steering arrangement.

DESCRIPTION

The invention relates to a steering arrangement for a vehicle which is movable along a predefined path in use, being automatically steered via at least one first axle.

The invention also relates to a vehicle provided with such a steering arrangement.

In public transport systems, and in particular in transport systems which make use of passenger buses, there is a continuous search for new developments that must make it possible, in particular in densely populated areas, to provide the public with a fast, comfortable and high-frequency public transport system.

A development that is frequently used already is the adaptation of the infrastructure, which involves the construction of special lanes intended only for public transport. This makes it possible to handle large passenger flows, in particular during the rush hours, with the means of public transport hardly, if at all, being impeded by other traffic flows.

At present there is an additional development in progress, according to which the vehicle is guided and steered along a predefined path. Said path generally consists of a lane specially reserved for this purpose within the infrastructure, which infrastructure may or may not exist yet, which lane is in principle closed to the other road users.

The guidance of such a guided and steered vehicle is realised, for example, by installing passive (for example magnetic) markers in the road surface, which markers are detected by a path tracking system in the vehicle, on the basis of which the steering arrangement of the guided and steered vehicle may make adjustments as regards the direction to be followed and the vehicle speed. Instead of using markers in the road surface it is also possible to use other tracking systems, for example reflectors and GPS. In use, the path tracking system will minimize a detected deviation of the vehicle from the predefined path as much as
The safety of the passengers being transported in such an automatically guided and steered vehicle is an important point of consideration. Such a vehicle must therefore be provided with means for preventing dangerous situations that may occur in case of a malfunction in the steering arrangement. It is in particular desirable that the steering function of the steering arrangement (and consequently also the path tracking system) remain operational in case of a malfunction in the steering arrangement, for example because part of the steering function is lost.

It is an object of the invention to provide a steering arrangement as described in the introduction for use in a guided and steered vehicle, which steering arrangement can continue to influence the steerage of the vehicle for a minimum period of time - and independently of a driver who may be present - in case of a malfunction, such that the risk of dangerous situations or accidents is minimised.

In order to further minimise undesirable deviation from the predefined path in case of a malfunction in the steering arrangement, for example at high speeds, the steering arrangement is according to the invention characterised in that it comprises further steering means designed to steer at least one further axle, said further steering means comprising at least two further drivelines, which further drivelines control said at least one further axle independently of each other.

By providing the vehicle not only with a first steerable axle but also with a further steerable axle, a supplementary steering action can be imposed on the vehicle in case of an unwished-for malfunction in the steering arrangement so as to have the vehicle follow the predefined path as much as possible and avoid an unacceptable deviation at all times, also at high speeds.

In this way the functionality of the steering arrangement is guaranteed, in particular when the vehicle is moving at a higher speed, in which case an unforeseen deviation from the predefined path could lead to unacceptable, dangerous situations. Thus, quick and adequate corrective action can be taken, making it possible to minimize a deviation from the predefined path of the vehicle, even at high speeds, and to stop the vehicle in time.

This prevents a situation in which the further axle is no longer being steered in case of a malfunction in the further steering means, since the drive and the steerage are directly taken over by the other driveline.
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In a specific embodiment of the further steering means, said further steering means are characterised in that said further drivelines control said at least one further axle independently of each other via a hydraulic piston/cylinder combination. The use of a hydraulic piston/cylinder combination provides a reliable and powerful control. More specifically, said hydraulic piston/cylinder combination is a double-acting piston/cylinder combination.

According to another embodiment, the steering arrangement is further characterised in that each further driveline controls a hydraulic valve, which valve is mounted in a hydraulic line that is in communication with the piston/cylinder combination.

In order to take over the control of the guided and steered vehicle in case of a malfunction in a part of the steering arrangement and thus avoid dangerous situations and deviations from the predefined path, the steering arrangement is according to the invention characterised in that the steering arrangement comprises a guidance control system for controlling said further steering means, which guidance control system more specifically controls said further steering means via separate signal lines.

The steering arrangement comprises a redundant and error-tolerant communication bus to ensure a reliable control and signal processing to the further steering means also in the case of a malfunction in one of the communication buses. As a result, it will at all times be possible to activate one of the drivelines of the further steering means and use said driveline for steering the vehicle such that a dangerous situation resulting from an unforeseen deviation from the path is eliminated or prevented as much as possible.

The guidance control system is in particular designed to stop the vehicle in case of a detected malfunction in the steering arrangement.

The invention will now be explained in more detail with reference to a drawing, in which:

Figure 1 shows a schematic embodiment of an automatically guided and steered vehicle in a specific lane;

Figure 2 shows a first embodiment of a steering arrangement according to the invention for a guided and steered vehicle.

For a better understanding of the invention, like parts will be indicated by the same numerals in the description of the figures below and in the
respective figures.

Figures 1a-1c are sketches showing the position of an automatically guided and steered vehicle 20 that follows a predefined path, being steered by a steering arrangement. The vehicle 20 is automatically guided and steered by means of a steering arrangement and can in principle be operated without a driver.

In a public transport system in which a vehicle 20 is automatically guided and steered by a steering arrangement supported by necessary control equipment, the path to be followed is usually a lane not intended for use by other road users, which lane is indicated at 10 in figures 1a-1c. Said lane is usually divided into a number of subsections 11-12-13, which are used by the path tracking system of the vehicle 20. Two lane sections 12 are defined on either side of the lane 10, between which lane sections the vehicle 20 is to move. The lane sections 12 can be regarded as forbidden areas for the vehicle 20, and consequently they are known as such to the path tracking system of the steering arrangement. Numeral 13 indicates an intermediate section, whilst the actual driving section is indicated at 11.

During normal operation of the path tracking system and the steering arrangement, the vehicle 20 can or is allowed to be present or move within the driving section 11 while normally following the predefined path.

Figure 1a is indicated as a normal operating state, in which the vehicle 20 follows the predefined path in the driving section 11.

In general the steering arrangement of an automatically guided and steered vehicle 20 comprises a path tracking system in which information characteristics or way points of the path to be followed are stored. Such a path tracking system is usually provided with an image or a map on which the path to be followed is projected in the form of way points. In addition to that, the steering arrangement is provided with so-called path sensor means, which determine the position of the vehicle relative to the path to be followed while the automatically guided and steered vehicle 20 follows the predefined path in the driving section 11.

For example, passive (for example magnetic) markers may be installed in the road surface, which markers are detected by a path sensor means in the vehicle 20. Instead of using markers in the road surface it is also possible to use other tracking systems, for example reflectors and GPS. The position detected by the path sensor means is used for determining a possible deviation from the path, on the basis of which necessary control signals for the steering means are
generated for correcting the vehicle's deviation from the path.

A deviation from the path that is irresponsibly large is shown in figure 1b, in which the vehicle 20', for reasons unknown, moves into the section 13, which deviation will be detected and subsequently be corrected by generating suitable corrective control signals to the steering arrangement and by carrying out a braking action on the wheels of the vehicle. In this way the vehicle's steerage will be continuously adjusted, so that the vehicle will follow the predefined path in the driving section 11.

Figure 1c shows a situation in which the vehicle 20', due to unforeseen circumstances, has deviated from the predefined path to such an extent that it leads to a dangerous traffic situation. Usually, such a situation develops upon failure of (part of) the steering arrangement, as a result of which the vehicle is no longer being guided, causing it to deviate from its predefined path.

If the speed of the vehicle 20' is high at the moment of failure of the steerage, the deviation from the predefined path (the driving section 11) may be unacceptably large, which will inevitably lead to accidents, in such a situation it is desirable that the vehicle, which is no longer being guided in that case, be stopped as soon as possible.

It is an object of the present invention to provide a solution in this regard, and in order to accomplish that object the steering arrangement comprises further steering means 30 designed to steer at least one further axle 31. The vehicle is not only provided with a first steering axle, therefore, but also with a further axle 31, which is also steerable. Thus, the vehicle being guided and steered along a predetermined path can also be steered by means of said further axle 31 and the wheels 32 connected thereto.

Using the further steering means 30, a path correction can be imposed on the vehicle by means of the additional steering axle 31. In an undesirable situation, a possible malfunction in the further steering means may lead to a potentially dangerous situation, in particular if the vehicle is moving at a high speed. According to the invention, said further steering means 30 are configured as twin steering means in this embodiment.

More specifically, said further steering means 30 are built up of two drivelines, indicated at 33a and 33b. Said drivelines drive said at least one further axle 32 independently of each other. Each driveline comprises a drive unit 33a-33b,
which drive units actuate a hydraulic piston/cylinder combination 34 independently of each other via servo valves V1 and V2, respectively, by means of which piston/cylinder combination said further axle 31 is steered. This prevents a situation in which said further axle is no longer being steered in case of a malfunction in the further steering means, since the drive and the steerage are immediately taken over by the other driveline.

Each trailing axle (i.e. not the front axle) comprises a (further) steering arrangement comprising two drivelines, so that the other driveline of a specific axle will keep the steering functionality intact in case of failure of one of the drivelines of a particular axle. The hydraulic piston/cylinder combination 34 is a double-acting piston/cylinder combination, which comprises a piston rod 35 that is connected to the further steering axle 31. In said cylinder, two pistons 36a-36b are mounted to the piston rod 35, which pistons divide the cylinder into two cylinder spaces 37a-37b. The cylinder space 37a is in communication with a buffer B1 for a hydraulic medium via a hydraulic line 38a and the servo valve V1. The servo valve V1, and thus the supply of hydraulic medium to the first cylinder space 37a via the line 38a, is controlled via the drive unit 33a of the first driveline. Likewise, the second cylinder space 37b is connected to a second buffer B2 for hydraulic medium via a hydraulic line 38b and the second servo valve V2.

The second servo valve V2 is controlled by the drive unit 33b. The two drive units 33a-33b are controlled by the guidance control system 24 via suitable signal lines 27a-27b. The signal lines 27a-27b form a redundant and error-tolerant communication bus. The communication bus 27a controls the driveline 33a, whilst the driveline 33b is controlled via the communication bus 27b. In case of a malfunction in a part of said multiple communication bus (for example failure of the communication bus 27), the guidance control system 24 will continue to control the driveline 33b via the still functioning communication bus 27b.

In case of a malfunction, the remaining driveline 33b will thus be controlled in such a manner that suitable steering adjustments via the further steerable axle 31 can still be made also during braking of the vehicle, and consequently dangerous road situations can be avoided. By driving the further steering means by means of the guidance control system 24 via the redundant and error-tolerant communication bus 27a-27b, it is thus possible to stop the vehicle, during which stopping action controlled attempts will be made to keep the vehicle on
the desired path by making steering adjustments.

The guidance control system 24 will to that end interfere with the brake system and, in addition to that, continue to steer the vehicle during braking via one of the still operative drivelines 33a-33b, in such a manner that the vehicle will follow the predefined path as much as possible.

Although the redundant and error-tolerant communication bus 27a-27b is represented in the form of control lines for controlling the various drivelines 33a-33b in figure 2, in an identical embodiment (not shown) the steering arrangement 24 comprises a redundant power source. Said redundant supply source supplies power (voltage/current) to the various drivelines (and other parts of the steering arrangement) in a similar manner via various independent feed connections (or feeders).

Analogously, the guidance control system 24 will detect an unwished-for power cutoff to one of the drivelines and consequently it will control the steering device in an analogous manner as described above. The driveline in question will be disabled and the steering functionality will be retained. The vehicle will be stopped, and controlled attempts to keep the vehicle on the desired path by making steering adjustments will continue to be made.
CLAIMS

1. A steering arrangement for a vehicle which is movable along a predefined path in use, being automatically steered via at least one first axle, which steering arrangement comprises:
   - a path tracking system comprising information characteristics relating to the predefined path to be followed;
   - path sensor means designed to detect a deviation from the predefined path by the vehicle;
   - steering means designed to steer the at least first axle so as to correct the detected deviation from the path; which steering device comprises further steering means designed to steer at least one further axle.

2. A steering arrangement according to claim 1, characterised in that said further steering means comprise at least two further drivelines, which further drivelines control said at least one further axle independently of each other.

3. A steering arrangement according to claim 2, characterised in that each further driveline comprises a drive unit coupled to said at least one further axle.

4. A steering arrangement according to claim 2 or 3, characterised in that said further drivelines control said at least one further axle independently of each other via a hydraulic piston/cylinder combination.

5. A steering arrangement according to claim 4, characterised in that said hydraulic piston/cylinder combination is a double-acting piston/cylinder combination.

6. A steering arrangement according to claim 4 or 5, characterised in that each further driveline controls a hydraulic valve, which valve is mounted in a hydraulic line which is in communication with the piston/cylinder combination.

7. A steering arrangement according to one or more of the preceding claims, characterised in that the steering arrangement comprises a guidance control system for controlling said further steering means.

8. A steering arrangement according to claim 7, characterised in that said guidance control system controls said further steering means via separate signal lines.

9. A steering arrangement according to claim 7 or 8, characterised in
that the guidance control system comprises a redundant and error-tolerant communication bus.

10. A steering arrangement according to one or more of claims 7-9, characterised in that the guidance control system is designed so that the guidance control system will stop the vehicle upon detection of a malfunction in the steering arrangement.

11. A vehicle provided with a steering arrangement according to one or more of the preceding claims.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62D1/28 B62D3/14 G05D1/00

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)

B62D A01B G05D

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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

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Date of the actual completion of the international search
3 November 2010

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