

The present invention relates to a device for automatically controlling the distance between vehicles which are following one another on the same track and are driven by means of drive devices, in accordance with the preamble to claim 1.

A device of this kind is disclosed in CH-A-426 923. A drive device and a control device with three parallel branches are present on each vehicle. The first branch has a DC voltage source with a series-connected working resistor, the second branch has an engine controller for controlling the drive device and the third branch has a monitoring device. These branches are connected on the one hand via a first sliding contact to a neutral rail running parallel to the carriageway of the vehicles and on the other hand via a further sliding contact, which is at the front viewed in the direction of travel of the vehicle, to a control rail which is also directed parallel to the track. The control rail is short-circuited to the neutral rail via a third, rear sliding contact, viewed in the direction of travel, on each vehicle. The control rail is divided up into equally long sections whose length is shorter than the spacing between the front and rear sliding contact of a vehicle. Between every two successive sections, in each case one diode is connected whose conducting direction corresponds to the direction of travel of the vehicles. These diodes form, together with the control rail, a recurrent network. A positive voltage generated by the voltage source is applied via the corresponding front sliding contact to the control rail, which voltage drops in a step-like manner along the control rail as a result of the short circuit between the control rail and the neutral rail

at the rear end of the vehicle in front. The voltage between the front sliding contact and the neutral rail is thus a distance variable which indicates the distance from the vehicle in front. The engine controller controls the speed of the vehicle as a function of this distance variable. The greater the distance to the vehicle in front, the higher is this voltage which indicates the distance variable. When the distance between vehicles is large, the distance variable is at its maximum value and in this case the drive device is controlled to the highest admissible travel speed by the engine controller. The lower limit of the control range is at a distance variable which corresponds to the spacing between several sections of the control rail. At this limit the vehicle is brought to a complete standstill by braking.

The voltage source is periodically briefly connected with reversed polarity to the control line. The monitoring device then tests the voltage between the front and rear sliding contact of a vehicle and triggers emergency braking as soon as this voltage deviates from a set value. As a result, a collision with a moving, or stationary, vehicle in front is prevented from occurring in the event of faults occurring in a diode of the recurrent network in the event of the connection between two diodes being broken, in the event of the contact to one of the sliding contacts being broken or in the event of other faults which result in failure of the automatic control.

The authorised safety control systems known hitherto for automatic or driverless operation are based either on block systems, as in the case of conventional interlocking control technology, or they are based on reliable control computers which are installed at the side of the rail route and receive reliable position information from reliable vehicle

computers and thus reliably control an "electrical sight running system". In this context, it is certain that the systems themselves detect faults and bring about a safe status when a fault is detected. Block systems operate with a rough sub-division of the track into so-called block sections. Systems of this kind which were customary previously are designed in such a way that a train that has travelled through leaves behind one to two items of safety information, with a low degree of differentiation, for example in the form of signal positions at red or green, for securing the block on the section of rail. Here, it is disadvantageous that a following train may possibly have constantly to change its speed as a function of the block length, and may unnecessarily have to stop. The entire expenditure in terms of material of a block section control of the design used hitherto is so high that finer subdivision of the block sections is too costly. The solution which has been devised more recently with reliable vehicle-side or rail route-side computers requires a costly safety test by complex software in multi-channel redundant structures.

Therefore, it is an object of the present invention to further develop the known device in such a way that it is more reliable in terms of signalling technology with a low level of expenditure.

This object is achieved with a device of the generic type which has the features in the preamble to claim 1. In the event of failure of components relevant for safety, the mechanical emergency braking is applied and thus collision between vehicles or running into an open set of points or travelling beyond the end of the rail line is prevented.

In a preferred embodiment of the invention as claimed in claim 6, the drive control unit which actuates the drive

device is itself actuated with a distance variable which is safe in terms of signalling technology and a speed signal derived therefrom, which permits the drive device to be controlled in a safe manner until the vehicle comes to a stop before an obstacle.

A particularly simple means for generating the distance variable corresponding to the distance between successive vehicles is disclosed in claim 7.

A further measure for increasing the safety of the device further is defined in claim 8.

In a preferred embodiment as claimed in claim 9 with in each case one diode unit between the sections and the neutral rail, a break in the control rail or a break between the control rail and the neutral rail located ahead of the vehicle can also be detected.

Further preferred embodiments are disclosed in the remaining dependent claims.

The present invention is described in greater detail below with reference to an exemplary embodiment illustrated in purely diagrammatic form in the drawing, in which:

Fig. 1 shows the device according to the invention with two vehicles travelling on the same track and a recurrent network running along the track for the purpose of generating a distance variable corresponding to the distance between the vehicles;

Fig. 2 shows the characteristic of the distance variable along the recurrent network according to Fig. 1 and a speed control variable, derived from the distance variable, for controlling the drive device of the respective vehicle;

Fig. 3 shows part of the control device of a vehicle according to Fig. 1;

Fig. 4 shows a preferred circuit of diodes and resistors between the individual sections of the control rail and the neutral rail, and

Fig. 5 shows the characteristic of the distance variable in the case of a short circuit between the control rail and the neutral rail and in the case of a break in the recurrent network.

Fig. 1 shows a first vehicle 12 travelling on a track 10, indicated by dot-dash lines, in the direction of travel F and a second vehicle 14 (only partially illustrated) which is travelling ahead on the same track 10. Each vehicle 12, 14 has a generally known drive device 16, a control device 18 and a mechanical emergency brake 20. In addition, a speed measuring device (indicated diagrammatically in Fig. 3) is provided on each vehicle 12, 14. The vehicles 12, 14 are of identical design. However, for reasons of better clarity the above-mentioned devices are indicated only in the first vehicle 12.

A control rail 24 and a neutral rail 26, which preferably conducts ground potential, runs parallel with the track 10. In the case of the front-most bogie, viewed in the direction of travel F, each vehicle 12, 14 has a front sensing device 28 with sliding blocks 30, 30' in order to connect the control rail 24 and neutral rail 26 to the control device 18. In the case of the bogie which is respectively at the extreme rear in the direction of travel F, a rear sensing device 32 with sliding blocks 34, 34' is arranged on each vehicle 12, 14 in order to short-circuit the control rail 24 to the neutral rail 26.

The control rail is divided up, as indicated diagrammatically in Fig. 1, into mutually insulated sections 24' of the same length, this length being smaller than the distance between the front and rear sensing device 28, 32 of the

vehicles 12, 14. Preferably, each section 24' is three to four times shorter than the distance between the sensing devices 28, 30. A diode block 36 is connected between two sections 24' in each case and for the sake of simplicity is simply illustrated in Fig. 1 as a diode. The diode blocks 36 have a conducting direction corresponding to the direction of travel F. The sections 24' and the diode blocks 36 thus form a recurrent network.

A control component 38 of the control device 18 is connected to the front sensing device 28 and to the emergency brake 20. Furthermore, the control component 38 is connected to the drive control unit 40 which, as described in greater detail below, controls the travel speed of the control device 16 in an open-and-closed loop manner.

In Fig. 3, the control component 38 of the control device 18 is shown in greater detail. Said component has a diagrammatically indicated voltage source unit 42 with a voltage source 44 which preferably generates a DC voltage, and a working resistor 46 connected in series thereto. The negative terminal of the voltage source 44 is connected via the sliding block 30' to the neutral rail 26 and the positive terminal is connected to the control rail 24 via the working resistor 46 and the sliding block 30. The voltage U_d generated by the voltage source unit 42 drops along the control rail 24 in a step-like manner via the diode blocks 36 between the front sensing device 28 of the first vehicle 12 and the rear sensing device 32 of the second vehicle 14 travelling in front, as shown by Fig. 2. An unequal gradation of the voltage increments can be achieved by means of the design of the diode blocks 36. The polarity of the diode blocks 36 prevents the current in the control rail 24 from flowing from the respectively front sensing device 28 to the rear sensing device 32. The

voltage U_d which is tapped off via the recurrent network, i.e. the control rail 24 and neutral rail 26 is thus a distance variable which constitutes a measure of the distance between the vehicle 12 and the vehicle 14 travelling in front. When the distance is large, the distance variable U_d is thus also larger than when the distance between the two vehicles 12, 14 is small.

The distance variable U_d is, as described below, monitored and evaluated in the control component 38 and fed to the drive control unit 40 which, according to generally known methods, smooths the step-like voltage jump when the sliding block 30 travels out onto a new section 24', and subtracts a voltage U (indicated diagrammatically in Fig. 2) from said smoothed signal in order to generate a speed control variable U_s . In Fig. 2, the speed control variable U_s is shown as a function of the distance from the vehicle 14 travelling in front; said speed control variable is always smaller than the distance variable U_d . This speed control variable U_s is a desired value for the speed which is dependent on the distance between the vehicles 12, 14 and the drive control unit 40 controls the travel speed according to this desired value.

The polarity of the voltage source 44 is periodically reversed so that a step-like voltage drop now occurs between the front and rear sensing device 28, 32 of the vehicle 12 via the diode blocks 36 on the control rail 24. This voltage drop U_p (test voltage) should be constant when the recurrent network is intact and is monitored by the control component 38 which initiates emergency braking as soon as the test voltage U_p drops outside a predetermined tolerance value. In this way, the diode blocks 36 are monitored each time a vehicle 12, 14 passes through, the frequency with which the polarity of the voltage source 44 is reversed

being preferably selected to be such that the testing of the corresponding diode blocks 36 takes place repeatedly during one passage of a vehicle.

As Fig. 3 shows, the control component 38 has two mutually independent control units 48, 48' and a comparator unit 50 connected downstream thereof. The two control units 48, 48' are fed the distance variable U_d which is generated and tapped off between the control rail 24 and the neutral rail 26, it being possible for the tapping off of the distance variable U_d to take place via separate sliding blocks in order to increase safety. The speed measuring device is provided with two mutually independent speed measuring units 52, 52' whose speed signals U_g and $U_{g'}$ which correspond to the measured speed are also respectively fed to the control units 48, 48' via the corresponding lines (indicated diagrammatically in Fig. 3). The two speed measuring units 52, 52' have pulse generators which are offset with respect to each other by a specific amount so that the speed signals U_g , $U_{g'}$ generated by them have a specific phase shift. Each of the control units 48, 48' determines the current travelling speed of the vehicle 12 from the frequency of the speed signals U_g , $U_{g'}$ and the direction of travel from the phase shift of these signals. If the speed which is determined from the speed signal U_g in a control unit 48, 48' lies outside a first speed tolerance value with respect to that speed determined from the speed signal $U_{g'}$ or if it is detected that a vehicle is travelling counter to the direction of travel F , the respective control unit 48, 48' triggers emergency braking which is symbolised by the arrow leading to the emergency brake 20.

A brake monitoring device 54 is provided as a supplementary device which monitors the function of the brake elements and also feeds their status to the two control units 48, 48'.

In an important function, the two control units 48, 48' compare, independently of each other, the distance variable U_d with the speeds determined from the speed signals U_g , U_g' and also initiates emergency braking as soon as the measured speed exceeds what is the maximum admissible one on the basis of the distance variable U_d .

The two control units 48, 48' pass on the distance variable U_d , designated in Fig. 3 by U_{d1} and U_{d2} , to the comparator unit 50 where they are compared with one another. If these distance variables U_{d1} and U_{d2} should differ by more than a predetermined distance tolerance value, the comparator unit 50 also initiates emergency braking, which is indicated with the arrow leading to the emergency brake 20. Furthermore, the control units 48, 48' also pass on to the comparator unit 50 the signals v_1 , v_2 corresponding to the speed determined from the speed signals U_g , U_g' . If said comparator unit 50 detects a difference between the signals v_1 and v_2 which exceeds a further predetermined speed tolerance value, emergency braking is also triggered.

Furthermore, the voltage source unit 42 is monitored by two mutually independent voltage monitoring units 56, 56' which feed corresponding status signals, for example the voltage generated by the voltage source 44 and its polarisation, to the comparator unit 50. If the comparator unit 50 detects a difference between the status signals generated by these voltage monitoring units 56, 56', emergency braking is also initiated.

If the conditions for the triggering of emergency braking are not fulfilled, the comparator unit 50 passes on the distance variable as a signal U_{d0} to the drive control unit 40. In order to generate the speed control variable U_s , said drive control unit 40 utilises the distance variable U_{d0} which is safe in terms of signalling

technology, to control the speed of the drive device 16 by subtracting a variable U according to Fig. 2. All speeds below the speed control variable are admissible, however their being exceeded leads to a safe emergency stop by means of the above-described arrangement. The safety speed signal v_0 is used to unlock the doors when the vehicle is at a standstill.

The diode blocks 36 are preferably designed as shown in Fig. 4. Between in each case two adjoining sections 24', two diode elements 58, 58' are connected in parallel with in each case one diode 60, 60' and series-connected resistor 62, 62'. Normally, the diode 60 is in operation and the control rail 24 can be configured by means of the respective resistor 62 to generate the desired voltage steps in the distance variable U_d . If, on the other hand, the diode 60 becomes defective, the diode 62' assumes the function, the respective resistor 62" being preferably selected in such a way that a fault in this diode block 36 can be detected on the basis of the test voltage U_d . The diode block 36 also has, viewed further in the conducting direction of the diode elements 58, 58', a diode unit 64 which is connected downstream of said elements and has a Zener diode 66 and a further resistor 68 which is connected in series therewith and is connected at the other end to the neutral rail 26. By means of the selection of the individual elements of the diode blocks 36, it is possible to construct rail sections with speed restrictions, a distance variable U_d which is generated in the control 24 in the region of these rail sections with speed restrictions being restricted to the desired value. Furthermore, it is possible with diode blocks 36, constructed in this way, for the control device 18 to detect a break in the recurrent network in front of the vehicle 12, 14, as represented in connection with Fig. 5.

In the lower curve in Fig. 5 the characteristic of the distance variable U_d is shown for the case of a short-circuit at the point designated by the arrow 70, the curve U_d being represented here as an approximation to the effective step curve shown in Fig. 2. In the upper curve U_d , the voltage characteristic of the distance variable U_d' along the control rail 24 is shown approximately in the case of a break in the recurrent network in front of the vehicle.

The short-circuit at 70 can be generated either by means of the rear sensing device 32 of the second vehicle 14 which is travelling ahead or stationary or by a connection between the control rail 24 and neutral rail 26. The drive control unit 40 controls the speed of the drive device 16, in the region between U_{max} and U_{min} of the measured distance variable U_d , in accordance with the speed control variable U_s (cf Fig. 2) which is derived from the distance variable U_b and is always slightly below the currently maximum permissible speed given by the distance variable U_d . If the speed control variable U_s falls to or below the voltage U_{min} , the vehicle 12 is stopped. It thus always stops in front of the short-circuit 70 at a distance designated in Fig. 5 by the double arrow 72. The control rail 24 is configured here in such a way that this distance 72 always includes several sections 24'. If, on the other hand, the short-circuit 70 or the vehicle 14 travelling in front is at such a large distance from the first vehicle that the speed control variable U_s is greater than the voltage U_{max} , the drive control unit 40 adjusts the drive device 16 to a predetermined speed. If the second vehicle 14 or short-circuit 70 is at a very large distance, the distance variable U_d corresponds to a value which is designated in Fig. 5 by U_{dmax} and is given by the voltage division of the no-load voltage of the voltage source 44 by the working

resistor 46 and the impedance of the recurrent network. If, on the other hand, there is a break in the latter, the voltage U_d rises with respect to the value U_{dmax} , as is shown by the upper curve U_d' in Fig. 5. The two control units 48, 48' (see Fig. 3) initiate emergency braking as soon as the distance variable U_d exceeds a threshold value designated in Fig. 5 by U_d open.

The described open-loop control, closed-loop control, comparison and monitoring functions are carried out in the control device 18 with generally known switching arrangements in analogue or digital technology. Of course, in digital embodiment analogue signals such as, for example, the distance variable U_d , are converted by means of analogue-to-digital convertors. Of course, the control device 18 can also have appropriate programmed micro-processors in order to assume the functions presented above. Of course, it is also conceivable for more than two control units to be connected in parallel and for the corresponding output to be compared by means of more than one comparator unit in order further to improve safety.

It is also conceivable to construct the control rail 24 as a continuous resistance element with impedance distributed uniformly over the length of the rail. It would also be conceivable to determine the distance and thus the distance variable between two successive vehicles 12, 14 with electromagnetic waves, microwaves, visible or infra-red radiation or with sound waves or ultrasonic waves.

In all the embodiments, it is important that the distance variable corresponding to the distance between the vehicles 12, 14 is determined in a manner which is safe in the terms of signalling technology and offers maximum reliability. It is equally necessary to determine the speed of the vehicles 12, 14 in a manner which is safe in terms of

signalling technology and also to compare and monitor these signals which are safe in terms of signalling technology by means of a reliable control device 18.

Whenever points are changed at the open end of the respective track the control rail 24 is preferably short-circuited to the neutral rail 26. This ensures that vehicles travelling towards the points on this track at a distance 72 (see Fig. 5) stop in front of the points if said points are not set to passage. At the end of the track, the control rail 24 is also preferably short-circuited to the neutral rail 26 in order to prevent the vehicles 12, 14 over-shooting the end of the track. It is also conceivable to leave the control rail 24 open at the points since this too will be detected by the control device 18. However, in order to be able to utilise the track 10 as far as the end of the track, instead of the short-circuit the control rail 24 can be artificially lengthened by inserting appropriate elements, for example a resistor, so that vehicles travelling towards the end of the track come to a standstill in front, or at the end, of the track.

In order to permit vehicles to travel in both directions of travel on one track, the diode blocks can have in each case one diode unit to the neutral rail between two sections on each side of the diode elements. The diode unit which, viewed in the conducting direction of the diode elements, is connected downstream of said elements can in this case have a series connection of a diode, with conducting direction from the diode element towards the neutral rail, and with a Zener diode connected between this diode and the neutral rail with opposite polarity. In the respective other diode unit, the diode and Zener diode are connected in series with reversed conducting direction. Of course, in this case a change-over device is provided on the vehicle in order to

connect the positive pole of the voltage source to the control rail and the negative pole to the neutral rail when travelling in the conducting direction of the diode elements and to connect them in an inverted manner when travelling in the opposite direction. The change-over device also short-circuits the sliding blocks which are at the rear in the respective direction of travel and connects the respective front sliding blocks with appropriate polarity.



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Patent claims

1. A device for automatically controlling the distance between vehicles (12, 14) which follow one another on the same track (10) and are driven by means of a respective drive device (16),, the speed of a subsequent vehicle (12) being reduced when it approaches a vehicle (14) located in front of it, having means for generating a distance variable signal (Ud) corresponding to the distance between the vehicles, a control device (18) for controlling the drive device (16) at a speed dependent on the distance variable signal (Ud), and having means for triggering emergency braking when a fault which makes automatic control impossible is detected, characterised in that the control device (18) is designed to form a speed control variable signal (Us) which is dependent on the distance variable signal (Ud) and is smaller than it for the purpose of controlling the drive device (16) at a speed which is lower than the maximum admissible speed in accordance with the distance variable signal (Ud), to compare a speed signal (Ug, Ug') generated by a speed measuring device (52, 52') with the distance variable signal (Ud) to initiate emergency braking as soon as the speed signal (Ug, U'') exceeds the distance variable signal (Ud).
2. A device according to claim 1, characterised in that the control device (18) has at least two mutually independent control units (48, 48') which are each designed to compare the speed signal (Ug, Ug') with the distance variable signal (Ud) and to initiate emergency braking as soon as the speed signal (Ug, U'') exceeds the distance variable signal (Ud).



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3. A device according to claim 1 or 2, characterised in that the speed measuring device (52, 52') has two mutually independent speed measuring units (52, 52') and the control device (18) and the control units (48, 48') is/are designed to compare the speed signals (Ug, Ug') of the speed measuring units (52, 52') and to initiate emergency braking as soon as the speed signals (Ug, Ug') differ by a predetermined speed tolerance value or indicate that a vehicle is travelling in the wrong direction.
4. A device according to claim 3, characterised in that the control device (18) comprises at least two control units (48, 48') and a comparator unit (50) connected downstream thereof, the control units (48, 48') being designed to pass on a speed signal (v1, v2) to the comparator unit (50) when there are speed signals (Ug, Ug') lying within the speed tolerance value and in that the comparator unit (50) is designed to compare the speed signals (v1, v2) received by the control units (48, 48') and to initiate emergency braking as soon as these speed signals (v1, v2) differ by a further predetermined speed tolerance value.
5. A device according to one of claims 2 to 4, characterised in that the control device (18) comprises at least two control units (48, 48') and a comparator unit (50) connected downstream thereof, each of the control units (48, 48') being designed to pass on the distance variable signal (Ud1, Ud2) to the comparator unit (50), and in that the comparator unit (50) is designed to compare the distance variable signals (Ud1, Ud2)



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received from the control units (48, 48') and to initiate emergency braking as soon as said signals differ by a predetermined distance tolerance value.

6. A device according to claims 4 and 5, characterised in that a drive control unit (40) is connected downstream of the comparator unit (50), the comparator unit (50) passing on the distance variable signal (Ud0) and the speed signal (v0) to the drive control unit (40), provided said variable and said signal lie within the corresponding tolerance values, said drive control unit (40) being designed to form the speed control variable signal (Us) and to control the drive device (16) appropriately.
7. A device according to one of claims 1 to 6, having a control rail (24) and a neutral rail (26) which are disposed along the track (10), having per vehicle (12, 14) in each case one front sensing device (28) and one rear sensing device (32) which interact with these rails (24, 26) and a voltage source (42) which is provided on each vehicle (12, 14) and whose poles are connected to the control rail (24) and neutral rail (26), respectively, via one sensing device (28), preferably the front one, the distance variable signal (Ud) on the control rail (24) being generated and sensed with the sensing devices (28, 32).
8. A device according to claim 7, characterised in that two mutually independent voltage monitoring units (56, 56') are provided for monitoring the voltage source (42) and are designed to supply the comparator unit (50) with status signals corresponding to the status of the



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voltage source (42), the comparator unit (50) being designed to compare the status signals and to initiate emergency braking as soon as the status signals differ by a predetermined status tolerance value.

9. A device according to claim 7 or 8, characterised in that the control rail (24) is divided into mutually insulated sections (24') whose length, measured at the control rail (24), is shorter than the distance between the front and rear sensing device (28, 32) of a vehicle (12, 14) and in that one diode element (58) is connected between each of the successive sections (24'), said diode elements all being disposed in the same conducting direction, preferably aligned in the direction of travel (F) and in that a diode unit (64) which has a Zener diode (66) and a series resistor (68) is provided preferably between each section (24) and the neutral rail (26).
10. A device according to claim 9, characterised in that in each case a plurality of diode elements (58, 58') and/or diode units (64) are connected in parallel.
11. A device according to one of claims 7 to 10, characterised in that the control rail (24) and the neutral rail (26) are short-circuited when a set of points is open and, if appropriate, at the end of the track.