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Asano et al.

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[54] **APPARATUS FOR CONTROLLING VEHICLES AT JUNCTION POINTS**

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[51] **Int. Cl.** **B61l 3/22**

[58] **Field of Search** ..... 246/187 B, 187 C, 167 R, 246/63 R, 63 A, 63 C; 104/148 R, 149, 152

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Attorney, Agent, or Firm—Oblon, Fisher, Spivak, McClelland & Maier

[57] **ABSTRACT**

An apparatus is disclosed for controlling separate or a few interconnected vehicles running along a track, such as separate rail cars, or types of similar vehicles. The system permits both high vehicle speeds and high traffic densities, and is especially effective for controlling the distance between vehicles at a junction or switching point in a track, path or roadway network.

7 Claims, 6 Drawing Figures

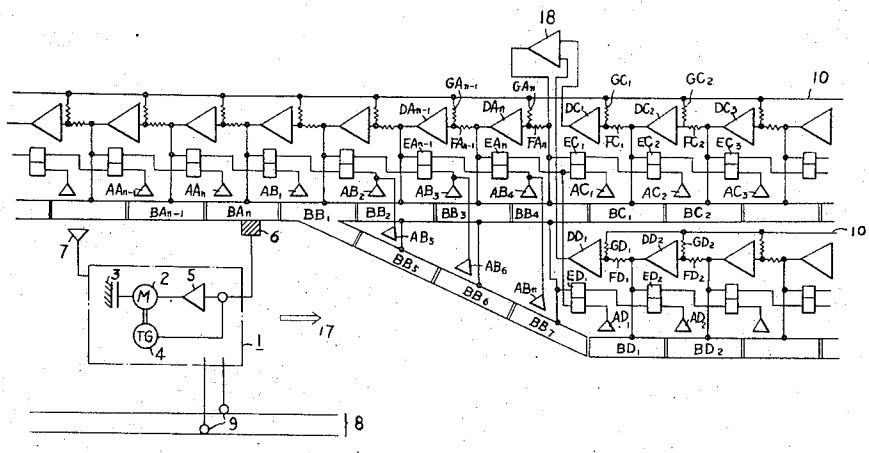


FIG. 1

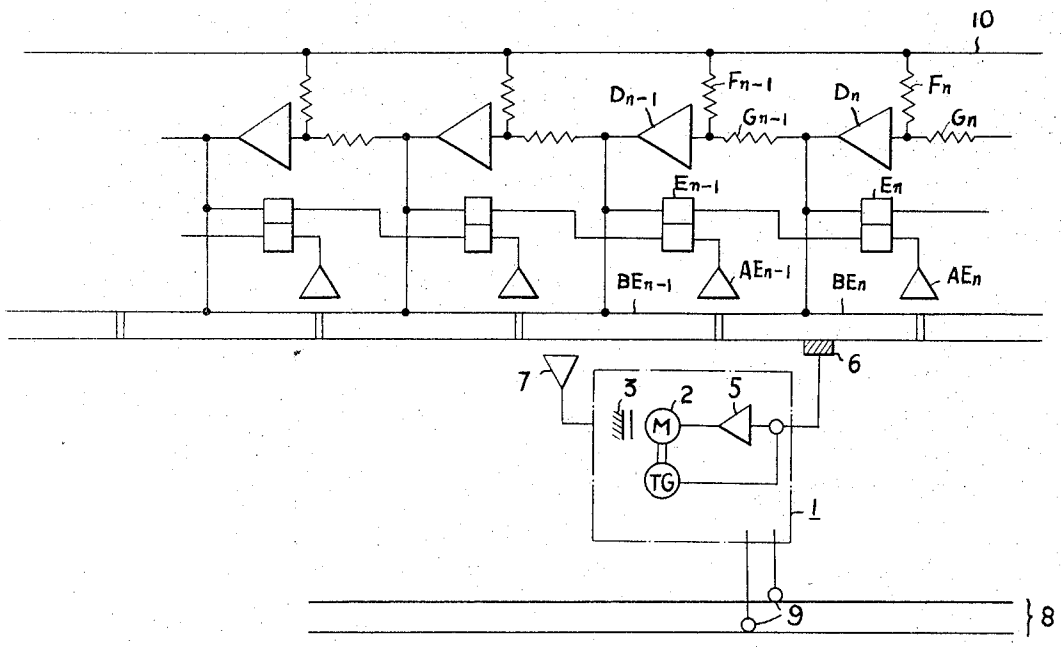

10
Dn-1
Fn-1
Gn-1
Dn
Fn
Gn
En-1
En
BEn-1
AEn-1
BEn
AEn
7
3
2
5
M
TG
6
1
9
8

FIG. 3

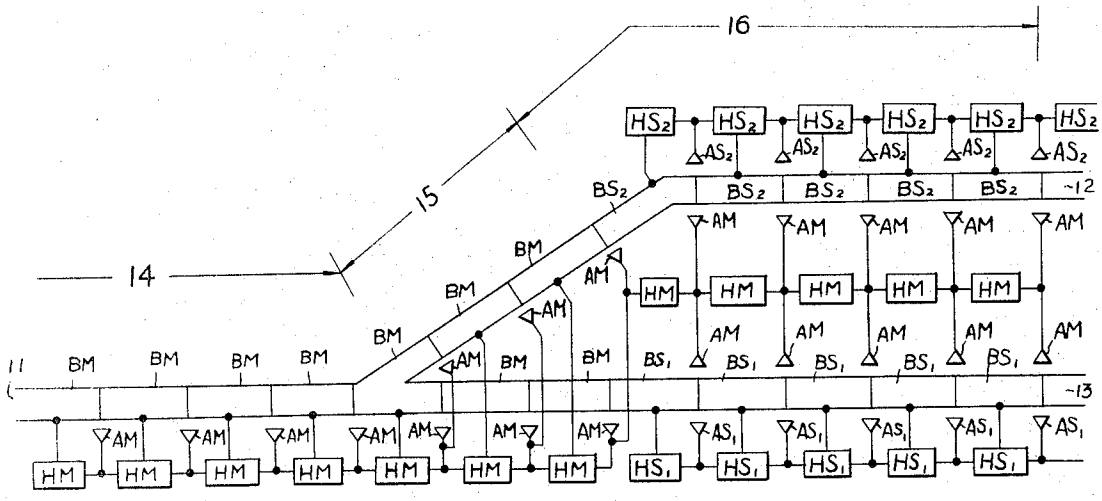
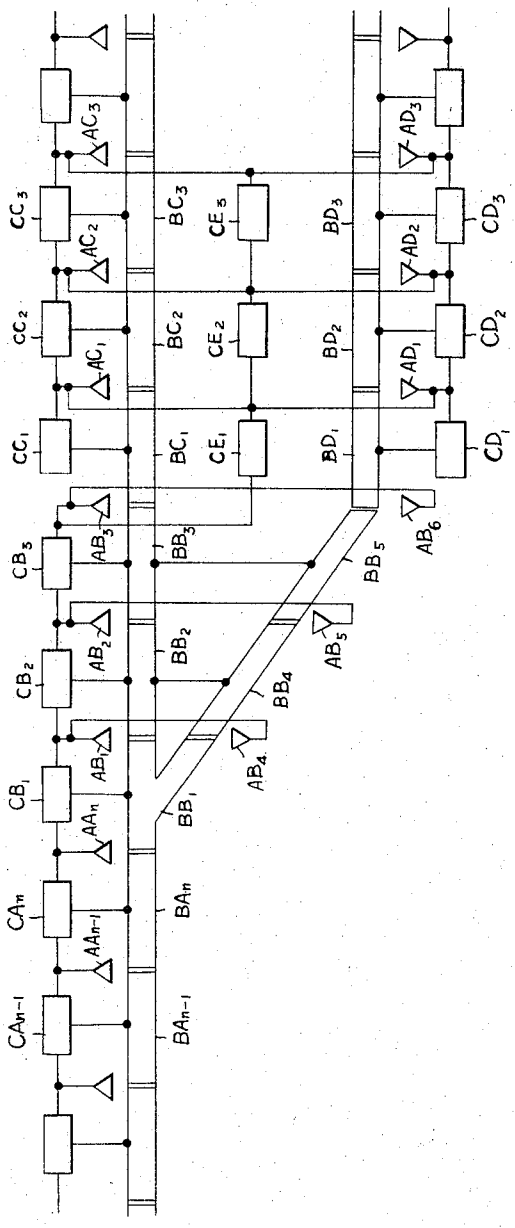

16
15
14
11
12
13
HS2
AS2
BS2
AM
HM
BM
BS1
AS1
HS1

FIG. 2


CC3
AC3
BC3
CE5
BD3
AD3
CD3
CC2
AC2
BC2
CE2
BD2
AD2
CD2
CC1
AC1
BC1
CE1
BD1
AD1
CD1
CB3
AB3
BB3
BB5
AB6
CB2
AB2
BB2
AB5
BB4
CB1
AB1
AB4
BB1
CAn
AAn
BAn
CAn-1
AAn-1
BAn-1

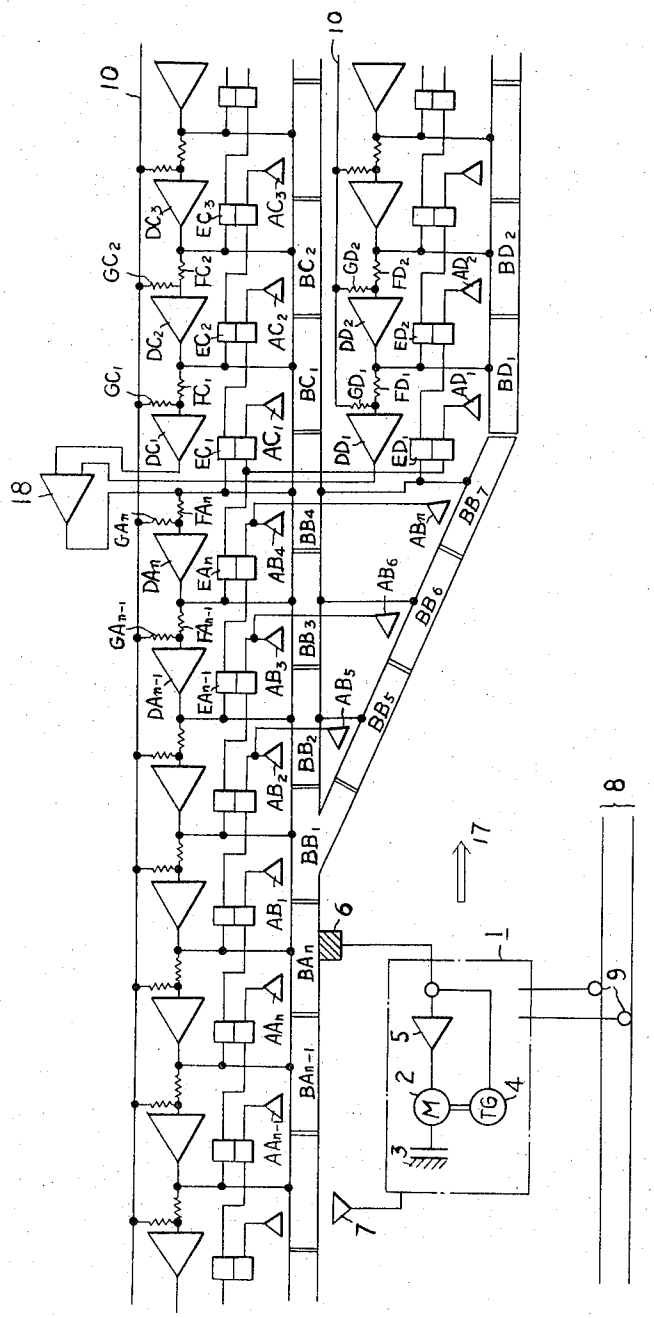

10
10
18
GC2
GC1
GAn
GAn-1
DC3
DC2
DC1
DAn
DAn-1
EC3
EC2
EC1
EAn
EAn-1
FC2
FC1
FAn
FAn-1
AC3
AC2
AC1
ABn
AB6
AB5
AB4
AB3
AB2
AB1
BC2
BC1
BB7
BB6
BB5
BB4
BB3
BB2
BB1
BAn
BAn-1
AAn
AAn-1
GD2
GD1
DD2
DD1
ED2
ED1
FD2
FD1
AD2
AD1
BD2
BD1
17
6
1
5
2
M
TG
4
3
7
9
8

FIG. 4

FIG. 5

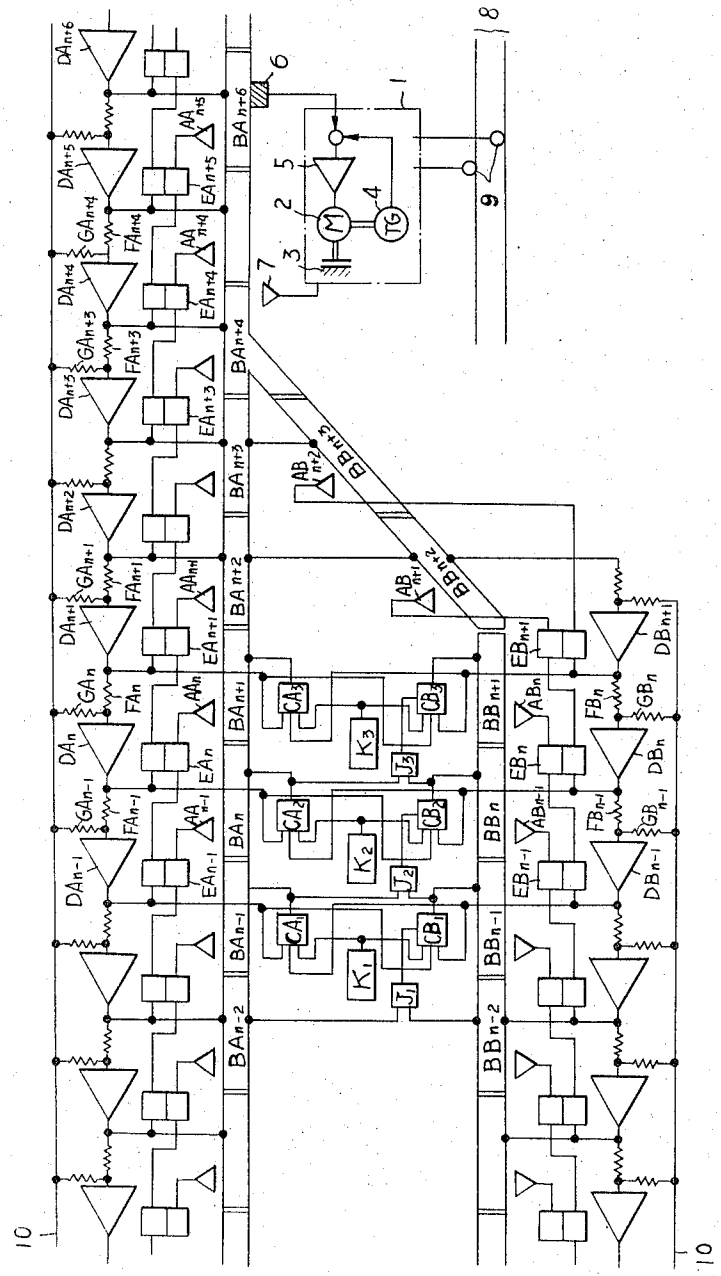
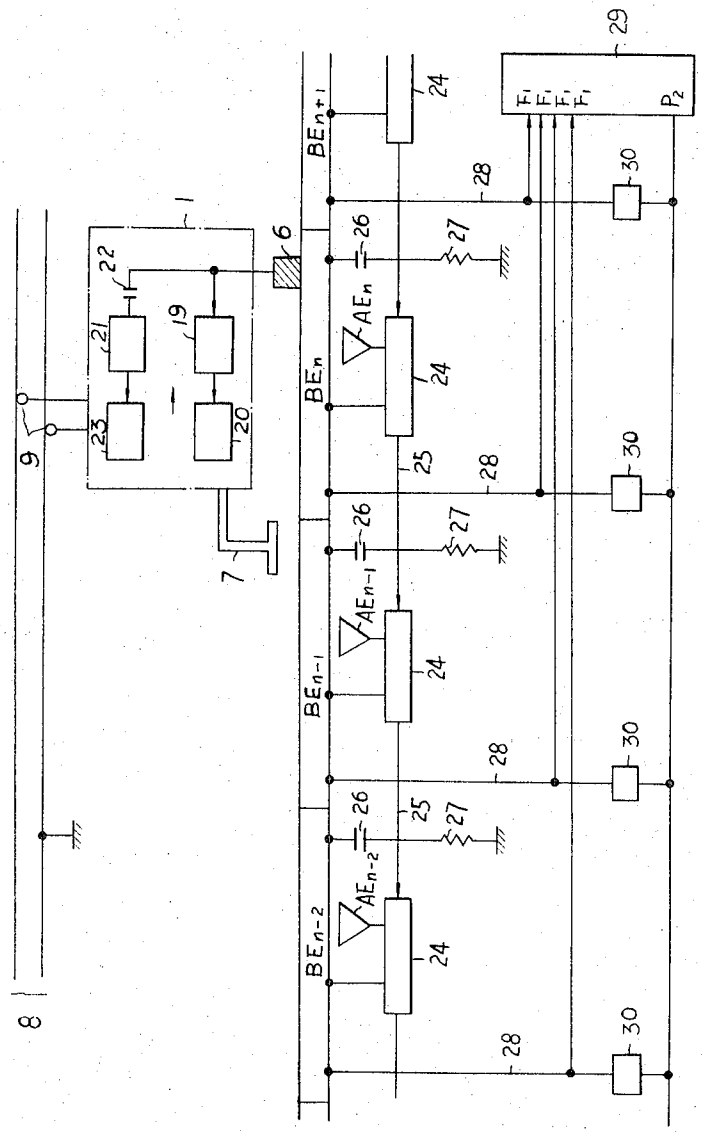

DAn+6
AAn+5
BAn+6
DAn+5
EAn+5
GAn+4
FAn+4
AAn+4
DAn+4
EAn+4
GAn+3
FAn+3
BAn+4
DAn+3
EAn+3
BAn+3
DAn+2
ABn+2
BBn+2
GAn+1
FAn+1
AAn+1
BAn+2
DAn+1
EAn+1
ABn+1
BBn+2
DAn
GAn
FAn
AAn
BAn+1
EAn
CA3
CB3
K3
J3
EBn+1
DBn+1
ABn
BBn+1
GBn
FBn
DBn
GAn-1
FAn-1
AAn-1
BAn
CA2
CB2
K2
J2
EBn
ABn-1
BBn
GBn-1
FBn-1
DBn-1
DAn-1
EAn-1
BAn-1
CA1
CB1
K1
J1
EBn-1
BBn-1
BAn-2
BBn-2
1
2
3
4
5
6
7
8
9
10
M
T6

FIG. 6


29
F_1
F_1
F_1
F_1
P_2
24
BE_{n+1}
28
30
26
27
AE_n
BE_n
25
AE_{n-1}
BE_{n-1}
AE_{n-2}
BE_{n-2}
1
6
22
21
19
23
20
9
7
8

APPARATUS FOR CONTROLLING VEHICLES AT JUNCTION POINTS

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates generally to an apparatus for controlling vehicles, and more particularly to an apparatus for controlling the spacing and speed of vehicles at a junction point in a track, path or roadway network.

2. Description Of The Prior Art:

In general, it is necessary to increase a radius of curvature of a branch line to control the centrifugal force developed by a high speed running vehicle, such as a railway car, as it diverges from a main or straight line. However, if a diverging line having large radius of curvature is provided, the area of interference or close proximity between the main line and a branched line is enlarged, making it difficult to permit both high vehicle speeds and high traffic densities at the divergence point.

In order to overcome the difficulty, it is possible to separate the systems controlling traffic on the main line and on the branch line for a specific distance on either side of the diverging or junction point, so as to provide vehicle control depending upon the vehicle's position with respect to either the main line or the branch line. However, a complicated apparatus is required for such control.

As stated above, if the radius of curvature of the branch line is increased, the space between the main line and the branch line is less than the width of the vehicles along a considerable distance which defines an area of interference. If the distance between a forward vehicle and a following vehicle is sufficient, no interference occurs. However, at high vehicle speeds and traffic densities, a long area of interference is considered dangerous because of the short distance between vehicles and the high running speed. Accordingly, it is necessary that vehicles passing on one line receive a warning or information signal from vehicles passing on the other line in the interference area.

Moreover, in addition to the problem created by two vehicles approaching two branch lines from the main line, it is also necessary to consider the problem of interference between a plurality of vehicles running from two branch lines onto a main line. Heretofore, in order to control such situations, vehicles on two lines have been alternatively stopped and then permitted to enter the main line, so as to pass without interference. The running interval ratio in such situations has been regulated depending upon the crowdedness of each line.

SUMMARY OF THE INVENTION

Accordingly, one object of the invention is to provide a novel apparatus for controlling individual vehicles running on a track, path or roadway.

Another object of the invention is to provide a novel apparatus for controlling the operation of separate vehicles near a junction or switching point.

Yet another object of this invention is to provide a novel apparatus for controlling a plurality of separate vehicles at an area where a main diverges into a plurality of branch lines.

A still further object of this invention is the provision of a system for automatically controlling vehicles so

that they take the most direct route to any selected destination.

Another object of this invention is to direct vehicles along the shortest route to any selected destination, taking into consideration the congested nature of traffic along the route.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic diagram showing basic circuit configurations used with the present invention;

FIG. **2** is a schematic diagram of one embodiment of the apparatus for controlling vehicles according to this invention;

FIG. **3** and **4** are, respectively, schematic diagrams of other embodiments according to the present invention;

FIG. **5** is a schematic diagram of another embodiment for controlling vehicles passing from two branch lines, according to this invention; and,

FIG. **6** is a schematic diagram of another embodiment of the present invention illustrating a system for switching vehicles among branch lines.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, wherein like reference numerals generally designate identical or corresponding parts throughout the several views, and especially to FIGS. **1** and **2**, one embodiment of the apparatus of this invention for controlling vehicles is shown, wherein the reference numeral **1** designates a car or an electrically powered vehicle, **2** designates a driving means or motor for the car **1**, **3** designates a damping or braking means for the car **1**, **4** designates a speed dynamo or tachometer generator and **5** designates an amplifier. Similarly, **6** designates a receiving element fitted on the front surface of car so as to progressively contact the below described conductive segments. The numeral **7** designates a car element, such as a car piece fitted to the back surface of the car, for progressively contacting the ground elements described below. The numeral **9** designates current collectors connected to feeder or power lines **8**, and **10** designates a constant voltage line carrying a reference voltage V_s.

The references A A_{n-1}, A A_n, A B_1. . . , AB_6, AC_2 . . . , AD_1, AD_2 . . . , . . . AE_{n-1}, AE_n designate, respectively, ground elements, which may be magnetic proximity switches, for example. The references BA_{n-1}, BA_n, BB_1 . . . . BB_5, BC_1, BC_2 . . . , BD_1 BD_2 . . . . , ... BE_{n-1}, BE_n designate, respectively, conductive segments which have impressed on them the output voltage of the below described addition devices. The conductive segments are insulated from each other and are positioned along the line of the track, path or roadway. The reference D_{n-1}, D_n . . . . designate addition devices, while E_{n-1}, E_n . . . . designate gates for switching the output signals of the addition devices after receiving signals from the ground elements, and F_{n-1}, F_n . . . designate addition resistances progressively having the output of constant voltage line **10** impressed upon them. The references G_{n-1}, G_n designate respectively

addition resistances for progressively feeding the output of each of the addition devices to the next addition device. The references . . . CA_{n-1}, CA_n, CB_1 . . . . CB_3, CC_1 CC_2 . . . . , CD_1, CD_2 . . . designate respectively output voltage controlling devices, each of which is comprised of an addition device, a gate for switching the output of the addition device, an addition resistance and the output of the constant voltage generator.

The references CE_1 . . . CE_3 designate respectively auxiliary output voltage controlling devices which include components similar to these of output voltage controlling devices CC_1 . . . CC_3 or CD_1 . . . CD_3. Although for the sake of simplicity the blocks containing the output voltage controlling devices and the auxiliary output voltage controlling devices are shown as being interconnected by a single line, it is to be understood that in fact the respective addition circuits, gate circuits and constant voltage generator outputs contained in each block are individually interconnected as in, for example, FIG. **4.** The final stage output of the output voltage controlling device CE_1 is connected so as to be the input of the output voltage controlling device CB_3. The track including the conductive segments BA_{n-a}, BA_n is called a main line, and the tracks connected to the main line are called a branch lines. The area of interference between two branch lines is called as an interference area or section and the remaining area is called the normal area or section. The conductive segments BB_2 and BB_4 and also BB_3 and BB_5 are respectively electrically connected.

The operation of the apparatus illustrated in FIG. **1** will now be described. As shown in FIG. **1,** through the receiving element **6,** the car receives the voltage impressed on the conductive segment B_n by the illustrated circuitry, which is described in greater detail in copending applications Ser No. 292,104 and Ser. No. 291,621, incorporated herein by reference. This voltage corresponds to the difference between. the car **1** and a lead or forward car (not shown). The voltage is passed through the amplifier **5** to the driving means or motor **2** to drive the car. The driving means **2** and the damping or braking means **3** are operated under the control of a feed-back network to return the output voltage of the speed dynamo or tachometer generator **4** to the input stage of the amplifier **5,** whereby the car **1** is run at the speed corresponding to the voltage on the conductive segment BE_n.

The voltages impressed on the conductive segments BE_{n-1}, BE_n . . . are the outputs of the addition devices D_{n-1}, D_n . . . . which are produced by progressively integrating the signal on the constant voltage line **10,** depending upon the distance between cars. For example, the output of the addition device D_n and the constant voltage signal are respectively added through the addition resistances G_{n-1} and F_{n-1} to the addition device D_{n-1}. When the output of the addition device D_{n-1} is impressed on the conductive segment BE_{n-1}, it becomes the input of the next addition device. The car element 7 faces closely the ground element AE_n, as the car moves and the signal received by the ground element AE_n is coupled to the switching gate E_n, whereby the output of the addition device D_n is made zero. Simultaneously, the addition device D_{n-1} is actuated by the switching gate E_{n-1}, whereby output voltages corresponding to the distance between one car and the following car are generated in the addition devices placed along the track, behind the addition device D_{n-1}.

More particularly, when the car element **7** of FIG. **1** faces the ground element AE_{n-1}, the switching gate E_{n-1} is set and the other switching gates are reset. The output of the addition device D_{n-1} is zero and the input of the addition device D_{n-2} (not shown in the drawing) is Vs. The input of the addition device D_{n-3} (not shown in the drawing) is the sum of the reference voltage Vs and the output of the addition device D_{n-2}, which is Vs, because of the reset condition of the switching gate E_{n-2}. The output of the addition device D_{n-3} is thus 2 Vs. Similarly, the voltage nVs is impressed on the conductive segment BE_x at a position n elements away from the ground element AE_x facing the car element **7.** The car **1** receives the voltage of the conductive segment BE_x through the brush **6,** and the motor is controlled by the damping means **3** which compares the output of the car speed detector **4** with the voltage of the conductive segment to control the speed of the car.

As shown in FIG. **2,** in the interference area beyond the diverging point, the ground elements of two lines are respectively laid along the tracks. The output voltage controlling devices CB_1 . . . . CB_3 are common to the two lines, and provide identical control signals.

A specific distance into the normal area from the interference area, the outputs of the ground elements AC_1 . . . . AC_3 are connected so as to simultaneously apply a signal to the output voltage controlling devices CC_1 . . . . CC_3 and to the auxiliary output voltage controlling devices CE_1 . . . CE_3 corresponding to the location of a vehicle at ground elements AC. The outputs of the ground elements AD_1 . . . AD_3 are similarly connected so as to simultaneously apply their outputs to the output voltage controlling devices CD_1 . . . . CD_3 and the auxiliary output voltage controlling devices CE_1 . . . CE_3 corresponding to the location of a vehicle at the ground elements AD_N.

When a first car passes the ground element AC_3 and a second car passes the ground element AD_1, the output voltage controlling devices CC_3 and the auxiliary output voltage controlling device CE_3 are operated, in response to the first car, and their outputs are transferred progressively through the interconnected devices to the output voltage controlling device CC_1 and the auxiliary output voltage controlling device CE_1 in accordance with the operation of the addition networks and gate circuits in each of the controlling devices CC_3, CC_2 and CC_1 and the auxiliary output voltage controlling devices CE_3, CE_2 and CE_1. On the other hand, the signal transmitted to the auxiliary output voltage controlling device CE_1, due to the output signal of the ground element AD_1 in response to the second car is converted to information concerning the position of the approaching second car by resetting the information transmitted by the output signal of the ground element AC_3 and instead transmitting a signal indicating the operation of the ground element AD_1 to the output voltage controlling devices beyond the including the device CB_3.

In this embodiment, the voltage corresponding to the distance between a particular car and a forward or lead car is impressed on the conductive segments. It is possible to convert the spacing information to car speed information by differentiating the signal corresponding to the car spacing.

In this embodiment, car spacing information is automatically provided from the car nearest to the diverg-

ing or junction point by the auxiliary controlling devices laid along a portion of the branch line, and this information is transmitted to the car running on the main line. There is no need for a car spacing information switching device which distinguishes the direction of the car running on the main line, according to the present invention, and accordingly an economical and accurate control of traffic can be attained using the above described system.

Referring again to the embodiment of the invention illustrated in FIG. 2, a decrease in the speed of a car which will be turned onto the branch line should be provided, which will cause the speed of this car to be different from the speed of following cars which do not turn onto the branch line. In addition the car should be accelerated after it passes the junction point. However the operation of the cars must be carefully regulated to secure safety, for the following reasons, If the car slowing for the turn to the branch line is not closely followed by another car, no hazard occurs. However, if the turning car is being closely followed by another car which does not reduce its speed, a collision can occur.

In this case, it is necessary to obtain information as to the spacing between a particular car and the forward or leading car. However, in accordance with the above described embodiment of the invention, the car heading for the branch line is automatically controlled depending upon the distnace to the nearest car on the other branch line and the car following that car is also controlled. Accordingly, accidients of the type mentioned will be prevented with the present invention.

Another embodiment of the apparatus of the invention is illustrated in FIG. 3, wherein the reference numeral 11 designates a main line; and the car 1 is run from the main line 11 through the junction point to a first branch line 12 or a second branch line 13. The reference numeral 14 designates a main line section and 15 designates an interference area or section, while 16 designates a specific branch section wherein no interference is caused, but the spacing of the cars in the interference section and the main line section are affected by cars in this section.

In FIG. 3, the reference H_M designates a series of ground devices which are essentially the same as the output voltage controlling devices CAn, etc., shown in FIG. 2, and A_M designates ground elements in the main line section 14, the interference section 15 and the branch line section 16. The reference B_M designates conductive segments in the main line and the interfering line, and H_{s1}, H_{s2} designate respectively ground devices in the first and the second branch sections 12 and 13, and A_{s1}, , A_{s2} designate respectively ground elements in the first and the second branch sections, while B_{s1}, B_{s2} designate respectively the conductive segments in the first and the second branch sections.

In the embodiment shown in FIG. 3, wherein the ground devices H_M, operating in essentially the same manner as the output voltage controlling devices of FIG. 2 are arranged, when the forward car is in the interference section on either the first or the second branch lines, information concerning the position of the forward car is transmitted to the ground devices H_M through the ground elements A_M, which are connected in parallel. The same signal is transmitted to the conductive segments B_M of the first and second branch lines, whereby the same car spacing control is provided on both the main line section and the interference section.

Even when the forward car is out of the interference section, if the forward car affects following cars beyond the interference section, the information as to the position of the forward car is transmitted to the following car by the ground elements A_M and the ground devices H_M arranged along the first and the second branch lines. The following car travels through the junction point at a speed depending upon the position of the forward car. Thus, for example, a car in the branch section 16 informs following cars of its position through the ground device H_M, and the following car receives this information through the ground devices H_{s1}, H_{s2}. The following car can thus diverge without interfering with the forward car at the point of divergence.

As stated above, especially in the embodiment of a traffic control system having short car spacing and vehicles running at high speeds and at high traffic densities, the vehicle spacing in the interference section and the main line are controlled so as to prevent interference at the diverging point, by dividing the interfering section to a plurality of segments. In the interference section, the same vehicle spacing is maintained as on the main line, and no accumulation of vehicles in front of the diverging or junction point occurs, whereby high speed and high traffic density operation can be maintained.

Another embodiment of the invention is illustrated in FIG. 4, wherein the reference numeral 17 designates an arrow indicating the direction of the car 1, and the references AA_{1-1}, AA_n, AB_1 . . . . AC_1, AC_2 . . . , and AD_1, AD_2 . . . . designate respectively ground elements, such as magnetic proximity switches, placed at specific intervals along the track, and the references EA_{n-1}, EA_n, EC_1, EC_2 . . . . and ED_1 ED_2 . . . designate respectively gates, for switching the output of the below-described addition devices under the control of the outputs of the ground elements. Similarly, the references DA_{n-1}, DA_n, DC_1, DC_2 . . . and DD_1 DD_2 . . . . respectively represent addition devices generating outputs corresponding to the distance from a forward or lead car, and BA_{n-1}, BA_n, BB_1 . . . . BB_7, BC_1, BC_2 . . . . BD_1, BD_2 designate respectively individually insulated conductive segments having impressed thereon the output voltages of the addition devices and arranged along the track line.

The references GA_{n-1} GA_n, GC_1, GC_1 . . . . and GD_1, GD_2 designate respectively addition resistances for providing inputs to the addition devices from the constant voltage line 10, and FA_{n-1} FA_n FC_1 FC_2 . . . . FD_1 FD_2 designate respectively addition resistances providing inputs to the addition devices from the outputs of preceding addition devices. The reference numeral 18 designates a comparision device for comparing the outputs of the addition devices DC_1 and DD_1 and for developing a signal from the smaller of these two outputs The operation of the system illustrated in FIG. 4 will now be described in detail. The car receives through the receiving element 6, the voltage on the conductive segment BA_n, which is proportional to the distance from the forward car, and this voltage is transmitted through the amplifier 5 to the driving means 2 to control the car speed, as previously described. The outputs of the addition devices progressively sum the voltage on the constant voltage line 10, developing a signal corresponding to the car spacing. The output of the addition device DC_3, for example, and the signal on the constant volt-

age line **10** are respectively transmitted through the addition resistances FC_2, GC_2 to the addition device DC_2 and are added at that device. The output of the addition device DC_2 is impressed on the conductive segment BC_1 as a voltage corresponding to car spacing.

As shown in FIG. **4**, the conductive segments in the interference section BB_2 and BB_5; BB_3 and BB_6; BB_4 and BB_7 are respectively electrically connected to carry the same voltage. In the gates for switching the outputs of the addition devices, for example, when the car element **7** faces the ground element AC_3, the switching gate EC_3 is closed, whereby the output of the addition device DC_3 is made zero, and the switching gate EC_2 is opened to actuate the addition device following DC_2. An output voltage proportional to car spacing is impressed onto the conductive segment following the conductive segment BC_1. When one car faces the ground element AC_3 and another car faces the ground element AD_5, the output voltage of the addition device DC_1 is smaller than the output voltage of the addition device DD_1. When the outputs of both devices are compared by the comparison device **18**, the smaller output of the addition device DC_1 is impressed on the next addition device DA_n. This signal is progressively transmitted whereby the car **1** runs according to a voltage determined by the distance from the forward car which faces the ground element AC_3.

In this embodiment, a voltage corresponding to the car spacing or distance from the forward car, is used. However, it is also possible to calculate the forward car speed from the car spacing information by differentiating the signal corresponding to the car spacing that is provided at the output of the addition device.

As stated above, in this embodiment, in order to properly control traffic at the divergence point using a simple apparatus, the main line and the interfering section of the branch lines are controlled by the same devices to prevent interference between two cars. In normal, non-interfering sections beyond the interfering sections, independent control is provided for each branch line. Accordingly, when a forward car is stopped at a point beyond the interfering section, following cars travelling on other branch lines can run without being affected by the stopped forward car. The control signal between the main line and the interfering branch line is a relatively small signal. If a larger signal is provided, the forward car in the normal section of the first branch line is stopped and the forward car in the normal section of the second branch line approaches from a distant position, and a signal is transmitted corresponding to the distance from the forward car in the second branch line. Accordingly, if the following car gets into the interfering section of the first branch line and the forward car is stopped in the normal section of the first branch line, the following car will collide with the forward car when it reaches the normal section of the first branch line. In order to prevent such accidents, the smaller of the signals from the normal section of the first branch line and the second branch line is transmitted to the interfering section. When the forward car in the normal section of the first branch line is stopped and the forward car in the second branch line approaches from a distant position, the smaller signal of the forward car in the first branch line is transmitted to the interfering section.

If the following car is on the first branch line, there is no problem because a normal car spacing is maintained. However, when the following car is on the interfering section of the second branch line, it runs at a speed corresponding to the distance from the forward car on the first branch line, and accordingly the car suddenly speeds up at the entrance of the normal section of the second branch line. The following car runs at a relatively low speed corresponding the distance from the nearer forward car, and accordingly, even though the car enters the second branch line, the car is under the control of the high traffic density control system, and does not slow down.

On the other hand, after passing the interfering section, it is possible to pass the forward car on the first branch line. In so doing, the speed of the passing car is decreased depending upon the position of the forward car on the same line, and after passing the forward car in the other line, the speed is increased. When the car enters the second branch line at a high speed with no forward or lead car, the following car is safe. However, when the following car enters the other line wherein there is a forward car, a collision with the forward car on the line is possible. Such accidents are caused by running the following car at the same speed as the forward car. Thus, it is necessary to obtain information as to the distance to a slowly moving or stopped forward car on different brances of the line. However, in accordance with the present embodiment of the invention, even cars on branch lines having no forward cars are automatically damped if a slowly moving or stopped forward car is detected on a different branch line, and the following car is also slowed correspondingly, so that no accident happens.

Another embodiment of the invention is illustrated in FIG. **5** wherein cars are run from two branch lines onto one main line, the opposite of the former embodiment. The cars are automatically and efficiently run from branch lines to one main line in the order of their arrival at the junction.

In FIG. **5**, the references AA_n . . . AB_n designate respectively ground elements, such as magnetic proximity switches, which are arranged at specific intervals along a track, and are progressively faced by the car element **7**. The references EA_n . . . EB_n designate respectively gates for switching outputs of addition devices upon receiving signals generated by the progressively triggered ground elements as the car passes, and DA_n . . . DB_n designate respectively addition devices summing progressively the output of the constant voltage generator to develop a signal corresponding to the distance between a following car and a forward car. The references FA_n . . . FB_n designate respectively addition resistances coupling the outputs of the addition devices DA_{n+1} . . . DB_{n+1} to inputs of the next respective addition devices, and GA_n . . . GB_n designate respectively addition resistances coupling the signal on the constant voltage line **10** to the input of the addition devices DD_n . . . . DB_n. The references BA_n . . . BB_n designate respectively conductive segments on which the output voltages of the addition devices DA_n . . . DB_n are impressed, and which are insulated from each other and are arranged along the track line. The references K_1 . . . K_3 designate respectively speed decreasing signal devices for generating decreasing output voltages in a predetermined section of two tracks near a junction point, while CA_1 . . . CA_3 designate respectively output voltage controlling devices for passing smaller output signals after measuring the outputs of the addition de-

vices DA_{n-1} . . . DA_{n+1}. The references CB_1 . . . CB_3 designate respectively output voltage controlling devices for passing smaller outputs after comparing the outputs of the addition devices DB_{n-1} . . . DB_{n+1} and which close the outputs of the addition device DA_{n-1} . . . DA_{n+1} when impressing the output of the below described zero detectors, and pass the smaller of the output of the addition devices DB_{n-1} . . . DB_{n+1} or the output of the speed decreasing signal devices K_1 . . . K_3. The references J_1 . . . J_3 designate respectively zero detectors for supplying an output signal indicating the detection of a zero to the output voltage controlling devices CB_1 . . . CB_3 when the voltages on the conductive segments of two tracks are zero by comparing the voltage on the conductive segments BA_{n-2} and BB_{n-2}.

The operation of the embodiment illustrated in FIG. 5 will now be described in detail. When the car element 7 faces the ground element AA_{n+4}, the signal received by the ground element is transmitted to the switch controlling gate EA_{n+4}, whereby the output of the addition device DA_{n+4} is made zero and is simultaneously transmitted to the switch controlling gate EA_{n+3} whereby the output of the addition gate is cut off. The addition device DA_{n+3}, which has an input from the constant voltage generator coupled through the addition resistance GA_{n+3}, generates an output which is impressed on the conductive segments BA_{n+3} and BB_{n+3} and is provided as the input of the addition device DA_{n+2}. Similarly, when the car element 7 faces the ground element AA_{n+5} as the car 1 moves, the signal received by the ground element AA_{n+5} is transmitted to the switch controlling gate EA_{n+5}, whereby the output of the addition device DA_{n+5} is made zero, and an output is simultaneously generated by the addition device DA_{n+4}. The output of the addition device is increased by specific voltage increments depending upon the progress of the car, and corresponds to the spacing between cars.

The track section including the conductive segments BA_{n+4}, BA_{n+3} . . . . BA_{n+2} and BB_{n+4} . . . BB_{n+2} is the junction section or interference section. In order to prevent collisions, the pairs of conductive segments BA_{n+3} and BB_{n+3}; and BA_{n+2} are electrically connected to control the two lines at the interference section with one control system. The interference section is usually more than 30 meters in length, for example. The section including the conductive segments BA_{n+1} . . . BA_{n-1} and BB_{n+1} . . . BB_{n-1} is the junction controlling section in front of the interference section, and is an important track section for attaining the desired effect of this invention. The junction controlling section is usually about 100 meters in length in a railway system.

The voltages impressed on the conductive segments BA_{n-1} . . . BA_{n+1} are controlled by the output voltage controlling devices CA_1 . . . CA_3 so as to impress the smaller of (1) the output voltage of the addition devices DA_{n-1} . . . DA_{n+1} on the line having a car thereon or (2) the higher of output voltage of the addition devices DB_{n-1} . . . DB_{n+1} on the other line and the output of the decreasing signal devices.

On the other hand, the voltages impressed on the conductive segments BB_{n-1} . . . BB_{n+1} are controlled by the output voltage controlling devices CB_1 . . . CB_3 so as to impress the higher of (1) the output voltage of the addition devices DA_{n-1} . . . DA_{n+1} on the car line or (2) the smaller of the output voltage of the addition devices DA_{n-1} . . . DA_{n+1} on the other line and the output voltage of the decreasing signal devices.

When two cars are running in parallel on each line at corresponding positions in the junction controlling section, the following control arrangement is provided to allow the car on the conductive segments BA_{n-1} . . . BA_{n+1} to pass first. First, it is pointed out that when two cars are running on each line in parallel, the car element of each car simultaneously faces the ground elements on each line. The resulting signal from the ground element is passed through the switch control gate whereby the output of the addition devices DA_{n-2} and DB_{n-2}; DA_n and DB_n are simultaneously reduced to zero and the impressed voltages of the conductive segments BA_{n-2} and BB_{n-2} . . . BA_n and BB_n carrying the above outputs are also zero. This condition is detected by the zero detectors J_1 . . . J_3. When the voltages impressed on corresponding conductive segments are simultaneously zero, the outputs of the zero detectors J_1 . . . J_3 are applied to the output voltage control devices CB_1 . . . . CB_3, whereby the output voltage control devices CB_1 . . . CB_3 cut off the outputs of the addition devices DA_{n-1} . . . DB_{n+1} on the other line to prevent these outputs from being supplied to the output voltage control devices CB_1 . . . CB_3. Accordingly, the system operates so as to impress only the smaller of (1) the output voltage of the addition devices DB_{n-1} . . . DB_{n+1} on the car line or (2) the output voltage of the decreasing signal devices K_1 . . . K_3, on the conductive segments BB_{n-1} . . . BB_{n+1}. The operation of this embodiment of the invention will now be further described in terms of several exemplary operating situations.

EXAMPLE 1

Running on Independent Lines

When cars runs on the main line before reaching the junction controlling section, or after passing the divergence point, the output of the addition device at the position of the forward car, is zero, and the voltage on the constant voltage line **10** is progressively integrated at areas behind the position of the forward car, whereby an output proportional to the distance from the forward car is provided at the position of the following car. The following car then runs at an appropriate speed for preventing a collision with the forward car.

EXAMPLE 2

Running in the Junction Controlling Section

(2–1) Control equation

The voltage provided to each conductive segment in the junction controlling section can be expressed in equation form. The appropriate voltage value can be calculated from the outputs of the voltage controlling devices CBi, CAi and the zero detector Ji. Thus:

E Ai = min. [V Ai, max (V Gi, V Bi) (normal Condition)] (1)

E Bi = min. [V Bi, max (V Gi, V Ai) (different distances from the junction)] (2)

E Bi = min. [B Bi, V Gi (same distance from the junction)] (3)

wherein:

E Ai is the voltage impressed on the conductive segment F Ai;

E Bi is the voltage impressed on the conductive segment F Bi;

V Ai is the output voltage of the addition device C Ai;

V Bi is the output voltage of the addition device C Bi; and

V Gi is the output voltage of the speed decreasing signal device.

In FIG. **5**, three conductive segments are shown where $i = 1, 2, 3$. However about **100** circuit segments are joined to form the junction controlling section. It is further noted that the term "same distance from the junction" in the Equation (3) means a situation in which two cars run on different branch lines but at the same distance from the junction point. The term "different distances from the junction" in the equation (2) means a situation in which two cars run on different branch lines at significantly different distances from the junction point.

(2–2) Single Car In the Junction Controlling Section

When one car runs into the junction controlling section from one branch line, as in the case when there is no forward car in the section, the movement of the car is as follows:

V Ai = V Bi > V Bi

* E Ai = E Bi = V Ai = V Bi Accordingly, the car runs as if a car running on the main line is considered as the forward car.

(2–3) Plurality of Cars Running on One Branch Line

When a plurality of cars run on only one branch line, the first car runs as the above described single car and, the next car runs keeping an appropriate distance behind the forward car. For example, when no car runs on line B (the lower branch in the FIGURE) and a plurality of cars run on line A (the upper branch in the FIGURE) the output voltages are as follows:

V Bi > V Gi, V Ai < V Bi;

* E Ai = V Ai The output voltage, proportional to the distance from the forward car on A line, is impressed on the conductive segment B Ai.

(2–4) Car Running on Both of the Branch Lines At Different Distances From the Junction

When one or more cars run on line A, and another car enters line B, the output voltages are as follows:

V Bi > V Ai, V Bi < V Gi,

* E Bi = max (V Gi, V Ai). In the case where V Ai < V Gi, the impressed voltage equation is E Bi = V Gi, and the car on line B stops at the end of the junction controlling section. However, when the car on line A runs, the output voltage will be V Ai > V Gi, and thereafter the impressed voltage is E Bi = V Ai, and the car runs at a speed corresponding to the distance from the car on the other line. When many cars run on line A at slow speed, and the car first reaching the junction controlling section is on line B, the car on line B passes ahead of the cars on line A. The technique of preventing interference at the junction is described below.

(2–5) Cars Running on Both of the Branch Lines At the Same Distances From the Junction

When cars reach the junction controlling section at the same time on both lines, the car on line A has priority, and the speed of the car on line B is decreased because the output voltage controlling line B is limited to the output voltage V Gi of the speed decreasing signal device Gi.

EXAMPLE 3

Evidence of No Interference

In order to understand how the present invention eliminates traffic interference, the following example is presented. Consider first the following equation:

E Ai = E Bi = min (V Ai, V Bi) The cars on each line are controlled to run at a speed which depends upon the position and speed of the nearest forward car running on either the same or a different line. One of the cars running in parallel is slowed down, so as to put the cars into the relationship of a forward car and a following car, even though they are on the different lines. Accordingly, any interference at the junction is prevented.

However, in this control system, if two cars enter the junction controlling section at high speed and separated by only a small distance, the following car, even though on a different line, is suddenly affected by the forward car on the other line, and a severe decrease in its speed may occur. In order to prevent this difficulty, when a forward car is present on another line, the signal for decreasing speed is provided by the speed decreasing signal device K_1. The output voltage V Gi can be a small value near the junction, and accordingly the following equation obtains:

E Ai = E Bi = min. (V Ai, V Bi). As stated above, the running voltage impressed on each conductive segment depends upon the distance from the forward car on each of the branch lines to allow cars to move from the branch lines onto the main line. Accordingly, as shown in FIG. **5**, the receiving element **6** of the car **1** contacts the conductive segment BA_{n+6}, so as to receive the voltage impressed thereon. This voltage is passed through the amplifier **5** to the driving means **2** to control the car. A feed-back control system for feeding back the output voltage of the speed dynamo **4** to the amplifier is provided whereby the damping or braking means **3** is actuated to control the driving means or motor **2** so as to regulate the car speed corresponding to the voltage impressed on the conductive segments.

In the above described embodiment, the voltage on the conductive segments corresponds to the car spacing. However, it is also possible to develop a signal proportional to the speed of the forward car, and to the car spacing and to impress this signal on the conductive segments. Furthermore, the system described above includes a network for progressively integrating the signal on the constant voltage line **10**, to provide inputs to the addition devices DA_n . . . . and DB_n, as a form of car spacing signal. It is alternatively possible to employ a digital system for detecting the car spacing using counters, the outputs of which correspond to the car spacing.

As is clear from the above disclosure, in this embodiment, the car speed instruction from one line, the car speed instruction from the other line and the speed decreasing information, are compared. The lowest car speed instruction is then used as the control signal. Otherwise, the higher of the car speed instruction from the line not carrying the car or the speed decreasing information is used as the control signal.

Referring now to the embodiment illustrated in FIG. **6**, an information transmission system is disclosed for vehicles such as cars, each of which have respectively

different destinations and carry cargoes or passengers to such different destinations. This novel control system allows the vehicles to arrive at their respective destinations as soon as possible, by electing the most efficient direction of travel. However in general, in order to change the distination of a vehicle running on a track using a ground switch system, the vehicle is allowed to approach a junction point only after the completion of the switching operation is confirmed for purposes of safety. If the switching is not completed, it is necessary for the vehicle to wait at the junction point. Accordingly, at the initiation of switching, it is necessary to maintain the vehicle at a position sufficiently far from the junction to permit it to stop if necessary. The initiation of switching may be carried out after the passing of a forward vehicle, accordingly, it is also necessary to keep the vehicle spacing longer than the stopping distance of the vehicle.

There is no problem is employing ground switching in conventional train controls to regulate car spacing. However, the present embodiment provides the possibility of increasing total traffic volume by controlling high traffic densities and transferring the vehicles to the shortest course. In this system, the speed of following vehicles is dependent upon the speed of forward or leading vehicles and vehicle spacing. Accordingly, the vehicle spacing is quite small when both vehicles run at the same speed, and only an excess safety distance corresponding to a difference in stopping distances is maintained. However, it is not allowable for vehicles having alternatively different distinations to use conventional ground switching systems. therefore, it is necessary to allow the vehicles having the same distination to occasionally enter junctions points for switching to other lines. Accordingly, each vehicle arrives through a roundabout route at its destination, which is inefficient and causes a decrease in total traffic volume. In order to overcome this difficulty, in the embodiment of FIG. **6** a device for controlling car switching is fitted to each vehicle, whereby each vehicle finishes the necessary preparation for switching before entering a divergence or junction point. However, it is necessary to transmit each switching instruction through certain ground devices, and there are various difficulties in the information transmission between a large number of vehicles and the ground devices. These difficulties can be overcome by providing a series transmission circuit along the tracks for transmitting information as to the forward vehicle speed and information as to the vehicle spacing and also providing parallel transmission circuits for transmitting the switching instructions between the vehicles and the ground controlling devices, which are placed predetermined distances apart along the tracks.

The embodiment illustrating these features is shown in FIG. **6**, wherein the reference numeral **19** designates a speed controlling device for controlling a driving means or motor **20** in the vehicle **1**, which is operated by DC current provided through the receiving element **6**. The numeral **21** designates a device for transmitting and receiving signals between a ground controlling device and the means which is connected through a DC blocking condenser **22** to the receiving element **6**. Similarly, **23** designates a device for controlling divergence or switching which is controlled by the output of the means for transmitting and receiving signals. The divergence controlling device causes selective connection of guide wheels to a groove in the track for straight running or a groove in the track for diverging, i.e., switching to another track. The reference numeral **24** designates distance detectors which are connected to each other by a series transmission line, and which provides a signal indicating the distance from a forward vehicle, that is, an output corresponding to the number of ground elements AE_x, and, thus the number of conductive segments BE_x between a particular car and the forward car. When the ground elements AE_x faces the element **7** of the vehicle and detects the presence of the vehicle, the ground element generates a signal indicating the presence of the vehicle until the forward ground element AE_x detects the vehicle.

The reference numeral **26**, designates a blocking condenser while **27** designates a ground resistance and **28** designates a parallel transmission line for transmitting a direction-information signal having a first frequency F_1 generated by the means **21**. The parallel transmission line transmits a switching instruction information signal having the second frequency F_2 from the ground controlling device **29** to the means **21**. The speed controlling device **19** determines the speed of the vehicle as a function of both of the vehicle spacing and the relative speed of two vehicles measured by differentiating the output signal of the spacing detector **24** whereby the driving means **20** is properly driven. In this embodiment, the ground element AE_{n-1} facing the element **7** of the forward vehicle (not shown in the drawing) generates a signal indicating the presence of the vehicle, until the element **7** faces the next ground element AE_n, whereby the integrated output of the unit or reference voltage generated by the spacing detector **24**, is impressed on the receiving element **6** of the following vehicle **1** as the forward vehicle moves. The unit voltage is proportional to the length of the conductive segment BE_x and the integrated value is proportional to the spacing between the two vehicles. Accordingly, the relative speed of the two vehicles determined by the input voltage of the receiving element **6** changes. The differentiated value of this input voltage is proportional to the relative speed of the vehicles. The speed of the forward vehicle can be measured by adding to the relative speed the speed of the following vehicle which can be detected by a speed dynamo or tachometer generator which is not shown in the drawing.

High traffic densities and safe operation are thus attained by driving the vehicle **1** depending upon the speed of the forward vehicle and the spacing between the two vehicles.

At a position sufficiently far from a diverging or junction point, a specific code number, or destination station code number, for each vehicle is transmitted from the means **21** to the ground controlling device **29**. This information is preferably transmitted in code at a first frequency F_1. The transmitted information is passed through the DC blocking condenser **22**, the receiving element **6**, the conductive element BE_x and the parallel transmission line **28**. More than two vehicles are not allowed on any one conductive segment BE_x at the same time. Accordingly, the ground controlling device **29** may receive signals having the same frequency from a plurality of vehicles without confusion.

When the destination information is transmitted to the ground controlling device **29**, the device **29** selects the course having the shortest time and the shortest distance to the desired destination, taking into account

traffic congestion on the tracks. The device **29** then decides the divergence or switching of the vehicle at the various diverging or junction points, and transmits this information to the vehicle. This information indicating the proper direction of the vehicle, may be in the form of a specific code transmitted at a second frequency F_2. Although many vehicles may receive this signal at the same time, each vehicles selects only infromation corresponding to its own specific code number, and the switch actuating device **23** is triggered. The result of this operation is transmitted back to the ground controlling device **29** and the vehicle is permitted to run through the junction point or switch.

It is noted that several spacing detector units **24** and frequency separating filters **30** may be packed in one control box.

To summarize, in the present invention the vehicle spacing information is utilized for obtaining the speed of a forward vehicle. As stated above, in accordance with the invention, high traffic density operation is attained and the minimum safe spacing between vehicles is shortened by providing a transmission line for transmitting vehicle spacing information and vehicle speed information between vehicles. In addition, switching instructions are transmitted by providing a transmission line between the ground controlling device and the vehicles, thereby switching each vehicle independently. Moreover, the present invention insures that all vehicles traveling to each destination take the shortest course without using a roundabout route, and when the shortest course is congested, the vehicles take the shortest uncongested route, so as to attain efficient traffic control depending upon the traffic conditions at each moment.

As stated above, in accordance with the apparatus of this invention, optimum control of vehicles running on a track can be attained. Control of the vehicles running on a main line can also be attained with both high vehicle speeds and high traffic densities, whereby the vehicles can run safely and accurately with high efficiency and without danger of collision.

More detailed information as to the operation and structure of the various specific circuit elements described hereinabove will be found in the two applications referenced previously.

Obviously, numerous additional modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An apparatus for controlling a vehicle comprising:

a first plurality of ground elements placed at predetermined intervals along a main line,

a second plurality of ground elements placed at predetermined intervals along a first branch of said main line,

a third plurality of ground elements placed at predetermined intervals along a second branch of said main line,

all of said ground elements generating output signals as said vehicle passes said ground elements,

a plurality of adding devices coupled to said ground elements for progressively summing said output signals and for generating output signals indicating said progressive summing.

control means responsive to said progressive summing output signals for regulating the speed of said vehicle and the spacing between said vehicle and other vehicles,

auxiliary control means responsive only to output signals generated by said second and third pluralities of ground elements; and,

circuit means responsive to said auxiliary control means for controlling said vehicle in a zone where said first and second branch lines merge with said main line.

2. An apparatus for controlling a vehicle as in claim **1** further comprising:

a plurality of conductive segments arranged along said main line and said first and second branch lines and connected to said ground elements.

3. An apparatus for controlling a vehicle as in claim **2,** further comprising:

a receiving element coupled to said vehicle for progressively contacting said conductive segments; and

driving means coupled to said receiving element for driving said vehicle in response to output signals from said receiving element.

4. An apparatus for controlling a vehicle as in claim **2,** further comprising:

a plurality of switching gate means coupled to said ground elements and actuated thereby for progressively transmitting the output signals of said adding devices to said vehicle.

5. An apparatus for controlling a vehicle as in claim **1,** wherein:

said control means includes a first plurality of control devices for regulating said speed and spacing on said main line,

a second plurality of control devices for regulating said speed and spacing on said first branch line; and,

a third plurality of control devices for regulating said speed and spacing on said second branch line.

6. An apparatus for controlling a vehicle as in claim **5,** further comprising:

comparing means coupled to said control devices for comparing the outputs of at least one control device in said second plurality of control devices and at least one control device in said third plurality of control devices, and for controlling said vehicle in said zone in response to the smaller of said compared outputs.

7. An apparatus for controlling a vehicle as in claim **1,** further comprising:

comparing means coupled to at least two of said adding devices located adjacet to said zone for comparing the outputs thereof.

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