

[54] **SHORT HEADWAY SWITCHING SYSTEM**

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[52] U.S. Cl. .... **104/130; 104/96**

[51] Int. Cl.<sup>2</sup> .... **E01B 25/06**

[58] Field of Search ..... 104/88, 96, 102, 103, 104,  
104/105, 130, 131

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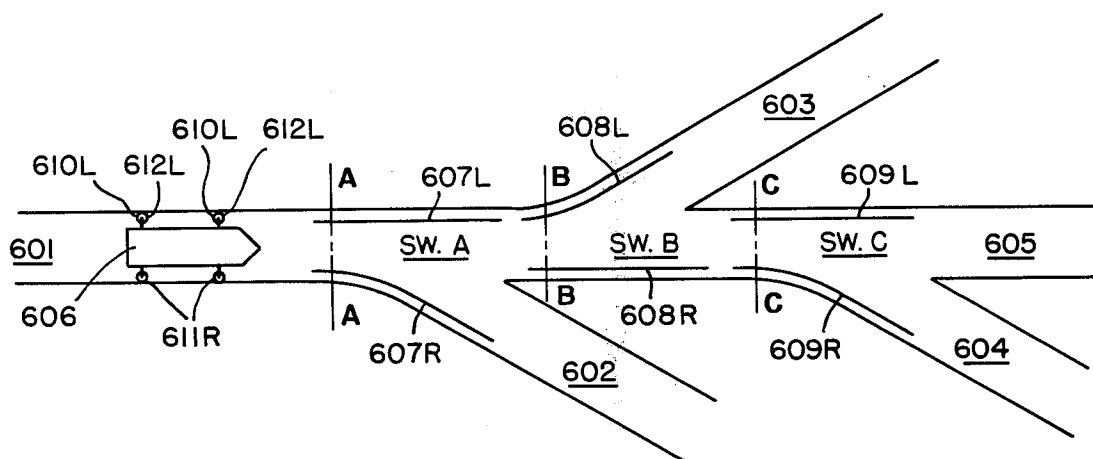
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[57] **ABSTRACT**

In a personalized rapid transit system employing way-

side switching, safety considerations require so much separation between successive vehicles that passenger handling capacity is too low. In an onboard switching system, safety considerations require so much separation between successive diverge points that excessive space is required at a major junction. A new switching concept is presented which employs a plurality of types of diverge points and/or a plurality of types of vehicles and which allows shorter headway between vehicles with no reduction in safety. A system having a plurality of types of diverge points and a vehicle having a plurality of onboard devices, individual ones of which may be selectively set to cooperate with any selected type of diverge point, is disclosed. This system permits the setting of the onboard devices and the passage of the vehicle through the plurality of diverge points without the need to adjust the onboard devices subsequent to the entry of the vehicle into the first diverge point and prior to the exit of the vehicle from the last diverge point. Another system is disclosed employing a single type of diverge point which cooperates in different manners with vehicles of different types.

**17 Claims, 16 Drawing Figures**



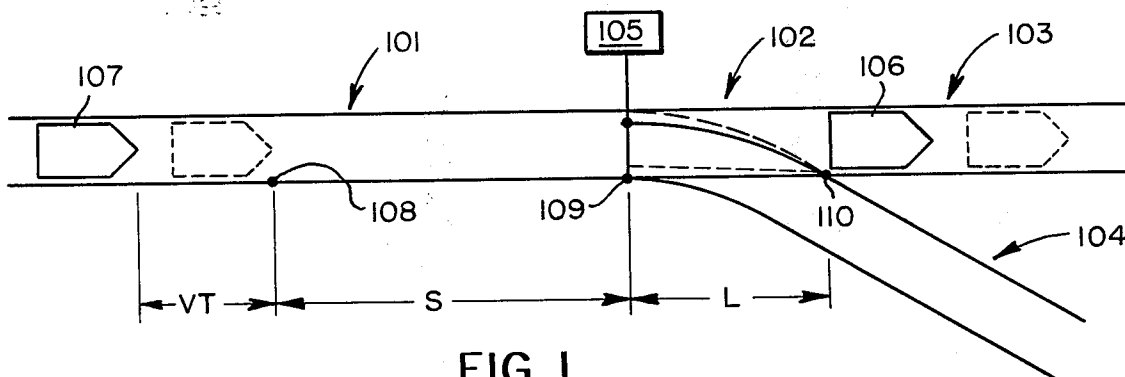


**FIG. 1**  
WAYSIDE SWITCHING  
PRIOR ART

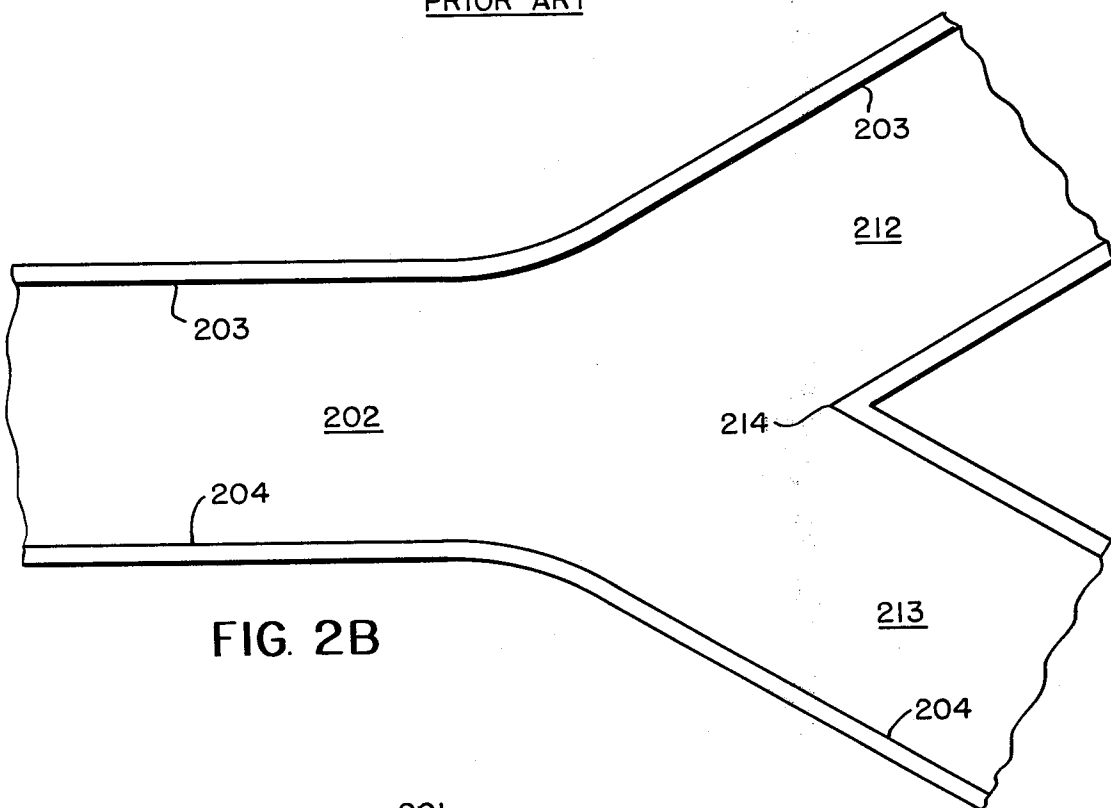


**FIG. 2B**

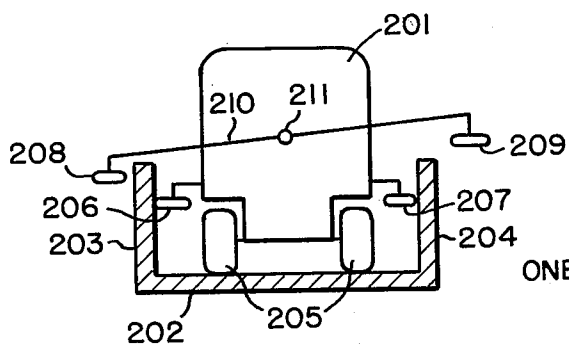


**FIG. 2A**  
ONBOARD SWITCHING  
PRIOR ART

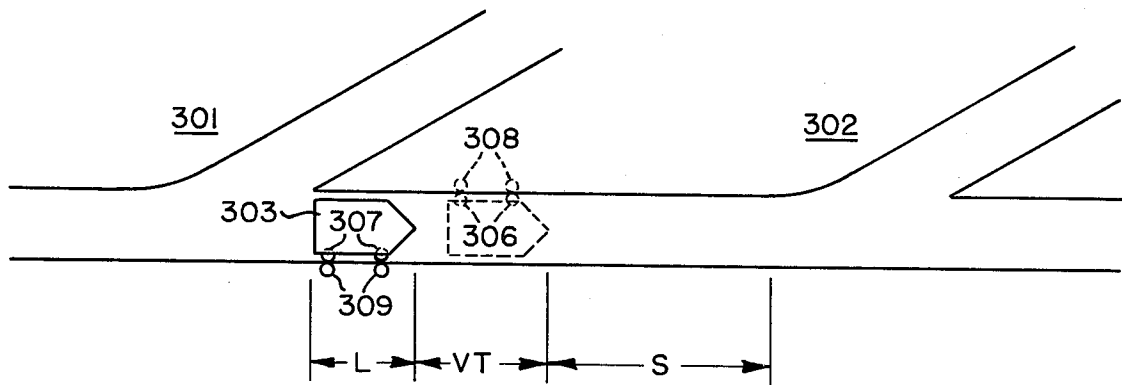


**FIG. 3**  
ONBOARD SWITCHING: SWITCH SPACING

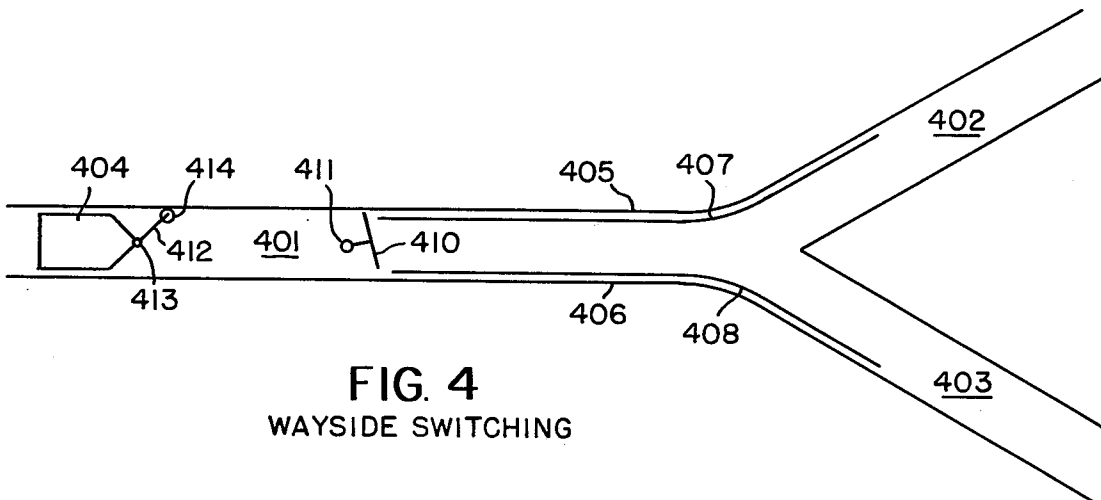


**FIG. 4**  
WAYSIDE SWITCHING

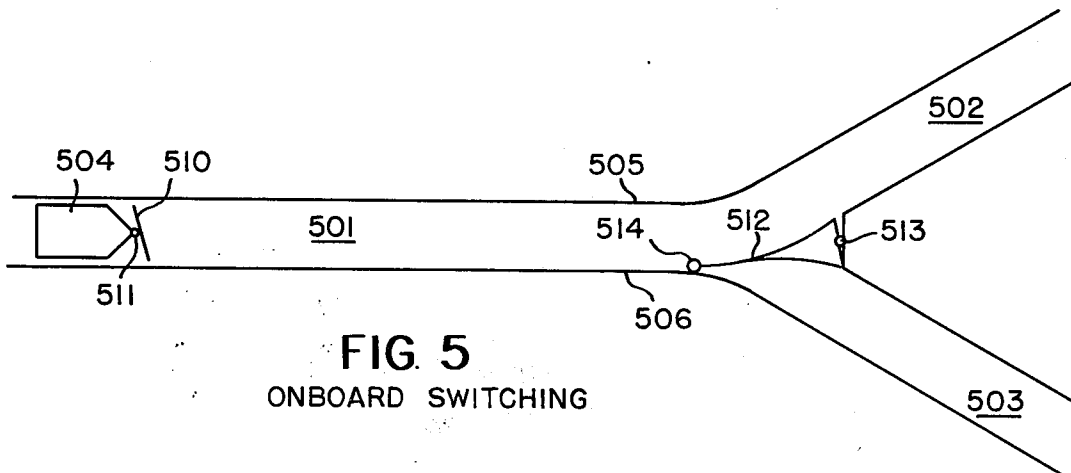


**FIG. 5**  
ONBOARD SWITCHING

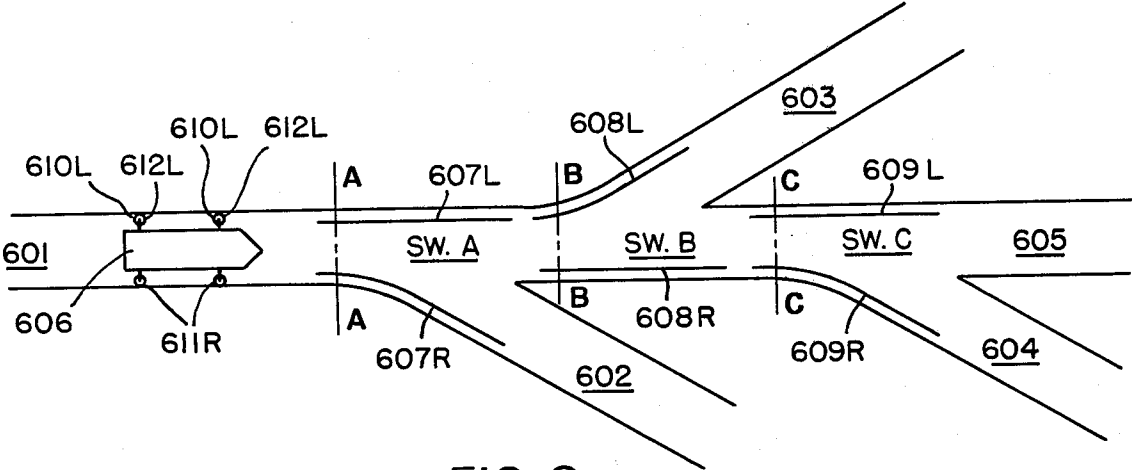


FIG. 6

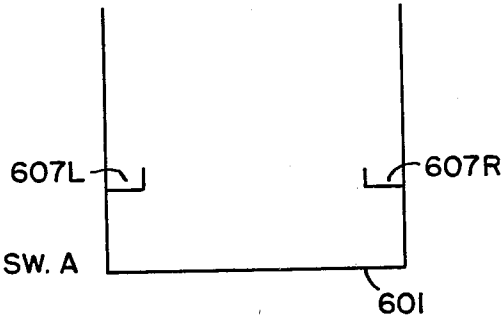


FIG. 6A

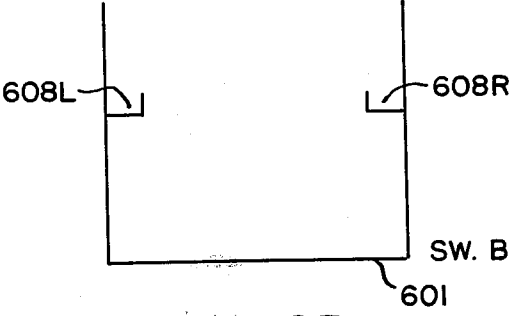


FIG. 6B

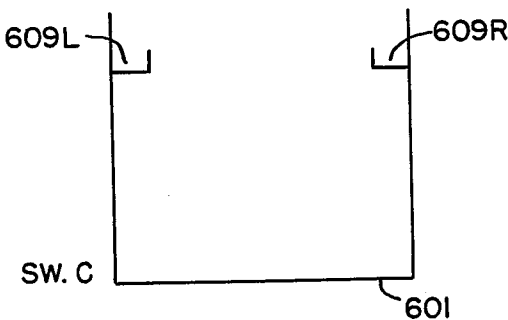


FIG. 6C

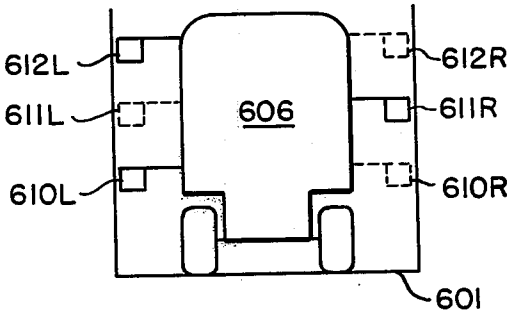


FIG. 6D

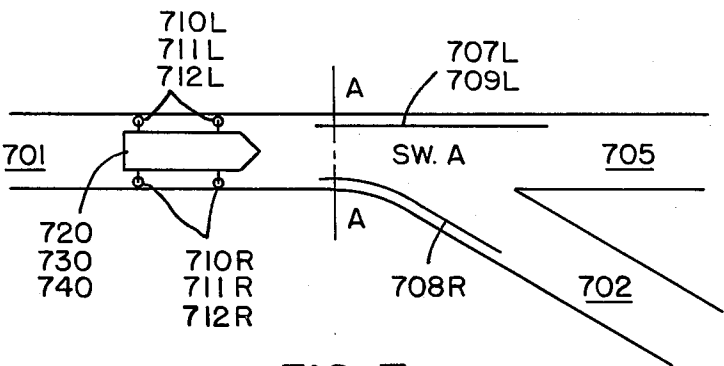


FIG. 7

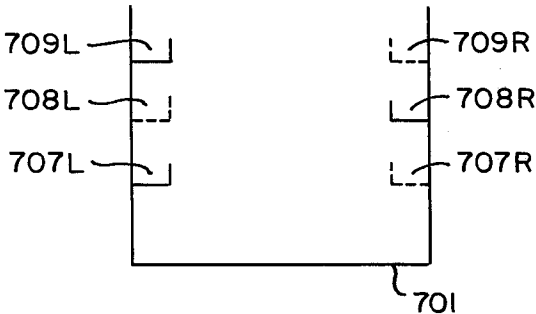


FIG. 7A

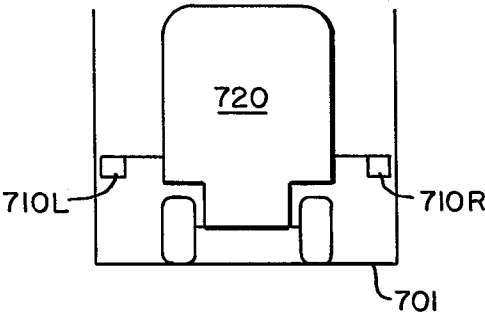


FIG. 7B

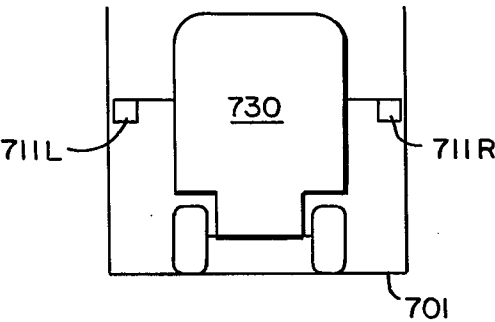


FIG. 7C

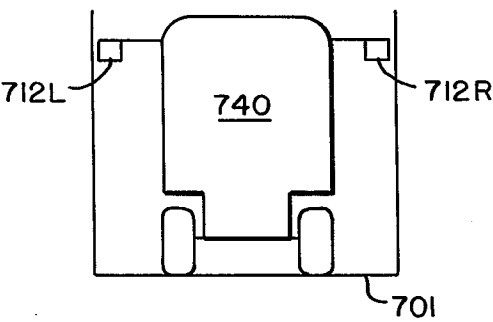


FIG. 7D

## SHORT HEADWAY SWITCHING SYSTEM

### BACKGROUND OF THE INVENTION

The present invention relates to a personalized rapid transit system, often designated PRT, which will provide personalized transit as a replacement for, or as an adjunct to, a mass transit system. A PRT system, as envisioned in this disclosure, comprises a vehicle which will transport the passenger, and his party up to approximately six or eight people, from the point of origin to any one of a plurality of terminals within the system without the need for any person to serve as the driver, or operator, during the trip. In a PRT system the route of travel and maneuvering through all diverge and/or merge points is controlled without any human intervention. More specifically, once the passenger has indicated the desired destination various sensors, electronic devices, mechanical switches, and computer systems will control the progress and route of the vehicle from its point of origin to its destination. Furthermore, it is quite possible that the route from a given origin to a specific destination will vary from time to time depending upon the existing traffic configuration.

Various types of PRT systems have been proposed and a few small systems have been built. Some systems employ rails or monorails for guiding the PRT vehicles and others employ normal appearing road surfaces having embedded therein some sort of signal conducting system which can communicate with the PRT vehicle and provide guidance, speed and switching signals. Other systems have been proposed which employ channels and sensors on the PRT vehicle to sense the channel sides and retain the vehicle within the channel. Other techniques are known to those skilled in the pertinent arts.

It is obvious that for any but the very simplest system there must be diverge and merge points in order to guide the PRT vehicle to a desired one among a plurality of possible destinations. In order to maintain safety and provide simpler and more economical systems, it is anticipated that the majority of merge and diverge points will comprise a merger from two lanes to one; or a separation from one lane to two. A merge point is one in which two lanes of traffic funnel into a single lane; while a diverge point is one in which a single lane of traffic may be separated into two lanes. It is immediately apparent that the traffic through a merge point must be controlled so that vehicles do not enter the point with a timed relation that will cause them both to attempt to occupy the same space at the same time in the single lane of traffic. With a diverge point it will be apparent that there must be some cooperation between the vehicle and the point to determine which of the alternate paths will be taken by the vehicle.

Considering more specifically a diverge point it will be seen that the route of the vehicle through the point may be determined by a particular adjustment of the point so that the approaching vehicle will be guided through the diverge point in a direction determined by the adjustment of the diverge point. This technique is typical of the manner in which railroad trains enter and pass through diverge points. However, one can readily envision a system wherein a mechanism on board the vehicle controls the direction of travel of the vehicle through the diverge point. It is for this reason that the diverge points are called "points" herein and not switches. That is, the present invention contemplates

the use of diverge points wherein the direction of travel through the points is a function of a mechanism on the vehicle and independent of any adjustment of the point.

In a system wherein the diverge point must be set to direct the flow of traffic therethrough it will be apparent that if successive vehicles are to be routed through a specific diverge point, in different directions, it will be necessary to readjust the diverge point after the first vehicle has negotiated the diverge point and before the second vehicle enters the diverge point. Since this change must take a finite time, it is evident that the second vehicle must be separated from the first vehicle by at least an amount to allow for the switch adjustment time. Furthermore, to insure safety, the second vehicle should lag the first vehicle and be travelling at a rate of speed which would allow the second vehicle to be stopped before it has entered the diverge point, if for any reason the diverge point is not positively set and locked in the required position.

A system wherein the diverge point is set in order to determine the direction of flow of a vehicle therethrough, is customarily referred to as a "wayside" switching system. An "onboard" switching system is one in which the direction which a vehicle takes through a diverge point is selected by the direct control of a switching element on the vehicle. Obviously, with onboard switching a vehicle can set its onboard mechanism long in advance of its approach to a diverge point. Accordingly, with an onboard system two vehicles, to be routed in different directions, may enter a diverge point with a minimum separation between the vehicles. However, in order to maintain safety it is normally considered desirable to have a vehicle separated from the one preceding it by no less than the distance which would be required to stop the second vehicle if for some reason the lead vehicle came to an instantaneous stop.

With onboard switching it is evident that two diverge points which will be sequentially traversed by a vehicle must be separated by a least a minimum amount which corresponds to the distance traveled by a vehicle during the time it will take to switch the onboard mechanism from one setting to another. In addition to ensure safety in the event that the onboard switching element should fail to lock when repositioned, the separation between diverge points must be increased by the distance required to stop a vehicle.

As a consequence of the limitations given, it is evident that with wayside switching vehicles must be separated by certain minimum distances to assure safety. The required vehicle separation obviously reduces the number of vehicles and passengers which may pass a given point in a given time interval. Onboard switching may appear to allow the passing of more vehicles and passengers within a given time interval. However, the requirement that diverge points be separated by at least a predetermined amount may create space consuming disadvantages at major junction points in a system.

### SUMMARY OF THE INVENTION

The present invention is directed to a system which overcomes the disadvantages of both the wayside and onboard switching systems. Very briefly, in the system of the present invention, multiple types of diverge points and/or multiple types of vehicles may be used. In one embodiment, a diverge point, which is wayside

controlled, might have first and second switching elements which may be individually set and which cooperate with and control vehicles of a first and second type, respectively. In this system the diverge point may be set before either vehicle enters the diverge point and, therefore, no diverge point setting time, and corresponding vehicle separation, is required between successive vehicles. The problem of diverge point separation with onboard switching may be solved by providing that diverge points which are in close proximity are of a different type and each vehicle carries structure for cooperating with the different types of diverge points. With this design, when an onboard switching vehicle approaches two diverge points in close proximity, it is possible to set the onboard structure for each of the diverge points prior to the entry of the vehicle into the first of the diverge points. One onboard mechanism cooperates with the first diverge point and the second onboard mechanism cooperates with the second diverge point. With this design no time for changing controls and the corresponding diverge point separation is required and the second diverge point may be located as close as is physically possible to the first point.

It is an object of the present invention to provide a new and improved personal rapid transit system.

It is another, and more specific, object of the invention to provide a PRT system capable of handling an increased number of vehicles per unit time without sacrificing safety.

It is another object of the invention to permit the design of a switching system wherein successive diverge points may be located closer together than heretofore.

It is another object of the invention to provide a PRT system which provides the advantages of both onboard and wayside switching without accepting the disadvantages of either system.

It is another object of the invention to provide a PRT system which can accommodate an increased number of vehicles and passengers without any reduction in safety.

### BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects, features and advantages of the present invention will be more fully appreciated, by those skilled in the related arts, by considering the following detailed description of an illustrative embodiment taken together with the drawing in which:

FIG. 1 illustrates the prior art spacing requirements of two vehicles approaching a diverge point with wayside switching;

FIGS. 2A and 2B illustrate the principle of prior art onboard switching;

FIG. 3 illustrates the switch separation constraint imposed by onboard switching;

FIG. 4 illustrates wayside switching with an onboard movable guiding element;

FIG. 5 illustrates onboard switching with a wayside movable guiding element;

FIG. 6 together with FIGS. 6A to 6D illustrates a system employing multiple type diverge points and one vehicle type; and

FIG. 7 together with FIGS. 7A to 7D illustrates a system employing a single type diverge point and multiple types of vehicles.

### ANALYSIS OF LIMITATION IN PRIOR ART SYSTEMS

In a personalized rapid transit system employing a vehicle moving in guideways, a potential hazard exists whenever switching occurs. For example, if a vehicle approaches a diverge point and some mechanism is not set, or is not securely set, at either or both the point location and the vehicle, there is a probability that the vehicle will wander through the diverge point in an indeterminate direction and/or that the vehicle and/or diverge point may be damaged. In a similar manner the uncontrolled entry of two vehicles into the opposite legs of a merge point may also present a hazard.

At least some protection against these potential hazards may be provided by the use of switch locking techniques combined with the interlocking of the diverge point such that the repositioning thereof can only occur when the vehicles are in a favorable position. Safety objectives may be achieved if design does not allow a diverge point to be in an unlocked position at any time that a vehicle is either occupying the diverge point or is travelling at such a velocity that it is not possible to stop the vehicle prior to its entry into the diverge point.

Switching schemes may normally be classified as either "wayside" or "onboard" switching. These may be defined as follows:

1. Wayside switching comprises a system wherein the direction of a vehicle through a diverge point is established by the position, or condition, of a wayside element.

2. Onboard switching comprises a system wherein the direction of a vehicle through a diverge point is established by the position, or condition, of an element on, or directly associated with the vehicle.

Both wayside and onboard switching have disadvantages when the safety requirements outlined hereinabove are followed. More specifically, safety requirements require considerable separation between vehicle and/or between successive diverge points; and/or a reduction in vehicle speed, all of which result in a reduction in vehicle and passenger capacity. This invention overcomes these difficulties without any reduction in safety.

### WAYSIDE SWITCHING: PRIOR ART

Considering now FIG. 1 and the problems associated with wayside switching, there will be seen a guideway 101 which leads into a diverge point 102 which may selectively guide a vehicle to guideway paths 103 or 104. The diverge point 102 may be selectively controlled to either of two stable positions by wayside control 105. Two vehicles 106 and 107 are shown on the guideways 103 and 101, respectively. Vehicle 106 is the lead vehicle and vehicle 107 is the following or lag vehicle. The diverge point 102, when adjusted to the position shown in solid lines, will permit the passage of a vehicle from guideway section 101 to guideway section 103 through the diverge point 102. When the diverge point 102 is adjusted to the position shown in dotted lines, a vehicle, such as vehicle 107 approaching from guideway section 101 will be diverted through diverge point 102 to guideway section 104. The minimum safe distance by which vehicle 107 must lag vehicle 106 at the instant that vehicle 106 has just cleared diverge point 102 will be shown. The minimum safe distance may be consid-

ered to be that distance within which the vehicle 107 may be safely stopped if the diverge point is not properly set and locked.

The distance required to stop the vehicle 107 will, of course, be a function of the speed of the vehicle and other factors including brake design, the mass of the vehicle and the coefficient of friction between the vehicle and its guideway. For the purposes of this discussion it will be assumed that the instantaneous speed of the vehicle 107 is such that it may be safely stopped without entering the diverge point 102 if a stop signal is applied no later than the time the vehicle 107 reaches point 108 on the guideway 101. The stopping distance between point 108 and the entry to the diverge point 102 is indicated as distance "S". The minimum distance between the solid line representation of the vehicle 107 and the dotted line representation is indicative of the distance the vehicle 107 will have travelled during the time that the diverge point 102 is unlocked, switched and relocked after the vehicle 106 has passed through the diverge point 102. This distance will, of course, be a function of the velocity of the vehicle 107. The distance involved, and marked VT, on FIG. 1 is that distance which will be travelled by the vehicle 107 travelling at a velocity V for a time T wherein the time T is that time which it takes to unlock the diverge point 102 after the lead vehicle 106 has left the diverge point 102 and to cause the wayside control 105 to readjust the diverge point 102 from its solid line position to its dotted line position and securely lock the diverge point 102 in its new position. The length of the diverge point 102 between its entry point 109 and its exit point 110 is designated "L".

To satisfy the safety requirements that it be possible to stop a travelling vehicle before it enters a diverge point, requires that the vehicle 107 lag the vehicle 106 by a distance which is the sum of  $L + S + VT$ . One way the total separation between vehicles 107 and 106 may be reduced (without reducing safety) is to slow the vehicle 107.

It should be obvious that the larger the minimum lagging distance between two successive vehicles is required to be, the smaller the number of vehicles which can pass a given point during a specific time interval if other factors remain constant. A systems approach is presented hereinbelow which provides for increased vehicular traffic, over that which may be obtained with wayside switching and, without any derogation of safety.

It should be observed that a vehicle should never be closer to a potential danger point than the distance required to stop the vehicle at the speed which it is travelling. For example, the vehicle 107 should never be closer than distance S to diverge point 102 unless diverge point 102 is securely locked in one or the other of its switching positions. An argument can be made that one vehicle could follow another, on a guideway section without any diverge points, by a distance less than the distance S on the theory that the lead vehicle cannot stop instantaneously. The minimum safe distance between a leading and lagging vehicle will be determined as a matter of philosophy and/or industry safety standards adopted by those organizations and agencies concerned with such matters. However, even if it is determined that a lagging vehicle may follow a leading vehicle by an amount smaller than the distance S, as illustrated in FIG. 1, it should be observed that as

the lagging vehicle 107 approaches the diverge point 102, the minimum separation S must be used. Furthermore, as already indicated, the minimum separation is increased by the distances L and VT. Accordingly, with a wayside switching system, it will normally not be practical for a lagging vehicle to be separated by as little as the distance S from a lead vehicle, even if safety standards should allow a separation equal to or slightly less than the distance S between two vehicles travelling on a guideway section.

#### ONBOARD SWITCHING: PRIOR ART

The problems of onboard switching will be described in conjunction with FIGS. 2A and 2B. A wide variety of techniques have been proposed for onboard switching and the technique illustrated in FIG. 2A is intended only as illustrative of the general principles involved. With onboard switching, separate elements may be provided at the two ends of a vehicle and/or, when two or more vehicles are coupled together to form a train, separate elements may be provided at the front of the train, the rear of the train and/or at intermediate points. When separate onboard switching elements are provided, steps should be taken to assure that all switching elements of a given car or train are positioned in the same direction. FIG. 2A illustrates in simplified schematic form a vehicle 201 which rides in a U-shaped guideway having a roadbed surface 202, a left guide side 203 and a right guide side 204. The vehicle 201 is propelled along the guideway roadbed 202 by the application of rotational power to wheels 205 by a means which is not shown. Guidance of the vehicle 201 along the guideway 202 is provided by the cooperation between the left guide side 203 and guide wheel 206 which contacts the inside of the left guide side 203; and by the inside right guide wheel 207 which contacts the inside of the right guide side 204. In addition to the left and right guide wheels 206 and 207 which cooperate with the inside of the left and right guide sides 203 and 204, respectively, there is also provided an outside left guide wheel 208 and an outside right guide wheel 209 on an arm 210 which pivots about point 211 such that outside left guide wheel 208 may contact the outside portion of the left guide side 203, or so that the outside right guide wheel 209 may contact the outside portion of the right guide side 204. In a manner which does not form a part of this invention, and which will be familiar to those skilled in the necessary arts, it will be possible to sense the contact of the various guide wheels with the guideway sides and have such contacts control the steering mechanism of the vehicle 201 such that it will be guided along the guideway 202 smoothly and accurately.

FIG. 2B is a top plan view of a diverge point within a system employing onboard switching. The main guideway roadbed 202 diverges into two separate and distinct guideway roadbeds 212 and 213. If it is desired to have the vehicle 201 travel from the guideway roadbed 202 and be switched to the left guideway roadbed 212, the onboard switching mechanism will be set and locked so that the arm 210 is in the position illustrated in FIG. 2A and the left outside guide wheel 208 is in a position to maintain continuous contact with the left guide side 203. During the time that the vehicle 201 is in the diverge point of FIG. 2B, the right guide wheel 207 will lose contact with the right guide side 204. However, the contact of the outside left guide wheel

208 and the inside left guide wheel 206 with the outside and inside, respectively, of the left guide side 203 will guide the vehicles 201 from the guideway roadbed 202 to the guideway roadbed 212.

In a similar manner, if it is desired to direct the vehicle 201 from the guideway roadbed 202 to the guideway roadbed 213, the arm 210 will be pivoted about point 211 so that the outside left guide wheel will no longer have a possible contact with the outside left guide side 203 and so that the outside right guide wheel 209 will be in a position to contact the outside right guide side 204.

It should be observed that without the use of one or the other of the outside guide wheels 208 or 209, the vehicle 201 could travel through the diverge point of FIG. 2B in a random direction following either the roadbed 212 or 213 or it might be impaled at the diverge separation point 214. Obviously to be assured that the vehicle 201 will follow the desired roadbed and not be impaled at the diverge separation point 214, it is essential that the arm 210 be pivoted and securely locked to effect the desired switching and that such pivoting and locking take place in advance of the entry of the vehicle 201 into the diverge point of FIG. 2B. Furthermore, the vehicle 201 must not be any closer to the diverge point of FIG. 2B than the safe stopping distance of the vehicle 201 before the arm 210 is securely positioned and locked in the desired switching direction. Under normal operating conditions this requirement is not a severely restricting requirement. For example, any number of vehicles could be sequentially following each other on guideway roadbed 202 and have their respective arms 210 pivoted and locked in their desired positions for their respective vehicles irrespective of the number of vehicles routed to go through the diverge point of FIG. 2B.

In view of the ability to set the onboard switch of a lagging vehicle, prior to the time that a lead vehicle has advanced through the diverge point of FIG. 2B, it will be evident that the separation between the leading and lagging vehicle need not be any greater than the safe stopping distance of the lagging vehicle. Furthermore, the separation between the leading and lagging vehicle could conceivably be somewhat less than the safe stopping distance of the lagging vehicle if other safety requirements and specifications permit. Accordingly, with onboard switching, successive vehicles may follow each other more closely than successive vehicles in wayside switching system. Therefore, onboard switching systems, as so far discussed, offer the distinct advantage of having the capability of handling an increased traffic load.

Although an onboard switching system has the advantages outlined, such systems do have the following disadvantages. At a major junction point in a PRT system, it will be desired to have a large number of diverge points so that vehicles may be switched from a main trunk line to any of numerous available branches. Accordingly, a vehicle may be required to pass through a substantial number of diverge points in a predetermined sequence and in an assortment of left and right directions. If the direction through two successive diverge points is to change, it will be obvious that the onboard switching equipment must be altered from one position to the other after leaving the first diverge point and prior to entering the second diverge point. Furthermore, to assure safety, the separation between the two

diverge points must be such as to assure that the onboard switching equipment may be unlocked, switched and relocked in the new position before the vehicle is any closer to the second diverge point than the safe stopping distance. The principles are illustrated in FIG. 3. More specifically, first and second diverge points 301 and 302 are illustrated. If it is assumed that vehicle 303 has just negotiated diverge point 301 by taking the right branch thereof and that the vehicle 303 is to negotiate diverge point 302 by taking the left branch thereof, it will be evident that the onboard switching equipment, which controls the guide wheels of the vehicle 303, must be unlocked and switched from one position to the other and relocked. The vehicle 303 includes inside right guide wheels 307 which correspond in every respect with the inside right guide wheel 207 as shown in FIG. 2A. In a similar manner, the outside right guide wheels 309, on vehicle 303, correspond with the outside right guide wheel 209 in FIG. 2. The vehicle 303 is illustrated in FIG. 3 at its position immediately after it has negotiated diverge point 301 and when it can start to unlock and switch its onboard switching mechanism. It will take a finite time to unlock and switch and to relock the onboard switching mechanism and during such time the vehicle 303 will advance from its position shown in solid lines to a position shown in dotted lines. More specifically, the vehicle 303 is shown in a dotted outline at its position along the guideway that it will have assumed when the onboard switching position is locked in its new position so that the left inside guide wheels 306 and the left outside guide wheels 308 will be in a position (all as explained with respect to similar elements in FIG. 2) to guide the vehicle 303 through diverge point 302 in a leftward direction.

Considering now more specifically the minimum separation required between diverge points 301 and 302, it should be understood that the vehicle 303 as shown in its dotted position where the onboard switching has just been completed must not be any closer than the safe stopping distance from diverge point 302. This distance is designated as distance S in FIG. 3. The distance travelled by the vehicle during the time required to unlock the onboard switching equipment and relock it in its new position, is designated in FIG. 3 by the distance VT where V is the velocity of the vehicle and T is the required switching time. Since the switching may not commence until the vehicle 303 has passed diverge point 301 by a distance equal to the length of L of vehicle 303, the total separation between the two successive diverge points 301 and 302 is increased by the amount L. In summary the minimum separation between two consecutive diverge points in an onboard switching system is equal to the sum of the distances  $L + VT + S$ . The maximum distances involved will, of course, depend upon various factors including at least the maximum allowable speed of the vehicle between successive switches.

At a major switching junction wherein it is desired to have the ability to switch a vehicle from a main trunk line to any one of numerous branches, it may be an unacceptable requirement that the consecutive diverge points be separated by the minimum distances shown. Accordingly, a disadvantage of an onboard switching system is the requirement for relatively large separations between successive diverge points.

In summary, both onboard and wayside switching systems have been shown to have certain undesirable limitations.

FIGS. 4 and 5 are provided to more clearly define wayside switching and onboard switching and, more particularly, to make it evident that the thing that classifies a diverge point in either the wayside or the onboard category is not necessarily the location of the movable guiding element so much as it is the location of the switching element which is directly controlled, that is, which is positively positioned and locked in response to control signals and the interlocking logic.

Considering now FIGS. 4 and 5 which illustrate another variation of wayside and onboard switching, respectively, it should be observed that the elements of the two systems which most closely correspond with each other have been given identification numbers which correspond in their last two digits. Since the two systems bear considerable similarity and since the numbering system has been chosen to accentuate the similarities, only the wayside switching system of FIG. 4 will be described in any detail and the onboard switching system of FIG. 5 will be described only in those features wherein it uniquely distinguishes from the wayside switching system of FIG. 4.

The wayside switching system of FIG. 4 comprises a guideway having a main trunk 401 which separates into left branch 402 and right branch 403. Travelling along the main trunk 401 is a vehicle 404. The vehicle 404 may have left and right guide wheels corresponding to those shown in FIG. 2 and designated 206 and 207. The vehicle 404 is guided down the guideway by being retained within the confines of the left guide side 405 and the right guide side 406. In addition to these guide sides the diverge point includes a left switching guide 407 and a right switching guide 408. The determination of which of the branches 402 and 403 the vehicle 404 is to follow is determined by the locked switching element 410 which may be positioned as shown, or which may pivot about point 411 and be locked in a complementary position such that the arm 410, as viewed in FIG. 4, slopes down to the left instead of down to the right as drawn. With the locked switching element 410 in the position shown in FIG. 4, the vehicle will be guided to the right branch 403. Associated with the vehicle 404 is a free switching element 412 which pivots at point 413 and has a follower 414. As the vehicle 404 travels down the guideway 401 towards diverge point, the follower 414 will contact the locked switching element 410 and the free switching element 412 will be pivoted about point 413 as the follower 414 follows the inclination of the locked switching element 410. As the vehicle 404 continues in a forward direction, the follower will be trapped between the right guide side 406 and the right switching guide 408 and the vehicle will be guided to branch 403. That is, the positioning of the free switching element 412 by the locked element 410 and the entrapment of the follower 414 between the right guide side 406 and right switching guide 408 will assure that the vehicle 404 is switched to branch 403.

Note well that although there is a movable element 412 on the vehicle 404 which plays a part in determining the direction that the vehicle 404 takes as it traverses the diverge point, the system is not an onboard switching system inasmuch as the free switching element 412 is not switched and locked in a specific position. The element that is switched and locked is the

locked switching element 410 and this element is not onboard the vehicle 404 and therefore this system comprises a wayside switching system.

It may be observed that if the locked switching element 410 was eliminated and the onboard switching element 412 were controlled and set to a locked position, the system illustrated in FIG. 4 would comprise an onboard switching system.

The principal difference between systems of FIGS. 4 and 5 is that FIG. 5 illustrates an onboard switching system and therefore the vehicle 504 includes a locked switching element. This switching element is designated 510 and may be set and locked in either of two positions. The position in which the locked switching element 510 is drawn is such, as will be seen, as to cause the vehicle 504 to travel from the main trunk guideway 501 to the branch 503. If it were desired to direct the vehicle 504 to the branch 502, the locked switching element 510 would be unlocked and pivoted about pivot point 511 so that, as viewed in FIG. 5, the locked switching element 510 would slope downwards to the left instead of downwards to the right as illustrated. As the vehicle 504 approaches the diverge point, the locked switching element 510 will contact a follower 514 on the free switching element 512 which is pivoted at pivot point 513. The follower 514 will follow the slope of the locked switching element 510 and thereby provide a passage way for the vehicle 504 to pass from the trunkline 501 to the branch 503.

The system of FIG. 5 is an onboard switching system because the locked switching element 510 is directly associated with the vehicle 504. The system of FIG. 5 could be changed to a wayside switching system by eliminating the locked switching element 510 on the vehicle 504 and making the free switching element 512 a locked switching element.

The wayside and onboard switching systems illustrated in FIGS. 4 and 5 have the various advantages and disadvantages of the wayside and onboard systems previously described.

The foregoing discussion relating to known prior art devices and systems, together with their relative advantages and disadvantages, is provided in order that the unique advantages of the invention may be more fully appreciated by comparison between the invention and the prior art.

#### DESCRIPTION OF PREFERRED EMBODIMENT

In each of the examples described above, there has been a single type of vehicle and a single type of diverge point. In accordance with the principles of this invention, a system will employ either multiple types of vehicles, multiple types of diverge points or both. By this technique, the inherent disadvantages of the previously described systems may be overcome. For example, it will be recalled that with wayside switching, it is necessary to have vehicles separated one from another to permit switch unlocking, repositioning, and relocking. In accordance with principles of the invention, a system may be designed using two types of vehicles; a type A and a type B. Each diverge point of the system would include two directly controlled and locked switching elements; a type A wayside switching element which cooperates only with type A vehicles, and a type B wayside switching element which cooperates only with type B vehicles. In a system as just described, if an A type vehicle is followed by a B type

vehicle it would be possible for both wayside switching elements associated with a particular diverge point to be positioned and locked to control the approaching vehicles before either vehicle has arrived at the diverge point. For example, switching element A could be set and locked left and switching element B could be set and locked right. Vehicle A, upon entering the diverge point, would go left and subsequently, vehicle B, as it enters the diverge point, would go to the right and there would be no requirement for making any adjustment between the passage of the two vehicles. Accordingly, the vehicles A and B could be as close together as desired without the diverge point constituting a hazard. Using the philosophy of vehicle separation described in the connection with FIG. 1, it would mean that the vehicles A and B could be separated only by the distance S and there would be no need to add the distance L and VT. By this means it is possible to have a wayside switching system which can handle and increased number of vehicles per unit time.

It will be recalled that with onboard switching, as described with respect to FIG. 3, there was a requirement that two successive diverge points be separated by an amount which would tend to cause hardships at main junction centers. In order to overcome this difficulty and inconvenience, it is proposed to use two types of diverge points, for example, type A and type B. In this system each vehicle will carry two directly controlled and lockable movable switching elements; a type A onboard switching element which is effective only at type A diverge points, and a type B onboard switching element which is effective only at type B diverge points. If a vehicle approaches two diverge points in series, the first being a type A diverge point and the second being a type B diverge point, both switching elements on the vehicle may be positioned and locked before the vehicle arrives at either diverge point. For example, the A element onboard the vehicle can be positioned left and the B element onboard the vehicle may be positioned for a right movement. When the vehicle passes through the A diverge point, it will go left and it will be guided to the right as it passes through the B diverge point. Since no time is required to unlock, set and relock an onboard switching element subsequent to the passage of the vehicle through the first diverge point, and prior to the passage of the vehicle through the second diverge point, the two diverge points may be as close together as may be expedient. Accordingly, by this means, the disadvantages of onboard switching may be overcome.

Other systems may be designed which employ more than two types of diverge points or more than two types of vehicles, or both. This combination of a plurality of types of diverge points and/or a plurality of types of vehicles provides improvement by maintaining required separation of vehicles or diverge points while permitting reduced separation so long as successive vehicles, or diverge points, are not of the same type. It must be noted that this improvement is realized only when the vehicles or diverge points, as the case may be, which are close together are not of the same type. This constraint is a little more difficult to implement when applied to the vehicles as the switching of the vehicles from one branch to another is likely to cause positioning of vehicles such that a vehicle of one type may be following a vehicle of the same type. However, diverge point types may be assigned and installed so that two

diverge points of the same type are never sequentially arranged. Accordingly, it is believed that under normal circumstances, a system employing a plurality of diverge point types and a single vehicle type will offer advantages over a system employing a single diverge point type and a plurality of vehicle types. An onboard system of this type employing a plurality of point types and a single vehicle type is illustrated in FIG. 6.

Referring now more specifically to FIG. 6, there is a main trunk guideway 601 with branch 602 leading off from diverge point A, (designated SW. A on the drawing) branch 603 leading off from diverge point B., (designated SW. B on the drawing) and branch 604 leading off from diverge point C, (designated SW. C on the drawing). Branch 605 is the straight through connection through points A, B, and C from main trunk guideway 601. A vehicle 606 starting on the main trunk guideway 601 may be directed to any one of the branches 602, 603, 604, and 605 depending upon the setting of controls onboard the vehicle 606. Point A includes guide rails 607L and 607R, which may cooperate with controls (to be described more fully herein below) onboard the vehicle 606 to guide the vehicle left and right, respectively, through diverge point A. In a similar manner, point B includes guide rails 608L and 608R to cooperate with additional controls (to be described more fully herein below) onboard the vehicle 606 to guide the vehicle left and right, respectively, through point B. In a similar manner, point C includes guide rails 609L and 609R to cooperate with additional controls (to be described more fully herein below) on vehicle 606 to guide vehicle 606 through point C to the left and right, respectively. FIGS. 6A, 6B, and 6C are cross-sectional views of points A, B, and C, respectively, taken along the lines A—A, B—B and C—C, respectively. As may be seen in FIG. 6A, the left and right guide rails 607L and 607R of point A are positioned relatively close to the roadbed of the guideway 601. The left and right guide rails 608L and 608R of point B are located at a level above the roadbed of the guideway 601 which is substantially greater than the distance of the guideways 607L and 607R. The guide rails 609L and 609R are an even greater distance from the roadbed of guideway 601 than are the guide rails for points A and B. Thus, a point of type A may be defined as one having its associated guide rails at a low level; a point of type C may be defined as one having its guide rails at a high level and a point of type B may be defined as one having its guide rails at an intermediate level. Associated with each vehicle, such as vehicle 606, are three pairs of guide wheels which are designed to selectively cooperate with particular guide rails. More specifically, the vehicle 606, as seen in FIG. 6D, has three pairs of guide wheels or followers. More specifically, the guide wheels of the pair 610L and 610R cooperate, respectively, with guide rails 607L and 607R. In a similar manner, one of the guide wheels of the pair 611L and 611R may selectively cooperate with guide rails 608L and 608R, respectively, to guide the vehicle through point B. In a similar manner one of the guide wheels of the pair 612L and 612R may be adjusted for selective engagement with guide rails 609L and 609R, respectively, to guide the vehicle 606 through point C.

The left and right guide wheels 610L and 610R, respectively, are onboard switching elements and only one or the other may be extended from the vehicle 606. In the illustration of FIG. 6D, the left guide wheel 610L

is presumed to be extended and is drawn with a full outline. The right guide wheel **610R** is shown in dotted outline to illustrate its position when it is extended. In a similar manner, the right guide wheel **611R** is extended and the left guide wheel **611L** is shown in a dotted outline to illustrate its position when it is extended. The left guide wheel **612L** is shown in the extended position while the right guide wheel **612R** is shown in dotted outline to indicate the position it would assume when it is extended. Only a selected one of each pair of guide wheels is extended and normally some type of interlock would be used so that only one guide wheel of each pair could be extended at any given time.

Since a selected one of each pair of guide wheels contacts with each of the three different types of diverge points, it is possible to extend the desired one of each pair of guide wheels prior to the time that the vehicle **606** has entered the first of the three sequential diverge points **A**, **B** and **C**. With the left guide wheel **610L** extended from the vehicle **606**, it will engage the left guide rail **607L**, and thereby prevent the vehicle **606** from being switched to branch guideway **602**. Point **B** may be placed as close as is physically possible to point **A** and no switching on board the vehicle **606** is required subsequent to leaving point **A** and prior to entering point **B**. The extended guide wheel **611R** will engage the guide rail **608R** and cause the vehicle **606** to proceed in a straight line through point **B** thereby preventing it from following guideway **603**. In a similar manner the extended guide wheel **612L** will co-act with guide rail **609L**, and thereby guide the vehicle **606** in the leftward direction through point **C** and to guideway **605**.

It should be observed that as soon as the vehicle **606** has emerged from point **A** that the onboard guide wheel pair **610L** and **610R** may be unlocked and relocked in the other position, that is, with guide wheel **610R** extended and guide wheel **610L** recessed. This switching action may take place during the time interval that the vehicle **606** is negotiating points **B** and **C** and before the vehicle enters another point of type **A**. When the guide wheels **610L** and **610R** are readjusted, the vehicle **606** may be directed to another point of type **A**. As long as the first and second (not shown) type **A** points are physically separated from each other by at least the minimum distance shown for point separation in FIG. 3, a second diverge point **A** may be made to follow immediately after point **C**. It is anticipated that normal vehicle speeds and the physical sizes of diverge points will be such that a second diverge point of type **A** could immediately follow a diverge point of type **C** even where the points of types **A**, **B**, and **C** are located as close together as physically possible. However, if this could ever result in two points of type **A** being closer together than is expedient for safe operation, it would be possible to include a fourth type of point and a fourth pair of guide wheels on the vehicle **606**.

It should be understood that the location of the guide wheels at the bottom, top and center of the sides of a vehicle **606** is for illustrative purposes only and that in actual practice these elements might be at only slightly different levels with respect to the roadbed of the guideway **601**. Such differences are merely a matter of engineering design. It should also be understood that other types of onboard mechanisms and cooperating switching elements could be used and a variety of such controls are known in the applicable arts.

FIG. 7 taken together with FIG. 7A, 7B, 7C and 7D discloses a wayside switching system wherein all diverge points are identical and three separate types of vehicles are used. More specifically, each of the diverge points has three sets of guide rails such as the set **707L**, **707R**; **708L**, **708R** and **709L**, **709R** as shown in FIGS. 7 and 7A where FIG. 7A is a cross-section of the diverge points SW. A taken along the line A—A of FIG. 7. The guide rail pairs are so designed and constructed that only one of each pair may be in the position shown in a solid line and the other is in a recessed position. Each of the vehicles **720**, **730**, and **740** has a pair of guide wheels such as **710L** and **710R** for vehicles **720**; **711L** and **711R** for vehicle **730** and **712L** and **712R** for vehicle **740**. The various guide wheels will cooperate with an extended guide rail at each of the diverge points for guiding the vehicle in the same manner as set forth with respect to FIG. 6, 6A, 6B, 6C and 6D. Since the elements of FIGS. 6 and 7 are so identical in form and function, they have, where practical, been given numbers which differ only in the first digit. In the system of FIG. 7, the diverge point **A** may be adjusted, by wayside switching, to route vehicles in the desired directions. For example, a vehicle of type **720** will be directed to the left because the guide wheel **710L** will co-act with the guide rail **707L**. A vehicle of type **730** will be directed through the diverge point **A** to the right as guide wheel **711R** co-acts with guide rail **708R**. In a similar manner, a vehicle of type **740** will be directed to the left as guide wheel **712L** cooperates with guide rail **709L**. Subsequent to the passage of a vehicle of any given type through the diverge point, the corresponding guide rails may be reset for controlling the direction in which a subsequent vehicle of the same type will emerge from the diverge point. The sequence of passage of the vehicles through the diverge point **A** is immaterial.

When vehicles of the same type are separated by other vehicles and/or do not follow each other too closely, it is possible to adjust diverge points for approaching vehicles while the vehicles are sufficiently far away that there is no need to stop or delay the progress of the vehicle.

By way of summary, FIG. 6 discloses an onboard switching system employing three separate types of diverge points and one type of vehicle while FIG. 7 discloses a wayside switching system employing one type of diverge point and three separate types of vehicles. A greater or lesser number of different types of diverge points and/or vehicles could be used to meet the requirements of a particular installation or traffic pattern. In addition, a system could be designed which may be adapted to use a combination of wayside and onboard switching.

FIGS. 6 and 7 illustrate a preferred method of implementing the invention but the invention may be applicable to almost any conceivable method of switching. The principles of the invention may be employed in a system using more than one type of vehicle or diverge point, or both, to obtain a system having the capacity for handling an increased number of vehicles in a given unit of time and without sacrificing any safety features.

While there has been shown and described what is considered at present to be the preferred embodiment of the invention, modifications thereto will readily occur to those skilled in the related arts. For example, in another system a combination of onboard and way-

side switching may be used, and/or the coupling between the cooperating switching elements of the vehicle and the diverge points may comprise electronic and/or magnetic means rather than mechanical means. It is believed that no further analysis or description is required and that the foregoing so fully reveals the gist of the present invention that those skilled in the applicable arts can adapt it to meet the exigencies of their specific requirements. It is not desired, therefore, that the invention be limited to the embodiment shown and described, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A vehicle guidance system comprising:
  - a. a vehicle guideway having a diverge point from which vehicles may emerge to be guided along a first or second selected route;
  - b. individual vehicles travelling along said guideway;
  - c. first selectively adjustable vehicle switching means for guiding a first selected one of said vehicles through said diverge point to emerge on a first predetermined one of said selected routes;
  - d. second selectively adjustable vehicle switching means for guiding a second selected one of said vehicles through said diverge point to emerge on a second predetermined one of said selected routes which may, or may not, correspond with said first predetermined one of said selected routes; and
  - e. cooperating means between said first and second selectively adjustable vehicle switching means and said first and second one of said plurality of vehicles and said diverge point for causing said first and second vehicle switching means to influence only the route of said first and second vehicles, respectively, through the diverge point, and independent of the sequence of passage of said first and second vehicles through said diverge point.
2. The combination as set forth in claim 1 wherein said first selectively adjustable switching means is selectively adjusted wayside switch associated with said diverge point.
3. The combination as set forth in claim 1 wherein said first selectively adjustable switching means is on-board said first selected one of said vehicles.
4. The combination as set forth in claim 1 wherein:
  - a. said first and second selectively adjustable switching means are associated with said diverge point; and wherein
  - b. said first and second vehicles have unique characteristics for responding only to said first and second adjustable switch means, respectively.
5. The combination as set forth in claim 1 wherein:
  - a. each of said individual vehicles has first and second selectively adjustable switch means.
6. The combination as set forth in claim 1 wherein the individual conditionable means on a selected one of said plurality of individual vehicles may be selectively conditioned to determine the route of emergence taken from each of a sequence of diverge points before said selected one of said vehicles has entered the first of said sequence of said diverge points.
7. The combination as set forth in claim 6 wherein the individual conditionable means on said selected one of said vehicles which cooperated with the first diverge point of said sequence of diverge points may be conditioned to cooperate with a diverge point subse-

quent to said first diverge point at any time after said one vehicle has emerged from said first diverge point.

8. A vehicle guidance system comprising:
  - a. a vehicle guideway having a trunk and a plurality of branches interconnected by a plurality of diverge points through which vehicles may be selectively routed towards a selected branch of said guideway;
  - b. a plurality of individual vehicles travelling from the trunk to a selected branch via one or more of said diverge points;
  - c. said diverge points divided into a plurality of types with each type having a unique characteristic; and
  - d. each of said vehicles having individual conditionable means for selectively cooperating with the different types of diverge points to determine the route of emergence taken from each type of diverge point in response to the entering thereof by one of the plurality of vehicles.
9. The combination as set forth in claim 8 wherein the unique characteristics of each type of diverge point comprises a guide member which is uniquely positioned to cooperate with at least a selectively conditioned one of the conditionable members of each of said vehicles.
10. The combination as set forth in claim 9 wherein the number of said selectively conditionable members on each of said plurality of vehicles corresponds to the number of types of diverge points.
11. A vehicle guidance system comprising:
  - a. a vehicle guideway having a trunk and a plurality of branches interconnected by a plurality of diverge points through which vehicles may be selectively directed towards a predetermined one of said branches of said guideway;
  - b. a plurality of individual vehicles travelling from the trunk to various branches of said guideway via selected diverge points;
  - c. each of said diverge points having a first and second switching element;
  - d. said vehicles comprising a first and second class which uniquely distinguish one from the other;
  - e. each vehicle of said first class having a first guide component, while each vehicle of said second class has a second guide component;
  - f. first control means comprising said first guide component and said first switching element for conjointly controlling the branch on which the vehicle emerges after entering the particular diverge point; and
  - g. second control means comprising said second guide component and said second switching element for conjointly controlling the branch on which the vehicle emerges after entering the particular diverge point;
  - h. whereby vehicles of said first and second class may sequentially pass through said particular diverge point, each emerging on its predetermined branch, irrespective of which class of vehicle leads the other and without the requirement to adjust either said first or second control means subsequent to the entering of the lead vehicle into said particular diverge point.
12. The combination as set forth in claim 11 wherein said first and second switching elements are wayside controlled.

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13. The combination as set forth in claim 12 wherein said first and second switching elements each comprise first and second guide rails.

14. The combination as set forth in claim 13 wherein only one of said first and second guide rails cooperates with a guide component of one of said plurality of vehicles for directing the vehicle through the diverge point.

15. A vehicle guidance system comprising:

- a. a vehicle guideway having a trunk and a plurality of branches interconnected by a plurality of diverge points through which vehicles may be selectively directed towards a predetermined one of said branches of said guideway;
- b. a plurality of individual vehicles travelling from the trunk to the various branches of said guideway via selected diverge point;
- c. each of said vehicles having a first and second switching element;
- d. said diverge points divided into a first and second class which uniquely distinguish one from the other and having first and second guide components, respectively;
- e. first control means comprising said first switching element and said first guide component for conjointly controlling the branch on which a vehicle emerges after entering a diverge point of said first class; and

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f. second control means comprising said second switching element and said second guide component for conjointly controlling the branch on which a vehicle emerges after entering a diverge point of said second class;

g. whereby one of said plurality of vehicles may sequentially pass through diverge points of said first and second class, with said one vehicle emerging on its predetermined branch, irrespective of which class of diverge point is first in the sequence and without the adjustment of either said first or second control means subsequent to the entering of said vehicle into the first of said diverge points.

16. The combination as set forth in claim 15 wherein said first and second switching elements are onboard switched.

17. The combination as set forth in claim 15 wherein subsequent to the passage of said one vehicle through the first encountered diverge point the one of the first and second control means which controlled the direction of emergence from the first encountered diverge point may be reset for controlling the direction of emergence when said one vehicle encounters another diverge point of the same type as said first encountered diverge point.

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