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(71) Applicant *(for all designated States except US)*: **MAGNEMOTION, INC.** [US/US]; 20 Sudbury Road, Acton, MA 01720 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **CLARK, Tracy, M.** [US/US]; 24 Winterberry Way, Bedford, MA 01730 (US). **MENDENHALL, Jesse** [US/US]; 27 Medford St., Apt. 3, Medford, MA 02155 (US). **THORNTON, Richard, D.** [US/US]; 330 Garfield Road, Concord, MA 01742 (US).

(74) Agents: **POWSNER, David, J.** et al.; NUTTER McCLENNEN & FISH LLP, WORLD TRADE CENTER WEST, 155 Seaport Boulevard, Boston, MA 02210-2604 (US).

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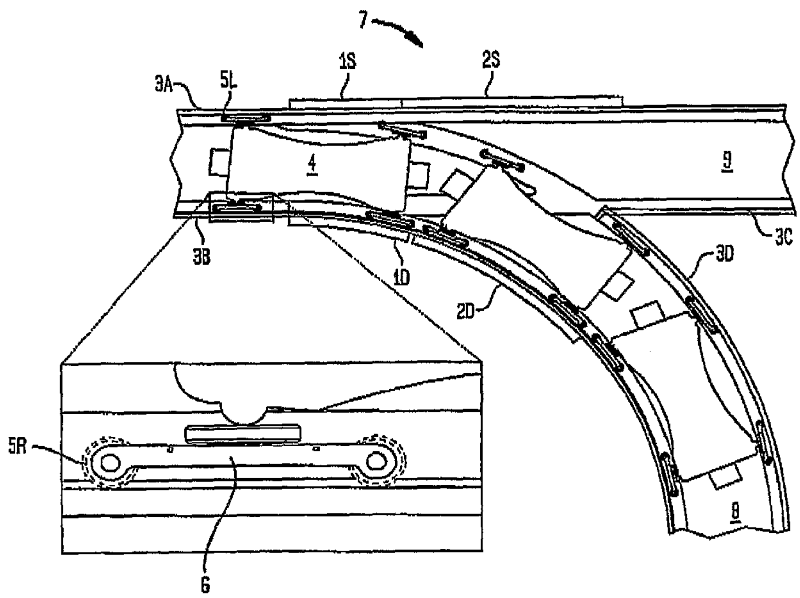
(54) Title: GUIDEWAY ACTIVATED MAGNETIC SWITCHING OF VEHICLES



(57) Abstract: A system for switching a transport vehicle comprising: a guideway, a vehicle that moves along the guideway, and a magnetic field source that creates a force on the vehicle to affect motion in a desired direction at a switch. Once the vehicle has started motion through the switch the guidance can be continued by use of permanent magnets until the normal guidance system is effective. The switching scheme can work with any suspension scheme, including wheels and maglev, and can work with any lateral guidance scheme, including horizontal guide wheels and magnetic guidance. The system can be used with very closely spaced vehicles, such as with Personal Rapid Transit, material handling, and elevators with multiple cabs in the same shaft.

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GUIDEWAY ACTIVATED MAGNETIC SWITCHING OF VEHICLES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of the filing date of U.S. Provisional Application No. 60/701,777, filed July 22, 2005, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention pertains to vehicular transport and, more particularly, to methods and apparatus for the switching of vehicles on a guideway.

All guideways must have means to choose between alternate directions of travel. Conventional trains use switches with mechanically movable rails that require several seconds to actuate and have maintenance problems. Monorail trains and systems using magnetic or air-cushion suspension typically require motion of large sections of a guideway. Some automated people movers use rubber-tired wheels for suspension and additional vertical-axle wheels for guidance with switching done by moving sections of the guideway.

For some applications, such as personal rapid transit or material handling in a factory or elevators, it is important to be able to operate with headways of only a few seconds. In these cases it is not safe to use switches that require substantial motion of sections of the guideway. So other ways to perform switching with vehicle activated mechanisms have been devised. The most common way to do this is to use mechanical wheels that interact with the guideway to divert the vehicle or allow it to move straight at a switch point as in U.S. Patents 4,132,175 and 6,857,374. In some cases the switching is done with switching-wheels that are mounted on the vehicle but activated by the guideway as in U.S. Patent 5,277,124. This makes it feasible to operate with short headway, but now there is a reliability problem because the vehicle control must be coordinated via guideway based controllers. With the activating mechanism on the vehicle and the control on the guideway the operation typically depends on a radio link with potential interference problems. Additionally, the switching mechanisms are mechanical which require maintenance and are vulnerable to failure.

A number of improved mechanical switching schemes by using magnetic forces have been proposed. There are two ways this has been done: 1) Use electromagnets on the vehicle to create attractive forces to ferromagnetic structures on the guideway as in U.S. Patents 3,763,788, 5,778,796 and 5,794,535; 2) Use coils on the guideway that can be open circuited or short circuited so as to create controllable repulsive force to a changing magnetic field as in U.S. Patents 3,994,236; 5,503,083, 5,517,924 and 5,865,123, and 5,904,101. Neither of these methods has achieved wide success and guideway-based mechanical mechanisms continuing to dominate switch design.

For the special case when ElectroDynamic Suspension (EDS) is used for magnetically suspended vehicles, it is possible to create magnetic switching by shorting coils in one path and opening them on the other path. This creates either a repulsive force or no force on a moving magnet and variations on this idea are covered in U.S. Patents 3,994,236, 5,503,083, 5,517,924, 5,865,123 and 6,784,572. These techniques have the advantage of being guideway activated and having no moving parts, but they do not work with most types of suspension in use today.

In view of the foregoing, an object of the invention is to provide improved methods and apparatus for vehicle switching. A more particular object of the invention is to provide such methods and apparatus as are applicable to vehicles on guideway.

A further object of the invention is to provide such methods and apparatus as work with a variety of vehicle suspension and guidance mechanisms.

A further object of the invention is to provide such methods and apparatus as can be used, by way of non-limiting example, with wheeled "road" vehicles, such as automobiles, buses and trucks, as well as with (by way of further non-limiting example) "track" vehicles, such as trains, trolleys, personal rapid transit vehicles and baggage-carrying vehicles.

A still further object of the invention is to provide such methods and apparatus as require fewer, if any, moveable mechanical guidance components and that can be applied in applications requiring relatively small headway.

SUMMARY OF THE INVENTION

The foregoing are among the objects attained by the invention which provides, in some aspects, transportation and other conveyance systems having magnets, e.g., electromagnets, on a guideway to create forces, e.g., lateral forces, on a vehicle so as to control the direction of vehicle travel at guideway switch points, e.g., merge and/or diverge locations. The magnets can be controlled, e.g., by a guideway-based controller that monitors the position of the vehicle (and, for example, others on the guideway) and controls the switching without the need to transmit control signals to the moving vehicle itself.

In related aspects of the invention, the aforementioned vehicle can have a normal guidance system, e.g., using either wheels, magnets, air pressure or other force producing means. However, according to aspects of the invention, switching is initiated by the guideway-based electromagnets.

According to further related aspects of the invention, the electromagnets are excited with DC or a low frequency AC so as to create attractive forces to a ferromagnetic plate or wheel or other switching structure, e.g., on the vehicle itself, or they can be excited with higher frequency AC so as to create repulsive forces to a conducting plate or wheel or other switching structure. It is also possible to use both attractive and repulsive forces working on opposite sides of the guideway to move the vehicle in the desired direction.

According to further aspects of the invention the switching is initiated by an electromagnet but once the vehicle moves a short distance the switching is completed by means of one or more permanent magnets located on the guideway. A permanent magnet can keep the vehicle on the desired path until the normal guidance mechanism is effective.

Methods and apparatus according to the invention are suited for, among other things, guiding vehicles that are propelled by a linear motor. With this propulsion scheme and guideway-based magnetic switching the entire propulsion and control system can be located on the guideway so the vehicle can be passive and there is no need to transmit control signals to a moving vehicle.

These and other aspects of the invention are evident in the drawings and in the claims that follow.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be attained by reference to the drawings, in which:

Fig. 1 depicts a vehicle moving on a branching path with motion that can be in either direction. In this example normal guidance is by wheels and both electromagnets and permanent magnets attract ferromagnetic wheels to achieve switching and guidance through the switch area.

Fig. 2 depicts the same system as Fig. 1 except that the vehicle is moving on the straight path.

Figs. 3A and 3B shows a top view and side view, respectively, of a suitable electromagnetic design for creating attractive forces to a ferromagnetic wheel.

Figs. 4A and 4B are the same as Figs. 3A and 3B except that the force is on a plate acting as the switching structure on the vehicle.

Figs. 5A and 5B show how permanent magnets can provide attractive guidance forces when there is a break in the normal guidance but the vehicle is already on the correct path. Figure 5A uses 3 magnets with different orientations, and Figure 5B shows a single magnet with ferromagnetic pole pieces used to focus the flux. The 3-magnet configuration produces more guidance force but may have a higher cost.

Fig. 6A shows field lines for an alternate magnet design in which permanent magnets are used to augment the field produced by the electromagnetic coils.

Fig. 6B shows field lines when the coil current is reversed and there is very little force produced by the magnet design of Fig. 6A.

DETAILED DESCRIPTIONS OF ILLUSTRATED EMBODIMENTS

Introduction

The invention described here is an outgrowth of earlier work by the inventors hereof, described in U.S. Patent 6,101,952, the teachings of which are incorporated herein by reference. The design discussed therein has been successfully used in a commercial application, though improvements of lower complexity and cost are always desirable. As will be appreciated from the discussion below, the magnetic switching disclosed in that patent is modified herein to work with a variety of suspension and guidance schemes, and to use electromagnets on the guideway to create controllable forces on the vehicle to force the vehicle to go in a specified direction at a diverge and to operate safely at a merge

As shown in the drawings and discussed below, the illustrated embodiment of the invention utilize magnetic forces for diverting or merging vehicles at switch points on a guideway. The switching is achieved by the interaction of a magnetic field produced by one or more magnets on the guideway interacting with one or more wheels or plates or other types of switching structures on the vehicle to produce forces (e.g., lateral forces) on the vehicle in the vicinity of merge or diverge locations, i.e., "switch points." The magnetic field can create either an attractive force or a repulsive force and in some cases an attractive force on one side can be augmented by a repulsive force on the other side.

In general, the phrase "switching structure" is used herein to refer to a one or more structures capable of interacting with the magnetic field to create a force that can influence the trajectory of a vehicle to which that structure is coupled (e.g., physically). Such switching structures, such as one or more wheels of a vehicle or any combination of one or more wheels and/or plates and/or other structures, can include the use of ferromagnetic or paramagnetic materials, i.e., a material that attains magnetic properties in the presence of a magnetic field.

The switching mechanisms discussed herein can work with any of a number of known suspension schemes, including wheels and magnetic levitation (maglev), and can work with any lateral guidance scheme, including horizontal guide wheels and magnetic guidance. Further, the vehicle can be either above or suspended from the guideway. By having the activation mechanism on the guideway, it is possible for the vehicle to be passive and without the need to transmit control information to a moving vehicle. The magnetic fields can be turned on and off in a fraction of a second so the system is usable with very closely spaced vehicles, such as with Personal Rapid Transit, material handling, and elevators with multiple cabs in the same shaft. Such systems are potentially more reliable and safe relative to systems requiring active vehicle control.

Use of guideway based magnetic switching when the normal guidance uses guide wheels.

Figures 1 and 2 depict top views of one implementation of the invention. For this embodiment, the vehicle 4 uses horizontal wheels 5L, 5R (i.e., vertical axle wheels) as a switching structure to provide lateral guidance by interacting with guide rails 3A, 3B, 3C, 3D. Vehicle 4 has eight guide wheels 5L, 5R. For clarity of discussion, the suspension and propulsion mechanisms are not shown. For normal travel away from switch points, the horizontal wheels 5L, 5R guide the vehicle 4. In the vicinity of a switch point 7, however, there is a break in the guidance rails and the guidance is done by a combination of electromagnets 1D, 1S and permanent magnets 2D, 2S. Following is a more detailed discussion of operational aspects of this embodiment.

In one operational instance, with respect to Fig. 1, the vehicle 4 is moving from left to right and it is desired to switch the vehicle 4 so that the vehicle 4 is diverted to the right branch 8. In order to achieve a divert, the electromagnet 1D is activated and electromagnet 1S is not activated. The activated magnet 1D attracts the right steel wheels 5R of the vehicle 4, located adjacent to the activated magnet 1D, so that the vehicle 4 moves toward the right branch 8. Shortly after the vehicle 4 starts down the divert path 8, it encounters permanent magnets 2D, which attract the vehicle 4 and keep it moving down the divert path 8. The use of permanent magnets can reduce cost and complexity and can ensure that once the vehicle has started to divert it will continue on the path even if there is a power failure. The field from permanent magnets 2S falls off fast enough so that it does not produce a significant attractive force on the vehicle 4. Eventually the vehicle 4 moves far enough down the right branch 8 so that the left guide-wheels 5L engage the left guide rail 3D. Such engagement, together with the right guide-wheels 5R, which maintained contact with guide rail 3B, allows the vehicle 4 to continue down right branch 8 with wheel guidance.

Figure 2 depicts the same system as Fig. 1 except that in this operational instance it is desired that the vehicle 4 continue straight along branch 9. In order to direct straight motion, electromagnet 1S is activated and electromagnet 1D is not activated. The activated magnet 1S attracts the left steel wheels 5L of the vehicle 4 so that the vehicle 4 stays on the straight path of the branch 9. Shortly after the vehicle 4 encounters the electromagnet 1S, it will encounter permanent magnets 2S, which continue to attract the vehicle 4 and keep it moving down the straight path of the branch 9. The use of permanent magnets can reduce cost and complexity and can ensure that once the vehicle has started on the straight path it will continue on the path even if there is a power failure. As in the previous operational instance, the field from permanent magnets 2D falls off fast enough so that it does not produce a significant attractive force on the vehicle 4. Eventually the vehicle 4 moves far enough so that the right guide wheels 5R engage the right guide rail 3C. Accordingly with the left guide-wheels 5L, which engage guide rail 3A, the vehicle 4 continues along the branch 9 with wheel guidance.

In other operational instances, if the vehicle 4 is moving in the opposite direction, i.e., from right to left in Figures 1 and 2, then the vehicle 4 is merging with another branch. The electromagnet adjacent to the appropriate side of a switching structure of the vehicle 4 (e.g., a wheel as embodied in Figures 1 and 2) is activated to insure that the vehicle 4 is guided through the region in which some of the guide wheels are not in contact with a guide rail. If, for any reason, the electromagnets are not activated the merging vehicle will tend to continue in a safe manner but there may be more lateral motion than if the appropriate electromagnet is excited.

In some embodiments, it is possible to replace the permanent magnets with electromagnets along a length of a switch point. This option tends to be more expensive but may be appropriate if a vehicle operates in a region where there are substantial ferromagnetic materials that could come in contact with the guideway magnets, or if permanent magnets are not desired for other reasons.

If it is not possible to use steel wheels, or other types of wheels, to get sufficient magnetic force on the wheels, a vehicle can use one or more ferromagnetic plates as a switching structure on the vehicle in order to achieve attractive forces. Conducting plates can also be used in order to achieve repulsive forces when such an interaction is desired. A way of implementing ferromagnetic plates is shown in Figure 1 with ferromagnetic plates 6 located in close proximity to, but not touching the electromagnets 1D or permanent magnets 2D.

When magnetic switching is used with a wheel suspension system there are at least two fairly distinct ways to provide turning at a switch. The magnetic forces can be used to steer the suspension wheels so that they perform the guidance, or the forces can be used to drag the suspension wheels into the turn. For example, when the propulsion is by a linear motor so that little to no wheel traction is required, the wheels can have low friction contact surfaces (e.g., be very smooth) so dragging the suspension wheels a short distance to the side may not take too much force. Creating a steering action on the suspension wheels may be more complex but will require less guidance force. Both of these approaches to steering can be achieved with the various magnetic switching embodiments described in the present application.

When using magnetic forces to steer a vehicle, it is sometimes desirable to have the wheels on opposite sides of the vehicle coupled together so that a magnetic force on one side of the vehicle can steer both wheels. Such coupling can also be implemented with respect to use of other types, and combinations of, switching structures (e.g., steering can be achieved by coordinated movement of switching structures, such as plates, to direct a vehicle).

Magnet design

Figures 3A and 3B show top and cross section views, respectively, of possible ways to use a U-shape electromagnet to create an attractive force on a guide wheel in accord with an embodiment of the invention. Guide wheel 14 has a thin rim of resilient material to reduce noise and wear on the guideway, and includes a ferromagnetic core so that the electromagnets can create an attractive force on the wheel. The wheel 14 contacts a running surface 13 made of stainless steel or other non ferromagnetic material with relatively high resistivity. The electromagnet 1S, 1D has a core 10, legs 12, and windings 11 forming a coil on the legs 12 that are excited with current so as to create a strong magnetic field in the vicinity of the wheel 14 where it rolls on the running surface 13.

The dimensions of the guideway and magnets can vary over a wide range depending on the size of the vehicles. For example, it can be desirable to choose guideway and magnet configurations to use as small a gap as possible in the magnetic structure, and/or to get enough force to ensure the vehicle will move in the desired direction.

Many variations are possible, including eliminating the resilient tread on the wheel and/or eliminating the running surface so that the wheels contact the legs of the electromagnet. These changes would increase the force, though greater noise and wear on the guideway magnets may result.

Figures 4A and 4B depict another embodiment of a system similar to that shown in Figs. 3A and 3B except that the attractive force is applied to ferromagnetic plate 16, acting as the switching structure, instead of to the wheels. A cover 17 may be used to protect the coils and laminations, though such cover is not required.

Alternatively, if the ferromagnetic plate 16 in Figs. 4A and 4B is replaced by a non-ferromagnetic but conducting plate, and the coil formed by the windings 11 is excited with a suitable AC frequency, then a repulsive force acts on the plate. This can be used to push the vehicle in a desired direction. In some cases it is possible to repel a ferromagnetic plate by using a high enough electrical frequency. The AC frequency is typically in the range of 50 to 500 Hz for repelling a non ferromagnetic plate, and higher for repelling a ferromagnetic plate.

Figures 5A and 5B show how permanent magnets can create a force as used in embodiments of the invention. The use of permanent magnets is effective once the vehicle has started moving in the desired direction at a switch point but is in a region where there is a break in the normal guidance mechanism. Fig. 5A shows a cross-sectional view of the use of 3 permanent magnets 21, 22, 23 with different field orientations as indicated by the arrows 41, 42, 43. Fig. 5B shows magnets 21 and 23 of Fig. 5A replaced by wedge-shaped steel poles 25, 26 that convey the magnetic flux to the air gap. In both cases there is a strong attractive force as indicated schematically by the field arrows 20 in the air gap. The use of 3 magnets will give a stronger force, though the cost may be somewhat higher. Either of these, or still other, configurations of permanent magnets can be used to hold the vehicle to the correct side of the guideway when other guidance forces are unavailable. The magnets can be almost any length in the direction perpendicular to the cross-sectional plane, and the surface of a magnet can be chosen to follow the contours of the guide rail.

In some cases, it may be desirable to use permanent magnets in conjunction with electromagnets to create a controllable attractive force. Consistent with embodiments of the invention, Figures 6A and 6B show magnetic field lines for a U-shaped magnet similar to the ones in Figures. 3A, 3B, 4A, and 4B except that the electromagnet legs 34 have permanent magnets 32 attached to them. Coils 33 are wound around both the magnets 32 and the legs 34. In order to attract the vehicle ferromagnetic structure 31, the winding 33 is excited so as to aid the field of the permanent magnet, as shown in Fig. 6A. In order to not attract the vehicle, the current is reversed so that it cancels most of the field, as shown in Fig. 6B. In some cases, this design can produce significantly more force for a given coil dissipation, particularly if the magnetic gap is large.

Still other magnet configurations can be used as will be apparent to those skilled in the art.

Elevators

The switching scheme described in the present application can be used for motion up inclines or for vertical motion in an elevator shaft. For example, vehicles can be propelled via linear motors up one shaft and down another, the shafts serving as guideways. Magnetic switching within the shaft can then used to move the vehicles (i.e., cabs) from one shaft to the other.

Such a system can resemble the system of Figs. 1-2 modified such that the straight guideway 9 is vertical, and the branching guideway 8 is horizontal to the ground. The electromagnets 1S, 1D and/or permanent magnets 2S, 2D can provide appropriate lateral force to move the vehicle 4 from one elevator shaft (i.e., the guideway 9) laterally on the branching guideway 8 to another elevator shaft (another straight guideway). Furthermore, the branching guideway 8 can be oriented such that the vehicle 4 always remain upright. For example, the straight guideway 9 can be perpendicular to the branching guideway 8, such that when the vehicle 4 reaches the intersection of guideways 8, 9, electromagnet 1S can be activated to push the vehicle 4 laterally into the branching guideway 8. Alternatively, electromagnet 1D can be activated to pull the vehicle 4 into the branching guideway 8, or possibly both electromagnets 1S, 1D can work in complementary fashion.

An advantage of using magnetic switching as disclosed herein for elevators from one shaft to another is the ability to work reliably with short headway. For a tall building, embodiments of the invention can allow the use of at least 4 cabs per shaft and operation with headways of only 10 to 15 seconds. This allows a factor of 4 or more reduction in the number of shafts required to achieve a given capacity and the reduced elevator area creates significantly more usable space on all floors.

Variations

There are many possible variations on aspects the invention beyond those described herein. The following are a few non-limiting examples.

It is understood that the illustrative embodiment depicted in Figures 1 and 2 and the operational modes described with respect to such an illustrative embodiment are all merely exemplary. Many variations of the components, and the workings of such components, can be implemented within the scope of the present application. For example the number of wheels that act as a switching structure (e.g., one or more); the number, size, and strength of any magnets positioned with respect to a guideway; the orientation of the wheels with respect to the guideway (e.g., wheels need not be horizontally-oriented, but can be vertically-oriented or any other angle); the types of vehicle suspensions (e.g., wheeled, magnetic, air-cushioned, etc.); the configuration of the guideway (e.g., having a portion extending laterally toward a vehicle moving thereon to orient a magnet adjacent to a switching structure of the vehicle, such as a U-shaped guideway); the number of branches in a switching point (e.g., 3 or more branches); and the number of vehicles in a train that utilize any embodiments of the invention described herein, can all be varied. These variations, among others described herein and those understood by skilled artisans, are all within the scope of the present application.

It is possible to use other methods than guide wheels for normal guidance. For example, if the normal vehicle guidance is magnetic, such as described in U.S. Patent 6,101,952 (which is hereby incorporated by reference herein in its entirety), then the magnetic switching forces may be so large as to cause the vehicle plate to touch the magnet. In this case, it is desirable to use gap sensors and feedback to control the force so contact does not occur.

The vehicle may be supported by two or more bogies, as with typical railroad cars. In this case each bogie can have either ferromagnetic wheels or plates or other switching structure(s) so that the magnetic switching forces can direct the bogies in the desired direction.

Figure 1 shows a vehicle with 8 guide wheels. It is definitely possible to operate with only 4 guide wheels and, in some cases, only 2 may be sufficient.

In many cases a vehicle will be supported by wheels, but it also possible to switch a vehicle that is supported by other mechanisms such as magnetic forces. In the case of systems utilizing ElectroDynamic Suspension (EDS) with repulsive forces acting on a conducting sheet or other conducting structure, the magnetic switching forces can control the lateral position of the vehicle through a switch area. In the case of systems utilizing ElectroMagnetic Suspension (EMS) with the vehicle suspended below the guideway, the magnetic switching can be used to move the vehicles laterally at a switch.

A further appreciation of the foregoing can be attained by reference to U.S. Patent No. 6,101,952, which discusses the use of magnetic forces for both guidance and switching. That material is hereby incorporated by reference herein in its entirety.

Although specific embodiments of the invention have been shown and described, it will be understood that other embodiments and modifications which will occur to those of ordinary skill in the art fall within the true spirit and scope of the invention as set forth in the appended claims. Indeed, one or more features illustrated or described in connection with one embodiment may be combined with one or more features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

What is claimed is:

Claims

1. A system for switching of a vehicle, comprising:

   a first switching structure disposed on the vehicle;

   a guideway for guiding movement of the vehicle; and,

   a first electromagnet disposed on the portion of the guideway for inducing a magnetic force between the first electromagnet and at least a portion of the first switching structure in the vicinity of the electromagnet, thereby directing the vehicle at a switch point.

2. The system of claim 1, wherein the first switching structure comprises at least one guide wheel.

3. The system of claim 1, wherein the first switching structure comprises at least one plate.

4. The system of claim 1, wherein the first switching structure comprises a ferromagnetic or paramagnetic material.

5. The system of claim 1, further comprising at least one permanent magnet disposed on the portion of the guideway for inducing a magnetic force between the permanent magnet and at least a portion of the first switching structure in the vicinity of the permanent magnet, thereby directing the vehicle at a switch point.

6. The system of claim 1, wherein the first electromagnet is excited with alternating current.

7. The system of claim 1, wherein the vehicle comprises at least two bogies, and the electromagnet induces a force between the electromagnet and each of the bogies.

8. The system of claim 1, wherein the guideway is inclined or vertical.

9. The system of claim 1, wherein the first electromagnet includes at least one integral permanent magnet, for decreasing a power requirement of the electromagnet or increasing the magnetic force.

10. The system of claim 1, further comprising:

a second switching structure disposed on the vehicle; and

a second electromagnet disposed on an opposed portion of the guideway relative to the first electromagnet for inducing a magnetic force between the second electromagnet and at least a portion of the second switching structure.

11. The system of claim 1, wherein the guideway comprises a first guide rail for guiding movement of the vehicle, and the first electromagnet is configured to induce a magnetic force between the first guide rail and at least a portion of the first switching structure in the vicinity of the first guide rail.

12. The system of claim 11, further comprising:

a second guide rail acting as a portion of the guideway, the vehicle configured to move between the first guide rail and the second guide rail;

a second switching structure disposed on the vehicle, for engaging the second guide rail; and,

a second electromagnet for inducing a second magnetic force between the second guide rail and at least a portion of the second switching structure in the vicinity of the second guide rail.

13. The system of claim 1, wherein the system is configured as an elevator system.

14. The system of claim 13, wherein the guideway is configured as a plurality of connected elevator shafts.

15. The system of claim 14, further comprising:

a plurality of elevator cabs configured to travel through the plurality of connected elevator shafts.

16. The system of claim 15, wherein the plurality of elevator cabs includes at least 4 elevator cabs.

17. A method of switching a vehicle, comprising:

moving a vehicle on a guideway;

inducing a magnetic force between the vehicle and at least a portion of the guideway situated laterally to the vehicle by using an magnet disposed on the guideway, thereby directing the vehicle at a switch point.

18. The method of claim 17, wherein inducing the magnetic force includes interacting the magnet with a switching structure coupled to the vehicle to induce the magnetic force.

19. The method of claim 17, wherein inducing the magnetic force includes activating an electromagnet using alternating current.

20. The method of claim 17, wherein inducing the magnetic force includes using a permanent magnet disposed on the guideway to direct the vehicle at the switch point.

21. A system for switching of a vehicle, comprising:

a switching structure disposed on the vehicle;

a guideway for guiding movement of the vehicle; and,

at least one magnet disposed on the portion of the guideway for inducing a magnetic force between the at least one magnet and at least a portion of the switching structure in the vicinity of the at least one magnet, thereby directing the vehicle at a switch point.

FIG. 1

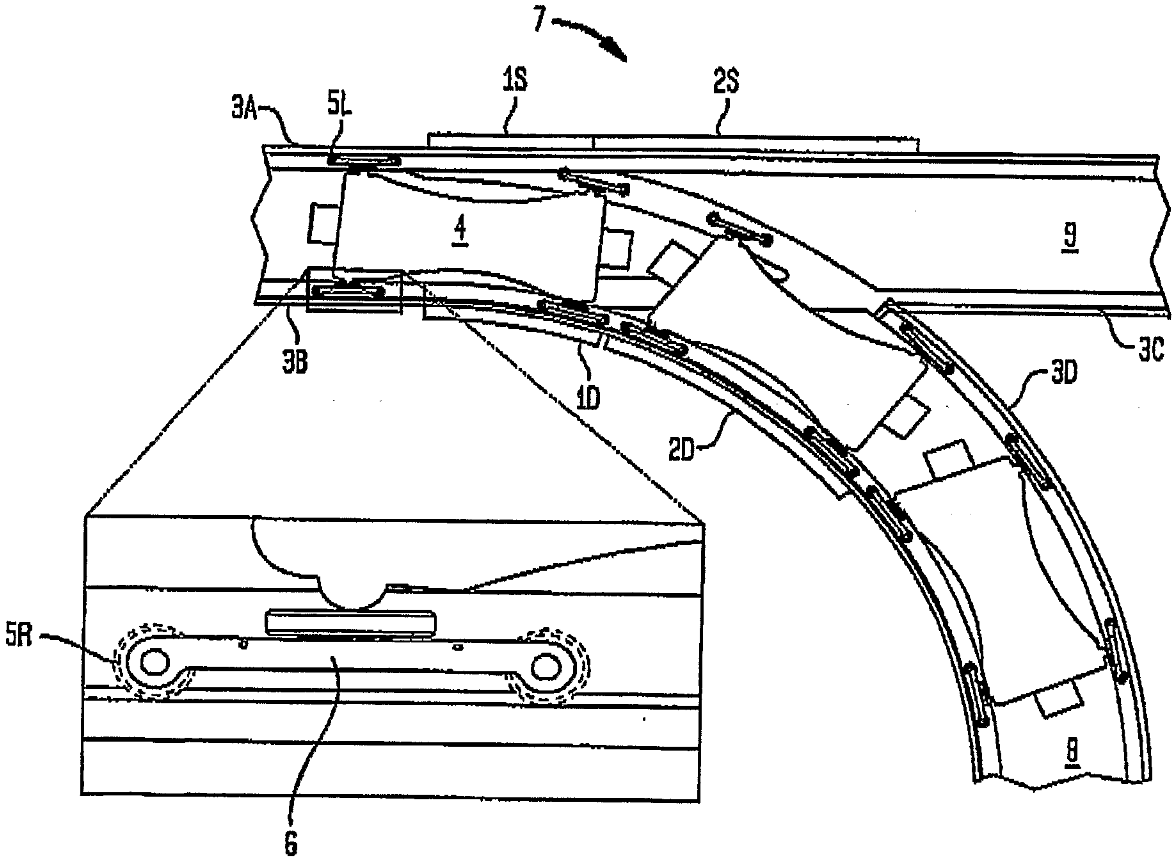

FIG. 2

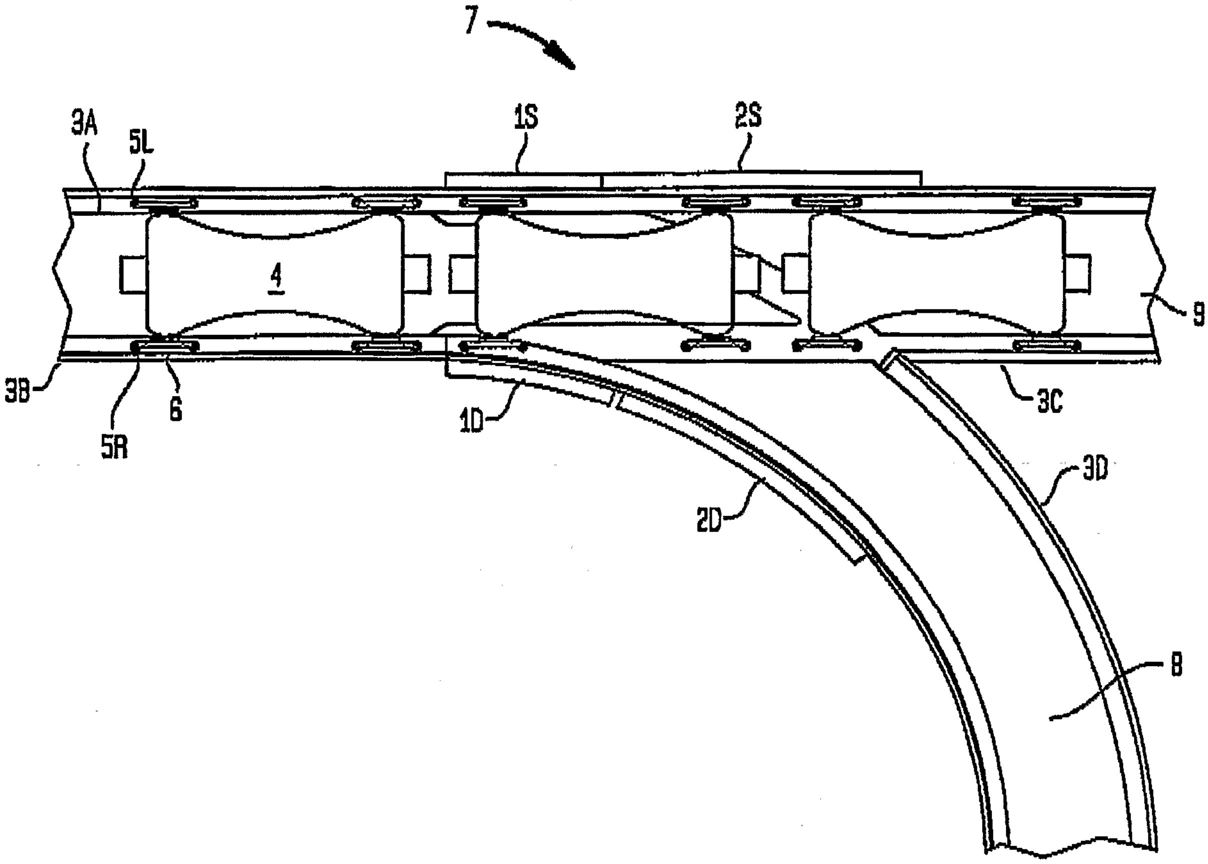

FIG. 3A

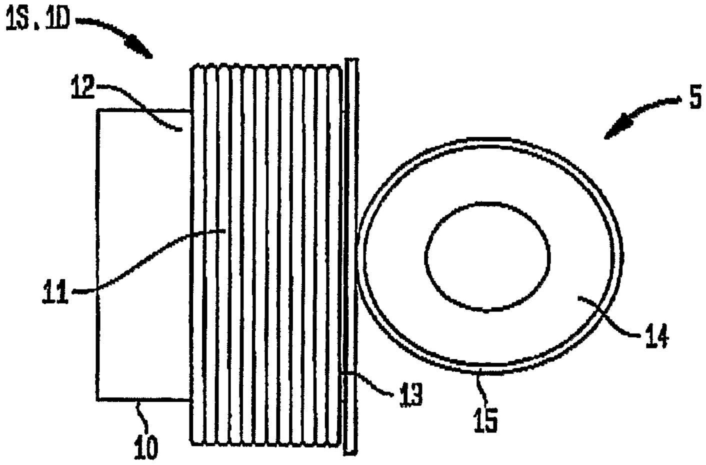

FIG. 3B

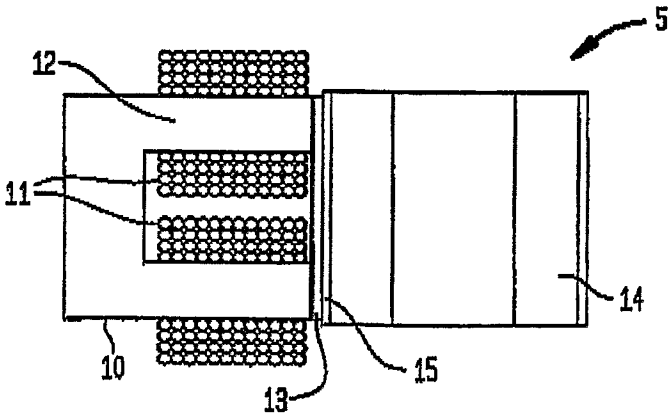

FIG. 4A

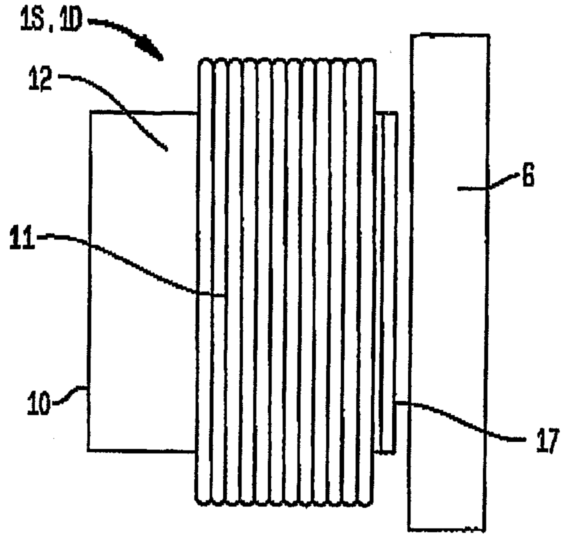

FIG. 4B

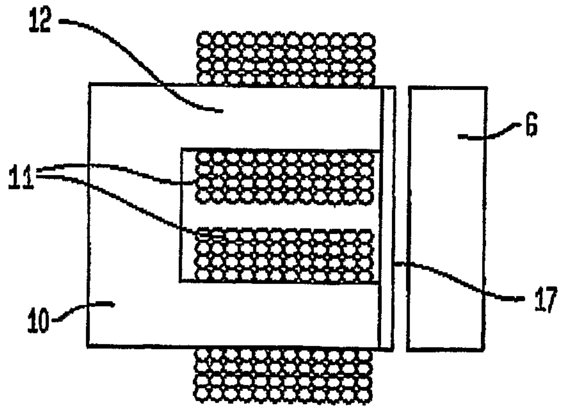

FIG. 5A

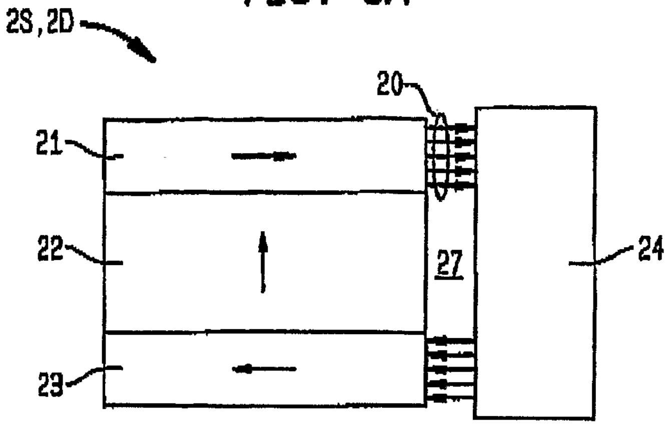

FIG. 5B

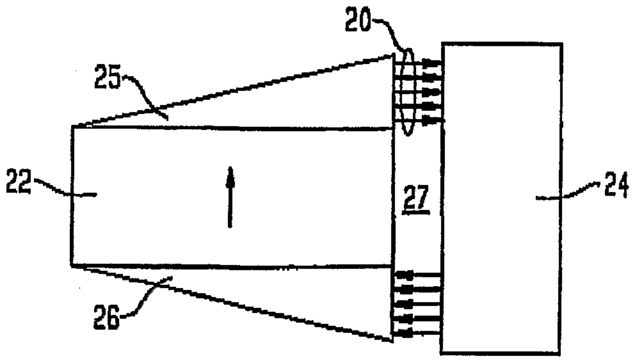

FIG. 6A

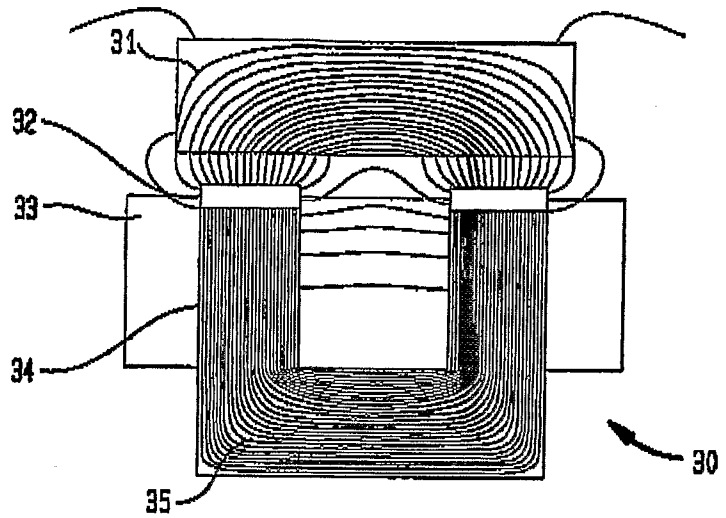

FIG. 6B