ELEVATED TRANSPORTATION SYSTEM HAVING IMPROVED SUPPORTING STRUCTURE
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ABSTRACT OF THE DISCLOSURE
A system of transportation wherein a train unit of individual cars, which are articulated for both lateral and vertical movement, travels along spaced supports and is carried alternately by two and by three supports, with cables interconnecting the supports and serving as guides, the elevation of the cables being sensed by controls on the cars which in turn operate power devices between the cars to cause the latter to swing about their transverse hinge pins.

This invention relates to vehicular travel and, more particularly, to a transportation system of novel construction.

Suspended monorail transportation systems have been successfully used for many years and, although they are relatively few in number throughout the world, such systems represent a distinct advance over conventional transportation systems in improving the economic structure of urban communities. Monorail systems, by virtue of their construction and disposition with respect to the ground, are capable of carrying large numbers of people above the regular traffic routes so as to avoid congestion on such routes and thereby traffic hazards associated therewith.

Since such systems are generally powered by electrically actuated prime movers, atmospheric pollution by exhaust gases of internal combustion engines used on mass transportation vehicles such as busses and the like is not a factor to be considered with the utilization of monorail systems. The parking of vehicles in congested areas becomes less of a problem because more people can be carried by the monorail system to their destinations in a shorter time so as to make travel by the monorail method more economical and attractive from a convenience standpoint than is possible with conventional methods of urban travel.

Notwithstanding the advantages of monorail transit systems, such systems have certain disadvantages associated with their use, among which are that they are bulky in construction, and impair the aesthetic qualities of areas through which they extend and operate. A monorail beam itself must be constructed to carry the weight of the monorail train and its occupants which, in turn, requires that the upright structures, which support the beam, be relatively close together and large in cross section to be sturdy enough to safely support the elevated track and the occupied train. Thus, a relatively large number of such support structures are required per unit length of train line, making the cost of construction and maintenance of the system proportionately high. Also, a conventional monorail system is generally too slow for use as a mass transportation facility because of its limited carrying capacity and because of the requirement of an operator for each train, thus rendering an automated system wherein a number of trains can be simultaneously operated and controlled from a single control center.

The present invention provides a transportation system having the foregoing advantages of so-called monorail systems and is of a construction and operates in a manner to overcome the disadvantages with respect thereto. To this end, the instant system relies not upon a monorail beam or the like for supporting a mobile train unit, but upon the structural rigidity of the train unit itself for a portion of its support as it is further and successively supported at spaced locations defined by a number of spaced, aligned, upright and/or suspended support structures during movement of the train unit over a path defined by the support structures. To provide this support, the train unit at all times, presents a beam extending between a number of the aforesaid support structures, i.e. always at least two and sometimes three or more of the support structures, depending upon the length of the train and the spacing between the structures themselves. The train unit presents a simple beam when it spans the distance defined by three successive, aligned support structures, and presents a cantilevered beam at each of its ends when it only spans the distance between two adjacent support structures. The construction of the train unit obviates a bulky, unsightly and costly monorail beam.

The present invention is further simplified in construction and operation by the provision of individual, relatively quiet power drive assemblies on the support structures, thus making possible the automatic operation of the system by effective speed control of one or more of the train units at all operative locations on the path of travel defined by the support structures. As a result, neighborhoods through which the system operates remain substantially undisturbed and substantial economies can be practiced inasmuch as the individual drive assemblies can be periodically actuated as required, rather than being continuously actuated. Provision is also made in the present system for safety procedures to be put into effect immediately upon failure of any part of the system. Hence, risks of structural damage and hazards to the occupants of the train unit are substantially minimized.

It is, therefore, the primary object of the present invention to provide a transportation system which provides the advantages of a monorail system, but which overcomes certain of the disadvantages thereof without sacrificing speed, capacity, or safety factors essential to this form of travel.

Another object of the instant invention is the provision of a transit system of the type described which utilizes to advantage the characteristics of simple and cantilevered beams in the construction of the train unit of the system so as to obviate bulky, costly, and unsightly supports, and to simplify the construction and minimize the cost of construction and operation of the system.

Still another object of this invention is the provision of a transportation system of the aforesaid character having a train unit whose path of movement can be changed as desired notwithstanding the beam-like character of the train unit itself.

Yet another object of the present invention is the provision of a transportation system having the aforesaid attributes wherein the operation of the system is substantially automatic and is accomplished in a manner to leave neighborhoods or areas through which the system operates substantially undisturbed in any way.

Still a further object of the invention is the provision of a system of the type described having a sectionalized train unit normally defining a rigid beam and capable of articulation whereby the train unit can change directions of travel without losing its beam-like character.

Other objects of the present invention will become apparent as the following specification progresses, reference being had to the accompanying drawings, wherein:

FIGURE 1 is a side elevational view of a preferred embodiment of the transportation system of the present invention illustrating a sectionalized train unit supported as a simple beam by three spaced, aligned, adjacent support structures above ground level;
FIG. 2 is a view of the transportation system similar to FIG. 1 but showing the train unit as a cantilever beam supported by two adjacent support structures;

FIG. 3 is an enlarged, end elevational view of the support structures illustrating the train unit coupled to one of a pair of drive assembles thereon;

FIG. 4 is a side elevational view of a support structure and a drive assembly thereof;

FIG. 5 is an enlarged, fragmentary, side elevational view of the train unit and the path-defining guide cables along which direction-sensing pilots move;

FIG. 6 is a top plan view of the train unit illustrated in FIG. 5;

FIG. 7 is a fragmentary, side elevational view of a pair of adjacent sections of the train unit and one form of the structure for interconnecting the same;

FIG. 8 is a view taken along line 8—8 of FIG. 7; and

FIG. 9 is a schematic view showing the mechanism for shifting one of the sections in a vertical plane relative to an adjacent section.

The present invention relates to a novel transportation system comprising a series of spaced supports, each having a drive assembly thereon and aligned to form a route or path for an articulated train movable successively by the assembles. The train is provided with sections which are interconnected by actuable structures, each of which permits the train longitudinally rigid with respect to up-and-down movement but permitting the train to articulate laterally to change horizontal direction. Means are coupled with the structure to sense elevation changes of the route or path and to actuate the structure so that the train itself will move upwardly or downwardly as required. Generally, the supports are equally spaced apart. The length of the train is at least equal to twice the distance between any two adjacent supports, the train itself being alternately carried by two supports and by three supports.

Transportation system 10, illustrated in FIGS. 1 and 2, includes a series of spaced supports 12 and an articulated train 14 having a number of interconnected sections 16, each section being compartmented in any suitable manner to receive passengers or cargo as desired. For purposes of illustration only, train 14 has four sections denoted by the numerals 16a, 16b, 16c and 16d, sections 16a being the lead section, sections 16d being the rearmost sections, and sections 16b and 16c being intermediate sections 16a and 16d.

As illustrated, train 14 is adapted for receiving passengers and each section 16 is provided with a series of compartments, access to which is obtained through upwardly sliding doors 18 movable on spaced tracks 20, as shown in FIG. 5. The width of each section 16 is such as to permit seating of a predetermined number of people, and structure (not shown) is provided for each section 16 respectively to effect raising and lowering of doors 18 at the proper time, for instance, when train 14 is at a specific location, such as a passenger depot or the like. Each section 16 can be constructed in a manner other than that illustrated and described if desired, the only requirement being that each section is substantially rigid throughout its length.

For purposes of illustration only, each support 12 extends upwardly from a base 22 secured in any suitable manner at ground level 24. A pair of arcuate, laterally projecting arms 26 are provided on each of the opposed sides of support 12 as shown in FIGS. 3 and 4, each pair of arms being relatively disengaged with respect to each other as their outer ends are approached. Bracing 27 secured to arms 26, as shown in FIG. 3, provides structural rigidity for support 12. As shown in FIG. 3, each pair of arms 26 provides means for suspending a train 14 therefrom. Thus, a train corresponding to one pair of arms 26 could be movable in one direction, while the train corresponding to the other pair of arms 26 could be movable in the opposite direction. It is to be understood, however, that each support 12 could merely define a point on a single path of travel rather than a pair of points or two paths of travel as shown.

A support member 28 having a pair of downwardly extending legs 30 and an upper crosspiece 32 is rotatably secured on a shaft 33 secured to and spanning the distance between the outer ends of a corresponding pair of arms 26. The lower end of each leg 30 supports a truck 34 having an axle 36 provided with a pair of drive wheels 38 at each end thereof respectively. A prime mover 40, such as an electric motor, is provided for each axle 36 respectively and is coupled therewith by means of a gear mechanism 41 disposed between the pairs of wheels 38 as illustrated in FIG. 3. Prime mover 40 effects rotation of wheels 38 and axles 36, corresponding to each suspension member 28, in the same direction. A housing 42, carried in any suitable manner on legs 30, encloses prime movers 40. Each of the prime movers 40 is preferably controlled remotely and actuated periodically only when required to drive train 14 so as to minimize power consumption and, thereby, maintain operating costs at a minimum.

A pair of generally parallel cables 44 defining the path of travel of train 14 are carried by coupling devices 46 on the outer sides of legs 30 as shown in FIGS. 3 and 4. Cables 44 are, the latter normally being in a vertical position with legs 30 and are disposed between trucks 34 and below crosspiece 32. Cables 44 are utilized for guiding sections 16 of train 14 when the latter is supported on and moved by wheels 38.

Each section 16 of train 14 has a pair of transversely L-shaped runners 48 extending upwardly from opposed sides thereof in the manner shown in FIG. 3. The horizontal portions 50 of runners 48 overlie and normally engage wheels 38 of trucks 34 as so as to be supported by the latter as train 14 moves along its path defined by cables 44. Wheels 38 frictionally engage the lower surfaces of portions 50 to thereby drive train 14 in the corresponding direction. The speed of train 14 will be determined by the speed of rotation of wheels 38 and, since prime movers 40 can be controlled remotely, the speed of train 14 at any point on its path of travel, can be predetermined by selectively maintaining the speeds of rotation of wheels 38 of all trucks 34 at specified values.

In this way, the operation of train 14 is similar to that of an automatic elevator. Moreover, train 14 may be decelerated as well as accelerated by wheels 38. This type of deceleration, shown as dynamic braking, is accomplished by rotating wheels 38 at a rotational speed less than that corresponding to the linear speed of train 14.

Runners 48 of sections 16 are normally all aligned with each other. Thus, one section successively follows another section into engagement with wheels 38 of any given support 12. By virtue of legs 30, trucks 34 may sway to allow for small departures of runners 48 from true alignment with each other. Any side sway of trucks 34 however, is kept to a minimum by the resistance offered by cables 44 to lateral movement of legs 30.

FIGS. 7 and 8 illustrate the preferred way in which each pair of adjacent sections 16, for instance, sections 16a and 16b, are interconnected by the compensator assembly 51 for normally free rotation about a vertical axis, while the same are normally held against swinging movement relative to each other about a horizontal axis transverse to the path of travel of train 14. Assembly 51 includes an upper joint or universal coupling 52 pivotally interconnected by link 54 to the tops and bottoms thereof, and a lower joint 54 interconnecting these sections at a location spaced below joint 52.

Joint 52 includes a first clevis 56 on section 16a and a second clevis 58 on section 16b. A normally horizontal pin 60 carried by clevis 58 is rotatably mounted in a vertical pin 62 carried by clevis 56. Sections 16a and 16b are thus rotatable relative to each other about an axis through
pin 60 in the absence of any restraint by portions of assembly 51 therebelow. In addition, pin 62 is rotatable with respect to clevis 56 and joint 54 so that sections 16a and 16b are rotatable with respect to each other about a vertical axis through pin 62. Therefore, one section can freely yaw in either direction relative to the other section within arcuate limits defined by the construction of the proximal end portions of the sections and joints 52 and 54.

A pin 62 extends downwardly from joint 52 to present a stabilizer rod 64 integral with pin 62 for connection with joint 54, the latter including a clevis 66 on the outer end of a first piston rod 68 forming a part of a piston and cylinder assembly 70 on section 16a. A projection 72 on the outer end of a piston rod 74 forms another part of joint 54 and is disposed within clevis 66 for movement therewith longitudinally of rod 64 and for movement relative to clevis 66 about rod 64. To permit longitudinal movement, respectively, and axis 66 and projection 72, clevis 66 has a pair of aligned openings therein and projection 72 has a bore therethrough, the openings and bore slidably receiving rod 64. Piston rod 74 forms a part of a piston and cylinder assembly 76 identical to assembly 70 and attached to section 16a. In each of these assemblies a piston 78 is coupled to the corresponding piston rod intermediate the ends of the latter as illustrated schematically in FIG. 9. The corresponding cylinder 80 of each of the assemblies 76 and 70 has a tubular extension 82 for receiving the opposite end of the corresponding piston rod, there being fluid lines 84 and 85 for directing fluid under pressure into and out of the corresponding cylinder 80 on opposed sides of its piston 78. Thus, the opposed sides of each piston 78 have the same area exposed to the fluid adjacent thereto.

Cylinders 80 of assemblies 76 and 70 are pivotally moved to respective sections 16 by pivot pins 86 and 88 to eliminate binding and structural damage in the components of assemblies 76 and 70 when one of the sections pivots relative to the other section about the horizontal axis through pin 60. Cylinders 80 are thus capable of rocking about the axes thereof through pins 86 and 88 respectively, and are normally held in their full-line positions of FIG. 7 by the coupling action of joint 54. By virtue of this construction, section 16a may pivot about pin 60 relative to section 16b when pistons 78 of assemblies 70 and 76 move toward and away from each other under the influence of fluid under pressure within respective cylinders 80.

Lines 84 are interconnected with each other and to a rotary, four-way valve 90 for connecting the respective cylinders 80 with a hydraulic circuit including a fluid pump 92, a fluid reservoir 94, conduits 96 and 98, and a bypass 100 provided with a relief valve 101. A conduit 103 couples reservoir 94 with pump 92. When valve 90 is disposed in its equilibrium position shown in FIG. 9, no fluid flows therethrough and the fluid pressures on opposed sides of pistons 78 are equal. When valve 90 is rotated in a counterclockwise direction when viewing FIG. 9, fluid under pressure is directed into lines 84 coupled to the outer ends of cylinders 80 and thence into the latter for forcing cylinders 89 away from each other. Lines 85 are interconnected with each other and to valve 90 for directing fluid from the inner ends of cylinders 80 through valve 90 and into reservoir 94 by way of conduit 103 simultaneously with the movement of fluid into cylinders 80 by way of lines 84. Conversely, when valve 90 is rotated clockwise through an arc of 45° from its equilibrium position, the opposite operative condition is obtained and the inner ends of cylinders 80 are moved into fluid communication with the output of pump 92, thus placing the outer ends of cylinders 80 in communication with the inlet of reservoir 94.

Lead section 16a is provided with a pair of forwardly and upwardly projecting arms 102 as illustrated in FIGS. 5 and 6. Each arm 102 is secured to the front end of section 16a by a hinge 104 for rotation in a normally vertical plane about a generally horizontal axis transverse to the path of travel of train 14. The body 105 of each arm 102 is provided with a pilot roller 106 which is disposed above and normally engages a respective cable 44. A limit pin 107 is provided for each arm 102 respectively, pin 108 being secured to and extending outwardly from opposed sides of section 16a as shown in FIG. 5.

Each arm is provided with a slot 108 for receiving the corresponding pin 107, the latter limiting the arcuate distance through which its arm travels upwardly and downwardly. Since cables 44 define the path of travel of train 14, pilot rollers 106 move upwardly or downwardly with corresponding changes in elevation of cables 44 to, in turn, swing arms 102 in the same direction. Mechanism including sensing apparatus 109 for each arm 102 respectively, is provided for sensing the angular movements of the corresponding arm 102, apparatus 109 being coupled to its arm adjacent respective hinges 104.

Each apparatus 109 is preferably a selsyn motor or the like having an operating shaft rotatable with its respective arm 102 in opposed directions. Any change in the elevation of cables 44 will cause a corresponding electrical signal to be generated in each apparatus 109, the signals from apparatuses 109 being then directed to a differential sensing device 110, preferably a differential selsyn motor, as shown schematically in FIG. 9 and associated with assembly 51 corresponding to and disposed between sections 16a and 16b. Device 110 is coupled with valve 90, the latter being of the type that is electrically actuated to effect 45° rotation of valve 90 in opposed directions beyond its equilibrium position in response to up and down movements of arm 102.

When sections 16a and 16b are in alignment with each other, the corresponding pistons 78 will be intermediate the ends of respective cylinders 80 and fluid pressure exerted on opposed sides of both pistons 78 will be substantially the same. Sections 16a and 16b will then be prevented from rotating relative to each other about pin 60 common thereto. The portion of train 14 defined by these two sections will thus be rigid to present a rigid beam segment having a length equal to the lengths of sections 16a and 16b. However, any change in the fluid pressures within adjacent cylinders 80 will cause movement of these cylinders 80 and thereby result in section 16a pivoting about pin 60 relative to section 16b. This is caused by the actuation of valve 90 under the influence of device 110 which, in turn, is energized ultimately by the swinging of arms 102.

Movement of cylinders 80 away from each other increases the effective lengths of rods 68 and 74 and causes section 16a to pivot upwardly relative to section 16b. Section 16a is shown in dashed lines in FIG. 7 after it has pivoted upwardly with respect to section 16b about the axis of pin 60. Conversely, movement of cylinders 80 toward each other decreases the effective lengths of rods 68 and 74, causing section 16a to pivot downwardly with respect to section 16b. It is to be noted that cylinders 80 move through equal distances with respect to their pistons 78 by virtue of the way in which the former are coupled with pump 92 through valve 90. Hence, rod 64 always remains substantially in bisection relative to the acute angle between sections 16a and 16b regardless of their relative positions. The structure of FIGS. 7-9 in no way precludes changes in horizontal direction of sections 16a and 16b inasmuch as each of these sections is rotatable at least through a limited extent about the corresponding pin 62 relative to the adjacent section since projection 72 is rotatable with respect to clevis 66.

Section 16a is provided with a pair of guide rails 112 each having a shaft 114 extending upwardly from a corresponding runner 48, a cylindrical roller 116, and a wheel-like flange 118 as shown in FIGS. 5 and 6. Rollers 116 normally engage cables 44 for movement along the latter to effect guidance in horizontal direction of section 16a.
Each flange 118 serves the same purpose as the flange on the wheel of a railroad car or engine, i.e., it holds section 16c and the corresponding cable in predetermined vertical dispositions with respect to each other.

A pair of arms 122 is rotatable relative to 14 and extends forward. Each arm 122 of which engages the corresponding cable 44, each arm 122 and its roller 126 serves to suspend the corresponding section 16b if runners 48 thereon were to fail. Sensing apparatus 109, such as a selsyn motor or the like, is coupled to arm 122 to generate an electrical signal in response to the swinging of arm 122 under the influence of elevation changes in the corresponding cable 44. Preferably, each arm has the same construction as arm 102 and is limited in rotation by suitable structure, such as a pin and slot arrangement similar to pin 107 and slot 108.

However, for purposes of illustration, each arm 122 is shown in FIGS. 1 and 2 as being mounted on an extension 124 rigid to section 16b. The selsyn motors 109 coupled with arms 122 form a part of grade compensator assembly 51 between sections 16b and 16c. Section 16b is thus slotted in a vertical plane relative to section 16c in the manner described above with respect to sections 16a and 16b.

Section 16c is provided with a pair of cable-engaging rollers 128 similar to and for the same purpose as rollers 126, rollers 128 being mounted on arms swingably mounted on respective extensions 130 on the front end of section 16c. Each extension 130 is also provided with a pair of rigid, upwardly and rearwardly projecting extensions 132, each having a swingable arm and a roller 134 on the arm thereof, rollers 134 and the corresponding arms serving the same function as rollers 126 and 128 and their corresponding arms. The grade compensator assembly 51 directly below rollers 134 is controlled by a sensing device, such as a selsyn motor or the like, coupled with a pair of swingable arms 136 on each of a pair of upwardly and rearwardly projecting extensions 138 on the rear extremity of section 16d. A roller 140 is provided for each extension 138 respectively, arms 136 and rollers 140 serving the same purpose as rollers 126, 128 and 134 and their corresponding arms.

Each of the sections 16b has front and rear skids 142 and 144 respectively, which are adapted to engage support structure disposed below train 14 to support the latter in lieu of supports 12. For instance, it is conceivable that train 14 could load and discharge cargo or passengers at a depot or the like at which roller structure underlying skids 142 and 144 could define the path of travel of train 14. In this respect, the rollers of such structure could be driven in any suitable manner so that, upon frictional engagement with skids 142 and 144, train 14 would be driven in the corresponding direction.

In this respect, conventional switching apparatus could be employed to switch train 14 from a main line route to a secondary path adjacent thereto. In addition, curved guide bars or segments could be employed to effect sharp turns of train 14 by articulating sections 16b with respect to each other. However, one of the sections 16b, either a section in advance of the section on the segment or a section to the rear thereof, would be in coupled relationship with trucks 34 of a support 12 so that train 14 would be movable over its path of travel while changing direction by moving along the segment.

Each support 12 is preferably spaced equally from adjacent supports and the length of train 14 is at least twice the distance between a pair of adjacent supports 12. Thus, train 14 will span the distance between the supports 12 next adjacent to and on opposite sides of the given support 12 in the manner shown in FIG. 1. In this case, the center of gravity of train 14 is aligned with or in the vicinity of the middle support 12.

When train 14 moves out of the disposition thereof shown in FIG. 1 and into the disposition shown in FIG. 2, it is carried by two supports 12 and the center of gravity of train 14 is then between two supports. The outwardly projecting portions of train 14, when the latter is in the disposition of FIG. 2, are cantilevered inasmuch as train 14 can be considered to be a rigid beam. In FIG. 1, train 14 is considered to be a simple beam; whereas, in FIG. 2, train 14 can be considered a cantilevered beam. The beam-like character of train 14 is obtained regardless of its disposition with respect to the ground and the relative angular positions of sections 16c. Hence, even though lead section 16c, monorail 44 is considered as section 16b continues to move horizontally, train 14 is still considered to be a rigid beam. However, this situation is insignificant in view of the normal speeds of operation of train 14.

By utilizing the structural rigidity of train 14, a monorail beam or similar structure spanning the distance between supports 12, is obviated. As a result, system 10 is greatly simplified over conventional monorail systems and substantial economies can be practiced from a standpoint of initial cost of system 10 as well as maintenance thereof. By eliminating a bulky and costly monorail beam, regions through which system 10 operates are substantially undisturbed except for the presence of supports 12 and their associated drive means. Since prime movers 49 may be made to operate periodically, the noise level in such regions is maintained at a minimum so that tenants and owners of properties adjacent to system 10 may continue to enjoy the use of their land without substantial interference from the operation of system 10. In this respect, wheels 38 may be provided with rubber tires to minimize the noise level associated with the engagement of runners 48 therewith.

Auxiliary power equipment such as heating, lighting, door operating, ventilation and other equipment may be operated electrically through transformer means or the like on train 14. Such means is energized by stationary contacts 146 carried by and extending downwardly from housing 42 corresponding to each set of trucks 34 respectively, as illustrated in FIGS. 3 and 4.

Contacts 146 are adapted to electrically engage strips 148 carried on a terminal member 150 mounted on train 14 in the manner shown in FIGS. 3 and 5. Thus, electrical power may be supplied at all times to train 14 as the latter moves along its path of travel.

Cables 44 may be subject to weather extremes and, for this reason, cable-tensioning devices coupled therewith preferably are provided at spaced locations along the path of travel of train 14. Such structure will assure that cables 44 remain under proper operating tension at all times.

OPERATION

Train 14 is placed in use by mounting runners 48 on at least a pair of supports 12 so that, upon energization of the corresponding prime movers 40, train 14 will move in the corresponding direction of rotation of wheels 38 coupled to the last-mentioned prime movers 40. Train 14 will continue to move under the influence of trucks 34 successively engaged thereby until train 14 is brought to a halt.

Since train 14 is essentially a rigid beam and supports 12 are all in alignment with each other, runners 48 will, at all times, move into engagement with wheels 38 so that train 14 will be effectively supported. Cables 44 guide lead section 16a by virtue of the engagement of rollers 106 and 116 with cables 44 in the manner shown in FIGS. 5 and 6. Any change in the vertical or horizontal direction of the path as defined by cables 44 will result in the corresponding change in the direction of movement of train 14.

Sections 16b are free to articulate with respect to each other about vertical axes so that no actuating mechanism is required in response to changes in the horizontal direction of the path of travel of train 14. For sharp curves

75 or 90° turns, segments of the above-described charac-
ter are preferably utilized in lieu of trucks 34, it being clear that only the equivalent of one section 16 would be substantially in the arc of such a sharp turn at any one time so that the remaining sections 16 could be driven in the usual manner.

For changes in elevation of the path of travel, lead section 16a is articulated initially with respect to section 16c. Similarly, section 16b is articulated with respect to section 16c and the latter is articulated finally with respect to section 16d. Arms 102 swing upwardly or downwardly, depending upon the upward or downward change in elevation of cables 44.

If the elevation of cables 44 increases, such increase is sensed by arms 102 which swing upwardly to actuate apparatus 100 associated therewith. This, in turn, will actuate valve 90 so that fluid is supplied under pressure to the outer ends of cylinders 80 to force the latter away from coupling 54. Since section 16b, 16c and 16d remain substantially horizontal, they will not articulate with respect to pin 60; whereas all of the movement, due to the increased fluid pressures on the outer faces of pistons 78, will be done by section 16a. This latter section will move into the dashed-line position of Fig. 7, for instance, with respect to section 16d and will, therefore, move upwardly along the inclined portion of the path while section 16c continues on the horizontal portion.

As soon as arm 122 on section 16b senses the inclination, assembly 51 between sections 16c and 16d is then actuated in the foregoing manner to effect articulation between the last-mentioned sections, whereupon section 16b will move upwardly along the inclined portion of the path. When this latter action occurs, arms 102 will sense upward movement of section 16b under the influence of section 16a and will actuate assembly 51 between sections 16a and 16b in the opposite manner from that illustrated for the operative condition corresponding to the initial movement of section 16c upwardly along the inclined portion of the path. Thereupon, section 16a will pivot downwardly with respect to section 16c and the latter sections will once again become aligned with each other.

As roller 128 moves onto the inclined portion of the path, the rearmost extremity of section 16d will tend to move downwardly which, in turn, will cause arms 136 to swing upwardly with respect to extensions 138 and much as the rollers on arms 136 are in engagement with cables 44. The upward swinging movements of arms 136 cause articulation of section 16c with respect to section 16d by the actuation of assembly 51 therebetween. Section 16d will then move upwardly along the inclined portion of the path as section 16c continues along the path. When this occurs, however, arms 122 sense the continued upward movement of section 16b under the influence of section 16c. This will, in effect, swing arms 122 downwardly relative to extensions 124 and actuate the corresponding assembly 51 in the opposite manner as that described hereinabove so that section 16b will pivot downwardly with respect to section 16c until sections 16b and 16c are once again aligned with each other. Hence, sections 16a, 16b and 16c will then be in alignment with each other as they move along the inclined portion of the path and as section 16d continues on the horizontal portion and approaches the inclined portion.

Since section 16d has no guide means on its forwardmost extremity it will follow the rear extremity of section 16c. As the rear extremity of section 16c moves onto the inclined portion of the path, section 16d, rigid to section 16c, although angularly disposed with respect thereto, moves upwardly therewith while remaining generally horizontal. However, arms 136 will sense the upward movement of section 16d and will swing downwardly with respect to sections 16a and 16b, thus actuating the corresponding assembly 51 between sections 16a and 16d in the opposite manner. This action will once again swing section 16d downwardly with respect to section 16c until these sections are in alignment with each other. At this juncture, sections 16a of train 14 are in alignment with each other in the manner shown in FIGS. 1 and 2.

For a change in the opposite direction or downwardly, the process is repeated in reverse. Generally, the changes in elevation are small enough to result in negligible movements of the various sections 16 with respect to each other inasmuch as engineered line construction will modify abrupt grade changes. The response times of the various components of the hydraulic circuit illustrated in FIG. 9 may be synchronized with the speed of the train so that the articulation of train 14 may be accomplished uniformly with time. Train 14 is thus highly maneuverable while retaining its essentially rigid beam characteristics. Train 14 is, therefore, suitable for use over various types of terrain, is operable in all types of weather, and can be driven at speeds which permit rapid transportation of large numbers of people or large volumes of cargo on the most economical basis.

As illustrated, train 14 is shown at ground level suspended from arms 26 of supports 12. However, train 14 can move through tunnels or underground while being suspended from overhead beams, or by being supported from beneath.

Train 14, when the same is suspended, can be made to have a low center of gravity to minimize the period of swinging movement thereof relative to shafts 33 on supports 12. The operation of train 14 can be made automatic inasmuch as prime movers 40 may be actuated periodically in response to the position of train 14 on its path of travel. No operator is, therefore, required for train 14 and the costs of operation are, therefore, minimized.

Supports 12 may be of other configurations from that illustrated and described herein. For instance, a bracket-type support fastened to the side or ceilings of buildings or the like, can be utilized. Also, train 14 can be suspended from the ceilings of tunnels and from the bottoms, sides or tops of bridges.

The speed of train 14 is specifically determined for all locations thereof along its path of travel so that train 14 may be brought to a halt or started at precise locations and at precise times with respect to the movements of other trains 14 on the same path, or at spaced locations therealong. The speed of train 14 would, of course, be determined by the speeds of rotation of the various trucks 34 and dynamic braking is preferably utilized to minimize the operational costs as well as the structure required for operation.

At stations and other stops, the train is held stationary by means of cable grips 152 of conventional construction that clasp around corresponding guide cables 44. Grip members 152 are comprised of movable jaws normally held open by electromagnetic forces. They grip the cables when the holding circuit is interrupted.

During emergencies, when malfunctioning of structural components or of power circuits of train 14 occurs, cable grips 152 operate automatically and remain actuated until safe conditions are restored. Each section 16 of train 14 is equipped with a pair of cable grips 152 near the rear end as shown in FIG. 2.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is: 1. In a transportation system: an elongated vehicular unit having a runner means extending longitudinally thereof; a series of spaced supports for said unit arranged along a predetermined route and disposed for successive engagement by the runner means as the unit travels along said route, said unit being at least as long as the distance defined by any three successive supports whereby, during
said travel the unit is alternately carried by two supports and by three supports, said unit having structure rendering the same self-sustaining when carried either by two or by three supports, said unit comprising a train of articulated sections, guide means for said sections extending along said route; and mechanism on the sections engaging the guide means for shifting one section relative to an adjacent section, said mechanism being provided with apparatus sensitive to changes in elevation of said guide means, the sections having means responsive to said apparatus for raising and lowering the same as said elevation varies.

2. In a transportation system:
   a plurality of spaced, aligned support structures defining a path spanning adjacent structures; a train unit having a length equal to at least the distance between the pair of structures next adjacent to and on opposed sides of each structure respectively, said train unit having means maintaining the unit self-sustaining when the unit is supported either by two structures or by three structures; and means carried by said train unit for mounting the latter on said supports for movement along said path, said structures being disposed for successively supporting said unit as the latter moves along said path, whereby the unit is at all times supported either by two structures or by three structures, said mounting means being disposed on the upper and lower extremities of said unit, certain of said structures being above said unit and coupled with the mounting means on said upper extremity to suspend the unit when the latter is adjacent to said certain structures, the remaining structures being disposed below said unit and coupled with the mounting means on said lower extremity to support the unit from below when it is adjacent to said remaining structures.

3. In a transportation system:
   a plurality of spaced, aligned support structures defining a path spanning adjacent structures; a train unit having a length equal to at least the distance between the pair of structures next adjacent to and on opposed sides of each structure respectively, said train unit having means maintaining the unit self-sustaining when the unit is supported either by two structures or by three structures; means carried by said train unit for mounting the latter on said supports for movement along said path, said structures being disposed for successively supporting said unit as the latter moves along said path, whereby the unit is at all times supported either by two structures or by three structures, said unit including a number of sections, said maintaining means being disposed between and interconnecting adjacent sections, said maintaining means including an assembly coupling each section with an adjacent section for lateral swinging movement relative thereto; and means coupled with each section for swinging the latter laterally in a predetermined direction in response to a change in said direction of said path as said unit moves therealong.

4. In a transportation system as set forth in claim 3, wherein said section swinging means includes a pair of parallel cables carried by said structures and extending along said path, and a roller for each cable respectively, the rollers being secured to a corresponding section, being held against lateral movement, and normally in engagement with respective cables.

5. In a transportation system:
   a plurality of spaced, aligned support structures defining a path spanning adjacent structures; a train unit having a length equal to at least the distance between the pair of structures next adjacent to and on opposed sides of each structure respectively, said train unit having means maintaining the unit self-sustaining when the unit is supported either by two structures or by three structures; means carried by said train unit for mounting the latter on said supports for movement along said path, said structures being disposed for successively supporting said unit as the latter moves along said path, whereby the unit is at all times supported either by two structures or by three structures, said unit including a number of sections, said maintaining means being disposed between and interconnecting adjacent sections, said maintaining means including an assembly coupling each section with an adjacent section for lateral swinging movement relative thereto; and means coupled with each section for swinging the latter laterally in a predetermined direction in response to a change in said direction of said path as said unit moves therealong.
the unit is at all times supported either by two structures or by three structures, said unit including a number of sections, said maintaining means being disposed between and interconnecting adjacent sections, said maintaining means including an assembly coupling each section with an adjacent section for lateral swinging movement and for up-and-down swinging movement relative thereto; and means responsive to a change in direction of said path and coupled to each section for swinging the latter in said direction as said unit moves along said path.

11. In a transportation system as set forth in claim 10, wherein said swinging means includes a pair of parallel cables carried by said structures and extending along said path, an arm for each cable respectively, the arms being secured to a corresponding section and normally in engagement with respective cables, said arms being held against lateral movement and being mounted on said corresponding section for up-and-down movement responsive to elevation changes of said cable, and mechanism responsive to the pivotal movement of said arms for swinging the corresponding section relative to the section adjacent thereto.

12. In a transportation system:

an elongated vehicular unit having a succession of sections interconnected for swinging movement relatively about axes traversing the path of travel of said unit;

power means between the sections for swinging the same relatively about said axes;

a series of spaced supports for said unit arranged along said path and disposed for successive engagement by said sections as the unit travels therealong, said unit being at least as long as the distance defined by any three successive supports whereby, during said travel, the unit is alternatively carried by two supports and by three supports;

structure interconnecting the supports; and

mechanism on said sections in engagement with said structure, coupled with said power means, and responsive to changes in the elevation of said structure for controlling said power means.

13. The invention of claim 12:

said sections being interconnected for swinging movement relatively about upright axes; and

guide means on the sections engaging said structure for holding said unit against displacement laterally out of said path of travel.

14. The invention of claim 12:

and a power drive carried by each support respectively and successively engaged by said sections for advancing the unit along said path of travel.

15. The invention of claim 12:

primary suspension means for said unit including wheel means on each support respectively and runner means on each section respectively successively engangeable with said wheel means, said mechanism overlying said structure, presenting secondary suspension means for said unit as a safety measure in the event of failure of said primary suspension means.

16. The invention of claim 15:

and prime mover means driving each of said wheel means respectively for advancing the unit along said path of travel.

17. The invention of claim 16:

said sections being interconnected for swinging movement relatively about upright axes; and

guide means on the sections engaging said structure for holding said unit against displacement laterally out of said path of travel.

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