

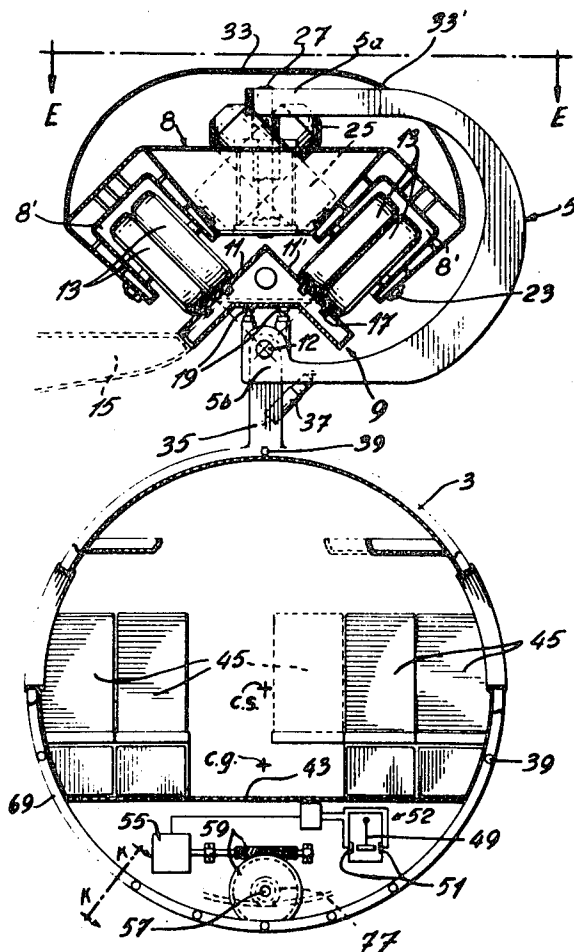
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[54] **SUSPENDED RAILWAY**
7 Claims, 14 Drawing Figs.

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101/101, 105/149, 105/150, 105/155, 105/164
[51] Int. Cl. **B61b 3/02,**
B61c 13/08, E01b 25/22
[50] Field of Search 104/89, 94,
95, 107, 120, 138; 105/148, 149, 150, 151, 152,
153, 154, 155, 156, 164, 199, 238

ABSTRACT: The present invention relates to a high-speed monorail suspension in which the car is carried within two rings pivotally suspended underneath two monorail carriages and in which the center of gravity of the monorail is automatically adjusted whenever the car is eccentrically loaded.



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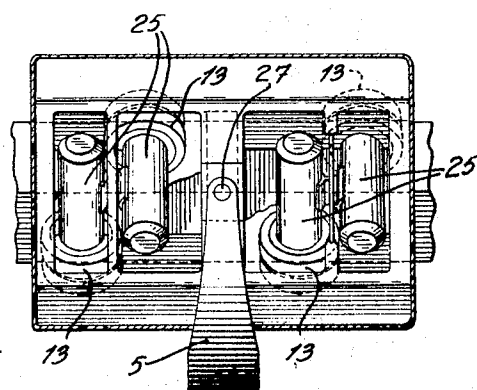
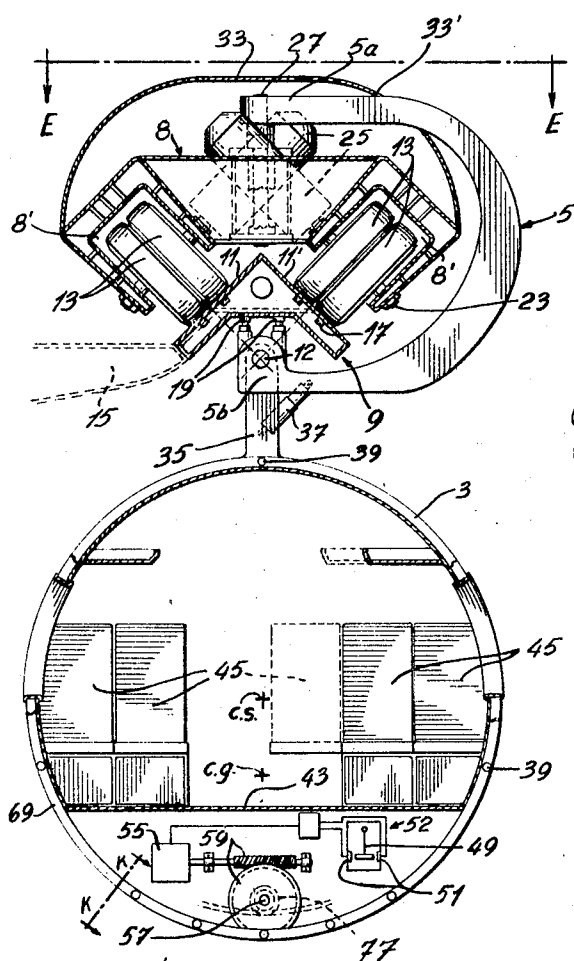
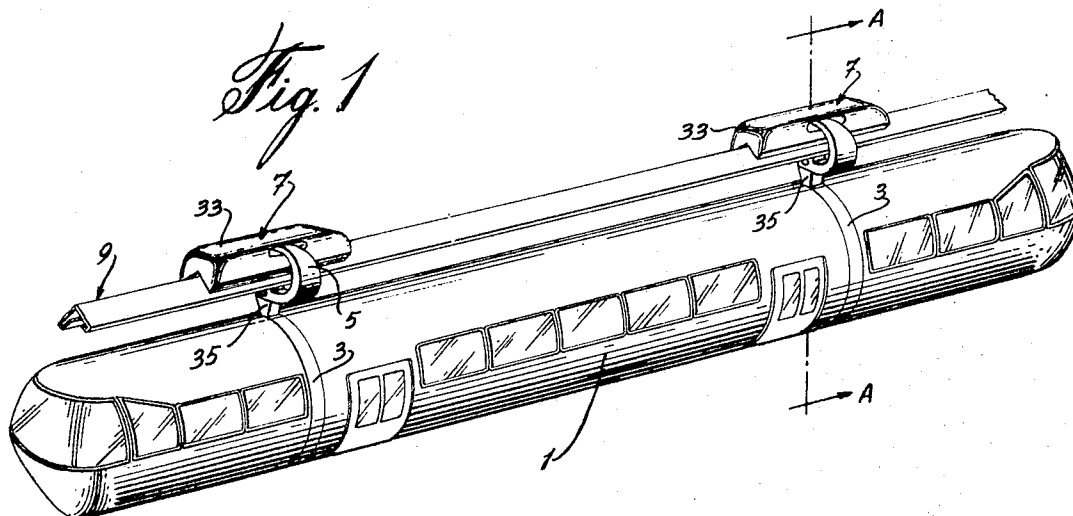


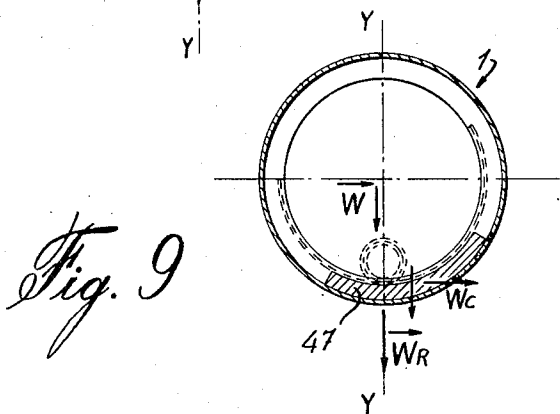
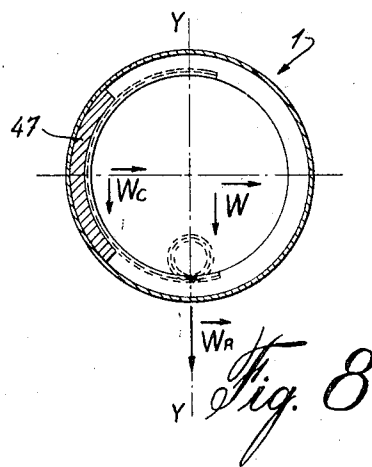
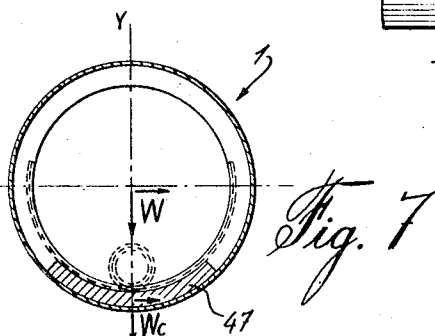
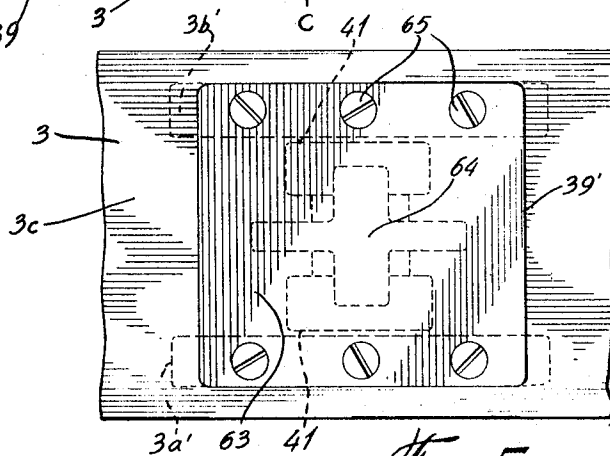
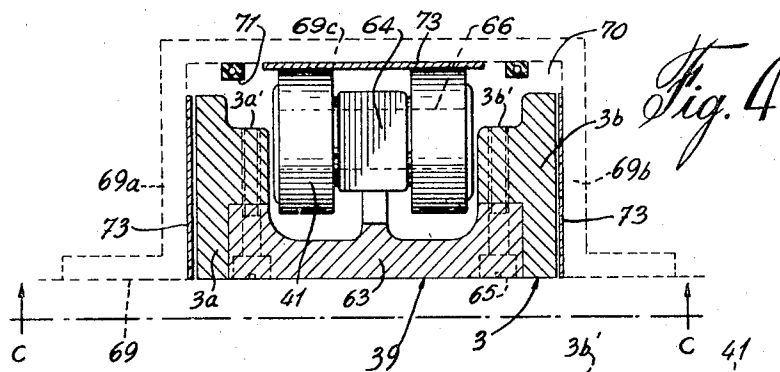
Fig. 3

Fig. 2

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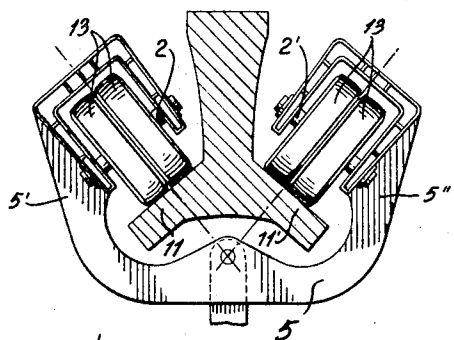
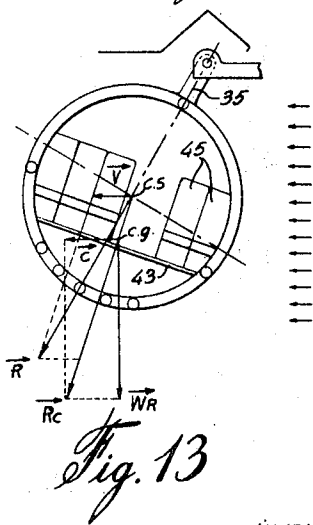
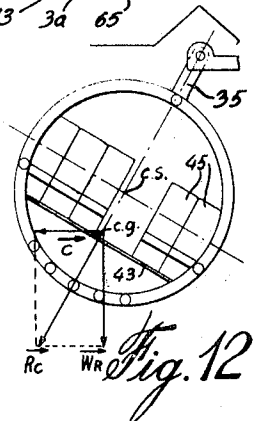
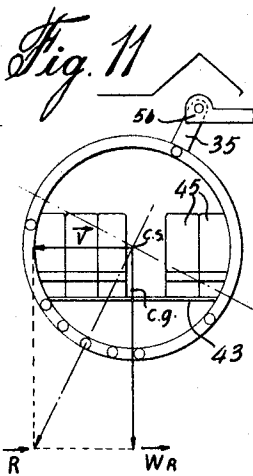
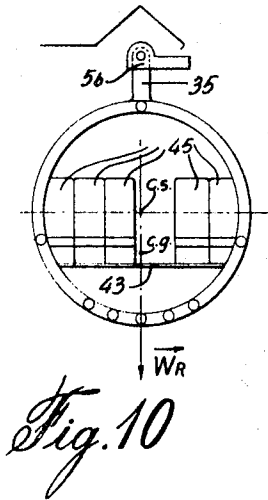
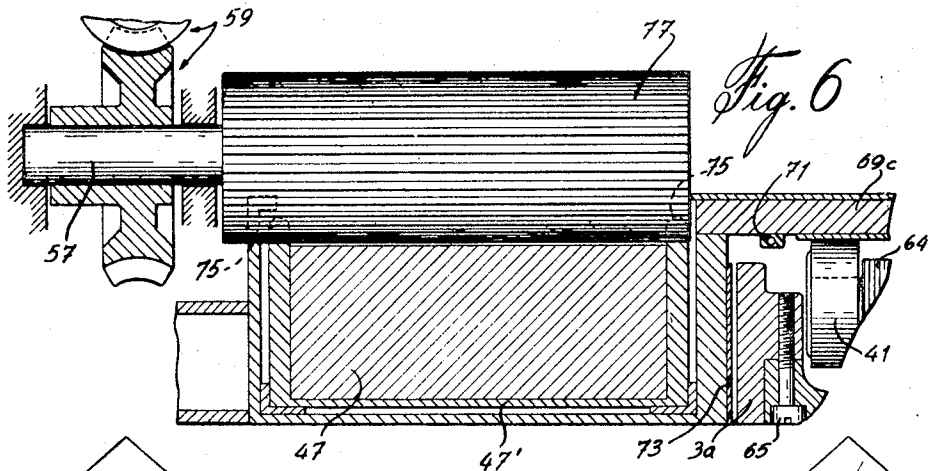


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SUSPENDED RAILWAY

The present invention generally relates to transportation by suspended monorail vehicles and more specifically to an improved assembly of self-balancing car suspension intended to provide greater comfort to the passengers as well as a more economical type of runway for monorail transportation.

Monorail transportation systems presently under study and, in some countries, in operation all have at least one of the following disadvantages with respect to their response to lateral wind action.

Some suspended railways are provided with means for pivotally suspending the vehicles either at the point of contact with the rail itself or at a pivot installed on the monorail carriage frame right below the runway but have no provision to prevent uncomfortable tilting of the passenger car under strong lateral winds resulting in discomfort to the passengers.

Such pivotally suspended vehicles also have a tendency to stay tilted when eccentrically loaded. If the car is brought back into straight position, some torsion is immediately applied to the carriage and runway requiring guide wheels and actually defeating the basic purpose of the pivotal suspension itself.

It is therefore one object of the invention to overcome the above disadvantages by providing an improved high-speed, all weather, monorail transportation system that will allow the use of simple monorail carriages without any provision for transmitting torsional loads resulting from eccentric lateral wind forces applied to the car below the runway.

Another object of the invention lies in the provision of such a monorail system using the economical runway and carriage design inherent to the pivotally suspended types of cars but without subjecting the passengers to uncomfortable tilting under strong lateral winds as has been the case so far with all pivotally suspended systems.

A still further object of the invention is to prevent pivotally suspended monorail vehicles to stay tilted when eccentrically loaded. This object is achieved, with the instant invention, without applying any torsion to the monorail carriages whereby the most economical, lightest and simplest designs of suspended monorail runways and carriages can be used.

The above-mentioned objects can be obtained with a monorail car transportation system according to the invention wherein there is provided, for each carriage, a suspension member connected to the carriage and extending beneath the runway. The car is formed with outwardly open fully circumferential recesses within which are received suspension rings and means between the rings and the car to allow free relative rotation between the rings and car. These rings are, in turn, pivotally connected to the suspension members below the runway whereby to allow swinging of the rings and car transversely of the runway so as to prevent rotation of the car about its longitudinal axis when it is acted upon by lateral winds.

In a preferred embodiment of the invention, the monorail car includes a gravity-type counterbalancing mechanism to overcome the effect of eccentric loading of the car, this mechanism comprising a counterweight mounted to be displaced along the periphery and transversely of the car with driving means to displace this counterweight, and a gravity position-control switch operatively connected to the driving means to cause its actuation and thus displacement of the counterweight when the car is eccentrically loaded.

In this preferred embodiment of the invention, the runway defines a pair of converging tracks merging into an apex and, for each carriage and suspension ring, the point of intersection of the rotation axes of the wheels, the pivotal axis of the ring, the point of connection of the suspension member to the carriage and the apex all substantially lie in a common vertical plane.

Other objects and advantages of the present invention will be apparent from the following detailed description and drawings, in which:

FIG. 1 is a perspective view of a monorail assembly according to the invention and showing the improved high speed suspension, car and runway system;

FIG. 2 is a cross-sectional view taken along a section A—A of FIG. 1 and illustrating in more details the overall suspension arrangement and suspended car;

FIG. 3 is a top view taken along section E—E of FIG. 2 with removed cover and showing the arrangement of electric drive means for the wheels as well as details of the suspension arrangement;

FIG. 4 is a cross-sectional view taken along a section K—K of FIG. 2 and illustrating in detail a roller unit disposed in the suspension ring;

FIG. 5 is a top view taken along a section C—C of FIG. 4 and shows a roller unit arranged in an opening in the suspension ring;

FIG. 6 is a cross-sectional view and illustrates the counterbalancing and roller system according to the invention and as incorporated in the monorail car;

FIG. 7 is a diagrammatic view of a section across the car illustrating the position of the counterweight when the car is evenly loaded;

FIG. 8 is a diagrammatic view similar to that of FIG. 7 but showing the counterweight when the car is overloaded to the maximum, on the right side;

FIG. 9 is a diagrammatic view similar to that of FIG. 7 but showing the counterweight when the car is slightly overloaded on the left side;

FIG. 10 is a diagrammatic view of a section across the car illustrating the position of the car on a straight run with no wind acting thereon;

FIG. 11 is a view similar to that of FIG. 10 with wind acting thereon;

FIG. 12 is a view similar to that of FIG. 10 with the car moving in a curve and being acted upon by centrifugal force;

FIG. 13 is a view similar to that of FIG. 12 with the wind also acting on the car;

FIG. 14 is a schematic view, illustrating an alternate embodiment of a suspension design according to the invention.

Referring now more specifically to FIG. 1, a monorail car 1 is suspended beneath an angular runway 9 by means of two suspension rings 3 circumscribing car 1 and each pivotally connected to the bottom of laterally extending bows 5 via two vertical lugs 35. The top of bows 5 is in turn connected to the top of a pair of motor carriages 7 sitting on angular runway 9 and provided for driving car 1. Runway 9 is preferably right-angular.

As shown in FIG. 2, the overhead angular runway 9 has downwardly slanting surfaces defining riding tracks 11, 11'. Rigidly secured to the lower end of one of the tracks 11 and opposite the suspension bow 5 is a bracket 15, shown in dotted lines, for supporting the runway 9. The motor carriages each comprise a housing frame 8 in which are mounted sets of wheels 13 and individual motors 25. As can be seen, frame 8 is formed with lateral openings 8' facing riding tracks 11, 11' and in each of which twin wheels 13 are mounted for rotation on shafts 23 the axes of which are parallel to the corresponding riding tracks 11, 11'. The sets of twin wheels 13 are individually driven by means of motors 25 coupled to shafts 23 and mounted on frame 8.

For esthetic as well as protective purposes, a cover 33 is removably secured over each frame 8, being provided with a suitable opening 33' for the entry of the top part of the corresponding suspension bow 5.

Wheels 13 are preferably provided with standard automobile tires or the like for smooth riding.

Power for energizing the drive motors 25 may be provided in any conventional manner such as through bus bar means 19 beneath runway 9 and bows 5.

Similarly, defrosting elements 17 for heating and defrosting tracks 11 and 11' may be arranged underneath the riding tracks 11, 11'.

Each bow 5 is connected to its motor carriage 7 by means of a kingpin 27 vertically extending through a suitable vertical opening across the upper end 5a of bow 5, kingpin 27 being received in an appropriate bearing in the frame 8. Similarly,

the lower end 5b of bow 5 may be formed as a fork for the reception of upward lug 35 of ring 3, a pivot pin 12 successively extending through the two sides of the forked end and through the upward lug 35.

It is to be noted that the vertical axis of kingpin 27, the horizontal axes of pivot pin 12 and the point of intersection of the rotating axes of wheels 13 all lie in a vertical plane extending through the apex of the angular runway 9.

As mentioned previously, the lower end of lug 35 is rigidly connected to a ring 3. The body 69 of car 1 is mounted inside rings 3 in such a manner that free rotation of the said rings 3 is allowed in relation to the car body 69. Preferably, rings 3 are inserted in recesses 70 (FIG. 4), formed around car body 69, so that the outer surface thereof be flush with the outer surface of the car body.

A series of roller units 39 are mounted inside rings 3 (see FIG. 4) to allow free relative rotation between the said rings 3 and the car body 69. As noted from FIG. 2, and as is always the case in public transportation vehicles, particularly when loaded, the center of gravity C.G. lies below the geometrical center of the vehicle or the center of suspension C.S. of rings 3 of the system under consideration. Under these conditions, when car 1 is acted upon by wind forces tending to shift it laterally in relation to pivots 12, the rings 3 will roll over car 1 so that the center of gravity C.G. and the center of suspension C.S. will always be along a vertical and floor 43 will remain horizontal.

A gravity-type counterbalancing mechanism is preferably provided in order to stabilize car 1 when passengers are moving in and out or when the car is otherwise eccentrically loaded. This mechanism comprises a counterweight 47 (FIG. 6) freely movable in relation to car body 69 and outside suspension rings 3. Its purpose is to retain the center of gravity C.G. and the center of suspension C.S. in vertical alignment when the car is eccentrically loaded as when people are getting on and off the car or when more people are sitting on one side thereof than the other. The counterbalancing mechanism further comprises a gravity position control switch mounted in a box 52 and provided with two contacts 51. Under the action of an eccentric load in the car, a pendulum 49 touches one of the two contacts 51 to close the switch which actuates a motor 55 which, in turn, causes rotation of an output shaft 57 through a worm reducer 59. Shaft 57 is connected to a pinion 77 (FIG. 6) that drives the counterweight 47. The arrangement is such, of course, that the counterweight is driven on the side of the car 1 opposite the side which is overloaded.

Now for a detailed description of the suspension ring 3 and the roller unit 39 illustrated in FIGS. 4 and 5.

Each suspension ring 3 is a channel-shaped flanged member having a pair of parallel inwardly directed radial flanges 3a, 3b and a web 3c interconnecting the lateral flanges. Web 3c is formed with a plurality of evenly spaced openings 39' and flanges 3a and 3b are each formed with shoulders 3a', 3b' respectively facing one another across openings 39'.

Each roller unit is formed with a base plate 63 intended to close the opening 39' into which it is received and about the outer faces of the corresponding shoulders 3a', 3b'. It is secured to the said shoulders by any convenient means such as screws 65. Centrally of base plate 63 is a projection 64 across which extends a shaft 66 on which the rollers 41 are mounted. As previously mentioned, each assembly of suspension ring 3 and roller units 39 is received into a rectangular recess 70 formed by walls 69a, 69b, 69c of the car body 69. Wear plates 73 may be provided at suitable locations to prevent damage to the recess walls 69a, b and c. In addition, defrosting elements 71 may be provided at the bottom of the recess 70.

A similar recess may be formed inwardly of the car body and peripherally thereof for the displacement of the previously mentioned counterweight 47, as shown in FIG. 6. Counterweight 47 may lie in a casing 47' having, along the upper periphery thereof, a series of gear teeth 75 engageable with the previously mentioned pinion 77 which is driven by the

counterbalancing mechanism illustrated in FIG. 2 and described above.

With reference to the counterbalancing mechanism, it is to be noted that it is not essential that it be provided on all passenger cars since some passenger cars may have sufficient inertia to provide adequate stability. The counterbalancing mechanism is recommended in the lighter type of passenger cars.

In order to dampen any oscillations of car 1 as rings 3 swing transversely of the runway 9 it is suggested that hydraulic pneumatic cylinders 37 be provided between lug 35 and the adjacent end of bow 5, as shown in FIG. 2.

FIGS. 7, 8 and 9 are schematic views showing the different deflection positions of the counterweight 47 as applicable when the car 1 inside the suspension rings 3 is eccentrically loaded. In these illustrations:

$\vec{W}$ = the weight of the loaded car

$\vec{W}_c$ = the weight of the counter-weight

$\vec{W}_R$ = the resultant of the weights.

In FIG. 7 it can be seen that the counterweight 47 is located in the lower central part of the car 1 when the weight $\vec{W}$ of the loaded car 1 which is equal to $\vec{W} = \vec{W}_R - \vec{W}_c$ is on the axis Y—Y.

In FIG. 8 it can be seen that the counterweight 47 has moved to the left side of the axis Y—Y because the car 1 is overloaded on the right side of the axis Y—Y; the resultant $\vec{W}_R$ of the weights remains on the axis Y—Y.

FIG. 9 illustrates the same counterweight correction in the case where overloading is slightly on the left side of axis Y—Y.

It is to be noted that, in most of passenger cars, the ratio of dead and live loads as well as the maximum possible live load eccentricity are such that the above optional counterweight arrangement will not be necessary, because the necessity for improvement in comfort will be negligible.

FIGS. 10, 11, 12 and 13 are schematic views showing operation of the system, under combined centrifugal and wind action, wherein:

$\vec{V}$ = wind force

$\vec{C}$ = centrifugal force

$\vec{R}_c$ = resultant of $\vec{C}$ + $\vec{W}_R$

$\vec{R}$ = resultant of the forces.

On a straight run without lateral winds (FIG. 10) the vertical lug 35 remains vertical and the floor 43 and the seats 45 of the car 1 remain horizontal because the center of gravity C.G. of the car 1 is below the center of the suspension ring C.S.

On this straight run with lateral wind action (FIG. 11) the horizontal force $\vec{V}$, representing the wind action combined with the weight $\vec{W}_R$ of the car 1 ($\vec{W}_R$ being the resultant of the weights of the loaded car and the counterweight: $\vec{W}_R = \vec{W} + \vec{W}_c$). This simply means that in this present case the car is provided with a counterweight) will give a resultant force $\vec{R}$ which in turn will determine an inclined position of the vertical lug 35. The floor 43 and the seats 45 of the car 1 will however remain horizontal because of the roller units 39 and the fact that the center of gravity C.G. of the car 1 always remains below the center C.S. of the suspension ring 3 and the resulting wind action does not have any tendency to rotate the car 1.

In the case of a centrifugal force $\vec{C}$ combined with the weight $\vec{W}_R$ of the car 1 (FIG. 12), the resultant force $\vec{R}_c$ keeps the floor 43 and the seats 45 of the car 1 perpendicular to the vertical lug 35, and this position is retained because the resultant force $\vec{R}_c$ acts at the center of gravity C.G. of the carriage 1 which is below the center C.S. of the suspension ring 3.

Any curve that would limit the speed of a conventional rigidly guided, monorail to 50 mph on account of passengers comfort could be taken, with the system of this invention, at speeds exceeding 100 mph without any discomfort.

Under combined centrifugal force $\bar{C}$ and wind action $\bar{V}$ (FIG. 13), the resultant $\bar{R}_c$ will position the car floor 43 and seats 45 so that the passengers will not be subjected to any lateral forces and overall resultant force $\bar{R}$ combining $\bar{R}_c$ and the wing action $\bar{V}$ will bring the lug 35 and the suspension ring 3 in a position in which the car 1 can receive a resultant force $\bar{R}$ without torsional effects applied to it.

FIG. 14 illustrates an alternate embodiment of a runway arrangement and suspension design according to the invention with the suspension bow 5 extending underneath the runway 9 and its two free outer ends 5' and 5'' extending upwardly and sideways of the tracks 11 and 11'. As can be seen, the wheels 13 in this particular embodiment are connected in pairs to these outer ends 5' and 5'' of the suspension bow 5 by means of axles 2 and 2'.

We claim:

1. In a monorail car transportation system including an overhead runway and carriages to ride on said runway, the combination therewith comprising:

- a. for each carriage, a suspension member connected thereto and extending beneath said runway;
- b. a car formed with outwardly open fully circumferential recesses;
- c. suspension rings mounted in said recesses with means between said rings and car to allow free relative rotation between said rings and car; and
- d. means to pivotally connect said rings at one point along the periphery thereof and said suspension members below said runway to allow swinging of said rings transversely of said runway, whereby to prevent rotation of said car about the longitudinal axis thereof when acted upon by lateral winds causing said car and rings to swing transversely of said runway.

2. A combination as claimed in claim 1 wherein said runway defines a pair of converging tracks merging into an apex and said carriages include wheels to ride on said converging tracks and wherein, for each carriage and suspension ring, the point of intersection of the rotation axes of said wheels, the pivotal axis of said ring, the point of connection of said suspension member to said carriage and said apex all substantially lie in a common vertical plane.

3. A combination as claimed in claim 2, wherein said wheels are individually motorized and the motors thereof are mounted on said carriages.

4. A combination as claimed in claim 2, wherein said suspension members each are shaped as a laterally extending bow having the top end thereof secured to the top of the corresponding carriage and the lower end extending beneath said runway.

5. A combination as claimed in claim 2, wherein said suspension members each are shaped as an upright U with the lateral branches thereof connected to said carriage and the center of the upright thereof lying beneath said runway.

6. A combination as claimed in claim 1 including a gravity-type counterbalancing means comprising:

- a counterweight mounted to be displaced along the periphery and transversely of said car;
- driving means to displace said counterweight transversely of said car, and
- a gravity position-control switch operatively connected to said driving means to cause actuation thereof and displacement of said counterweight when said car is eccentrically loaded.

7. A combination as claimed in claim 1 wherein said means between said rings and car to allow free relative rotation therebetween is a series of roller units secured to and along said rings with the rollers thereof projecting inwardly to be applied against the bottom of said car's circumferential recesses.

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