

Sept. 28, 1971

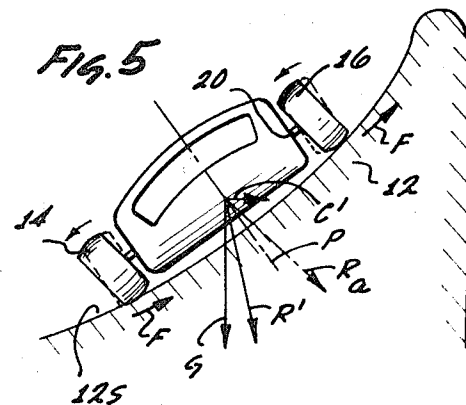
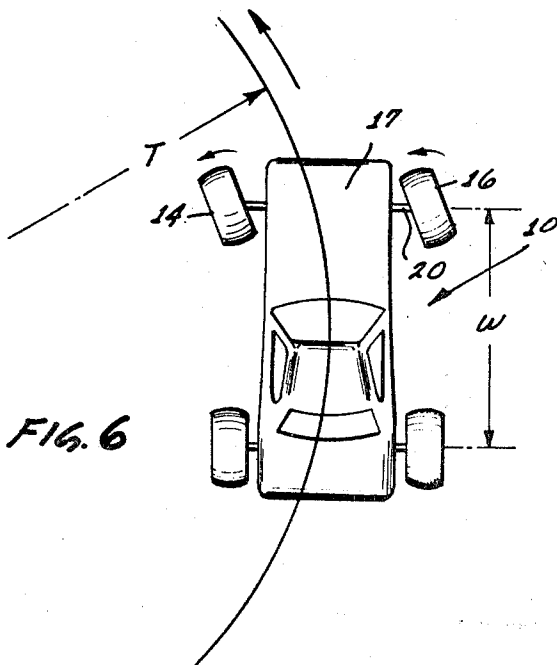
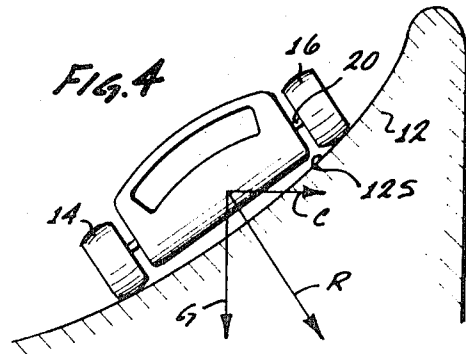
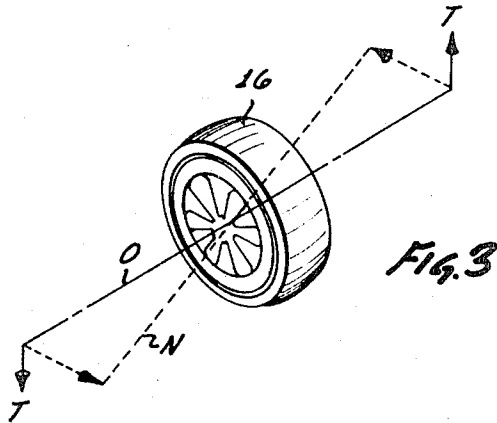
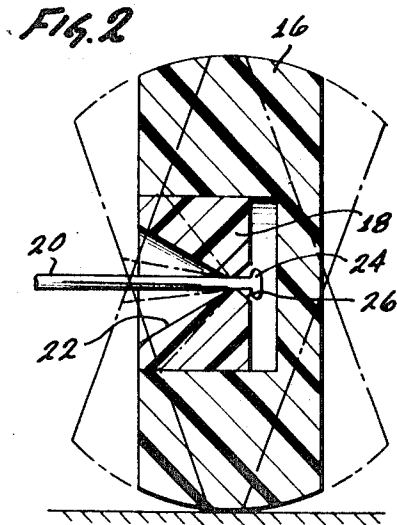
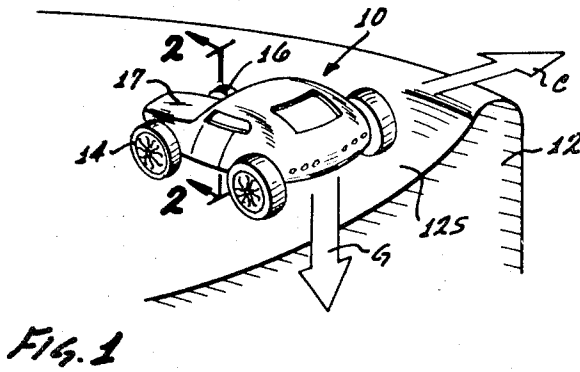
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3,608,236

STEERABLE TOY VEHICLE

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

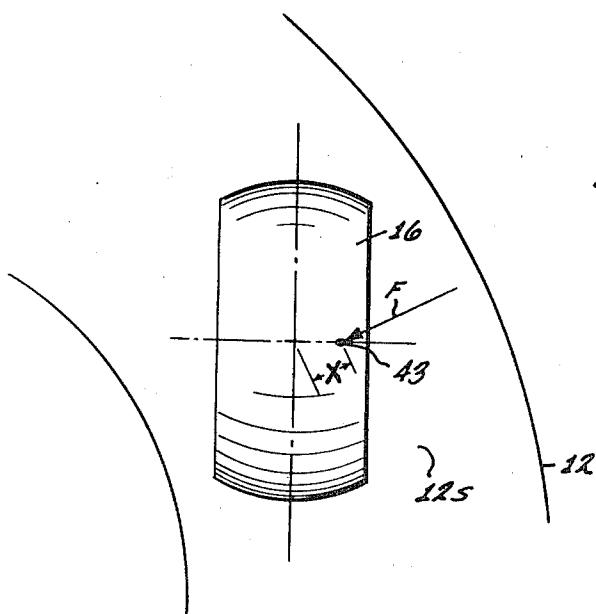


FIG. 7

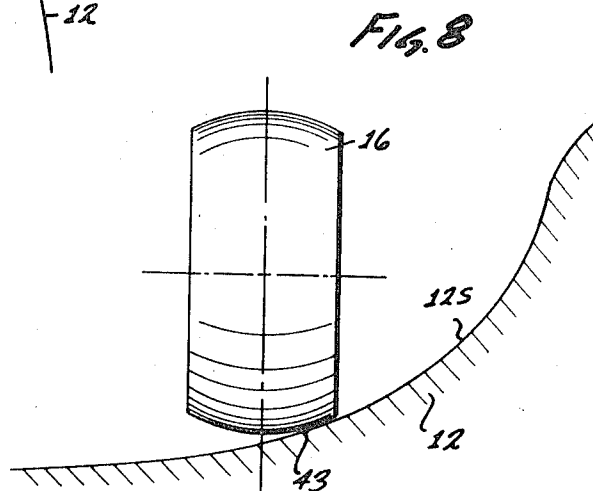


FIG. 8

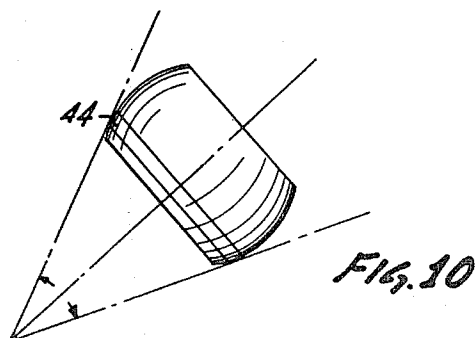


FIG. 10

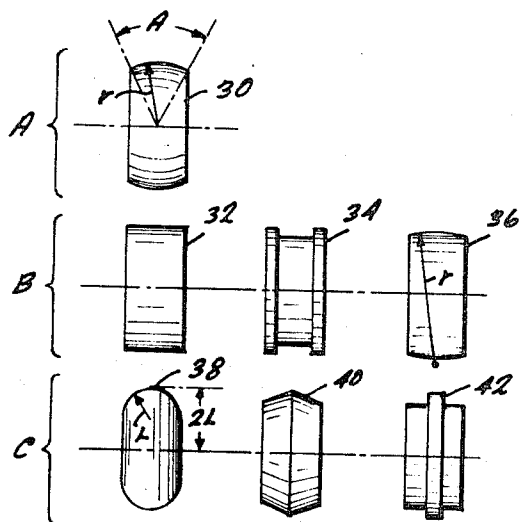


FIG. 9

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STEERABLE TOY VEHICLE

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6 Claims

ABSTRACT OF THE DISCLOSURE

A toy vehicle with front wheels that tend to steer it around banked curves, wherein the wheels are rotatably mounted on their axle in a manner to permit wobbling of the wheels by up to about 20° from the straight-away direction.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to toy vehicles.

(2) Description of the prior art

Toy vehicles generally have a front axle and wheels rotatably mounted on the axle to carry the vehicle straight ahead. Such a vehicle tends to move straight ahead even on banked curves, and may climb the embankment or spin out of control. Simple means that would tend to steer the vehicle around such curves could not only prevent the vehicle from running off the track or spinning out of control, in many instances, but could also reduce sideward sliding or scrubbing that results in friction which considerably slows the vehicle.

OBJECTS AND SUMMARY OF THE INVENTION

An object of the present invention is to provide a toy vehicle which can better negotiate banked curves.

Another object is to provide a toy vehicle that automatically steers itself into and out of banked curves.

In accordance with the present invention, a toy vehicle is provided in which the front wheels are mounted on their axle to permit them to steer toward the right or left. When the vehicle enters a banked curve at a substantial speed, the banking causes the vehicle to tilt and the axis of wheel rotation to tilt from the horizontal to an angle from the horizontal. For steep banking and moderately low vehicle speeds, torques may be applied to tilt the wheel even more than the vehicle body. Gyroscopic precession causes the wheel to also steer toward the right or left, to lead the wheel around the banked curve.

In one embodiment of the invention, the wheels have tread portions which are rounded, with a radius of curvature equal to the radius of the wheel. The rounding makes the wheel sensitive to small precessing forces (low speed or only slight banking), yet relatively stable.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a vehicle and track section in accordance with the invention;

FIG. 2 is a sectional view of a front wheel of the vehicle of FIG. 1, taken on the line 2—2 thereof;

FIG. 3 is a diagram indicating the forces acting on a front wheel of the vehicle of FIG. 1 when negotiating a banked curve;

FIG. 4 is a rear view of the vehicle of FIG. 1, showing the forces thereon at a particular relationship of speed, banking angle, and radius of track curvature;

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FIG. 5 is a view similar to that of FIG. 4, but for a different relationship of speed, banking angle, and radius of curvature;

FIG. 6 is a plan view of the vehicle of FIG. 1;

FIG. 7 is a plan view of a front wheel of the vehicle of FIG. 1, showing the shift in point of contact with the track at a banked curve;

FIG. 8 is a rear view of the wheel of FIG. 7;

FIG. 9 is a plan view of three series of wheels with different tread forms; and

FIG. 10 is a rear elevation view of a front wheel of the vehicle of FIG. 1, showing the manner of negotiating a banked curve at a slow speed.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates a toy vehicle 10 moving around a curved track section 12 which is banked, the banking angle increasing at peripheral portions of the track. The illustrated vehicle is an unpowered type which initially moves down a long incline and thereafter coasts around the track, although this invention can be applied to a powered vehicle. The vehicle has front wheels 14, 16 which are mounted on the vehicle body 17 to enable them to steer around curves. As shown in FIG. 2, wheel 16 has a bearing 18 for coupling it to a front wheel shaft or axle 20 on the vehicle. The bearing has a conical bearing aperture 22 that allows the wheel to pivot up to about 20° in any direction with respect to the shaft, while the wheel rotates. The shaft has an enlarged end 24 for holding the wheel thereon, and the bearing aperture has a small conical outer portion 26 which can receive the enlarged shaft end. The "wobble" mounting of the wheel 16 enables it to steer around curves, and the wheel tends to automatically steer around banked curves.

As the vehicle moves on the banked curve, a gravity force G and centrifugal force C act on it. FIG. 4 illustrates the gravity force G, centrifugal force C and the resultant R of these forces. If the resultant R is perpendicular to the track surface 12S, the vehicle will be in equilibrium and the wheels will rotate on an axis coincident with the axis of axle 20. However, for a lower vehicle velocity, represented in FIG. 5, the resultant R' of the gravity force G and reduced centrifugal force C' is not parallel to a perpendicular P to the track surface. This will result in sideward frictional forces F on the wheels 14, 16. The sideward frictional forces F on the wheels 14, 16 establishes a torque that tends to tilt them. Since the wheels are rotating, they react to the tilting force like a gyroscope by precessing or steering to the left in FIG. 5. The diagram of FIG. 3 shows the tilting forces T applied to the wheel 16 and the manner of its gyroscopic precession from original axis O to a new axis of rotation N. As a result of the precession, the wheels steer around the curve in the track by turning to the left, as shown in FIG. 6.

On sharp turns and/or at high velocities, the resultant of the gravity and centrifugal forces will lie outside a perpendicular to the curve surface on which the vehicle is running, i.e., at an orientation such as R_a in FIG. 5. In that case, the wheels will be tilted so that they precess in the opposite direction, and they will steer toward the outside of the curve. However, the curved track section 12 has a steeper banking angle near its outer periphery. When the vehicle reaches a position at the outer area, where the resultant of its centrifugal and gravity forces lie within the perpendicular to the outer track surface, the wheels will then turn to steer around the curve.

The precessional steering torque applied to the vehicle depends upon the mass of the front wheels, so that heavier front wheels provide increased precessional steering around curves. Actually, although a heavier wheel will be subjected to a greater precessional torque, this is offset by

the greater resistance to steering of a heavier wheel. Thus, if a heavy wheel and a light wheel are rolled onto a banked curve at the same speed, they will take the same path. However, as the mass of the front wheels increases as a proportion of the entire weight of the vehicle, it effects a greater control over steering. While the mass of each of the front wheels heretofore has typically been less than one-twentieth the mass of the entire vehicle, a mass of each front wheel of more than one-tenth that of the entire vehicle will give better steering around banked curves for vehicles constructed in accordance with this invention. As compared with conventional toy vehicles wherein the front and rear wheels are generally of the same mass, the front wheels hereof preferably have a mass which is greater than the mass of the rear wheels, and preferably at least twice as great.

The shape of the wheel tread affects the sensitivity to precessional steering and the stability of the wheel in returning to a straight-ahead direction. Various tread shapes shown in FIG. 9 have been tried, and the tread shown in Group A at 30 have been found most satisfactory, in providing both necessary sensitivity and stability. This tread is convex, with a radius of curvature r which is approximately equal to the radius of the wheel. The tread extends over an angle A which should be at least equal to the maximum angle of tilting of the wheel on its axis, which is $\pm 20^\circ$ from a neutral position. The particular angle A which was employed was about 50° . The treads on wheels 32, 34 and 36 in Group B of FIG. 9 were found to be too stable, and hence insensitive to small precessing force. The tread on wheel 36 is similar to that on wheel 30 except that it has a radius of curvature m that is greater than the diameter of the wheel. On short, high speed turns, these wheels 32, 34 and 36 are very effective in steering around the curve. However, they generally take too long to regain a flat footing. The treads on wheels 38, 40 and 42 in Group C were found to be too unstable on both straight-away and curved track sections. The tread on wheel 38 is similar to that on wheel 30 except that it has a radius of curvature L which is only one-half the radius of the wheel.

The angle over which the wheels can steer can also affect stability. An angle of $\pm 20^\circ$ from the neutral or straight-ahead position has been found satisfactory for turning around sharp turns, while retaining stability. Steering angles of more than about $\pm 20^\circ$ cause excessive wheel wobble on uneven surfaces.

As shown in FIGS. 7 and 8, the point of contact 42 of the wheel 16 on the track, shifts as the wheel enters a banked turn. The shift is from the center of rotation of the wheel, as viewed from above in FIG. 7, toward the the outside of the turn, by the distance X . This results in the track reaction or sideward frictional force F imparting a torque F times X to the wheel. This torque tends to steer the wheel toward the outside of the curve, which is opposite to the desired direction of steering. However, the shift distance X is small so the effect is relatively small. A smaller radius tread would reduce the shift distance, but would tend to make the wheel unstable, as discussed above.

The minimum turning radius of a vehicle is governed by the wheel base W , shown in FIG. 6, and also by the maximum angle at which the wheels can turn relative to the vehicle body. This radius T is given by $T=W/\text{steering angle}$ for the inside wheel. For a wheel base W of 1.65 inches and a steering angle of 20° (0.35 radian), this yields a turning radius of 4.53 inches. For a sharply banked turn, the turning radius is much less as viewed from above.

While precession steering is effective only at moderate or high speeds, the "wobble" mounting allows steering around banked curves even at low speeds. At low speeds on a banked curve, the front wheels will lean over as far as they can, as shown in FIG. 10. The wheels then

roll on a substantially conical portion 44 of their surface and direct the vehicle around the curve.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art, and consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. A toy vehicle comprising:

vehicle body means having forward and rearward portions;

rear wheel means mounted on said vehicle body means; a front wheel having a conically shaped bearing hole at its center; and

front axle means mounted on said vehicle body means forward of said rear wheel means, said axle means including a rod projecting through said conically shaped bearing hole of said wheel to rotatably mount it in a manner for allowing free pivoting of its axis of rotation within predetermined limits to permit precessional steering on banked turns.

2. A toy vehicle comprising:

vehicle body means having forward and rearward portions;

rear wheel means mounted on said vehicle body means; front axle means mounted on said vehicle body means forward of said rear wheel means; and

a front wheel rotatably mounted on said axle means, said front wheel having a conically shaped bearing hole at its center, said hole subtending an angle on the order of 40° at a cross-section thereof, to permit precessional wheel steering of on the order of $\pm 20^\circ$ from a straight-ahead direction.

3. A toy vehicle comprising:

a vehicle body with forward and rearward ends;

a pair of axles mounted on said body, one forward of the other;

a first pair of wheels rotatably mounted on a first of said axles; and

a second pair of wheels mounted on opposite ends of a second of said axles, each of said second wheels having a central aperture with a narrow diameter portion closely encompassing said axle and a relieved portion extending at an acute angle from said narrow diameter portion to permit steerable turning of said wheel on said axle.

4. The toy vehicle described in claim 3 wherein:

each of said second wheels has a tread which is convexly rounded with a radius of curvature approximately equal to the radius of said wheel.

5. A toy vehicle comprising:

a vehicle body having forward and rearward end portions;

first wheel means mounted at one end portion of said vehicle body;

axle means mounted at the end portion of said vehicle body which is opposite said first wheel means; and

a wheel rotatably mounted on said axle means in a manner for allowing pivoting of its axis of rotation within predetermined limits, free of both rigid and resilient restraints from the rest of said vehicle within said limits, whereby to permit precessional steering on banked turns.

6. A toy vehicle comprising:

a vehicle body having forward and rearward end portions;

at least a first wheel rotatably mounted at one end portion of said vehicle body;

an axle mounted on the end portion of said vehicle body opposite said first wheel; and

a pair of second wheels rotatably mounted at opposite ends of said axle, each of said second wheels mounted on said axle in a manner for allowing free

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pivoting of its axis of rotation within predetermined limits, whereby to permit precessional steering on banked turns.

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3,264,780 8/1966 Doe ----- 46—221
3,343,793 9/1967 Waser ----- 46—202

References Cited

UNITED STATES PATENTS

2,994,545 8/1961 Gass ----- 301—1
3,206,890 9/1965 Freyermuth ----- 46—202

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U.S. Cl. X.R.

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