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(54) Railroad vehicle.

(57) A railroad vehicle in which power is transmitted by a right angle cardan system and the body (1) of which is inclined by a natural pendulum system. In a construction based on a right angle cardan system in which the axis of an output shaft (4S) extends in the longitudinal direction of the vehicle, two prime movers (4) are mounted on one vehicle body in the vicinity of the centre thereof so as to face in the opposite directions, or one prime mover (4) having a pair of output shafts (4S) disposed at its opposite ends is mounted on the vehicle body generally at the centre thereof, and power is transmitted from each output shaft (4S) to the corresponding one of axles (10) disposed at longitudinal ends of the vehicle through a propeller shaft (3). The pair of propeller shafts (3) are rotated in opposite directions by the corresponding output shafts (4S), thereby cancelling the reaction torques produced when the output shafts (4S) rotate with equal torques. There is therefore no possibility of the vehicle body being forcibly inclined. It is therefore possible to smoothly incline

the vehicle body by the natural pendulum effect.

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Railroad Vehicle

This invention relates to a railroad vehicle and, more particularly, to a railroad vehicle in which motive power is transmitted by a right angle cardan system, and the body of which is inclined by a natural pendulum system.

When the speed of a railroad vehicle is high as it travels along a curve, it is desirable to prevent any centrifugal force from acting on passengers and making them feel uncomfortable as a result of lack of rail cant. For this reason, a vehicle body inclining system is known based on a natural pendulum system in which the vehicle body is inclined by the centrifugal force to provide a natural balance. Such a system has already been adopted for 381-system express trains run by electricity in Japan, resulting in achievement of the desired effects. For this type of vehicle, a parallel cardan system in which the main motor is incorporated in a truck is adopted as a power transmission system. In the parallel cardan system, the vehicle body is not forcibly inclined by the reaction torque of the driving torque of the main motor.

However, many railcars in the world have diesel engines disposed under the floors of the vehicles and make use of the right angle cardan system in which power is transmitted through a propeller shaft at right angles to wheels incorporated in a truck at one end of the vehicle.

In this system, the axis of the output shaft of the diesel engine extends in the longitudinal direction of the vehicle. The vehicle body is therefore forcibly inclined by the reaction torque of the driving torque produced by the diesel engine. For this reason, no vehicle based on the right angle cardan system has been designed in which the vehicle body is inclined by a natural pendulum system.

For example, a 391-type natural pendulum railcar for three-unit trains was made on an experimental basis using a gas turbine engine. In this railcar, front and rear units connected to a central motive power unit were of pendulum type, but the motive power unit in which the gas turbine was mounted was designed as a non-pendulum type. As a result, the desired objects, including those relating to other factors, were not achieved and no practical vehicle of the desired type has been developed.

However, the need to speed-up railroad transportation in non-electrified sections has become more stringent. Development of the technology for high-speed railcars is therefore needed whereby vehicle body inclination based on a natural pendulum system may be realized.

According to the present invention there is provided a railroad vehicle comprising a vehicle

body inclined by a natural pendulum system, a pair of trucks respectively disposed at longitudinally opposed ends of said vehicle, each said truck having an axle and a pair of drive wheels, and each said pair of drive wheels being driven by a respective output shaft from a prime mover disposed in the vicinity of the centre of said vehicle, said output shafts extending longitudinally of said vehicle and being caused to rotate with equal output torques in opposite directions, whereby reaction torques produced in response to said output torques are cancelled and the possibility of any forced inclination of the vehicle body due to such reaction torques is substantially eliminated.

By means of this arrangement there is provided a vehicle construction whereby, even in the case of a railcar having a prime mover disposed on the vehicle body side and having a power transmission system based on the right angle cardan system, the vehicle body can be inclined by a natural pendulum system while eliminating the possibility of the vehicle body being forcibly inclined at the time of transmission of the power of the prime mover, thereby enabling development of a high-speed vehicle or rail car.

In one embodiment a pair of prime movers having the same performance are mounted on the vehicle body in the vicinity of the centre thereof so as to face in the opposite directions with their respective output shafts facing respective axles and drive wheels.

In another embodiment a single prime mover may be provided having a pair of output shafts disposed at its opposite ends, the prime mover being mounted on the vehicle body in the vicinity of the centre thereof.

In a preferred arrangement the output torque is transmitted from the output shafts to the axles by respective propeller shafts. Preferably each propeller shaft includes an expansion section formed from mutually engaging splined portions. It is particularly preferred that these splined portion be provided with friction reducing means such as ball bearings or a coating of low friction material. This limits the likelihood of any friction induced forces that may undesirably incline the vehicle body.

Some embodiments of the present invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Figs. 1 to 3 show a natural pendulum railroad vehicle based on a right angle cardan system which vehicle represents a first embodiment of the present invention;

Fig. 1 is a side view of a vehicle illustrating the relationship between the placement of prime

movers and the directions of rotation of propeller shafts;

Fig. 2 is a plan view of the vehicle of Fig. 1 illustrating in particular the relationship between the arrangement of the propeller shafts and gears in speed reducers and the direction in which the vehicle travels;

Fig. 3 is an end view of a natural pendulum vehicle;

Figs. 4 and 5 show a second embodiment of the present invention;

Fig. 4 is a side view corresponding to Fig. 1;

Fig. 5 is a plan view corresponding to Fig. 2;

Fig. 6 is a partially sectional view of a propeller shaft of the natural pendulum vehicle in accordance with an embodiment of the present invention;

Fig. 7 is a cross-sectional view taken along the line III - III of Fig. 6; and

Fig. 8 is a partially sectional perspective view of another example of the propeller shaft.

A first embodiment of the present invention will be described below with reference to Figs. 1 to 3.

Figs. 1 to 3 are diagrams of the basic construction of a natural pendulum railroad vehicle based on a right angle cardan system.

The railroad vehicle of this embodiment comprises a two-shaft bogie and has a two-prime-mover system in which a pair of trucks has power shafts disposed coaxially with each other on their inner sides alone.

As shown in Fig. 3, a vehicle body 1 is provided with pendulum beams 12 with bolster springs 11 interposed between the vehicle body 1 and the pendulum beams 12.

Pendulum rollers 2 are disposed on trucks 13, and the pendulum beams 12 are supported on the pendulum rollers 2, thereby enabling the vehicle body to be inclined about the centre 8 of pendulum rotation. A reference character 9 denotes the vehicle inclination angle.

As shown in Figs. 1 and 2, a pair of prime movers 4 are mounted to a bottom portion of the vehicle body 1 in the vicinity of the centre thereof, and each prime mover 4 has an output shaft 4S extending in the longitudinal direction of the vehicle body.

Ordinarily, the prime mover 4 is an internal combustion engine, but it may be an electric motor, or any type of engine.

In this example, the pair of prime movers 4, having substantially the same outputs and having the same performance, are oppositely disposed in the vicinity of the centre of the vehicle and are controlled to produce equal power outputs at all times. The output shafts 4S are connected to propeller shafts 3 to rotate the shafts 3 in a rotational direction 5 and a direction 6 opposite to the direc-

tion 5, respectively.

The power of each prime mover 4 is transmitted from the output shaft 4S to an axle 10 via propeller shaft 3 and a speed reducer 7.

The axle 10 carries a pair of driving wheels 15.

The speed reducers 7 include bevel gears disposed on the axles and engaging bevel gears operatively connected to the propeller shafts. The bevel gears are so arranged that both pairs of drive wheels rotate in the same direction to move the vehicle in one direction, e.g., the direction of the arrow D, when the propeller shafts 3 are rotated in the directions 5 and 6 opposite to each other. To this end the gears on axles 10 face in the same direction as each other, whereas the propeller shaft gears face in opposite directions.

In this embodiment, two prime movers 4 having the same performance are provided on one vehicle, and the propeller shafts 3 are respectively rotated by the prime movers 4 in the opposite directions, thereby cancelling reaction torques produced when the prime movers 4 rotate with equal powers.

There is therefore no possibility of the vehicle body 1 being forcibly inclined by any reaction torque. In consequence, the vehicle body can be smoothly inclined by the natural pendulum effect.

A second embodiment of the present invention will be described below with reference to Figs. 4 and 5.

The embodiment shown in Figs. 4 and 5 is based on a single prime mover system.

A prime mover 4 disposed generally at the centre of the vehicle has a pair of output shafts 4S extending toward the front and rear ends of the vehicle, respectively. The output shafts 4S are connected to propeller shafts 3 to rotate the propeller shafts 3 in a rotational direction 5 and a direction 6 opposite to the direction 5, respectively. The power is transmitted from each output shaft 4S to an axle 10 via propeller shaft 3 and speed reducer 7. The axle 10 carries a pair of driving wheels 15.

In this embodiment, one prime mover 4 having a pair of output shafts disposed at its opposite ends is mounted to the vehicle body 1 generally at the centre thereof, and the power is transmitted from output shafts 4S to axles 10 disposed at the front and rear ends of the vehicle through respective propeller shafts 3. The propeller shafts 3 are rotated by the one prime mover 4 in the opposite directions, thereby cancelling reaction torques produced when the output shafts 4 rotate with equal powers. There is therefore no possibility of the vehicle body 1 being forcibly inclined by any reaction torque. In consequence, the vehicle body can be smoothly inclined by the natural pendulum effect.

Next, the structure of a propeller shaft for natu-

ral pendulum railcars based on the right angle cardan system for use with the present invention will be described below with reference to Figs. 6 to 7.

A propeller shaft 3 has, as shown in Figs. 6 and 7, stationary yokes 21 and 22, a spline shaft yoke 23, and a sleeve yoke 24 having an inner splined portion. An expansion section 25 is formed by the spline-fitting the slide shaft yoke 23 within the sleeve yoke 24 and interposing ball bearings 26 between spline portions of the yokes 23 and 24. The ball bearings 26 enable a reduction in the frictional resistance caused when the expansion section 25 extends or contracts.

That is, the ball bearings 26 are interposed between the spline portions of the spline shaft yoke 23 and the yoke 24 with the spline sleeve, and the frictional resistance of the expansion section 25 is therefore small ($\text{Kgf/Kgf} \cdot \text{m} = 0.04 \text{ to } 0.35$). In consequence, the frictional resistance between the yokes 23 and 24 is reduced, thereby enabling the vehicle body to effect a natural pendulum motion under a low-resistance condition.

Next, another example of the propeller shaft will be described below with reference to Fig. 8.

A propeller shaft 3 in accordance with this embodiment has, as in the case of the arrangement shown in Fig. 6, stationary yokes 21 and 22, a spline shaft yoke 23, and a sleeve yoke 24 having a spline. An expansion section 25 is formed by spline-fitting the slide shaft yoke 23 and the yoke 24 with the spline sleeve. Resin coatings (nylon coating) 23a, 24a are formed on spline portions of the yokes 23 and 24, thereby reducing the friction coefficients ($\mu = \text{about } 0.075$) of the spline portions.

In this example also, the frictional resistance between the two yokes during sliding is reduced, thereby enabling the vehicle body to effect a natural pendulum motion under a low-resistance condition.

As is clear from the above description of the embodiments, the present invention enables, for railroad vehicles such as railcars, a pendulum vehicle construction utilizing a natural pendulum action to make passengers feel more comfortable during travelling along a curve at a high speed even in the case of a vehicle having a prime mover such as an internal combustion engine mounted on the vehicle transmission mechanism. The present invention therefore enables an increase in the curve passage speed of vehicles having this type of power transmission mechanism.

In the propeller shaft in accordance with preferred embodiments of the present invention, the frictional coefficients of spline portions of the propeller shaft connecting the prime mover and the driving wheel can be reduced, thereby enabling a

reduction in the slide resistance at the time of expansion/contraction of the propeller shaft and removing a force resulting from the slide resistance which impedes the pendulum action.

Claims

1. A railroad vehicle comprising a vehicle body, inclined by a natural pendulum system, a pair of trucks respectively disposed at longitudinally opposed ends of said vehicle, each said truck having an axle and a pair of drive wheels, and each said pair of drive wheels being driven by a respective output shaft from a prime mover disposed in the vicinity of the centre of said vehicle, said output shafts extending longitudinally of said vehicle and being caused to rotate with equal output torques in opposite directions, whereby reaction torques produced in response to said output torques are cancelled and the possibility of any forced inclination of the vehicle body due to such reaction torques is substantially eliminated.

2. A railroad vehicle according to claim 1 wherein a single prime mover is provided driving both said pairs of drive wheels.

3. A railroad vehicle according to the claim 1 wherein a respective prime mover is provided for each pair of drive wheels.

4. A railroad vehicles according to any of claims 1, 2 and 3 wherein a propeller shaft is connected between each said output shaft and its respective axle to transmit the power of said prime mover to said axle.

5. A railroad vehicle according to claim 4 wherein said propeller shaft includes mutually engaging splined portions, a plurality of ball bearings being disposed between said splined portions.

6. A railroad vehicle according to claim 4 wherein said propeller shaft includes mutually engaging splined portions, at least one of said splined portions being provided with a coating having a low friction coefficient.

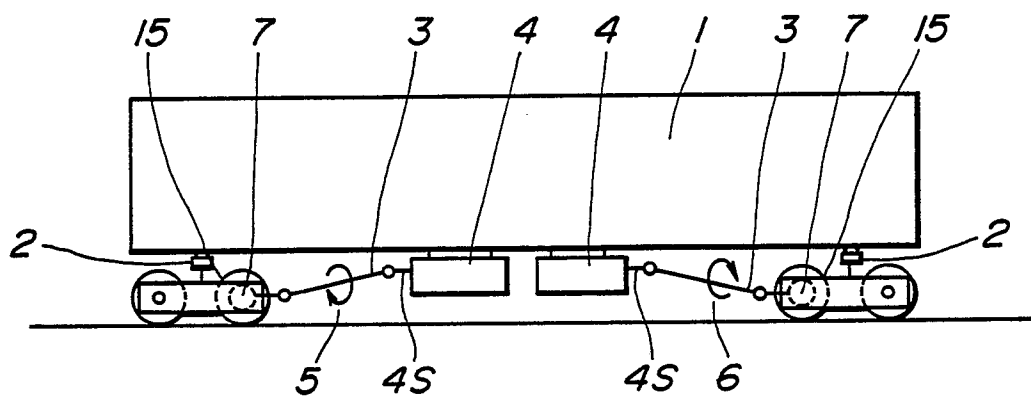


FIG. 1

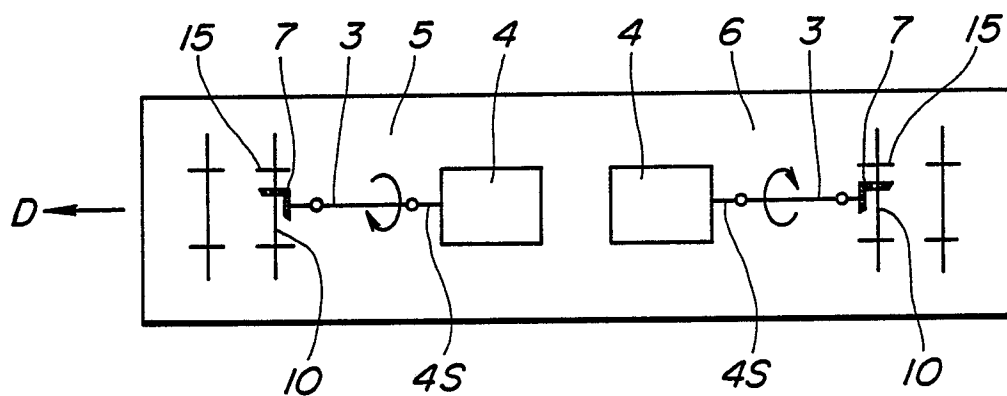


FIG. 2

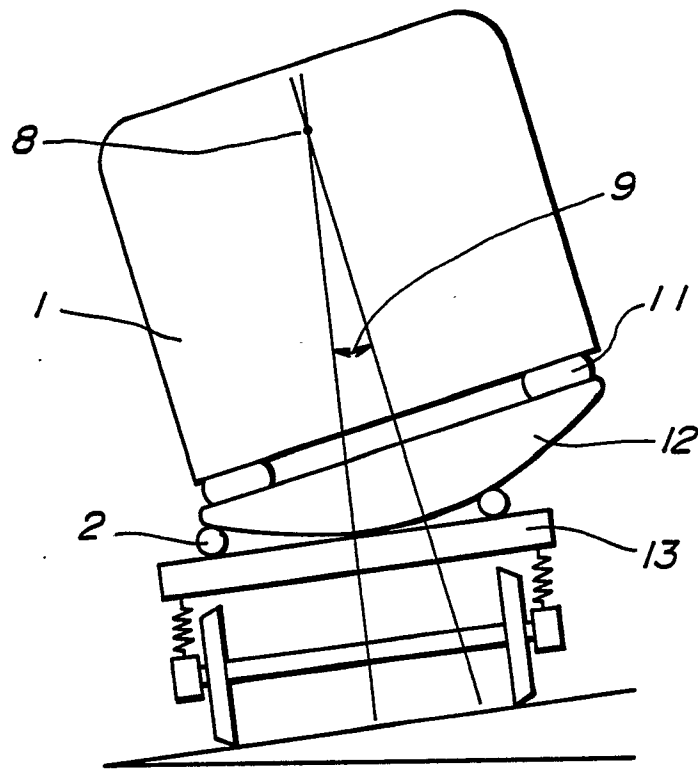


FIG. 3

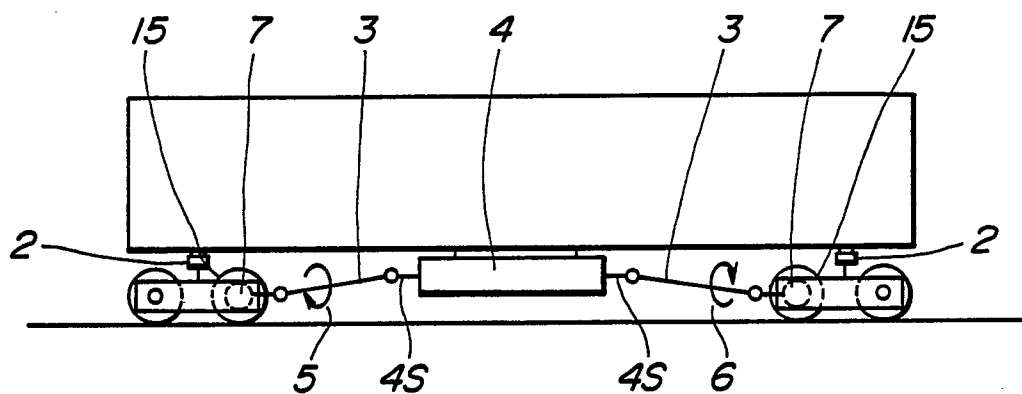


FIG. 4

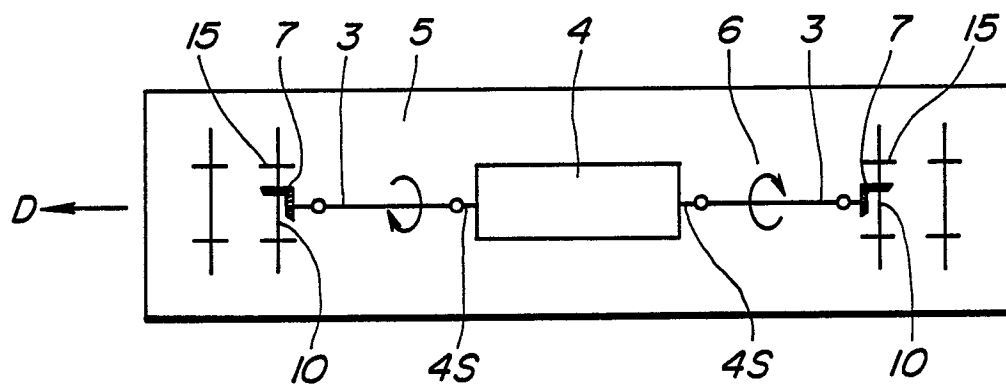


FIG. 5

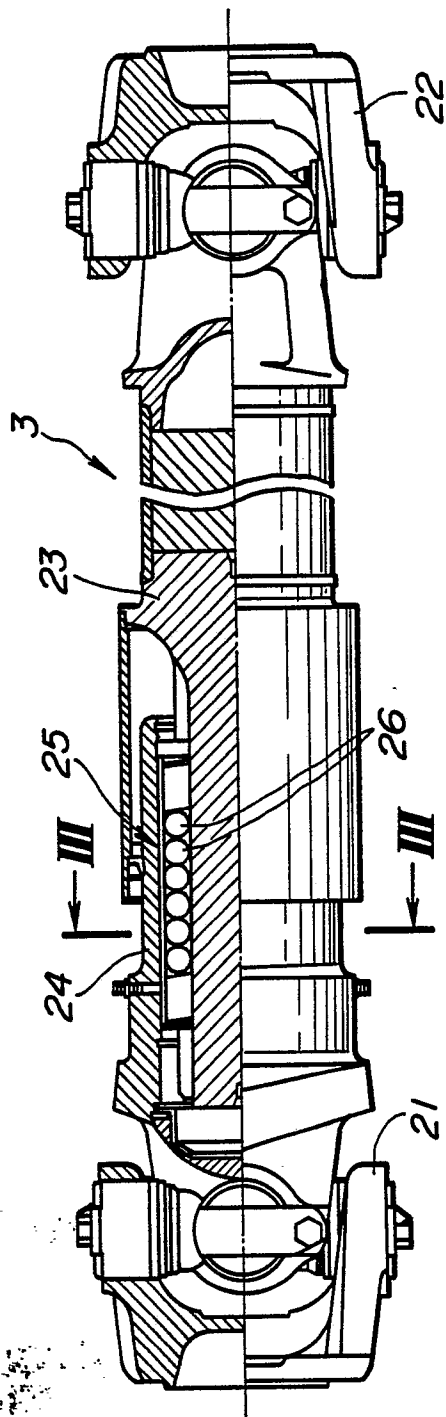


FIG. 6

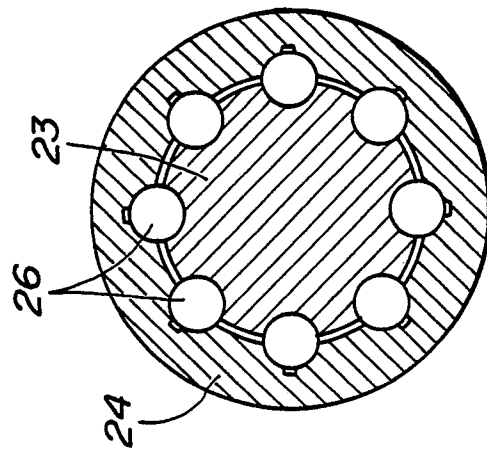


FIG. 7

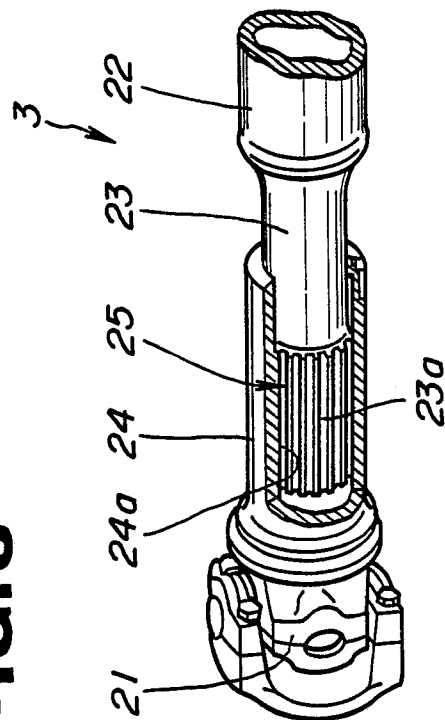


FIG. 8