United States Patent Office

3,470,828

Patented Oct. 7, 1969

3,470,828

ELECTROMAGNETIC INDUCTIVE SUSPENSION AND STABILIZATION SYSTEM FOR A GROUND VEHICLE

James R. Powell, Jr., 5 Clifton Ave., Rocky Point, N.Y. 11778, and Gordon T. Danby, Sound Road, Wading River, N.Y. 11792

Filed Nov. 21, 1967, Ser. No. 684,775
Int. Cl. B61b *13/08;* H01f *7/00;* H02k *41/00*
U.S. Cl. 104—148 25 Claims

ABSTRACT OF THE DISCLOSURE

This invention relates to a suspension and stabilization system for a high-speed train utilizing superconducting magnets. The superconducting magnets are carried by the train and interact, through electromagnetic induction, with a track bed formed by a plurality of longitudinally-extending arrays of shorted loops. The shorted loops are composed of non-magnetic metal conductors, such as aluminum. This system generates a suspension force, for floating the train above the ground and restoring and damping forces, for maintaining the traveling vehicle at an equilibrium position above the track bed stabilized against vertical, lateral, rotational and oscillatory displacements. The train is advanced along the track bed by propeller, jet, rocket or other suitable propulsion means. It is supported on wheels when at rest and while operating at transitional speeds, as it is started or stopped, which are below the speeds necessary for operable electromagnetic suspension.

Background

Much attention is now being given by the United States Department of Transportation and by private research and development firms, to the design of passenger-carrying ground vehicles capable of traveling at high speed, 100 to 300 miles per hour and faster. There is a growing need for fast inter-urban ground transportation between neighboring cities of high population density where automobile and plane transport are not efficient, such as in the northeast corridor of the United States.

At these high speeds, operation of a vehicle supported on the conventional steel wheels riding on rails becomes impractical because of friction, wind disturbances, inertial effects, roadbed irregularities, etc. Design efforts searching for a satisfactory solution to these problems have been concerned with ground effect supports such as levitation on a cushion of air. However, the air-cushion suspension of a large-mass vehicle requires the expenditure of considerable power. Also, the clearance between the bottom skirt of a ground-effect machine and the surface is typically only an inch or so; as a practical matter this restricts its use, over ground, to very level, rock-free roadbeds. Because of these limitations, air-cushion suspensions appear to be technically and economically unfeasible for high-speed train transport applications.

The present invention is directed to an electromagnetic suspension and stabilization system for high-speed ground vehicles, which system is sometimes referred to hereinafter as a magnetic system. It inherently possesses great advantages over conventional wheeled and air cushion vehicular suspensions since only a very small amount of power is required.

Without undue expenditure of energy, the train can be suspended at a sufficient elevation (typically, one foot) above the ground surface so as to eliminate the need for the flat and regular roadbed required by ground-effect machines. Furthermore, unlike air-cushioned vehicles, the electromagnetically-suspended train of the present invention can be satisfactorily and efficiently operated in a non-atmospheric environment such as an evacuated tube transport system.

Proposals for the magnetic suspension of trains have been made in the past. For example, one of the present inventors in a 1963 article (J. R. Powell, "The Magnetic Road: A New Form of Transport," Paper 63-RR4, ASME Railroad Conference, Apr. 23–25, 1963) suggested a train suspension system based on the magnetic repulsion generated between two superconducting loops carrying D.C. current, one on the moving train and one on a stationary track. However, the cost of superconductor material and the necessary refrigeration required for the construction of the lengthy superconductive track loop makes the design economically prohibitive, although technically feasible. In 1961 Westinghouse employees proposed that the force of magnetic repulsion between iron or ferrite permanent-magnets on both the train and track be used to provide the necessary suspension. (C. Kerr and C. Lyn, "The Roller Road," Westinghouse Engineer, March 1961 and January 1963). However, the size of the magnets required to satisfy the design objectives appear too expensive and too heavy for a commercial train suspension system.

Summary of the invention

The present invention is directed to a new form of electromagnetic suspension and stabilization for high-speed trains. Suspension and stabilization is provided by the interaction of the magnetic field of superconducting magnets, carried on the train, with currents induced in a track bed of a longitudinal series of arrays of shorted non-magnetic, electrically conducting metal loops. The system is technically and economically feasible since it utilizes presently-available materials and requires minimal power consumption for operation. Theoretical calculations indicate that a 100-foot long passenger train weighing 60,000 pounds can be suspended magnetically by the system of the present invention, with a power consumption on the order of only 200 horsepower. This is at least an order of magnitude less than the power required for the suspension of a comparably-sized train by air-cushion means. In fact, the power required to suspend the vehicle by the present electromagnetic system is negligible compared to the power required to overcome the high speed air friction on the vehicle.

In brief, the electromagnetic suspension system of the present invention comprises a small number of well insulated, current-carrying superconducting loops (hereinafter referred to as superconducting magnets), carried on a moving train, and a track bed formed of a series of oriented arrays of shorted loops composed of ordinary metal conductors. The high magnetic fields generated by the superconducting magnets induce high currents in the track bed loops. The interaction of the magnetic fields accompanying these induced currents and the magnetic fields of the superconducting loops suspends and stabilizes the train as it travels over the track bed.

Whereas the superconductor loops on the train carry several hundred thousand amperes there is virtually no power loss in the train loops due to the minimal electrical resistivity at cryogenic temperatures. There is only small I^2R power loss, on the order of a few hundred horsepower, produced in the track loops by the induced currents which themselves are on the order of several thousand amperes. Even this power loss can be reduced, if desired, by supercooling the track loops. An added advantage of supercooled track loops is that the transitional speed necessary for operable electromagnetic suspension is lowered to a few miles per hour. Thus it may sometimes be desirable to cool the track loops, for example, in train stations.