

Magnetically Levitated Transport System

5

Background

Related Applications

- [1] This application claims international priority from a prior filed U.S. Utility Patent Application having serial no. 11209916 and entitled "Magnetically Levitated Transport System" filed on 8/22/05.

10

Field of the Present Disclosure

- [2] This disclosure relates generally to electric motor-generators and more particularly to a DC linear electromagnetic machine operating by electrical induction.

15

Description of Related Art

- [3] The following art defines the present state of the field of the apparatus described and claimed herein:

20

- [4] Tu et al, US 2004/0135452, discloses a flat rotary electric generator that includes at least one toroidal coil structure for cutting magnetic lines to induce a current and at least one disc-shaped magnetic pole structure oriented parallel to the helical coil structure. If multiple toroidal coil structures and disc-shaped magnetic coil structures are included, the toroidal coil structures and disc-shaped magnetic coil structures are arranged in alternating manner. The toroidal coil structure and disc-shaped magnetic pole structure are not provided with a permeable material. When either the toroidal coil structures or the at least one disc-shaped magnetic pole structure is rotated by an external force, the toroidal coil structure cuts the magnetic lines passing therethrough

25

30

to generate an induced current. Neal, US 2002/0135263, discloses a plurality of stator arc segments that form a toroidal core for a stator assembly used to make a motor. In a preferred embodiment, a plurality of magnetic fields is created when electrical current is conducted through wire wound around poles on the toroidal core.

5 A monolithic body of phase change material substantially encapsulates the conductors and holds the stator arc segments in contact with each other in the toroidal core. Hard disc drives using the motor, and methods of constructing the motor and hard disc drives are also disclosed. Rose, US 6803691, discloses an electrical machine that comprises a magnetically permeable ring-shaped core centered on an

10 axis of rotation and having two axially-opposite sides. Coils are wound toroidally about the core and disposed sequentially along the circumferential direction. Each coil includes two side legs extending radially alongside respectively sides of the core. Coil-free spaces exist between adjacent side legs. A bracket has first and second side flanges that are connected by a bridging structure and respectively about the first and

15 second sides of the coil. Mohler, US 6507257, discloses a bi-directional latching actuator that is comprised of an output shaft with one or more rotors fixedly mounted thereon. The shaft and rotor are mounted for rotation in a magnetically conductive housing having a cylindrical coil mounted therein and is closed by conductive end caps. The end caps have stator pole pieces mounted thereon. In one embodiment, the

20 rotor has at least two oppositely magnetized permanent magnets which are asymmetrically mounted, i.e., they are adjacent at one side and separated by a non-magnetic void on the other side. The stator pole piece has asymmetric flux conductivity and in one embodiment is axially thicker than the remaining portion of the pole piece. An abutment prevents the rotor from swinging to the neutral position

25 (where the rotor magnets are axially aligned with the higher conductivity portion of the pole piece). Thus, the rotor is magnetically latched in one of two positions being drawn towards the neutral position. Energization of the coil with an opposite polarity current causes the rotor to rotate towards its opposite latching position whereupon it is magnetically latched in that position. Mohler, US 5337030, discloses a permanent

30 magnet brushless torque actuator that is comprised of an electromagnetic core capable of generating an elongated toroidally shaped magnet flux field when energized. Outside the generally cylindrical coil is an outer housing with upper and

lower end plates at each end. Mounted to the end plates and extending towards each other are stator pole pieces separated from its opposing pole piece by an air gap. A permanent magnet rotor is disposed in the air gap and mounted on a shaft which in turn is rotatably mounted in each of the end plates. The permanent magnet rotor comprises at least two permanent magnets, each covering an arcuate portion of the rotor and having opposite polarities. Energization of the coil with current in one direction magnetizes the pole pieces such that each of the two pole pieces attracts one of the magnets of the rotor and repels the other magnet of the rotor resulting in a torque generated by the output shaft. Reversal of the current flow results in a reversal of the torque and rotation of the rotor in the opposite direction. Preferred embodiments are disclosed having multiple cells, i.e. a plurality of stator rotor stator combinations and/or cells in which there are a plurality of pole pieces at each stator pole plane. Kloosterhouse et al, US 5191255, discloses an electromagnetic motor that includes a rotor having a plurality of magnets mounted along a perimeter of the rotor. Preferably, adjacent magnets have opposite poles facing outward. One or more electromagnets are disposed adjacent to the perimeter of the rotor so that as the rotor rotates, the magnets mounted on the rotor are carried near the poles of the electromagnets. Current is supplied to the electromagnets by a drive circuit in a predetermined phase relationship with the rotation of the rotor such that, for substantially all angular positions of the rotor, magnetic attraction and repulsion between the poles of the electromagnets and the magnets mounted on the rotor urge the rotor to rotate in a desired direction. Reflective material is mounted on the rotor in predetermined angular positions. The drive circuit includes a photosensitive device which produces a signal whose value varies according to whether the device is receiving light reflected from the reflective material. The signal is amplified to produce drive current for the electromagnets. Westley, 4623809, discloses a stepper motor housing a pole structure in which a pair of identical stator plates, each having a plurality of poles, are positioned back to back with the poles projecting in opposite directions, the stator plates being positioned between a pair of substantially identical stator cups, each stator cup having a plurality of poles projecting inwardly from a back wall with a peripheral side wall terminating in an outwardly extending flange. A major surface of each flange is in contact with a face on one of the stator plates so as

to assure a low reluctance magnetic path. Fawzy, 4565938, discloses an electromechanical device which can be used as a motor or as a generator. The device has a housing, including bearing means to support a rotatable shaft. Disc magnet means are provided, and poled to have alternating polarity and are mounted on the shaft to define a rotor. The device includes at least one first pole shoe in contact with the magnet means, having a portion extending radially therefrom to define a virtual pole chamber, of a first polarity. Also included is at least one second pole shoe in contact with the magnet and having a portion extending radially therefrom to define a virtual pole chamber of the other polarity. A toroid stator is mounted on the housing and has windings thereon. The stator is positioned annularly around the disc magnets such that the virtual pole chambers of the first and second pole shoes surround portions of said windings with circumferentially alternating fields of alternating polarity. Means are provided for electrical contact with the stator to draw off current when the device is operated as a generator, or provide current to operate the device as a motor. Fawzy, 4459501, discloses an electromechanical device which can be used as a motor or as a generator that has a housing, including bearing means to support a rotatable shaft. A pair of disc magnets are poled to have opposite polarity on the two faces of each. The magnets are mounted face to face together on the shaft to define a rotor. The device includes at least one first pole shoe in contact with one face of each magnet, and having a portion extending radially therefrom to define, in its preferred form, a pair of virtual pole chambers, of the same polarity as said one face. Also included is at least one second pole shoe in contact with the other face of each magnet and having a portion extending radially therefrom to define in its preferred form a pair of virtual pole chambers of the same polarity as the other face. A toroidal stator is mounted on the housing and has windings thereon. The stator is positioned annularly around the disc magnets such that the virtual pole chambers of the first and second pole shoes surround portions of said windings with circumferentially alternating fields of alternating polarity. Means for electrical contact with the stator draw off current when the device is operated as a generator, or provide current to operate the device as a motor.

[5] Our prior art search with abstracts described above teaches rotating electromagnet machines; in both motor and generator forms. Thus, the prior art shows in Neal, a toroidal core with radial arc segments, in Fawzy, we see a N-N and S-S pole face adjacency, in Tu et al, a N-S and S-N pole adjacency with radial coil windings, in
5 Rose, we find radially wound coils in sequence around a toroidal core and with permanent magnet segments with N-N and S-S adjacency. However, the prior art fails to teach a linear electromagnetic machine that provides electromagnetic fields immersed in monopole permanent magnet fields of opposite polarities as is shown in the present apparatus and which provides operation by electrical induction.

10

[6] The present disclosure distinguishes over the prior art providing heretofore unknown advantages as described in the following summary.

Summary

15

[7] This disclosure teaches certain benefits in construction and use which give rise to the objectives described below.

[8] The present invention is a magnetically levitated transport system showing a
20 suspended vehicle for carrying passengers and freight fixedly mounted to a translating portion of the linear motor system of the present invention which has the functions of providing levitated positioning of the vehicle as well as propulsion and braking. The translating portion is movably engaged with a long linear ferromagnetic core which is fixed to railway supports mounted above a ground surface. Other ways
25 of supporting and suspending the vehicle are clearly possible as well. Electromagnets are located at opposing sides of a fixed linear ferromagnetic core of a DC linear electric motor-generator. These electromagnets, in a typical application are interconnected initially in parallel electrical interconnection and are later switched to series electrical interconnection as will be described below. Certain benefits may be
30 obtained by this ability to switch between parallel and series interconnection.

[9] A primary objective inherent in the above described apparatus and method of use is to provide advantages not taught by the prior art.

[10] Another objective is to provide an electromagnetic linear machine which
5 develops a linear propulsive force and levitation using electromagnetic induction.

[11] A further objective is to provide such a machine useful as a transport.

[12] A further objective is to provide such a machine capable of recovering electrical
10 energy upon braking.

[13] A further objective is to provide such a machine capable of maintaining a
desirable vehicle orientation about an axis in the direction of propulsion regardless of
load imbalance or centripetal force vectors.

[14] A further objective is to provide such a machine capable of developing propulsion
15 and braking forces without direct physical contact for electrical current supply.

[15] A further objective is to provide such a machine that is operated using energy
20 supplied from an on-board power supply or an external power feed, or a combination
of both.

[16] Other features and advantages of the described apparatus and method of use will
become apparent from the following more detailed description, taken in conjunction
25 with the accompanying drawings, which illustrate, by way of example, the principles
of the presently described apparatus and method of its use.

Brief Description of the Drawings

[17] The accompanying drawings illustrate at least one of the best mode embodiments
30 of the present apparatus and method of it use. In such drawings:

[18] Figure 1 is a vertical frontal cross-sectional schematic view of the present invention showing a transport system with a vehicle suspended from a support system and a means for propulsion shown above the vehicle;

5 [19] Figure 2 is a table of symbols used in the further figures;

[20] Figure 3 is a schematic diagram of a fixed, i.e., static portion of said propulsion system, an electromagnetic linear motor;

10 [21] Figure 4 is a schematic diagram of a moving or translational portion of said electromagnetic linear motor showing the vehicle engaged therewith;

[22] Figure 5 is a schematic diagram; enlarged from Fig. 1; showing the principals and operating mechanisms of the present invention and clearly showing the
15 interrelationship between the static and moving portions of the linear motor as well as an auto-balancing mechanism for the vehicle.

Detailed Description

20 [23] The above described drawing figures illustrate the described apparatus and its method of use in at least one of its preferred, best mode embodiments, which is further defined in detail in the following description. Those having ordinary skill in the art may be able to make alterations and modifications to what is described herein without departing from its spirit and scope. Therefore, it must be understood that
25 what is illustrated is set forth only for the purposes of example and that it should not be taken as a limitation in the scope of the present apparatus and its method of use.

[24] Figs. 1-5 are views of the presently described apparatus operating according to principals that represent an important application as an extension to the apparatus
30 defined in U.S. application serial number 11200920 filed on 09 AUG 2005, and which embodies a common theoretical basis therewith.

[25] Fig. 1 is a sectional view of a magnetically levitated transport system showing suspended vehicle 10 for carrying passengers and freight fixedly mounted to translator 142 of the present invention. Translator 142 is movably engaged with a stator 141 as will be described below and which is fixed to railway supports 20, one of which being shown in Fig. 1 fixed to and extending upwardly from a ground surface 5. Other ways of supporting and suspending the vehicle will be known to those of skill in the art and may be employed without deviating from the intensions of the invention and the achievement of its objectives.

10 [26] Fig. 3 is a schematic representation showing the instant invention railway system supported by railway supports 20 and represents the track upon which the railway vehicle 10 moves. The stator 141 is shown schematically. The present enablement is a DC linear electric motor-generator. As shown in Fig. 3 the stator comprises a linear series of electromagnets 147 interconnected by windings 148 where each is a cell of the track. In this diagram the electromagnets 147 are represented by rectangular boxes. Those along the top of the diagram are physically positioned at the vertical center of the track while those along the bottom of the diagram are located horizontally to the left and right of the center of the track. Until the vehicle 10 arrives at each cell, the electromagnets are not energized.

20

[27] Fig. 4 schematically depicts the interaction between the translator 142 and the stator 141. At the left of Fig. 4 we see the identical condition of the several electromagnets 147 as in Fig. 3. Now, the translator 142 carries a plurality of electromagnets 147 which interact with those of the stator 141 as will be described. As the vehicle approaches each cell of the stator, the cell is automatically switched to receive current to that each cell is energized. As the translator 142 passes the energized cells it is levitated. Inductive interaction between stator 141 and translator 142 produced electromotive force which drives the vehicle forward.

25

30 [28] In Fig. 5, it is shown that the stator's electromagnets 147 are located laterally with respect to the axis of travel at both edges of a curved triangular shaped linear

ferromagnetic core 141' and also at its apex. These electromagnets 147 may be interconnected in series or parallel as will be determined by use objectives. The ferromagnet core 141' has a continuous peripheral aperture 162. Windings 148 are laid within this aperture 162. Windings 148 form a continuous circuit around the
5 ferromagnet core 141' and the electromagnets 147.

[29] The linear ferromagnetic core's wiring system, as shown for each segment of this vertebral column is electrically interconnected in series and-or in parallel so that the coils end in a short cut interconnection and than a general protection switch where
10 each of the coils has the same function, i.e., energy transfer, magnetic levitation, guidance and propulsion.

[30] In Fig. 5 we find sets of electromagnets which have several functions. First, the electromagnets 147A and coil 148 in stator 141 carries a switched-in pulsating direct
15 current which energizes all of the electromagnets in the stator 141. Second, a pulsed current is induced into electromagnets 147A' by electromagnets 147A. This induced current is received by all electrical devices on the translator 142 and in the vehicle 10. Electromagnets 147B interact with electromagnets 147B' to provide lateral stability and centering of the translator 142 on stator 141. Also, electromagnets 147B interact
20 with electromagnets 147C' to maintain levitation and vertical stability of the translator 142 about stator 141. Propulsive force is provided by large electromagnets 147D' which react with coils 148 to provide inductive electromotive forces.

[31] Electromagnets 147A', 147B' and 147C' have permanent magnet cores to
25 provide levitation and stability in the absence of electrical current and in the absence of forward motion when no induction of current is available to the translator 142.

[32] Additionally, the mobile portion provides a load support & auto balance assembly
190 which sustains the load, i.e., passengers, freight and enables the vehicle 10 to tilt
30 according to necessity of traversing curves.

[33] The enablements described in detail above are considered novel over the prior art of record and are considered critical to the operation of at least one aspect of the apparatus and its method of use and to the achievement of the above described objectives. The words used in this specification to describe the instant embodiments are to be understood not only in the sense of their commonly defined meanings, but to include by special definition in this specification: structure, material or acts beyond the scope of the commonly defined meanings. Thus if an element can be understood in the context of this specification as including more than one meaning, then its use must be understood as being generic to all possible meanings supported by the specification and by the word or words describing the element.

[34] The definitions of the words or drawing elements described herein are meant to include not only the combination of elements which are literally set forth, but all equivalent structure, material or acts for performing substantially the same function in substantially the same way to obtain substantially the same result. In this sense it is therefore contemplated that an equivalent substitution of two or more elements may be made for any one of the elements described and its various embodiments or that a single element may be substituted for two or more elements in a claim.

[35] Changes from the claimed subject matter as viewed by a person with ordinary skill in the art, now known or later devised, are expressly contemplated as being equivalents within the scope intended and its various embodiments. Therefore, obvious substitutions now or later known to one with ordinary skill in the art are defined to be within the scope of the defined elements. This disclosure is thus meant to be understood to include what is specifically illustrated and described above, what is conceptually equivalent, what can be obviously substituted, and also what incorporates the essential ideas.

[36] The scope of this description is to be interpreted only in conjunction with the appended claims and it is made clear, here, that each named inventor believes that the claimed subject matter is what is intended to be patented.

Claims

What is claimed is:

5 Claim 1. A magnetically levitated transport apparatus comprising: a vehicle for carrying a payload; mounted to a translator movably engaged with a fixed stator; the stator providing a ferromagnetic core with a winding engaged therein; plural electromagnets engaged with the ferromagnetic core forming an electrical circuit with the winding; the translator carrying a plurality of electromagnets proximal to the electromagnets of the
10 stator, the electromagnets mutually interactive through magnetic forces provided by a pulsed direct current received by the electrical circuit of the stator, to provide levitation, centering and propulsion to the translator relative to the stator.

Claim 2. The apparatus of claim 1, wherein the stator electromagnets comprise a centrally positioned electromagnet enabled for inducing the pulsed direct current, a pair
15 of laterally positioned electromagnets enabled for centering the translator on the stator.

Claim 3. The apparatus of claim 2, wherein the translator electromagnets are positioned relative to the stator electromagnets for effective mutual magnetic interaction.

Claim 4. The apparatus of claim 3 wherein the stator comprises a plurality of stator cells arranged in side-by-side positions along a direction of travel of the translator.

20 Claim 5. The apparatus of claim 4 wherein each of the cells is electrically and magnetically independent.

Claim 6. The apparatus of claim 5 wherein each of the cells is switched to receive the pulsed direct current by a proximity switch associated with the presence of the translator.

25