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WO 2012/126726 A2 **US 6421600 B1**
US 20110184842 A1

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(54) Title of the Invention: **Arrangement and method for transferring energy to a vehicle by generating a magnetic field**
Abstract Title: **Charging electric vehicles using plural magnetic field generators arranged sequentially along a vehicle path, one being located at a vehicle stop**

(57) Energy is transferred to a vehicle by generating a magnetic field to induce a voltage in a vehicle receiver (fig 1, 4). Plural magnetic field generators T1 - T6 are individually controlled and arranged one after the other in a sequence along a vehicle travel path. A first electromagnetic generator T2 is located at a vehicle stopping location such as a bus stop, traffic light or intersection and a second generator T1,T3 is arranged along its travel path, where the vehicle may decelerate to halt at, or may accelerate to depart from, the stop position. The length of the second acceleration generator T3 may be greater than the length of the stop generator T2 and less than the length of a third generator T4 in the travelling direction. Controller 15 may separately control each generator by detecting a vehicle from the inductance in a loop alongside the generator. A generator may operate only when it is at least partially covered by the vehicle and not operate when a person, animal or foreign object is in its vicinity. Energy transmitted to the vehicle may charge a battery via a rectifier and charger (fig 1, 9, 6, 8).

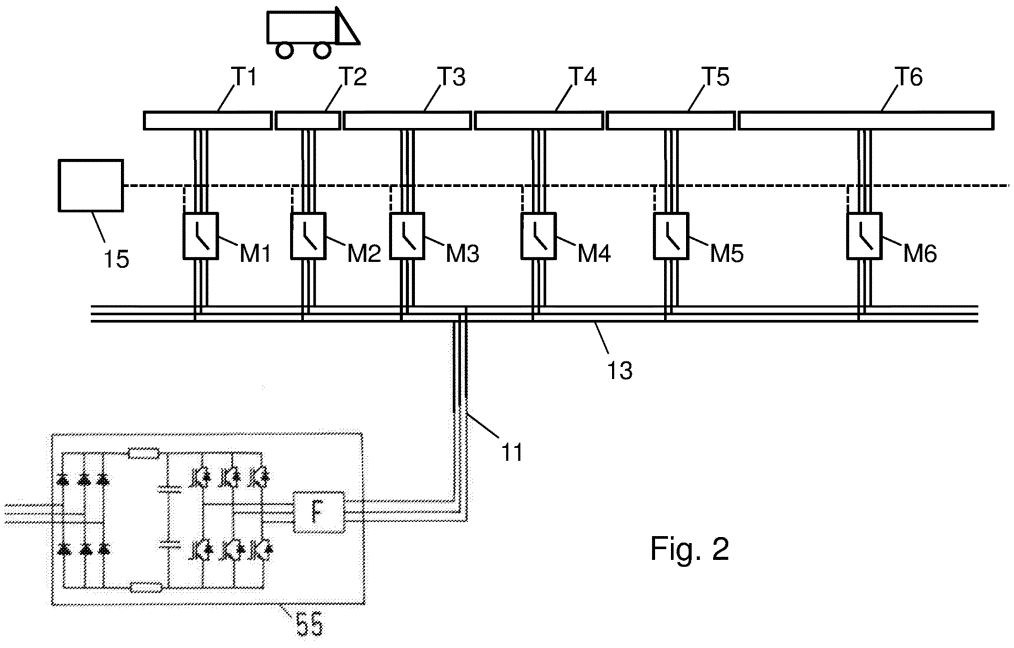

Fig. 2

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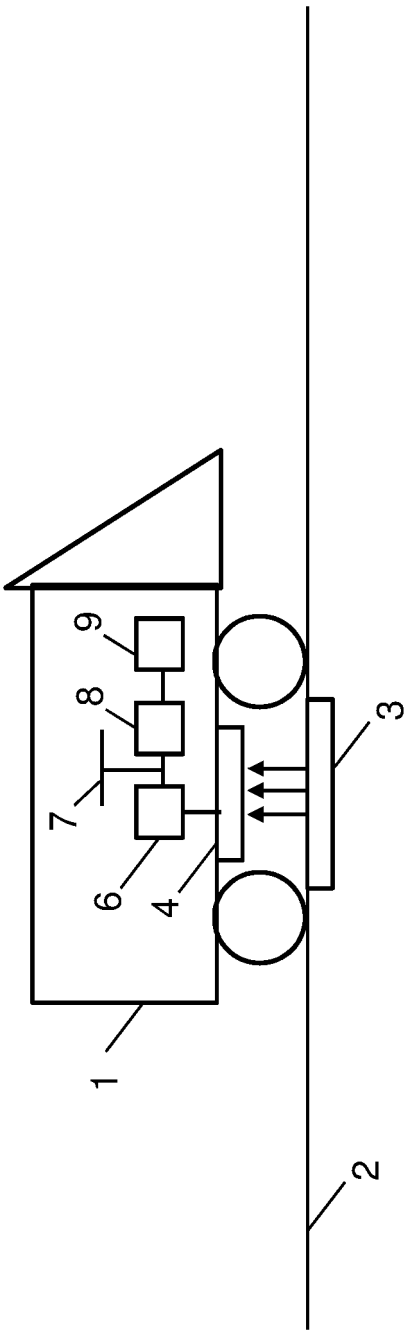

Fig. 1

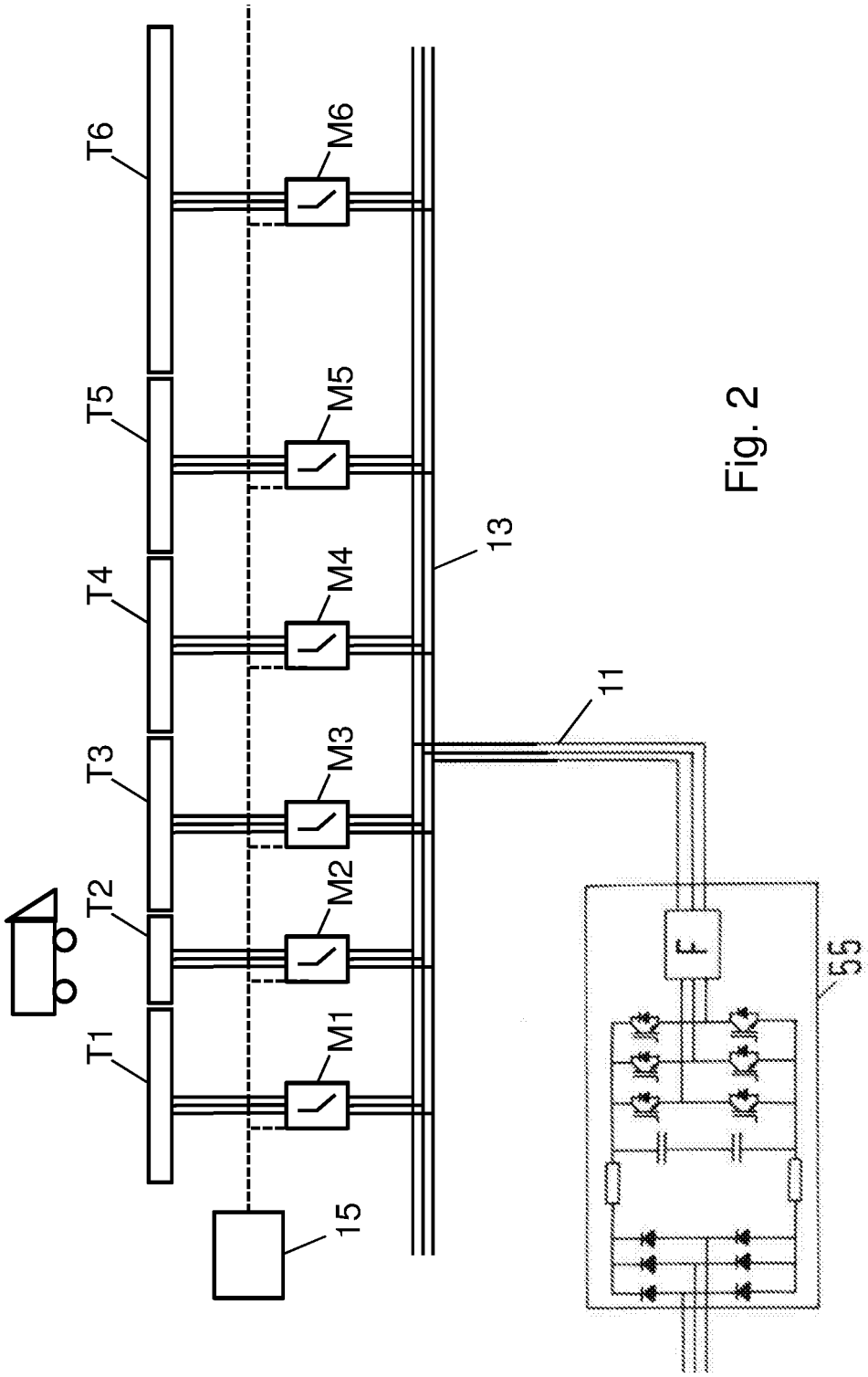

Fig. 2

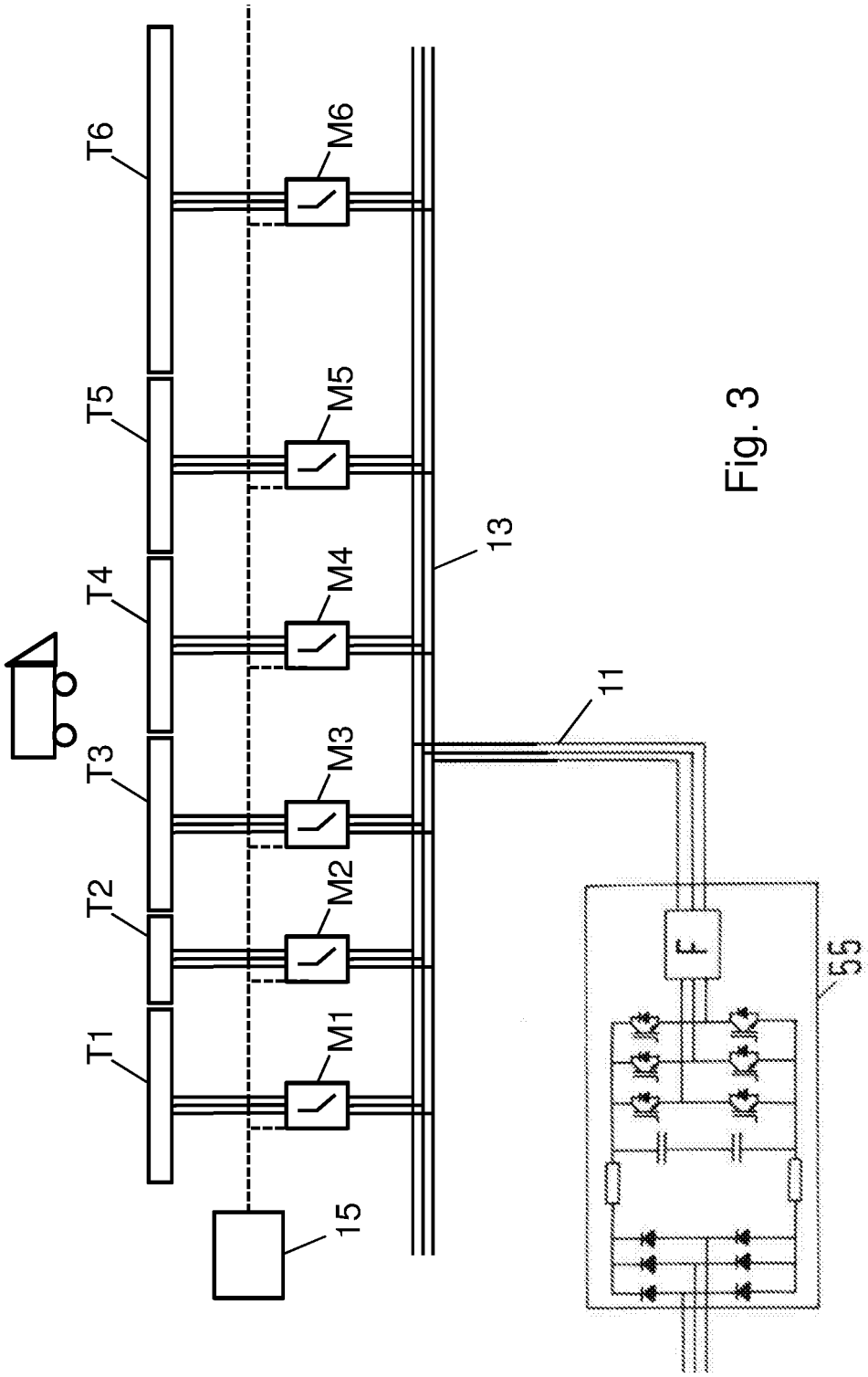

Fig. 3

Arrangement and method for transferring energy to a vehicle by generating a magnetic field

The invention relates to an arrangement for transferring energy to a vehicle by generating a magnetic field and by inducing an electric voltage in a receiving device of the vehicle. Furthermore, the invention relates to a method of transferring energy to a vehicle by generating a magnetic field, so that a receiving device of the vehicle may receive the magnetic field and an electric voltage may be induced in the receiving device of the vehicle.

In principle, generating a static magnetic field would be sufficient in order to transfer magnetic field energy to the vehicle. However, in practice, most systems generate an alternating electromagnetic field. Consequently, an alternating voltage induced in the receiving device. Typically, an on board energy storage, such as a battery, is charged using the electric energy produced by the receiving device. In case of an alternating voltage induced in the receiving device, the corresponding alternating current is rectified by a rectifier and the rectified current is used to charge the storage and/or is directly fed into the onboard electric network of the vehicle.

WO 2010/031595 A2 discloses an arrangement for providing a vehicle, in particular a track bound vehicle, with electric energy, wherein the arrangement comprises a receiving device adapted to receive an alternating electromagnetic field and to produce an alternating electric current by electromagnetic induction. The energy is transferred from a track-side electric conductor arrangement extending along the path of travel to the vehicle while the vehicle travels. In the following, this kind of energy transfer to the vehicle is referred to as dynamic transfer.

WO 2014/057100 A1 discloses that energy may be transferred to a land vehicle, in particular a track-bound vehicle, such as a rail vehicle, but also to road automobiles, such as individual (private) passenger cars or public transport vehicles (e.g. busses). A primary side conductor arrangement of a generating device produces an alternating electromagnetic field and is integrated in a track, road or parking area of the vehicle, so that the electric lines of the primary side conductor arrangement extend in a plane which is nearly parallel to the surface of the road, track or parking area on which the vehicle may travel or may be parked. In the following, the energy transfer to a vehicle while the vehicle stops is referred to as static transfer.

The present invention can be applied to the arrangements and systems described in WO 2010/031595 A2 and WO 2014/057100 A1 or to similar systems. For example, the generating device which generates the magnetic field may comprise at least one of the conductor arrangements described in these documents. In addition or alternatively, the conductor arrangement(s) can be integrated in the track, road or stopping area of the vehicle so that the vehicle may travel and/or stop above the conductor arrangement(s) of the generating device.

When the vehicle is stopped in the vicinity (in particular above) a way-side generating device (in particular a so-called charging pad) and receives the magnetic field from the generating device, this is known as static transfer. Static transfer is effective for transferring energy to the vehicle at a high power level, in particular for charging the vehicle battery in short time intervals. One disadvantage is that the vehicle (for example a public transport vehicle) cannot move during the energy transfer. If the vehicle is exclusively or mainly operated using electric energy, static transfer requires that the onboard energy storage is charged up to a charging level which is sufficient to operate the vehicle during the journey to the next generating device. In particular, the path of travel starting at the location of static transfer may be predetermined and a respective charging level may be calculated in advance.

Dynamic transfer has the advantage that the vehicle can receive energy during travel if required. In particular, the onboard storage can be charged during travel by receiving magnetic field energy. However, typical systems for dynamic transfer do not have generating devices along the complete path of travel. The amount of energy which can be received by the vehicle by dynamic transfer depends on the transfer power and on the duration of the time intervals while the vehicle travels along one of the generating devices

which generate magnetic fields. For example assuming that the power level of dynamic transfer is constant, longer sections of the path of travel have to be equipped with generating devices in order to increase the amount of energy which can be transferred to the vehicle. As a consequence, the effort for mounting and operating the generating devices along the path of travel is increased. Furthermore, if the vehicle is travelling at a higher velocity, the duration of the time interval for dynamic transfer is reduced. In addition, maximum values for magnetic field intensities are to be observed in public areas in order to protect people, animals and other technical devices which may be influenced by the magnetic field.

It is an object of the present invention to provide an arrangement for transferring energy to a vehicle by generating a magnetic field and to provide a method of transferring energy to a vehicle by generating a magnetic field, which allow for effective energy transfer at moderate effort for mounting and operating the generating device(s) and allow for adapting the amount of energy to be transferred to the vehicle.

According to a basic idea of the present invention, a combination of static and dynamic energy transfer to a vehicle is proposed. This provides for the opportunity to transfer energy in at least one stopping area, which may be a scheduled stopping area on the scheduled path of travel, for example in case of a public transport vehicle. In addition or alternatively, there may be at least one non-scheduled stopping area on the scheduled or non-scheduled path of travel or in the vicinity of the path of travel. In the following, the location where a vehicle may stop in order to receive energy by static transfer is referred to as vehicle stop location.

A first generating device for generating a magnetic field, which first generating device is located at the vehicle stop location, is combined with at least one further, second generating device for generating a magnetic field next to or at a distance to the vehicle stop location on the path of travel. This second generating device or one of the second generating devices may extend along a section of the path of travel which starts or ends close to or directly at a first section of the path of travel along which the first generating device extends. The first section is the vehicle stop location. Since the first generating device and the second generating device(s) are arranged next to each other, a vehicle travelling on the path of travel can receive energy not only by static transfer at the vehicle stop location, but also while it travels to the vehicle stop location and/or departs from the vehicle stop location.

In particular, the operation of the second generating device(s) may depend on the amount of energy required to be transferred to the vehicle and/or on the duration of the time interval while the vehicle stops at the vehicle stop location. If there is no demand for dynamic transfer, the second generating device(s) may not be operated. For example, an onboard control device of the vehicle may communicate the required amount of energy or a requirement signal for indicating a demand of energy in addition to the energy received by static transfer to a control connected to the generating devices. If this wayside control decides that the vehicle should also receive energy by dynamic transfer and/or if the wayside control receives a corresponding signal from the vehicle, it controls operation of the second generating device and therefore energy is transferred to the vehicle while the vehicle approaches and/or departs from the vehicle stop location. In particular, two of the second generating devices may be provided/operated, one in front of the vehicle stop location and one behind the vehicle stop location on the path of travel. These second generating device(s) can be distinguished from any further generating device by the fact that there is no further generating device on the path of travel in between the second generating device and the vehicle stop location. However, any other generating device which is separated from the first generating device by at least one other generating device is also referred to as second generating device, provided that vehicle deceleration or acceleration is expected in the section of the path of travel next to the generating device. Using a second generating device next to the vehicle stop location has the advantage that the vehicle travels at low speed while the vehicle travels along the second generating device.

In particular, the following is proposed: An arrangement for transferring energy to a vehicle by generating a magnetic field and by inducing an electric voltage in a receiving device of the vehicle, the arrangement comprising:

- a plurality of generating devices for generating the magnetic field,
- a control connected to the generating devices, the control being adapted to control operation of each of the generating devices individually and separately from the other generating devices,

wherein the plurality of generating devices is arranged one after the other in a sequence along a path of travel for a vehicle, wherein a first generating device of the plurality of generating device is located at a vehicle stop location, where the path of travel is designed for a stopping vehicle, so that the stopping vehicle can be provided with magnetic field energy generated by the first generating device, and wherein at least one

second generating device of the plurality of generating devices is arranged along an acceleration section of the path of travel, where a vehicle may decelerate in order to stop at the vehicle stop location or where the vehicle may accelerate in order to depart from the vehicle stop location. Therefore, the term acceleration section also includes a section where the vehicle decelerates (negatively accelerates).

Furthermore, a method is proposed of transferring energy to a vehicle by generating a magnetic field, so that a receiving device of the vehicle may receive the magnetic field and an electric voltage may be induced in the receiving device of the vehicle, the method comprising:

- operating a plurality of generating devices for generating the magnetic field, wherein the plurality of generating devices are arranged one after the other in a sequence along a path of travel for a vehicle,
- controlling the operation of each of the generating devices individually and separately from the other generating devices,
- operating a first generating device of the plurality of generating devices for transferring energy to a vehicle while the vehicle stops at a vehicle stop location,
- operating at least one second generating device of the plurality of generating devices for transferring energy to the vehicle while the vehicle decelerates in order to stop at the vehicle stop location or while the vehicle accelerates in order to depart from the vehicle stop location.

The control of the operation of each of the generating devices individually and separately from the other generating devices means that the operation of each of the generating devices can be started and stopped independently of the operation of any other generating device. If, for example, a single vehicle is travelling on the path of travel, one of the generating devices may be operated so that a magnetic field is generated while the vehicle is next to the generating device, this means there is no other generating device which is nearer to the vehicle than the generating device being operated. Only one generating device may be operated at a time. However, it is preferred that the next generating device following in the sequence along the path of travel onto the generating device in operation before or as soon as the vehicle has reached the generating device or has reached a predetermined position along the generating device.

Generally speaking, it is preferred that the presence of a vehicle next to at least one of the generating devices and preferably next to each of the generating devices, and/or a

position of a vehicle with respect to one or each of the generating devices is detected, in particular by a detecting device which is combined with the generating device or with each of the generating devices. Some examples of such a detecting device are disclosed by WO 2011/103999 A1.

The sequence of generating devices along the path of travel in particular means that each of the generating devices extends along a section of the path of travel and these sections form the path of travel in consecutive order where the vehicle may receive energy by a magnetic field produced by at least one of the generating devices.

Each of the generating devices may comprise one or more than one conductor arrangement, wherein in case of a plurality of conductor arrangements, these conductor arrangements can be operated simultaneously only. The conductor arrangement(s) may form a coil or coils of at least one electric conductor (for example an electric cable). Alternatively, at least one conductor may be laid in serpentine form, thereby extending along the path of travel. For example WO 2010/031595 A2, Fig. 1, illustrates such a serpentine configuration.

For example, the vehicle may be a public bus, in particular a BRT (bus rapid transit) typically stopping at bus stops for short time intervals. Any public transport vehicle should stop only for comparatively short time intervals at passenger stops, unless the stop is a terminal stop.

Generally speaking, the invention has the advantage that the duration of the time interval required for static transfer is comparatively small, since at least one additional generating device extending along the path of travel at a distance to the vehicle stop location can be used for dynamic transfer of energy. Compared to pure dynamic transfer systems, the required length of all generating devices extending along the path of travel is significantly reduced. In addition, the static transfer can be performed in a different manner than the dynamic transfer with respect to the type of generating device used and with respect to the relative position of the generating device on the wayside and the receiving device onboard the vehicle. In particular, static transfer can be performed while the generating device and the receiving device are nearly perfectly aligned to each other. Therefore, higher power levels of energy transfer can be reached compared to dynamic transfer. In addition, the receiving device may be positioned closer to the generating device during static transfer compared to dynamic transfer. For example, the receiving device may be

lowered from the vehicle bottom towards the generating device while the vehicle stops. As a result, the efficiency of energy transfer is increased and less field energy is distributed to the surrounding area. Another advantage is that energy can be transferred dynamically to the vehicle while the vehicle is accelerating and, therefore requires particularly high power for propulsion.

Furthermore, people, animals and technical devices in the surrounding of the generating device and receiving device can be protected more easily against high magnetic field intensities during static transfer. One reason is that the vehicle may fully cover the area where the generating device is located. Another reason is that shielding equipment for example comprising electrically and/or magnetically conducting material, can be arranged sideways of the generating device and/or receiving device during static transfer.

In case of dynamic transfer, additional shielding is difficult or requires high effort. If no or little shielding is to be used, the exposure of the environment to the magnetic field can be reduced by using short generating devices which are covered by the vehicle during operation as far as possible. However, costs and operational effort for a plurality of short generating devices is significantly higher than for a smaller number of generating devices extending over longer sections of the path of travel.

The corresponding problem is therefore to provide an arrangement and a method which reduces exposure of the environment to magnetic field, but is also cost effective and requires moderate operational effort.

It is proposed to operate the generating devices for dynamic transfer only while the vehicle at least partially covers the generating device. Preferably, the same applies to static transfer.

In particular, the control is adapted to operate each of the generating devices for transferring energy to the vehicle stopping or travelling on the path of travel only while the vehicle at least partially covers the generating device. If the generating devices are, as preferred, placed below the vehicle, for example by integrating the generating devices into the track or ground, a generating device is covered by the vehicle if the vehicle is above the generating device. However, it is also possible that the generating devices are arranged sideways of the vehicle or rather sideways of the space which is traversed by the vehicle during travel. In this case, the vehicle covers the respective generating device

while it is next to the generating device, if viewed from the opposite side of the vehicle. The backside of the generating device may, for example, be shielded using electrically and/or magnetically conducting material.

According to a corresponding embodiment of the method, each of the generating devices is operated only while the generating device is at least partially covered by the vehicle. “At least partially” also includes the case that the respective generating device is operated only while the generating device is fully covered by the vehicle.

Preferably, there is a detection device for detecting a person, an animal and/or a foreign object (such as a metallic object, in particular, another vehicle) in a vicinity of the generating device. If the detecting device outputs a corresponding signal to the control of the generating devices, the respective generating device is preferably not operated. Generally speaking, the generating device may not be operated if a person, an animal and/or a foreign object is detected to be present in a vicinity of the generating device. Concerning the arrangement, the control can be adapted not to operate the generating device in this case.

In order to solve the problem of exposure of the environment to magnetic field, it is also proposed to use generating devices of different lengths. In particular, the first generating device may extend over a first length along the path of travel and the second generating device may extend over a second length along the path of travel, wherein the first length is smaller than the second length. This means that a generating device of larger length is used for dynamic transfer compared to the generating device which is used for static transfer. With respect to the method, the first generating device extends over a first length along the path of travel, thereby generating the magnetic field over the first length while the vehicle stops at the vehicle stop location, and the second generating device extends over a second length along the path of travel, thereby generating the magnetic field over the second length while the vehicle drives along the second length, wherein the first length is smaller than the second length.

Since the length of the second generating device is larger than the length of the first generating device, the exposure of the environment to magnetic field is larger during operation of the second generating device. On the other hand, since the second generating device is operated for dynamic transfer, i.e. the vehicle is driving, the time interval of operating the second generating device is smaller than the time interval of

operating the first generating device. In particular, the time interval of operating the second generating device may be less than one third, preferably less than one fifth of the time interval of operating the first generating device.

The concept of different generating device lengths can be extended to further generating devices.

In particular, the sequence may comprise a third generating device of the plurality of generating devices followed by the second generating device or by a plurality of the second generating devices which in turn is/are followed by the first generating device in a travelling direction of the vehicle or opposite to the travelling direction, wherein the third generating device extends over a third length along the path of travel and wherein the third length is greater than the second length. With reference to the method, a third generating device of the plurality of generating devices may be operated, wherein - with respect to the sequence of the plurality of generating devices - the third generating device is followed by the second generating device or by a plurality of the second generating devices which in turn is/are followed by the first generating device in a travelling direction of the vehicle or opposite to the travelling direction, wherein the third generating device extends over a third length along the path of travel and wherein the third length is greater than the second length.

If the vehicle stops at the vehicle stop location and decelerates during travel from the third generating device via the second generating device towards the first generating device and/or accelerates while departing from the first generating device via the second generating device to the third generating device the vehicle velocity is larger while driving along the third generating device compared to the second generating device. Therefore, the length of the third generating device can be larger compared to the second generating device without increasing the exposure of the environment to magnetic field significantly or at all.

Examples of the invention will be described with reference to the attached drawing. The individual figures of the drawing show:

Fig. 1 schematically a road vehicle stopping at a vehicle stop location on a road where a generating device is integrated in the road,

Fig. 2 schematically an arrangement for transferring energy to a vehicle, the arrangement comprising a plurality of generating devices for generating magnetic fields, wherein a vehicle stops at a vehicle stop location, and

Fig. 3 the arrangement shown in Fig. 2, wherein the vehicle is departing the vehicle stop location and is provided with energy from a generating device located at a distance to the vehicle stop location.

As schematically shown in Fig. 1, a vehicle 1 (in particular a public transport bus) can travel on a path of travel 2, such as a road. There is a generating device 3 integrated in the path of travel for generating a magnetic field at the vehicle position shown in Fig. 1. By operating the generating device 3, magnetic field energy (as indicated by arrows) can be transferred to a receiving device 4 on board the vehicle 1 at the vehicle's bottom. On board the vehicle 1, the receiving device 4 is connected to a rectifier 6, which in turn is connected to an electric network 7 of the vehicle 1 and, via a charger 8, to an energy storage 9.

Fig. 2 schematically shows six generating devices T1, T2, T3, T4, T5, T6, each extending along a different one of consecutive sections of the path of travel, which extends from left to right in the figure. The generating devices T1, T2, T3, T4, T5, T6 (in practice, less or further generating devices can be provided) can be operated (i.e. energized) separately from and independently of each other. A control 15 for controlling operation of the generating devices T1, T2, T3, T4, T5, T6 is connected via control lines to in each case one switch M1, M2, M3, M4, M5, M6 for switching on and off an assigned generating device T1, T2, T3, T4, T5, T6. Alternatively, the operation of the generating devices T1, T2, T3, T4, T5, T6 may be controlled by separate controls. The switches M1, M2, M3, M4, M5, M6 are connected to a three-phase supply line 13 for conducting a three-phase alternating current which is generated by an inverter 55 and provided via a connecting line 11.

Optionally, there may be a loop of an electric line (not shown) also extending along each section of the path of travel of the corresponding generating device T. Each loop may be, for example, a single or multiple winding of an electric conductor. Electromagnetic waves produced by a signal transmitter of the vehicle induce a corresponding electric voltage in the loop. Alternatively, the effective inductance of each loop varies with the presence of a

vehicle nearby and the change of inductance is detected. Each loop may be connected, directly or indirectly, to the control 15.

The generating device T2 is located at a vehicle stop location, such as a bus stop or a stop location at an intersection with traffic lights where vehicles regularly stop. Other possible stop locations are, for example, vehicle parking spaces. In this case, the generating devices for dynamic transfer of energy may be integrated in the access lane to be used by vehicles to access and leave the parking space.

Generally, the plurality of generating devices are arranged in a sequence, one after the other along the path of travel. In the example shown in Fig. 2 and Fig. 3, there is one generating device T1 in front of the generating device T2 at the vehicle stop location and there are four generating devices T3, T4, T5, T6 behind the generating device T2 in the sequence of generating devices. The generating devices T1 and T3 are located next to the first generating device T2. These two generating devices T1, T3 and two other generating devices T4, T5 are designed for dynamic transfer of energy during deceleration (device T1) and acceleration (devices T3, T4, T5) of the vehicle. These four devices T1, T3, T4, T5 have the same length which is larger than the length of the first generating device T2. In the example, the second generating devices T1, T3, T4, T5 have lengths which are twice as long as the length of the first generating device T2. There is a third generating device T6 at the end of the sequence of generating devices. It is designed for dynamic transfer of energy at a higher vehicle velocity, in particular when the vehicle has reached its constant travelling velocity.

In the following, a preferred example of the method of transferring energy to a vehicle is described with reference to Fig. 2 and Fig. 3. When the vehicle is approaching the vehicle stop location, it decelerates and drives along the second generating device T1 in front of the vehicle stop location while the velocity is reduced. For example by detecting the vehicle's position on the path of travel and/or by detecting the presence of the vehicle next to the second generating device T1, it is decided that the vehicle can be provided with energy by the second generating device T1. As a result, the control 15 switches on switch M1 and the second generating device T1 is provided with electric energy by the inverter 55 via the lines 11, 13 and generates a magnetic field.

When it is detected that the vehicle is leaving the section of the path of travel next to (in particular above) the second generating device T1, or when it is detected that the vehicle

has left this section, the control 15 switches off the switch M1. As a result, the second generating device T1 stops operating.

Before, at the same time or after switching off the switch M1, the control 15 switches on switch M2. This switching action may be triggered by the same event (e.g. the detection that the vehicle has left the section next to the second generating device T1) or by another event (such as the detection that the vehicle has reached the vehicle stop location and fully covers the first generating device T2). When the switch M2 is switched on, the operation of the first generating device T2 starts and a corresponding magnetic field for static energy transfer is generated. The transfer power may be significantly higher than the transfer power of the second generating devices T1, T3, T4, T5 and of the third generating device T6. Fig. 2 shows that the vehicle is located at the vehicle stop location and fully covers the first generating device T2 if viewed from above.

When the vehicle is starting acceleration or when the vehicle is leaving or has left the section next to the first generating device T2 (i.e. the vehicle stop location), a corresponding detection can be performed and the control 15 switches off the switch M2. Triggered by the same detection or by another detection (such as the vehicle has reached or fully entered the section next to the second generating device T3) the control 15 switches on the switch M3 and operation of the second generating device T3 starts.

In this manner, while the vehicle is accelerating and is further departing from the vehicle stop location, the consecutive generating devices T3, T4, T5, T6 are started and stopped by switching on and off the assigned switch M3, M4, M5, M6. As mentioned before for the generating devices T1, T2 and for the generating devices T2, T3, the next following generating device T4, T5, T6 may start operation before, at the same time as or after the foregoing generating device T3, T4, T5 stops operation. In particular, the detections mentioned before can be performed in a corresponding manner.

Fig. 3 shows the vehicle when it has almost completely left the section next to the second generating device T3. Preferably, the operation of the second generating device was stopped before and the operation of the second generating device T4 has been started before.

When the vehicle reaches the section next to the third generating device T6, the acceleration performs since the vehicle has left the vehicle stop location terminates and the vehicle travels at constant velocity.

Modifications of this procedure and of the arrangement shown in Fig. 2 and Fig. 3 are possible. For example, the number of generating devices in front of and/or behind the first generating device at the vehicle stop location may differ. In addition or alternatively, the lengths of the second generating devices which are arranged along the deceleration and acceleration section of the path of travel may not be constant as shown in Fig. 3, but may differ. In particular, second generating devices having a larger distance to the vehicle stop location than other second generating devices have larger lengths. With respect to Fig. 2 and Fig. 3, the second generating devices T4 and T5 may be modified to have lengths which are larger than the length of the second generating device T3, but smaller than the length of the third generating device T6. More generally speaking, the higher the vehicle's velocity is expected in the section next to the respective generating device, the longer is the generating device in the direction of the path of travel. Therefore, the exposure of the environment to magnetic fields is reduced, while the effort for mounting and operating the arrangement is moderate.

Claims

1. An arrangement for transferring energy to a vehicle (1) by generating a magnetic field and by inducing an electric voltage in a receiving device (4) of the vehicle (1), the arrangement comprising:
   - a plurality of generating devices (T1, T2, T3, T4, T5, T6) for generating the magnetic field,
   - a control connected to the generating devices (T1, T2, T3, T4, T5, T6), the control (15) being adapted to control operation of each of the generating devices (T1, T2, T3, T4, T5, T6) individually and separately from the other generating devices (T1, T2, T3, T4, T5, T6),

   wherein the plurality of generating devices (T1, T2, T3, T4, T5, T6) is arranged one after the other in a sequence along a path of travel for the vehicle (1),
   wherein a first generating device (T2) of the plurality of generating devices (T1, T2, T3, T4, T5, T6) is located at a vehicle stop location, where the path of travel is designed for a stopping vehicle (1), so that the stopping vehicle (1) can be provided with magnetic field energy generated by the first generating device (T2),
   wherein at least one second generating device (T1, T3, T4, T5) of the plurality of generating devices (T1, T2, T3, T4, T5, T6) is arranged along an acceleration section of the path of travel, where the vehicle (1) may decelerate in order to stop at the vehicle stop location or where the vehicle (1) may accelerate in order to depart from the vehicle stop location.

2. The arrangement of claim 1, wherein the first generating device (T2) extends over a first length along the path of travel and the second generating device (T1, T3,T4, T5) extends over a second length along the path of travel, and wherein the first length is smaller than the second length.

3. The arrangement of claim 2, wherein the sequence comprises a third generating device (T6) of the plurality of generating devices (T1, T2, T3, T4, T5, T6) followed by the second generating device or by a plurality of the second generating devices (T3, T4, T5) which in turn is/are followed by the first generating device (T2) in a travelling direction of the vehicle (1) or opposite to the travelling direction, wherein the third generating device (T6) extends over a third length along the path of travel and wherein the third length is greater than the second length.

4. The arrangement of one of claims 1 to 3, wherein the control (15) is adapted to operate each of the generating devices (T1, T2, T3, T4, T5, T6) for transferring energy to the vehicle (1) stopping or travelling on the path of travel only while the vehicle (1) at least partially covers the generating device (T1, T2, T3, T4, T5, T6).

5. The arrangement of claim 4, wherein the control (15) is adapted not to operate the generating device (T1, T2, T3, T4, T5, T6) if a person, an animal and/or a foreign object is detected to be present in a vicinity of the generating device (T1, T2, T3, T4, T5, T6).

6. A method of transferring energy to a vehicle (1) by generating a magnetic field, so that a receiving device (4) of the vehicle (1) may receive the magnetic field and an electric voltage may be induced in the receiving device (4) of the vehicle (1), the method comprising:
   - operating a plurality of generating devices (T1, T2, T3, T4, T5, T6) for generating the magnetic field, wherein the plurality of generating devices (T1, T2, T3, T4, T5, T6) are arranged one after the other in a sequence along a path of travel for a vehicle (1),
   - controlling the operation of each of the generating devices (T1, T2, T3, T4, T5, T6) individually and separately from the other generating devices (T1, T2, T3, T4, T5, T6),
   - operating a first generating device (T2) of the plurality of generating devices (T1, T2, T3, T4, T5, T6) for transferring energy to a vehicle (1) while the vehicle (1) stops at a vehicle stop location,
   - operating at least one second generating device (T1, T3, T4, T5) of the plurality of generating devices (T1, T2, T3, T4, T5, T6) for transferring energy to the vehicle (1) while the vehicle (1) decelerates in order to stop at the vehicle stop location or while the vehicle (1) accelerates in order to depart from the vehicle stop location.

7. The method of claim 6, wherein the first generating device (T2) extends over a first length along the path of travel, thereby generating the magnetic field over the first length while the vehicle (1) stops at the vehicle stop location, and the second generating device (T1, T3, T4, T5) extends over a second length along the path of travel, thereby generating the magnetic field over the second length while the

vehicle (1) drives along the second length, and wherein the first length is smaller than the second length.

8. The method of claim 6 or 7, wherein a third generating device (T6) of the plurality of generating devices (T1, T2, T3, T4, T5, T6) is operated, wherein - with respect to the sequence of the plurality of generating devices (T1, T2, T3, T4, T5, T6) - the third generating device (T6) is followed by the second generating device or by a plurality of the second generating devices (T3, T4, T5) which in turn is/are followed by the first generating device (T2) in a travelling direction of the vehicle (1) or opposite to the travelling direction, wherein the third generating device (T6) extends over a third length along the path of travel and wherein the third length is greater than the second length.

9. The method of one of claims 6 to 8, wherein each of the generating devices (T1, T2, T3, T4, T5, T6) is operated only while the generating device is at least partially covered by the vehicle (1).

10. The method of claim 9, wherein the generating device (T1, T2, T3, T4, T5, T6) is not operated if a person, an animal and/or a foreign object is detected to be present in a vicinity of the generating device (T1, T2, T3, T4, T5, T6).

Application No:	GB1508160.7	**Examiner:**	Robert Barrell
Claims searched:	1 to 10	**Date of search:**	26 November 2015

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 to 4 and 6 to 9	US 6421600 B1 (ROSS) See: column 13, lines 23 to 45; column 19, line 51 to column 20, line 16; column 21, line 64 to column 22, line 12; and figs 1 and 6
X	1, 4, 5, 6, 9 and 10	US 2011/0184842 A1 (MELEN) See: the abstract; figs 2, 4C, 11A and 11B; and paragraphs 0045, 0053, 0085 and 0087
X	1, 4 , 6 and 9	WO 2012/126726 A2 (SIEMENS) See: page 2, line 28 to page 4, line 12; and figs 1 and 2

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B60L; B60M

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B60L	0011/18	01/01/2006
B60M	0007/00	01/01/2006