Patent Claims

1. An arrangement for providing a vehicle, in particular a track bound vehicle and/or a road automobile, with electric energy, wherein
   - the arrangement comprises a receiving device (1) adapted to receive an alternating electromagnetic field and to produce an alternating electric current by electromagnetic induction,
   - the receiving device (1) comprises at least one inductance (3) which is formed by an electrically conducting material for producing one phase of the alternating electric current by the electromagnetic induction,
   - the at least one inductance (3) and optionally at least one further electrical element (4), which is connected to the inductance (3) in order to produce one phase of the alternating electric current, comprise(s) a resonance frequency at which the phase of the alternating electric current is produced if an alternating electromagnetic field of corresponding frequency is received by the receiving device (1),
   - the inductance (3) and optionally the at least one further electrical element (4) is/are connected to a rectifier (10) for rectifying the alternating electric current and thereby producing a direct electric current,
   - the rectifier (10) comprises at least one automatically controllable switch (12, 13) which is or – in case of more than one automatically controllable switch (12, 13) - which are arranged in such a manner that closing the switch (12, 13) or closing a plurality of the switches results in a short circuit across the inductance (3) or across two or more of the inductances (3), optionally including the at least one further electrical element(s) (4),
   - the arrangement comprises a control device which is adapted to control the at least one automatically controllable switch (12, 13) and
   - the control device is adapted to switch on and off the at least one automatically controllable switch (12, 13) at a frequency which is smaller than the resonance frequency.

2. The arrangement of the preceding claim, wherein the receiving device (1) comprises a plurality of phase lines (2a, 2b, 2c) of electrically conducting material, wherein each phase line (2a, 2b, 2c) comprises one of the inductances (3), each inductance (3) being adapted to produce one of a plurality of phases of the alternating electric current and wherein the phase lines (2a, 2b, 2c) are connected to each other to form a star

point connection at one end of the phase line (2a, 2b, 2c) and are connected to the rectifier (10) at the opposite end of the phase line (2a, 2b, 2c).

3. The arrangement of the preceding claim, wherein each of the opposite ends of the phase lines (2a, 2b, 2c) is connected to one of a plurality of bridges of the rectifier (10), wherein each bridge comprises two one-way valves (14, 15) which are connected in series to each other, wherein each valve (14, 15) is adapted to conduct an electric current in one direction only and wherein at least one of the valves of each bridge is a combined with one of the automatically controllable switches (12, 13), so that – if the switch (12, 13) is on – an electric current can flow in the opposite direction through the valve (14, 15) or can bypass the valve (14, 15) in the opposite direction.

4. The arrangement of one of the preceding claims, wherein the at least one automatically controllable switch (12, 13) is combined with a valve (14, 15) of the rectifier (10), wherein the valve (14, 15) is adapted to conduct an electric current in one direction only and wherein – if the switch (12, 13) is on – an electric current can flow in the opposite direction through the valve or can bypass the valve (14, 15) in the opposite direction, wherein the control device is adapted to enable switching on the switch (12, 13) only while the size of the electric current through the valve (14, 15) is zero or is smaller than a predetermined threshold value.

5. The arrangement of one of the preceding claims, wherein the control device comprises a controller which is adapted to control the ratio of the time intervals while the at least one automatically controllable switch (12, 13) is on – and therefore the short circuit exists - to the time intervals while the at least one automatically controllable switch (12, 13) is off.

6. The arrangement of one of the preceding claims, wherein the control device is adapted to control the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current at the direct current side of the rectifier (10).

7. The arrangement of the preceding claim, wherein the arrangement comprises a storage for storing electric energy which is delivered by the rectifier (10), wherein the rectifier (10) is connected to the storage and wherein the control device is adapted to

control the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current which is required for charging the storage.

8. A vehicle comprising the arrangement of one of the preceding claims, wherein the rectifier (10) is connected to a storage for storing electric energy.

9. A method of operating a vehicle, in particular a track bound vehicle and/or a road automobile, using electric energy, wherein
   - an alternating electromagnetic field is received and is used to produce an alternating electric current by electromagnetic induction,
   - the alternating electromagnetic field is received by at least one inductance (3) which is formed by an electrically conducting material and which produces one phase of the alternating electric current by the electromagnetic induction,
   - the inductance (3) and optionally at least one further electrical element (4), which is connected to the inductance (3), produce the phase of the alternating electric current at a resonance frequency,
   - the alternating electric current is rectified by a rectifier (10) and thereby a direct electric current is produced,
   - the rectifier (10) is operated using at least one automatically controllable switch (12, 13) which is or – in case of more than one automatically controllable switch (12, 13) - which are temporarily closed so that a short circuit across the inductance (3) or across two or more of the inductances (3) - optionally including the at least one further electrical element(s) (4) - is effected,
   - the at least one automatically controllable switch (12, 13) is to controlled by a control device so that the at least one automatically controllable switch (12, 13) is switched on and off at a frequency which is smaller than the resonance frequency.

10. The method of the preceding claim, wherein the alternating electric current is produced using a plurality of phase lines (2a, 2b, 2c) of electrically conducting material, wherein each phase line (2a, 2b, 2c) comprises one of the inductances (3) which produces one of a plurality of phases of the alternating electric current.

11. The method of one the preceding claims, wherein the rectifier (10) comprises a valve (14, 15) which is used to rectify the alternating electric current, wherein the

automatically controllable switch (12, 13) is combined with the valve (14, 15), wherein the valve (14, 15) conducts - in a first operating state while the switch (12, 13) is off – an electric current in one direction only and the valve or a bypass of the valve (14, 15) can conduct - in a second operating state while the switch (12, 13) is on – an electric current in the opposite direction, wherein switching on the switch (12, 13) is enabled only while the size of the electric current through the valve (14, 15) is zero or is smaller than a predetermined threshold value.

12. The method of one of the preceding claims, wherein the ratio of the time intervals while the at least one automatically controllable switch (12, 13) is on – and therefore the short circuit exists - to the time intervals while the at least one automatically controllable switch (12, 13) is off is controlled by the control device.

13. The method of one of the preceding claims, wherein the control device controls the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current at the direct current side of the rectifier (10).

14. The method of the preceding claim, wherein electric energy is delivered by the rectifier (10) to an energy storage of the vehicle and wherein the control device controls the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current which is required for charging the storage.

15. A method of manufacturing a vehicle, in particular a track bound vehicle and/or a road automobile, comprising the following steps:
    - providing a receiving device (1) adapted to receive an alternating electromagnetic field and to produce an alternating electric current by electromagnetic induction,
    - providing for the receiving device (1) at least one inductance (3) which is formed by an electrically conducting material for producing one phase of the alternating electric current by the electromagnetic induction,
    - adapting the at least one inductance (3) and optionally at least one further electrical element (4), which is connected to the inductance (3) in order to produce one phase of the alternating electric current, to operate at a resonance frequency at which the phase of the alternating electric current is produced if an alternating electromagnetic field of corresponding frequency is received by the receiving device (1),

- connecting the inductance (3) and optionally the at least one further electrical element to a rectifier (10) for rectifying the alternating electric current and thereby producing a direct electric current,
- arranging at least one automatically controllable switch (12, 13) of the rectifier (10) in such a manner that closing the switch (12, 13) or closing a plurality of the switches (12, 13) results in a short circuit across the inductance (3) or across two or more of the inductances (3), optionally including the at least one further electrical element(s) (4),
- providing a control device and adapting the control device so that it is able to control the at least one automatically controllable switch (12, 13) and
- adapting the control device so that it is able to switch on and off the at least one automatically controllable switch (12, 13) at a frequency which is smaller than the resonance frequency.

Claims

1. An arrangement for providing a vehicle, in particular a track bound vehicle and/or a road automobile, with electric energy, wherein

   - the arrangement comprises a receiving device (1) adapted to receive an alternating electromagnetic field and to produce an alternating electric current by electromagnetic induction,

   - the receiving device (1) comprises at least one inductance (3) which is formed by an electrically conducting material for producing one phase of the alternating electric current by the electromagnetic induction,

   - the at least one inductance (3) and optionally at least one further electrical element (4), which is connected to the inductance (3) in order to produce one phase of the alternating electric current, comprise(s) a resonance frequency at which the phase of the alternating electric current is produced if an alternating electromagnetic field of corresponding frequency is received by the receiving device (1),

   - the inductance (3) and optionally the at least one further electrical element (4) is/are connected to a rectifier (10) for rectifying the alternating electric current and thereby producing a direct electric current, the arrangement characterized in that

   - the rectifier (10) comprises at least one automatically controllable switch (12, 13) which is or - in case of more than one automatically controllable switch (12, 13) - which are arranged in such a manner that closing the switch (12, 13) or closing a plurality of the switches results in a short circuit across the inductance (3) or across two or more of the inductances (3), optionally including the at least one further electrical element(s) (4),

   - the arrangement comprises a control device which is adapted to control the at least one automatically controllable switch (12, 13) and

   - the control device is adapted to switch on and off the at least one automatically controllable switch (12, 13) at a frequency which is smaller than the resonance frequency.

2. The arrangement of the preceding claim, wherein the receiving device (1) comprises a plurality of phase lines (2a, 2b, 2c) of electrically conducting material, wherein each

phase line (2a, 2b, 2c) comprises one of the inductances (3), each inductance (3) being adapted to produce one of a plurality of phases of the alternating electric current and wherein the phase lines (2a, 2b, 2c) are connected to each other to form a star point connection at one end of the phase line (2a, 2b, 2c) and are connected to the rectifier (10) at the opposite end of the phase line (2a, 2b, 2c).

3. The arrangement of the preceding claim, wherein each of the opposite ends of the phase lines (2a, 2b, 2c) is connected to one of a plurality of bridges of the rectifier (10), wherein each bridge comprises two one-way valves (14, 15) which are connected in series to each other, wherein each valve (14, 15) is adapted to conduct an electric current in one direction only and wherein at least one of the valves of each bridge is combined with one of the automatically controllable switches (12, 13), so that - if the switch (12, 13) is on - an electric current can flow in the opposite direction through the valve (14, 15) or can bypass the valve (14, 15) in the opposite direction.

4. The arrangement of one of the preceding claims, wherein the at least one automatically controllable switch (12, 13) is combined with a valve (14, 15) of the rectifier (10), wherein the valve (14, 15) is adapted to conduct an electric current in one direction only and wherein - if the switch (12, 13) is on - an electric current can flow in the opposite direction through the valve or can bypass the valve (14, 15) in the opposite direction, wherein the control device is adapted to enable switching on the switch (12, 13) only while the size of the electric current through the valve (14, 15) is zero or is smaller than a predetermined threshold value.

5. The arrangement of one of the preceding claims, wherein the control device comprises a controller which is adapted to control the ratio of the time intervals while the at least one automatically controllable switch (12, 13) is on - and therefore the short circuit exists - to the time intervals while the at least one automatically controllable switch (12, 13) is off.

6. The arrangement of one of the preceding claims, wherein the control device is adapted to control the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current at the direct current side of the rectifier (10).

7. The arrangement of the preceding claim, wherein the arrangement comprises a

storage for storing electric energy which is delivered by the rectifier (10), wherein the rectifier (10) is connected to the storage and wherein the control device is adapted to control the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current which is required for charging the storage.

8. A vehicle comprising the arrangement of one of the preceding claims, wherein the rectifier (10) is connected to a storage for storing electric energy.

9. A method of operating a vehicle, in particular a track bound vehicle and/or a road automobile, using electric energy, wherein

   - an alternating electromagnetic field is received and is used to produce an alternating electric current by electromagnetic induction,
   - the alternating electromagnetic field is received by at least one inductance (3) which is formed by an electrically conducting material and which produces one phase of the alternating electric current by the electromagnetic induction,
   - the inductance (3) and optionally at least one further electrical element (4), which is connected to the inductance (3), produce the phase of the alternating electric current at a resonance frequency,
   - the alternating electric current is rectified by a rectifier (10) and thereby a direct electric current is produced, the method characterized in that
   - the rectifier (10) is operated using at least one automatically controllable switch (12, 13) which is or - in case of more than one automatically controllable switch (12, 13) - which are temporarily closed so that a short circuit across the inductance (3) or across two or more of the inductances (3) - optionally including the at least one further electrical element(s) (4) - is effected,
   - the at least one automatically controllable switch (12, 13) is controlled by a control device so that the at least one automatically controllable switch (12, 13) is switched on and off at a frequency which is smaller than the resonance frequency.

10. The method of the preceding claim, wherein the alternating electric current is produced using a plurality of phase lines (2a, 2b, 2c) of electrically conducting material, wherein each phase line (2a, 2b, 2c) comprises one of the inductances (3)

which produces one of a plurality of phases of the alternating electric current.

11. The method of one the preceding claims, wherein the rectifier (10) comprises a valve (14, 15) which is used to rectify the alternating electric current, wherein the automatically controllable switch (12, 13) is combined with the valve (14, 15), wherein the valve (14, 15) conducts - in a first operating state while the switch (12, 13) is off - an electric current in one direction only and the valve or a bypass of the valve (14, 15) can conduct - in a second operating state while the switch (12, 13) is on - an electric current in the opposite direction, wherein switching on the switch (12, 13) is enabled only while the size of the electric current through the valve (14, 15) is zero or is smaller than a predetermined threshold value.

12. The method of one of the preceding claims, wherein the ratio of the time intervals while the at least one automatically controllable switch (12, 13) is on - and therefore the short circuit exists - to the time intervals while the at least one automatically controllable switch (12, 13) is off is controlled by the control device.

13. The method of one of the preceding claims, wherein the control device controls the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current at the direct current side of the rectifier (10).

14. The method of the preceding claim, wherein electric energy is delivered by the rectifier (10) to an energy storage of the vehicle and wherein the control device controls the switching of the at least one automatically controllable switch (12, 13) depending on the size(s) of the voltage and/or current which is required for charging the storage.

15. A method of manufacturing a vehicle, in particular a track bound vehicle and/or a road automobile, comprising the following steps:

    - providing a receiving device (1) adapted to receive an alternating electromagnetic field and to produce an alternating electric current by electromagnetic induction,

    - providing for the receiving device (1) at least one inductance (3) which is formed by an electrically conducting material for producing one phase of the alternating electric current by the electromagnetic induction,

- adapting the at least one inductance (3) and optionally at least one further electrical element (4), which is connected to the inductance (3) in order to produce one phase of the alternating electric current, to operate at a resonance frequency at which the phase of the alternating electric current is produced if an alternating electromagnetic field of corresponding frequency is received by the receiving device (1),

- connecting the inductance (3) and optionally the at least one further electrical element to a rectifier (10) for rectifying the alternating electric current and thereby producing a direct electric current,
  characterized in the steps:

- arranging at least one automatically controllable switch (12, 13) of the rectifier (10) in such a manner that closing the switch (12, 13) or closing a plurality of the switches (12, 13) results in a short circuit across the inductance (3) or across two or more of the inductances (3), optionally including the at least one further electrical element(s) (4),

- providing a control device and adapting the control device so that it is able to control the at least one automatically controllable switch (12, 13) and

- adapting the control device so that it is able to switch on and off the at least one automatically controllable switch (12, 13) at a frequency which is smaller than the resonance frequency.