Claims

1. An arrangement for providing a vehicle (81) with electric energy, wherein the arrangement comprises a receiving device (85) adapted to receive an alternating electromagnetic field and to produce an alternating electric current by magnetic induction, wherein the receiving device (85) comprises at least one phase line (9, 10, 11; 19), wherein in case of a single phase line (19) the phase line (19) is adapted to carry a phase current of the alternating electric current and wherein in case of a plurality of phase lines (9, 10, 11), each phase line (9, 10, 11) being is adapted to carry a different one of a plurality of phase currents of the alternating electric current,

   wherein

   - each the phase line (19) or at least one of the phase lines (9, 10, 11) forms at least two three coils (C),
   - each coil (C) consists of at least one turn of the phase line (9, 10, 11),
   - if any one of the coils (C) consists of one turn, the turn is turning around a central axis of the coil,
   - if any one of the coils (C) consists of more than one turn, the turns are consecutive sections of the phase line (9, 10, 11) turning around a central axis of the coil (C),
   - the at least two three coils (C) of each the phase line (9, 10, 11; 19) are located next to each other so as to form a sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) which covers an effective area in a plane that extends perpendicularly to the central axes of the coils (C), so that there are a first (GCL; RCL; BCL; CL) and a second (GCR; RCR; BCR; CR) end coil at the opposite ends of the sequence and optionally, in the case of three or more coils, at least one middle coil (GCM1, GCM2; RCM1, RCM2; BCM, BCM2; CM1, CM2) in between the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) of the sequence,

   for at least one of the phase lines (9, 10, 11), the number of turns per coil of the sequence (G, R, B) of coilswherein each of the end coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CR) differs of the sequence (G, R, B) consists of a smaller number of turns than the middle coil or middle coils (GCM1, GCM2; RCM1, RCM2; BCM, BCM2; CM1, CM2).

~~2. The arrangement of the preceding claim, wherein the at least one of the phase lines (9, 10, 11) comprises three or more than three coils (C), so that the sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR) comprises at least one middle coil (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2) in between the end coils of the sequence, and wherein each of the end coils (GCL, GCR; RCL, RCR; BCL, BCR) consists of a smaller number of turns than the middle coil or middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2).~~

~~3~~2. The arrangement of claim 1 ~~or 2~~, wherein the phase line (19) or the at least one of the phase lines (9, 10, 11) comprises at least four coils (C), so that the sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) comprises at least two middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2; CM1, CM2), and wherein the ratio of the number of turns forming each of the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) to the number of turns forming each of the middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2; CM1, CM2) next to the respective end coil is in the range of 0.4 to 0.6~~, in particular 0.5~~.

3. The arrangement of claim 2, wherein the ratio of the number of turns forming each of the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) to the number of turns forming each of the middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2) next to the respective end coil is 0.5.

4. The arrangement of one of ~~the preceding~~ claims 1 to 3, wherein each of the coils (C) of the phase line (19) or of the at least one of the phase lines (9, 10, 11) covers an area of the same size as the other coils (C) of the same sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) within the plane that extends perpendicularly to the central axes of the coils (C).

5. The arrangement of one of ~~the preceding~~ claims 1 to 4, wherein the coils (C) of the phase line (19) or of the at least one of the phase lines (9, 10, 11) which are parts of the same sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) are positioned shifted relative to each other – with respect to a longitudinal direction extending from the first end coil (GCL; RCL; BCL; CL) to the second end coil (GCR; RCR; BCR; CR) – by a constant first shift length (SL1), wherein the first shift length (SL1) is equal to one half of a wave length of a pre-

defined electromagnetic wave which is produced by the alternating electromagnetic field while propagating in the longitudinal direction during operation of the arrangement.

6. The arrangement of one of ~~the preceding~~ claims 1 to 5, wherein the coils (C) of each of the ~~at least one~~ plurality of phase lines (9, 10, 11) which are parts of the same sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR) are positioned shifted relative to each other – with respect to a longitudinal direction extending from the first end coil (GCL; RCL; BCL) to the second end coil (GCR; RCR; BCR) – by a constant first shift length (SL1), wherein the different sequences of coils of the phase lines (9, 10, 11) are positioned shifted relative to each other – with respect to a longitudinal direction extending from the first end coil (GCL; RCL; BCL) to the second end coil (GCR; RCR; BCR) of any of the sequences of coils – at a second shift length (SL2), wherein the second shift length (SL2) is equal to an integer multiple of the first shift length (SL1) divided by the number of phase lines (9, 10, 11).

7. A vehicle (81) comprising the arrangement of one of ~~the preceding~~ claims 1 to 6, wherein the arrangement is located at the bottom of the vehicle (81), so that the central axes of the coils (C) extend in vertical direction, provided that the vehicle (81) travels on a horizontal underground or horizontal track.

8. A system for transferring energy to a vehicle (81), wherein the system comprises a primary side electric conductor arrangement, which is arranged along a path of travel of the vehicle (81), wherein the primary side conductor arrangement is adapted to carry an alternating current which generates a respective alternating electromagnetic field and wherein the system comprises the arrangement of one of claims 1 to 6 as a secondary side arrangement for receiving the alternating electromagnetic field in order to produce an alternating electric current by magnetic induction.

9. The system of ~~the preceding~~ claim 8, wherein the coils (C) of the phase line (19) or of the at least one of the phase lines (9, 10, 11) which are parts of the same sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) are positioned shifted relative to each other – with respect to a longitudinal direction extending from the first end coil (GCL; RCL; BCL; CL) to the second end coil (GCR; RCR; BCR; CR) – by a constant first shift length (SL1), wherein the first shift length (SL1) is equal to one half of a wave length of a pre-defined electromagnetic wave which is produced by the alternating electromagnetic field while propagating in the

longitudinal direction during operation of the arrangement and wherein the primary side electric conductor arrangement is adapted to produce the pre-defined electromagnetic wave.

10. A method of manufacturing an arrangement for providing a vehicle (81) with electric energy, wherein a receiving device (85) of the arrangement is manufactured which is adapted – during operation - to receive an alternating electromagnetic field and to produce an alternating electric current by magnetic induction, wherein the receiving device (85) is equipped with a ~~plurality of~~ phase lines ~~(19, 10, 11),~~ or a plurality of phase lines (9, 10, 11; 19), wherein in case of a single phase line (19) the phase line (19) is adapted – during operation – to carry a phase current of the alternating electric current and wherein in case of a plurality of phase lines (9, 10, 11) each phase line (9, 10, 11) ~~being~~ is adapted – during operation - to carry a different one of a plurality of phases currents of the alternating electric current,

wherein

- at least ~~two~~ three coils (C) are formed by ~~each~~ the phase line (19) or by at least one of the phase lines (9, 10, 11),
- each coil is constituted by at least one turn of the phase line (9, 10, 11; 19),
- if any one of the coils (C) is constituted by one turn, the turn is formed so as to turn around a central axis of the coil,
- if any one of the coils (C) is constituted by more than one turn, the turns are formed as consecutive sections of the phase line (9, 10, 11; 19) so as to turn around a central axis of the coil,
- the at least ~~two~~ three coils (C) of ~~each~~ the phase line (9, 10, 11; 19) are located next to each other so as to form a sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) which covers an effective area in a plane that extends perpendicularly to the central axes of the coils (C), so that there are a first (GCL; RCL; BCL; CL) and a second (GCR; RCR; BCR; CR) end coil at the opposite ends of the sequence and ~~optionally~~ at least one middle coil (GCM1, GCM2; RCM1, RCM2; BCM, BCM2; CM1, CM2) in between the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) of the sequence,
- ~~for at least one of the phase lines (9, 10, 11), the number of turns per~~each of the end coils ~~of the sequence (G, R, B) of coils~~ (GCL, ~~GCM1, GCM2,~~ GCR; RCL, ~~RCM1, RCM2,~~ RCR; BCL, ~~BCM1, BCM2,~~ BCR) ~~differs~~ of the sequence (G, R, B)

is constituted by a smaller number of turns than the middle coil or middle coils (GCM1, GCM2; RCM1, RCM2; BCM, BCM2; CM1, CM2).

~~11. The method of the preceding claim, wherein the at least one of the phase lines (9, 10, 11) is equipped with three or more than three coils (C), so that the sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR) comprises at least one middle coil (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2), and wherein each of the end coils (GCL, GCR; RCL, RCR; BCL, BCR) is constituted by a smaller number of turns than the middle coil or middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2).~~

~~12~~11. The method of claim 10 ~~or 11~~, wherein the phase line (19) or the at least one of the phase lines (9, 10, 11) is equipped with at least four coils (C), so that the sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) comprises at least two middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2; CM1, CM2), and wherein the ratio of the number of turns forming each of the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) to the number of turns forming the middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2; CM1, CM2) next to the respective end coil is chosen to be in the range of 0.4 to 0.6~~, in particular 0.5~~.

12. The method of claim 11, wherein the ratio of the number of turns forming each of the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) to the number of turns forming the middle coils (GCM1, GCM2; RCM1, RCM2; BCM1, BCM2; CM1, CM2) next to the respective end coil is chosen to be 0.5.

13. The method of one of claims 10 to 12, wherein at least one measurement, simulation and/or calculation of a field intensity of an electromagnetic, electric or magnetic field produced by the arrangement and alternatively or in addition produced by a system, which includes the arrangement and further includes a primary side conductor arrangement for generating an electromagnetic field, is performed and based on a result of the measurement, simulation and/or calculation the number of turns of the coils of the phase line (19) or of the at least one of the phase lines (9, 10, 11) is varied and chosen for the arrangement to be used in practice.

14. A method of operating a vehicle (81) by means of a receiving device (85) which receives an alternating electromagnetic field and produces an alternating electric current

by magnetic induction, wherein ~~a plurality of~~ at least one phase lines (9, 10, 11) is used by the receiving device (85), wherein in case of a single phase line (19) the phase line (19) carries a phase current of the alternating electric current and wherein in case of a plurality of phase lines (9, 10, 11) each phase line (9, 10, 11) carries a different one of a plurality of phases of the alternating electric current,

wherein

- ~~each~~ the phase line (19) or at least one of the phase lines (9, 10, 11) is operated using at least ~~two~~ three coils (C),
- in each coil the alternating electric current is carried by at least one turn of the phase line (9, 10, 11),
- if any one of the coils (C) consists of one turn, the turn is turning around a central axis of the coil,
- if any one of the coils (C) consists of more than one turn, the turns are consecutive sections of the phase line (9, 10, 11) turning around a central axis of the coil,
- the at least ~~two~~ three coils (C) of ~~each~~ the phase line (9, 10, 11; 19) are used as a sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) which covers an effective area in a plane that extends perpendicularly to the central axes of the coils (C), so that there are a first (GCL; RCL; BCL; CL) and a second (GCR; RCR; BCR; CR) end coil at the opposite ends of the sequence and ~~optionally~~ at least one middle coil (GCM1, GCM2; RCM1, RCM2; BCM, BCM2; CM1, CM2) in between the end coils (GCL, GCR; RCL, RCR; BCL, BCR; CL, CR) of the sequence,
- ~~in at least one of the phase lines (9, 10, 11)~~ sequence, the phase current of the alternating electric current flows through ~~coils having a different number of turns per coil within the sequence (G, R, B) of~~ the end coils (GCL, ~~GCM1, GCM2,~~ GCR; RCL, ~~RCM1, RCM2,~~ RCR; BCL, ~~BCM1, BCM2,~~ BCR; CL, CR) of the sequence consisting of a smaller number of turns than the middle coil or middle coils (GCM1, GCM2; RCM1, RCM2; BCM, BCM2; CM1, CM2) of the sequence.

15. The method of ~~the preceding~~ claim 14, wherein the coils (C) of the ~~at least one~~ phase line (19) or of the at least one of the phase lines (9, 10, 11) which coils (C) are parts of the same sequence (G, R, B) of coils (GCL, GCM1, GCM2, GCR; RCL, RCM1, RCM2, RCR; BCL, BCM1, BCM2, BCR; CL, CM1, CM2, CR) are used at shifted positions – with respect to a longitudinal direction extending from the first end coil (GCL; RCL; BCL; CL) to the second end coil (GCR; RCR; BCR; CR) – by a constant first shift length (SL1),

wherein the first shift length (SL1) is equal to one half of a wave length of a pre-defined electromagnetic wave which is produced by the alternating electromagnetic field while propagating in the longitudinal direction.