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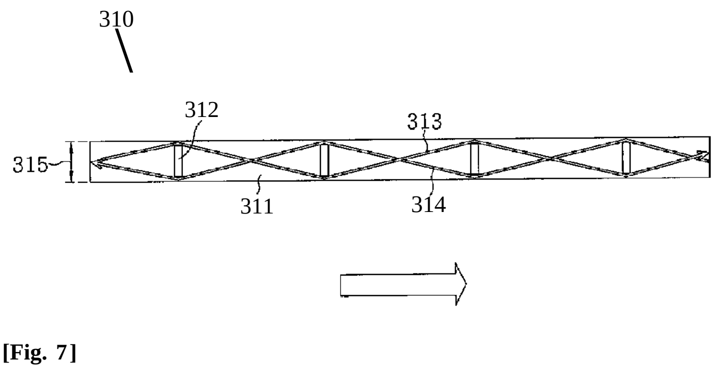
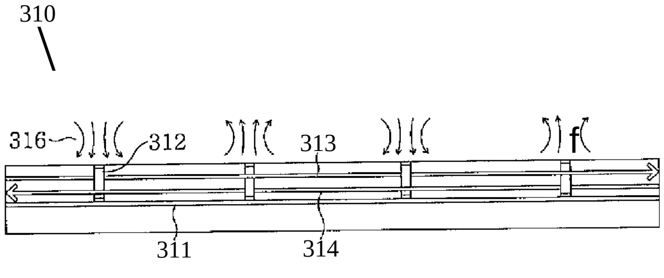
(54) **Title:** POWER SUPPLY AND ACQUISITION DEVICE FOR ON-LINE ELECTRIC VEHICLE

[Fig. 6]



[Fig. 7]



(57) Abstract: A power supply device which supplies power to an electric vehicle in a magnetic induction method, includes a plurality of power supply core units. Each of the power supply core units has a plurality of magnetic poles arranged at a predetermined distance from each other along a traveling direction of a road and has a width equal to or less than 1/2 of the distance between the magnetic poles in a direction perpendicular to the traveling direction of the electric vehicle on the road. Further, the power supply device includes a plurality of power supply lines arranged along the traveling direction of the electric vehicle on the road such that the magnetic poles of the adjacent power supply core units have different polarities.

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Description

Title of Invention: POWER SUPPLY AND ACQUISITION DEVICE FOR ON-LINE ELECTRIC VEHICLE

Technical Field

[1] The present invention relates to a non-contact power supply and acquisition device for an on-line electric vehicle, and more particularly, to a power supply device which includes a power supply core unit having a plurality of magnetic poles arranged at a predetermined distance from each other along the traveling direction of the electric vehicle on a road and having a small width in a direction perpendicular to the traveling direction of the electric vehicle on the road, and a power supply line disposed along the traveling direction of the road such that the adjacent magnetic poles of the power supply core unit have different polarities, and a power acquisition device which is capable of receiving power from the power supply device in a magnetic induction method and installed in the electric vehicle.

[2]

Background Art

[3] Existing battery-powered electric vehicles have problems such as an excessive capacity, a long charging time, low charging efficiency and a short lifetime of batteries, a request for a charging station, and an increase in weight or volume and cost of the vehicles due to such batteries.

[4] In order to solve the above problems, there has been proposed a non-contact power delivery scheme using magnetic induction. In particular, one example of the non-contact power delivery scheme includes a power supply and acquisition apparatus for an on-line electric vehicle, which has been developed by the assignee of the present application, Korea Advanced Institute of Science and Technology (KAIST). The power supply and acquisition apparatus includes a power supply device embedded along a road and a power acquisition device installed on the on-line electric vehicle, which is capable of supplying a power required for the vehicle from the road, and charges a battery with the power, while being driven.

[5] The on-line electric vehicle requires a structure capable of normally delivering power, even though a distance between a power acquisition device and the road surface, that is, an air gap is increased. Furthermore, in order to allow the on-line electric vehicle to travel along the road, power acquisition needs to be smoothly performed, even though the on-line electric vehicle deviates from the center of the power supply device embedded in the road and moves more or less in the left or right direction.

[6] Fig. 1 illustrates an exemplary power supply and acquisition apparatus for an on-line electric vehicle. The apparatus includes an E-shaped power supply device 110 embedded along a road and a power acquisition device 120 installed on the on-line electric vehicle 130. The power supply device 110 includes a power supply core unit 111 and power supply lines 113. The power supply core unit 111 includes three magnetic poles 112 upwardly formed in a direction perpendicular to the traveling direction of the electric vehicle. The power acquisition device 120 is typically attached under the electric vehicle 130, and includes a power acquisition core unit 121 and a power acquisition coil 123. The power acquisition core unit 121 has three magnetic poles 122 opposite to the three magnetic poles 112, respectively. In the power supply and acquisition apparatus, the distribution of magnetic force lines is the same anywhere in the longitudinal direction of the road. Furthermore, a voltage induced in the power acquisition device 120 has the same as that induced when the electric vehicle 130 is stopped as well as being driven.

[7] Based on such a principle, for example, the PATH (Partners for Advanced Transit and Highways) team led by University of California at Berkeley has developed a non-contact power delivery technology since from 1988. In the non-contact power delivery technology, an air gap of 2-3 inch (about 5-7.5 cm) could be realized, and power could be transferred even though a vehicle is deviated about 15 cm in the left or right.

[8] In addition, Bombardier Inc. of Germany, headquartered in Canada, has applied a non-contact power delivery technology to a railway vehicle, and it is reported that an air gap of about 6 cm has been realized. In the railway vehicle, since left and right steering is not required, no deviation occurs in the left and right direction. Therefore, the width of the power supply device could be reduced to about 15 cm, and system power efficiency has been increased to about 92% or more.

[9] Figs. 2 and 3 show a front view and a plan view, respectively, of a monorail power supply and acquisition apparatus; and Figs. 4 and 5 show a front view and a plan view, respectively, of a dual-rail power supply and acquisition apparatus.

[10] In Figs. 2 and 3, the monorail power supply and acquisition apparatus includes a power supply device 210 embedded along a road and a power acquisition device 220 installed on an on-line electric vehicle. The power supply device 210 includes an E-shaped power supply core unit 211 and a power supply line 212; and the power acquisition device 220 includes a flat power acquisition unit 213 and a power acquisition coil 214. Similarly, In Figs. 4 and 5, the dual-rail power supply and acquisition apparatus includes a power supply device 230 embedded along a road and a power acquisition device 240 installed on an on-line electric vehicle. The power supply device 230 includes two E-shaped power supply core units 231 and two power supply lines 232; and the power acquisition device 240 includes a flat power acquisition unit 233

and two power acquisition coils 234. In this connection, one power supply line defines a monorail and two power supply lines define a dual-rail.

[11] One example of a power supply and acquisition apparatus is disclosed in a PCT application PCT/KR2010/000856, filed on February 11, 2010, entitled POWER SUPPLY DEVICE, POWER ACQUISITION DEVICE AND SAFETY SYSTEM FOR ELECTROMAGNETIC INDUCTION-POWERED ELECTRIC VEHICLE, which is assigned to the assignee of the present application.

[12] On June and August, 2009, the assignee of the present application has accomplished a system power efficiency of about 70% or more while increasing an air gap to about 16 cm or more by using the power supply acquisition apparatus as shown in Figs. 2 to 5. Considering a depth at which the power supply device is embedded in the road, an air gap of about 20 cm has been accomplished. Furthermore, the permissible amount of the left and right deviation in the power supply and acquisition apparatus ranges from about 20 to 40 cm. Accordingly, it is expected that the power supply and acquisition apparatus is highly likely to be put to practical use.

[13] However, in the power supply and acquisition apparatus, there exists a problem in that the width of a power supply rail needs to be about two times larger than a desired air gap. For example, given the desired air gap of 25 cm, the width of the power supply rail needs to be about 50 cm. In the case of the monorail power supply and acquisition apparatus shown in Figs. 2 and 3, the width of the power supply device 210 is the same as that of the power supply rail. In the case of the dual-rail power supply and acquisition apparatus shown in Figs. 4 and 5, however, the width of the power supply device 231 is two times larger than that of the power supply rail. As such, if the width of the power supply device is excessively increased, the material cost of the core unit and a road building cost may increase. Further, the intensity of the electromagnetic field (EMF) in a lateral of the vehicle may also increase, and thus, it is not easy to satisfy a permissible reference value (62.5 mG or less in a band of 20 kHz).

[14] On the contrary, if the width of the power supply rail is reduced to 30 cm or less, a magnetic field from one magnetic pole of the power supply device tends to immediately enter another magnetic pole.

[15] Furthermore, in the power supply and acquisition apparatus, as the air gap is increased, the width of the acquisition device also needs to be increased. The width of the power acquisition device not only needs to be increased more than the width of the power supply device by the air gap, but also a permissible value of the steering deviation in the left and right direction of the vehicle also needs to be added to the increased width. For example, given that the air gap is 25 cm and the steering deviation is 30 cm, the width of the power supply device of the dual rail approaches 210 cm (= 25 cm (air gap) x 2 (two times) x 2 (dual rail) + 25 cm (air gap) x 2 (left/right) + 30 cm

(steering deviation) x 2 (left/right)). The width amounts to the overall width of a typical bus, and a passenger car does not satisfy such a condition.

[16]

Disclosure of Invention

Technical Problem

[17] In view of the above, the present invention s provides a power supply and acquisition device for an on-line electric vehicle, which has a large air gap between the power acquisition device and a road surface, sufficiently allows the permissible range of a steering deviation, includes a power supply line and a power acquisition module of which the width is reduced, and significantly reduces a generation amount of electromagnetic field (EMF).

[18]

Solution to Problem

[19] In accordance with a first aspect of the present invention, there is provided a power supply device which supplies power to an electric vehicle in a magnetic induction method, the power supply device including:

[20] a plurality of power supply core units each having a plurality of magnetic poles arranged at a predetermined distance from each other along a traveling direction of a road and having a width equal to or less than 1/2 of the distance between the magnetic poles in a direction perpendicular to the traveling direction of the electric vehicle on the road; and

[21] a plurality of power supply lines arranged along the traveling direction of the electric vehicle on the road such that the magnetic poles of the adjacent power supply core units have different polarities.

[22] One end of a magnetic pole and the opposite end of an adjacent magnetic pole may be connected in a diagonal direction such that the length of the power supply lines is minimized.

[23] Further, the power supply lines may be installed in parallel to the traveling direction of the electric vehicle on the road at positions where the magnetic pole are not provided, and may be installed to wrap one side of the left and right sides of the magnetic poles around the magnetic poles.

[24] The power supply lines may be installed in a straight line parallel to the traveling direction of the electric vehicle on the road, and the magnetic poles may be alternately installed in the left and right sides of the power supply lines in the traveling direction of the electric vehicle on the road.

[25] Further, the magnetic poles may include a semi-circular cylinder-shape groove provided in parallel to the traveling direction of the road, and the power supply lines

may be installed to pass through the groove in a straight line parallel to the traveling direction of the electric vehicle on the road.

[26] The cross-section of the magnetic poles, which is perpendicular to the traveling direction of the road, may be formed in such an S shape including two spaces in which the power supply lines are contained in upper and lower portions, and the power supply lines may pass through the spaces in the traveling direction the electric vehicle on the road.

[27] The power supply device may further comprise a I-shaped magnetism shielding member installed in the traveling direction of the electric vehicle on the road.

[28] In accordance with a second aspect of the present invention, there is provided a power supply device which supplies power to an electric vehicle in a magnetic induction method, the power supply device including:

[29] a plurality of power supply core units each having a plurality of power supply core modules, of which each includes one ore more magnetic poles and coupling members provided at front and rear ends thereof and which are connected along a traveling direction of the electric vehicle on a road; and

[30] a plurality of power supply lines arranged along the traveling direction of the electric vehicle on the road such that the magnetic poles of the adjacent power supply core units have different polarities.

[31] The width of the power supply core units, which is perpendicular to the traveling direction of the road, may be equal to or less than 1/2 of a distance between the magnetic poles.

[32] Preferably, the power supply core units are connected by the connection members and spaced at a predetermined distance to handle thermal expansion and contraction.

[33] Further, the power supply core units may include fiber reinforced plastic (FRP) installed in an upper or lower portion thereof.

[34] In accordance with a third aspect of the present invention, there is provided a power acquisition device which receives power from the power supply device of claim 1 in a magnetic induction method, the power acquisition device including:

[35] two or more power acquisition core units spaced at a predetermined distance from the power supply device and installed under an electric vehicle in a direction perpendicular to a traveling direction of the electric vehicle on a road;

[36] a plurality of connection members for connecting the power acquisition core units such that the power acquisition core units are spaced at the distance between the magnetic poles of the power supply device; and

[37] a plurality of power acquisition coils wound around the power acquisition core units or the connection members.

[38] The power acquisition core units may be formed in a plate or lattice shape.

[39] Further, a distance between the power acquisition devices is preferably set to 1/n of the distance between magnetic poles such that a variation of an effective value of an acquired voltage is prevented in the traveling direction of the electric vehicle on the road.

[40] The power acquisition device may further comprise a loop-shape magnetism shielding member installed around the power acquisition core units.

[41]

[42]

Advantageous Effects of Invention

[43] In the I-shape power supply device in accordance with the embodiments of the present invention, a large air gap may be realized by the plurality of magnetic poles arranged at a predetermined distance from each other along the traveling direction on the road and the power supply line disposed such that the adjacent magnetic poles have different polarities. To extend the air gap, the pole gap may be increased. As the width of the power supply device is significantly reduced without increasing the width of the power supply device, it is possible to reduce an installation cost.

[44] Furthermore, the I-shape power supply device may allow a large steering deviation. That is, when the width of the power acquisition device is increased more than that of the power supply device, there is no large change in transmitted power, as long as the resistance of the magnetic circuit is constantly maintained even though the vehicle leans to the right or left direction, that is, even though the steering deviation increases.

[45] Furthermore, the I-shape power supply device has an advantage in that the generation amount of EMF observed in side surfaces of the road is considerably reduced in comparison with the prior art.

[46]

Brief Description of Drawings

[47] The objects and features of the present invention will become apparent from the following description of embodiments given in conjunction with the accompanying drawings, in which:

[48] Fig. 1 illustrates an exemplary power supply and acquisition apparatus for an on-line electric vehicle;

[49] Figs. 2 and 3 respectively illustrate a front view and a plan view of a monorail power supply and acquisition apparatus;

[50] Figs. 4 and 5 respectively illustrate a front view and a plan view of a dual-rail power supply and acquisition apparatus;

[51] Figs. 6 and 7 respectively illustrate a plan view and a side view of an I-shape slim-type power supply device in accordance with an embodiment of the present invention;

[52] Figs. 8 and 9 respectively illustrate a plan view and a side view of a case in which two power supply lines are arranged in parallel to the traveling direction on a road except for the surroundings of magnetic poles in the I-shape power supply device in accordance with another embodiment of the present invention;

[53] Figs. 10 and 11 respectively illustrate a plan view and a side view of a case in which magnetic poles are formed in a circular shape that power supply lines are easily bent in the I-shape power supply device in accordance with another embodiment of the present invention;

[54] Figs. 12 and 13 respectively illustrate a plan view and a side view of a case in which magnetic poles are alternately arranged in the left and right sides of power supply lines along the traveling direction on the road such that the power supply lines do not need to be bent in the I-shape power supply device in accordance with another embodiment of the present invention;

[55] Fig. 14 is a diagram illustrating the structure of magnetic poles having semi-circular cylinder- shape grooves through which power supply lines pass in accordance with another embodiment of the present invention;

[56] Figs. 15 to 17 respectively illustrate a plan view, a side view and a longitudinal cross sectional view of a case in which magnetic poles are lengthened in the traveling direction on the road to increase the area of the magnetic poles in an I-shape power acquisition device in accordance with an embodiment of the present invention;

[57] Figs. 18 to 20 respectively illustrate a plan view, a side view and a longitudinal cross sectional view of the power acquisition device including a power acquisition core unit formed in a lattice shape in accordance with another embodiment of the present invention;

[58] Fig. 21 is a graph showing how an effective value of an acquired voltage changes at each position when the power acquisition device passes over the I-shape power supply device;

[59] Figs. 22 and 23 respectively illustrate a plane view and a side view of a power supply core module manufactured in a size corresponding to a pole gap such that the power supply device may be easily built in a curved road;

[60] Figs. 24 and 25 respectively illustrate a plane view and a side view of the power supply core modules coupled through connection members in accordance with another embodiment of the present invention;

[61] Figs. 26 and 27 respectively illustrate a plane view and a side view of a power supply device in accordance with another embodiment of the present invention, the power supply device having a structure capable of handling contraction depending on a temperature variation of the power supply device;

[62] Figs. 28 and 29 respectively illustrate a plane view and a side view of a power supply

device in accordance with another embodiment of the present invention, the power supply device having a structure capable of handling expansion depending on a temperature variation of the power supply device, and Fig. 30 shows a longitudinal cross sectional view of the power supply device;

[63] Fig. 31 is a diagram showing a method for installing the I-shape power supply device;

[64] Fig. 32 is a diagram showing another method for installing the I-shape power supply device;

[65] Figs. 33 and 34 show diagrams illustrating an S-shape power supply core unit including power supply core units and power supply lines which are reduced in thickness thereof; and

[66] Figs. 35 and 36 respectively illustrate a plane view and a cross sectional view describing a magnetism shielding method of the I-shape power supply and acquisition device.

[67]

Best Mode for Carrying out the Invention

[68] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings which form a part hereof.

[69] Figs. 6 and 7 respectively illustrate a plan view and a side view of an I-shape slim-type power supply device 310 in accordance with an embodiment of the present invention in which the width 315 of a power supply line is significantly reduced to equal to or less than 1/2 of the distance between magnetic poles 312. The distance between magnetic poles means a distance between the centers of the magnetic poles, and the width of the power supply line means a length of a power supply core unit including the power supply line in a direction perpendicular to the traveling direction on a road, as shown in Fig. 4. Hereinafter, the distance and the width have the same meaning in the following drawings. The reason that the term 'I -shape' has been used is that the longitudinal cross-sectional view of the power supply device taken along a direction perpendicular to the traveling direction of the road is an I-shape, for example, as can be seen in Fig. 17. Figs. 6, 7 and the following drawings illustrate I-shape power supply devices, even though the shapes thereof are slightly different depending on embodiments.

[70] The power supply lines 313 and 314 are provided over the power supply core units 311 such that the N pole and S pole of a magnetic force line 316 are alternately generated in the respective magnetic poles 312 of the power supply core units 311. When the number of power supply lines is one, the structure corresponds to a monorail. When the number of power supply lines is two, the structure corresponds to

a dual rail. In the embodiment of the present invention, upper end portions of the magnetic poles 312 of the power supply core units are not exposed to the surface of the road, but completely buried in the road.

[71] Figs. 6 and 7 illustrate an example of the dual rail. In the case of the dual rail, currents flowing in the two power supply lines 313 and 314 have opposite directions.

[72] Figs. 6 and 7 illustrate an example in which the length of the power supply lines 313 and 314 is minimized. The width 315 of the power supply lines may be reduced to 10 cm or less. Even in this case, there is no problem in increasing an air gap to 20 cm or more. Seen from the side, the installation direction of the power supply lines 313 and 314 is almost the same as the traveling direction on the road. Therefore, the power supply lines 313 and 314 and the power supply core unit 311 are buried in almost the same direction as the traveling direction on the road. However, although the width 315 of the power supply lines 313 and 314 is reduced in such a manner, transferred power does not decrease in proportion to the width 315 of the power supply lines 313 and 314. When the reduction in the area of the power supply lines 313 and 314 is smaller than the power reduction, it is advantageous in terms of an effect against cost.

[73] Figs. 8 and 9 respectively illustrate a plan view and a side view of a case in which two power supply lines 413 and 414 are arranged in parallel to the traveling direction on the road except for the surroundings of magnetic poles 412 in the I-shape power supply device 410 in accordance with another embodiment of the present invention. Further, Figs. 8 and 9 show an example in which each of upper and lower surfaces of the magnetic poles 412 is formed in a rectangular shape. Then, the power supply lines 413 and 414 and the power supply core units 411 are arranged in parallel to the traveling direction on the road, except for the surroundings of the magnetic poles 412. In such an arrangement, the generation of electromagnetic field (EMF) toward a side-direction by the two power supply lines 413 and 414 is suppressed as much as possible.

[74] Figs. 10 and 11 respectively illustrate a plan view and a side view of a case in which each of upper and lower surfaces of the magnetic poles 512 is formed in a circular shape that power supply lines 513 and 514 are easily bent in the I-shape power supply device 510 in accordance with another embodiment of the present invention. In this case, the power supply lines 513 and 514 and the power supply core units 511 are arranged in parallel to the traveling direction on the road, except for the surroundings of the magnetic poles 512. Consequently, the generation of electromagnetic field (EMF) toward a side-direction by the two power supply lines 513 and 514 is suppressed as much as possible as in the case of Figs. 8 and 9.

[75] Figs. 12 and 13 respectively illustrate a plan view and a side view of a case in which magnetic poles 612 are alternately arranged in the left and right sides of power supply lines 613 and 614 along the traveling direction on the road such that the power supply

lines 613 and 614 do not need to be bent in the I-shape power supply device 610. In this case, the two power supply lines 613 and 614 have a distance from each other only in the upward and downward direction, and are arranged in parallel to each other within the same plane perpendicular to the road in the traveling direction of the road.

[76] Fig. 14 is a diagram illustrating the structure of magnetic poles 702 having semi-circular cylinder-shape grooves 703 through which power supply lines 704 and 706 pass. Fig. 14 illustrates a power supply line 704 through which current flows in the traveling direction 705 on the road and a power supply line 706 through which current flows in the opposite direction, that is, the reverse direction 707 of traveling.

[77] The power supply lines 704 and 706 pass through the semi-circular cylinder-shape grooves 703 of the magnetic poles 702 such that the magnetic poles 702 are positioned in the center of the power supply core unit 701. Furthermore, the two power supply lines 704, 706 and the power supply core unit 701 are vertically positioned in parallel. Then, the width of a power supply rail may be reduced to a small value which is obtained by adding the diameter of the power supply line 704 or 706 and twice the thickness of the power supply core unit 701. For example, when the diameter of the power supply line 704 or 706 is 2 cm and the thickness of the power supply core unit 701 is 1 cm, the width of the power supply rail is no more than 4 cm. That is, an ultra slim I-shape power supply device is implemented.

[78] Figs. 15 to 17 respectively illustrate a plan view, a side view and a longitudinal cross sectional view of a case in which magnetic poles 812 are lengthened in the traveling direction on the road to increase the area of the magnetic poles 812 in an I-shape power acquisition device 815 in accordance with an embodiment of the present invention. As shown in Fig. 17, magnetic fluxes 832 coming from the power supply device 831 are collected over the width 816 of a power acquisition module which is two times larger than an air gap 833. Here, the power acquisition module indicates a term which includes a power supply core unit and a power acquisition coil and an electric apparatus which are included in the power supply core unit. Then, the resistance of a magnetic circuit is reduced. That is, when the magnitude of magnetic poles 812 is increased in the traveling direction on the road even though the width 834 of a power supply rail is small, power delivering may be smoothly performed.

[79] In addition, when power delivering efficiency needs to be increased, the width 834 of the power supply rail may be increased by about 10-20 cm. As described above, however, when the width 834 of the power supply rail is increased, an increase in power delivering capacity is not so large, but only a saturated magnetic flux density of the power supply core unit is effectively reduced. Furthermore, the power supply core unit may be transformed in such a manner that the power supply lines 613, 614, 704 and 706 are not bent but maintained in a straight line as shown in Figs. 12 to 8, even

though the power supply device 831 is transformed into such a shape. Furthermore, as the end and middle portions of the power supply core unit 811 are transformed in various manners, the distribution of magnetic force lines may be improved.

[80] Meanwhile, Figs. 15 to 17 illustrate a power acquisition device 815 including power supply core units arranged at the same distance as a pole gap along the traveling direction on the road. The power acquisition device 815 corresponding to an I-shape power supply device includes the plate-shaped power acquisition core units 813 arranged in a direction perpendicular to the traveling direction on the road and a connection member 814 connecting the power supply core units 813. Power acquisition coils may be wound around the magnetic path including the power acquisition core units 813 and the core connection member 814. In Fig. 15, two power acquisition core units 813 are provided. However, three power acquisition core units may be provided. As the number of power acquisition core units increases, a larger amount of power may be collected. An on-line electric vehicle may include several power acquisition devices in correspondence to the overall length of the vehicle. When three power acquisition core units are arranged, three power acquisition coils may not be provided. That is, only one power acquisition coil may be provided in the center, and the power acquisition core units may be provided in the front and rear side. Then, the power acquisition core units in the front and rear side serve as only a magnetic circuit, but does not deliver power.

[81] Figs. 18 to 20 respectively illustrate a plan view, a side view and a longitudinal cross sectional view of a power acquisition device 915 including a power acquisition core unit 916 formed in a lattice shape. When the power acquisition core unit 916 is formed in a lattice shape, the weight of the power acquisition core unit 916 may be reduced, and the power acquisition device 915 is advantageous in cooling and may be manufactured with a firm structure. In this case, when the distance between lattice bars is sufficiently reduced to equal to or less than 1/2 of an air gap 921 in Fig. 19, it does not have an effect upon electrical performance.

[82] Fig. 21 is a diagram showing how an effective value of an acquired voltage at each coordinate changes when the I-shape power supply device passes over the power acquisition device. The acquired voltage drops to 0 at each pole gap in the traveling direction of the road, that is, in a direction (x axis) where the vehicle travels. It is important to design the power acquisition device in such a manner that the effective values of the acquired voltage exhibit a flat portion as much as possible. In this case, since the average value of the effective values increases, the amount of delivered power increases. Such a variation in the acquired voltage may be buffered by a regulator included in the power acquisition device of the on-line electric vehicle. Therefore, the variation may not be a big problem for practical use. When a plurality of

power acquisition devices are used, the respective acquisition devices may be arranged to deviate from each other by 1/2 or 1/3 of the pole gap, and the maximum voltage of each power acquisition device may be selected by the regulator or the average of voltages of the respective acquisition devices may be obtained. Then, it is possible to prevent such a variation in the acquired voltage. Figs. 18 to 20 show a case in which the power acquisition devices 915 deviate from each other by 1/2 of the air gap 922. In this case, when the voltage of one power acquisition device 915 has a minimum value, the voltage of the other power acquisition device 915 has a maximum value.

[83] Meanwhile, when the power acquisition device 915 is moved in the left or right direction (y axis) of the road, that is, when a steering deviation occurs, a deviation may increase. In this case, the effective value of the acquired voltage decreases. When the deviation is small, the width of the acquisition device may be sufficiently increased. Then, the effective value of the acquired voltage is rarely reduced. However, when the deviation is too large, the leakage inductance of a power acquisition coil becomes too large. Then, since the power acquisition efficiency may decrease, proper trade-off is necessary.

[84] Figs. 22 and 23 respectively illustrate a plane view and a side view of a power supply core module manufactured in a size corresponding to a pole gap such that the power supply device may be easily built in a curved road in accordance with another embodiment of the present invention. The power supply core module includes male and female coupling members 1111 and 1112 formed at both ends thereof and having a wide contact area. The male coupling member 1111 of one power supply core module may be mechanically and simply coupled to the female connection member 1112 of another adjacent power supply core module. When the power supply core modules constructed in such a manner are combined in the field, the connection portion between the power supply core modules may be turned along the road curved in the left or right direction. Figs. 24 and 25 respectively illustrate a plane view and a side view of the power supply core modules coupled through connection members in accordance with the embodiment of the present invention. Furthermore, although not illustrated in Figs. 22 to 25, it is possible to implement power supply core modules which may be built along a road curved in the upward and downward direction, such as an inclined surface, based on the same principle.

[85] Figs. 26 and 27 respectively illustrate a plane view and a side view of a power supply device in accordance with another embodiment of the present invention, the power supply device having a structure capable of handling shrinkage depending on a temperature variation of the power supply device, Figs. 28 and 29 respectively illustrate a plane view and a side view of a power supply device in accordance with another embodiment of the present invention, the power supply device having a structure capable

of handling expansion depending on a temperature variation of the power supply device, and Fig. 30 shows a longitudinal cross sectional view of the power supply device;

[86] Typically, a road needs to endure a temperature change of -20 to +80 degrees. A magnetic material forming the power supply device, a cable, a cable protection mechanism such as FRP or PVC pipe, and asphalt or cement thermally expand and have different thermal expansion coefficients. Therefore, the thermal expansion and the thermal expansion coefficients need to be considered. Furthermore, a waterproof property needs to be maintained favorably.

[87] Accordingly, the respective structures need to be separated at a constant distance from each other in the traveling direction of the road, and the connection surfaces thereof need to have a waterproof property. Fig. 27 shows a case in which the power supply device includes connection members 1232 formed of the same magnetic material and provided between power supply core units 1231 in the traveling direction of the road. Furthermore, Fig. 27 shows a case in which fiber reinforced plastics (FRP) 1233 are intermittently connected through O-rings 1234. When FRP or PVC pipes are connected, a shrinkable tube or bond connection may be used. Furthermore, a flexible connection member does not need to be used at every connection portion, but may be used at every several meters or several tens meters. In general, however, since a cable has flexibility, such a treatment may be not required.

[88] Fig. 31 is a diagram showing a method for installing the I-shape power supply device.

[89] First, a T-shaped groove 1301 is hollowed out in the road in step S1301, and a power supply core unit 1302 is attached on an FRP plate 1303 in step S1302. A power supply line 1304 is wound around the power supply core unit 1302 in step S1303, and an umbrella- type FRP pipe 1305 is put on the power supply core unit 1302 to obtain an additional waterproof effect in step S1304. Then, the resultant structure is put into the T-shaped groove 1301 in step S1305, and the road is paved with asphalt concrete 1305 in step S1306.

[90] Fig. 32 is a diagram showing another method for installing the I-shape power supply device.

[91] First, a 1-shaped groove 1401 is hollowed out in the road in step S1401, and drains 1402 are formed at a predetermined distance from each other on the bottom of the groove in step S1402. A power supply line 1404 is wound around a power supply core unit 1403 instep S1403, and put into a rectangular FRP pipe 1405 such that the structure is waterproofed in step S1404. Then, the resultant structure is put into the 1-shaped groove in step S1405, and the road is paved with asphalt concrete 1406 in step S1406.

[92] Figs. 33 and 34 show diagrams illustrating an S-shape power supply core unit including power supply core units and power supply lines which are reduced in thickness thereof.

[93] Fig. 33 illustrates a structure in which power supply lines 1511 through which a current flows in the traveling direction on the road and power supply lines 1512 through which a current flows in the opposite direction, that is, the reverse direction of the traveling direction on the road are positioned in the upper and lower portions of the S-shape power supply core unit, respectively.

[94] The width 1513 of the power supply rail is determined by the diameters of the power supply lines 1511 and 1512, the thickness of the power supply core unit 1511, and the thickness of FRP 1514. When the diameter of a cable is 3 cm, the thickness of the power supply core unit is about 1 cm, and the thickness of FRP is 0.5 cm, the width of the power supply rail is no more than 5 cm.

[95] Fig. 34 illustrates a structure in which plate-shaped power supply lines 1521 and 1522 are used to reduce the thickness and integrated with the S-shape power supply core unit 1501. In this case, since the thickness is further reduced, the width of the power supply rail may be only 3 cm.

[96] When the ultra-slim I-shape power supply device is constructed in such a manner, the ultra-slim I-shape power supply device may be directly buried in a narrow groove hollowed out in the road. In this case, since the asphalt and concrete pavement may not be necessary, a road building cost significantly decreases. When the width of the power supply rail is reduced in comparison with the height (about lOto 25 cm) of the power supply device, a leakage flux caused by the S shape may decrease as much.

[97] Figs. 35 and 36 respectively illustrate a plane view and a cross sectional view describing a magnetism shielding method of the I-shape power supply and acquisition device, respectively.

[98] The size of the I-shape power acquisition device may be reduced to about a half of the width of the vehicle. Therefore, the I-shape power acquisition device has a spatial margin for magnetism shielding. Accordingly, referring to Figs. 35 and 36, when the surroundings of the I-shape power acquisition device are covered with a loop-shaped magnetism shielding material 1601, a leakage flux is magnetically grounded along the magnetism shielding loop 1601. Therefore, a magnetism shielding effect is exhibited. The magnetism shielding may be performed only along a side surface, but may be performed while the upper surface of the I-shape power acquisition device is covered.

[99] In the case of the I-shape power device, magnetic poles are alternated at a predetermined distance such that an EMF is generated in a side direction. Therefore, referring to Figs. 35 and 36, when I-shaped magnetism shielding lines 1602 are provided in a longitudinal direction, magnetic ground is performed in the longitudinal

direction. Then, a magnetism shielding effect is exhibited.

[100] While the invention has been shown and described with respect to the preferred embodiments, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the following claims.

[101]

Claims

[Claim 1] A power supply device which supplies power to an electric vehicle in a magnetic induction method, the power supply device comprising:
a plurality of power supply core units each having a plurality of magnetic poles arranged at a predetermined distance from each other along a traveling direction of a road and having a width equal to or less than 1/2 of the distance between the magnetic poles in a direction perpendicular to the traveling direction of the electric vehicle on the road; and
a plurality of power supply lines arranged along the traveling direction of the electric vehicle on the road such that the magnetic poles of the adjacent power supply core units have different polarities.

[Claim 2] The power supply device of claim 1, wherein one end of a magnetic pole and the opposite end of an adjacent magnetic pole are connected in a diagonal direction such that the length of the power supply lines is minimized.

[Claim 3] The power supply device of claim 1, wherein the power supply lines are installed in parallel to the traveling direction of the electric vehicle on the road at positions where the magnetic pole are not provided, and are installed to wrap one side of the left and right sides of the magnetic poles around the magnetic poles.

[Claim 4] The power supply device of claim 1, wherein the power supply lines are installed in a straight line parallel to the traveling direction of the electric vehicle on the road, and the magnetic poles are alternately installed in the left and right sides of the power supply lines in the traveling direction of the electric vehicle on the road.

[Claim 5] The power supply device of claim 1, wherein the magnetic poles include a semi-circular cylinder- shape groove provided in parallel to the traveling direction of the road, and the power supply lines are installed to pass through the groove in a straight line parallel to the traveling direction of the electric vehicle on the road.

[Claim 6] The power supply device of claim 1, wherein the cross-section of the magnetic poles, which is perpendicular to the traveling direction of the road, is formed in such an S shape including two spaces in which the power supply lines are contained in upper and lower portions, and the power supply lines pass through the spaces in the traveling direction the electric vehicle on the road.

[Claim 7] The power supply device of claim 1, further comprising a I-shaped magnetism shielding member installed in the traveling direction of the electric vehicle on the road.

[Claim 8] A power supply device which supplies power to an electric vehicle in a magnetic induction method, the power supply device comprising:
a plurality of power supply core units each having a plurality of power supply core modules, of which each includes one ore more magnetic poles and coupling members provided at front and rear ends thereof and which are connected along a traveling direction of the electric vehicle on a road; and
a plurality of power supply lines arranged along the traveling direction of the electric vehicle on the road such that the magnetic poles of the adjacent power supply core units have different polarities.

[Claim 9] The power supply device of claim 8, wherein the width of the power supply core units, which is perpendicular to the traveling direction of the road, is equal to or less than 1/2 of a distance between the magnetic poles.

[Claim 10] The power supply device of claim 8, wherein the power supply core units are connected by the connection members and spaced at a predetermined distance to handle thermal expansion and contraction.

[Claim 11] The power supply device of claim 8, wherein the power supply core units include fiber reinforced plastic (FRP) installed in an upper or lower portion thereof.

[Claim 12] A power acquisition device which receives power from the power supply device of claim 1 in a magnetic induction method, the power acquisition device comprising:
two or more power acquisition core units spaced at a predetermined distance from the power supply device and installed under an electric vehicle in a direction perpendicular to a traveling direction of the electric vehicle on a road;
a plurality of connection members for connecting the power acquisition core units such that the power acquisition core units are spaced at the distance between the magnetic poles of the power supply device; and
a plurality of power acquisition coils wound around the power acquisition core units or the connection members.

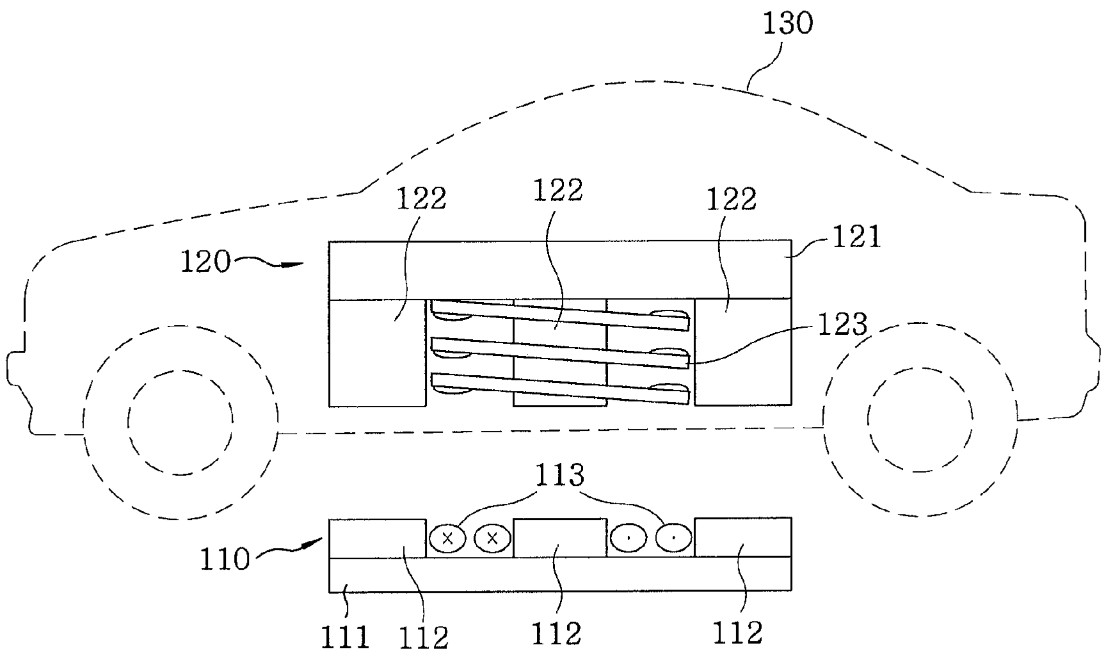
[Claim 13] The power acquisition device of claim 12, wherein the power acquisition core units are formed in a plate or lattice shape.

[Claim 14] The power acquisition device of claim 12, wherein a distance between the power acquisition devices is set to 1/n of the distance between magnetic poles such that a variation of an effective value of an acquired voltage is prevented in the traveling direction of the electric vehicle on the road.

[Claim 15] The power acquisition device of claim 12, further comprising a loop-shape magnetism shielding member installed around the power acquisition core units.

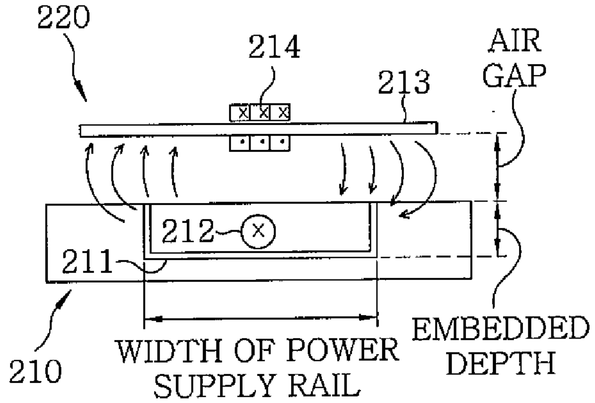
[Fig. 1]

(PRIOR ART)



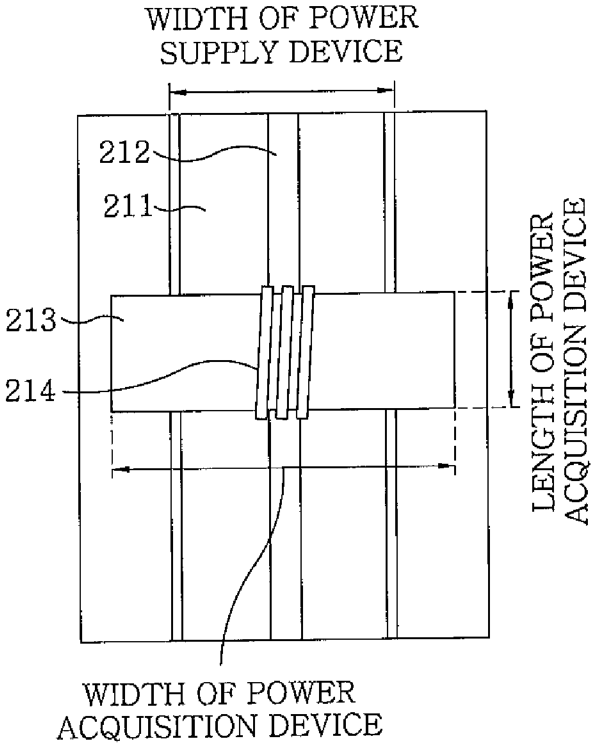
[Fig. 2]

(PRIOR ART)



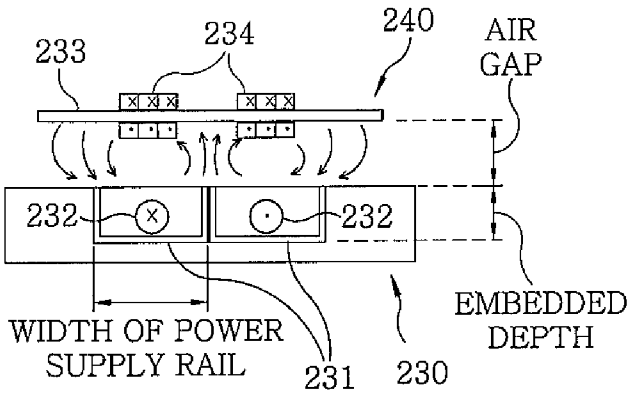
[Fig. 3]

(PRIOR ART)

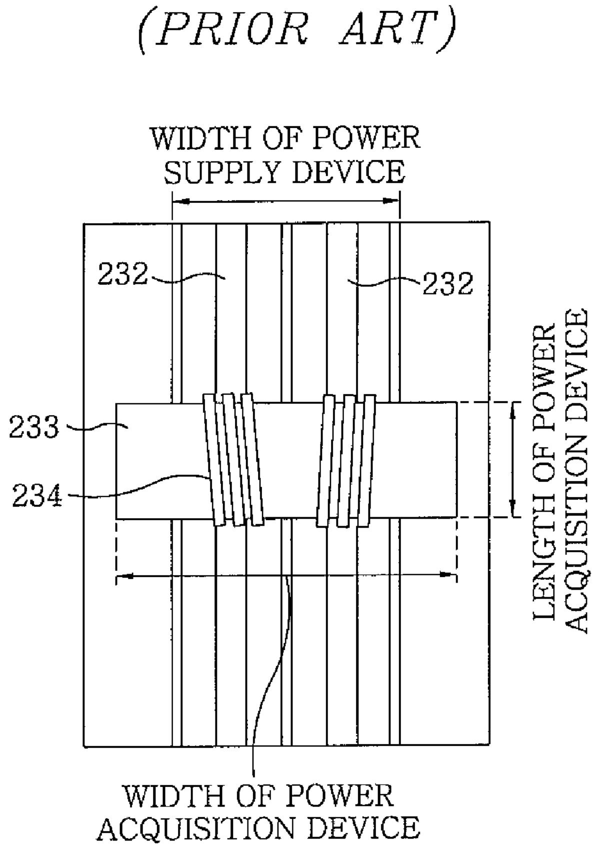


[Fig. 4]

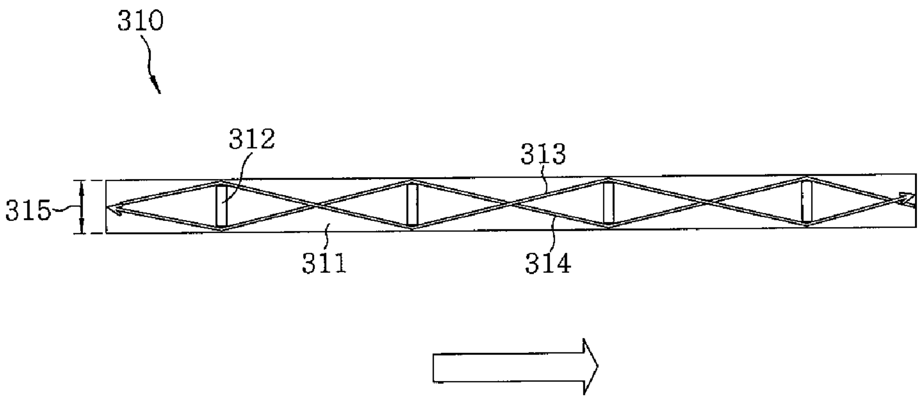
(PRIOR ART)



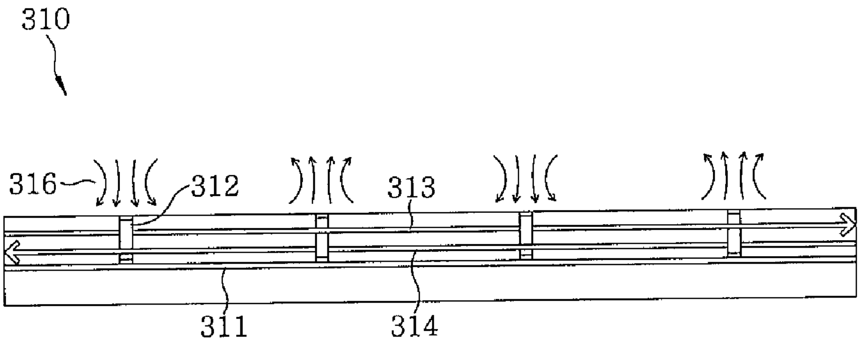
[Fig. 5]



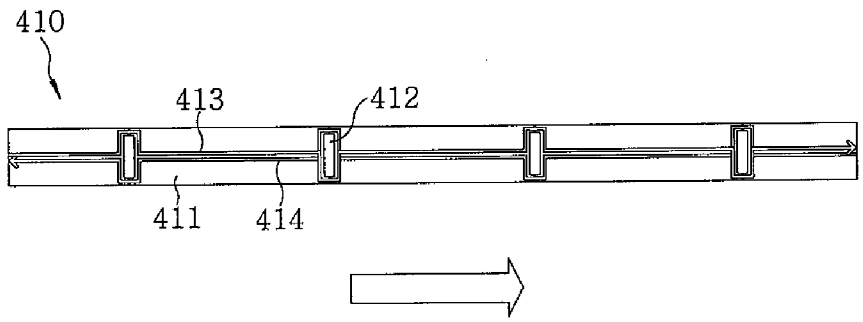
[Fig. 6]



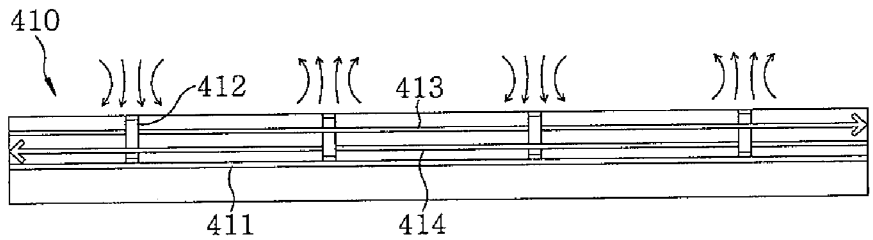
[Fig. 7]



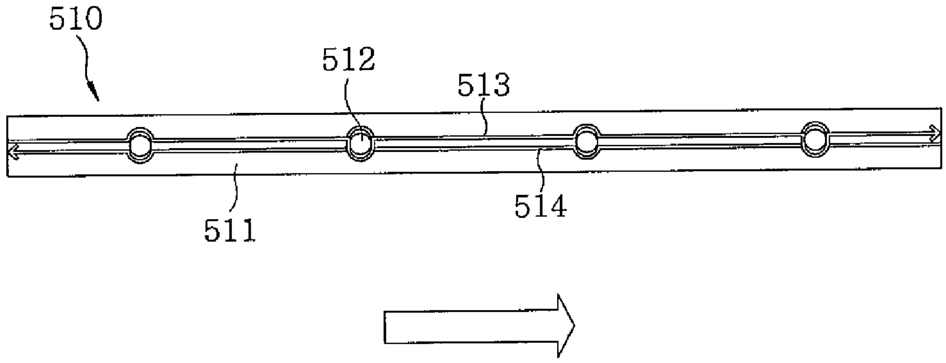
[Fig. 8]



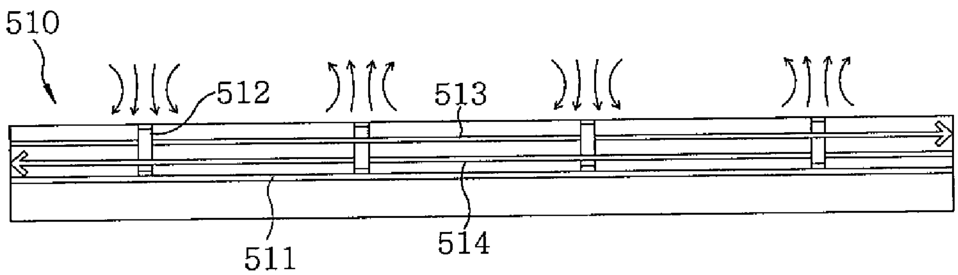
[Fig. 9]



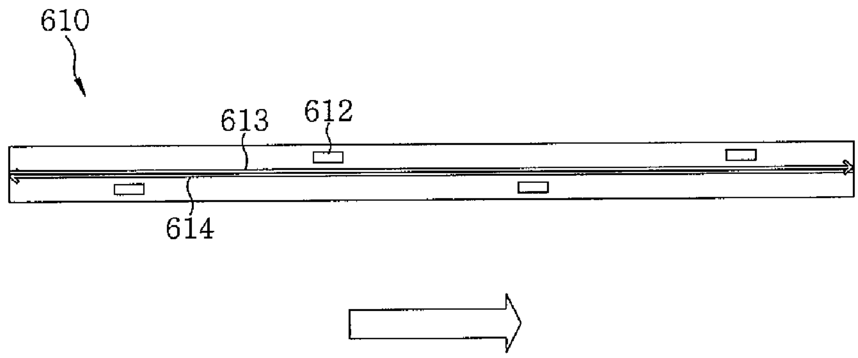
[Fig. 10]



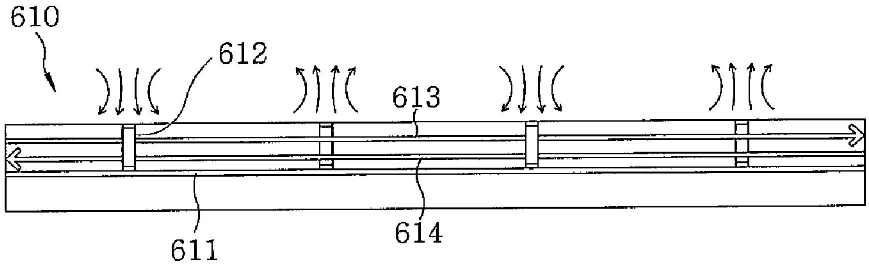
[Fig. 11]



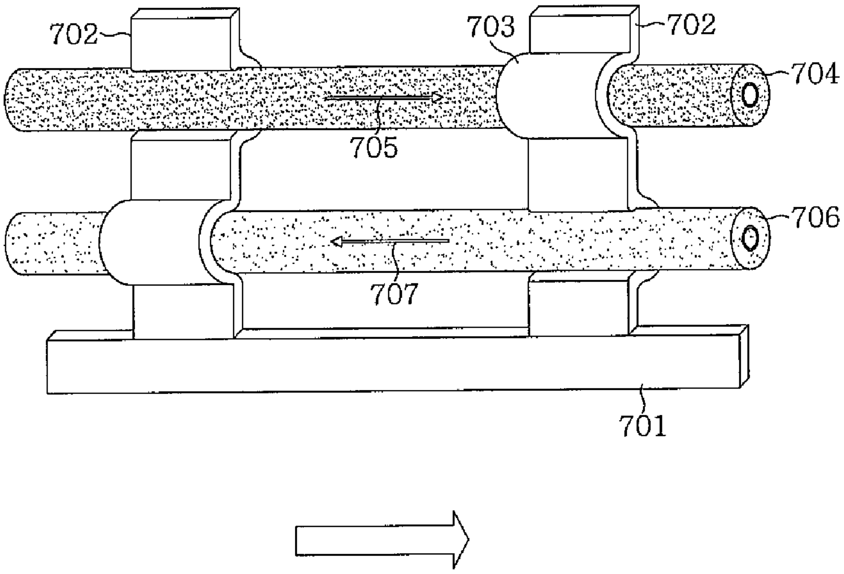
[Fig. 12]



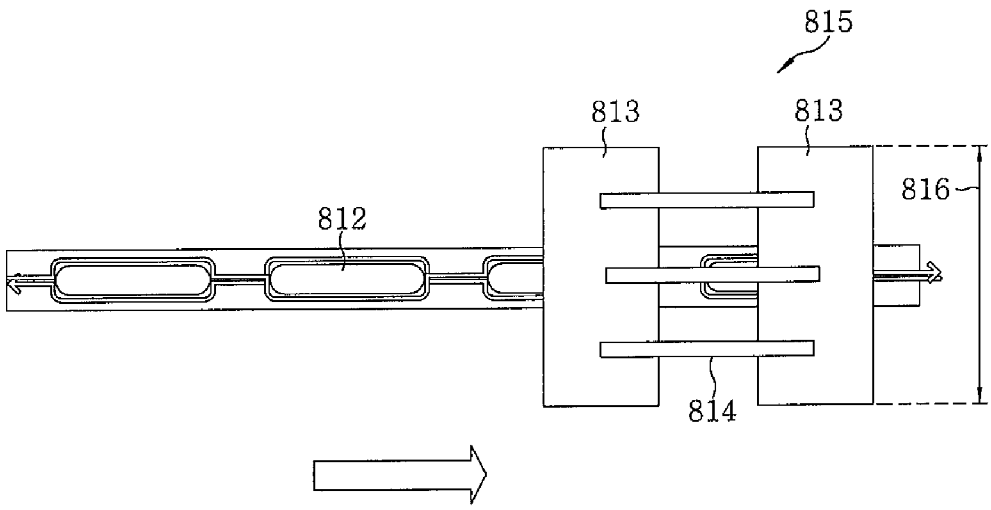
[Fig. 13]



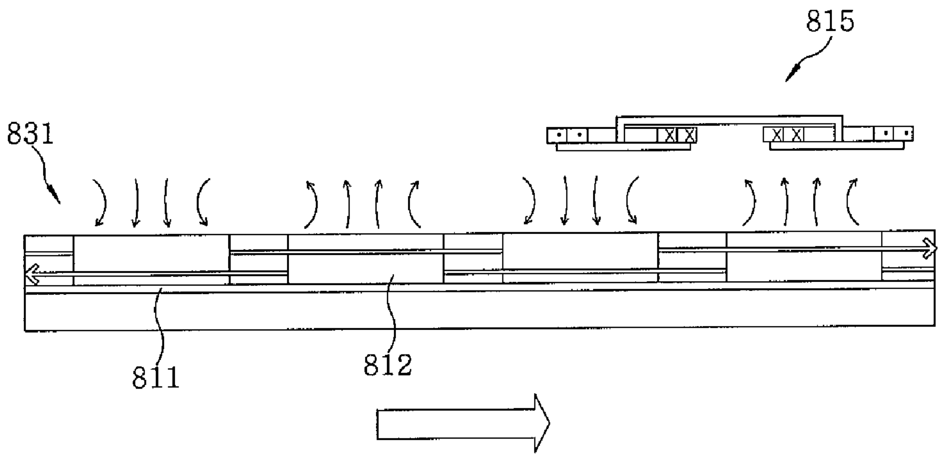
[Fig. 14]



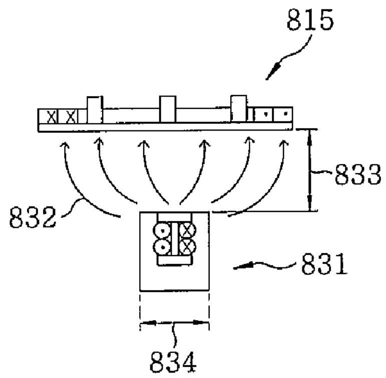
[Fig. 15]



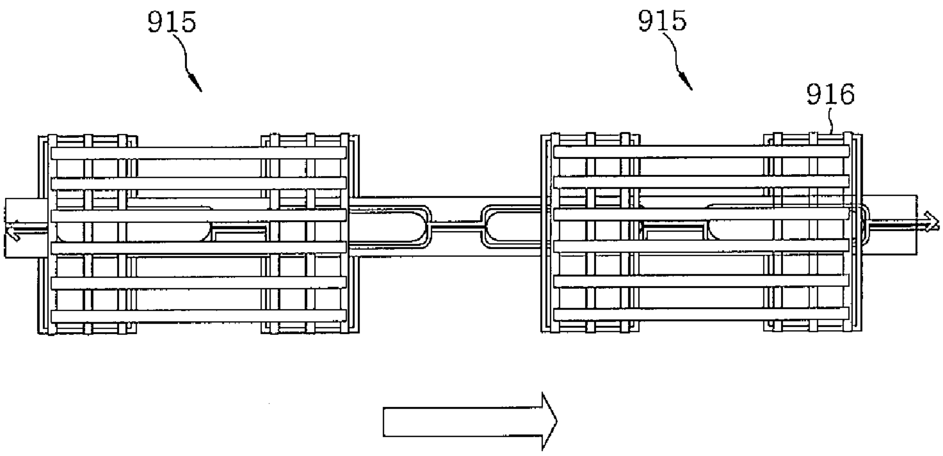
[Fig. 16]



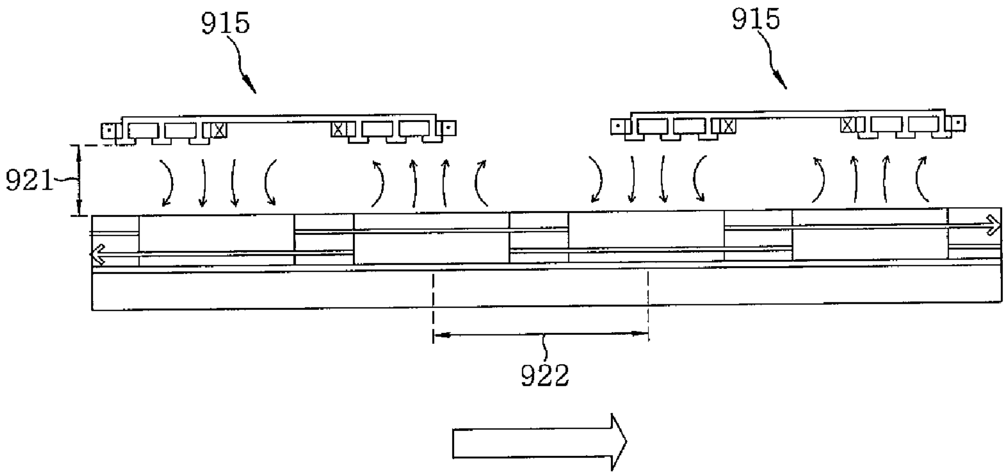
[Fig. 17]



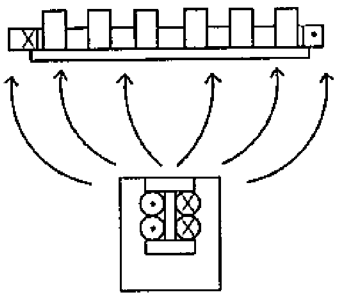
[Fig. 18]



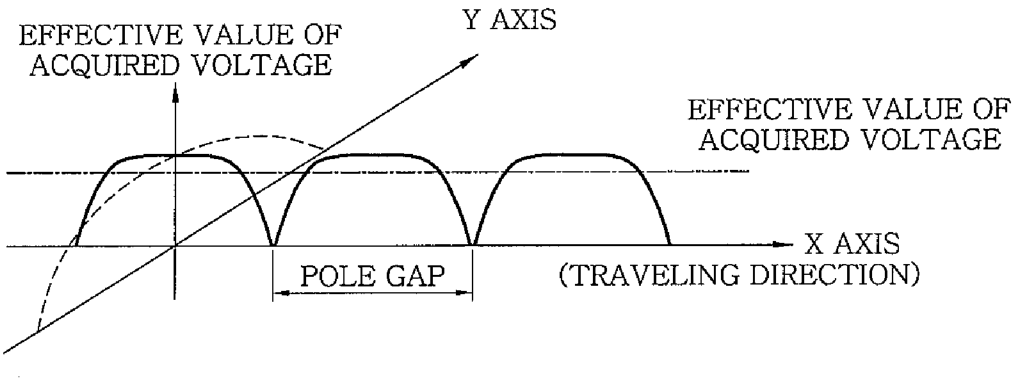
[Fig. 19]



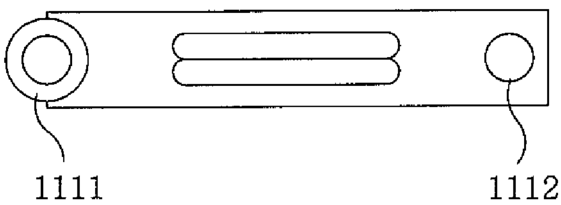
[Fig. 20]



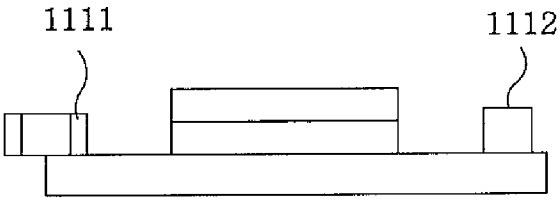
[Fig. 21]



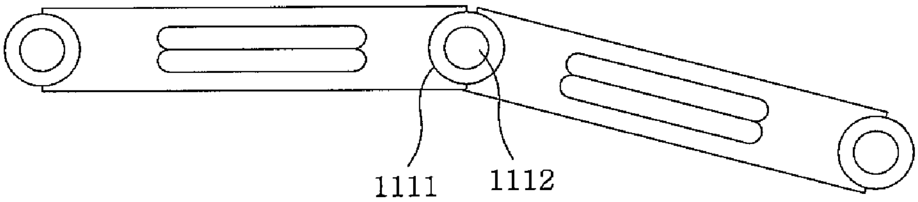
[Fig. 22]



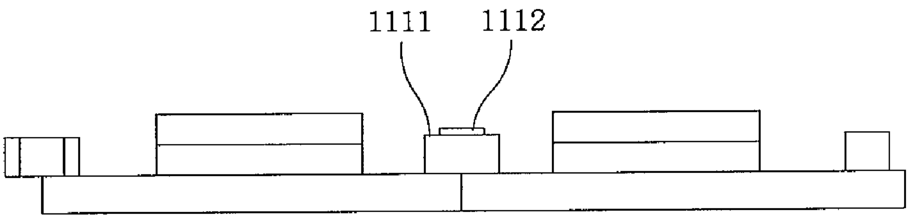
[Fig. 23]



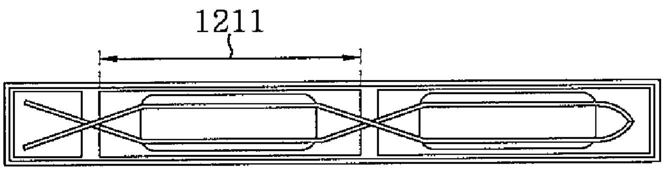
[Fig. 24]



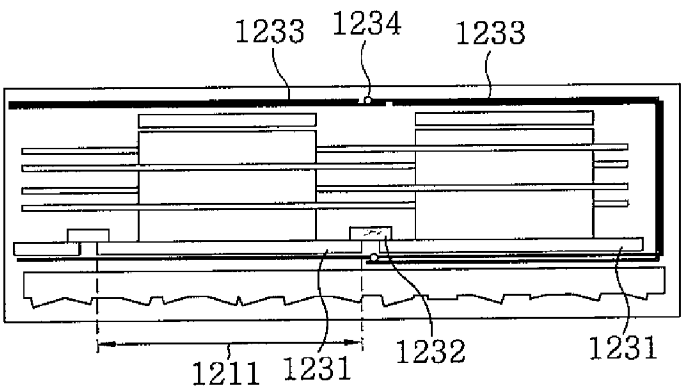
[Fig. 25]



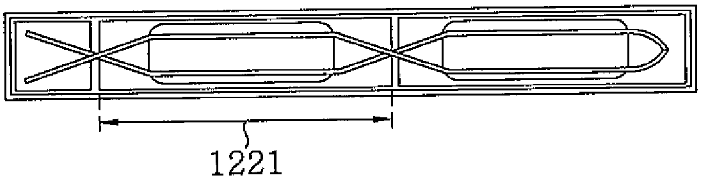
[Fig. 26]



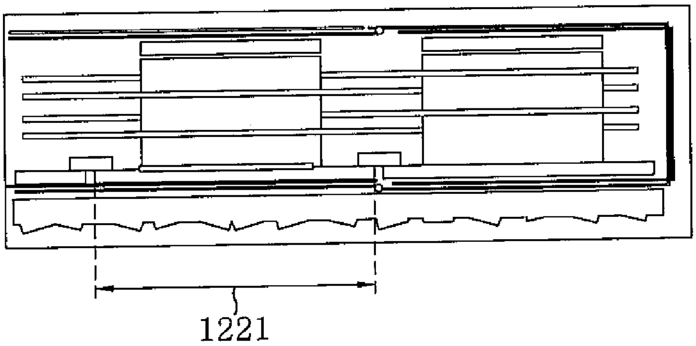
[Fig. 27]



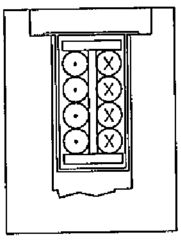
[Fig. 28]



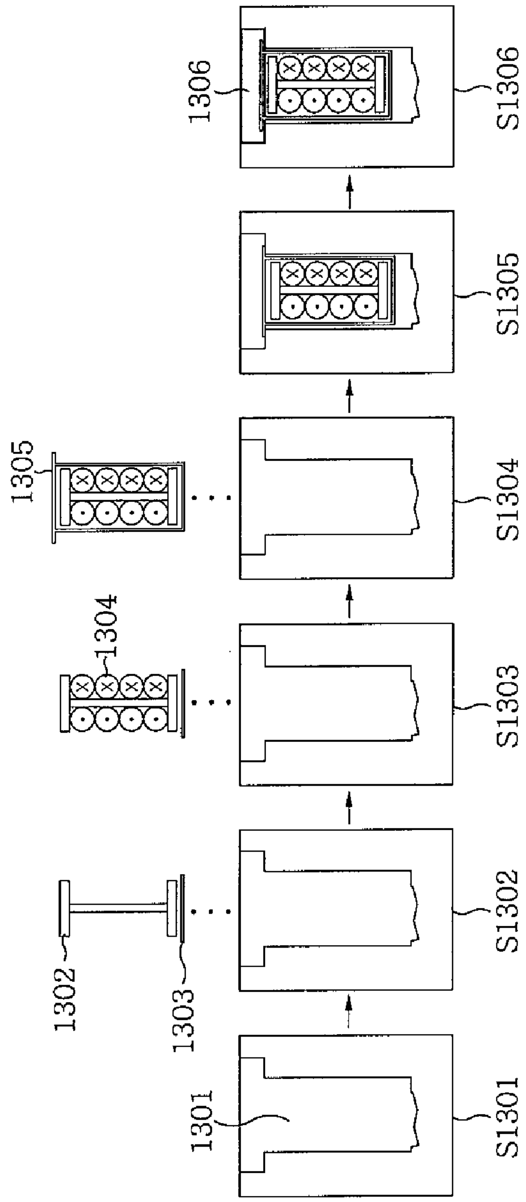
[Fig. 29]



[Fig. 30]



[Fig. 31]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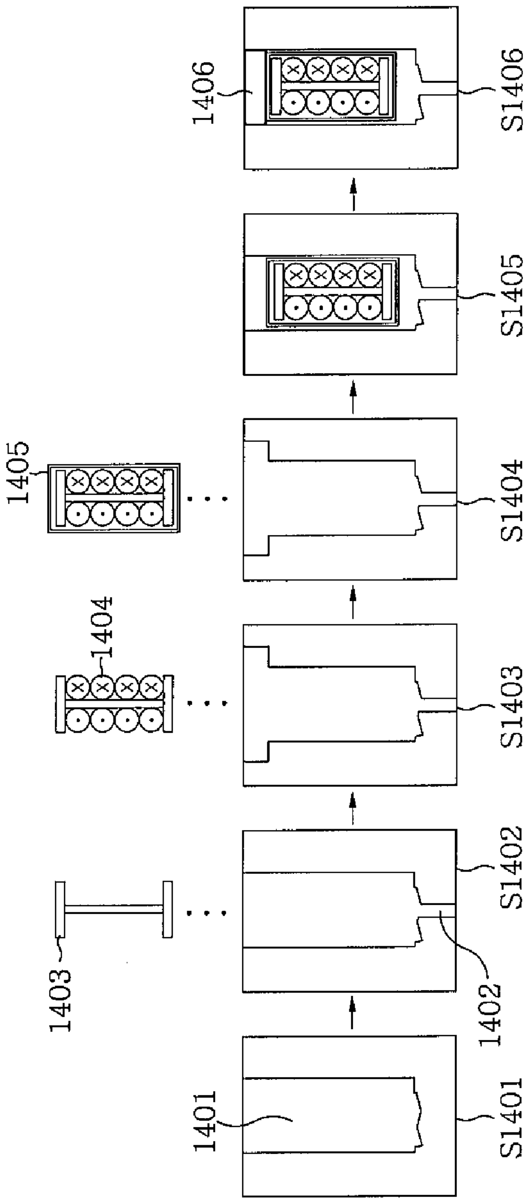
[Fig. 32]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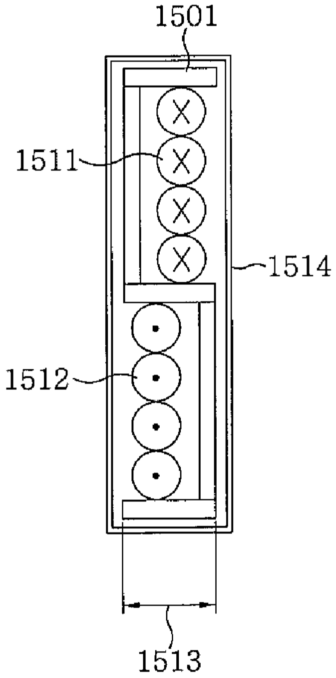
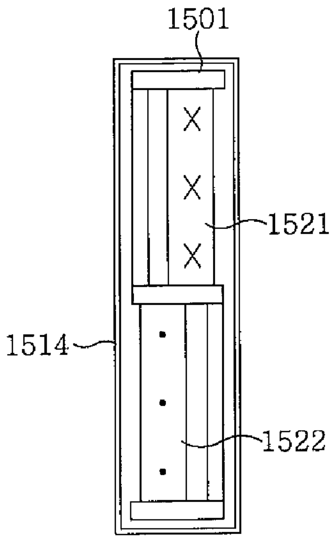
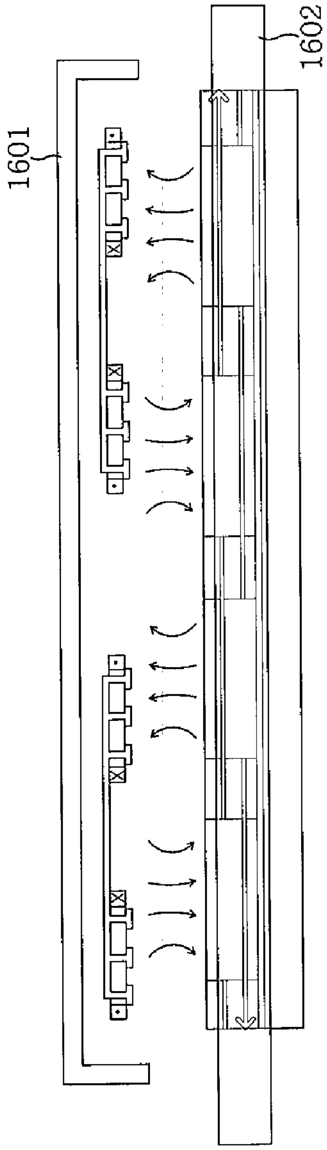
[Fig. 33]



[Fig. 34]



[Fig. 35]



[Fig. 36]