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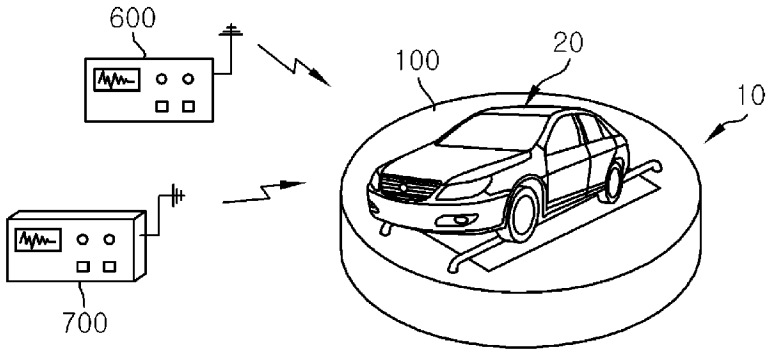
(54) **Title**: APPARATUS AND METHOD FOR TESTING ELECTROMAGNETIC SUSCEPTIBILITY OF ON-LINE ELECTRIC VEHICLE

[Fig. 5]



(57) **Abstract**: An apparatus for testing electromagnetic susceptibility of a vehicle, the apparatus includes a mounting table for mounting thereon the vehicle; a first antenna for radiating an electromagnetic wave; and a second antenna for receiving an electromagnetic signal. The mounting table includes a supporting plate for supporting the vehicle, the supporting plate being rotatable while supporting the vehicle; an inverter for outputting an AC power; and a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter.

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Description

Title of Invention: APPARATUS AND METHOD FOR TESTING ELECTROMAGNETIC SUSCEPTIBILITY OF ON-LINE ELECTRIC VEHICLE

Technical Field

[1] The present invention relates to an apparatus and method for testing electromagnetic susceptibility of a vehicle, and more particularly, to an apparatus for testing electromagnetic susceptibility of an on-line electric vehicle and a method for testing electromagnetic susceptibility of the on-line electric vehicle using the same.

Background Art

[2] Recently, various types of electromagnetic waves exist in the environment due to the development of wireless communications technology and the wide use of electric devices. Consequently, the possibility that the electromagnetic waves may affect operations of electronic devices has been brought up. In particular, in case of a vehicle, there is a high possibility that ambient electromagnetic waves will cause malfunction of the electronic devices constituting the vehicle and lead to a vehicle accident. Thus, an electromagnetic susceptibility (EMS) test has been performed on a vehicle to inspect the electromagnetic susceptibility of the vehicle, which refers to correct operation of the vehicle even in an environment where the vehicle is exposed to the ambient electromagnetic waves. In order to perform the electromagnetic susceptibility test on the vehicle, a testing equipment suitable for the vehicles is required (e.g., Korean Patent Laid-Open Publication No. 10-2001-0057735).

[3] Referring to Fig. 1, the conventional art for testing the electromagnetic susceptibility of a vehicle is described. Specifically, the vehicle 20' is disposed on a turntable 10'. Then, various devices constituting the vehicle are operated while the turntable 10' rotates. Further, an electromagnetic wave having a predetermined intensity is radiated to the vehicle 20' by a radiating antenna 30. In the meantime, an electromagnetic signal is received by an electromagnetic wave reception antenna 40, and a spectrum of a waveform of the received electromagnetic signal is then analyzed to inspect whether or not a waveform of an electromagnetic wave caused by malfunction of the vehicle has been received.

[4] Meanwhile, the electromagnetic susceptibility test may also need to be performed on a vehicle (hereinafter, referred to as an 'on-line electric vehicle') driven by an electric power supplied from a power supply device installed at an outside of the vehicle such as a roadway, and the like. In order to perform the electromagnetic susceptibility test on the on-line electric vehicle, the on-line electric vehicle needs to be exposed to elec-

tromagnetic waves while the on-line electric vehicle is in operation and being fed with the electric power from the power supply device. However, the conventional electromagnetic susceptibility testing equipment illustrated in Fig. 1 may not be adapted to supply the electric power to the on-line electric vehicle. In addition, in the conventional electromagnetic susceptibility testing equipment, the influence on test results due to electromagnetic waves generated in the process of feeding the electric power into the on-line electric vehicle, may not be restrained.

Disclosure of Invention

Technical Problem

[5] Therefore, the present invention provides an apparatus and method for testing electromagnetic susceptibility, which can be used for a vehicle, for example, an on-line electric vehicle.

[6] Further, the present invention provides an apparatus and method for testing electromagnetic susceptibility, which are capable of restraining the influence of electromagnetic waves, generated in the course of feeding power to an on-line vehicle, on testing results.

Solution to Problem

[7] In accordance with one aspect of the present invention, there is provided an apparatus for testing electromagnetic susceptibility of a vehicle, the apparatus includes a mounting table for mounting thereon the vehicle; a first antenna for radiating an electromagnetic wave; and a second antenna for receiving an electromagnetic signal, wherein the mounting table includes a supporting plate for supporting the vehicle, the supporting plate being rotatable while supporting the vehicle; an inverter for outputting an AC power; and a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter.

[8] In accordance with another aspect of the present invention, there is provided a mounting table for testing electromagnetic susceptibility of a vehicle, the mounting table includes a supporting plate for supporting the vehicle, the supporting plate being rotatable while supporting the vehicle; an inverter for outputting an AC power; and a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter.

[9] In accordance with still another aspect of the present invention, there is provided a method for testing electromagnetic susceptibility of a vehicle by using an apparatus having a mounting table for mounting thereon the vehicle, wherein the mounting table includes a supporting plate for supporting the vehicle, an inverter for outputting an AC

power, and a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter, the method includes radiating a testing electromagnetic wave to the apparatus while supplying the AC power to the power feed line, without disposing the vehicle in the apparatus, and receiving a first electromagnetic wave from the apparatus; radiating the testing electromagnetic wave to the apparatus while mounting the vehicle on the mounting table of the apparatus and supplying the AC power to the power feed line, and receiving a second electromagnetic wave from the electromagnetic susceptibility testing apparatus; and inspecting the electromagnetic susceptibility of the vehicle based on the first and second electromagnetic wave.

Advantageous Effects of Invention

[10] In accordance with the present invention, the apparatus and method for testing electromagnetic susceptibility can be used for a vehicle, for example, an on-line electric vehicle, other than an internal combustion engine.

[11] In addition, in accordance with the present invention, the apparatus and method for testing electromagnetic susceptibility can restrain the influence of a power feed line provided for an on-line electric vehicle.

Brief Description of Drawings

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

[13] Fig. 1 shows a view for explaining a conventional art for testing electromagnetic susceptibility;

[14] Fig. 2 illustrates a plan view of a mounting table of an apparatus for testing electromagnetic susceptibility in accordance with an embodiment of the present invention;

[15] Fig. 3 presents a side view of the mounting table of the apparatus for testing electromagnetic susceptibility in accordance with the embodiment of the present invention;

[16] Figs. 4 and 5 are views for explaining a method for testing electromagnetic susceptibility in accordance with the embodiment of the present invention;

[17] Figs. 6 and 7 are views illustrating the configuration of a power feed line of the apparatus for testing electromagnetic susceptibility in accordance with the embodiment of the present invention; and

[18] Fig. 8 illustrates a side view of the mounting table of the apparatus for testing electromagnetic susceptibility in accordance with the embodiment of the present invention.

Best Mode for Carrying out the Invention

[19] Hereinafter, preferred embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[20] Fig. 4 illustrates an apparatus for testing an electromagnetic susceptibility of the on-line electric vehicle in accordance with an embodiment of the present invention. The apparatus includes a mounting table 10 for mounting thereon the on-line electric vehicle as a target of the electromagnetic susceptibility test (hereinafter, referred to as a 'vehicle'), an radiating antenna 600 for radiating an electromagnetic wave having a specific frequency and intensity, and an electromagnetic wave reception antenna 700 for receiving an electromagnetic signal. The radiating antenna 600 includes an electromagnetically susceptible antenna, such as a log-array periodical antenna.

[21] Figs. 2 and 3 illustrate the mounting table 10 of the apparatus for testing an electromagnetic susceptibility in accordance with this embodiment. In this embodiment, the mounting table 10 includes a supporting plate 100 for supporting the vehicle, an inverter 500 for outputting an alternating current (AC) power, a power feed line 300 connected to the inverter 500 for supplying an electric power to the vehicle in a contactless manner, and an electromagnetic wave interception unit 200 for intercepting electromagnetic waves generated from the vicinity of the power feed line 300.

[22] The supporting plate 100 supports the vehicle mounted on an upper surface thereof, and is configured to rotate on an axis which is perpendicular to the upper surface. A rotational driving unit (not shown) is provided on the supporting plate 100 in order to rotate the supporting plate 100. A lower plate 400 as illustrated in Fig. 3 is provided under the supporting plate 100, and the supporting plate 100 is combined with the lower plate 400 so as to rotate together.

[23] The inverter 500 generates the AC power and supplies it to the power feed line 300. The inverter 500 is installed on the lower plate 400, and because the supporting plate 100 and the lower plate 400 are combined, the lower plate 400 and the inverter 500 fixed on the lower plate 400 rotate at the same rotation speed as that of the supporting plate 100. Thus, even when the supporting plate 100 rotates, the power feed line 300 may be stably connected to the inverter 500, without being entangled or separated from the supporting plate 100. Also, as shown in Fig. 3, the inverter 500 is disposed in the interior of a housing 510 made of a material including a ferrite. The housing 510 prevents electromagnetic waves generated by the inverter 500 from leaking and affecting the operation of the vehicle and the test results.

[24] As shown in Fig. 6, the power feed line 300 connected to the inverter 500 is formed as a cable including a wire 301 and as an insulator 302 covering the wire 301. For example, the power feed line 300 includes a urethane coil stranded wire covered with silicon, polystyrene (PS) film, a cross-linked polyethylene (XLPE), and the like. Alternatively, as shown in Fig. 7, the power feed line 300 may be formed as a power feeding rail linearly disposed on the upper surface of the supporting plate 100 and including a conductive panel 303 formed of a conductive material (e.g., copper).

[25] The power feed line 300 is installed on the supporting plate 100. More specifically, as shown in Fig. 2, the power feed line 300 includes a first power feed line section 310 and a second power feed line section 320 which are disposed in two rows on the upper surface of the supporting plate 100 when viewed from above the upper surface of the supporting plate 100. The first power feed line section 310 and the second power feed line section 320 are disposed to be upwardly protruded from the upper surface of the supporting plate 100. Alternatively, the first and second power feed line section 310, 320 may be disposed such that they are buried in the supporting plate 100 or partially exposed in a manner that the exposed portions of the first and second power feed line section 310, 320 are substantially flush with the upper surface of the supporting plate 100.

[26] One end of the first power feed line section 310 is connected to a first terminal 501 of the inverter 500 by means of a first extension section 311 extending to the first terminal 501 of the inverter 500 by passing through the supporting plate 100 via a through hole 312 formed on the supporting plate 100, and one end of the second power feed line section 320 is connected to a second terminal 502 of the inverter 500 by means of a second extension section 321 extending to a second terminal 502 of the inverter 500 by passing through the supporting plate 100 via a through hole 322 formed on the supporting plate 100. Meanwhile, the other end of the first power feed line section 310 and the other end of the second power feed line section 320 are connected to each other (as indicated by a dotted line in Fig. 2) at a space below the supporting plate 100 by means of a connection section 330 of the power feed line 300. The connection section 330 extends between two through holes 314, 324 while passing through the supporting plate 100 via the through hole 314 and the through hole 324 formed on the supporting plate 100, thereby allowing the power feed line 300 to form a loop overall.

[27] Alternatively, as shown in Fig. 8, both ends of the first power feed line section 310 are connected to the first terminal 501 and a third terminal 503 of the inverter 500 installed at the lower side of the supporting plate 100 by means of the first extension section 311 and a third extension section 313 which extend by passing through the supporting plate 100 via the through holes 312, 314 formed on the supporting plate 100, and, both ends of the second power feed line section 320 are also connected to the second terminal 502 and a fourth terminal 504 of the inverter 500 by means of the second extension section 321 and a fourth extension section 323 which extend by passing through the supporting plate 100 via the through holes 322, 324 formed on the supporting plate 100. In this case, a loop for providing the AC power is formed by a circuit structure within the inverter 500 connected to the power feed line 300.

[28] The power feed line 300 is fed with the Ac power from the inverter 500. Then, a

magnetic field is generated around the power feed line 300 and the generated magnetic field induces an electric current to an induction circuit (a current collecting circuit) which is disposed on the vehicle while facing the power feed line 300. In this manner, the power feed line 300 supplies the electric power to the vehicle 20 in a contactless manner. The current induced to the induction circuit within the vehicle is used to charge a battery installed in the vehicle or directly to drive the vehicle.

[29] Meanwhile, the electromagnetic wave interception unit 200 made of a ferrite containing material is installed at a portion adjacent to the power feed line 300 on the supporting plate 100. In order to intercept electromagnetic waves which are propagated in substantially horizontal directions along the upper surface of the supporting plate 100 from the power feed line 300, the electromagnetic wave interception unit 200 includes a side structure 220 having both sidewalls extending in parallel to the first and second power feed line section 310, 320. Also, in order to intercept electromagnetic waves propagated in a downward direction of the supporting plate 100, the electromagnetic wave interception unit 200 includes a bottom structure 210 disposed below the first and second power feed line section 310, 320 and extending to cross the first and second power feed line section 310, 320 when viewed from above the upper surface of the supporting plate 100. Even when the first and second power feed line section 310, 320 are buried in the supporting plate 100 or disposed to be flush with the upper surface of supporting plate 100, rather than being protruded from the upper surface of the supporting plate 100, the bottom structure 210 is disposed below the first and second power feed line section 310, 320.

[30] The electromagnetic wave interception unit 200 forms a U-shape wherein the side structure 220 corresponds to both sidewalls of the U-shape and the bottom structure 210 corresponds to the bottom thereof. Also, the first and second power feed line 310, 320 are disposed above the bottom structure 210 in a manner that they are accommodated within the U-shaped electromagnetic wave interception unit 200. In this regard, when the first and second power feed line section 310, 320 are formed as the power feed rail as shown in Fig. 7, the bottom structure 210 is also formed as a panel and extend to be parallel to the supporting plate 100. In this case, an insulator 304 is disposed between the conductive panel 303 forming the first and second power feed line section 310, 320 and the bottom structure 210 of the electromagnetic wave interception unit 200 so that the first and second power feed line section 310, 320 are separated from the bottom structure 210 by means of the insulator 304.

[31] The electromagnetic wave interception unit 200 is buried in the supporting plate 100. Alternatively, the electromagnetic wave interception unit 200 and/or the first and second power feed line section 310, 320 are covered by an insulating cover. In both cases, the electromagnetic wave interception unit 200 and/or the first and second

power feed line 310, 320 is protected from harmful external factors, without being exposed thereto.

[32] By providing the electromagnetic wave interception unit 200, electromagnetic waves generated from the power feed line 300 are restrained from affecting the results of the electromagnetic susceptibility test.

[33] Hereinafter, a method for testing the electromagnetic susceptibility of the on-line electric vehicle by using the apparatus as described above will be described with reference to Figs. 4 and 5.

[34] First, as shown in Fig. 4, AC power is supplied to the power feed line 300 in a state in which the vehicle is not disposed on the mounting table 10. These arrangements are designed to simulate an environment where the on-line electric vehicle is enabled to be fed with the electric power from the roadway but there is no on-line electric vehicle on the roadway. At this point, an electromagnetic wave having a preset intensity is radiated toward the mounting table 10 through a radiating antenna 600. On the other hands, an electromagnetic wave is received from the mounting table 100 by the electromagnetic wave reception antenna 700. In this case, the electromagnetic wave radiated from the radiating antenna 600 may have a intensity of 24 V/m (an effective value) and a frequency within the range of 20 to 1000 MHz.

[35] Next, as shown in Fig. 5, the vehicle 20 is disposed on the supporting plate 100 of the mounting table 10 and the AC power is supplied the power feed line 300. Thus, an environment in which the vehicle 20 is fed with the electric power is created. Once current is supplied to the power feed line 300, various devices of the vehicle 20 are operated. Also, an electromagnetic wave having a preset intensity is radiated toward the vehicle 20 from the electromagnetically susceptible antenna 600. On the other hand, an electromagnetic wave is received from the vehicle 20 and various devices constituting the vehicle 20 by the electromagnetic wave reception antenna 700. In this regard, the electromagnetic waves are received from the vehicle 20 at various angles by rotating the supporting plate 100 of the mounting table 10. Further, the various devices of the vehicle 20 includes, for example, electronic devices (not shown) such as an electric light, a wiper, an audio cassette, an air-conditioner, and the like, installed in the vehicle, as well as a motor for driving the vehicle. In addition, electromagnetic waves are received from the vehicle 20 while transiting states of the vehicle, starting from a state in which power is supplied to the electronic devices but not to the motor for driving the vehicle 20 (a so-called ignition-on state or key-on state), a vehicle state in which power is supplied to the electronic devices including the motor but a rotational force of the motor is not transferred to wheels of the vehicle (a so-called idle state), and a vehicle state in which, while power is being supplied to the electronic devices including the motor, the rotational force of the motor is transferred to the

wheels to rotate the wheels (a so-called running state).

[36] The electromagnetic susceptibility of the vehicle 20 is determined based on the electromagnetic signals received two times in this way, namely, the electromagnetic signal received in the absence of the vehicle (in Fig. 4) and the electromagnetic signal received in the presence of the vehicle (in Fig. 5). That is, affects of the ambient electromagnetic waves on the vehicle 20 and an abnormal electromagnetic waves generated by malfunction of the vehicle 20 in response are inspected by means of comparing the electromagnetic signal received in the absence of the vehicle 20 and the electromagnetic signal received in the presence of the vehicle 20 while using the electromagnetic signal received in the absence of the vehicle 20 is used as an offset value. In particular, because the electromagnetic signal received in the absence of the vehicle 20 is used as an offset value, in detecting the abnormal electromagnetic wave due to malfunction of the vehicle, the influence of electromagnetic waves generated in the process of power feeding can be restrained.

[37] As described above, the electromagnetic susceptibility testing can be performed on the on-line electric vehicle by employing the electromagnetic susceptibility testing apparatus in accordance with the present invention.

[38] While the invention has been shown and described with respect to the embodiments, it will be understood by those skilled in the art that various changes and modifications may without departing from the scope of the invention as defined in claims. For example, the electromagnetic susceptibility test in accordance with the present invention may be performed in an anechoic chamber of which an inner surface is provided with a member restraining the reflection of electromagnetic wave. In addition, multiple rollers configured to be rotated by a rotational force of the wheels of the vehicle while being in contact with the wheels, may be disposed on the mounting table, whereby, the vehicle is prevented from departing from the mounting table even when the wheels of the vehicle are rotated. Also, a means for monitoring and determining the state or performance of the vehicle, such as a chassis dynamometer, or a process for detecting whether or not the vehicle malfunctions by the naked eyes may be additionally provided to the present invention. Moreover, the present invention has been mainly described with respect to the on-line electric vehicle, but the use of any other types of vehicles requiring a power feed line may not be excluded. The function blocks or means described herein may be implemented as various known elements such as an electronic circuit, an integrated circuit, an application specific integrated circuit (ASIC), and the like, and they may be separately implemented or two or more of them may be integrated to be implemented.

Claims

[Claim 1] An apparatus for testing electromagnetic susceptibility of a vehicle, the apparatus comprising:
a mounting table for mounting thereon the vehicle;
a first antenna for radiating an electromagnetic wave; and
a second antenna for receiving an electromagnetic signal,
wherein the mounting table includes:
a supporting plate for supporting the vehicle, the supporting plate being rotatable while supporting the vehicle;
an inverter for outputting an AC power; and
a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter.

[Claim 2] The apparatus of claim 1, wherein the power feed line includes a wire and an insulator covering the wire.

[Claim 3] The apparatus of claim 1, wherein the power feed line includes a conductive panel.

[Claim 4] The apparatus of claim 1, wherein at least one end of the power feed line is connected to the inverter while penetrating the supporting plate.

[Claim 5] The apparatus of claim 1, further comprising:
an electromagnetic wave interception unit for intercepting an electromagnetic wave generated from the power feed line, the electromagnetic wave interception unit being made of a material including ferrite and installed on the supporting plate.

[Claim 6] The apparatus of claim 5, wherein the electromagnetic wave interception unit includes a side structure extending in a direction parallel to a section of the power feed line disposed on the upper surface of the supporting plate.

[Claim 7] The apparatus of claim 5, wherein the electromagnetic wave interception unit includes a bottom structure disposed below a section of the power feed line which is located on the upper surface of the supporting plate.

[Claim 8] The apparatus of claim 5, wherein the electromagnetic wave interception unit is buried in the supporting plate.

[Claim 9] The apparatus of claim 1, wherein the inverter is rotatable together with the supporting plate as a single unit.

[Claim 10] The apparatus of claim 1, wherein the inverter is disposed within a

housing made of a material including a ferrite.

[Claim 11] A mounting table for testing electromagnetic susceptibility of a vehicle, the mounting table comprising:
a supporting plate for supporting the vehicle, the supporting plate being rotatable while supporting the vehicle;
an inverter for outputting an AC power; and
a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter.

[Claim 12] The mounting table of claim 11, wherein the power feed line includes a conductive panel.

[Claim 13] The mounting table of claim 11, wherein at least one end of the power feed line is connected to the inverter while penetrating the supporting plate.

[Claim 14] The mounting table of claim 11, further comprising:
an electromagnetic wave interception unit for intercepting an electromagnetic wave generated from the power feed line, the electromagnetic wave interception unit being made of a material including ferrite and installed on the supporting plate.

[Claim 15] The mounting table of claim 14, wherein the electromagnetic wave interception unit includes a side structure extending in a direction parallel to a section of the the power feed line disposed on the upper surface of the supporting table.

[Claim 16] The mounting table of claim 14, wherein the electromagnetic wave interception unit includes a bottom structure disposed below a section fo the power feed line which is located on the upper surface of the supporting plate.

[Claim 17] The mounting table of claim 14, wherein the electromagnetic wave interception unit is buried in the supporting plate.

[Claim 18] The mounting table of claim 11, wherein the inverter is rotatable together with the supporting plate as a single unit.

[Claim 19] A method for testing electromagnetic susceptibility of a vehicle by using an apparatus having a mounting table for mounting thereon the vehicle, wherein the mounting table includes a supporting plate for supporting the vehicle, an inverter for outputting an AC power, and a power feed line for feeding an electric power into the vehicle in a contactless manner, the power feed line being provided at the supporting plate and fed with the AC power from the inverter, the method

comprising:

radiating a testing electromagnetic wave to the apparatus while supplying the AC power to the power feed line, without disposing the vehicle in the apparatus, and receiving a first electromagnetic wave from the apparatus;

radiating the testing electromagnetic wave to the apparatus while mounting the vehicle on the mounting table of the apparatus and supplying the AC power to the power feed line, and receiving a second electromagnetic wave from the electromagnetic susceptibility testing apparatus; and

inspecting the electromagnetic susceptibility of the vehicle based on the first and second electromagnetic wave.

[Claim 20] The method of claim 19, wherein in said inspecting the electromagnetic susceptibility of the vehicle, the second electromagnetic wave is used as an offset value.

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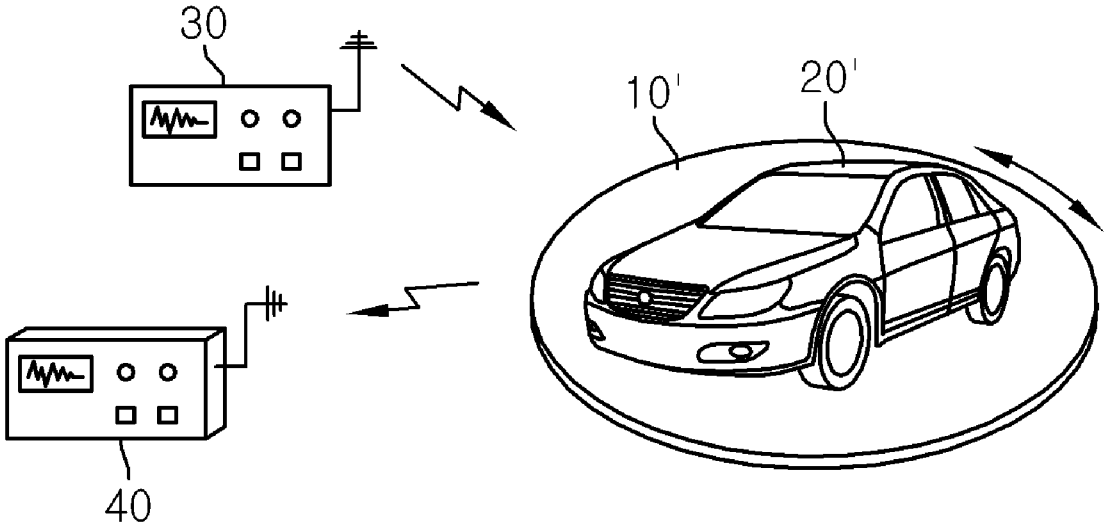
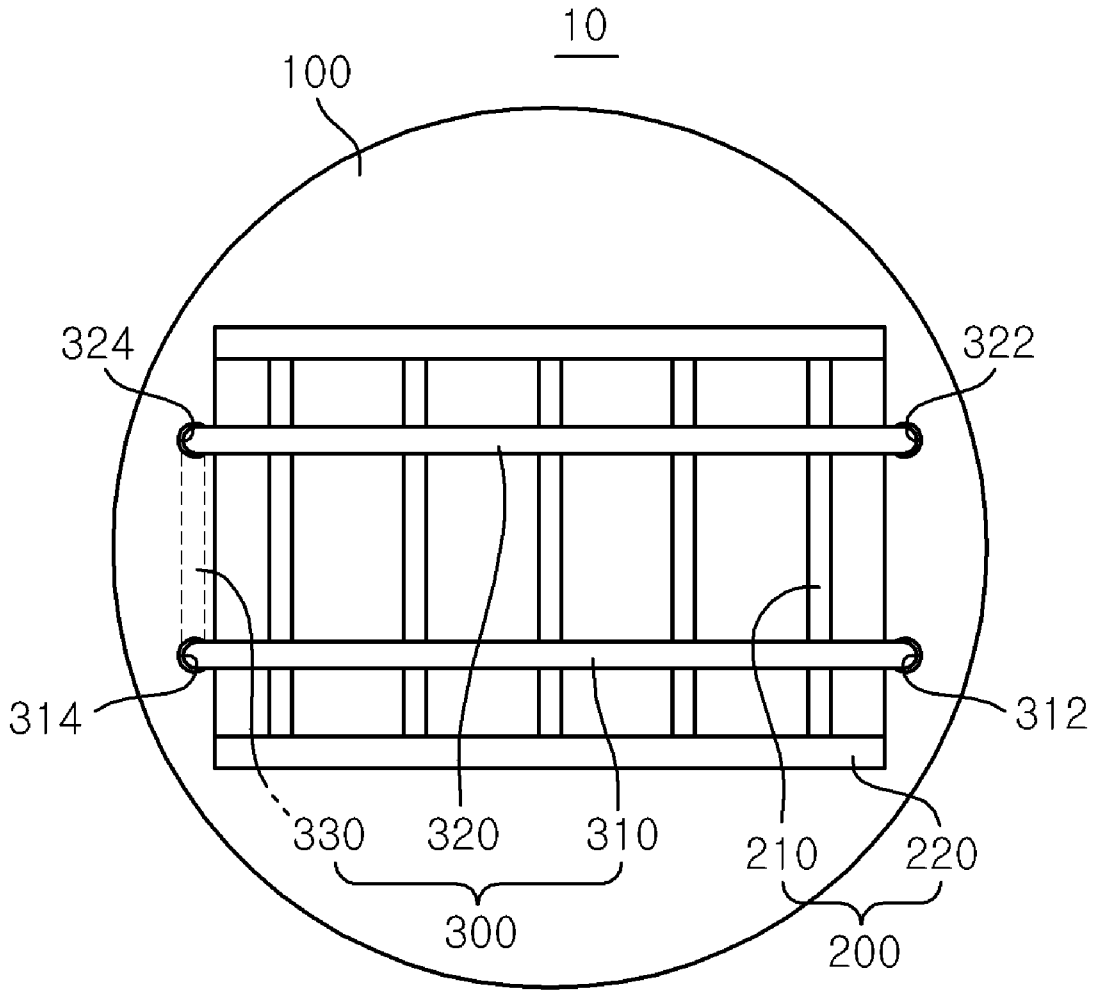
[Fig. 1]

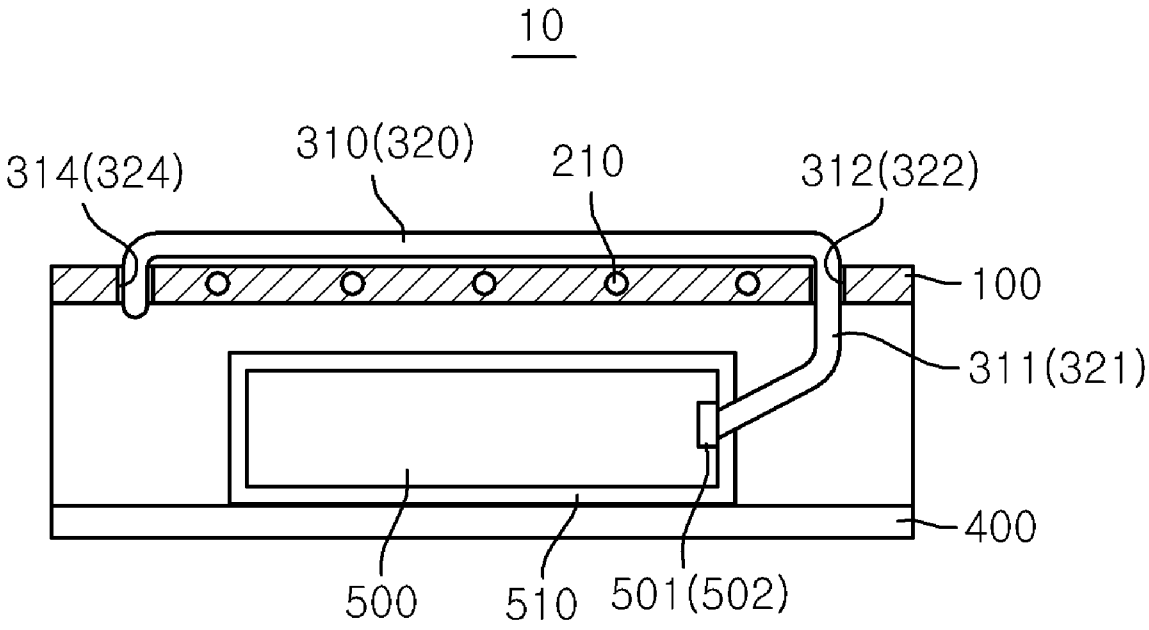
(PRIOR ART)



[Fig. 2]



[Fig. 3]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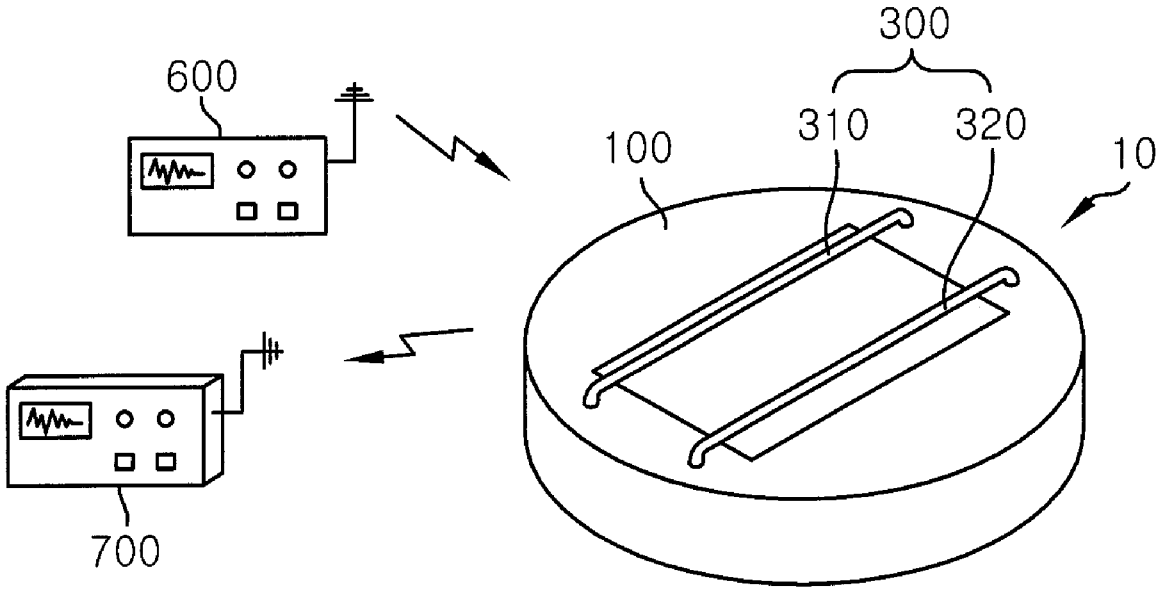
[Fig. 4]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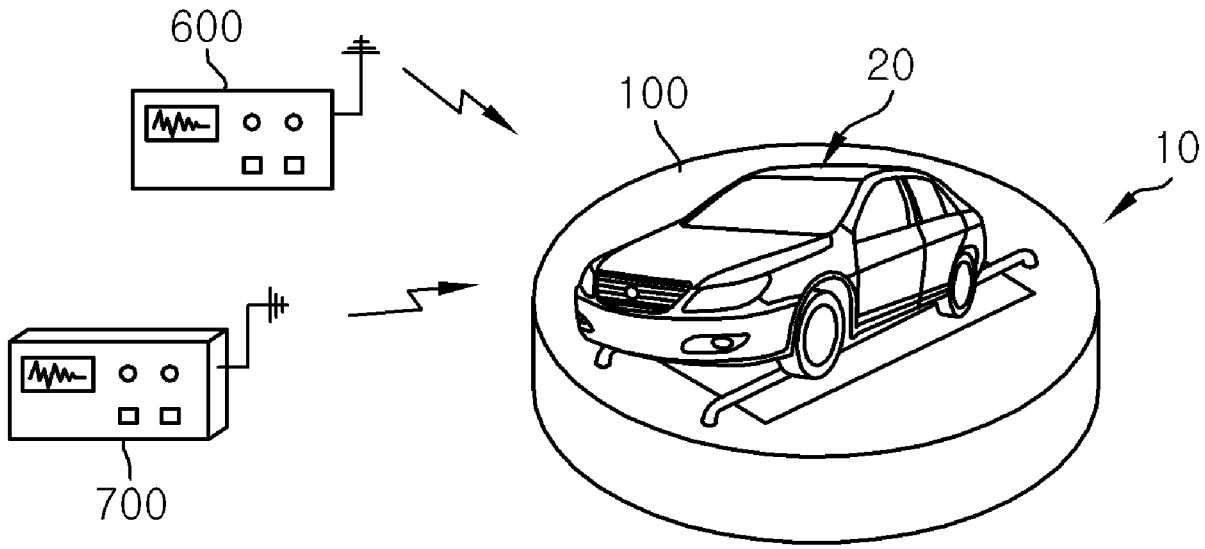
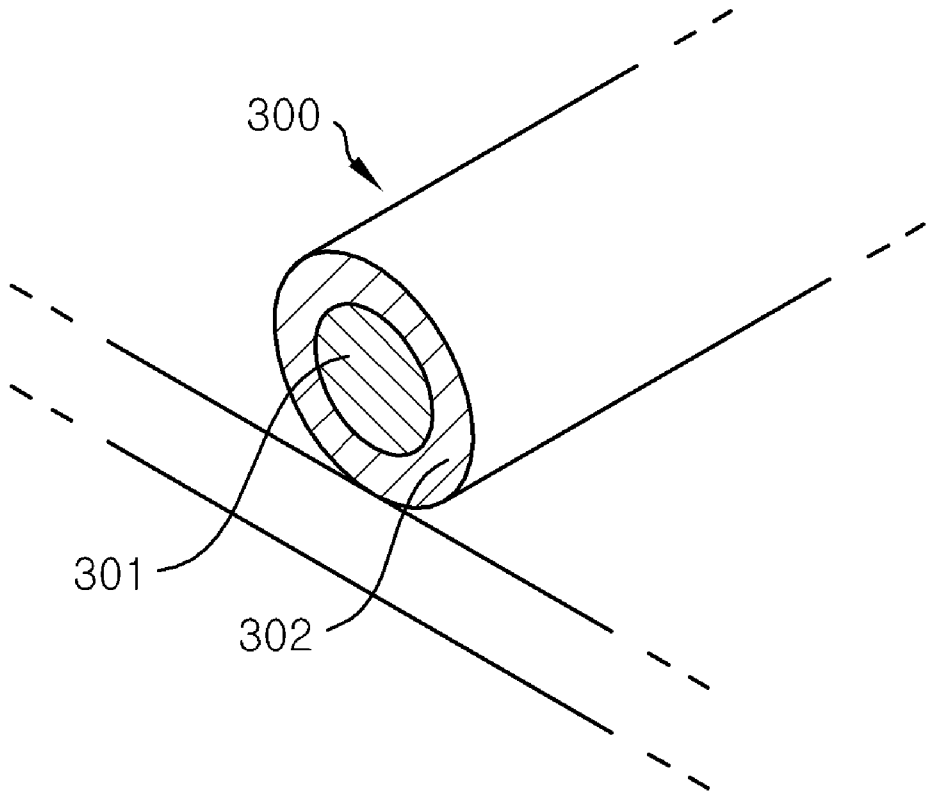
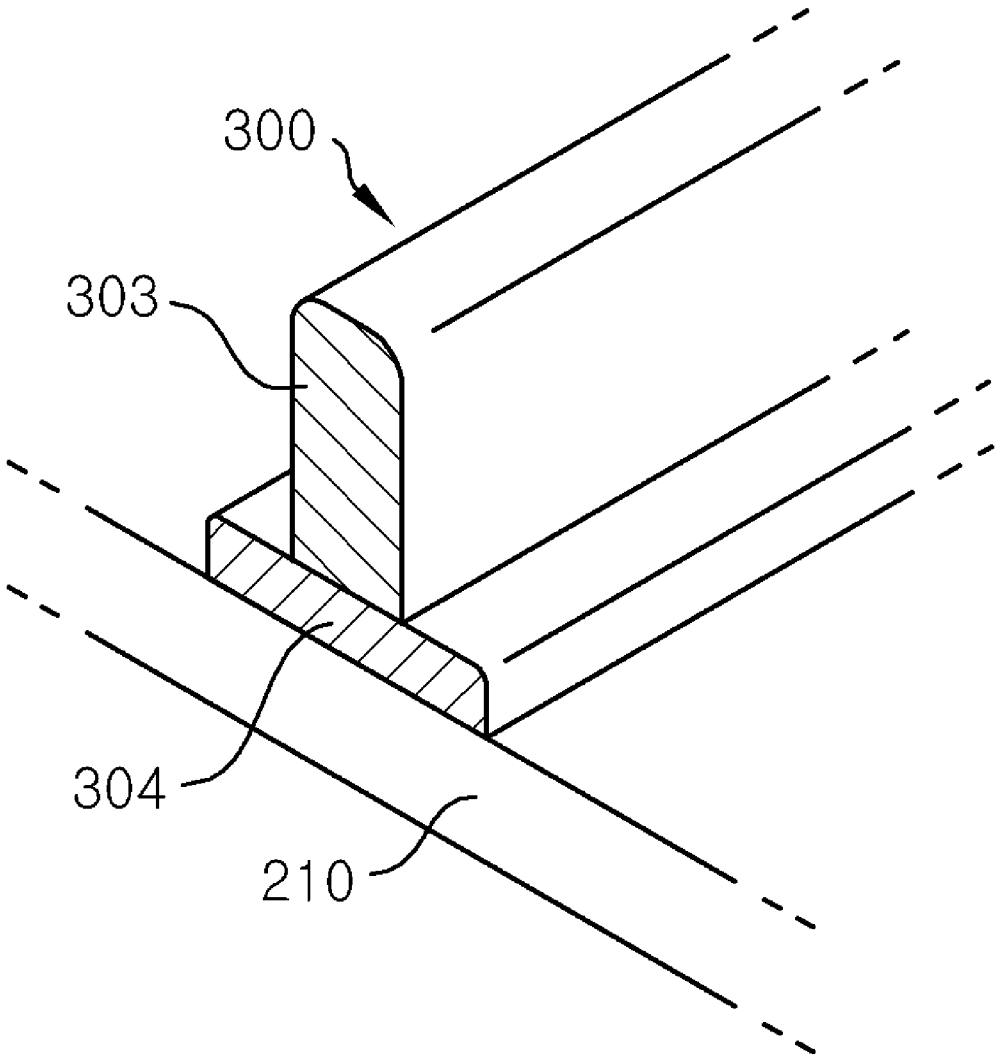
[Fig. 5]



[Fig. 6]



[Fig. 7]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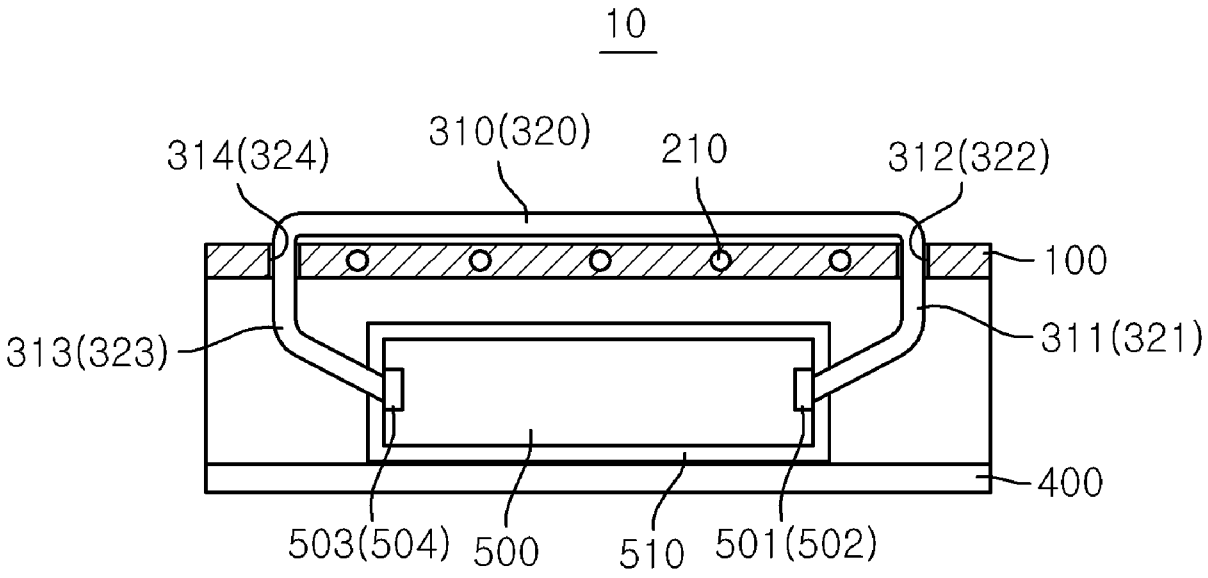
[Fig. 8]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100
313(323)
311(321)
400
503(504)
500
510
501(502)