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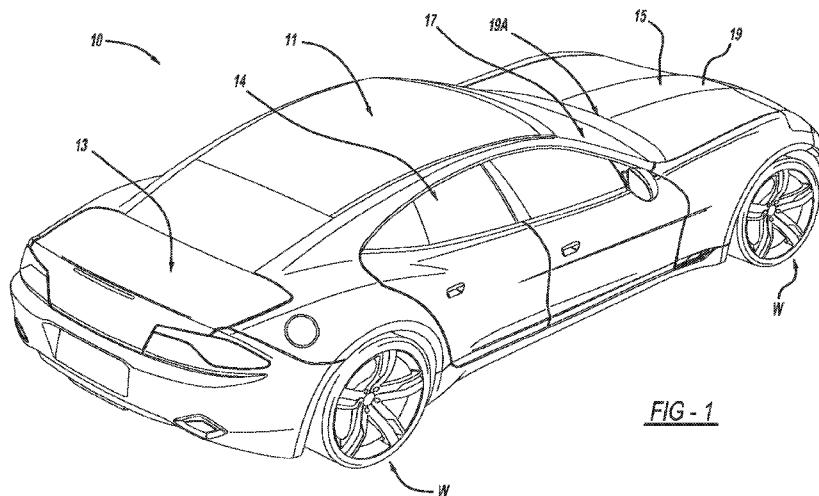


FIG - 1

(57) Abstract: A wireless charging system is provided. The system includes a power transmitter having a power source and a first inductive element for transmitting inductive power. The transmitter is positioned in a location to allow for proximity placement to the vehicle. They system includes a power receiver having a second inductive element adjacent the vehicle and adapted to wirelessly absorb inductive power transmitted from the power transmitter and convert the absorbed power to electrical current that is delivered to an electric storage device in the vehicle when the power receiver and power transmitter are within a predetermined proximity of each other.



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WIRELESS CHARGING DEVICE FOR ELECTRIC AND PLUG-IN HYBRID VEHICLES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 61/315547, filed March 19, 2010, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates generally to a wireless charging device for vehicles. More specifically, the present disclosure relates to a wireless charging device for electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs).

[0003] EVs are vehicles which utilize one or more electric motors for propulsion. PHEVs utilize one or more electric motors in combination with a conventional (e.g., combustion powered) powertrain. The electric motors of EVs and PHEVs may receive their power from a number of sources including fossil fuels, nuclear power, or renewable sources such as solar power, wind power, and the like. The energy derived from these sources may be transmitted to the vehicle through various means such as overhead lines or direct connection through an electrical cable. EVs and PHEVs typically require the user to plug the vehicle into a charger or wall outlet prior to use when the vehicle is idle in order to recharge the vehicle. This is known as direct wired contact or direct coupling or conductive charging and requires direct electrical contact between the batteries and the charger. Conductive charging is achieved by connecting a device (e.g., vehicle battery, etc.) to a power source with plug-in wires, such as a docking station, or by moving batteries from a device to the charger.

[0004] While conventional charging systems work, they can have a number of disadvantages. For example, there is a risk of electrical shock because the electrical conductors are exposed when plugging in and unplugging the electrical charger. The presence of liquids, such as water, rain, or the like, can increase the risk of electrical shock when plugging in and unplugging the electrical charger. In addition, if the user forgets to recharge the vehicle, the user runs the risk of not being able to complete a journey, or in the case of a PHEV, not achieving the benefits of partial

electric operation and therefore optimal performance. Further, it may be difficult to position or maneuver the vehicle with respect to the electrical charger

[0005] Thus, there is a need for a charging system and method that utilizes an interactive display and finite adjustment between the power transmitter and the power receiver to provide for wireless charging of the vehicle energy storage device.

SUMMARY

[0006] Accordingly, the present disclosure relates to a wireless charging system for a vehicle including a power transmitter having a power source and a first inductive element for transmitting inductive power. The transmitter is positioned in a location to allow for proximity placement to the vehicle. The system includes a power receiver having a second inductive element adjacent the vehicle and is adapted to wirelessly absorb inductive power transmitted from the power transmitter and convert the absorbed power to electrical current that is delivered to an electric storage device in the vehicle when the power receiver and power transmitter are within a predetermined proximity of each other.

[0007] In an example the wireless charging system can transmit inductive power to the vehicle with no active involvement of the user. The wireless charging system also includes an interactive visual display system that guides the vehicle operator to move the vehicle into position for recharging. The wireless power transmitter can be mobile and automatically align itself with the wireless power receiver to initiate electrical charging.

[0008] The present disclosure further provides for a method of wireless charging for a vehicle, the method includes the steps of locating a power transmitter having a power source and a first inductive element for transmitting inductive power to the vehicle. A wireless power receiver having a second inductive element is mounted adjacent the vehicle, and the vehicle includes an energy storage device in communication with the power receiver, to wirelessly absorb inductive power transmitted from the power transmitter and convert the absorbed power to electrical current. The relative position of the vehicle and the receiver is adjusted with respect to the transmitter to allow for wireless inductive power transfer between the vehicle and the transmitter using the interactive display device. The electrical current is delivered to the vehicle electrical storage device by the power transmitter after the

power transmitter and power receiver are within a predetermined proximity of each other.

[0009] An advantage of the present disclosure is that the wireless charging device is provided with improved safety features as compared to a conventional plug in charger. Another advantage of the present disclosure is that the wireless charging device can be used in the presence of liquids, such as water, with no risk of electrical shock. Yet another advantage of the present disclosure is that the wireless charging device does not require active involvement by the operator and therefore does not require the operator to remember to plug the vehicle into a charger. Still another advantage of the present disclosure is that the wireless charging device has a simple and compact design which does not require a large amount of space or extraneous secondary structures. A further advantage of the present disclosure is that the power transmitter and power receiver can be positioned relative to each other using an interactive display device associated with the vehicle. Still a further advantage of the present disclosure is that each of the power transmitter or power receiver includes a moveable portion so that finite positional adjustments can be made to optimize charging.

[0010] Other features and advantages of the present disclosure will be readily appreciated, as the same becomes better understood after reading the subsequent description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] FIG. 1 is a perspective view of an exemplary electric powered vehicle.

[0012] FIG. 2 is a perspective cut-away view showing a battery.

[0013] FIG. 3 is front view of an instrument panel for the vehicle.

[0014] FIGS. 4A-4B are front views of an information display for a vehicle.

[0015] FIG. 5 is a diagram of a wireless charging device.

[0016] FIG. 6 is diagram of a wireless charging device.

[0017] FIG. 7 is a side view of an electric vehicle positioned over a wireless charging device.

[0018] FIG. 8 is a flow diagram illustrating a method of charging of the present disclosure.

DETAILED DESCRIPTION

[0019] Referring to FIGS. 1 and 2, a hybrid vehicle 10 having one or more rechargeable electric motors according to an exemplary embodiment is shown. The vehicle 10 may be any type of vehicle, such as an EV, or PHEV, or the like. In addition, while the vehicle 10 shown is a 2-door sedan, it should be understood that vehicle 10 may be a mini-van, sport utility vehicle or any other means in or by which someone travels. Vehicle 10 can be any hybrid vehicle including a solar and electric powered vehicle, a combustion engine and electric vehicle, a plug-in hybrid vehicle having a battery that obtains an electrical charge from a standard electrical outlet, or a fully electric battery powered vehicle.

[0020] Generally, vehicle 10 includes a body structure 11 having a frame surrounding and typically enclosing an interior space 17 referred to as a passenger compartment 17. A rear compartment 13, often used as a trunk or luggage compartment 13 extends rearwardly from the passenger compartment 17. Typically the passenger compartment 17 and luggage compartment 13 are separated by passenger seats 14. Often the seats 14 are foldable and/or removable to allow for storing and carrying larger objects thereby effectively extending the size of the rear compartment 13. A front or engine compartment 15 typically extends forwardly from the passenger compartment 17 and is covered from above by a hood 19. The hood is pivotably mounted at a proximal end 19A of the front compartment 15 adjacent the passenger compartment 17 to allow access to mechanical and electrical components mounted in the front compartment 15. A power source, such as an engine, typically engage a drive shaft (not shown) and in combination with the wheels W define a drive train (i.e., also referred to as a power train), commonly referred to as a group of components that generate power and deliver it to the road surface. In certain embodiments, the engine may be located in or below the rear compartment 13.

[0021] The vehicle 10 includes a power train that controls the operation of the vehicle. In this example, the power train is a plug-in hybrid, and includes an electrically powered motor and motor controller, although the power train could be of a dedicated electric type. The vehicle may also include a gasoline powered engine that supplements the electric motor when required under certain operating conditions.

[0022] The electrical energy used to operate the vehicle is stored in an energy storage device, such as the battery 18. The battery 18 may be a single unit, or a plurality of modules arranged in a predetermined manner, such as in series to be described in more detail below. Various types of batteries are available, such as lead acid, or lithium-ion or the like. The battery 18 is contained within a battery housing 12.

[0023] The vehicle 10 may include more than one type of battery 18 or energy storage device. The battery 18 supplies the power in the form of electricity to operate various vehicle components. In this example, there is a low voltage battery that provides electrical power to vehicle components such as the various auxiliary systems and a high voltage battery (i.e. 400 V traction battery) that provides electrical power to an electric drive motor. The battery may be in communication with a control system that regulates the distribution of power within the vehicle, such as to the electric drive motor, or a vehicle component or other accessories or the like. In this example, the high voltage battery receives electrical energy from a plug-in source, and the low voltage battery receives electrical energy from a solar source and from the higher voltage battery as needed.

[0024] The battery 18 can be supported within the vehicle by a battery tray 16. In an example, the battery 18 and battery tray 16 extend longitudinally along the length of the vehicle. The battery tray can be fabricated from a metal material, such as Aluminum or the like. The battery tray can be secured to the vehicle frame 11 using a fastener, such as a bolt. In an example, a seal is applied between a flange portion of the base member and the battery housing to prevent the intrusion of elements such as moisture or dirt or like into the interior of the battery. An example of a sealant is rubber or foam or adhesive, or the like. The housing 12 is a generally box-like structure that provides additional protection to the battery 18. The housing 12 is secured to the battery tray, such as using a fastener.

[0025] Referring now to FIGS. 3, 4A, and 4B, an instrument panel (IP) (or dashboard, instrument cluster (IC), etc.) 30 and a display device (e.g., interactive interface, human machine interface (HMI), touch screen interface, etc.) 32 is shown which is interchangeably referred to as a display and/or visual display. The instrument panel 30 extends laterally in the front portion of the vehicle 10 from one side of the vehicle 10 to the other side of the vehicle 10 in the passenger

compartment 17, as shown in FIG. 3. The instrument panel 30 may support a variety of visual displays 32 that provide a variety of information pertaining to the vehicle 10, such as safety, performance, entertainment options, or the like. The display 32 may also be an interactive display device that enables the operator and/or occupant of the vehicle 10 to control and regulate the features of the vehicle 10, such as the interior climate, audio system, phone, navigation, system, battery recharging system, or the like, as shown in FIGS. 4A and 4B. The display 32 may also include a variety of visual and/or audible indicators informing/warning the operator or occupant of the vehicle 10 of issues such as low tire pressure, low fuel, low battery power, battery level, recharging progress, or the like. The display 32 may also include a visual and/or audible indicator that guides or navigates the operator or occupant of the vehicle to a particular location or position, such as a position proximate a wireless charging device 50, or the like. The display device 32 is operatively in communication with the charging system 50 and provides the vehicle operator with information about the charging system 50.

[0026] Referring now to FIGS. 5-7, a wireless charging device 50 is shown. According to an exemplary embodiment, the wireless charging device 50 operates on induction charging, although other types of energy transfer is contemplated. The wireless charging device 50 includes a charging base station 52 and a power transmitter 54 having a first induction coil 56. A power receiver 70 having a second induction coil 72 is hosted on the vehicle 10. The power receiver 70 can be located either on or within the frame or the like. During charging, receiver 70 is positioned within direct physical proximity of transmitter 54. The power transmitter 54 can be connected to the charging base station 52 via a cable 58. The transmitter can create an alternating electromagnetic field. Alternatively, the power transmitter 50 can be located on or located within the charging base station 52 as shown in FIG. 6.

[0027] In this example, the power receiver 70 is secured to the vehicle 10 and in electrical communication with a charging system of the vehicle 10. Alternatively, the power receiver (receiver) 70 can be located on or located within the vehicle 10. The power receiver 70 takes power from the electromagnetic field and converts it back into electrical current to charge the vehicle battery 18. When the first induction coil 56 of the power transmitter 54 and the second induction coil 72 of the

power receiver 70 are in proximity of one another, they combine to effectively form an electrical transformer. The wireless charging device 50 can be positioned on a stationary surface (S) (e.g., garage floor, wall, ceiling, etc.), as shown in FIG. 5.

Alternatively, the wireless charging device 50 can be positioned within a stationary surface (S) (e.g., garage floor, wall, ceiling, etc.), as shown in FIG. 6.

[0028] Referring to FIG. 7, an electric vehicle 10 positioned in a predetermined location with respect to a wireless charging device 50 is shown. The wireless charging device 50 transmits power to a rechargeable battery 18 located within the vehicle 10, such as the inductive power of this example. Charging device can be designed to be simple and compact in design if desirable. The wireless charging device 50 may be positioned on a surface such as a floor of an area, such as a garage, parking space, or the like. A vehicle 10 may be parked within the vicinity (e.g., over, etc.) of the wireless charging device 50, and the relative position of the wireless charging device and power receiver automatically initiates the charging process. As a result of the proximity, the wireless charging device 50 begins to wirelessly transmit power from the first induction coil 56 associated with the power transmitter 54 to the second induction coil 72 associated with the power receiver device 70 mounted on the vehicle 10. As the power receiver 70 absorbs the conductive power from the wireless charging device 50 the power receiver 70 converts the power to electrical power in a manner that it can effectively capture the inductive power transmitted from the wireless charging device 50. Because an operator need merely to park his or her vehicle 10 within the vicinity of the wireless charging device 50, the likelihood that the vehicle 10 is charged between uses and reduces the burden on the operator to initiate the charging process. The transfer of energy or recharging can be initiated automatically by the vehicle (e.g., vehicle control system, vehicle computer, vehicle recharging system, etc.) under predetermined conditions (e.g., battery low, vehicle in proximity of battery recharging system, etc.). Alternatively, the transfer of energy or recharging can be initiated manually (e.g., by the vehicle operator, etc.) by using the interactive display device 32.

[0029] It is contemplated that a number of alternative embodiments may be designed based on the aforementioned configuration. For example, according to another exemplary embodiment, other power transmission techniques may be

implemented in lieu of induction, such as microwaves, resonant induction, and the like.

[0030] The wireless charging device 50 may be placed in other locations other than the floor, such as the ceiling, wall, and the like. The wireless charging device 50 operates using inductive charging and is designed to have no exposed electrical conductors and therefore can be positioned and used on virtually any surface even surfaces having a liquid, such as a garage floor covered in water, with no risk of electrical shock.

[0031] The wireless charging device 50 may also include a moveable portion to facilitate finite adjustment of the wireless charging device. For example, a moveable member 57, i.e. arm, plate, portion, extension member, etc. disposed on the power base 54 may be used to vary the relative position of the power transmitter with respect to the power receiver. For example, the power receiver 70 can be moved to be in contact or in close proximity to the power transmitter for optimal performance (e.g., higher energy transfer efficiency, etc.). In another example, the power receiver 70 includes a moveable portion 71, such as an arm, plate, portion, extension member or the like to locate the to the puck 54 to optimize performance (e.g., maximize energy transfer efficiency, decrease the distance between the power transmitter and the power receiver to enhance energy transfer, etc.). As a further alternative, both the power transmitter 54 and the power receiver 70 may each have a portion 57, 71 respectively that can be manipulated to control the proximity between the power transmitter 54 and the power receiver 70 and thereby improve electrical charging.

[0032] The wireless charging device 50 may also includes a mobile power transmission device 54 that automatically moves to the proper location (similar to a robotic device which maneuvers on its own, or the like) to minimize the burden on the vehicle operator and to ensure that the power transmission device 54 and the vehicle power receiver 70 are aligned.

[0033] The system also includes an interactive visual display device 3 may be used that guides the vehicle operator to position/park the vehicle 10 in the most suitable location in relation to the charger 50 and more specifically, to the power transmitter 54. The visual display system 14 may include a navigation or other interface screen, directional arrows (e.g., turn signal, etc.), and/or audible indicators

to indicate the vehicle's position in relation to the wireless charging device 50 or the power transmitter 54 and/or to guide the driver to the optimal location for alignment, charging, or the like. Although the visual display system of this example is located within the vehicle, it could also be located external to the vehicle 10, such as on a wall, or other location.

[0034] Referring to Fig. 8, a method of charging a vehicle is provided using the system previously described. The methodology starts with box 100 with the step of locating a power transmitter having a power source. For example, the power transmitter may be permanently positioned on a wall, or on a floor, or beneath a floor. In another example, the power transmitter is portable.

[0035] The methodology advances to box 110 where a wireless power receiver, as previously described, is mounted adjacent the vehicle. In an example, the receiver can be mounted within the vehicle frame. In another example, the wireless power receiver is mounted adjacent the vehicle frame. The wireless power receiver may be fixed or removable mounted.

[0036] The methodology advances to box 120 and the relative position of the vehicle and the receiver can be adjusted with respect to the transmitter using the interactive display device. For example, an image of the vehicle and the power receiver with respect to the power transmitter is displayed on the display device. The display device may include other icons to assist the user with maneuvering the vehicle so that charging may be initiated.

[0037] The methodology advances to box 125 and the position of the receiver and/or the transmitter may be adjusted using a moveable element to provide closer proximity of each to each other. Once the proximity of the transmitter and receiver is achieved and inductive power is transferred between them, the electric current generated in the receiver is delivered to the vehicle electric storage device as represented in box 130.

[0038] The present disclosure has been described in an illustrative manner. It is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

[0039] Many modifications and variations of the present disclosure are possible in light of the above teachings. Therefore, within the scope of the appended claim, the present disclosure may be practiced other than as specifically described.

WHAT IS CLAIMED IS:

1. A wireless charging system for a vehicle comprising:
 - a power transmitter having a power source and a first inductive element for transmitting inductive power, the transmitter positioned in a location to allow for proximity placement to the vehicle;
 - a power receiver having a second inductive element adjacent the vehicle and adapted to wirelessly absorb inductive power transmitted from the power transmitter and convert the absorbed power to electrical current that is delivered to an electric storage device in the vehicle when the power receiver and power transmitter are within a predetermined proximity of each other.
2. The system of claim 1 further comprising an interactive visual display system in communication with the power receiver and transmitter and adapted to display information to a vehicle operator to guide the vehicle for recharging so that the power receiver and power transmitter are within the predetermine proximity of each other.
3. The system of claim 2 wherein the display provides feedback to a driver indicating activation of the charging system is needed resulting from a preset condition being satisfied.
4. The system of claim 2 wherein the display provides feedback indicating the transmitter and the receiver are within the predetermined proximity of each other to allow for charging.
5. The system of claim 1 wherein the power transmitter is mobile and operable to align itself within the predetermined proximity of the power receiver to initiate charging.
6. The system of claim 1 wherein at least one of the power transmitter and the power receiver includes a portion that is moveable to adjust a relative proximity between the power transmitter and the power receiver.

7. The system of claim 1 wherein the first inductive element is mounted on an extendable member that positions the first inductive element with respect to the second inductive member.
8. The system of claim 1 wherein the second inductive element of the receiver is mounted on an extendable member that positions the second inductive element with respect to the first inductive member.
9. The system of claim 1 wherein the power transmitter includes a mobility member used to align itself relative to the receiver.
10. The system of claim 1 wherein the power transmitter is stationary and fixed in place.
11. The system of claim 1 wherein charging is automatically induced when the transmitter and receiver are positioned within a preset distance relative to each other.
12. The system of claim 11 wherein charging is induced when a vehicle controller measures a parameter reaching below a preset threshold.
13. The system of claim 1 wherein charging is induced via a manual control in the vehicle.
14. The system of claim 1 wherein the battery is a high voltage battery adapted to power the vehicle.
15. The system of claim 1 wherein the first inductive element and the second inductive element are each inductive coils.

16. A method of wireless charging for a vehicle, said method comprising the steps of:

locating a power transmitter having a power source and a first inductive element for transmitting inductive power to the vehicle;

mounting a wireless power receiver having a second inductive element adjacent the vehicle, wherein the vehicle includes an energy storage device in communication with the power receiver, to wirelessly absorb inductive power transmitted from the power transmitter and convert the absorbed power to electrical current;

adjusting the relative position of the vehicle and the receiver with respect to the transmitter to allow for wireless inductive power transfer between the vehicle and the transmitter using the interactive display device; and

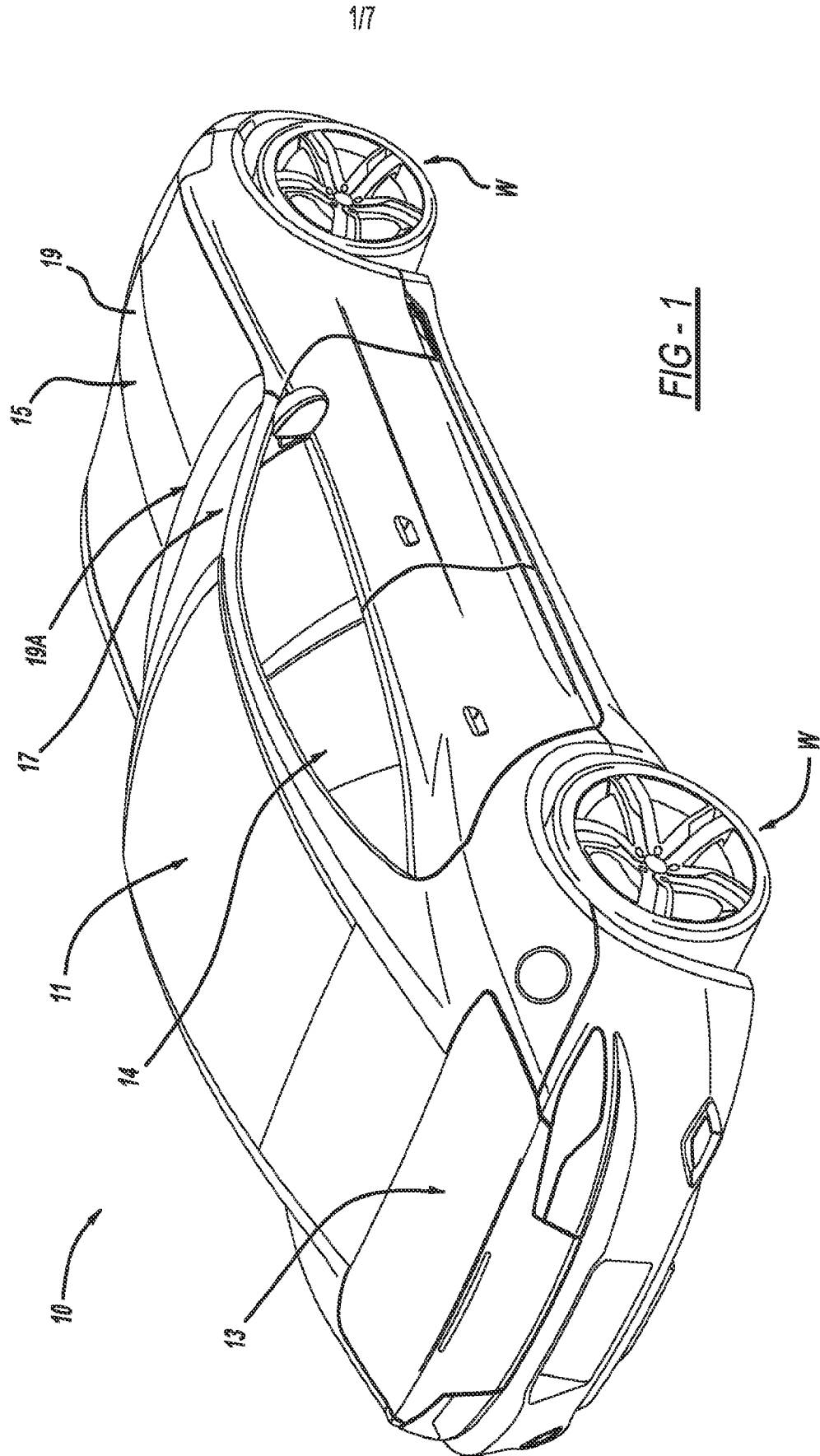
delivering the electrical current to the vehicle electrical storage device by the power transmitter after the power transmitter and power receiver are within a predetermined proximity of each other.

17. The method of claim 16 further comprising the step of automatically initiating electrical charging after the power transmitter has aligned itself with the power receiver.

18. The method of claim 16 further comprising the step of inducing charging when a vehicle controller measures a parameter reaching below a preset threshold

19. The method of claim 16 further comprising the step of continuing to adjust the relative position of the power transmitter and the power receiver by adjusting an adjustable portion of the power transmitter to increase the proximity between the power transmitter and the power receiver.

20. The method of claim 16 further comprising the step of continuing to adjust the relative position of the power transmitter and the power receiver by adjusting an adjustable portion of the power receiver to increase the proximity between the power transmitter and the power receiver.



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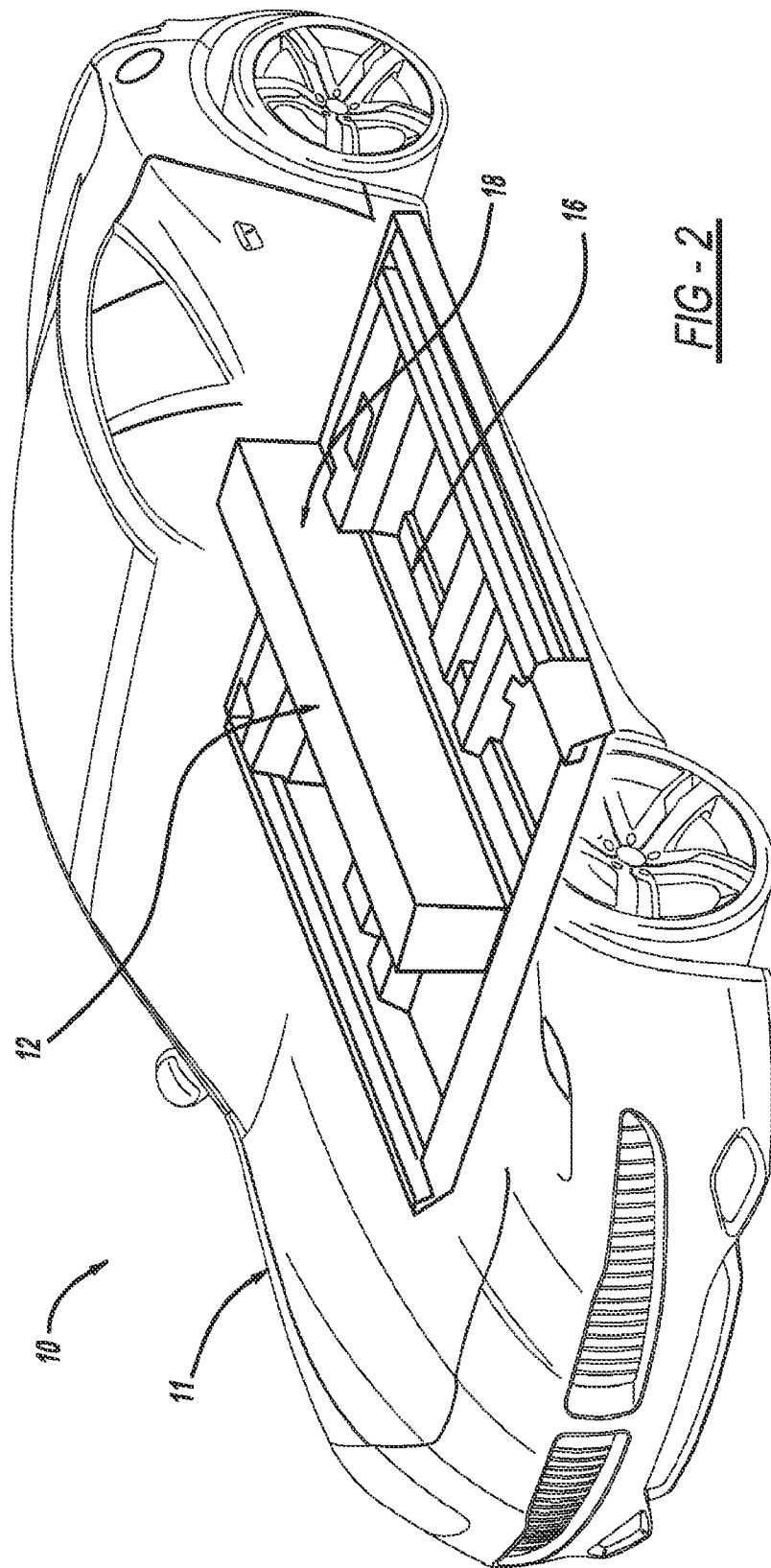


FIG - 2

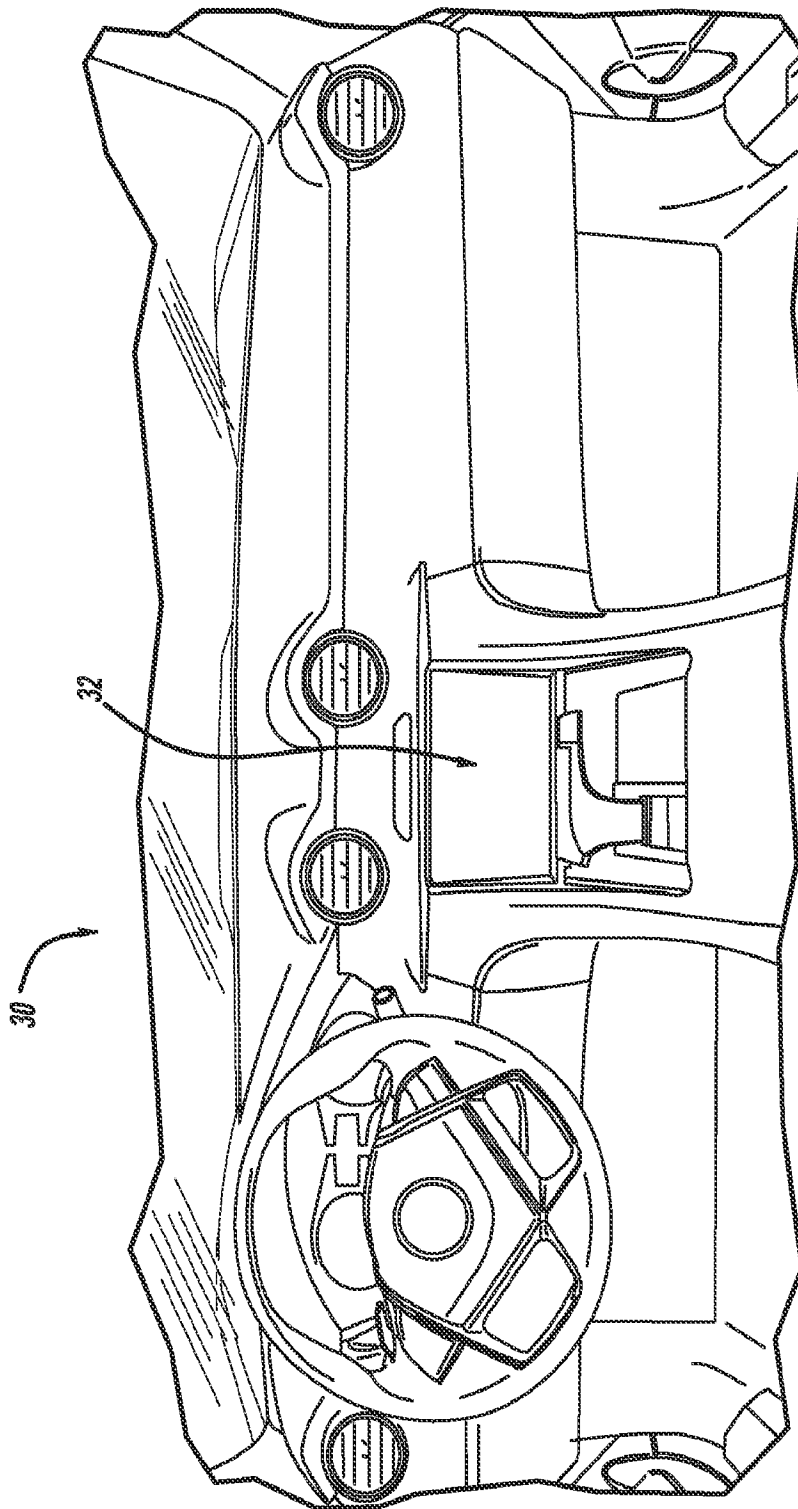


FIG - 3

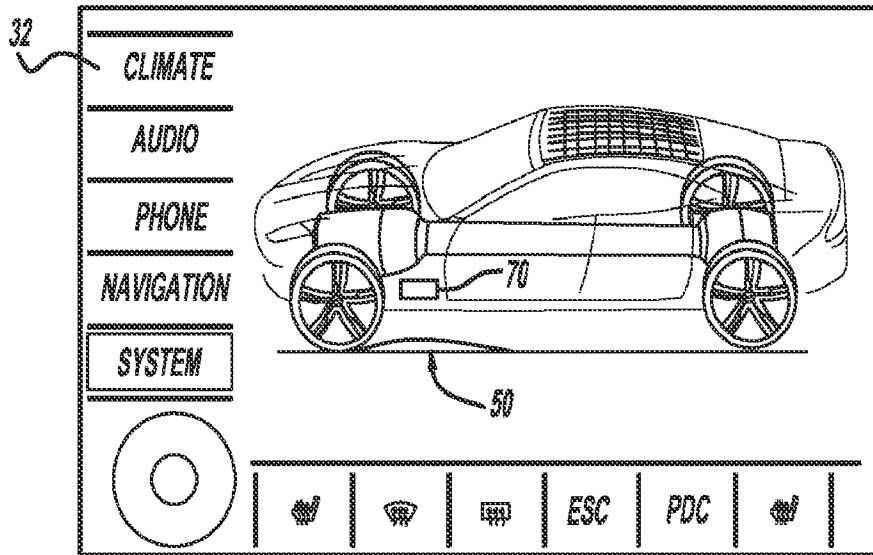


FIG - 4A

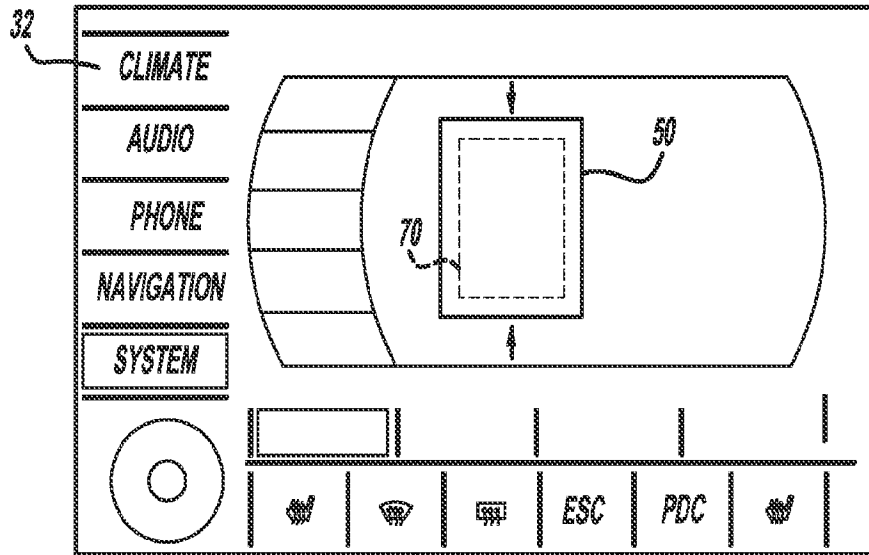
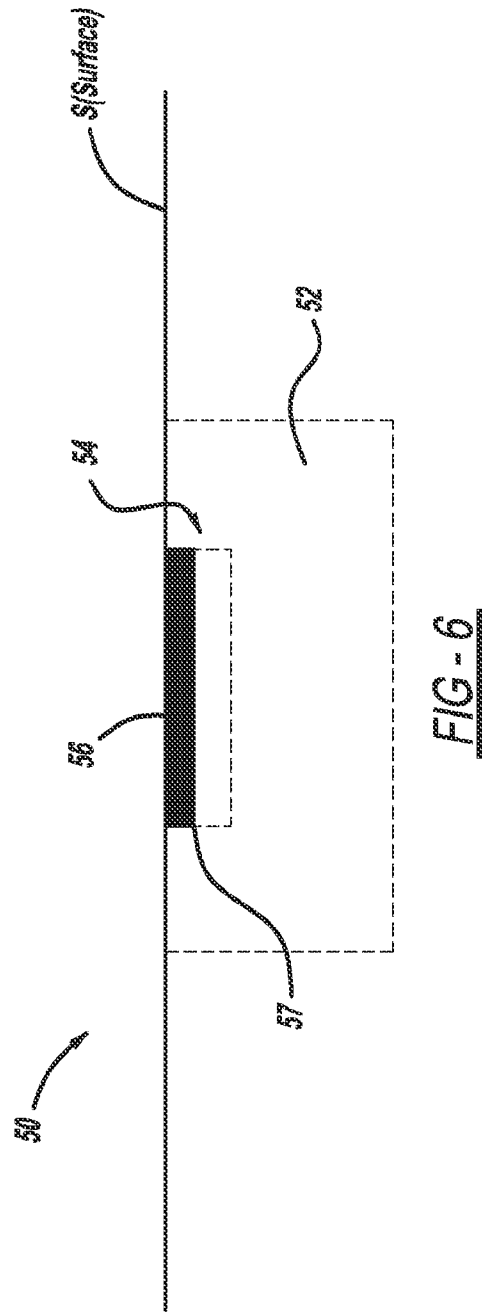
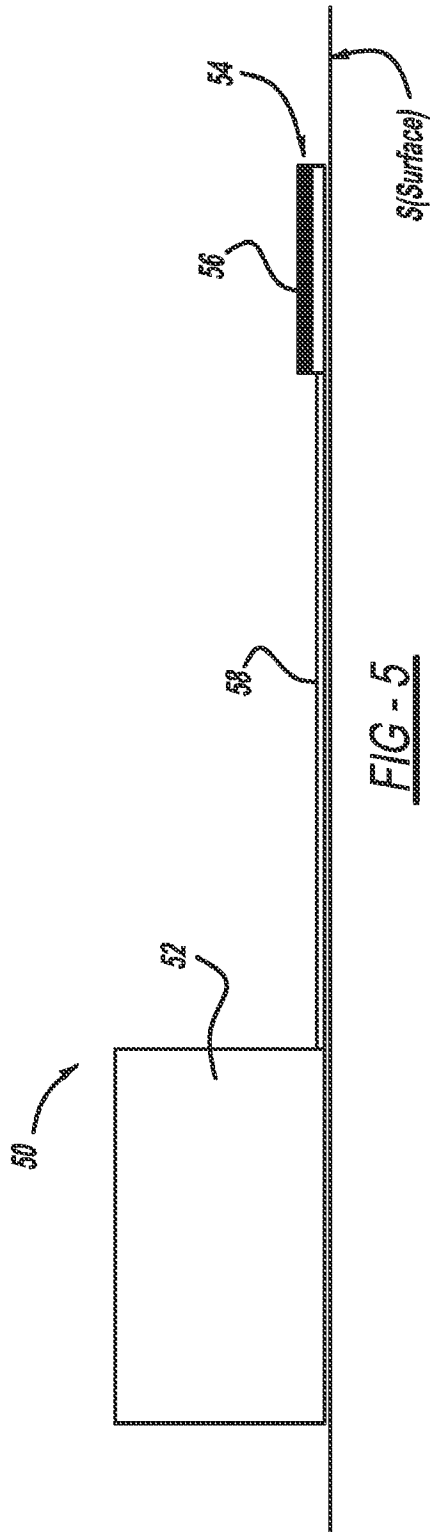


FIG - 4B



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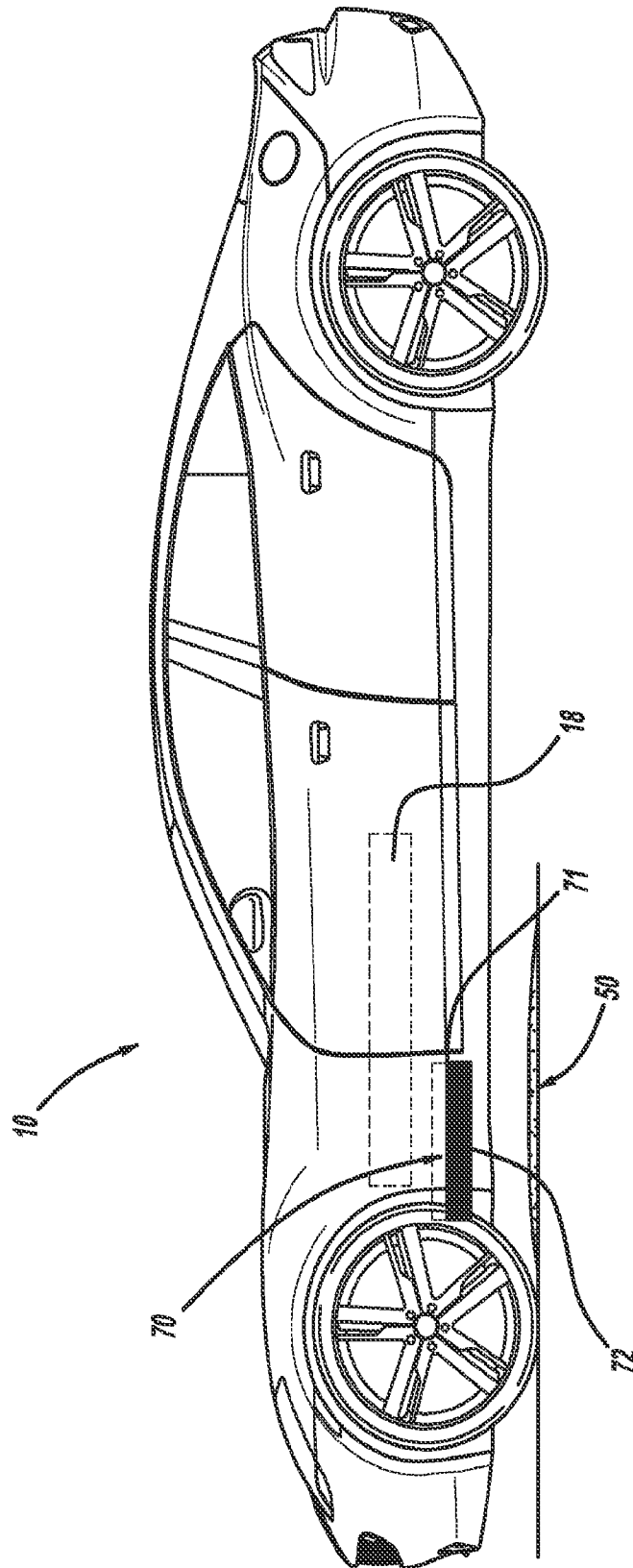


FIG - 7

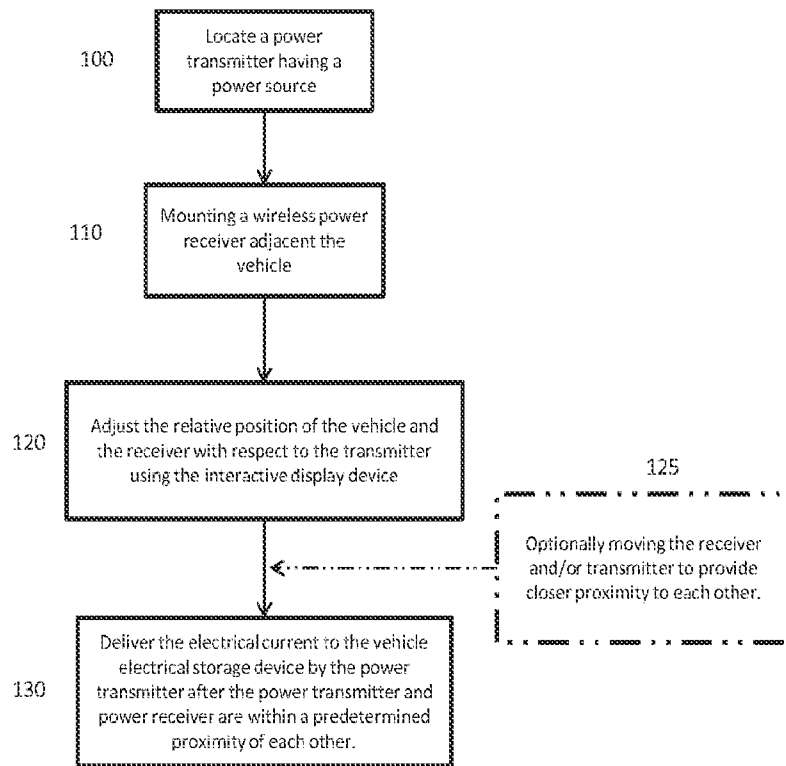


FIG. 8: A method of charging a vehicle

INTERNATIONAL SEARCH REPORT

PCT/US2011/029266

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H02J 7/00 (2011.01)

USPC - 320/109

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - H01M 10/44, 10/46; H02J 7/00 (2011.01)

USPC - 320/108, 109, 137

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

MicroPatent, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	WO 2010/022059 A1 (AUSTIN) 25 February 2010 (25.02.2010) entire document	1-4, 10, 13, 16, 18
Y		5-9, 11, 12, 14, 15, 17, 19, 20
Y	US 5,498,948 A (BRUNI et al) 12 March 1996 (12.03.1996) entire document	5-7, 9, 15, 19, 20
Y	US 6,879,889 B2 (ROSS) 12 April 2005 (12.04.2005) entire document	8, 14
Y	US2009/0166103 A1 (BOWERS et al) 02 July 2009 (02.07.2009) entire document	11, 12, 17
A	US 5,654,621 A (SEELIG) 05 August 1997 (05.08.1997) entire document	1-20
A	US 5,617,003 A (ODACHI et al) 01 April 1997 (01.04.1997) entire document	1-20

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Date of the actual completion of the international search

11 May 2010

Date of mailing of the international search report

24 MAY 2011

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