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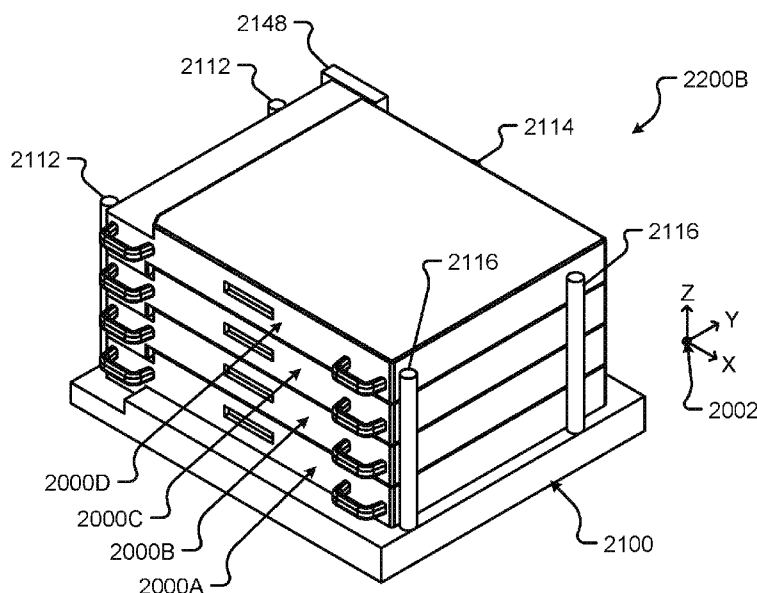


Fig. 22B

(57) Abstract: Methods, devices, and systems for a universal modular battery and power system are provided. The universal modular battery may include a number of modular interconnection features that enable a number of universal modular batteries to be stacked for use in a universal battery power system. The modular interconnection features facilitate the modular addition or subtraction of batteries in the universal battery power system to, among other things, alter a power capacity of the system. The universal batteries in a power system may be exchanged, swapped, or moved from one power system to another, including power systems associated with different vehicles and/or buildings.



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UNIVERSAL BATTERY AND MODULAR POWER SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefits of and priority, under 35 U.S.C. § 119(e), to U.S. Patent Application Serial No. 15/282,869, filed on September 30, 2016, entitled “Universal Battery and Modular Power System,” which claims, under 35 U.S.C. § 119(e), the benefits of and priority to U.S. Provisional Application Serial No. 62/359,563, filed on July 7, 2016, and U.S. Provisional Application Serial No. 62/378,348, filed on August 23, 2016, both entitled “Next Generation Vehicle.” The entire disclosures of the applications listed above are hereby incorporated by reference, in their entirety, for all that they teach and for all purposes.

FIELD

[0002] The present disclosure is generally directed to vehicle systems, in particular, toward electric and/or hybrid-electric vehicles.

BACKGROUND

[0003] In recent years, transportation methods have changed substantially. This change is due in part to a concern over the limited availability of natural resources, a proliferation in personal technology, and a societal shift to adopt more environmentally friendly transportation solutions. These considerations have encouraged the development of a number of new flexible-fuel vehicles, hybrid-electric vehicles, and electric vehicles.

[0004] While these vehicles appear to be new they are generally implemented as a number of traditional subsystems that are merely tied to an alternative power source. In fact, the design and construction of the vehicles is limited to standard frame sizes, shapes, materials, and transportation concepts. Among other things, these limitations fail to take advantage of the benefits of new technology, power sources, and support infrastructure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Fig. 1 shows a vehicle in accordance with embodiments of the present disclosure;

[0006] Fig. 2 shows a vehicle in an environment in accordance with embodiments of the present disclosure;

[0007] Fig. 3 is a diagram of an embodiment of a data structure for storing information about a vehicle in an environment;

[0008] Fig. 4A shows a vehicle in a user environment in accordance with embodiments of the present disclosure;

- [0009] Fig. 4B shows a vehicle in a fleet management and automated operation environment in accordance with embodiments of the present disclosure;
- [0010] Fig. 4C shows an embodiment of the instrument panel of the vehicle according to one embodiment of the present disclosure;
- [0011] Fig. 5 shows charging areas associated with an environment in accordance with embodiments of the present disclosure;
- [0012] Fig. 6 shows a vehicle in a roadway charging environment in accordance with embodiments of the present disclosure;
- [0013] Fig. 7 shows a vehicle in a robotic charging station environment in accordance with another embodiment of the present disclosure;
- [0014] Fig. 8 shows a vehicle in an overhead charging environment in accordance with another embodiment of the present disclosure;
- [0015] Fig. 9 shows a vehicle in a roadway environment comprising roadway vehicles in accordance with another embodiment of the present disclosure;
- [0016] Fig. 10 shows a vehicle in an aerial vehicle charging environment in accordance with another embodiment of the present disclosure;
- [0017] Fig. 11 shows a vehicle in an emergency charging environment in accordance with embodiments of the present disclosure;
- [0018] Fig. 12 is a perspective view of a vehicle in accordance with embodiments of the present disclosure;
- [0019] Fig. 13 is a plan view of a vehicle in accordance with at least some embodiments of the present disclosure;
- [0020] Fig. 14 is a plan view of a vehicle in accordance with embodiments of the present disclosure;
- [0021] Fig. 15 is a block diagram of an embodiment of an electrical system of the vehicle;
- [0022] Fig. 16 is a block diagram of an embodiment of a power generation unit associated with the electrical system of the vehicle;
- [0023] Fig. 17 is a block diagram of an embodiment of power storage associated with the electrical system of the vehicle;
- [0024] Fig. 18 is a block diagram of an embodiment of loads associated with the electrical system of the vehicle;
- [0025] Fig. 19A is a block diagram of an exemplary embodiment of a communications subsystem of the vehicle;

[0026] Fig. 19B is a block diagram of a computing environment associated with the embodiments presented herein;

[0027] Fig. 19C is a block diagram of a computing device associated with one or more components described herein;

[0028] Fig. 20A is a front perspective view of a universal battery in accordance with embodiments of the present disclosure;

[0029] Fig. 20B is a rear perspective view of the universal battery of Fig. 20A;

[0030] Fig. 20C is a top plan view of the universal battery of Fig. 20A;

[0031] Fig. 20D is a front elevation view of the universal battery of Fig. 20A;

[0032] Fig. 20E is a bottom plan view of the universal battery of Fig. 20A;

[0033] Fig. 20F is a rear elevation view of the universal battery of Fig. 20A;

[0034] Fig. 21A is a front perspective view of a universal battery receiving system in accordance with embodiments of the present disclosure;

[0035] Fig. 21B is a rear perspective view of the universal battery receiving system of Fig. 21A;

[0036] Fig. 22A is a front perspective view showing a single universal battery interconnected with a universal battery receiving system in accordance with embodiments of the present disclosure;

[0037] Fig. 22B is a front perspective view showing multiple universal batteries interconnected with a universal battery receiving system in accordance with embodiments of the present disclosure;

[0038] Fig. 23 is a front elevation view of multiple universal batteries interconnected with a universal battery receiving system in accordance with embodiments of the present disclosure;

[0039] Fig. 24 is a block diagram of a universal battery power management system in accordance with embodiments of the present disclosure;

[0040] Fig. 25A is a block diagram of a first embodiment of a universal battery system for a vehicle;

[0041] Fig. 25B is a block diagram of a second embodiment of a universal battery system for a vehicle;

[0042] Fig. 25C is a block diagram of a first embodiment of a universal battery system for a building;

[0043] Fig. 26 is a flow chart depicting a first method of recruiting battery power in a universal battery power management system; and

[0044] Fig. 27 is a flow chart depicting a second method of recruiting battery power in a universal battery power management system.

DETAILED DESCRIPTION

[0045] Embodiments of the present disclosure will be described in connection with a vehicle, and in accordance with one exemplary embodiment an electric vehicle and/or hybrid-electric vehicle and associated systems.

[0046] With attention to Figs. 1-11, embodiments of the electric vehicle system 10 and method of use are depicted.

[0047] Referring to Fig. 1, the electric vehicle system comprises electric vehicle 100. The electric vehicle 100 comprises vehicle front 110, vehicle aft 120, vehicle roof 130, vehicle side 160, vehicle undercarriage 140 and vehicle interior 150.

[0048] Referring to Fig. 2, the vehicle 100 is depicted in a plurality of exemplary environments. The vehicle 100 may operate in any one or more of the depicted environments in any combination. Other embodiments are possible but are not depicted in Fig. 2. Generally, the vehicle 100 may operate in environments which enable charging of the vehicle 100 and/or operation of the vehicle 100. More specifically, the vehicle 100 may receive a charge via one or more means comprising emergency charging vehicle system 270, aerial vehicle charging system 280, roadway system 250, robotic charging system 254 and overhead charging system 258. The vehicle 100 may interact and/or operate in an environment comprising one or more other roadway vehicles 260. The vehicle 100 may engage with elements within the vehicle 100 comprising vehicle driver 220, vehicle passengers 220 and vehicle database 210. In one embodiment, vehicle database 210 does not physically reside in the vehicle 100 but is instead accessed remotely, e.g. by wireless communication, and resides in another location such as a residence or business location. Vehicle 100 may operate autonomously and/or semi-autonomously in an autonomous environment 290 (here, depicted as a roadway environment presenting a roadway obstacle of which the vehicle 100 autonomously identifies and steers the vehicle 100 clear of the obstacle). Furthermore, the vehicle 100 may engage with a remote operator system 240, which may provide fleet management instructions or control.

[0049] Fig. 3 is a diagram of an embodiment of a data structure 300 for storing information about a vehicle 100 in an environment. The data structure may be stored in vehicle database 210. Generally, data structure 300 identifies operational data associated with charging types 310A. The data structures 300 may be accessible by a vehicle

controller. The data contained in data structure 300 enables, among other things, for the vehicle 100 to receive a charge from a given charging type.

[0050] Data may comprise charging type 310A comprising a manual charging station 310J, robotic charging station 310K such as robotic charging system 254, a roadway charging system 310L such as those of roadway system 250, an emergency charging system 310M such as that of emergency charging vehicle system 270, an emergency charging system 310N such as that of aerial vehicle charging system 280, and overhead charging type 310O such as that of overhead charging system 258.

[0051] Compatible vehicle charging panel types 310B comprise locations on vehicle 100 wherein charging may be received, such as vehicle roof 130, vehicle side 160 and vehicle lower or undercarriage 140. Compatible vehicle storage units 310C data indicates storage units types that may receive power from a given charging type 310A. Available automation level 310D data indicates the degree of automation available for a given charging type; a high level may indicate full automation, allowing the vehicle driver 220 and/or vehicle passengers 230 to not involve themselves in charging operations, while a low level of automation may require the driver 220 and/or occupant 230 to manipulate/position a vehicle charging device to engage with a particular charging type 310A to receive charging. Charging status 310E indicates whether a charging type 310A is available for charging (i.e. is "up") or is unavailable for charging (i.e. is "down"). Charge rate 310F provides a relative value for time to charge, while Cost 310G indicates the cost to vehicle 100 to receive a given charge. The Other data element 310H may provide additional data relevant to a given charging type 310A, such as a recommended separation distance between a vehicle charging plate and the charging source. The Shielding data element 310I indicates if electromagnetic shielding is recommended for a given charging type 310A and/or charging configuration. Further data fields 310P, 310Q are possible.

[0052] Fig. 4A depicts the vehicle 100 in a user environment comprising vehicle database 210, vehicle driver 220 and vehicle passengers 230. Vehicle 100 further comprises vehicle instrument panel 400 to facilitate or enable interactions with one or more of vehicle database 210, vehicle driver 220 and vehicle passengers 230. In one embodiment, driver 210 interacts with instrument panel 400 to query database 210 so as to locate available charging options and to consider or weigh associated terms and conditions of the charging options. Once a charging option is selected, driver 210 may engage or operate a manual control device (e.g., a joystick) to position a vehicle charging receiver panel so as to receive a charge.

[0053] Fig. 4B depicts the vehicle 100 in a user environment comprising a remote operator system 240 and an autonomous driving environment 290. In the remote operator system 240 environment, a fleet of electric vehicles 100 (or mixture of electric and non-electric vehicles) is managed and/or controlled remotely. For example, a human operator may dictate that only certain types of charging types are to be used, or only those charging types below a certain price point are to be used. The remote operator system 240 may comprise a database comprising operational data, such as fleet-wide operational data. In another example, the vehicle 100 may operate in an autonomous driving environment 290 wherein the vehicle 100 is operated with some degree of autonomy, ranging from complete autonomous operation to semi-automation wherein only specific driving parameters (e.g., speed control or obstacle avoidance) are maintained or controlled autonomously. In Fig. 4B, autonomous driving environment 290 depicts an oil slick roadway hazard that triggers that triggers the vehicle 100, while in an automated obstacle avoidance mode, to automatically steer around the roadway hazard.

[0054] Fig. 4C shows one embodiment of the vehicle instrument panel 400 of vehicle 100. Instrument panel 400 of vehicle 100 comprises steering wheel 410, vehicle operational display 420 (which would provide basic driving data such as speed), one or more auxiliary displays 424 (which may display, e.g., entertainment applications such as music or radio selections), heads-up display 434 (which may provide, e.g., guidance information such as route to destination, or obstacle warning information to warn of a potential collision, or some or all primary vehicle operational data such as speed), power management display 428 (which may provide, e.g., data as to electric power levels of vehicle 100), and charging manual controller 432 (which provides a physical input, e.g. a joystick, to manual maneuver, e.g., a vehicle charging plate to a desired separation distance). One or more of displays of instrument panel 400 may be touch-screen displays. One or more displays of instrument panel 400 may be mobile devices and/or applications residing on a mobile device such as a smart phone.

[0055] Fig. 5 depicts a charging environment of a roadway charging system 250. The charging area may be in the roadway 504, on the roadway 504, or otherwise adjacent to the roadway 504, and/or combinations thereof. This static charging area 520B may allow a charge to be transferred even while the electrical vehicle 100 is moving. For example, the static charging area 520B may include a charging transmitter (e.g., conductor, etc.) that provides a transfer of energy when in a suitable range of a receiving unit (e.g., an inductor

pick up, etc.). In this example, the receiving unit may be a part of the charging panel associated with the electrical vehicle 100.

[0056] The static charging areas 520A, 520B may be positioned a static area such as a designated spot, pad, parking space 540A, 540B, traffic controlled space (e.g., an area adjacent to a stop sign, traffic light, gate, etc.), portion of a building, portion of a structure, etc., and/or combinations thereof. Some static charging areas may require that the electric vehicle 100 is stationary before a charge, or electrical energy transfer, is initiated. The charging of vehicle 100 may occur by any of several means comprising a plug or other protruding feature. The power source 516A, 516B may include a receptacle or other receiving feature, and/or vice versa.

[0057] The charging area may be a moving charging area 520C. Moving charging areas 520C may include charging areas associated with one or more portions of a vehicle, a robotic charging device, a tracked charging device, a rail charging device, etc., and/or combinations thereof. In a moving charging area 520C, the electrical vehicle 100 may be configured to receive a charge, via a charging panel, while the vehicle 100 is moving and/or while the vehicle 100 is stationary. In some embodiments, the electrical vehicle 100 may synchronize to move at the same speed, acceleration, and/or path as the moving charging area 520C. In one embodiment, the moving charging area 520C may synchronize to move at the same speed, acceleration, and/or path as the electrical vehicle 100. In any event, the synchronization may be based on an exchange of information communicated across a communications channel between the electric vehicle 100 and the charging area 520C. Additionally or alternatively, the synchronization may be based on information associated with a movement of the electric vehicle 100 and/or the moving charging area 520C. In some embodiments, the moving charging area 520C may be configured to move along a direction or path 532 from an origin position to a destination position 520C'.

[0058] In some embodiments, a transformer may be included to convert a power setting associated with a main power supply to a power supply used by the charging areas 520A-C. For example, the transformer may increase or decrease a voltage associated with power supplied via one or more power transmission lines.

[0059] Referring to Fig. 6, a vehicle 100 is shown in a charging environment in accordance with embodiments of the present disclosure. The system 10 comprises a vehicle 100, an electrical storage unit 612, an external power source 516 able to provide a charge to the vehicle 100, a charging panel 608 mounted on the vehicle 100 and in electrical communication with the electrical storage unit 612, and a vehicle charging panel

controller 610. The charging panel controller 610 may determine if the electrical storage unit requires charging and if conditions allow for deployment of a charging panel. The vehicle charging panel 608 may operate in at least a retracted state and a deployed state (608 and 608' as shown in Fig. 6), and is movable by way of an armature.

[0060] The charging panel controller 610 may receive signals from vehicle sensors 626 to determine, for example, if a hazard is present in the path of the vehicle 100 such that deployment of the vehicle charging panel 608 is inadvisable. The charging panel controller 610 may also query vehicle database 210 comprising data structures 300 to establish other required conditions for deployment. For example, the database may provide that a particular roadway does not provide a charging service or the charging service is inactive, wherein the charging panel 108 would not be deployed.

[0061] The power source 516 may include at least one electrical transmission line 624 and at least one power transmitter or charging area 520. During a charge, the charging panel 608 may serve to transfer energy from the power source 516 to at least one energy storage unit 612 (e.g., battery, capacitor, power cell, etc.) of the electric vehicle 100.

[0062] Fig. 7 shows a vehicle 100 in a charging station environment 254 in accordance with another embodiment of the present disclosure. Generally, in this embodiment of the disclosure, charging occurs from a robotic unit 700.

[0063] Robotic charging unit 700 comprises one or more robotic unit arms 704, at least one robotic unit arm 704 interconnected with charging plate 520. The one or more robotic unit arms 704 manoeuvre charging plate 520 relative to charging panel 608 of vehicle 100. Charging plate 520 is positioned to a desired or selectable separation distance, as assisted by a separation distance sensor disposed on charging plate 520. Charging plate 520 may remain at a finite separation distance from charging panel 608, or may directly contact charging panel (i.e. such that separation distance is zero). Charging may be by induction. In alternative embodiments, separation distance sensor is alternatively or additionally disposed on robotic arm 704. Vehicle 100 receives charging via charging panel 608 which in turn charges energy storage unit 612. Charging panel controller 610 is in communication with energy storage unit 612, charging panel 608, vehicle database 300, charge provider controller 622, and/or any one of elements of instrument panel 400.

[0064] Robotic unit further comprises, is in communication with and/or is interconnected with charge provider controller 622, power source 516 and a robotic unit database. Power source 516 supplies power, such as electrical power, to charge plate 520 to enable charging of vehicle 100 via charging panel 608. Controller 622 manoeuvres or

operates robotic unit 704, either directly and/or completely or with assistance from a remote user, such as a driver or passenger in vehicle 100 by way of, in one embodiment, charging manual controller 432.

[0065] Fig. 8 shows a vehicle 100 in an overhead charging environment in accordance with another embodiment of the present disclosure. Generally, in this embodiment of the disclosure, charging occurs from an overhead towered charging system 258, similar to existing commuter rail systems. Such an overhead towered system 258 may be easier to build and repair compared to in-roadway systems. Generally, the disclosure includes a specially-designed overhead roadway charging system comprising an overhead charging cable or first wire 814 that is configured to engage an overhead contact 824 which provides charge to charging panel 608 which provides charge to vehicle energy storage unit 612. The overhead towered charging system 258 may further comprise second wire 818 to provide stability and structural strength to the roadway charging system 800. The first wire 814 and second wire 818 are strung between towers 810.

[0066] The overhead charging cable or first wire 814 is analogous to a contact wire used to provide charging to electric trains or other vehicles. An external source provides or supplies electrical power to the first wire 814. The charge provider comprises an energy source i.e. a provider battery and a provider charge circuit or controller in communication with the provider battery. The overhead charging cable or first wire 814 engages the overhead contact 824 which is in electrical communication with charge receiver panel 108. The overhead contact 824 may comprise any known means to connect to overhead electrical power cables, such as a pantograph 820, a bow collector, a trolley pole or any means known to those skilled in the art. Further disclosure regarding electrical power or energy transfer via overhead systems is found in US Pat. Publ. No. 2013/0105264 to Ruth entitled "Pantograph Assembly," the entire contents of which are incorporated by reference for all purposes. In one embodiment, the charging of vehicle 100 by overhead charging system 800 via overhead contact 824 is by any means known to those skilled in the art, to include those described in the above-referenced US Pat. Publ. No. 2013/0105264 to Ruth.

[0067] The overhead contact 824 presses against the underside of the lowest overhead wire of the overhead charging system, i.e. the overhead charging cable or first wire 814, aka the contact wire. The overhead contact 824 may be electrically conductive. Alternatively or additionally, the overhead contact 824 may be adapted to receive electrical power from overhead charging cable or first wire 814 by inductive charging.

[0068] In one embodiment, the receipt and/or control of the energy provided via overhead contact 824 (as connected to the energy storage unit 612) is provided by receiver charge circuit or charging panel controller 110.

[0069] Overhead contact 824 and/or charging panel 608 may be located anywhere on vehicle 100, to include, for example, the roof, side panel, trunk, hood, front or rear bumper of the charge receiver 100 vehicle, as long as the overhead contact 824 may engage the overhead charging cable or first wire 814. Charging panel 108 may be stationary (e.g. disposed on the roof of vehicle 100) or may be moveable, e.g. moveable with the pantograph 820. Pantograph 820 may be positioned in at least two states comprising retracted and extended. In the extended state pantograph 820 engages first wire 814 by way of the overhead contact 824. In the retracted state, pantograph 820 may typically reside flush with the roof of vehicle 100 and extend only when required for charging. Control of the charging and/or positioning of the charging plate 608, pantograph 820 and/or overhead contact 824 may be manual, automatic or semi-automatic (such as via controller 610); said control may be performed through a GUI engaged by driver or occupant of receiving vehicle 100 and/or driver or occupant of charging vehicle.

[0070] Fig. 9 shows a vehicle in a roadway environment comprising roadway vehicles 260 in accordance with another embodiment of the present disclosure. Roadway vehicles 260 comprise roadway passive vehicles 910 and roadway active vehicles 920. Roadway passive vehicles 910 comprise vehicles that are operating on the roadway of vehicle 100 but do not cooperatively or actively engage with vehicle 100. Stated another way, roadway passive vehicles 910 are simply other vehicles operating on the roadway with the vehicle 100 and must be, among other things, avoided (e.g., to include when vehicle 100 is operating in an autonomous or semi-autonomous manner). In contrast, roadway active vehicles 920 comprise vehicles that are operating on the roadway of vehicle 100 and have the capability to, or actually are, actively engaging with vehicle 100. For example, the emergency charging vehicle system 270 is a roadway active vehicle 920 in that it may cooperate or engage with vehicle 100 to provide charging. In some embodiments, vehicle 100 may exchange data with a roadway active vehicle 920 such as, for example, data regarding charging types available to the roadway active vehicle 920.

[0071] Fig. 10 shows a vehicle in an aerial vehicle charging environment in accordance with another embodiment of the present disclosure. Generally, this embodiment involves an aerial vehicle ("AV"), such as an Unmanned Aerial Vehicle (UAV), flying over or near a vehicle to provide a charge. The UAV may also land on the car to provide an emergency

(or routine) charge. Such a charging scheme may be particularly suited for operations in remote areas, in high traffic situations, and/or when the car is moving. The AV may be a specially-designed UAV, aka RPV or drone, with a charging panel that can extend from the AV to provide a charge. The AV may include a battery pack and a charging circuit to deliver a charge to the vehicle. The AV may be a manned aerial vehicle, such as a piloted general aviation aircraft, such as a Cessna 172.

[0072] With reference to Fig. 10, an exemplar embodiment of a vehicle charging system 100 comprising a charge provider configured as an aerial vehicle 280, the aerial vehicle 280 comprising a power source 516 and charge provider controller 622. The AV may be semi-autonomous or fully autonomous. The AV may have a remote pilot/operator providing control inputs. The power source 516 is configured to provide a charge to a charging panel 608 of vehicle 100. The power source 516 is in communication with the charge provider controller 622. The aerial vehicle 280 provides a tether 1010 to deploy or extend charging plate 520 near to charging panel 608. The tether 1010 may comprise a chain, rope, rigid or semi-rigid tow bar or any means to position charging plate 520 near charging panel 608. For example, tether 1010 may be similar to a refueling probe used by airborne tanker aircraft when refueling another aircraft.

[0073] In one embodiment, the charging plate 520 is not in physical interconnection to AV 280, that is, there is no tether 1010. In this embodiment, the charging plate 520 is positioned and controlled by AV 280 by way of a controller on AV 280 or in communication with AV 280.

[0074] In one embodiment, the charging plate 520 position and/or characteristics (e.g. charging power level, flying separation distance, physical engagement on/off) are controlled by vehicle 100 and/or a user in or driver of vehicle 100.

[0075] Charge or power output of power source 516 is provided or transmitted to charger plate 620 by way of a charging cable or wire, which may be integral to tether 1010. In one embodiment, the charging cable is non-structural, that is, it provides zero or little structural support to the connection between AV 280 and charger plate 520.

[0076] Charging panel 608 of vehicle 100 receives power from charger plate 520. Charging panel 608 and charger plate 520 may be in direct physical contact (termed a "contact" charger configuration) or not in direct physical contact (termed a "flyer" charger configuration), but must be at or below a threshold (separation) distance to enable charging, such as by induction. Energy transfer or charging from the charger plate 520 to the charging panel 608 is inductive charging (i.e. use of an EM field to transfer energy

between two objects). The charging panel 608 provides received power to energy storage unit 612 by way of charging panel controller 610. Charging panel controller 610 is in communication with vehicle database 210, vehicle database 210 comprising an AV charging data structure.

[0077] Charging panel 508 may be located anywhere on vehicle 100, to include, for example, the roof, side panel, trunk, hood, front or rear bumper and wheel hub of vehicle 100. Charging panel 608 is mounted on the roof of vehicle 100 in the embodiment of Fig. 10. In some embodiments, charging panel 608 may be deployable, i.e. may extend or deploy only when charging is needed. For example, charging panel 608 may typically reside flush with the roof of vehicle 100 and extend when required for charging. Similarly, charger plate 520 may, in one embodiment, not be connected to AV 280 by way of tether 1010 and may instead be mounted directly on the AV 280, to include, for example, the wing, empennage, undercarriage to include landing gear, and may be deployable or extendable when required. Tether 1010 may be configured to maneuver charging plate 520 to any position on vehicle 100 so as to enable charging. In one embodiment, the AV 280 may land on the vehicle 100 so as to enable charging through direct contact (i.e. the aforementioned contact charging configuration) between the charging plate 520 and the charging panel 608 of vehicle 100. Charging may occur while both AV 280 and vehicle 100 are moving, while both vehicle 100 and AV 280 are not moving (i.e., vehicle 100 is parked and AV 280 lands on top of vehicle 100), or while vehicle 100 is parked and AV 280 is hovering or circling above. Control of the charging and/or positioning of the charging plate 520 may be manual, automatic or semi-automatic; said control may be performed through a GUI engaged by driver or occupant of receiving vehicle 100 and/or driver or occupant of charging AV 280.

[0078] Fig. 11 is an embodiment of a vehicle emergency charging system comprising an emergency charging vehicle 270 and charge receiver vehicle 100 is disclosed. The emergency charging vehicle 270 is a road vehicle, such as a pick-up truck, as shown in Fig. 11. The emergency charging vehicle 270 is configured to provide a charge to a charge receiver vehicle 100, such as an automobile. The emergency charging vehicle 270 comprises an energy source i.e. a charging power source 516 and a charge provider controller 622 in communication with the charging power source 516. The emergency charging vehicle 270 provides a towed and/or articulated charger plate 520, as connected to the emergency charging vehicle 270 by connector 1150. The connector 1150 may comprise a chain, rope, rigid or semi-rigid tow bar or any means to position charger plate

520 near the charging panel 608 of vehicle 100. Charge or power output of charging power source 516 is provided or transmitted to charger plate 520 by way of charging cable or wire 1140. In one embodiment, the charging cable 1140 is non-structural, that is, it provides little or no structural support to the connection between emergency charging vehicle 270 and charging panel 608. Charging panel 608 (of vehicle 100) receives power from charger plate 520. Charger plate 520 and charging panel 608 may be in direct physical contact or not in direct physical contact, but must be at or below a threshold separation distance to enable charging, such as by induction. Charger plate 520 may comprise wheels or rollers so as to roll along roadway surface. Charger plate 520 may also not contact the ground surface and instead be suspended above the ground; such a configuration may be termed a "flying" configuration. In the flying configuration, charger plate may form an aerodynamic surface to, for example, facilitate stability and control of the positioning of the charging plate 520. Energy transfer or charging from the charger plate 520 to the charge receiver panel 608 is through inductive charging (i.e. use of an EM field to transfer energy between two objects). The charging panel 608 provides received power to energy storage unit 612 directly or by way of charging panel controller 610. In one embodiment, the receipt and/or control of the energy provided via the charging panel 608 is provided by charging panel controller 610.

[0079] Charging panel controller 610 may be located anywhere on charge receiver vehicle 100, to include, for example, the roof, side panel, trunk, hood, front or rear bumper and wheel hub of charge receiver 100 vehicle. In some embodiments, charging panel 608 may be deployable, i.e. may extend or deploy only when charging is needed. For example, charging panel 608 may typically stow flush with the lower plane of vehicle 100 and extend when required for charging. Similarly, charger plate 520 may, in one embodiment, not be connected to the lower rear of the emergency charging vehicle 270 by way of connector 1150 and may instead be mounted on the emergency charging vehicle 270, to include, for example, the roof, side panel, trunk, hood, front or rear bumper and wheel hub of emergency charging vehicle 270. Connector 1150 may be configured to maneuver connector plate 520 to any position on emergency charging vehicle 270 so as to enable charging. Control of the charging and/or positioning of the charging plate may be manual, automatic or semi-automatic; said control may be performed through a GUI engaged by driver or occupant of receiving vehicle and/or driver or occupant of charging vehicle.

[0080] Fig. 12 shows a perspective view of a vehicle 100 in accordance with embodiments of the present disclosure. Although shown in the form of a car, it should be

appreciated that the vehicle 100 described herein may include any conveyance or model of a conveyance, where the conveyance was designed for the purpose of moving one or more tangible objects, such as people, animals, cargo, and the like. The term “vehicle” does not require that a conveyance moves or is capable of movement. Typical vehicles may include but are in no way limited to cars, trucks, motorcycles, busses, automobiles, trains, railed conveyances, boats, ships, marine conveyances, submarine conveyances, airplanes, space craft, flying machines, human-powered conveyances, and the like. In any event, the vehicle 100 may include a frame 1204 and one or more body panels 1208 mounted or affixed thereto. The vehicle 100 may include one or more interior components (*e.g.*, components inside an interior space 150, or user space, of a vehicle 100, etc.), exterior components (*e.g.*, components outside of the interior space 150, or user space, of a vehicle 100, etc.), drive systems, controls systems, structural components.

[0081] Referring now to Fig. 13, a plan view of a vehicle 100 will be described in accordance with embodiments of the present disclosure. As provided above, the vehicle 100 may comprise a number of electrical and/or mechanical systems, subsystems, etc. The mechanical systems of the vehicle 100 can include structural, power, safety, and communications subsystems, to name a few. While each subsystem may be described separately, it should be appreciated that the components of a particular subsystem may be shared between one or more other subsystems of the vehicle 100.

[0082] The structural subsystem includes the frame 1204 of the vehicle 100. The frame 1204 may comprise a separate frame and body construction (*i.e.*, body-on-frame construction), a unitary frame and body construction (*i.e.*, a unibody construction), or any other construction defining the structure of the vehicle 100. The frame 1204 may be made from one or more materials including, but in no way limited to steel, titanium, aluminum, carbon fiber, plastic, polymers, etc., and/or combinations thereof. In some embodiments, the frame 1204 may be formed, welded, fused, fastened, pressed, etc., combinations thereof, or otherwise shaped to define a physical structure and strength of the vehicle 100. In any event, the frame 1204 may comprise one or more surfaces, connections, protrusions, cavities, mounting points, tabs, slots, or other features that are configured to receive other components that make up the vehicle 100. For example, the body panels, powertrain subsystem, controls systems, interior components, communications subsystem, and safety subsystem may interconnect with, or attach to, the frame 1204 of the vehicle 100.

[0083] The frame 1204 may include one or more modular system and/or subsystem connection mechanisms. These mechanisms may include features that are configured to provide a selectively interchangeable interface for one or more of the systems and/or subsystems described herein. The mechanisms may provide for a quick exchange, or swapping, of components while providing enhanced security and adaptability over conventional manufacturing or attachment. For instance, the ability to selectively interchange systems and/or subsystems in the vehicle 100 allow the vehicle 100 to adapt to the ever-changing technological demands of society and advances in safety. Among other things, the mechanisms may provide for the quick exchange of batteries, capacitors, power sources 1308A, 1308B, motors 1312, engines, safety equipment, controllers, user interfaces, interiors exterior components, body panels 1208, bumpers 1316, sensors, etc., and/or combinations thereof. Additionally or alternatively, the mechanisms may provide unique security hardware and/or software embedded therein that, among other things, can prevent fraudulent or low quality construction replacements from being used in the vehicle 100. Similarly, the mechanisms, subsystems, and/or receiving features in the vehicle 100 may employ poka-yoke, or mistake-proofing, features that ensure a particular mechanism is always interconnected with the vehicle 100 in a correct position, function, etc.

[0084] By way of example, complete systems or subsystems may be removed and/or replaced from a vehicle 100 utilizing a single minute exchange principle. In some embodiments, the frame 1204 may include slides, receptacles, cavities, protrusions, and/or a number of other features that allow for quick exchange of system components. In one embodiment, the frame 1204 may include tray or ledge features, mechanical interconnection features, locking mechanisms, retaining mechanisms, etc., and/or combinations thereof. In some embodiments, it may be beneficial to quickly remove a used power source 1308A, 1308B (*e.g.*, battery unit, capacitor unit, etc.) from the vehicle 100 and replace the used power source 1308A, 1308B with a charged power source. Continuing this example, the power source 1308A, 1308B may include selectively interchangeable features that interconnect with the frame 1204 or other portion of the vehicle 100. For instance, in a power source 1308A, 1308B replacement, the quick release features may be configured to release the power source 1308A, 1308B from an engaged position and slide or move away from the frame 1204 of a vehicle 100. Once removed, the power source 1308A, 1308B may be replaced (*e.g.*, with a new power source, a charged power source, etc.) by engaging the replacement power source into a system receiving position adjacent to the vehicle 100. In some embodiments, the vehicle 100 may include

one or more actuators configured to position, lift, slide, or otherwise engage the replacement power source with the vehicle 100. In one embodiment, the replacement power source may be inserted into the vehicle 100 or vehicle frame 1204 with mechanisms and/or machines that are external or separate from the vehicle 100.

[0085] In some embodiments, the frame 1204 may include one or more features configured to selectively interconnect with other vehicles and/or portions of vehicles. These selectively interconnecting features can allow for one or more vehicles to selectively couple together and decouple for a variety of purposes. For example, it is an aspect of the present disclosure that a number of vehicles may be selectively coupled together to share energy, increase power output, provide security, decrease power consumption, provide towing services, and/or provide a range of other benefits. Continuing this example, the vehicles may be coupled together based on travel route, destination, preferences, settings, sensor information, and/or some other data. The coupling may be initiated by at least one controller of the vehicle and/or traffic control system upon determining that a coupling is beneficial to one or more vehicles in a group of vehicles or a traffic system. As can be appreciated, the power consumption for a group of vehicles traveling in a same direction may be reduced or decreased by removing any aerodynamic separation between vehicles. In this case, the vehicles may be coupled together to subject only the foremost vehicle in the coupling to air and/or wind resistance during travel. In one embodiment, the power output by the group of vehicles may be proportionally or selectively controlled to provide a specific output from each of the one or more of the vehicles in the group.

[0086] The interconnecting, or coupling, features may be configured as electromagnetic mechanisms, mechanical couplings, electromechanical coupling mechanisms, etc., and/or combinations thereof. The features may be selectively deployed from a portion of the frame 1204 and/or body of the vehicle 100. In some cases, the features may be built into the frame 1204 and/or body of the vehicle 100. In any event, the features may deploy from an unexposed position to an exposed position or may be configured to selectively engage/disengage without requiring an exposure or deployment of the mechanism from the frame 1204 and/or body. In some embodiments, the interconnecting features may be configured to interconnect one or more of power, communications, electrical energy, fuel, and/or the like. One or more of the power, mechanical, and/or communications connections between vehicles may be part of a single interconnection mechanism. In some embodiments, the interconnection mechanism may include multiple connection

mechanisms. In any event, the single interconnection mechanism or the interconnection mechanism may employ the poka-yoke features as described above.

[0087] The power system of the vehicle 100 may include the powertrain, power distribution system, accessory power system, and/or any other components that store power, provide power, convert power, and/or distribute power to one or more portions of the vehicle 100. The powertrain may include the one or more electric motors 1312 of the vehicle 100. The electric motors 1312 are configured to convert electrical energy provided by a power source into mechanical energy. This mechanical energy may be in the form of a rotational or other output force that is configured to propel or otherwise provide a motive force for the vehicle 100.

[0088] In some embodiments, the vehicle 100 may include one or more drive wheels 1320 that are driven by the one or more electric motors 1312 and motor controllers 1314. In some cases, the vehicle 100 may include an electric motor 1312 configured to provide a driving force for each drive wheel 1320. In other cases, a single electric motor 1312 may be configured to share an output force between two or more drive wheels 1320 via one or more power transmission components. It is an aspect of the present disclosure that the powertrain include one or more power transmission components, motor controllers 1314, and/or power controllers that can provide a controlled output of power to one or more of the drive wheels 1320 of the vehicle 100. The power transmission components, power controllers, or motor controllers 1314 may be controlled by at least one other vehicle controller described herein.

[0089] As provided above, the powertrain of the vehicle 100 may include one or more power sources 1308A, 1308B. These one or more power sources 1308A, 1308B may be configured to provide drive power, system and/or subsystem power, accessory power, etc. While described herein as a single power source 1308 for sake of clarity, embodiments of the present disclosure are not so limited. For example, it should be appreciated that independent, different, or separate power sources 1308A, 1308B may provide power to various systems of the vehicle 100. For instance, a drive power source may be configured to provide the power for the one or more electric motors 1312 of the vehicle 100, while a system power source may be configured to provide the power for one or more other systems and/or subsystems of the vehicle 100. Other power sources may include an accessory power source, a backup power source, a critical system power source, and/or other separate power sources. Separating the power sources 1308A, 1308B in this manner may provide a number of benefits over conventional vehicle systems. For example,

separating the power sources 1308A, 1308B allow one power source 1308 to be removed and/or replaced independently without requiring that power be removed from all systems and/or subsystems of the vehicle 100 during a power source 1308 removal/replacement. For instance, one or more of the accessories, communications, safety equipment, and/or backup power systems, etc., may be maintained even when a particular power source 1308A, 1308B is depleted, removed, or becomes otherwise inoperable.

[0090] In some embodiments, the drive power source may be separated into two or more cells, units, sources, and/or systems. By way of example, a vehicle 100 may include a first drive power source 1308A and a second drive power source 1308B. The first drive power source 1308A may be operated independently from or in conjunction with the second drive power source 1308B and vice versa. Continuing this example, the first drive power source 1308A may be removed from a vehicle while a second drive power source 1308B can be maintained in the vehicle 100 to provide drive power. This approach allows the vehicle 100 to significantly reduce weight (*e.g.*, of the first drive power source 1308A, etc.) and improve power consumption, even if only for a temporary period of time. In some cases, a vehicle 100 running low on power may automatically determine that pulling over to a rest area, emergency lane, and removing, or “dropping off,” at least one power source 1308A, 1308B may reduce enough weight of the vehicle 100 to allow the vehicle 100 to navigate to the closest power source replacement and/or charging area. In some embodiments, the removed, or “dropped off,” power source 1308A may be collected by a collection service, vehicle mechanic, tow truck, or even another vehicle or individual.

[0091] The power source 1308 may include a GPS or other geographical location system that may be configured to emit a location signal to one or more receiving entities. For instance, the signal may be broadcast or targeted to a specific receiving party. Additionally or alternatively, the power source 1308 may include a unique identifier that may be used to associate the power source 1308 with a particular vehicle 100 or vehicle user. This unique identifier may allow an efficient recovery of the power source 1308 dropped off. In some embodiments, the unique identifier may provide information for the particular vehicle 100 or vehicle user to be billed or charged with a cost of recovery for the power source 1308.

[0092] The power source 1308 may include a charge controller 1324 that may be configured to determine charge levels of the power source 1308, control a rate at which charge is drawn from the power source 1308, control a rate at which charge is added to the power source 1308, and/or monitor a health of the power source 1308 (*e.g.*, one or more

cells, portions, etc.). In some embodiments, the charge controller 1324 or the power source 1308 may include a communication interface. The communication interface can allow the charge controller 1324 to report a state of the power source 1308 to one or more other controllers of the vehicle 100 or even communicate with a communication device separate and/or apart from the vehicle 100. Additionally or alternatively, the communication interface may be configured to receive instructions (*e.g.*, control instructions, charge instructions, communication instructions, etc.) from one or more other controllers of the vehicle 100 or a communication device that is separate and/or apart from the vehicle 100.

[0093] The powertrain includes one or more power distribution systems configured to transmit power from the power source 1308 to one or more electric motors 1312 in the vehicle 100. The power distribution system may include electrical interconnections 1328 in the form of cables, wires, traces, wireless power transmission systems, etc., and/or combinations thereof. It is an aspect of the present disclosure that the vehicle 100 include one or more redundant electrical interconnections 1332 of the power distribution system. The redundant electrical interconnections 1332 can allow power to be distributed to one or more systems and/or subsystems of the vehicle 100 even in the event of a failure of an electrical interconnection portion of the vehicle 100 (*e.g.*, due to an accident, mishap, tampering, or other harm to a particular electrical interconnection, etc.). In some embodiments, a user of a vehicle 100 may be alerted via a user interface associated with the vehicle 100 that a redundant electrical interconnection 1332 is being used and/or damage has occurred to a particular area of the vehicle electrical system. In any event, the one or more redundant electrical interconnections 1332 may be configured along completely different routes than the electrical interconnections 1328 and/or include different modes of failure than the electrical interconnections 1328 to, among other things, prevent a total interruption power distribution in the event of a failure.

[0094] In some embodiments, the power distribution system may include an energy recovery system 1336. This energy recovery system 1336, or kinetic energy recovery system, may be configured to recover energy produced by the movement of a vehicle 100. The recovered energy may be stored as electrical and/or mechanical energy. For instance, as a vehicle 100 travels or moves, a certain amount of energy is required to accelerate, maintain a speed, stop, or slow the vehicle 100. In any event, a moving vehicle has a certain amount of kinetic energy. When brakes are applied in a typical moving vehicle, most of the kinetic energy of the vehicle is lost as the generation of heat in the braking mechanism. In an energy recovery system 1336, when a vehicle 100 brakes, at least a

portion of the kinetic energy is converted into electrical and/or mechanical energy for storage. Mechanical energy may be stored as mechanical movement (*e.g.*, in a flywheel, etc.) and electrical energy may be stored in batteries, capacitors, and/or some other electrical storage system. In some embodiments, electrical energy recovered may be stored in the power source 1308. For example, the recovered electrical energy may be used to charge the power source 1308 of the vehicle 100.

[0095] The vehicle 100 may include one or more safety systems. Vehicle safety systems can include a variety of mechanical and/or electrical components including, but in no way limited to, low impact or energy-absorbing bumpers 1316A, 1316B, crumple zones, reinforced body panels, reinforced frame components, impact bars, power source containment zones, safety glass, seatbelts, supplemental restraint systems, air bags, escape hatches, removable access panels, impact sensors, accelerometers, vision systems, radar systems, etc., and/or the like. In some embodiments, the one or more of the safety components may include a safety sensor or group of safety sensors associated with the one or more of the safety components. For example, a crumple zone may include one or more strain gages, impact sensors, pressure transducers, etc. These sensors may be configured to detect or determine whether a portion of the vehicle 100 has been subjected to a particular force, deformation, or other impact. Once detected, the information collected by the sensors may be transmitted or sent to one or more of a controller of the vehicle 100 (*e.g.*, a safety controller, vehicle controller, etc.) or a communication device associated with the vehicle 100 (*e.g.*, across a communication network, etc.).

[0096] Fig. 14 shows a plan view of the vehicle 100 in accordance with embodiments of the present disclosure. In particular, Fig. 14 shows a broken section 1402 of a charging system for the vehicle 100. The charging system may include a plug or receptacle 1404 configured to receive power from an external power source (*e.g.*, a source of power that is external to and/or separate from the vehicle 100, etc.). An example of an external power source may include the standard industrial, commercial, or residential power that is provided across power lines. Another example of an external power source may include a proprietary power system configured to provide power to the vehicle 100. In any event, power received at the plug/receptacle 1404 may be transferred via at least one power transmission interconnection 1408. Similar, if not identical, to the electrical interconnections 1328 described above, the at least one power transmission interconnection 1408 may be one or more cables, wires, traces, wireless power transmission systems, etc., and/or combinations thereof. Electrical energy in the form of

charge can be transferred from the external power source to the charge controller 1324. As provided above, the charge controller 1324 may regulate the addition of charge to the power source 1308 of the vehicle 100 (*e.g.*, until the power source 1308 is full or at a capacity, etc.).

[0097] In some embodiments, the vehicle 100 may include an inductive charging system and inductive charger 1412. The inductive charger 1412 may be configured to receive electrical energy from an inductive power source external to the vehicle 100. In one embodiment, when the vehicle 100 and/or the inductive charger 1412 is positioned over an inductive power source external to the vehicle 100, electrical energy can be transferred from the inductive power source to the vehicle 100. For example, the inductive charger 1412 may receive the charge and transfer the charge via at least one power transmission interconnection 1408 to the charge controller 1324 and/or the power source 1308 of the vehicle 100. The inductive charger 1412 may be concealed in a portion of the vehicle 100 (*e.g.*, at least partially protected by the frame 1204, one or more body panels 1208, a shroud, a shield, a protective cover, etc., and/or combinations thereof) and/or may be deployed from the vehicle 100. In some embodiments, the inductive charger 1412 may be configured to receive charge only when the inductive charger 1412 is deployed from the vehicle 100. In other embodiments, the inductive charger 1412 may be configured to receive charge while concealed in the portion of the vehicle 100.

[0098] In addition to the mechanical components described herein, the vehicle 100 may include a number of user interface devices. The user interface devices receive and translate human input into a mechanical movement or electrical signal or stimulus. The human input may be one or more of motion (*e.g.*, body movement, body part movement, in two-dimensional or three-dimensional space, etc.), voice, touch, and/or physical interaction with the components of the vehicle 100. In some embodiments, the human input may be configured to control one or more functions of the vehicle 100 and/or systems of the vehicle 100 described herein. User interfaces may include, but are in no way limited to, at least one graphical user interface of a display device, steering wheel or mechanism, transmission lever or button (*e.g.*, including park, neutral, reverse, and/or drive positions, etc.), throttle control pedal or mechanism, brake control pedal or mechanism, power control switch, communications equipment, etc.

[0100] An embodiment of the electrical system 1500 associated with the vehicle 100 may be as shown in Fig. 15. The electrical system 1500 can include power source(s) that generate power, power storage that stores power, and/or load(s) that consume power.

Power sources may be associated with a power generation unit 1504. Power storage may be associated with a power storage system 612. Loads may be associated with loads 1508. The electrical system 1500 may be managed by a power management controller 1324. Further, the electrical system 1500 can include one or more other interfaces or controllers, which can include the billing and cost control unit 1512.

[0101] The power generation unit 1504 may be as described in conjunction with Fig. 16. The power storage component 612 may be as described in conjunction with Fig. 17. The loads 1508 may be as described in conjunction with Fig. 18.

[0102] The billing and cost control unit 1512 may interface with the power management controller 1324 to determine the amount of charge or power provided to the power storage 612 through the power generation unit 1504. The billing and cost control unit 1512 can then provide information for billing the vehicle owner. Thus, the billing and cost control unit 1512 can receive and/or send power information to third party system(s) regarding the received charge from an external source. The information provided can help determine an amount of money required, from the owner of the vehicle, as payment for the provided power. Alternatively, or in addition, if the owner of the vehicle provided power to another vehicle (or another device/system), that owner may be owed compensation for the provided power or energy, e.g., a credit.

[0103] The power management controller 1324 can be a computer or computing system(s) and/or electrical system with associated components, as described herein, capable of managing the power generation unit 1504 to receive power, routing the power to the power storage 612, and then providing the power from either the power generation unit 1504 and/or the power storage 612 to the loads 1508. Thus, the power management controller 1324 may execute programming that controls switches, devices, components, etc. involved in the reception, storage, and provision of the power in the electrical system 1500.

[0104] An embodiment of the power generation unit 1504 may be as shown in Fig. 16. Generally, the power generation unit 1504 may be electrically coupled to one or more power sources 1308. The power sources 1308 can include power sources internal and/or associated with the vehicle 100 and/or power sources external to the vehicle 100 to which the vehicle 100 electrically connects. One of the internal power sources can include an on board generator 1604. The generator 1604 may be an alternating current (AC) generator, a direct current (DC) generator or a self-excited generator. The AC generators can include induction generators, linear electric generators, and/or other types of generators. The DC

generators can include homopolar generators and/or other types of generators. The generator 1604 can be brushless or include brush contacts and generate the electric field with permanent magnets or through induction. The generator 1604 may be mechanically coupled to a source of kinetic energy, such as an axle or some other power take-off. The generator 1604 may also have another mechanical coupling to an exterior source of kinetic energy, for example, a wind turbine.

[0105] Another power source 1308 may include wired or wireless charging 1608. The wireless charging system 1608 may include inductive and/or resonant frequency inductive charging systems that can include coils, frequency generators, controllers, etc. Wired charging may be any kind of grid-connected charging that has a physical connection, although, the wireless charging may be grid connected through a wireless interface. The wired charging system can include an connectors, wired interconnections, the controllers, etc. The wired and wireless charging systems 1608 can provide power to the power generation unit 1504 from external power sources 1308.

[0106] Internal sources for power may include a regenerative braking system 1612. The regenerative braking system 1612 can convert the kinetic energy of the moving car into electrical energy through a generation system mounted within the wheels, axle, and/or braking system of the vehicle 100. The regenerative braking system 1612 can include any coils, magnets, electrical interconnections, converters, controllers, etc. required to convert the kinetic energy into electrical energy.

[0107] Another source of power 1308, internal to or associated with the vehicle 100, may be a solar array 1616. The solar array 1616 may include any system or device of one or more solar cells mounted on the exterior of the vehicle 100 or integrated within the body panels of the vehicle 100 that provides or converts solar energy into electrical energy to provide to the power generation unit 1504.

[0108] The power sources 1308 may be connected to the power generation unit 1504 through an electrical interconnection 1618. The electrical interconnection 1618 can include any wire, interface, bus, etc. between the one or more power sources 1308 and the power generation unit 1504.

[0109] The power generation unit 1504 can also include a power source interface 1620. The power source interface 1620 can be any type of physical and/or electrical interface used to receive the electrical energy from the one or more power sources 1308; thus, the power source interface 1620 can include an electrical interface 1624 that receives the electrical energy and a mechanical interface 1628 which may include wires, connectors, or

other types of devices or physical connections. The mechanical interface 1608 can also include a physical/electrical connection 1634 to the power generation unit 1504.

[0110] The electrical energy from the power source 1308 can be processed through the power source interface 1624 to an electric converter 1632. The electric converter 1632 may convert the characteristics of the power from one of the power sources into a useable form that may be used either by the power storage 612 or one or more loads 1508 within the vehicle 100. The electrical converter 1624 may include any electronics or electrical devices and/or component that can change electrical characteristics, *e.g.*, AC frequency, amplitude, phase, etc. associated with the electrical energy provided by the power source 1308. The converted electrical energy may then be provided to an optional conditioner 1638. The conditioner 1638 may include any electronics or electrical devices and/or component that may further condition the converted electrical energy by removing harmonics, noise, etc. from the electrical energy to provide a more stable and effective form of power to the vehicle 100.

[0111] An embodiment of the power storage 1612 may be as shown in Fig. 17. The power storage unit can include an electrical converter 1632b, one or more batteries, one or more rechargeable batteries, one or more capacitors, one or more accumulators, one or more supercapacitors, one or more ultrabatteries, and/or superconducting magnetics 1704, and/or a charge management unit 1708. The converter 1632b may be the same or similar to the electrical converter 1632a shown in Fig. 16. The converter 1632b may be a replacement for the electric converter 1632a shown in Fig. 16 and thus eliminate the need for the electrical converter 1632a as shown in Fig. 16. However, if the electrical converter 1632a is provided in the power generation unit 1504, the converter 1632b, as shown in the power storage unit 612, may be eliminated. The converter 1632b can also be redundant or different from the electrical converter 1632a shown in Fig. 16 and may provide a different form of energy to the battery and/or capacitors 1704. Thus, the converter 1632b can change the energy characteristics specifically for the battery/capacitor 1704.

[0112] The battery 1704 can be any type of battery for storing electrical energy, for example, a lithium ion battery, a lead acid battery, a nickel cadmium battery, etc. Further, the battery 1704 may include different types of power storage systems, such as, ionic fluids or other types of fuel cell systems. The energy storage 1704 may also include one or more high-capacity capacitors 1704. The capacitors 1704 may be used for long-term or short-term storage of electrical energy. The input into the battery or capacitor 1704 may be different from the output, and thus, the capacitor 1704 may be charged quickly but drain

slowly. The functioning of the converter 1632 and battery capacitor 1704 may be monitored or managed by a charge management unit 1708.

[0113] The charge management unit 1708 can include any hardware (*e.g.*, any electronics or electrical devices and/or components), software, or firmware operable to adjust the operations of the converter 1632 or batteries/capacitors 1704. The charge management unit 1708 can receive inputs or periodically monitor the converter 1632 and/or battery/capacitor 1704 from this information; the charge management unit 1708 may then adjust settings or inputs into the converter 1632 or battery/capacitor 1704 to control the operation of the power storage system 612.

[0114] An embodiment of one or more loads 1508 associated with the vehicle 100 may be as shown in Fig. 18. The loads 1508 may include a bus or electrical interconnection system 1802, which provides electrical energy to one or more different loads within the vehicle 100. The bus 1802 can be any number of wires or interfaces used to connect the power generation unit 1504 and/or power storage 612 to the one or more loads 1508. The converter 1632c may be an interface from the power generation unit 1504 or the power storage 612 into the loads 1508. The converter 1632c may be the same or similar to electric converter 1632a as shown in Fig. 16. Similar to the discussion of the converter 1632b in Fig. 17, the converter 1632c may be eliminated, if the electric converter 1632a, shown in Fig. 16, is present. However, the converter 1632c may further condition or change the energy characteristics for the bus 1802 for use by the loads 1508. The converter 1632c may also provide electrical energy to electric motor 1804, which may power the vehicle 100.

[0115] The electric motor 1804 can be any type of DC or AC electric motor. The electric motor may be a direct drive or induction motor using permanent magnets and/or winding either on the stator or rotor. The electric motor 1804 may also be wireless or include brush contacts. The electric motor 1804 may be capable of providing a torque and enough kinetic energy to move the vehicle 100 in traffic.

[0116] The different loads 1508 may also include environmental loads 1812, sensor loads 1816, safety loads 1820, user interaction loads 1808, etc. User interaction loads 1808 can be any energy used by user interfaces or systems that interact with the driver and/or passenger(s). These loads 1808 may include, for example, the heads up display, the dash display, the radio, user interfaces on the head unit, lights, radio, and/or other types of loads that provide or receive information from the occupants of the vehicle 100. The environmental loads 1812 can be any loads used to control the environment within the

vehicle 100. For example, the air conditioning or heating unit of the vehicle 100 can be environmental loads 1812. Other environmental loads can include lights, fans, and/or defrosting units, etc. that may control the environment within the vehicle 100. The sensor loads 1816 can be any loads used by sensors, for example, air bag sensors, GPS, and other such sensors used to either manage or control the vehicle 100 and/or provide information or feedback to the vehicle occupants. The safety loads 1820 can include any safety equipment, for example, seat belt alarms, airbags, headlights, blinkers, etc. that may be used to manage the safety of the occupants. There may be more or fewer loads than those described herein, although they may not be shown in Fig. 18.

[0117] Fig. 19 illustrates an exemplary hardware diagram of communications componentry that can be optionally associated with the vehicle.

[0118] The communications componentry can include one or more wired or wireless devices such as a transceiver(s) and/or modem that allows communications not only between the various systems disclosed herein but also with other devices, such as devices on a network, and/or on a distributed network such as the Internet and/or in the cloud.

[0119] The communications subsystem can also include inter- and intra-vehicle communications capabilities such as hotspot and/or access point connectivity for any one or more of the vehicle occupants and/or vehicle-to-vehicle communications.

[0120] Additionally, and while not specifically illustrated, the communications subsystem can include one or more communications links (that can be wired or wireless) and/or communications busses (managed by the bus manager 1974), including one or more of CANbus, OBD-II, ARCINC 429, Byteflight, CAN (Controller Area Network), D2B (Domestic Digital Bus), FlexRay, DC-BUS, IDB-1394, IEBus, I²C, ISO 9141-1/-2, J1708, J1587, J1850, J1939, ISO 11783, Keyword Protocol 2000, LIN (Local Interconnect Network), MOST (Media Oriented Systems Transport), Multifunction Vehicle Bus, SMARTwireX, SPI, VAN (Vehicle Area Network), and the like or in general any communications protocol and/or standard.

[0121] The various protocols and communications can be communicated one or more of wirelessly and/or over transmission media such as single wire, twisted pair, fibre optic, IEEE 1394, MIL-STD-1553, MIL-STD-1773, power-line communication, or the like. (All of the above standards and protocols are incorporated herein by reference in their entirety)

[0122] As discussed, the communications subsystem enables communications between any if the inter-vehicle systems and subsystems as well as communications with non-allocated resources, such as those reachable over a network such as the Internet.

[0123] The communications subsystem, in addition to well-known componentry (which has been omitted for clarity), the device communications subsystem 1900 includes interconnected elements including one or more of: one or more antennas 1904, an interleaver/deinterleaver 1908, an analog front end (AFE) 1912, memory/storage/cache 1916, controller/microprocessor 1920, MAC circuitry 1922, modulator/demodulator 1924, encoder/decoder 1928, a plurality of connectivity managers 1934-1966, GPU 1940, accelerator 1944, a multiplexer/demultiplexer 1954, transmitter 1970, receiver 1972 and wireless radio 1978 components such as a Wi-Fi PHY/Bluetooth® module 1980, a Wi-Fi/BT MAC module 1984, transmitter 1988 and receiver 1992. The various elements in the device 1900 are connected by one or more links/busses 5 (not shown, again for sake of clarity).

[0124] The device 400 can have one more antennas 1904, for use in wireless communications such as multi-input multi-output (MIMO) communications, multi-user multi-input multi-output (MU-MIMO) communications Bluetooth®, LTE, 4G, 5G, Near-Field Communication (NFC), etc. The antenna(s) 1904 can include, but are not limited to one or more of directional antennas, omnidirectional antennas, monopoles, patch antennas, loop antennas, microstrip antennas, dipoles, and any other antenna(s) suitable for communication transmission/reception. In an exemplary embodiment, transmission/reception using MIMO may require particular antenna spacing. In another exemplary embodiment, MIMO transmission/reception can enable spatial diversity allowing for different channel characteristics at each of the antennas. In yet another embodiment, MIMO transmission/reception can be used to distribute resources to multiple users for example within the vehicle and/or in another vehicle.

[0125] Antenna(s) 1904 generally interact with the Analog Front End (AFE) 1912, which is needed to enable the correct processing of the received modulated signal and signal conditioning for a transmitted signal. The AFE 1912 can be functionally located between the antenna and a digital baseband system in order to convert the analog signal into a digital signal for processing and vice-versa.

[0126] The subsystem 1900 can also include a controller/microprocessor 1920 and a memory/storage/cache 1916. The subsystem 1900 can interact with the memory/storage/cache 1916 which may store information and operations necessary for

configuring and transmitting or receiving the information described herein. The memory/storage/cache 1916 may also be used in connection with the execution of application programming or instructions by the controller/microprocessor 1920, and for temporary or long term storage of program instructions and/or data. As examples, the memory/storage/cache 1920 may comprise a computer-readable device, RAM, ROM, DRAM, SDRAM, and/or other storage device(s) and media.

[0127] The controller/microprocessor 1920 may comprise a general purpose programmable processor or controller for executing application programming or instructions related to the subsystem 1900. Furthermore, the controller/microprocessor 1920 can perform operations for configuring and transmitting/receiving information as described herein. The controller/microprocessor 1920 may include multiple processor cores, and/or implement multiple virtual processors. Optionally, the controller/microprocessor 1920 may include multiple physical processors. By way of example, the controller/microprocessor 1920 may comprise a specially configured Application Specific Integrated Circuit (ASIC) or other integrated circuit, a digital signal processor(s), a controller, a hardwired electronic or logic circuit, a programmable logic device or gate array, a special purpose computer, or the like.

[0128] The subsystem 1900 can further include a transmitter 1970 and receiver 1972 which can transmit and receive signals, respectively, to and from other devices, subsystems and/or other destinations using the one or more antennas 1904 and/or links/busses. Included in the subsystem 1900 circuitry is the medium access control or MAC Circuitry 1922. MAC circuitry 1922 provides for controlling access to the wireless medium. In an exemplary embodiment, the MAC circuitry 1922 may be arranged to contend for the wireless medium and configure frames or packets for communicating over the wireless medium.

[0129] The subsystem 1900 can also optionally contain a security module (not shown). This security module can contain information regarding but not limited to, security parameters required to connect the device to one or more other devices or other available network(s), and can include WEP or WPA/WPA-2 (optionally + AES and/or TKIP) security access keys, network keys, etc. The WEP security access key is a security password used by Wi-Fi networks. Knowledge of this code can enable a wireless device to exchange information with an access point and/or another device. The information exchange can occur through encoded messages with the WEP access code often being

chosen by the network administrator. WPA is an added security standard that is also used in conjunction with network connectivity with stronger encryption than WEP.

[0130] The exemplary subsystem 1900 also includes a GPU 1940, an accelerator 1944, a Wi-Fi/BT/BLE PHY module 1980 and a Wi-Fi/BT/BLE MAC module 1984 and wireless transmitter 1988 and receiver 1992. In some embodiments, the GPU 1940 may be a graphics processing unit, or visual processing unit, comprising at least one circuit and/or chip that manipulates and changes memory to accelerate the creation of images in a frame buffer for output to at least one display device. The GPU 1940 may include one or more of a display device connection port, printed circuit board (PCB), a GPU chip, a metal-oxide-semiconductor field-effect transistor (MOSFET), memory (e.g., single data rate random-access memory (SDRAM), double data rate random-access memory (DDR) RAM, etc., and/or combinations thereof), a secondary processing chip (e.g., handling video out capabilities, processing, and/or other functions in addition to the GPU chip, etc.), a capacitor, heatsink, temperature control or cooling fan, motherboard connection, shielding, and the like.

[0131] The various connectivity managers 1934-1966 (even) manage and/or coordinate communications between the subsystem 1900 and one or more of the systems disclosed herein and one or more other devices/systems. The connectivity managers include an emergency charging connectivity manager 1934, an aerial charging connectivity manager 1938, a roadway charging connectivity manager 1942, an overhead charging connectivity manager 1946, a robotic charging connectivity manager 1950, a static charging connectivity manager 1954, a vehicle database connectivity manager 1958, a remote operating system connectivity manager 1962 and a sensor connectivity manager 1966.

[0132] The emergency charging connectivity manager 1934 can coordinate not only the physical connectivity between the vehicle and the emergency charging device/vehicle, but can also communicate with one or more of the power management controller, one or more third parties and optionally a billing system(s). As an example, the vehicle can establish communications with the emergency charging device/vehicle to one or more of coordinate interconnectivity between the two (e.g., by spatially aligning the charging receptacle on the vehicle with the charger on the emergency charging vehicle) and optionally share navigation information. Once charging is complete, the amount of charge provided can be tracked and optionally forwarded to, for example, a third party for billing. In addition to being able to manage connectivity for the exchange of power, the emergency charging connectivity manager 1934 can also communicate information, such as billing information

to the emergency charging vehicle and/or a third party. This billing information could be, for example, the owner of the vehicle, the driver of the vehicle, company information, or in general any information usable to charge the appropriate entity for the power received.

[0133] The aerial charging connectivity manager 1938 can coordinate not only the physical connectivity between the vehicle and the aerial charging device/vehicle, but can also communicate with one or more of the power management controller, one or more third parties and optionally a billing system(s). As an example, the vehicle can establish communications with the aerial charging device/vehicle to one or more of coordinate interconnectivity between the two (e.g., by spatially aligning the charging receptacle on the vehicle with the charger on the emergency charging vehicle) and optionally share navigation information. Once charging is complete, the amount of charge provided can be tracked and optionally forwarded to, for example, a third party for billing. In addition to being able to manage connectivity for the exchange of power, the aerial charging connectivity manager 1938 can similarly communicate information, such as billing information to the aerial charging vehicle and/or a third party. This billing information could be, for example, the owner of the vehicle, the driver of the vehicle, company information, or in general any information usable to charge the appropriate entity for the power received etc., as discussed.

[0134] The roadway charging connectivity manager 1942 and overhead charging connectivity manager 1946 can coordinate not only the physical connectivity between the vehicle and the charging device/system, but can also communicate with one or more of the power management controller, one or more third parties and optionally a billing system(s). As one example, the vehicle can request a charge from the charging system when, for example, the vehicle needs or is predicted to need power. As an example, the vehicle can establish communications with the charging device/vehicle to one or more of coordinate interconnectivity between the two for charging and share information for billing. Once charging is complete, the amount of charge provided can be tracked and optionally forwarded to, for example, a third party for billing. This billing information could be, for example, the owner of the vehicle, the driver of the vehicle, company information, or in general any information usable to charge the appropriate entity for the power received etc., as discussed. The person responsible for paying for the charge could also receive a copy of the billing information as is customary. The robotic charging connectivity manager 1950 and static charging connectivity manager 1954 can operate in a similar manner to that described herein.

[0135] The vehicle database connectivity manager 1958 allows the subsystem to receive and/or share information stored in the vehicle database. This information can be shared with other vehicle components/subsystems and/or other entities, such as third parties and/or charging systems. The information can also be shared with one or more vehicle occupant devices, such as an app on a mobile device the driver uses to track information about the vehicle and/or a dealer or service/maintenance provider. In general any information stored in the vehicle database can optionally be shared with any one or more other devices optionally subject to any privacy or confidentiality restrictions.

[0136] The remote operating system connectivity manager 1962 facilitates communications between the vehicle and any one or more autonomous vehicle systems. These communications can include one or more of navigation information, vehicle information, occupant information, or in general any information related to the remote operation of the vehicle.

[0137] The sensor connectivity manager 1966 facilitates communications between any one or more of the vehicle sensors and any one or more of the other vehicle systems. The sensor connectivity manager 1966 can also facilitate communications between any one or more of the sensors and/or vehicle systems and any other destination, such as a service company, app, or in general to any destination where sensor data is needed.

[0138] In accordance with one exemplary embodiment, any of the communications discussed herein can be communicated via the conductor(s) used for charging. One exemplary protocol usable for these communications is Power-line communication (PLC). PLC is a communication protocol that uses electrical wiring to simultaneously carry both data, and Alternating Current (AC) electric power transmission or electric power distribution. It is also known as power-line carrier, power-line digital subscriber line (PDSL), mains communication, power-line telecommunications, or power-line networking (PLN). For DC environments in vehicles PLC can be used in conjunction with CAN-bus, LIN-bus over power line (DC-LIN) and DC-BUS.

[0139] The communications subsystem can also optionally manage one or more identifiers, such as an IP (internet protocol) address(es), associated with the vehicle and one or other system or subsystems or components therein. These identifiers can be used in conjunction with any one or more of the connectivity managers as discussed herein.

[0140] Fig. 19B illustrates a block diagram of a computing environment 1901 that may function as the servers, user computers, or other systems provided and described above. The environment 1901 includes one or more user computers, or computing devices, such

as a vehicle computing device 1903, a communication device 1907, and/or more 1911. The computing devices 1903, 1907, 1911 may include general purpose personal computers (including, merely by way of example, personal computers, and/or laptop computers running various versions of Microsoft Corp.'s Windows® and/or Apple Corp.'s Macintosh® operating systems) and/or workstation computers running any of a variety of commercially-available UNIX® or UNIX-like operating systems. These computing devices 1903, 1907, 1911 may also have any of a variety of applications, including for example, database client and/or server applications, and web browser applications. Alternatively, the computing devices 1903, 1907, 1911 may be any other electronic device, such as a thin-client computer, Internet-enabled mobile telephone, and/or personal digital assistant, capable of communicating via a network 1909 and/or displaying and navigating web pages or other types of electronic documents. Although the exemplary computer environment 1901 is shown with two computing devices, any number of user computers or computing devices may be supported.

[0141] Environment 1901 further includes a network 1909. The network 1909 may be any type of network familiar to those skilled in the art that can support data communications using any of a variety of commercially-available protocols, including without limitation SIP, TCP/IP, SNA, IPX, AppleTalk, and the like. Merely by way of example, the network 1909 may be a local area network ("LAN"), such as an Ethernet network, a Token-Ring network and/or the like; a wide-area network; a virtual network, including without limitation a virtual private network ("VPN"); the Internet; an intranet; an extranet; a public switched telephone network ("PSTN"); an infra-red network; a wireless network (e.g., a network operating under any of the IEEE 802.9 suite of protocols, the Bluetooth® protocol known in the art, and/or any other wireless protocol); and/or any combination of these and/or other networks.

[0142] The system may also include one or more servers 1913, 1915. In this example, server 1913 is shown as a web server and server 1915 is shown as an application server. The web server 1913, which may be used to process requests for web pages or other electronic documents from computing devices 1903, 1907, 1911. The web server 1913 can be running an operating system including any of those discussed above, as well as any commercially-available server operating systems. The web server 1913 can also run a variety of server applications, including SIP servers, HTTP servers, FTP servers, CGI servers, database servers, Java servers, and the like. In some instances, the web server 1913 may publish operations available operations as one or more web services.

[0143] The environment 1901 may also include one or more file and/or application servers 1915, which can, in addition to an operating system, include one or more applications accessible by a client running on one or more of the computing devices 1903, 1907, 1911. The server(s) 1915 and/or 1913 may be one or more general purpose computers capable of executing programs or scripts in response to the computing devices 1903, 1907, 1911. As one example, the server 1915, 1913 may execute one or more web applications. The web application may be implemented as one or more scripts or programs written in any programming language, such as Java™, C, C#®, or C++, and/or any scripting language, such as Perl, Python, or TCL, as well as combinations of any programming/scripting languages. The application server(s) 1915 may also include database servers, including without limitation those commercially available from Oracle, Microsoft, Sybase™, IBM™ and the like, which can process requests from database clients running on a computing device 1903, 1907, 1911.

[0144] The web pages created by the server 1913 and/or 1915 may be forwarded to a computing device 1903, 1907, 1911 via a web (file) server 1913, 1915. Similarly, the web server 1913 may be able to receive web page requests, web services invocations, and/or input data from a computing device 1903, 1907, 1911 (e.g., a user computer, etc.) and can forward the web page requests and/or input data to the web (application) server 1915. In further embodiments, the server 1915 may function as a file server. Although for ease of description, Fig. 19B illustrates a separate web server 1913 and file/application server 1915, those skilled in the art will recognize that the functions described with respect to servers 1913, 1915 may be performed by a single server and/or a plurality of specialized servers, depending on implementation-specific needs and parameters. The computer systems 1903, 1907, 1911, web (file) server 1913 and/or web (application) server 1915 may function as the system, devices, or components described in Figs. 1-19A.

[0145] The environment 1901 may also include a database 1917. The database 1917 may reside in a variety of locations. By way of example, database 1917 may reside on a storage medium local to (and/or resident in) one or more of the computers 1903, 1907, 1911, 1913, 1915. Alternatively, it may be remote from any or all of the computers 1903, 1907, 1911, 1913, 1915, and in communication (e.g., via the network 1909) with one or more of these. The database 1917 may reside in a storage-area network ("SAN") familiar to those skilled in the art. Similarly, any necessary files for performing the functions attributed to the computers 1903, 1907, 1911, 1913, 1915 may be stored locally on the respective computer and/or remotely, as appropriate. The database 1917 may be a

relational database, such as Oracle 20i[®], that is adapted to store, update, and retrieve data in response to SQL-formatted commands.

[0146] Fig. 19C illustrates one embodiment of a computer system 1919 upon which the servers, user computers, computing devices, or other systems or components described above may be deployed or executed. The computer system 1919 is shown comprising hardware elements that may be electrically coupled via a bus 1921. The hardware elements may include one or more central processing units (CPUs) 1923; one or more input devices 1925 (e.g., a mouse, a keyboard, etc.); and one or more output devices 1927 (e.g., a display device, a printer, etc.). The computer system 1919 may also include one or more storage devices 1929. By way of example, storage device(s) 1929 may be disk drives, optical storage devices, solid-state storage devices such as a random access memory ("RAM") and/or a read-only memory ("ROM"), which can be programmable, flash-updateable and/or the like.

[0147] The computer system 1919 may additionally include a computer-readable storage media reader 1931; a communications system 1933 (e.g., a modem, a network card (wireless or wired), an infra-red communication device, etc.); and working memory 1937, which may include RAM and ROM devices as described above. The computer system 1919 may also include a processing acceleration unit 1935, which can include a DSP, a special-purpose processor, and/or the like.

[0148] The computer-readable storage media reader 1931 can further be connected to a computer-readable storage medium, together (and, optionally, in combination with storage device(s) 1929) comprehensively representing remote, local, fixed, and/or removable storage devices plus storage media for temporarily and/or more permanently containing computer-readable information. The communications system 1933 may permit data to be exchanged with a network and/or any other computer described above with respect to the computer environments described herein. Moreover, as disclosed herein, the term "storage medium" may represent one or more devices for storing data, including read only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage mediums, flash memory devices and/or other machine readable mediums for storing information.

[0149] The computer system 1919 may also comprise software elements, shown as being currently located within a working memory 1937, including an operating system 1939 and/or other code 1941. It should be appreciated that alternate embodiments of a computer system 1919 may have numerous variations from that described above. For

example, customized hardware might also be used and/or particular elements might be implemented in hardware, software (including portable software, such as applets), or both. Further, connection to other computing devices such as network input/output devices may be employed.

[0150] Examples of the processors 1923 as described herein may include, but are not limited to, at least one of Qualcomm[®] Snapdragon[®] 800 and 801, Qualcomm[®] Snapdragon[®] 620 and 615 with 4G LTE Integration and 64-bit computing, Apple[®] A7 processor with 64-bit architecture, Apple[®] M7 motion coprocessors, Samsung[®] Exynos[®] series, the Intel[®] Core™ family of processors, the Intel[®] Xeon[®] family of processors, the Intel[®] Atom™ family of processors, the Intel Itanium[®] family of processors, Intel[®] Core[®] i5-4670K and i7-4770K 22nm Haswell, Intel[®] Core[®] i5-3570K 22nm Ivy Bridge, the AMD[®] FX™ family of processors, AMD[®] FX-4300, FX-6300, and FX-8350 32nm Vishera, AMD[®] Kaveri processors, Texas Instruments[®] Jacinto C6000™ automotive infotainment processors, Texas Instruments[®] OMAP™ automotive-grade mobile processors, ARM[®] Cortex™-M processors, ARM[®] Cortex-A and ARM926EJ-S™ processors, other industry-equivalent processors, and may perform computational functions using any known or future-developed standard, instruction set, libraries, and/or architecture.

[0151] Figs. 20A-F show various views of a universal battery 2000 in accordance with embodiments of the present disclosure. Figs. 20A-B include reference origin 2002 to show the difference in position between the front and rear perspective views. As provided herein, the universal battery 2000 may be the power source 516, power source 1308, battery 1704, and/or any other device, apparatus, or system configured to provide power (e.g., in the form of electrical energy, etc.) to one or more components of the vehicle 100. In one embodiment, the universal battery 2000 may be used to charge other batteries, capacitors, and/or power sources associated with the vehicle 100. In some embodiments, the universal battery 2000 may be a battery, capacitor, and/or power source of the vehicle 100. For instance, the universal battery 2000 may be used to provide electromotive force for the vehicle 100. As can be appreciated, the universal battery 2000 may be used as a power source for an electric vehicle, a hybrid-electric vehicle, or any other conveyance. Additionally or alternatively, the universal battery 2000 may be used as a power source for another system, device, building, dwelling, etc.

[0152] As shown in Fig. 20A, the universal battery 2000 may include a base or body 2006 having one or more features to interconnect with a mating system. The mating

system may include, but is in no way limited to, one or more receiving systems, batteries, and/or combinations thereof. The body 2006 of the universal battery 2000 may contain, or house, at least one cathode and anode of the battery 2000. In some embodiments, the universal battery 2000 may include a number of battery cells housed in the body 2006. The interconnection features may include one or more surfaces 2032, 2030, protrusions 2024, reliefs 2020, connections 2044 (see Fig. 20B), etc. In some embodiments, one or more features in a mating system may be configured to correspond to, or match, the interconnection features of the universal battery 2000 such that the battery 2000 may be selectively, quickly, and/or securely interconnected with, and/or disconnected from, the mating system.

[0153] The universal battery 2000 may include one or more handling features 2012, 2016. The handling features 2012, 2016 may be configured for a particular type of handling or accept multiple handling types. For instance, the universal battery 2000 may include one or more carrying handles 2012. The carrying handles 2012 may be used by a machine and/or an operator to carry, lift, push, pull, and/or otherwise manipulate the universal battery 2000. For example, a user may wish to remove a universal battery 2000 from a vehicle 100 (e.g., for replacement, alternative use, etc.). In this example, the user may remove the universal battery 2000 via the handles 2012 and even carry the battery 2012 to a location using the handles 2012.

[0154] In some embodiments, the universal battery 2000 may include one or more machine-handling connection features 2016. The machine-handling connection features 2016 may be configured with one or more cuts, slots, tabs, grooves, shapes, etc. for a machine to connect to when handling the universal battery 2000. By way of example, a robot may be equipped with an end-effector for handling one or more universal batteries 2000. The robot may automatically remove, replace, and/or add universal batteries 2000 to a receiving system (e.g., in a vehicle 100, building, etc.) via the machine-handling connection feature 2016. In some cases, the machine-handling connection features 2016 may allow handling by a machine while restricting handling by a user. At least one benefit to restricting handling to machine-handling only is to prevent the unauthorized alteration, removal, or addition of a universal battery 2000 with a vehicle 100 or other receiving system. The restriction may be enforced by requiring an interfacing machine to provide an authorization code via wired or wireless communication. In one embodiment, the restriction may be enforced by a geometry of the machine-handling connection features 2016. For instance, the machine-handling connection features 2016 may be configured to

prevent removal from a vehicle 100 without a mating removal tool. As shown in Fig. 20A, the machine-handling connection feature 2016 does not include any features external to the body 2006 of the battery 2000 that would encourage user-handling. By way of example, the machine-handling connection feature 2016 may be a slot inset to the body 2006 of the battery 2000 with internal connection features that mate with a matching robotic end-effector.

[0155] The universal battery 2000 may include a front 2004, a rear 2008, a first side 2010, and an opposite side having various modular connection features 2020, 2024. In some embodiments, the universal battery 2000 may be separated internally into a power cell area and a power management area. For example, the power cell area may be contained at least partially within the body 2006 of the battery 2000 between the top surface 2030 and the bottom surface 2034 (see Figs. 20E-F). Continuing this example, the power management area may be contained inside the battery but in an area outside of the power cell area. For instance, the power management area may be contained at least partially within the body 2006 of the battery 2000 between the receiving surface 2032 and the sliding surface 2038. In some embodiments, the power management area may include a controller that is electrically interconnected with one or more power cells of the battery 2000. The controller may determine a state of charge associated with the one or more power cells, control power output by the battery 2000, control charging of the battery 2000, and/or maintain a state of the one or more power cells and/or the battery 2000.

[0156] In some embodiments, multiple universal batteries 2000 may be stacked to, among other things, modularly increase a capacity of a power system. The universal batteries 2000 may be stacked in various configurations (e.g., horizontally in the X and/or Y axis, vertically in the Z axis, etc., and/or combinations thereof). Stacking may include adding universal batteries 2000 to an existing power system. As can be appreciated, one or more universal batteries 2000 may be removed from a stack (e.g., destacking) to decrease the capacity of the power system. In any event, the universal battery 2000 may include one or more features 2020, 2024 to enable stacking and/or destacking. For instance, each battery 2000 may include a protruding portion 2024 and a receiving portion 2020. The protruding portion 2024 may extend outwardly from a center, or at least one body surface, of the battery 2000. The receiving portion 2020 may be configured as a landing, relief, cut, slot, hollow, or portion of the battery that is configured to receive a protrusion or protruding portion 2024 of another battery 2000 or member.

[0157] The universal battery 2000 may include a number of features that allow a universal battery 2000 to be slidably engaged with the power system and at least one battery 2000 of the power system. For example, at least one battery 2000 may be engaged, or electrically and mechanically interconnected with a receiving system. Another universal battery 2000 may be added, or stacked, on top of the engaged battery 2000 in the power system. In this example, a protruding portion 2024 of the added universal battery 2000 may be positioned on a sliding surface 2032 of the receiving portion 2020 of the engaged universal battery 2000. The added universal battery 2000 may then be guided into position and slid in the Y-axis direction along at least one guide edge 2036 of the engaged universal battery 2000 (as shown in Figs. 20A-D). The receiving portion 2020 of the engaged universal battery 2000 may include a chamfer, radius, or other lead-in feature 2028 (see Figs. 20A-D) to assist in aligning the added universal battery 2000 relative to the engaged universal battery 2000. In some embodiments, the protruding portion 2024 of the added universal battery 2000 may slide or move along the sliding surface 2032 of the engaged universal battery 2000 while a bottom surface 2034 of the added universal battery 2000 may slide along the top surface 2030 of the engaged universal battery 2000 until the added universal battery 2000 is engaged with the power system. It is an aspect of the present disclosure that another universal battery 2000 may be engaged with the power system by sliding on top of the added universal battery 2000, and so on.

[0158] Referring to Fig. 20B, a rear perspective view of the universal battery 2000 of Fig. 20A is shown in accordance with embodiments of the present disclosure. Figs. 20B and 20F show the rear 2008 of the universal battery 2000 including a power system interconnection portion 2022 extending beyond a rear surface 2026 of the body 2006. The power system interconnection portion 2022 may include one or more electrical interconnection features 2040A, 2040B and/or mechanical interconnection features 2044. In some embodiments, the one or more electrical interconnection features 2040A, 2040B may include shrouded, enclosed, concealed, or otherwise protected electrical contacts. Maintaining the electrical contacts in a recess or protected portion of the battery 2000 or body 2006 may serve to prevent unwanted discharge, arcing, electrical contact, electrocution, and/or other power dissipation from the universal battery 2000. In addition to the various safety advantages, this protected contact design can allow for foolproof handling of the battery 2000. As shown in Figs. 20B and 20F, the universal battery 2000 includes a recessed positive electrical contact shrouded by a first slot or cut feature 2040A and a recessed negative electrical contact shrouded by a second slot or cut feature 2040B.

In some embodiments, the positive electrical contact may be shrouded separately from the negative electrical contact providing further protection.

[0159] The mechanical interconnection feature 2044 may include a locking feature that engages with one or more of another battery 2000, a power system component, a backplane, and/or some other receiving feature of a mating device, component, or system. In some embodiments, the mechanical interconnection feature 2044 may be a recess, cut, slot, or relief in the body 2006 of the universal battery configured to receive a protrusion from a mating system and selectively lock with that protrusion. In other embodiments, the mechanical interconnection feature 2044 may be a protrusion, bar, extension, extrusion, and/or other member extending from a portion of the power system interconnection portion 2022. In this case, the protruding mechanical interconnection feature 2044 may mate with a recess, cut, slot, or relief in a mating system and selectively lock therewith.

[0160] Figs. 21A and 21B show various perspective views of a universal battery receiving system 2100. It is an aspect of the present disclosure that the universal battery 2000 may be interconnected with one or more vehicles 100, systems, buildings, and/or devices. In one embodiment, multiple batteries 2000 may be installed in a system (e.g., a conveyance, vehicle 100, building, etc.) to increase the capacity and/or power output provided by the multiple batteries 2000. The receiving system 2100 may be a part of the one or more vehicles 100, systems, buildings, and/or devices. For instance, a compact, or low power, vehicle 100 (e.g., a small car, motorcycle, scooter, etc.) may only require one battery to operate or travel for a specific range, while a larger, or high power, vehicle 100 (e.g., a truck, an excavator, a backhoe, a sports car, van, recreational vehicle, etc.) may require a greater number of batteries 2000 to travel for the same range. In any event, each vehicle 100 may be configured to receive the same universal battery 2000 but in different numbers. As provided above, the batteries 2000 may include a number of features to allow for a modular increase in power and/or capacity by increasing the number of batteries 2000 interconnected with a vehicle 100.

[0161] The receiving system 2100 may include a base 2106, a first receiving surface 2134, a second receiving surface 2138, one or more guides 2112, 2116, 2146, stops 2114, a backplane 2148, and a number of electrical interconnections 2140A, 2140B, and an electrical power output connection 2140C. The receiving system 2100 may include a receiving portion 2120 that is similar, if not identical, to the receiving portion 2020 described in conjunction with Figs. 20A-F. The receiving portion 2120 of the receiving system 2100 may be configured as a landing, relief, cut, slot, hollow, or portion of the base

2106 that is configured to receive a protrusion or protruding portion 2024 of a universal battery 2000. As a universal battery 2000 is engaged with the receiving system 2100, the universal battery 2000 may be pushed in an engagement direction 2118 in the Y-axis from a front 2104 of the system 2100 toward a rear 2108, or back, of the system 2100. When pushed, the battery 2000 may slide along the first and second receiving surfaces (e.g., the bottom surface 2034 of the universal battery 2000 may slide along the first receiving surface 2134 while the sliding surface 2038 of the universal battery 2000 may slide along the second receiving surface 2138, etc.) guided by the at least one guide edge 2136 of the receiving system 2100 and one or more guides 2112, 2116. The universal battery 2000 may stop when an electrical interconnection is made between the electrical contacts of the universal battery 2000 and the electrical interconnections 2140A, 2140B of the receiving system 2100 and/or when the universal battery contacts a backstop 2114. Although shown as cylindrical members, it should be appreciated that the guides 2112, 2116 and/or the backstop 2114 may be any rail, edge, block, roller, bearing, or other mechanical shape. A universal battery 2000 may be disengaged from the receiving system 2100 by moving (e.g., pulling) the universal battery 2000 in a disengagement direction opposite the engagement direction 2118 in the Y-axis from a rear 2108 of the system 2100 toward a front 2108 of the system 2100.

[0162] Fig. 21A shows a front perspective view of a universal battery receiving system 2100 in accordance with embodiments of the present disclosure. As shown in Fig. 21A, the receiving system 2100 includes a number of electrical interconnections 2140A, 2140B disposed on a backplane 2148. The number of electrical interconnections 2140A, 2140B may correspond to the number of universal batteries 2000 the receiving system 2100 can receive. In particular, the backplane 2148 may include a positive electrical interconnection 2140A and a negative electrical interconnection 2140B for each universal battery 2000 the receiving system 2100 is capable of interconnecting with. The backplane 2148 in Fig. 21A is shown having four separate universal battery 2000 interconnections (e.g., including a positive and negative contact probe for each of the four interconnections). In one embodiment, as a universal battery 2000 is engaged with the receiving system 2100 and the battery 2000 is pushed toward the backstop 2114, the electrical contacts of the universal battery 2000 may physically contact the electrical interconnections 2140A, 2140B creating the electrical interconnection between the universal battery 2000 and the receiving system 2100. In some embodiments, the electrical interconnections 2140A, 2140B may be electrically isolated from a power management system until a battery 2000

physically contacts the electrical interconnections 2140A, 2140B. By way of example, the electrical interconnections 2140A, 2140B may be push-contact probes that only electrically connect with the power of the receiving system 2100 when the electrical interconnections 2140A, 2140B are deflected, compressed, or otherwise moved from a disconnected state into a connected state. In this example, the electrical interconnections 2140A, 2140B for the receiving system are only electrically connected when a universal battery 2000 is connected to the receiving system 2100.

[0163] Fig. 21B shows a rear perspective view of the universal battery receiving system 2100 of Fig. 21A. In particular, Fig. 21B shows an electrical power output connection 2140C for the receiving system 2100. The electrical power output connection 2140C may electrically interconnect the receiving system 2100, and one or more connected universal batteries 2000, to an electrical system of an associated vehicle 100, system, building, and/or device. In some embodiments, the electrical power output connection 2140C may be electrically connected, or selectively electrically connected, to the electrical interconnections 2140A, 2140B of the backplane 2148.

[0164] In some embodiments, the vehicle 100 may include battery slots and/or receptacles configured to accept a specific number of batteries 2000. Each slot/receptacle may be configured to receive a battery 2000 and a vehicle 100, or other system, may include a number of slots configured to receive a corresponding number of batteries 2000. In some embodiments, the number of batteries 2000 may be selected or recruited based on a desired power output or capacity. As can be appreciated, a small vehicle may require fewer batteries 2000 or power output than compared to a larger vehicle. In one embodiment, a particular conveyance may require a specific number of batteries 2000 (e.g., one or more, two or more, etc.) to provide a specific power output.

[0165] Additionally or alternatively, each battery 2000 may be configured as a modular unit. The modular battery may allow a number of batteries to be selectively stacked, combined, joined, or otherwise interconnected. These interconnections/connectors may not require cables to be attached and detached. For instance, the battery 2000 may be slid and locked into a contact position, such as in a drawer or rail system, with connector sites on the vehicle 100 or backplane 2148 of a vehicle receiving system. The battery may unlock from the contact position by machine/user manipulation of a lock state selector and be removed easily. Any number of batteries 2000 could be connected depending on the available connector sites on the vehicle 100 and/or receiving system 2100. This approach

can allow for the dynamic increase or decrease in power output, capacity, storage, etc. associated with the vehicle 100 and/or system

[0166] Fig. 22A is a front perspective view of a first power system 2200A showing a single universal battery 2000 interconnected with a universal battery receiving system 2100 in accordance with embodiments of the present disclosure. As shown, the universal battery 2000 is interconnected mechanically and electrically with the receiving system 2100. In one embodiment, the universal battery 2000 may be slidably connected with the receiving system. For example, a universal battery 2000 may be placed onto one or more receiving surfaces 2134, 2138 of the receiving system 2100 and moved or slid in a direction 2118 toward the backplane 2148 and/or electrical interconnection of the receiving system 2100. As described herein the universal battery 2000 may be guided into an interconnected or engaged position by one or more guides, rails, or features 2112, 2114, 2116, 2136. Once connected, the power system 2200A may be configured to provide power via the electrical power output connection 2140C to one or more connected systems (e.g., vehicle 100, building, system, etc.). In some cases, the power system 2200A may include a number of spare/available slots or electrical interconnections that are configured to accept additional universal batteries 2000. These additional universal batteries 2000 may be added to the power system 2200A until all of the available slots are filled or when a desired power capacity and/or output is met.

[0167] Fig. 22B is a front perspective view of a second power system 2200B showing multiple universal batteries interconnected with a universal battery receiving system in accordance with embodiments of the present disclosure. The power system 2200B of Fig. 22B shows four universal batteries 2000A-D stacked on top of one another and interconnected mechanically and electrically with the receiving system 2100 (e.g., via the electrical contacts 2140A, 2140B in the backplane 2148). In some embodiments, the first universal battery 2000A may be interconnected with the receiving system 2100 first, the second universal battery 2000B may be interconnected next, and so on, until the last universal battery (e.g., the fourth universal battery 2000D in Fig. 22B) is interconnected. Once the universal batteries 2000A-D are interconnected, logic and/or programming associated with the receiving system 2100, or power management system (2404 of Fig. 24), may determine to draw power from the universal batteries 2000A-D together, selectively, in an order, and/or in groups.

[0168] For instance, the power management system may determine to draw power from the universal batteries 2000A-D in a last-in-first-out (LIFO) manner. In this example, the

vehicle 100 may draw power from the upper-most or last universal battery 2000D interconnected with the receiving system 2100. At least one benefit to this LIFO power draw allows used, expired, or depleted batteries to be easily removed and/or replaced without moving the remaining batteries in the receiving system 2100.

[0169] In another example, the power management system may determine to draw power from multiple batteries 2000A-D in the receiving system 2100. In one embodiment, the power provided from multiple batteries 2000A-D may be controlled by the power management system to increase an output voltage. For example, the power management system or receiving system 2100 may selectively connect the universal batteries 2000 in series and provide the added voltage output via the electrical power output connection 2140. In one embodiment, the power provided from multiple batteries 2000A-D may be controlled by the power management system to increase a capacity of the second power system 2200B. By way of example, as universal batteries 2000 are added to a system, the power management system or receiving system 2100 may selectively connect two or more of the universal batteries 2000 in parallel providing additional capacity to a system.

[0170] Fig. 23 is a front elevation view of a third power system 2300 having multiple universal batteries 2000A, 2000B, 2308 interconnected with a universal battery receiving system 2304 in accordance with embodiments of the present disclosure. While embodiments of the present disclosure show that the universal batteries 2000 may be stacked on one another, it should be appreciated that the arrangement of universal batteries connected in a system is not so limited. For example, Fig. 23 shows that two or more universal batteries 2000A, 2000B, 2308 may be electrically and mechanically interconnected with a universal battery receiving system 2304 in a horizontal (e.g., along the X-Axis, etc.) arrangement. In some embodiments, the universal batteries 2000 may be connected in a vertical (e.g., in the Z-Axis direction) and a horizontal (e.g., in the X-axis, etc.) arrangement. In any event, the receiving system 2304 may include a backplane 2148 and electrical contacts 2140A, 2140B that are similar, if not identical, to those shown in Figs. 21A and 22A.

[0171] Fig. 24 is a block diagram of a universal battery power management system environment 2400 in accordance with embodiments of the present disclosure. The universal battery power management system environment 2400 may include a power system 2402 comprising a number of universal batteries 2000A-C, 2412 and a receiving system 2100, a power management system 2404, and one or more electric motors 2408A-N or other loads. Although shown apart from the receiving system 2100, the power

management system 2404 may be a part of the receiving system 2100. In any event, the power management system 2404 may be configured to manage and/or control a power output provided by the universal batteries 2000A-C, 2412 in the receiving system 2100.

[0172] The power management system 2404 may comprise switching circuitry, relays, and/or other electro-mechanical components configured to provide a power output from the universal batteries 2000A-C, 2412 to one or more loads or electric motors 2408A-N. In some embodiments, the power management system 2404 may increase an output voltage, a system capacity, or other electrical characteristic associated with the power provided from the connected universal batteries 2000A-C, 2412. For example, the power management system 2404 may selectively switch or connect the universal batteries 2000A-C, 2412 in series and provide the added voltage output via an electrical power output connection 2140 (not shown) to one or more loads or electric motors 2408A-N. In one embodiment, the power provided from multiple batteries 2000A-D may be controlled by the power management system 2404 to increase a capacity of the power system 2402. By way of example, as universal batteries 2000 are added to a system, the power management system 2404 may selectively connect two or more of the universal batteries 2000 in parallel providing additional capacity available for the loads or electric motors 2408A-N.

[0173] Figs. 25A-C show embodiments of universal battery systems 2504, 2508, 2512 in various receiving systems 100, 100', 2516. Among other things, the embodiments described in Figs. 25A-C show that universal batteries 2000 may be swapped between, or added to, one or more vehicles 100, 100' and/or buildings 2516 or other systems. For instance, Fig. 25A is a block diagram of a first embodiment of a universal battery system 2504 for a vehicle 100. As shown in Fig. 25A, a vehicle 100 may require a number of universal batteries 2000 in a battery system 2504 to provide a particular or desired power capacity, voltage, output, or range. Figs. 25A-C show that various universal battery systems 2504, 2508, 2512 may be part of a vehicle 100, 100', building 2516, or other system.

[0174] In some embodiments, the range of a vehicle 100, 100' may be increased by increasing a number of universal batteries 2000 included in a providing universal battery system 2504, 2508. By way of example, the vehicle 100 of Fig. 25A may require two universal batteries 2000 to travel a range of 300 miles, while adding another universal battery 2000 may increase the range of the vehicle by 100 miles.

[0175] In one embodiment, a particular vehicle 100' may require a greater number of batteries 2000 to power components and/or demands of the particular vehicle 100'. For instance, the particular vehicle 100' may be a heavy-duty electric vehicle (e.g., truck, excavator, backhoe, crane, lift, etc.) as shown in Fig. 25B. As can be appreciated, the heavy-duty electric vehicle may place an increased load on a power system and drain the power system faster than another vehicle may. For example, in Fig. 25B the particular vehicle 100' requires a greater number of batteries 2000 in the universal battery system 2508 than the vehicle 100 shown in Fig. 25A. Similar to the adding of universal batteries 2000 to the power system 2504 of Fig. 25A, universal batteries 2000 may be added to the power system 2508 of Fig. 25B to increase a capability, range, or operation time of the particular vehicle 100' drawing power from the power system 2508.

[0176] Fig. 25C is a block diagram of a first embodiment of a universal battery system 2512 for a building 2516. The building 2516 may correspond to a dwelling, business, outbuilding, etc., or other power storage building. By way of example, the building 2516 may be powered by solar, or other, energy that is stored in batteries. At least some of this energy may be stored in one or more universal batteries 2000 forming a power system 2512 as described herein. The energy may be used for commercial or domestic consumption, load shifting, and/or backup power. In any event, it is an aspect of the present disclosure that the universal batteries 2000 used in the power system 2512 may be identical to the universal batteries 2000 used in the power systems 2504, 2508 for the vehicles 100, 100' and vice versa. These universal batteries 2000 may be added, replaced, and/or swapped between power systems 2504, 2508, 2512 and the power output can be controlled by the power management system associated with each of the power systems 2504, 2508, 2512.

[0177] In some embodiments, at least one of the universal batteries 2000 from the universal battery system 2504 may be swapped with one or more of the universal battery system 2508 of the particular vehicle 100' and/or the universal battery system 2512 of the building 2516 or other system. For instance, a user may be planning a family road trip from the user's house to a destination 400 miles away. The user may have a vehicle 100 and power system 2504 having two batteries 2000 providing an operating range of 300 miles. The vehicle 100 may have unused, or available, slots in the power system 2504 to receive additional batteries 2000. In the event that the user does not wish to stop, or otherwise charge, the vehicle 100 during the road trip, the user may add additional batteries 2000 from another vehicle 100, 100', a home or building 2516, or other universal

power system. In other words, the user may take at least one universal battery 2000 from another system 100, 100', 2516, etc., and interconnect it with the vehicle 100 power system 2504 that the user is taking for the trip. As can be appreciated, the user may take the entire family in the vehicle 100 on the trip, and as such, another of the user's vehicle or the home of the user may not require all of the batteries 2000 to operate or remain inoperable during the time of the road trip. In some cases, the user may have spare universal batteries 2000 that can be used in any of the vehicles 100, 100', buildings 2516, etc.

[0178] In one embodiment, a user may be at home when a power outage occurs causing a power loss to the house from an electrical energy source (e.g., the electrical grid, power plant, substation, etc.). In this case, the house or specific portions of the house may be switched to run from a universal battery power system 2512 connected thereto. In some embodiments, the user may remove one or more universal batteries 2000 from a vehicle 100 and electrically interconnect the one or more universal batteries 2000 with the house's power system 2512 increasing a capacity or power availability of the power system 2512. Because the universal batteries 2000 are modular in nature, they can be easily added, replaced, swapped, and/or exchanged with minimal effort and no reconfiguration of the power management system of the system that receives a universal battery 2000.

[0179] Fig. 26 is a flow chart depicting a first method 2600 of recruiting battery power in a universal battery power management system. While a general order for the steps of the method 2600 is shown in Fig. 26, the method 2600 can include more or fewer steps or can arrange the order of the steps differently than those shown in Fig. 26. Generally, the method 2600 starts with a start operation 2604 and ends with an end operation 2624. The method 2600 can be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer readable medium. Hereinafter, the method 2600 shall be explained with reference to the systems, components, data structures, user interfaces, environments, software, etc. described in conjunction with Figs. 1-25.

[0180] The method 2600 may begin at step 2604 and proceed by determining the number of universal batteries 2000 connected in the system (step 2608). In some embodiments, the system may refer to one or more of the power system, the receiving system 2100, etc., and/or combinations thereof. In one embodiment, once a universal battery 2000 is electrically interconnected with a system, a power management system may count the interconnected universal battery 2000 as available for providing power or

electricity to one or more loads. The interconnection may refer to a contact made between one or more electrical interconnection features 2040A, 2040B of a universal battery 2000 and electrical contacts 2140A, 2140B of a receiving system 2100. In some cases, the interconnection may require the universal battery 2000 to be electrically and mechanically interconnected with a receiving system 2100 to be considered “available.” For instance, while a universal battery 2000 may be mechanically engaged with a receiving system 2100 and one or more electrical interconnection features 2040A, 2040B may be in contact with the electrical contacts 2140A, 2140B of the receiving system 2100, the power management system may have switched-off the electrical contacts 2140A, 2140B from receiving power from a connected battery 2000. Although this battery 2000 can be counted in determining the number of batteries 2000 connected (e.g., because the electrical contacts or probes are deflected, a sensor sees the battery 2000, or other switch detects a battery 2000 is in place, etc.), the power management system may not switch-on the electrical contacts 2140A, 2140B to receive power from the counted/connected battery 2000 until other determinations, as described herein, are made.

[0181] Next, the method 2600 proceeds by determining the power requirements of the vehicle 100 (step 2612). These power requirements may include a voltage, current, power, range, capacity, battery type, etc., and/or combinations thereof. The power requirements may be set by a manufacturer, agency, administrator, and/or user of a vehicle 100. For instance, a manufacturer may require that a power system for the manufacturer’s vehicle have a minimum power capacity of 70 kWh and a maximum of 140 kWh. This capacity band may allow a vehicle 100 to use any number of universal batteries 2000 that are capable of providing capacity in this range, but may restrict the vehicle 100 from adding more batteries 2000 (e.g., to fall outside of or beyond the capacity range) or removing batteries 2000 (e.g., to fall below the capacity range specified). In some cases, the vehicle power requirements may be determined based at least partially on input provided by a user. For example, a user enter the travel plans (e.g., via a travel application running on the vehicle 100 or on a device associated with the vehicle 100, etc.) for a trip that define a specific distance to travel, a terrain, and/or other conditions that may affect power usage by the vehicle 100 during the trip. The vehicle 100 may then determine, based on the travel plans, that a specific capacity or range is required to enable one or more portions of the trip and travel.

[0182] In some cases, the determined number of batteries 2000 connected in the system and/or the determined vehicle power requirements may be communicated to a user or third

party via a communication device, graphical user interface (GUI), or other display device associated with the vehicle 100. In one embodiment, the vehicle 100 may provide this information in an alert or notification. The alert or notification may be sent by the vehicle 100 over a wireless communication network to one or more communication devices associated with the vehicle 100.

[0183] The method 2600 may continue by recruiting batteries 2000 connected in the system in accordance with the determined power requirements (step 2616). Recruiting batteries 2000 may include recruiting a voltage, power output, capacity, and/or number of batteries 2000 from which the vehicle 100 will draw energy. In the event that the determined power requirements need more batteries than connected, the vehicle 100 may communicate this information to a user via an alert or notification as described above. In some embodiments, the power management system 2404 may determine to recruit batteries 2000 together, selectively, in an order, and/or in groups as defined above.

[0184] In some embodiments, the method 2600 may determine a change in power requirements for the vehicle 100 (step 2620). For instance, a vehicle 100 may determine a change in driving conditions associated with a particular route or travel plan. The driving conditions may require more or fewer batteries depending on the embodiment. By way of example, the vehicle 100 may determine icy conditions on the road along a particular route. As can be appreciated, icy conditions may cause more wheel turns, or motor revolutions, per unit of distance, and the vehicle 100 may determine more batteries 2000 need to be recruited to travel the trip. Additionally or alternatively, the vehicle 100 may determine that traffic is lighter than usual in an area, and as such, the vehicle 100 can rely on rolling momentum to carry the vehicle 100 greater distances. In this case, the vehicle 100 may determine to adjust to recruiting fewer batteries 2000. In any event, a change in power requirements (e.g., increased/decreased load, change in conditions, etc.) may cause the method 2600 to return to determining the vehicle power requirements for the change at step 2612. The method 2600 ends at step 2624.

[0185] Fig. 27 is a flow chart depicting a second method 2700 of recruiting battery power in a universal battery power management system. While a general order for the steps of the method 2700 is shown in Fig. 27, the method 2700 can include more or fewer steps or can arrange the order of the steps differently than those shown in Fig. 27. Generally, the method 2700 starts with a start operation 2704 and ends with an end operation 2732. The method 2700 can be executed as a set of computer-executable instructions executed by a computer system and encoded or stored on a computer readable

medium. Hereinafter, the method 2700 shall be explained with reference to the systems, components, data structures, user interfaces, environments, software, etc. described in conjunction with Figs. 1-26.

[0186] The method 2700 may begin at step 2704 and proceed by determining the number of universal batteries 2000 connected in the system (step 2708). As provided above, the system may refer to one or more of the power system, the receiving system 2100, etc., and/or combinations thereof. In one embodiment, once a universal battery 2000 is electrically interconnected with a system, a power management system may count the interconnected universal battery 2000 as available for providing power or electricity to one or more loads. The interconnection may refer to a contact made between one or more electrical interconnection features 2040A, 2040B of a universal battery 2000 and electrical contacts 2140A, 2140B of a receiving system 2100. In some cases, the interconnection may require the universal battery 2000 to be electrically and mechanically interconnected with a receiving system 2100 to be considered “available.” For instance, while a universal battery 2000 may be mechanically engaged with a receiving system 2100 and one or more electrical interconnection features 2040A, 2040B may be in contact with the electrical contacts 2140A, 2140B of the receiving system 2100, the power management system may have switched-off the electrical contacts 2140A, 2140B from receiving power from a connected battery 2000. Although this battery 2000 can be counted in determining the number of batteries 2000 connected (e.g., because the electrical contacts or probes are deflected, a sensor sees the battery 2000, or other switch detects a battery 2000 is in place, etc.), the power management system may not switch-on the electrical contacts 2140A, 2140B to receive power from the counted/connected battery 2000 until other determinations, as described herein, are made.

[0187] Next, the method 2700 may proceed by determining an order of the batteries 2000 connected in the system (step 2712). This order may be determined by the power management system, or other battery receiving system of the vehicle 100. The order may correspond to an order of the batteries 2000 relative to an installation position of the receiving system 2100. In one embodiment, the order may define a position of each battery 2000 in a receiving system 2100. The position in a receiving system 2100 may include a reference from a datum, reference, position, or other installation point. In some embodiments, the order of the batteries 2000 may correspond to an order relative to one or more other batteries in the system. For example, in Fig. 22B an order of the batteries

2000A-D may correspond to a position of the batteries 2000A-D relative to an uppermost and/or lowermost position in the receiving system 2100.

[0188] The method 2700 may continue by determining a power recruitment scheme based on the determined order (step 2716). The power recruitment scheme may include selectively switching, connecting, disconnecting, and/or forming a power circuit for the recruited batteries 2000. As described herein, the power management system may include the switching circuitry and/or other electrical interconnections to facilitate this dynamic recruitment reconfiguration. For example, the power management system may determine to draw power from the universal batteries 2000A-D, as shown in Fig. 22B, in a LIFO manner. In this example, the vehicle 100 may draw power from the upper-most or last-in universal battery 2000D interconnected with the receiving system 2100. At least one benefit to this LIFO power draw allows used, expired, or depleted batteries to be easily removed and/or replaced without moving the remaining (e.g., undepleted or unused) batteries in the receiving system 2100. This battery power recruiting arrangement may be best suited for applications where multiple batteries 2000 are included in a system to increase a range or operation time of a vehicle 100.

[0189] Next, the method 2700 determines whether the power from the recruited battery 2000 or batteries 2000 has been depleted (step 2720). In the event that the power of at least one of the recruited batteries 2000 has been depleted, the method 2700 may arrange switching to recruit power from an alternative set of one or more batteries 2000 connected in the system (step 2724). This alternative set may include changing the switching to exclude at least one of the depleted batteries from the recruitment circuit. For instance, in the LIFO example above, the switch may move to select and/or recruit the next battery 2000 below the expired or depleted battery. This recruitment of different batteries 2000, or groups of batteries 2000, may continue until all batteries 2000 have been depleted (steps 2728, 2724). Once all of the batteries 2000 have been depleted, the method 2700 may end at step 2732.

[0190] Any of the steps, functions, and operations discussed herein can be performed continuously and automatically.

[0191] The exemplary systems and methods of this disclosure have been described in relation to vehicle systems and electric vehicles. However, to avoid unnecessarily obscuring the present disclosure, the preceding description omits a number of known structures and devices. This omission is not to be construed as a limitation of the scope of the claimed disclosure. Specific details are set forth to provide an understanding of the

present disclosure. It should, however, be appreciated that the present disclosure may be practiced in a variety of ways beyond the specific detail set forth herein.

[0192] Furthermore, while the exemplary embodiments illustrated herein show the various components of the system collocated, certain components of the system can be located remotely, at distant portions of a distributed network, such as a LAN and/or the Internet, or within a dedicated system. Thus, it should be appreciated, that the components of the system can be combined into one or more devices, such as a server, communication device, or collocated on a particular node of a distributed network, such as an analog and/or digital telecommunications network, a packet-switched network, or a circuit-switched network. It will be appreciated from the preceding description, and for reasons of computational efficiency, that the components of the system can be arranged at any location within a distributed network of components without affecting the operation of the system.

[0193] Furthermore, it should be appreciated that the various links connecting the elements can be wired or wireless links, or any combination thereof, or any other known or later developed element(s) that is capable of supplying and/or communicating data to and from the connected elements. These wired or wireless links can also be secure links and may be capable of communicating encrypted information. Transmission media used as links, for example, can be any suitable carrier for electrical signals, including coaxial cables, copper wire, and fiber optics, and may take the form of acoustic or light waves, such as those generated during radio-wave and infra-red data communications.

[0194] While the flowcharts have been discussed and illustrated in relation to a particular sequence of events, it should be appreciated that changes, additions, and omissions to this sequence can occur without materially affecting the operation of the disclosed embodiments, configuration, and aspects.

[0195] A number of variations and modifications of the disclosure can be used. It would be possible to provide for some features of the disclosure without providing others.

[0196] In yet another embodiment, the systems and methods of this disclosure can be implemented in conjunction with a special purpose computer, a programmed microprocessor or microcontroller and peripheral integrated circuit element(s), an ASIC or other integrated circuit, a digital signal processor, a hard-wired electronic or logic circuit such as discrete element circuit, a programmable logic device or gate array such as PLD, PLA, FPGA, PAL, special purpose computer, any comparable means, or the like. In general, any device(s) or means capable of implementing the methodology illustrated

herein can be used to implement the various aspects of this disclosure. Exemplary hardware that can be used for the present disclosure includes computers, handheld devices, telephones (*e.g.*, cellular, Internet enabled, digital, analog, hybrids, and others), and other hardware known in the art. Some of these devices include processors (*e.g.*, a single or multiple microprocessors), memory, nonvolatile storage, input devices, and output devices. Furthermore, alternative software implementations including, but not limited to, distributed processing or component/object distributed processing, parallel processing, or virtual machine processing can also be constructed to implement the methods described herein.

[0197] In yet another embodiment, the disclosed methods may be readily implemented in conjunction with software using object or object-oriented software development environments that provide portable source code that can be used on a variety of computer or workstation platforms. Alternatively, the disclosed system may be implemented partially or fully in hardware using standard logic circuits or VLSI design. Whether software or hardware is used to implement the systems in accordance with this disclosure is dependent on the speed and/or efficiency requirements of the system, the particular function, and the particular software or hardware systems or microprocessor or microcomputer systems being utilized.

[0198] In yet another embodiment, the disclosed methods may be partially implemented in software that can be stored on a storage medium, executed on programmed general-purpose computer with the cooperation of a controller and memory, a special purpose computer, a microprocessor, or the like. In these instances, the systems and methods of this disclosure can be implemented as a program embedded on a personal computer such as an applet, JAVA® or CGI script, as a resource residing on a server or computer workstation, as a routine embedded in a dedicated measurement system, system component, or the like. The system can also be implemented by physically incorporating the system and/or method into a software and/or hardware system.

[0199] Although the present disclosure describes components and functions implemented in the embodiments with reference to particular standards and protocols, the disclosure is not limited to such standards and protocols. Other similar standards and protocols not mentioned herein are in existence and are considered to be included in the present disclosure. Moreover, the standards and protocols mentioned herein and other similar standards and protocols not mentioned herein are periodically superseded by faster or more effective equivalents having essentially the same functions. Such replacement

standards and protocols having the same functions are considered equivalents included in the present disclosure.

[0200] The present disclosure, in various embodiments, configurations, and aspects, includes components, methods, processes, systems and/or apparatus substantially as depicted and described herein, including various embodiments, subcombinations, and subsets thereof. Those of skill in the art will understand how to make and use the systems and methods disclosed herein after understanding the present disclosure. The present disclosure, in various embodiments, configurations, and aspects, includes providing devices and processes in the absence of items not depicted and/or described herein or in various embodiments, configurations, or aspects hereof, including in the absence of such items as may have been used in previous devices or processes, *e.g.*, for improving performance, achieving ease, and/or reducing cost of implementation.

[0201] The foregoing discussion of the disclosure has been presented for purposes of illustration and description. The foregoing is not intended to limit the disclosure to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the disclosure are grouped together in one or more embodiments, configurations, or aspects for the purpose of streamlining the disclosure. The features of the embodiments, configurations, or aspects of the disclosure may be combined in alternate embodiments, configurations, or aspects other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claimed disclosure requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment, configuration, or aspect. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the disclosure.

[0202] Moreover, though the description of the disclosure has included description of one or more embodiments, configurations, or aspects and certain variations and modifications, other variations, combinations, and modifications are within the scope of the disclosure, *e.g.*, as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights, which include alternative embodiments, configurations, or aspects to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges, or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures,

functions, ranges, or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

[0203] Embodiments include a universal rechargeable battery, comprising: a housing, comprising: a power cell area including one or more power cells electrically interconnected with one another, wherein each of the one or more power cells includes an electrolyte having positive and negative ions; a modular mechanical connection feature extending from at least one surface of the housing and having a mechanical contact surface; and a modular receiving feature disposed opposite the modular mechanical connection feature, the modular receiving feature having at least one receiving surface substantially matching the mechanical contact surface of the modular mechanical connection feature, and wherein the modular receiving feature includes at least one relief portion that is inverse to a corresponding protrusion feature in the modular mechanical connection feature.

[0204] Aspects of the above universal rechargeable battery further comprise: a first electrical contact electrically interconnected with the one or more power cells; and a second electrical contact electrically interconnected with the one or more power cells, wherein the second electrical contact is physically separate from the first electrical contact, and wherein an electrical difference exists between the first electrical contact and the second electrical contact. Aspects of the above universal rechargeable battery include wherein the first electrical contact and the second electrical contact are shrouded by at least a portion of the housing. Aspects of the above universal rechargeable battery include wherein the first electrical contact and the second electrical contact are disposed inside an outer peripheral surface of the housing. Aspects of the above universal rechargeable battery further comprise: a power management area disposed at least partially inside the housing and adjacent to the power cell area, wherein the power management area includes a controller, and wherein the controller is electrically interconnected to the one or more power cells. Aspects of the above universal rechargeable battery further comprise: a handling feature operatively connected to an outer peripheral surface of the housing. Aspects of the above universal rechargeable battery include wherein the handling feature includes a robotic end-effector receiving feature, and wherein the handling feature allows automatic handling by a robot and restricts manual handling by a user.

[0205] Embodiments include a universal rechargeable battery stack, comprising: two or more universal rechargeable batteries arranged in a stack, wherein each of the two or more universal rechargeable batteries comprises: a housing, comprising: a power cell area

including one or more power cells electrically interconnected with one another, wherein each of the one or more power cells includes an electrolyte having positive and negative ions; a modular mechanical connection feature extending from at least one surface of the housing and having a mechanical contact surface; and a modular receiving feature disposed opposite the modular mechanical connection feature, the modular receiving feature having at least one receiving surface substantially matching the mechanical contact surface of the modular mechanical connection feature, and wherein the modular receiving feature includes at least one relief portion that is inverse to a corresponding protrusion feature in the modular mechanical connection feature; and wherein the modular mechanical connection feature of a first universal rechargeable battery of the two or more universal rechargeable batteries engages the modular receiving feature of a second and different universal rechargeable battery of the two or more universal rechargeable batteries.

[0206] Aspects of the above universal rechargeable battery stack include wherein the modular mechanical connection feature of each universal rechargeable battery of the two or more universal rechargeable batteries includes a first guide feature arranged as a planar surface running from a front of each universal rechargeable battery to a rear of each universal rechargeable battery. Aspects of the above universal rechargeable battery stack include wherein the planar surface of the first guide feature is perpendicular to a front surface of the universal rechargeable battery stack. Aspects of the above universal rechargeable battery stack include wherein the modular receiving feature of the second universal rechargeable battery of the two or more universal rechargeable batteries includes a second guide feature configured to engage with the first guide feature of the first universal rechargeable battery. Aspects of the above universal rechargeable battery stack include wherein the first and second guides provide a sliding bearing surface between the first and second universal rechargeable batteries. Aspects of the above universal rechargeable battery stack include wherein the two or more universal rechargeable batteries are stacked directly on top of one another.

[0207] Embodiments include a universal rechargeable battery power system, comprising: two or more universal rechargeable batteries arranged in a stack, wherein each of the two or more universal rechargeable batteries comprises: a housing, comprising: a power cell area including one or more power cells electrically interconnected with one another, wherein each of the one or more power cells includes an electrolyte having positive and negative ions; a modular mechanical connection feature extending from at

least one surface of the housing and having a mechanical contact surface; and a modular receiving feature disposed opposite the modular mechanical connection feature, the modular receiving feature having at least one receiving surface substantially matching the mechanical contact surface of the modular mechanical connection feature, and wherein the modular receiving feature includes at least one relief portion that is inverse to a corresponding protrusion feature in the modular mechanical connection feature; wherein the modular mechanical connection feature of a first universal rechargeable battery of the two or more universal rechargeable batteries engages the modular receiving feature of a second and different universal rechargeable battery of the two or more universal rechargeable batteries; and a universal rechargeable battery receiving system having pairs of battery interconnections, wherein each pair of battery interconnections is configured to receive and electrically interconnect each of the two or more universal rechargeable batteries together.

[0208] Aspects of the above universal rechargeable battery power system include wherein each of the two or more universal rechargeable batteries further comprises: a first electrical contact electrically interconnected with the one or more power cells; and a second electrical contact electrically interconnected with the one or more power cells, wherein the second electrical contact is physically separate from the first electrical contact, and wherein an electrical difference exists between the first electrical contact and the second electrical contact. Aspects of the above universal rechargeable battery power system include wherein each pair of battery interconnections includes first and second electrical probes configured to mate with first and second electrical contacts of a mating universal rechargeable battery. Aspects of the above universal rechargeable battery power system include wherein the universal rechargeable battery receiving system further comprises: at least one receiving feature disposed in a base thereof, and wherein the modular mechanical connection feature of a first mating universal rechargeable battery engages the at least one receiving feature. Aspects of the above universal rechargeable battery power system include wherein the universal rechargeable battery receiving system further comprises: an electrical interconnection backplane, wherein each pair of battery interconnections is disposed on the electrical interconnection backplane. Aspects of the above universal rechargeable battery power system include wherein the first and second electrical probes of each pair of battery interconnections displace when an inserted universal rechargeable battery is connected with the universal rechargeable battery receiving system. Aspects of the above universal rechargeable battery power system

further comprise: an electrical power output connector configured to only conduct electricity from inserted universal rechargeable batteries connected with the universal rechargeable battery receiving system.

[0209] The phrases “at least one,” “one or more,” “or,” and “and/or” are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions “at least one of A, B and C,” “at least one of A, B, or C,” “one or more of A, B, and C,” “one or more of A, B, or C,” “A, B, and/or C,” and “A, B, or C” means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

[0210] The term “a” or “an” entity refers to one or more of that entity. As such, the terms “a” (or “an”), “one or more,” and “at least one” can be used interchangeably herein. It is also to be noted that the terms “comprising,” “including,” and “having” can be used interchangeably.

[0211] The term “automatic” and variations thereof, as used herein, refers to any process or operation, which is typically continuous or semi-continuous, done without material human input when the process or operation is performed. However, a process or operation can be automatic, even though performance of the process or operation uses material or immaterial human input, if the input is received before performance of the process or operation. Human input is deemed to be material if such input influences how the process or operation will be performed. Human input that consents to the performance of the process or operation is not deemed to be “material.”

[0212] Aspects of the present disclosure may take the form of an embodiment that is entirely hardware, an embodiment that is entirely software (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module,” or “system.” Any combination of one or more computer-readable medium(s) may be utilized. The computer-readable medium may be a computer-readable signal medium or a computer-readable storage medium.

[0213] A computer-readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer-readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an

erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer-readable storage medium may be any tangible medium that can contain or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0214] A computer-readable signal medium may include a propagated data signal with computer-readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer-readable signal medium may be any computer-readable medium that is not a computer-readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

Program code embodied on a computer-readable medium may be transmitted using any appropriate medium, including, but not limited to, wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

[0215] The terms “determine,” “calculate,” “compute,” and variations thereof, as used herein, are used interchangeably and include any type of methodology, process, mathematical operation or technique.

[0216] The term “electric vehicle” (EV), also referred to herein as an electric drive vehicle, may use one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery or generator to convert fuel to electricity. An electric vehicle generally includes a rechargeable electricity storage system (RESS) (also called Full Electric Vehicles (FEV)). Power storage methods may include: chemical energy stored on the vehicle in on-board batteries (e.g., battery electric vehicle or BEV), on board kinetic energy storage (e.g., flywheels), and/or static energy (e.g., by on-board double-layer capacitors). Batteries, electric double-layer capacitors, and flywheel energy storage may be forms of rechargeable on-board electrical storage.

[0217] The term “hybrid electric vehicle” refers to a vehicle that may combine a conventional (usually fossil fuel-powered) powertrain with some form of electric propulsion. Most hybrid electric vehicles combine a conventional internal combustion engine (ICE) propulsion system with an electric propulsion system (hybrid vehicle drivetrain). In parallel hybrids, the ICE and the electric motor are both connected to the

mechanical transmission and can simultaneously transmit power to drive the wheels, usually through a conventional transmission. In series hybrids, only the electric motor drives the drivetrain, and a smaller ICE works as a generator to power the electric motor or to recharge the batteries. Power-split hybrids combine series and parallel characteristics. A full hybrid, sometimes also called a strong hybrid, is a vehicle that can run on just the engine, just the batteries, or a combination of both. A mid hybrid is a vehicle that cannot be driven solely on its electric motor, because the electric motor does not have enough power to propel the vehicle on its own.

[0218] The term “rechargeable electric vehicle” or “REV” refers to a vehicle with on board rechargeable energy storage, including electric vehicles and hybrid electric vehicles.

What Is Claimed Is:

1. A universal rechargeable battery, comprising:
a housing, comprising:
a power cell area including one or more power cells electrically interconnected with one another, wherein each of the one or more power cells includes an electrolyte having positive and negative ions;
a modular mechanical connection feature extending from at least one surface of the housing and having a mechanical contact surface; and
a modular receiving feature disposed opposite the modular mechanical connection feature, the modular receiving feature having at least one receiving surface substantially matching the mechanical contact surface of the modular mechanical connection feature, and wherein the modular receiving feature includes at least one relief portion that is inverse to a corresponding protrusion feature in the modular mechanical connection feature.
2. The universal rechargeable battery of claim 1, further comprising:
a first electrical contact electrically interconnected with the one or more power cells; and
a second electrical contact electrically interconnected with the one or more power cells, wherein the second electrical contact is physically separate from the first electrical contact, and wherein an electrical difference exists between the first electrical contact and the second electrical contact.
3. The universal rechargeable battery of claim 2, wherein the first electrical contact and the second electrical contact are shrouded by at least a portion of the housing.
4. The universal rechargeable battery of claim 3, wherein the first electrical contact and the second electrical contact are disposed inside an outer peripheral surface of the housing.
5. The universal rechargeable battery of claim 1, further comprising:
a power management area disposed at least partially inside the housing and adjacent to the power cell area, wherein the power management area includes a controller, and wherein the controller is electrically interconnected to the one or more power cells.
6. The universal rechargeable battery of claim 1, further comprising:
a handling feature operatively connected to an outer peripheral surface of the housing.

7. The universal rechargeable battery of claim 6, wherein the handling feature includes a robotic end-effector receiving feature, and wherein the handling feature allows automatic handling by a robot and restricts manual handling by a user.

8. A universal rechargeable battery stack, comprising:

two or more universal rechargeable batteries arranged in a stack, wherein each of the two or more universal rechargeable batteries comprises:

a housing, comprising:

a power cell area including one or more power cells electrically interconnected with one another, wherein each of the one or more power cells includes an electrolyte having positive and negative ions;

a modular mechanical connection feature extending from at least one surface of the housing and having a mechanical contact surface; and

a modular receiving feature disposed opposite the modular mechanical connection feature, the modular receiving feature having at least one receiving surface substantially matching the mechanical contact surface of the modular mechanical connection feature, and wherein the modular receiving feature includes at least one relief portion that is inverse to a corresponding protrusion feature in the modular mechanical connection feature; and

wherein the modular mechanical connection feature of a first universal rechargeable battery of the two or more universal rechargeable batteries engages the modular receiving feature of a second and different universal rechargeable battery of the two or more universal rechargeable batteries.

9. The universal rechargeable battery stack of claim 8, wherein the modular mechanical connection feature of each universal rechargeable battery of the two or more universal rechargeable batteries includes a first guide feature arranged as a planar surface running from a front of each universal rechargeable battery to a rear of each universal rechargeable battery.

10. The universal rechargeable battery stack of claim 9, wherein the planar surface of the first guide feature is perpendicular to a front surface of the universal rechargeable battery stack.

11. The universal rechargeable battery stack of claim 9, wherein the modular receiving feature of the second universal rechargeable battery of the two or more universal rechargeable batteries includes a second guide feature configured to engage with the first guide feature of the first universal rechargeable battery.

12. The universal rechargeable battery stack of claim 11, wherein the first and second guides provide a sliding bearing surface between the first and second universal rechargeable batteries.

13. The universal rechargeable battery stack of claim 12, wherein the two or more universal rechargeable batteries are stacked directly on top of one another.

14. An universal rechargeable battery power system, comprising:
two or more universal rechargeable batteries arranged in a stack, wherein each of the two or more universal rechargeable batteries comprises:

a housing, comprising:

a power cell area including one or more power cells electrically interconnected with one another, wherein each of the one or more power cells includes an electrolyte having positive and negative ions;

a modular mechanical connection feature extending from at least one surface of the housing and having a mechanical contact surface; and

a modular receiving feature disposed opposite the modular mechanical connection feature, the modular receiving feature having at least one receiving surface substantially matching the mechanical contact surface of the modular mechanical connection feature, and wherein the modular receiving feature includes at least one relief portion that is inverse to a corresponding protrusion feature in the modular mechanical connection feature;

wherein the modular mechanical connection feature of a first universal rechargeable battery of the two or more universal rechargeable batteries engages the modular receiving feature of a second and different universal rechargeable battery of the two or more universal rechargeable batteries; and

a universal rechargeable battery receiving system having pairs of battery interconnections, wherein each pair of battery interconnections is configured to receive and electrically interconnect each of the two or more universal rechargeable batteries together.

15. The universal rechargeable battery power system of claim 14, wherein each of the two or more universal rechargeable batteries further comprises:

a first electrical contact electrically interconnected with the one or more power cells; and

a second electrical contact electrically interconnected with the one or more power cells, wherein the second electrical contact is physically separate from the first electrical

contact, and wherein an electrical difference exists between the first electrical contact and the second electrical contact.

16. The universal rechargeable battery power system of claim 15, wherein each pair of battery interconnections includes first and second electrical probes configured to mate with first and second electrical contacts of a mating universal rechargeable battery.

17. The universal rechargeable battery power system of claim 16, wherein the universal rechargeable battery receiving system further comprises:

at least one receiving feature disposed in a base thereof, and wherein the modular mechanical connection feature of a first mating universal rechargeable battery engages the at least one receiving feature.

18. The universal rechargeable battery power system of claim 17, wherein the universal rechargeable battery receiving system further comprises:

an electrical interconnection backplane, wherein each pair of battery interconnections is disposed on the electrical interconnection backplane.

19. The universal rechargeable battery power system of claim 18, wherein the first and second electrical probes of each pair of battery interconnections displace when an inserted universal rechargeable battery is connected with the universal rechargeable battery receiving system.

20. The universal rechargeable battery power system of claim 18, further comprising:

an electrical power output connector configured to only conduct electricity from inserted universal rechargeable batteries connected with the universal rechargeable battery receiving system.

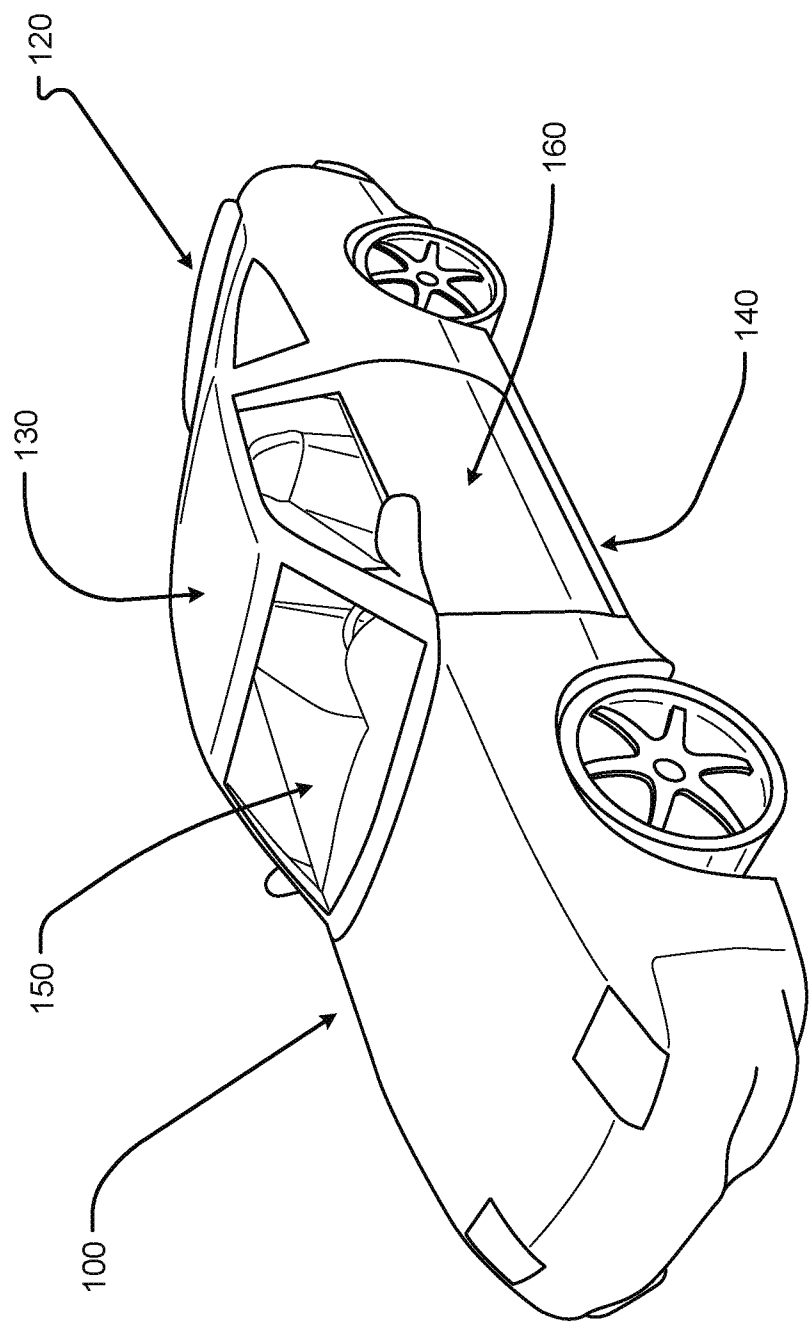


Fig. 1

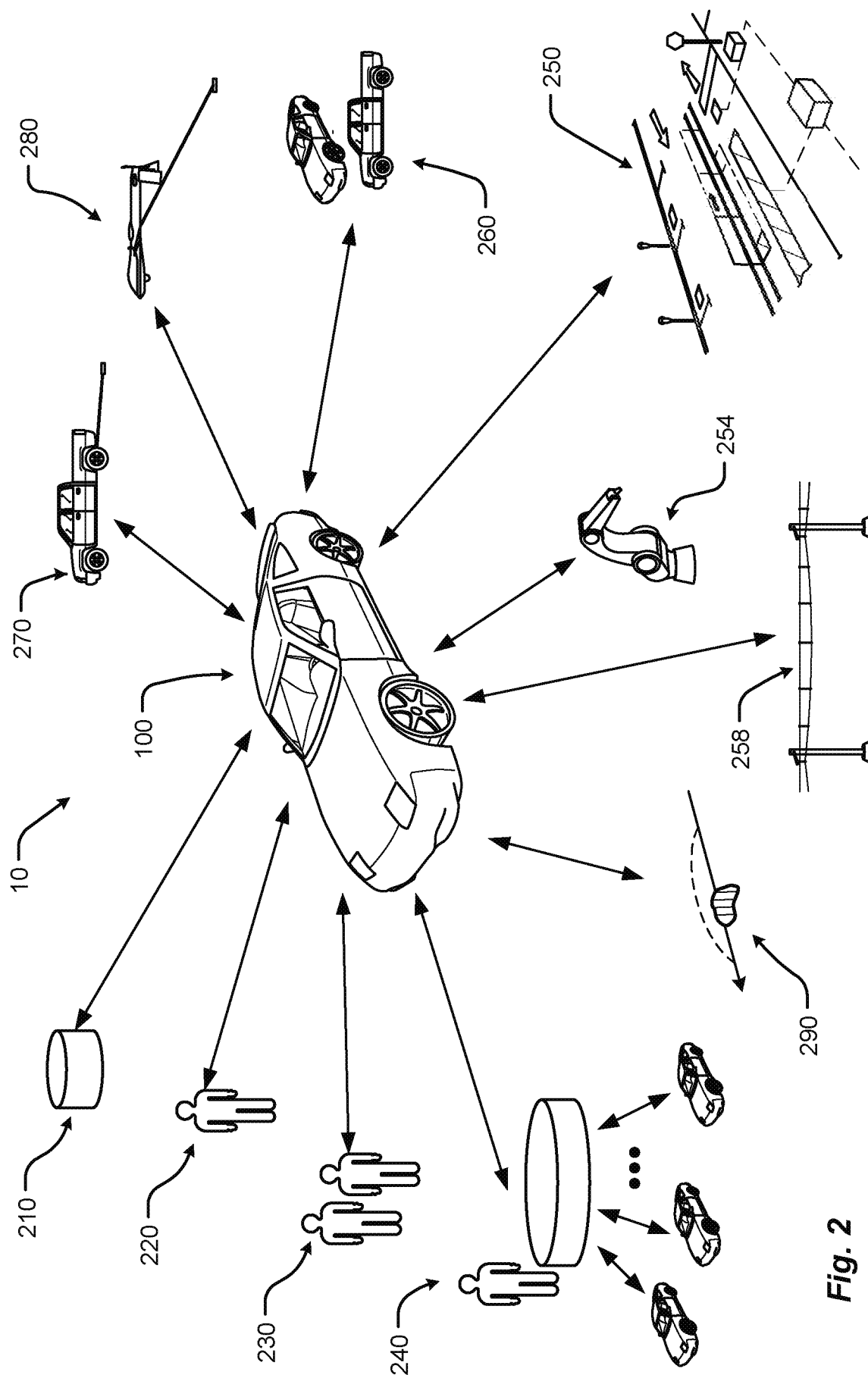
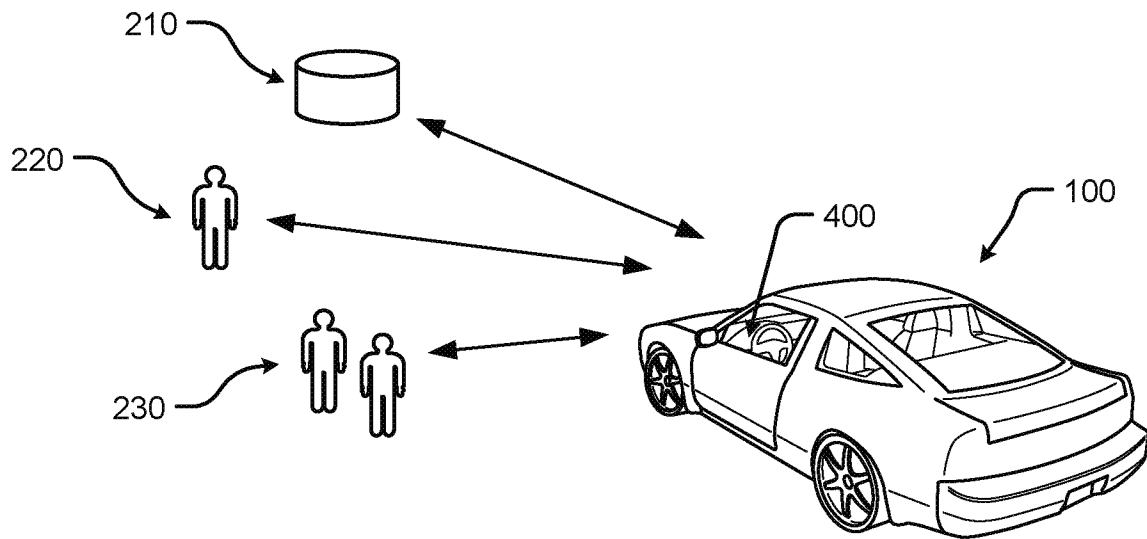
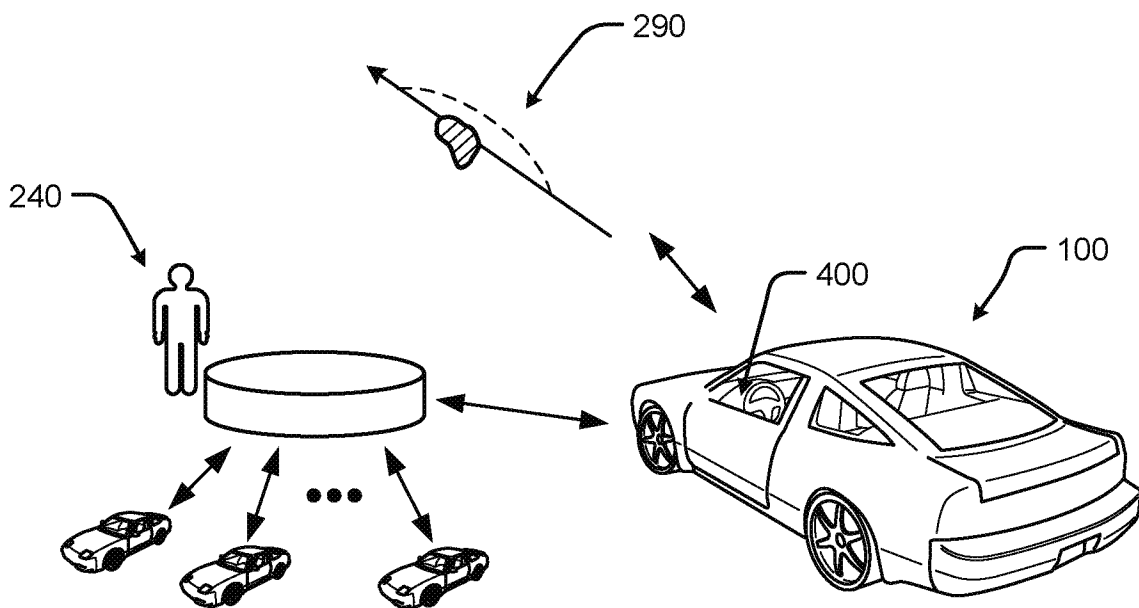


Fig. 2

300	310A	310B	310C	310D	310E	310F	310G	310H	310I	
	Charging Type	Compatible Vehicle Charging Panel Types	Compatible Vehicle Storage Units	Available Automation Level	Charging Service Status	Charge Rate	Cost	Other	Shielding	
310J	Station: manual	Roof, Side	x, z	Low	Up	Low	\$100	A, B, C	On	
	Station: manual	Roof, Side	x, z	Low	Up	Medium	\$150	A, C	On	
310K	Station: manual	Roof, Side	x, z	Low	Up	High	\$400	A, B, C	On	
	Station: robotic	Roof, Side	x, z	Medium	Down	Medium	\$150	A, B, D	On	
	Station: robotic	Roof, Side	x, z	High	Down	High	\$500	B, D	On	
310L	Station: robotic	Roof, Side	x, z	High	Down	High	\$500	B, C	On	
	Roadway	Side, Lower	x, z	Low	Up	Low	\$50	A, C, E	Off	
	Roadway	Side, Lower	x, z	Medium	Up	Low	\$100	A, C, E	Off	
310M	Roadway	Side, Lower	x, z	Medium	Up	Low	\$100	A, C, E	Off	
	Emergency: truck	Side, Lower	x, y	Low	Up	Low	\$150	A, B	Off	
	Emergency: truck	Roof, Side, Lower	x, y	Medium	Up	Medium	\$200	A, B	Off	
310N	Emergency: truck	Roof, Side, Lower	x, y	Medium	Up	High	\$500	A, D	Off	
	Emergency: UAV	Roof	x	Medium	Down	Medium	\$500	A, B, C	Off	
	Emergency: UAV	Roof	x	High	Down	High	\$800	B	Off	
310O	Emergency: UAV	Roof	x	High	Down	High	\$800	B	Off	
	Overhead	Roof	x, y	Low	Up	Low	\$150	B, D	Off	
	Overhead	Roof	x, y	Medium	Up	Low	\$200	B, C	Off	
	Overhead	Roof	x, y	Medium	Up	Low	\$200	B, C	Off	

Fig. 3

**Fig. 4A****Fig. 4B**

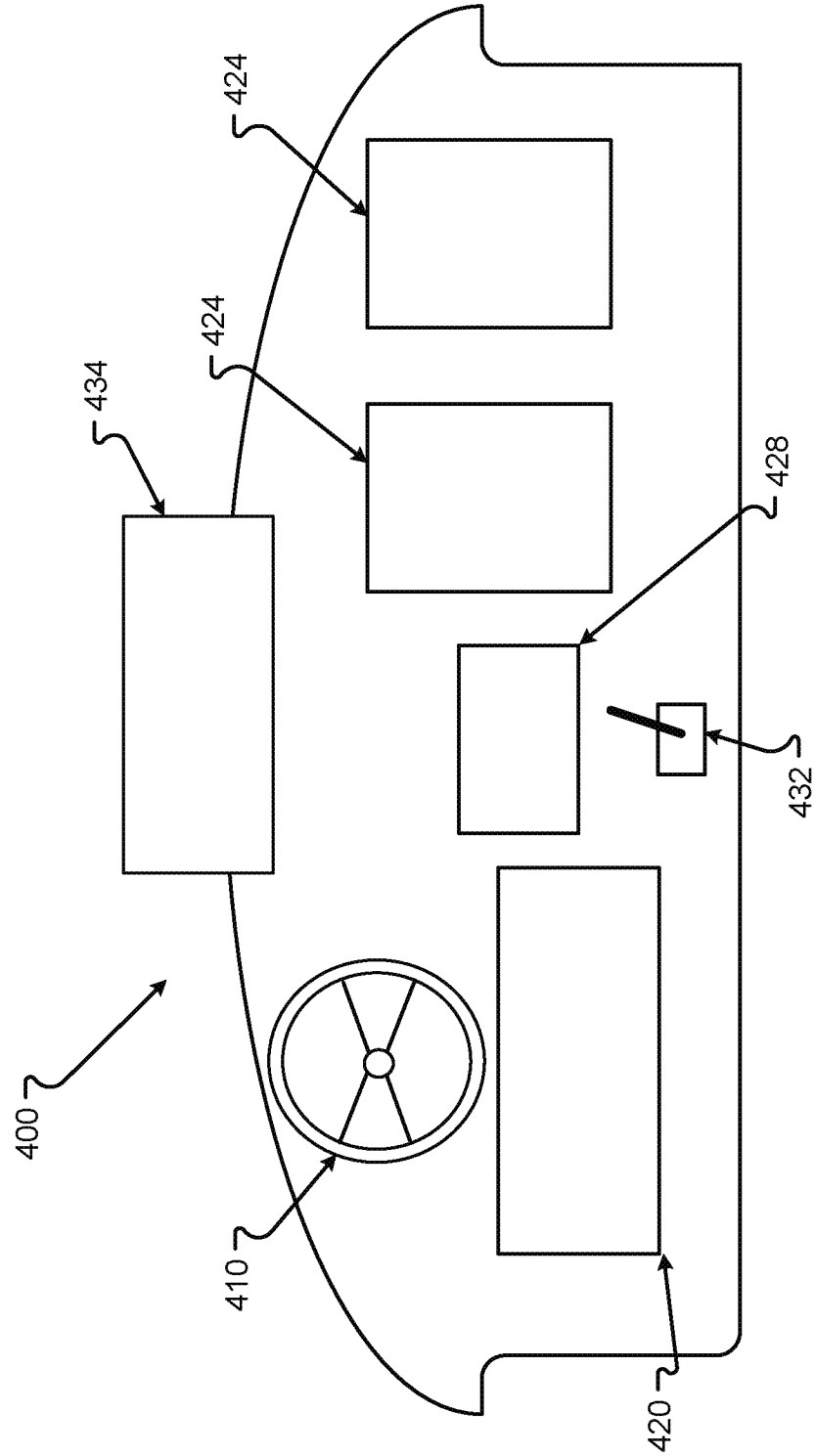


Fig. 4C

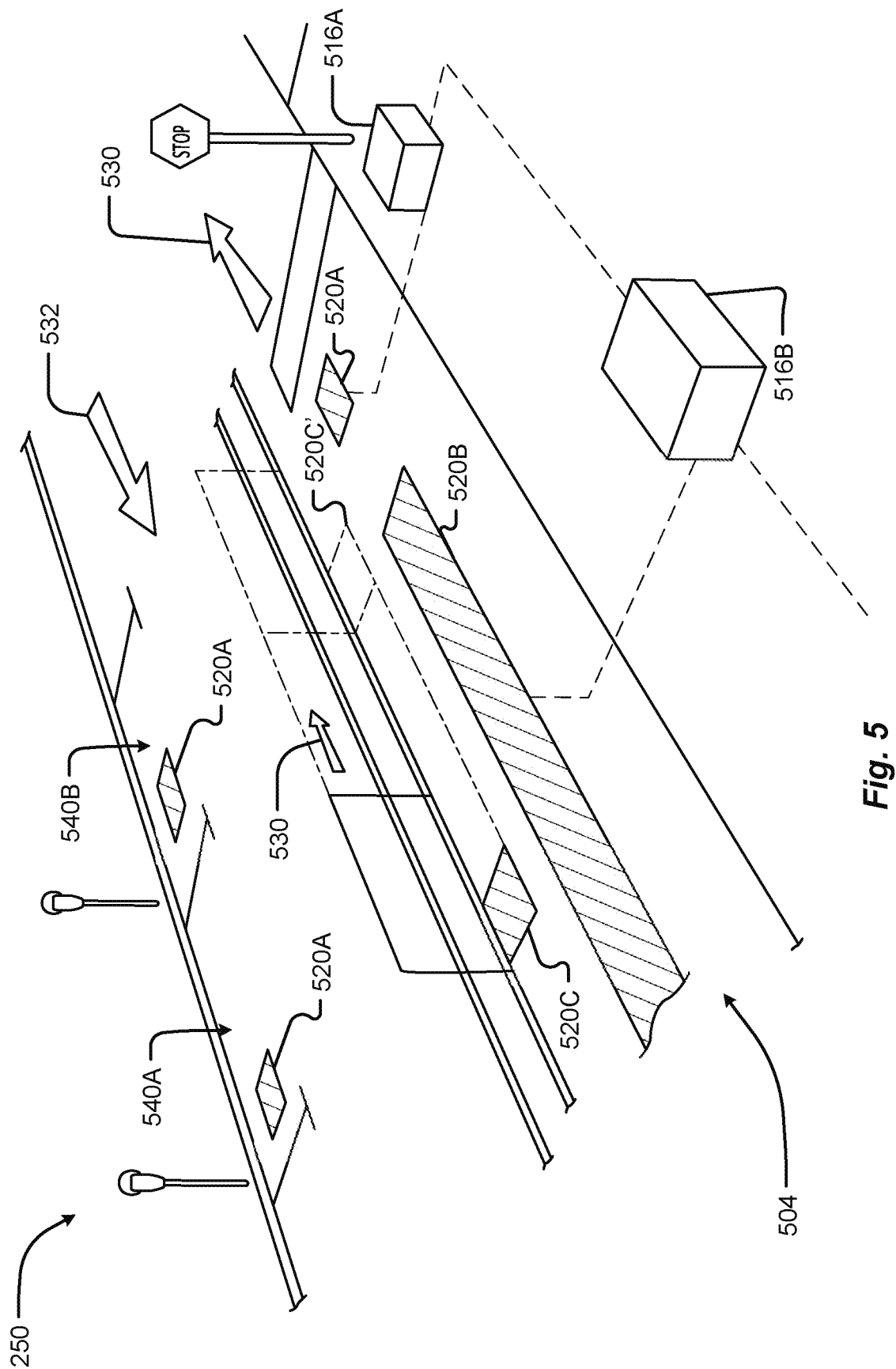


Fig. 5

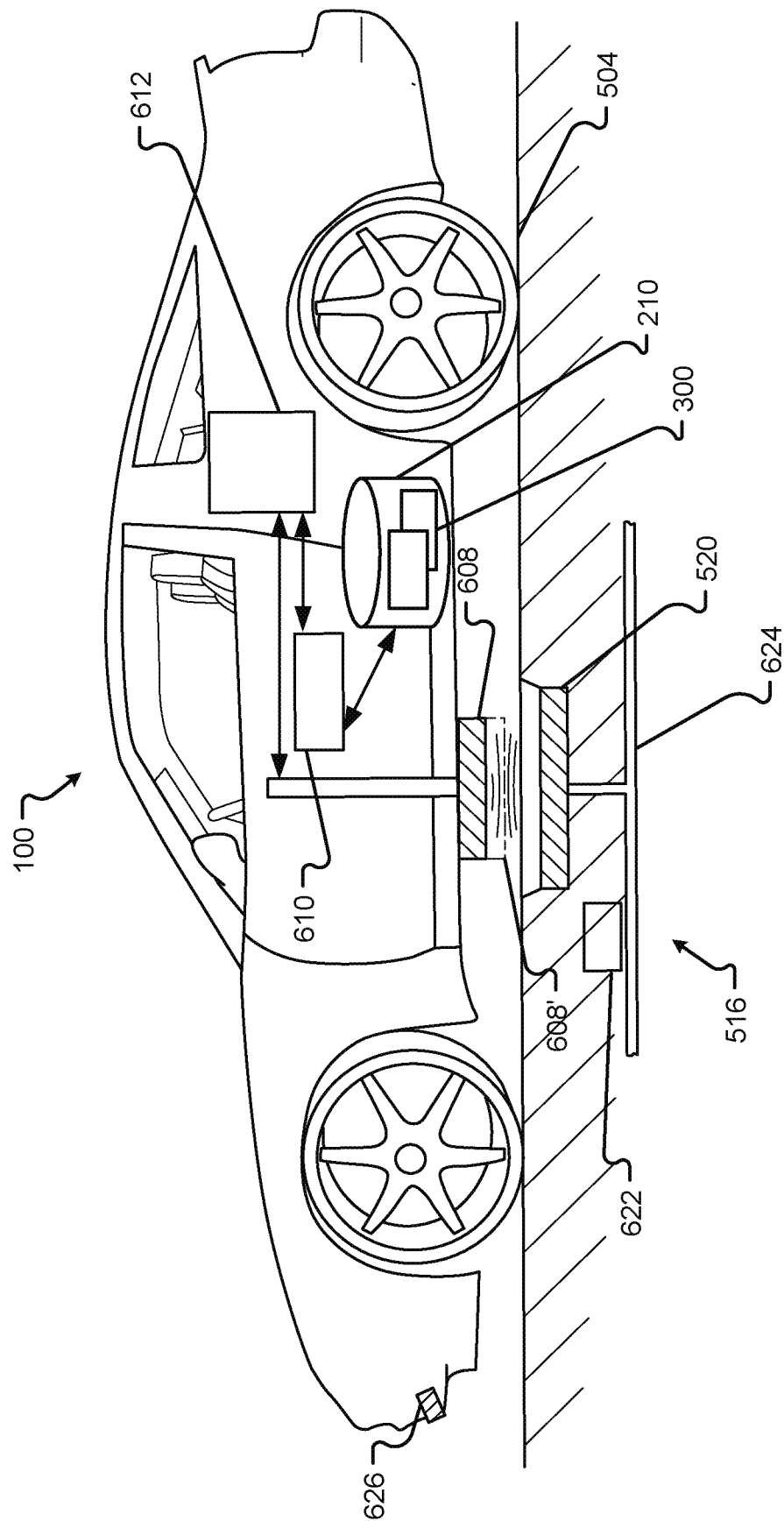


Fig. 6

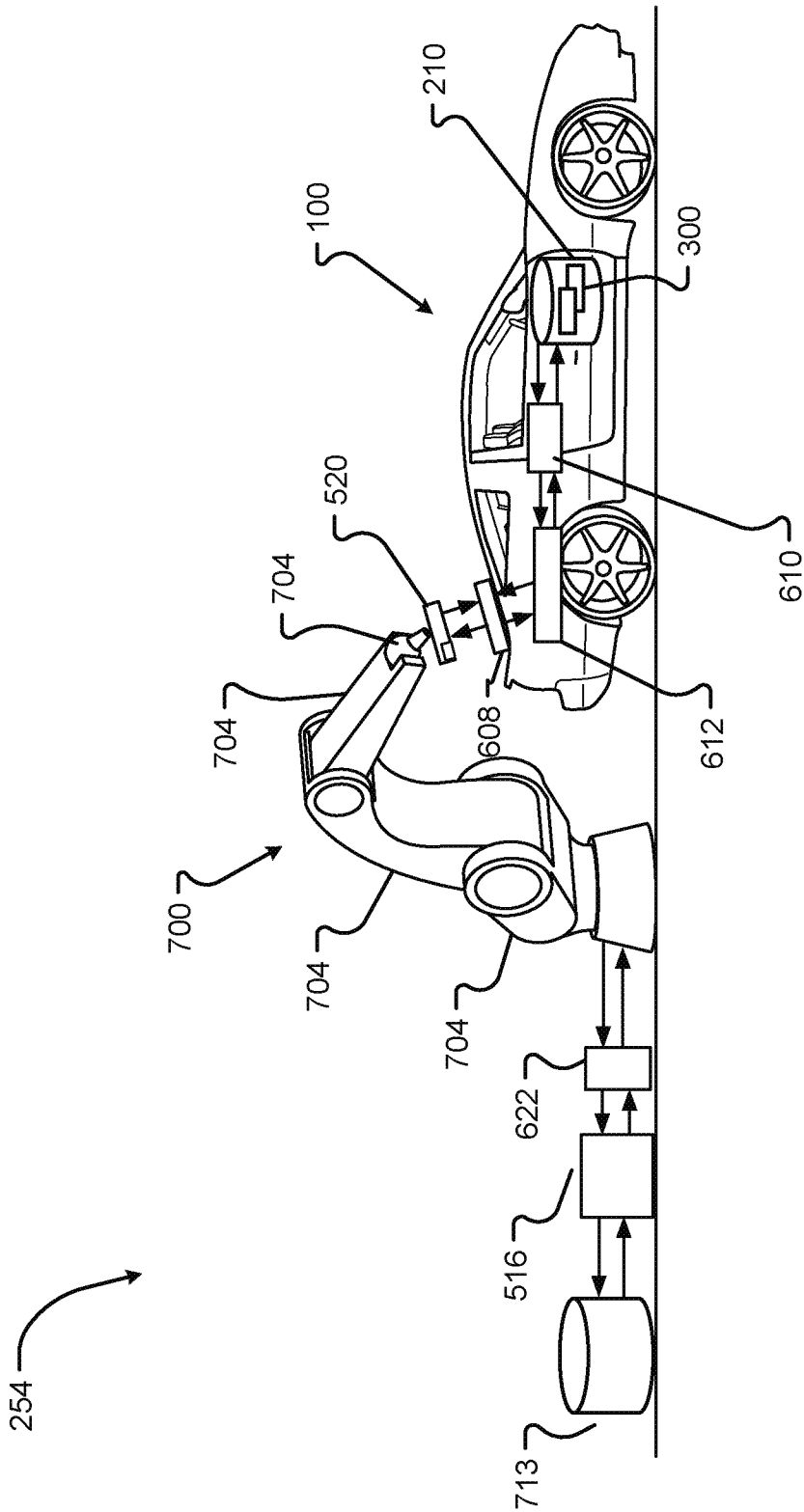


Fig. 7

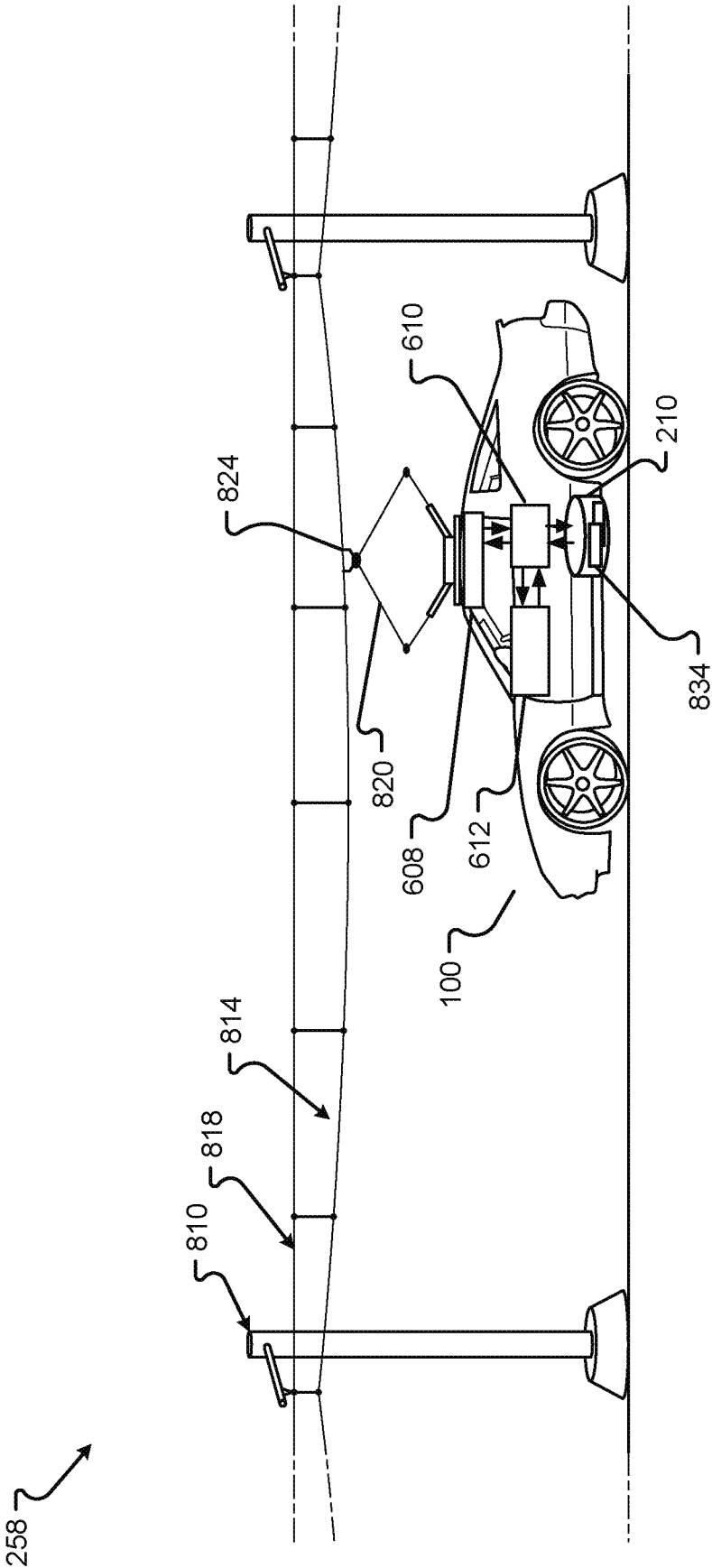


Fig. 8

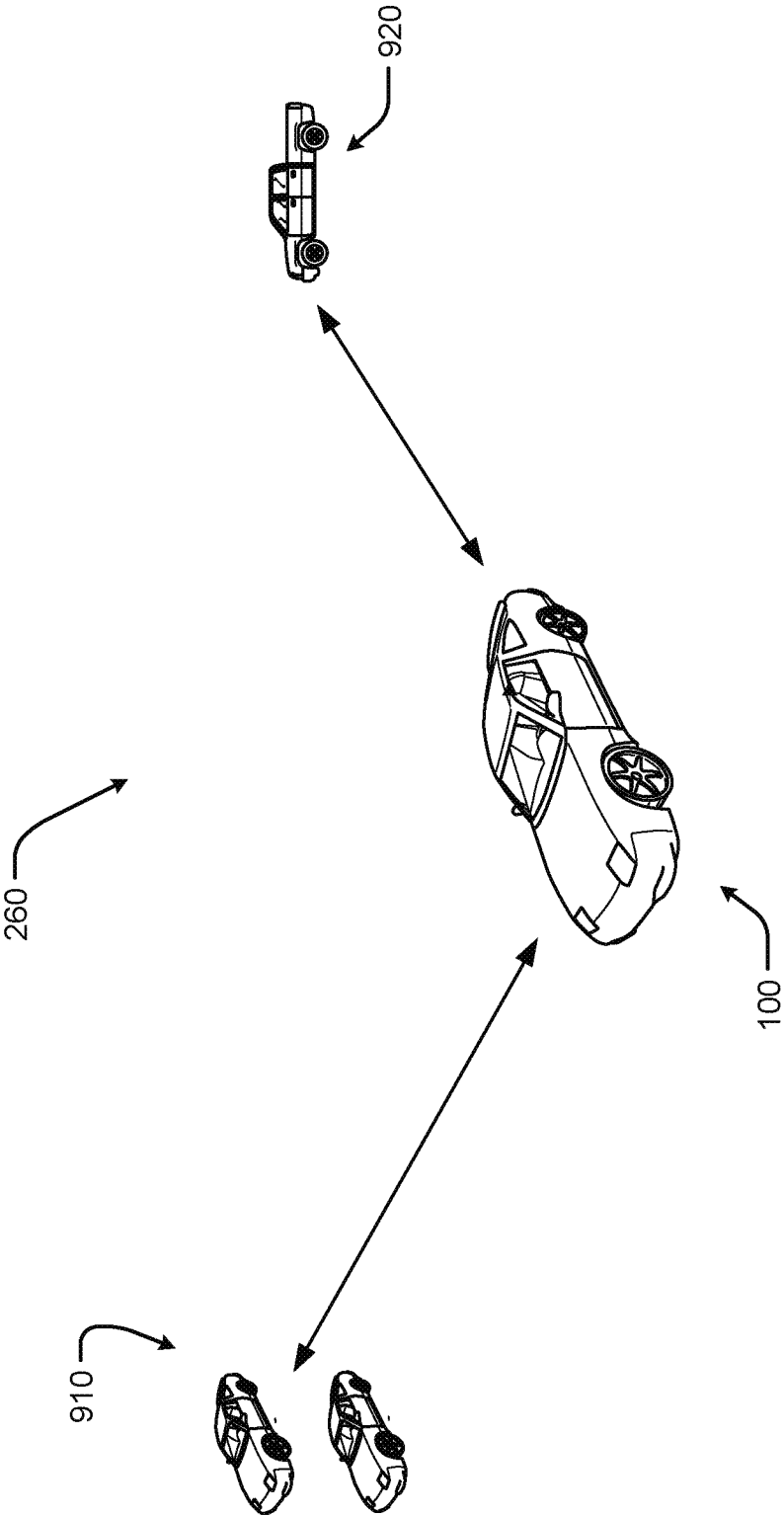


Fig. 9

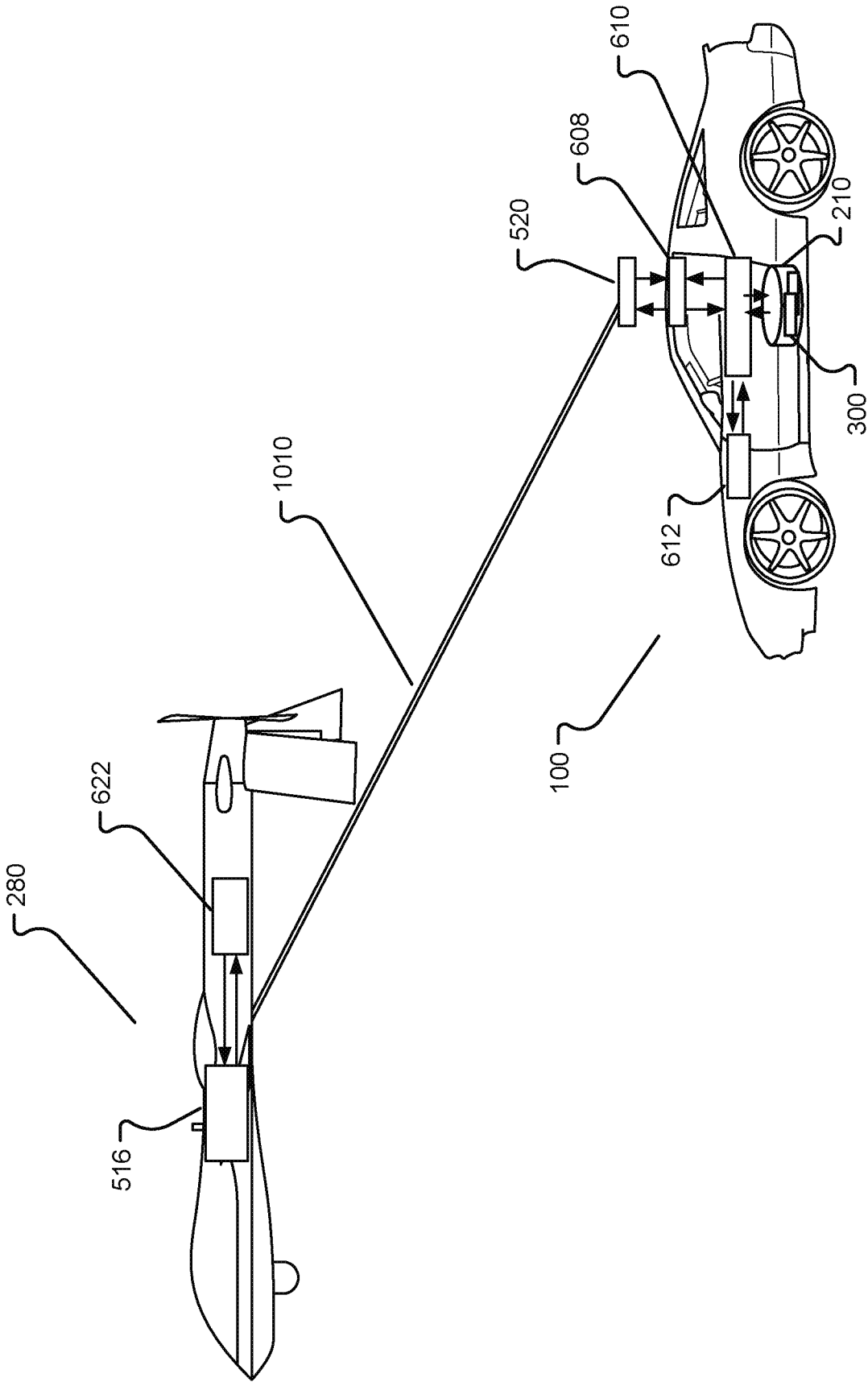


Fig. 10

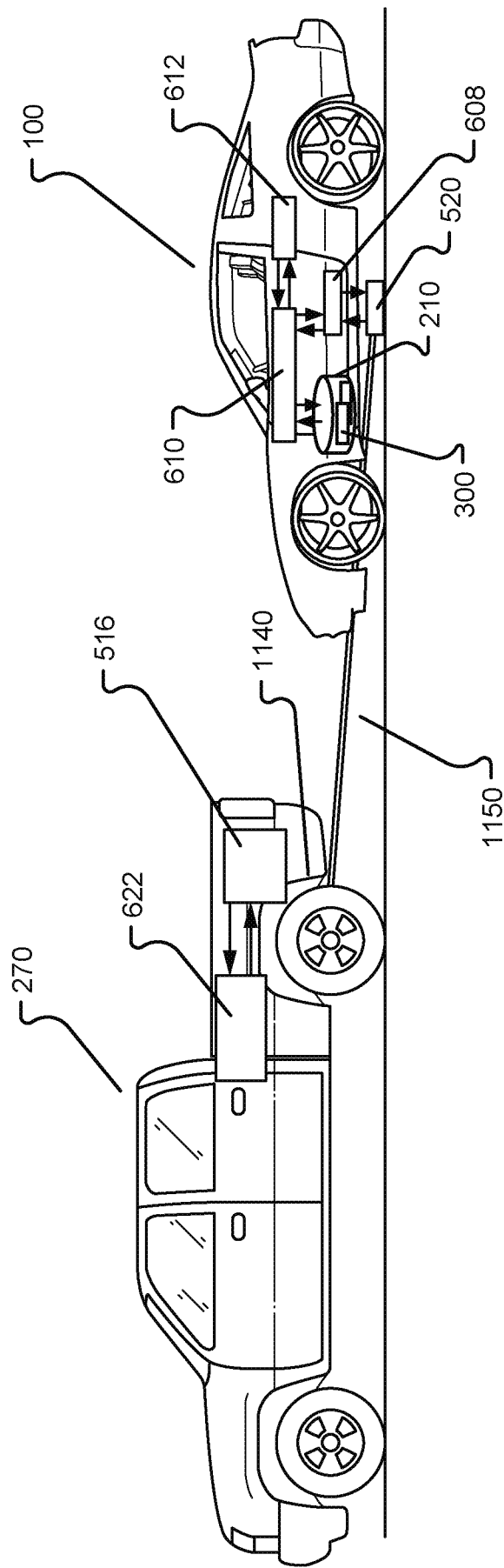


Fig. 11

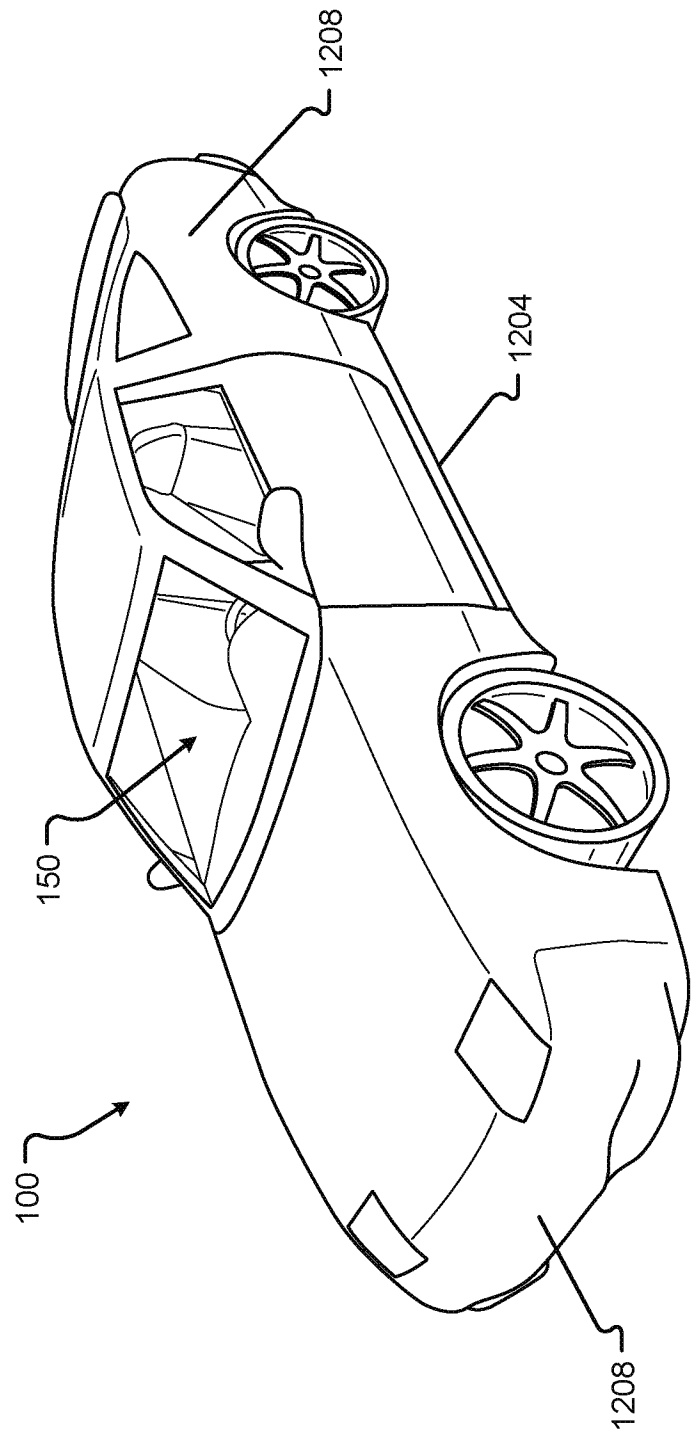


Fig. 12

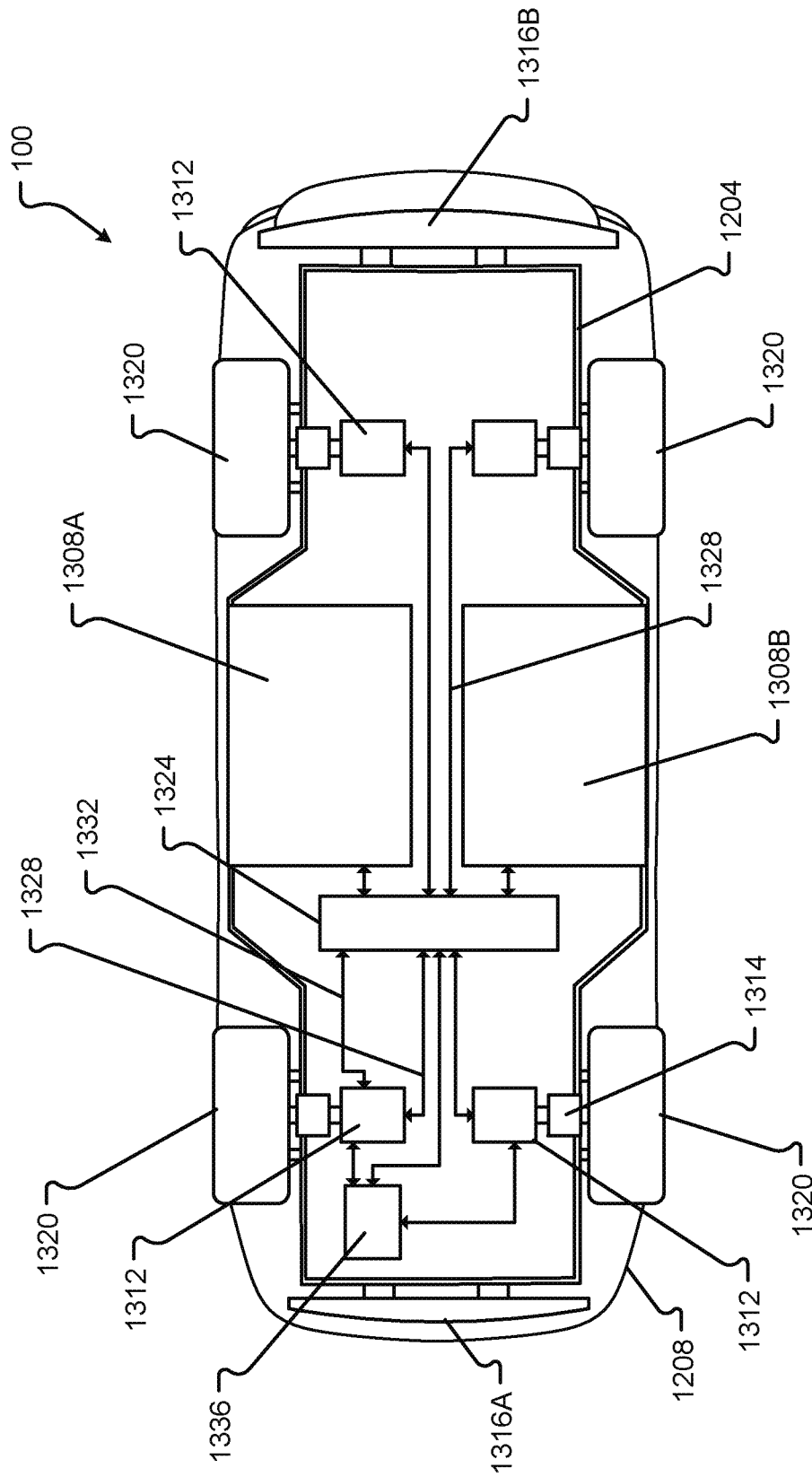


Fig. 13

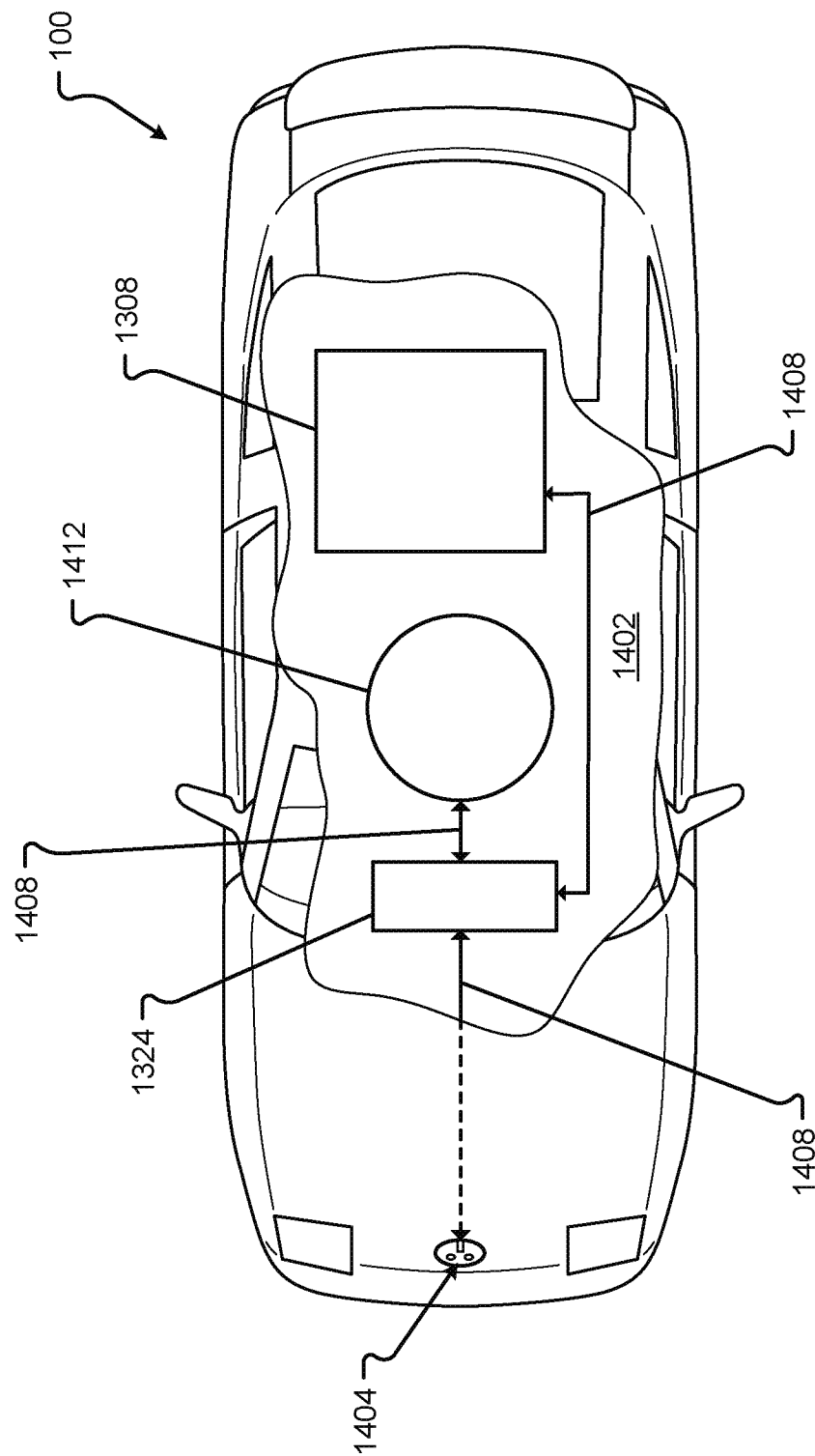


Fig. 14

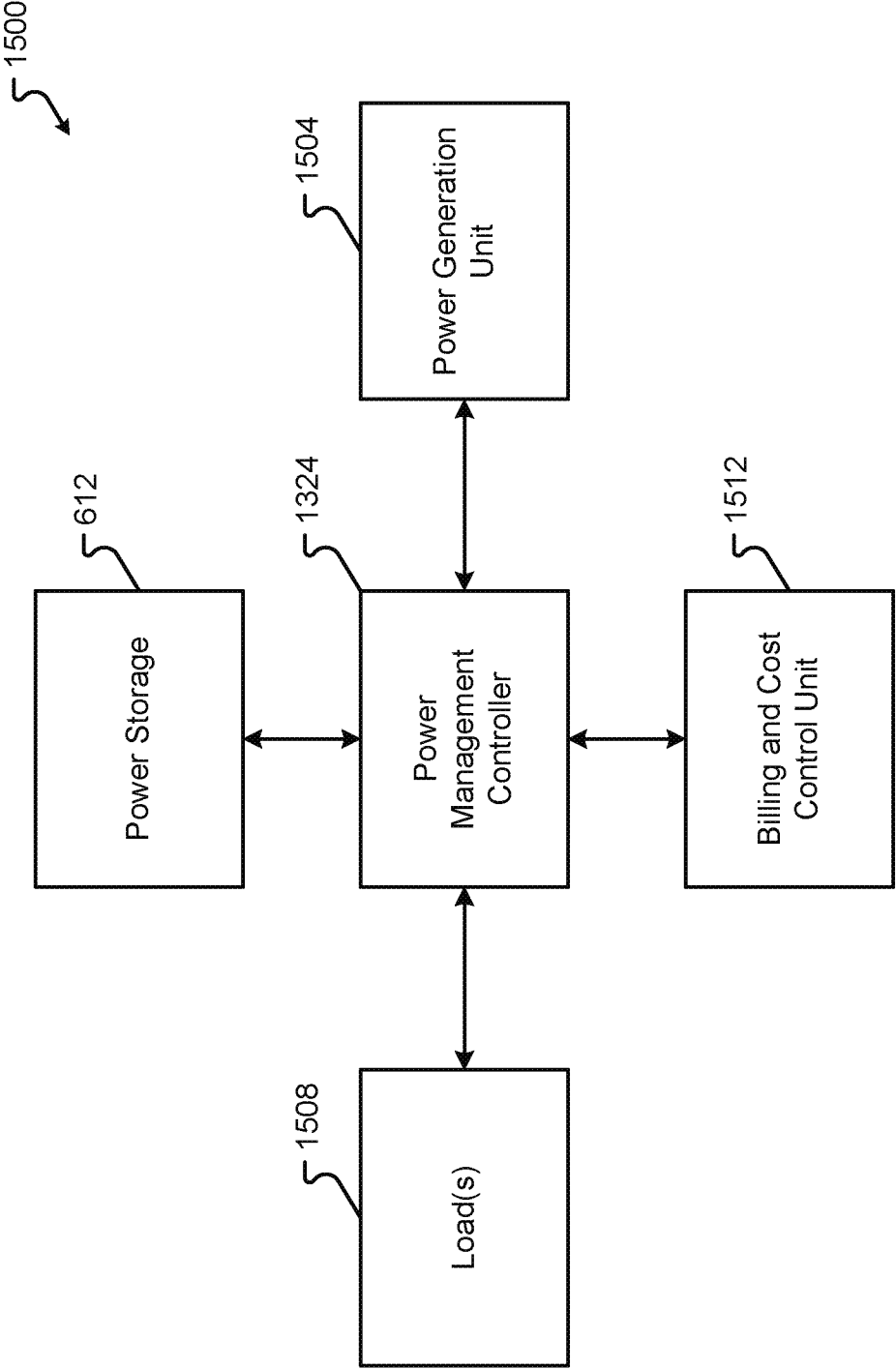


Fig. 15

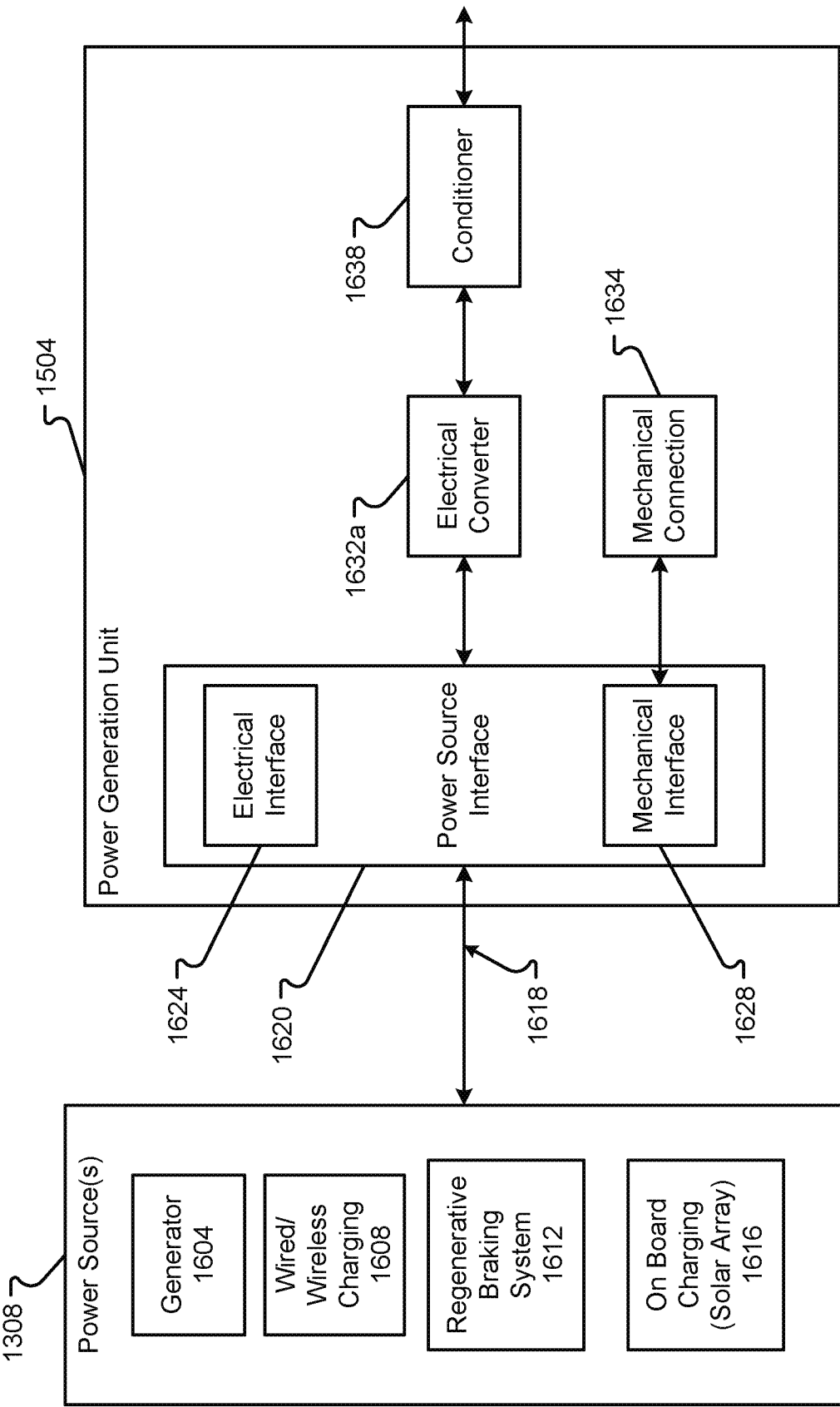


Fig. 16

1700

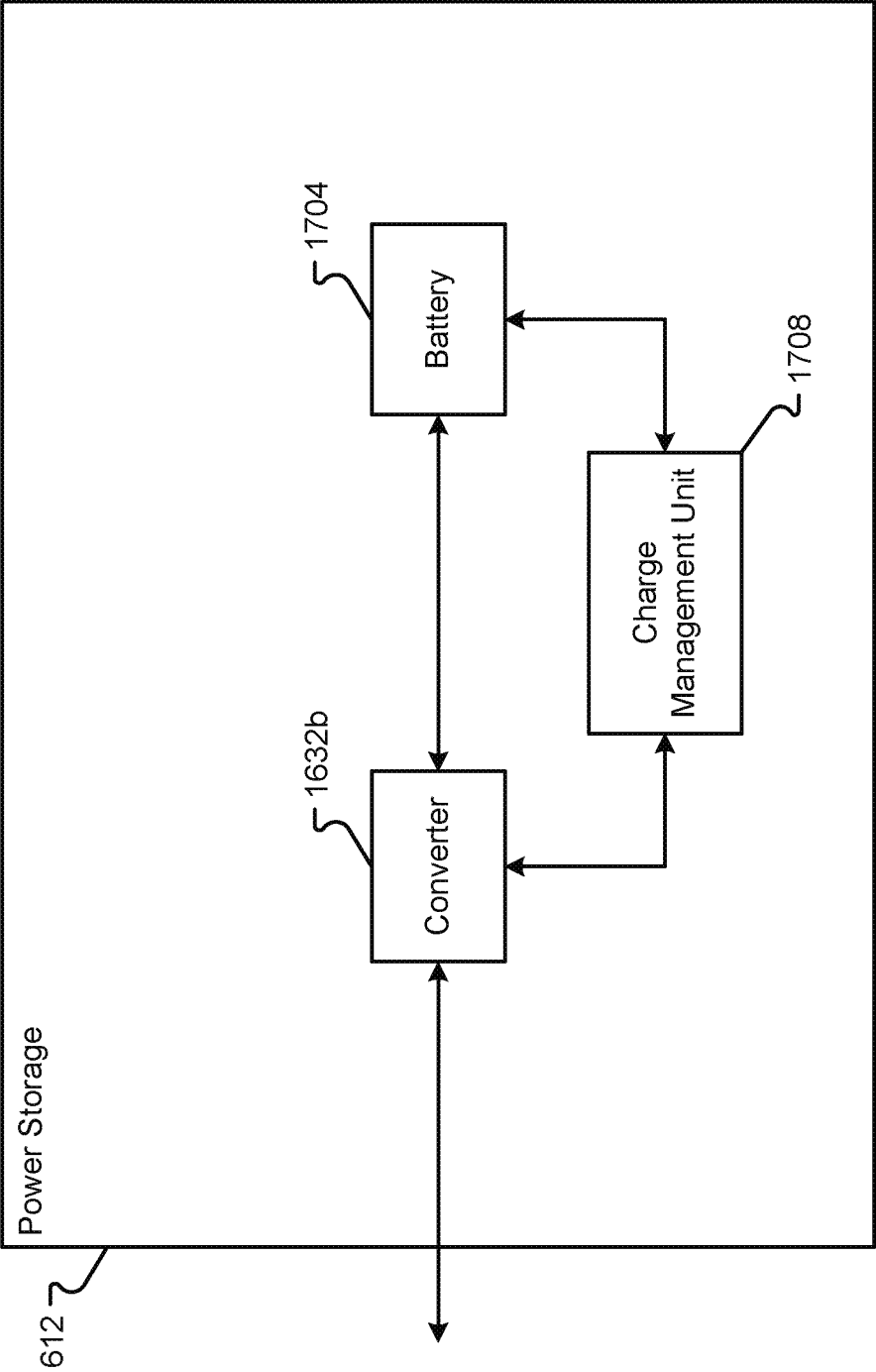


Fig. 17

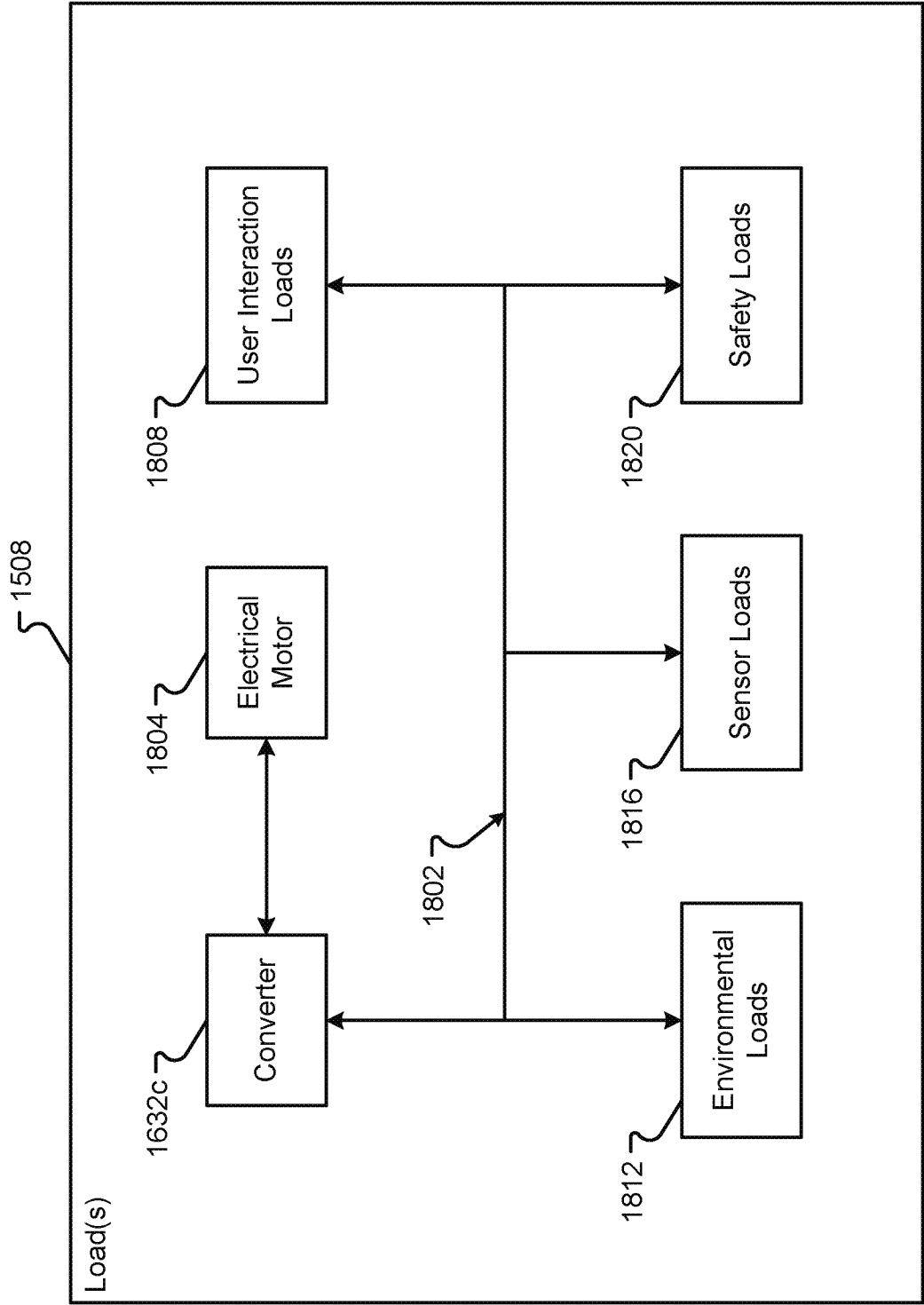
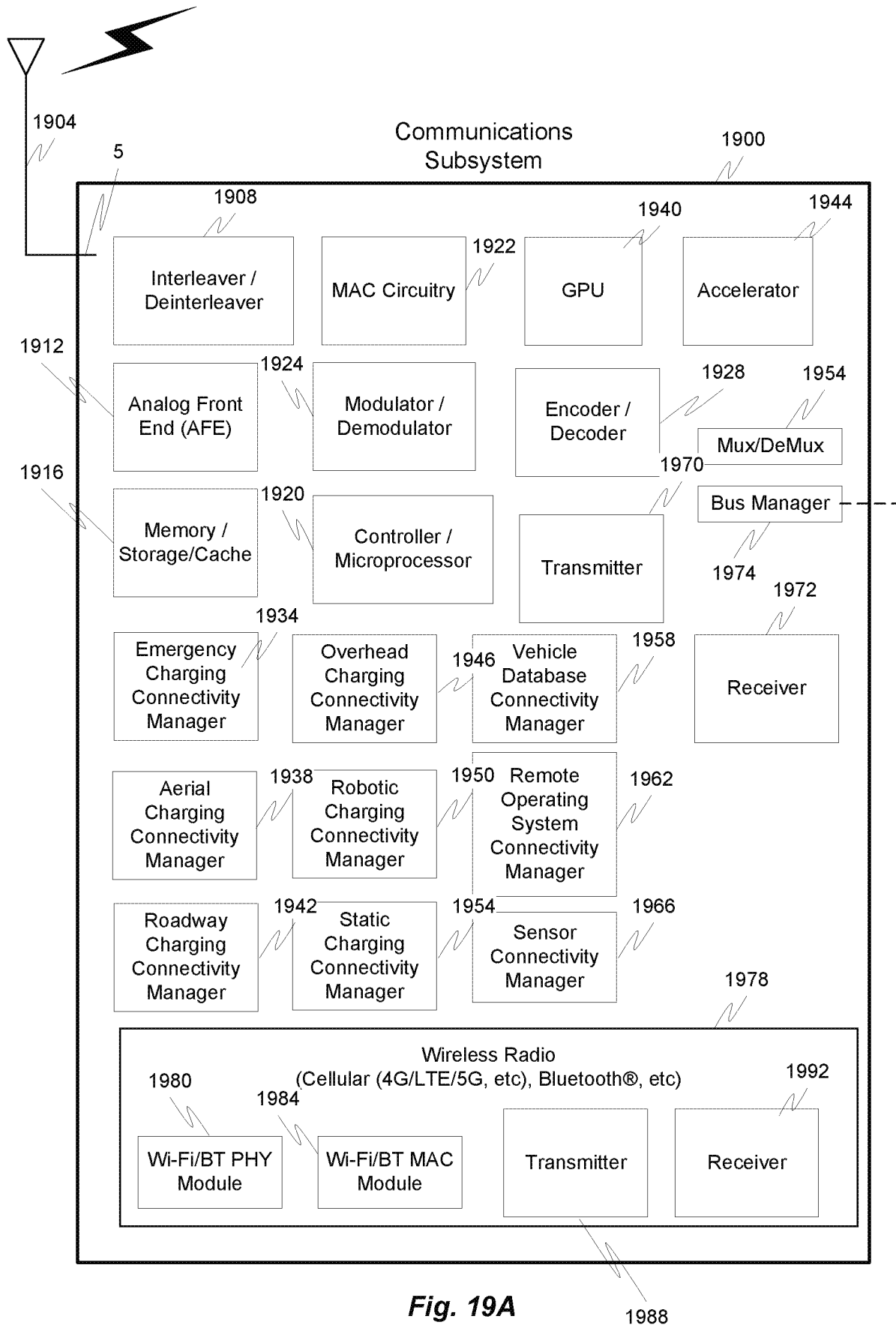
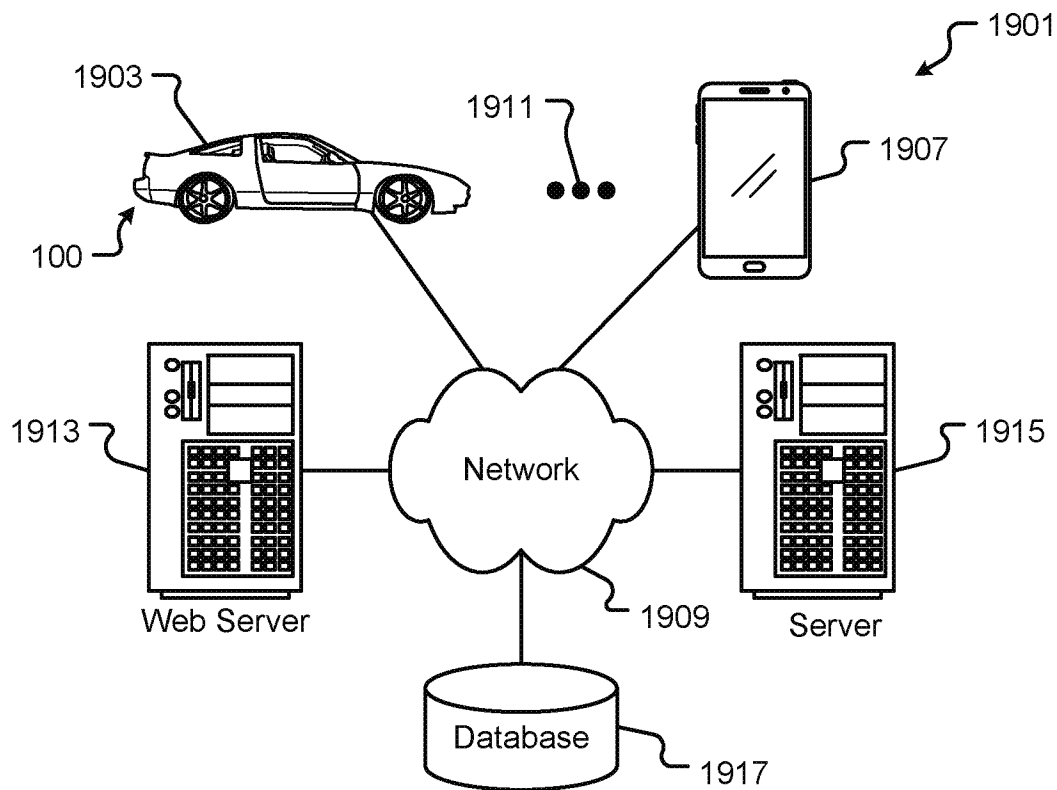
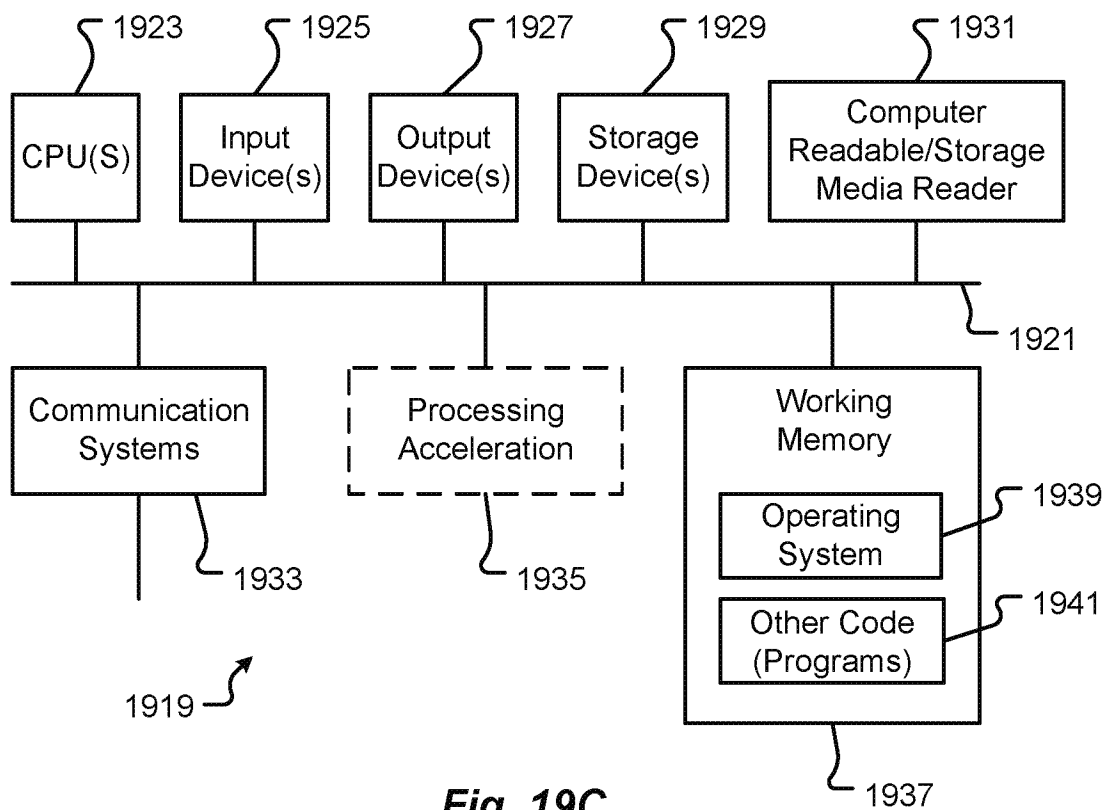


Fig. 18



**Fig. 19B****Fig. 19C**

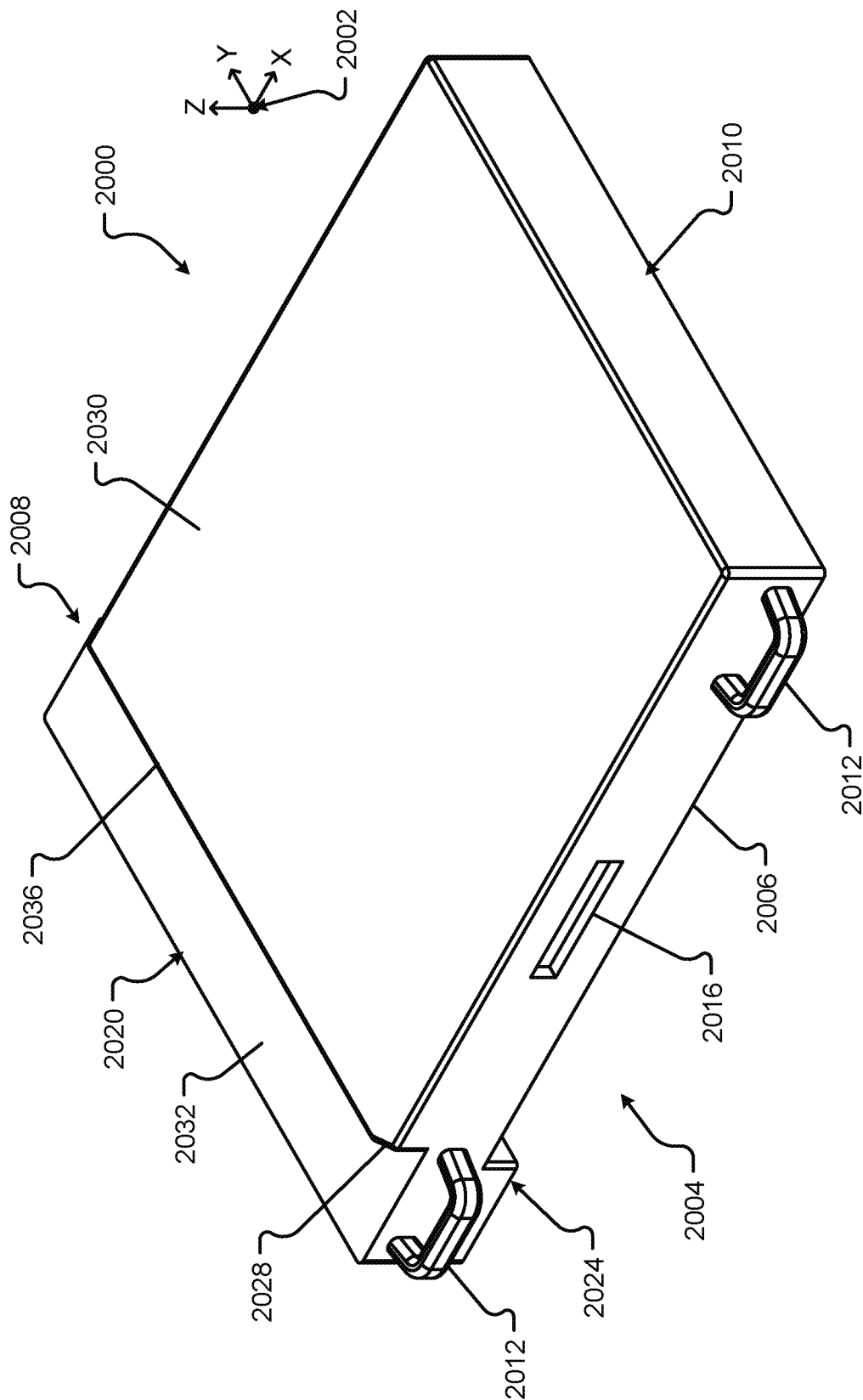


Fig. 20A

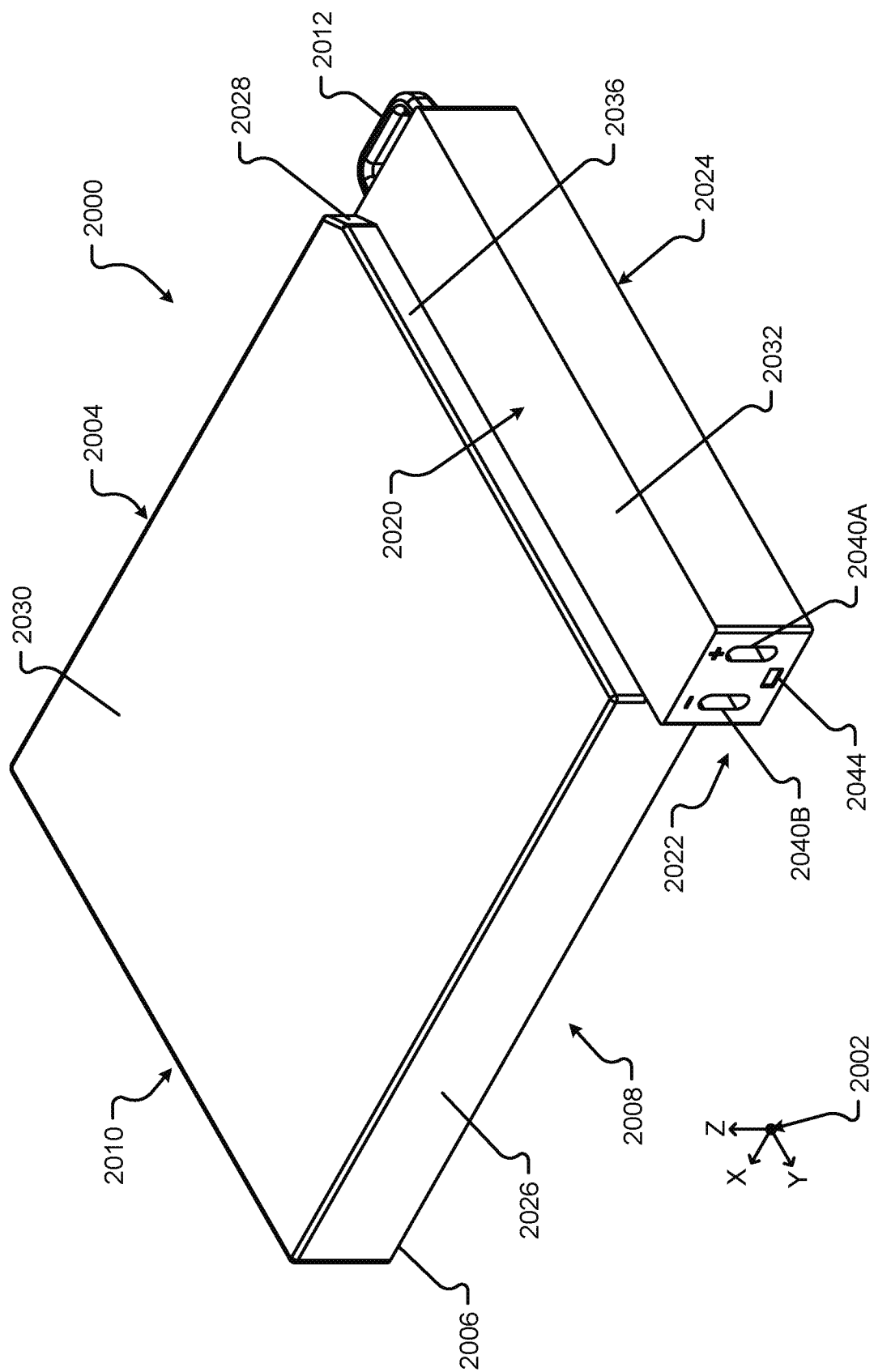


Fig. 20B

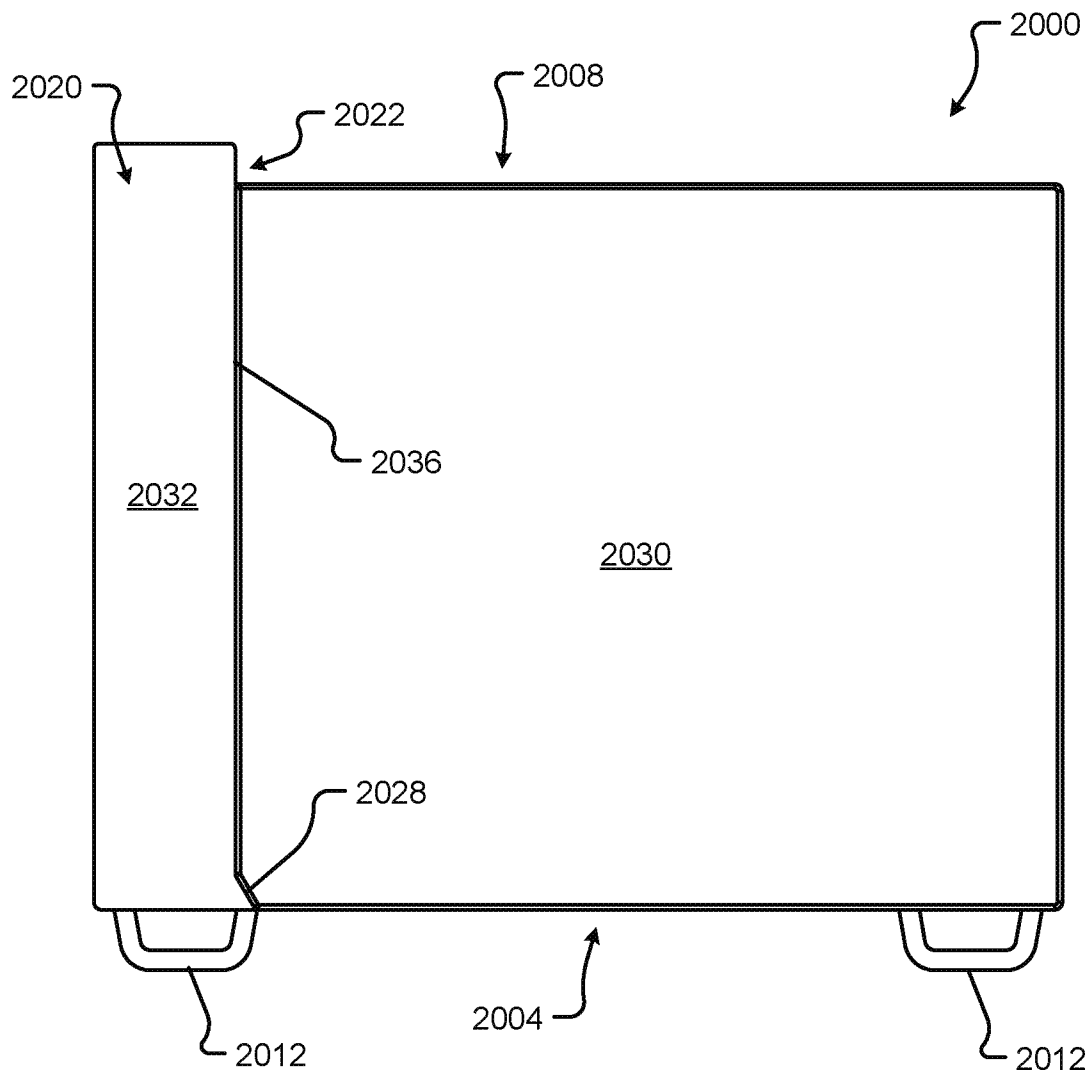


Fig. 20C

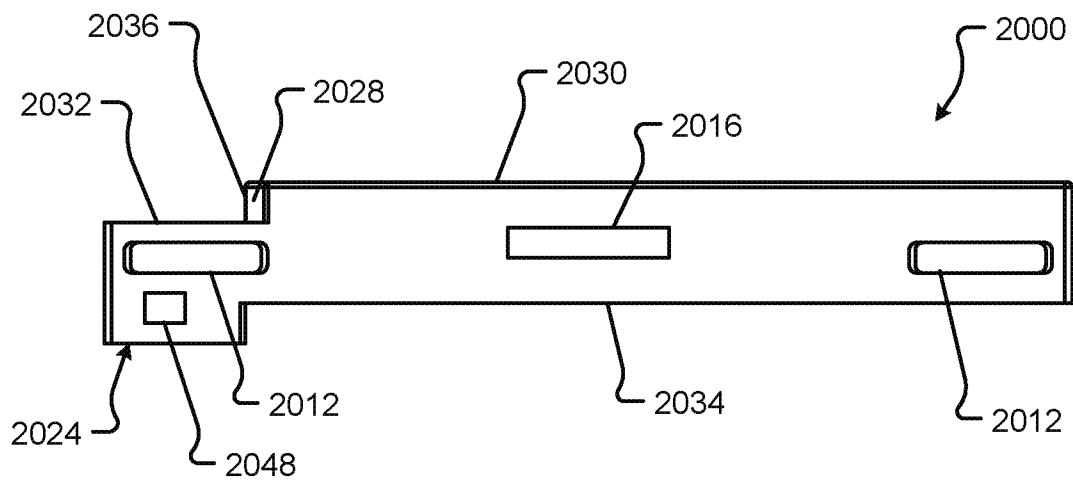
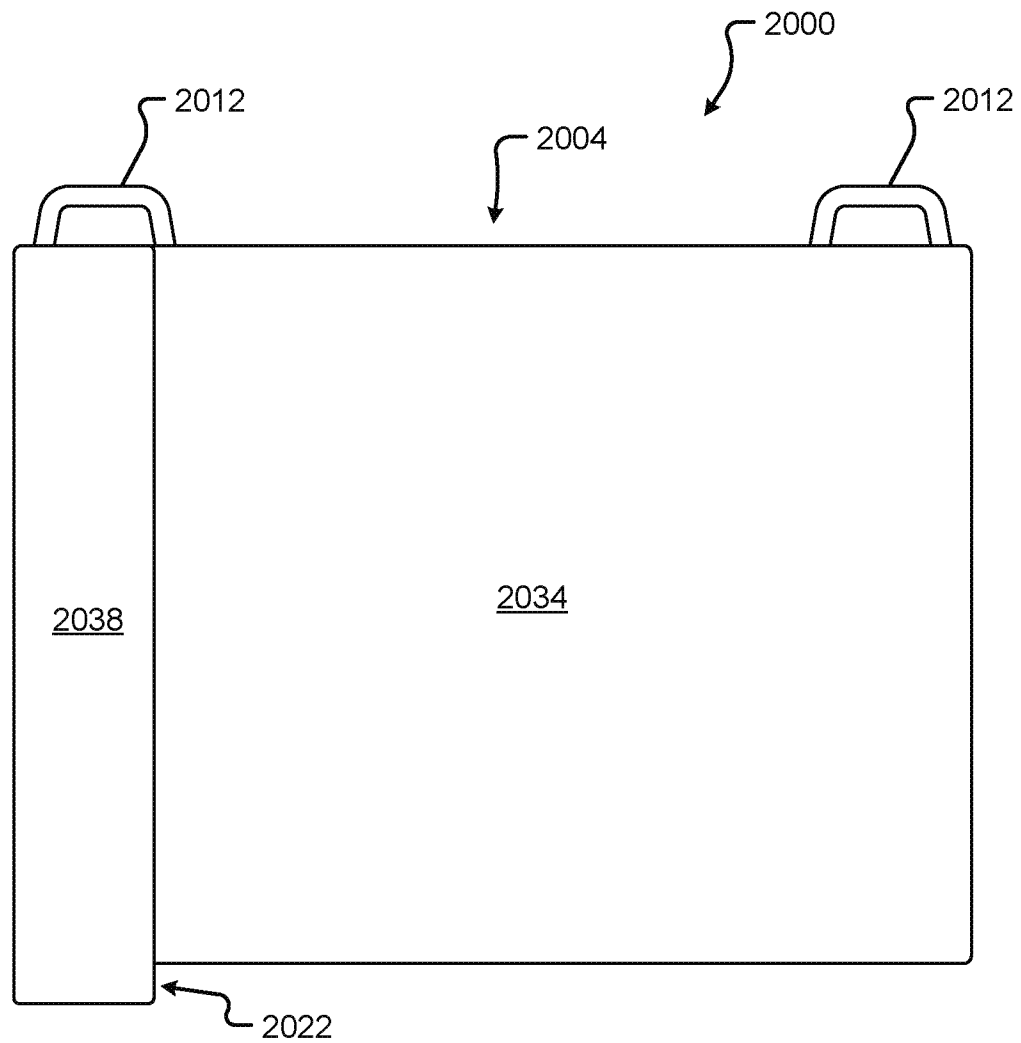
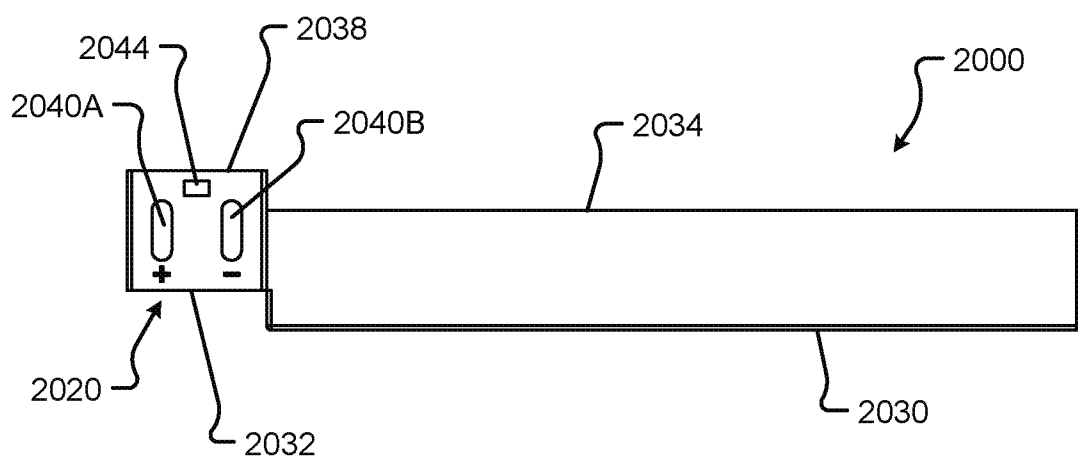


Fig. 20D

**Fig. 20E****Fig. 20F**

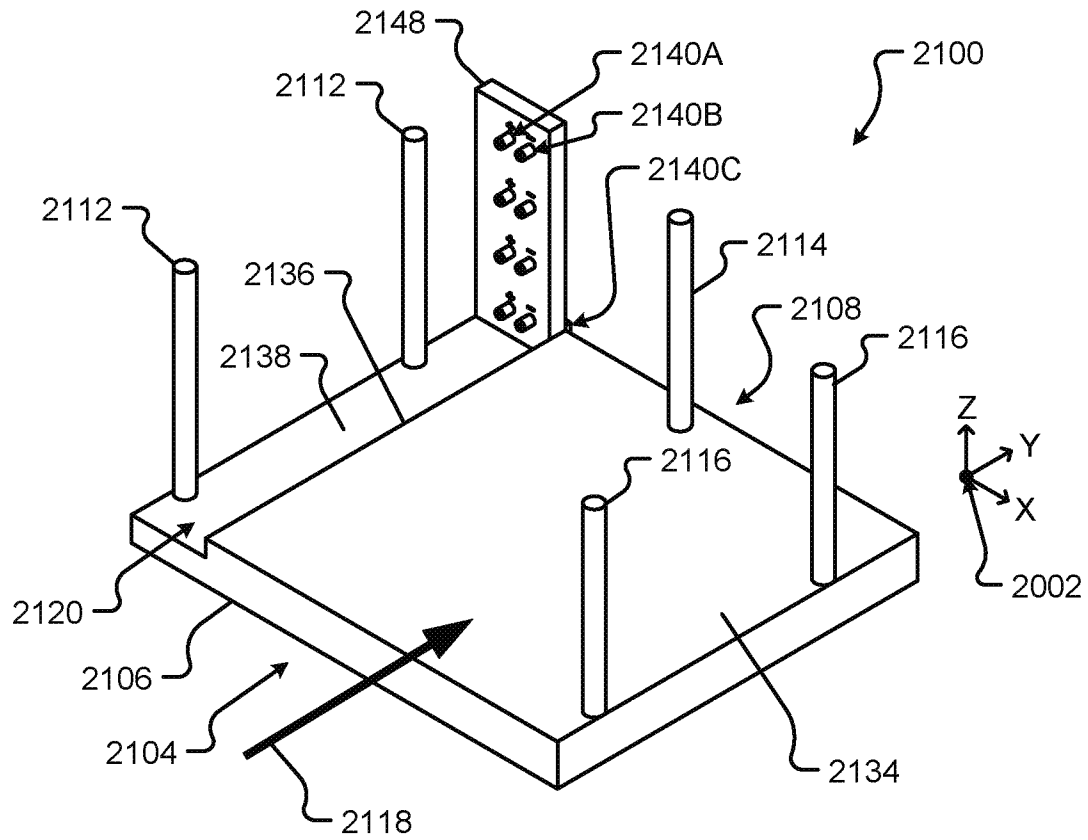


Fig. 21A

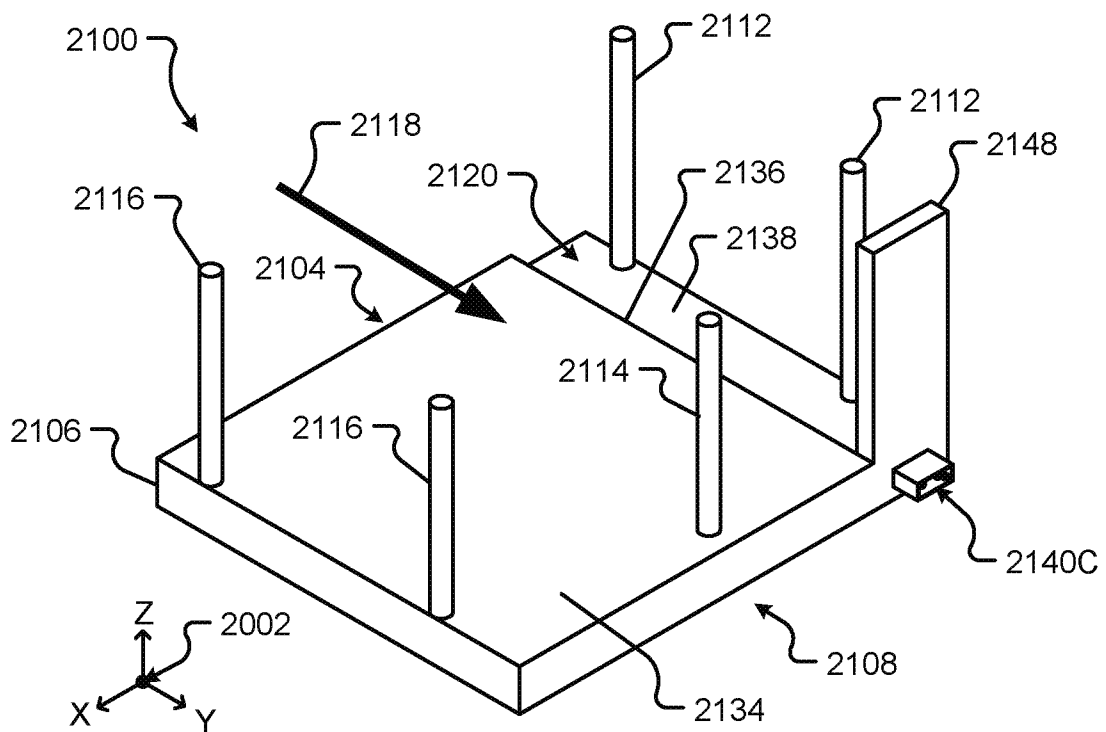


Fig. 21B

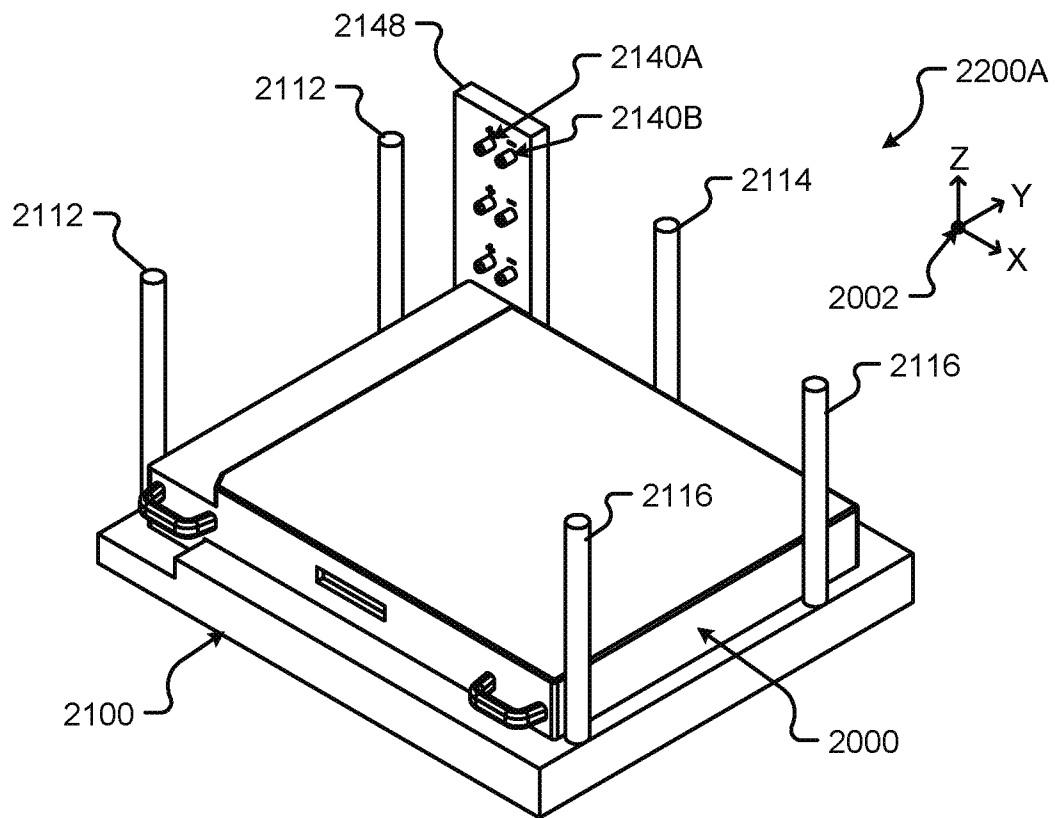


Fig. 22A

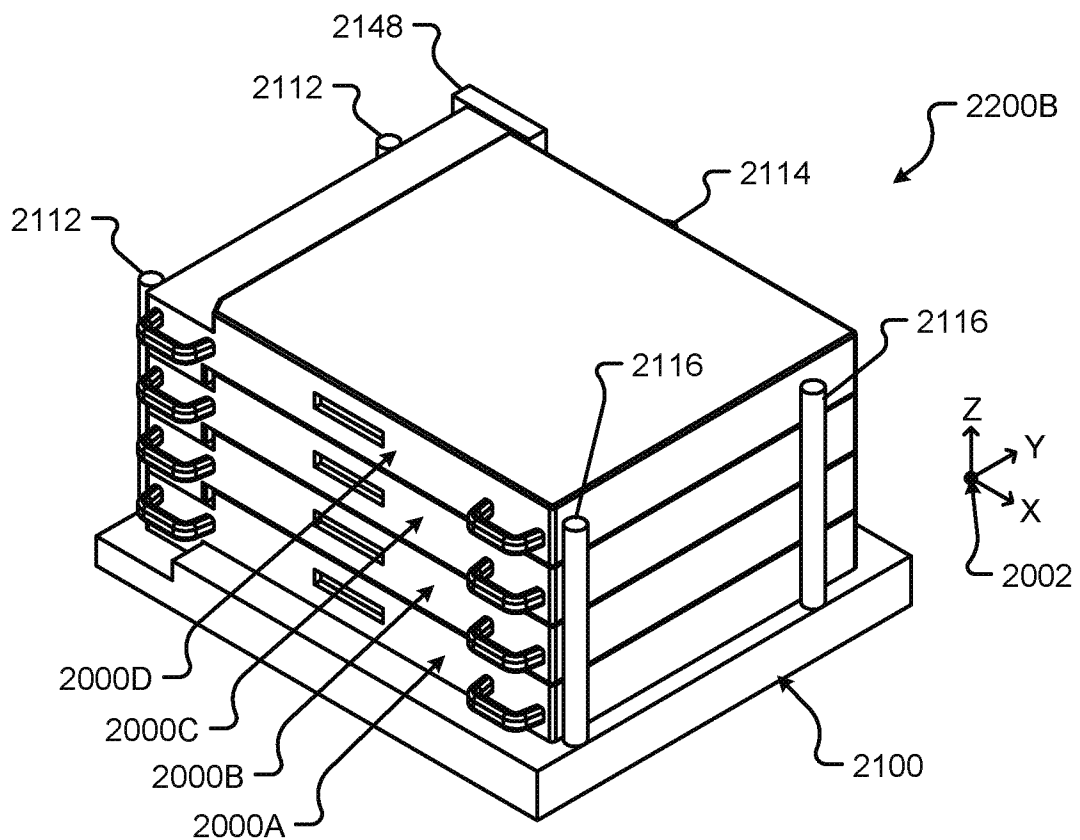


Fig. 22B

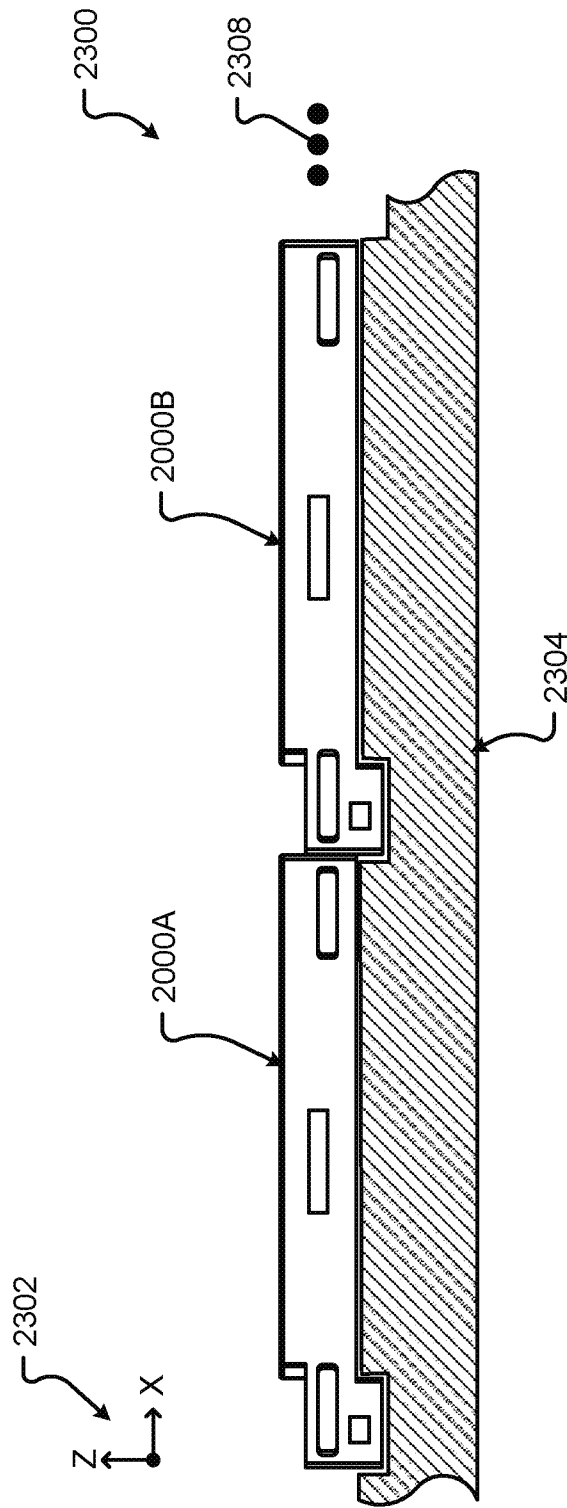


Fig. 23

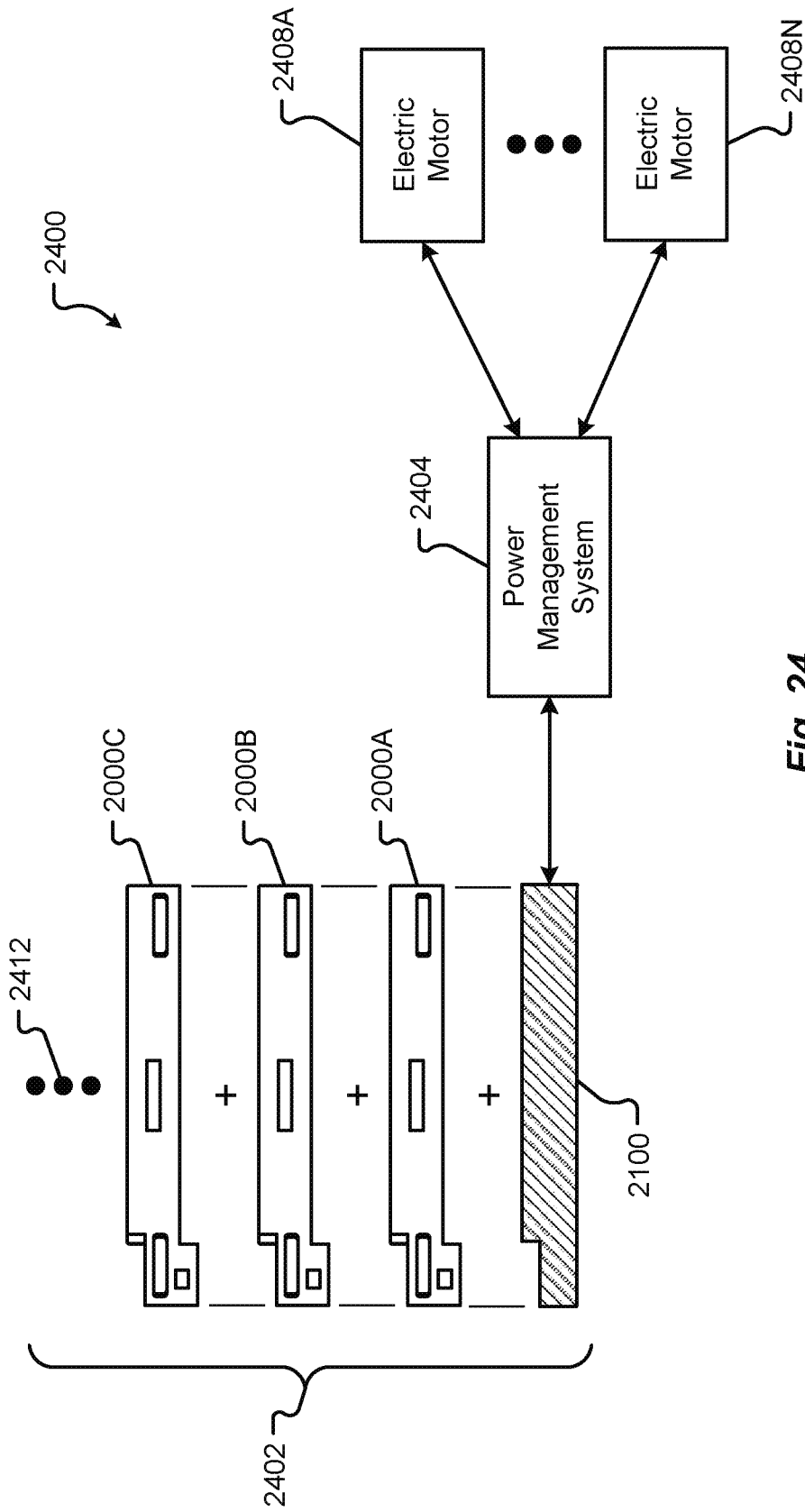


Fig. 24

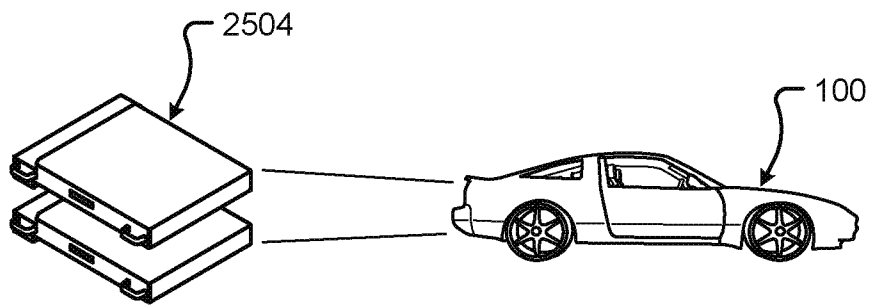


Fig. 25A

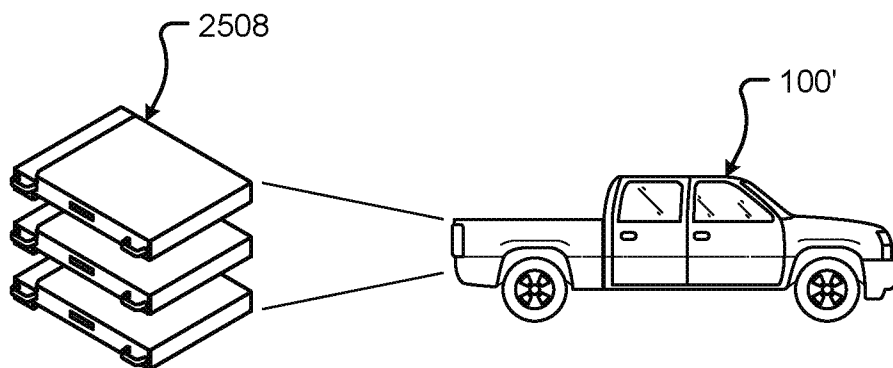


Fig. 25B

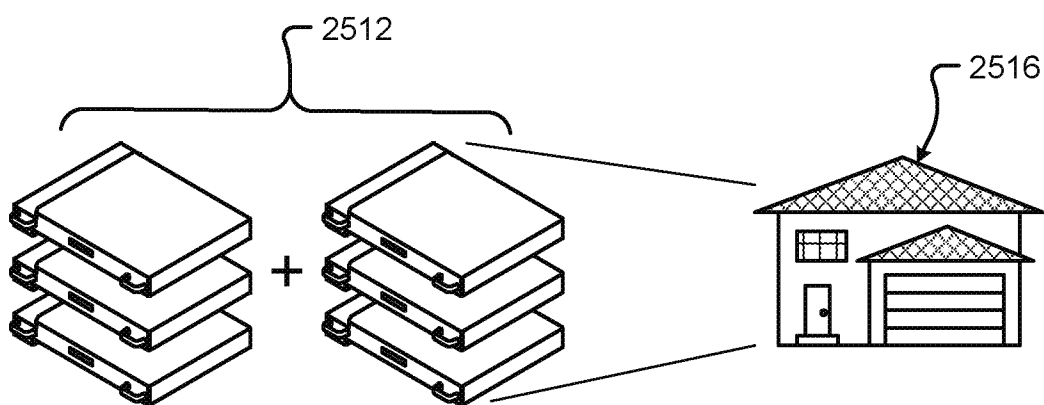
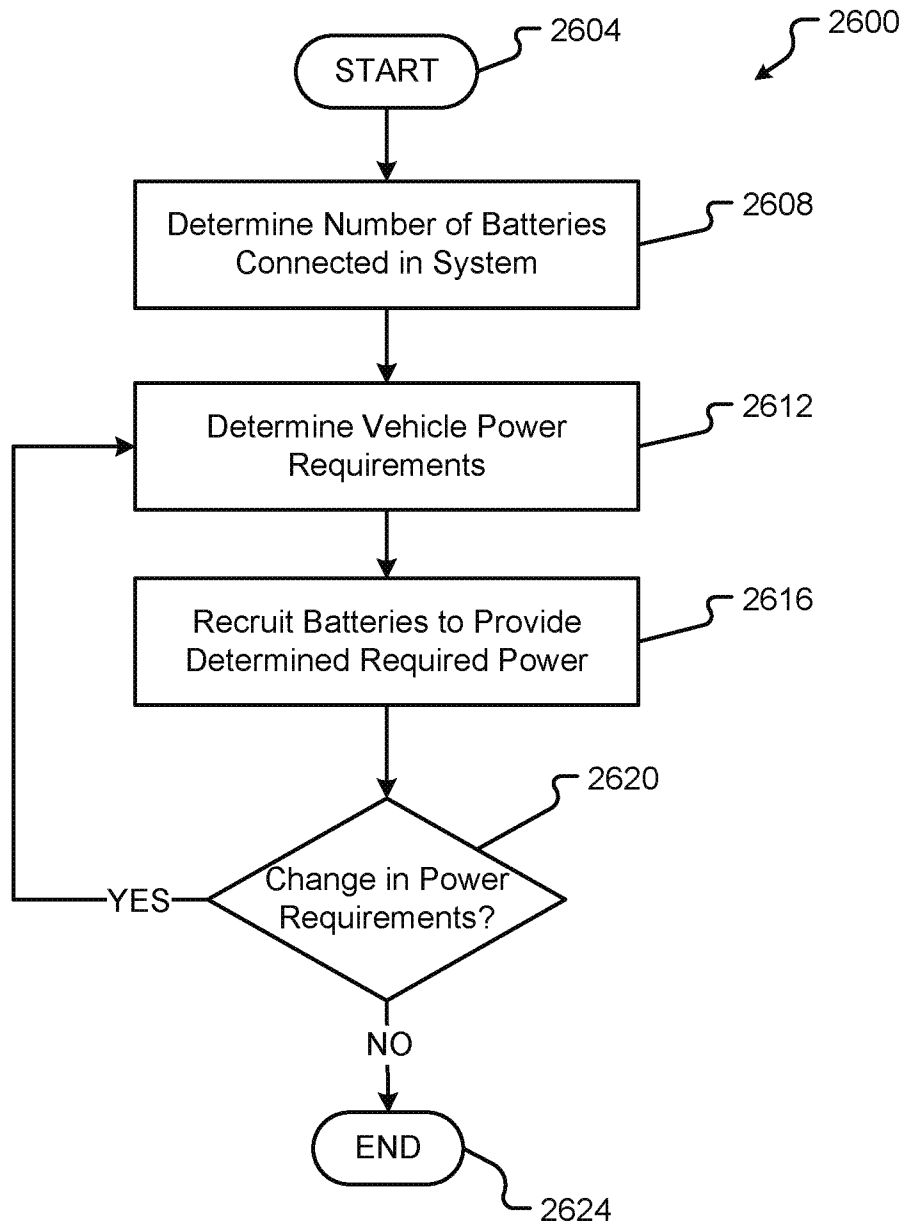
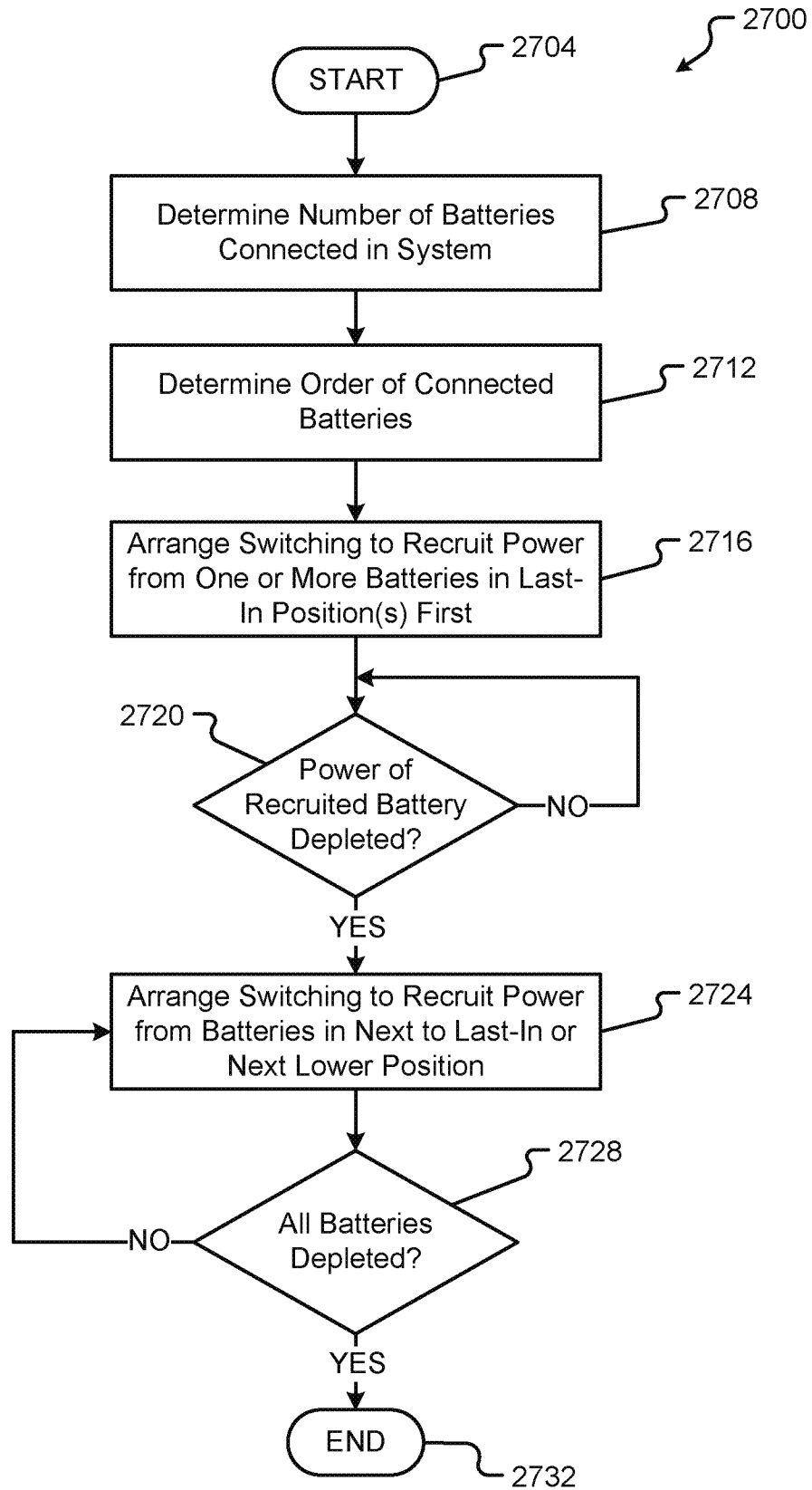


Fig. 25C

**Fig. 26**

**Fig. 27**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US17/41176

A. CLASSIFICATION OF SUBJECT MATTER

IPC - B60R 16/04; B60L 11/18; H01M 2/10, 2/20, 10/42, 10/44 (2017.01)

CPC - B60R 16/04; B60L 11/1809, 11/182, 11/1822, 11/1846, 11/1848, 11/1864; G01C 21/3469, 21/3673, 21/3697; H01M 2/1077, 2/206, 10/425, 10/441, 10/48, 2/1083

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)

See Search History document

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

See Search History document

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

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 6,265,091 B1 (PIERSON, J et al.) July 24, 2001; figures 1, 5; column 1, lines 8-25, lines 59-65; column 4, lines 29-55; column 5, lines 30-42	1-4 --- 5-20
Y	US 6,027,828 A (HAHN, S) February 22, 2000; figures 1A, 1B, 5A, 5B, 6; column 2, lines 40-62; column 3, lines 33-44, lines 60-67; column 5, lines 30-42	8-20
Y	US 2003/0143455 A1 (PARTINGTON, K et al.) July 31, 2003; figure 1; paragraph [0013]	9-13
Y	KR 10-1523588 B1 (KOREA ADVANCED INSTITUTE OF SCIENCE & TECHNOLOGY) May 28, 2015; see machine translation; figures 1, 5; paragraphs [0008], [0028], [0029]	5
Y	CN 204160485 U (YUNNAN JOHNCHESHER FLEXIBLE AUTOMATION EQUIPMENT CO) February 18, 2015; see machine translation; figures 1, 2; paragraphs [0002], [0022]-[0024]	6-7

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

11 September 2017 (11.09.2017)

Date of mailing of the international search report

28 SEP 2017

Name and mailing address of the ISA/

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