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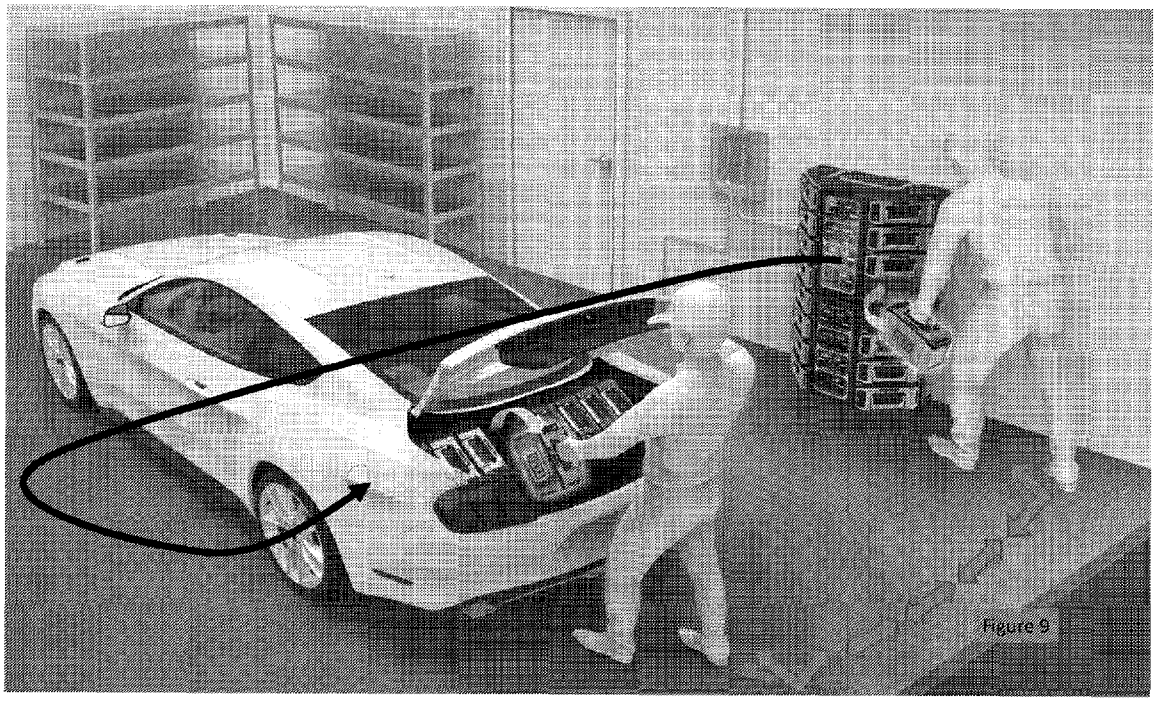
(54) Title: BATTERY SYSTEM



(57) Abstract: A vehicle power station including a housing, a control circuit for controlling charging and discharging, a receptacle, a removable power module configured to be received in the receptacle, a vehicle electrical system electrically coupled to the power station, and a vehicle motor electrically coupled to the power station wherein the control circuit is configured to discharge power from the removable power module into the vehicle electrical system.

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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

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Battery System

RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application No. 62/417,759, filed November 4, 2016, titled "Battery System" which is incorporated herein by reference.

TECHNICAL FIELD

[0002] This application relates to a system and method for a battery system for use in automotive and residential applications. In one implementation, the system includes a rechargeable and removable battery pack, also referred to as a power module, that is transferable between and connectable to a plurality and variety of vehicles, power tools and equipment and residential and/or commercial buildings.

BACKGROUND

[0003] There is a growing market prevalence of electric vehicles (EVs) and hybrid electric vehicles (HEVs). The batteries in these vehicles are being considered as energy sources for other applications, such as vehicle to grid energy arbitrage, to get the most utility out of the batteries. Having multiple uses for these high energy, high power, and high cost batteries increases their value proposition with competing technologies.

[0004] EV/HEV batteries are primarily single function (i.e. to power the vehicle) and fixed (i.e. non-removable) energy sources. The expandability and additional utility outside of the EV/HEV is limited.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 illustrates an exemplary feature of an automotive portion of an exemplary battery system of the present disclosure.

[0006] Figure 2 illustrates another exemplary feature of an automotive portion of the exemplary battery system of the present disclosure.

[0007] Figure 3 illustrates another exemplary feature of an automotive portion of the exemplary battery system of the present disclosure.

[0008] Figure 4 illustrates another exemplary feature of an automotive portion of the exemplary battery system of the present disclosure.

[0009] Figure 5 illustrates another exemplary feature of an automotive portion of the exemplary battery system of the present disclosure.

[0010] Figure 6 illustrates an exemplary implementation of the exemplary feature illustrated in Figure 5.

[0011] Figure 7 illustrates various exemplary features of an automotive portion of the exemplary battery system of the present disclosure.

[0012] Figure 8 illustrates an exemplary feature of a cross automotive-tool portion of the exemplary battery system of the present disclosure.

[0013] Figure 9 illustrates an exemplary feature of a cross automotive-building portion of the exemplary battery system of the present disclosure.

[0014] Figure 10 illustrates an exemplary feature of a building portion of the exemplary battery system of the present disclosure.

[0015] Figure 11 illustrates an exemplary feature of an outdoor activities portion of the exemplary battery system of the present disclosure.

DETAILED DESCRIPTION

[0016] An electric vehicle (EV) or hybrid electric vehicle (HEV) may be equipped with a vehicle power station having one or more ports (i.e. rails, terminals, housing, electronics) for receiving removable batteries (also referred to as power modules).

[0017] Referring to Figure 1, in an exemplary embodiment, an automotive portion of a battery system is disclosed. Figure 1 illustrates an exemplary electric vehicle. In this embodiment, the vehicle is a pickup truck. Other types of vehicles, such as cars, sport utility vehicles, and buses, are encompassed by the present invention. The electric vehicle includes a primary drive vehicle battery and an electric motor electrically coupled to the vehicle battery and the driven vehicle

wheels, as is well known in the art. The vehicle may also be a hybrid electric vehicle that includes an internal combustion engine, which either supplements the vehicle battery or is supplemented by the vehicle battery to provide a motive force to the driven wheels. The battery system includes a vehicle power station. The power station may be originally designed, built and integrated to the electric vehicle or it may be installed on the vehicle as an aftermarket component after the electric vehicle leaves the factory. The vehicle power station includes at least one port (also referred to as a receptacle) for receiving a power module (also referred to as a battery pack). Each vehicle power station port includes an interface for electrically and mechanically coupling to the power module. Each power module includes an interface for electrically and mechanically coupling to the interface of the port of the vehicle power station. The power modules connect into the electrical system of the electric vehicle through the vehicle power station. The vehicle power station is electrically coupled to the vehicle battery. The vehicle power station may also be electrically coupled to the vehicle motor. The vehicle power station may also include a control module to control charging and discharging of the power modules, as discussed in more detail below.

[0018] As illustrated in Figure 1, the vehicle battery may charge one or more of the power modules in the vehicle power station.

[0019] Referring also to Figure 2, the vehicle power station may discharge one or more of the power modules into the vehicle electrical system to increase the electric vehicle's range and/or performance. More specifically, the vehicle user place the battery system in a "charge mode" which will draw energy from the electric vehicle system (vehicle battery) and transfer it into the power models or select from a number of options which draw energy from the power modules and supply the energy to the vehicle system. For example, the battery system may include a fuel economy mode which increases the range on pure electric or electric assist or a power boost (performance) mode which uses the additional current delivery capability of the power modules. Through the operation of an in car interface, the user can select how to the fuel economy mode or the boost mode and determine how the energy from the power modules will be deployed. As such, the power modules may supplement the vehicle battery to provide extended range or increased performance. In this instance, the power modules may provide

energy to the vehicle motor through the vehicle battery or directly to the vehicle motor. Alternatively, the power modules may be used as a backup power source and only used when the vehicle battery is fully depleted. In this case, the power modules remain fully charged unless the vehicle battery is fully depleted and power modules may be used for other purposes, as described below. In such an instance, the power modules may provide power directly to the vehicle motor. Alternatively, the power modules may simply charge the vehicle battery but not drive the vehicle motor.

[0020] Referring to Figure 3, another feature of the battery system is that the power modules may be transferred between multiple vehicles, wherein each vehicle includes a vehicle power station. As illustrated, the power modules may be transferred between the electric pickup truck and an electric or hybrid electric car. The power modules may have a variety of different configurations such as high capacity versions, high power versions, super capacitor extreme performance versions and fuel cell range extending versions, as well as internal combustion engine power generating versions. Each power module configuration will include an interface to allow it to be connected into the electrical system of the electric vehicle through the vehicle power station.

[0021] Referring to Figures 4 and 5, another feature of the battery system is that an internal combustion engine (ICE) vehicle may be converted to a hybrid electric vehicle or a pure electric vehicle. As illustrated in Figure 4, a vehicle power station is installed in a trunk of the ICE vehicle and coupled to the driven wheels of the vehicle. As illustrated in Figure 5, the original vehicle wheels/tires are removed and replaced with wheels/tires with in-hub motors. The vehicle power station is electrically coupled to the in-hub motors. As such, when desired, the power modules may provide power to the in-hub motors to drive the vehicle. The vehicle may also use the original internal combustion engine to drive the driven wheels alone or in conjunction with the energy from the power modules. This system will provide the converted vehicle with either increased performance or increased range. This may also provide a backup system if the ICE breaks down or runs out of fuel.

[0022] Referring to Figure 6, illustrates the various benefits of having supplemental or auxiliary power through the use of add-on power modules and a vehicle power station in an electric, hybrid electric or gasoline vehicle.

[0023] Referring to Figure 7, another feature of the battery system is that the power modules may be transferred between the electric vehicle and a power tool tools (e.g. concrete saw, power trowel), or power equipment (e.g. lawn mowers, fork lifts, inverters), or other vehicles (e.g. motorcycle, UTV) (collectively, device) that includes a port having an electrical and mechanical interface to accept the power module. The user may remove the power module from the electric vehicle and plug it into the device and vice versa as long as both the vehicle and the device are equipped with an interface designed to mechanically and electrically couple to the power module.

[0024] Referring to Figure 8, another feature of the battery system is that the power modules, through the vehicle power station, may power a vehicle or equipment towed or otherwise associated with the electric vehicle. For example, as illustrated in Figure 8, a trailer carrying a lawn mower is mechanically coupled to the electric vehicle (pickup truck) so that the electric vehicle can transport the trailer from location to location. The vehicle power station may be coupled to the lawn mower through a power cord to discharge energy from the power modules to battery packs on the lawn mower. Alternatively, the recreational vehicle may be mechanically coupled to the electric vehicle and the vehicle power station may provide energy to the various loads/appliances in the RV, either through a power cord or through the hitching mechanism.

[0025] Referring to Figure 9, another feature of the battery system is that the power modules/battery packs can be used as part of a residential or commercial electrical system. In the case of a residential or home electrical system, the system may include a home power station. The home power station includes a plurality of ports for receiving the power modules. The home power station may be coupled to the home electrical system. As such, the power modules – through the home power station – may receive power from the utility system (through the home electrical system) to charge the power modules or the power modules –

through the home power station – may provide power to the home electrical system to power various appliances, tools, etc. plugged into the home electrical system or even provide power back to the utility grid, for example, when utility grid power costs are high. The power modules may be transferred from the electric vehicle to the home power station for charging or discharging through the home power station. Alternatively, the home power station can be coupled to the vehicle to charge the power modules in the vehicle power station, either from power modules in the home power station or from the utility grid. Alternatively, the home power station may be coupled to the electric vehicle (with or without a vehicle power station) to power the vehicle battery. The home power station may include a control module to monitor and control the charging and discharging of the power modules. The home power station may also include a communication system to communicate with a homeowner regarding the status of the power modules and any device coupled to the home power station.

[0026] Referring to Figure 10, another feature of the battery system is that the home power station may be coupled to a photovoltaic solar system. As such, the solar system may charge the power modules in the home power station. This may occur whether or not the utility grid is available to charge power modules. Alternatively, the solar system can charge the power modules when possible (the sun is shining) either primarily (charging the power modules as a higher priority than providing power to the home electrical grid to power home appliances) or secondarily (charging the power modules as a lower priority than providing power to the home electrical grid to power home appliances) and the power modules can discharge to the home electrical grid when the sun is not shining or when power from the utility grid is selling for a relatively high cost. The home power station can also serve as a backup system when the utility grid is not available and/or the sun is not shining. Alternatively, the home includes a home power station but not a solar system, the home power station could charge the power modules from the utility grid when utility grid power is relatively low (during off peak hours, e.g., at night) and discharge the power modules to the home electrical grid to power home appliances or back to the utility grid when utility grid power is relatively high (during peak hours).

[0027] Additionally, using the electric vehicle's main charging port, the electric vehicle may be electrically coupled to the home power station to charge the vehicle battery and/or the power

modules from energy generated by the solar system. This solar system energy may be used to charge the vehicle battery or the power modules directly or from energy generated by the solar system that is stored in power modules in the home power station. In addition, the battery system may be used to arbitrage energy. More specifically, the home power station may draw energy from the utility grid when utility energy prices are low and store the energy in the power modules and return/sell the energy to the utility grid when utility energy prices are high. Alternatively, the home power station may (1) draw energy from the solar system and power the home loads and/or sell excess energy to the utility grid when the when utility prices are high and (2) draw energy from the utility grid and store energy from the solar system in the power modules when utility energy prices are low.

[0028] Referring to Figure 11, the electric vehicle may be coupled to an electric vehicle charger in the home (or outside of the home) through the vehicle's main charging port to charge the power modules in addition to charging the vehicle battery.

[0029] Referring to Figure 12, the power modules/battery packs can be removed and used to supply power not only to power equipment used in construction or industry, such as circular saws but also for leisure appliances such as blenders, televisions, speakers, and electric grills. Alternatively, the power modules/battery packs installed in the auxiliary power station can provide power to auxiliary devices such as AC products (e.g. microwaves, stereos), high voltage DC products (e.g. power tools, equipment), or low voltage DC products (e.g. phone chargers, jump starters) through an interface on the auxiliary power station.

[0030] The battery system may report information about the condition of the power modules (e.g. state of charge, cycles, temperature) directly to the user, through the vehicle's display system, through the home power station, or through connected devices (e.g. smart phone).

[0031] The power modules may provide power directly to the home through the use of an inverter, which may be integrated as part of the home power station.

[0032] The power modules may be substantially the same working voltage as the vehicle's electrical system.

[0033] The power modules and/or the vehicle power station and/or the home power station may include electronics for the safe removal and connection of the power modules from/to the vehicle's or home's electrical system.

[0034] Advantages

[0035] Advantages of this system include Increased vehicle power, increased vehicle runtime, a scalable and expandable system, the ability to use battery packs to power the system and for power tools, power equipment, and home energy needs.

[0036] Numerous modifications may be made to the exemplary implementations described above. These and other implementations are within the scope of this application.

CLAIMS:

1. A vehicle power station, comprising:

a housing;

a control circuit for controlling charging and discharging;

a receptacle;

a removable power module configured to be received in the receptacle;

a vehicle electrical system electrically coupled to the power station;

a vehicle motor electrically coupled to the power station;

the control circuit being configured to discharge power from the removable power module into the vehicle electrical system.

2. The vehicle power station, as recited in claim 1, further comprising a vehicle battery electrically coupled to the power station, wherein the control circuit is configured to have the vehicle battery charge the power module or the power module charge the vehicle battery.

3. The vehicle power station, as recited in claim 2, wherein the control circuit is configured to have the power module provide energy to supplement vehicle battery or directly to the vehicle motor.

4. The vehicle power station, as recited in claim 2, wherein the control circuit is configured to have the power module provide energy to the vehicle battery and/or to vehicle motor.

5. The vehicle power station, as recited in claim 2, wherein the control circuit is configured to have the power module provide energy only when vehicle battery depleted.

6. The vehicle power station, as recited in claim 1, wherein the power module is transferable between a first vehicle power station and a second vehicle power station.

7. A hybrid electrical vehicle conversion system, comprising:

an internal combustion engine;

a pair of driven wheels coupled to the internal combustion engine;

an in-hub motor coupled to each of the pair of driven wheels; and

a vehicle power station coupled to the in-hub motors, the vehicle power station comprising at least one removable power module, a user/vehicle control system, a charger, and a motor control system.

8. The hybrid electrical vehicle conversion system, as recited in claim 7, wherein the user/vehicle control system selects powering the driven wheels using the internal combustion engine and/or using the vehicle power station.

9. The hybrid electrical vehicle conversion system, as recited in claim 7, wherein the user/vehicle control system selects using the vehicle power station to improve vehicle performance or to improve vehicle efficiency.

10. The hybrid electrical vehicle conversion system, as recited in claim 7, wherein the user/vehicle control system selects using the vehicle power station instead of the internal combustion engine.

11. The hybrid electrical vehicle conversion system, as recited in claim 7, wherein the user/vehicle control system selects using the vehicle power station to charge a vehicle battery.

12. A battery system, comprising:

a removable battery pack, including a plurality of battery cells and an interface for electrically and mechanically coupling to a load bearing device;

a vehicle, including a power station for providing power to drive the vehicle, the power station including a port for accepting the removable battery pack; and

a power tool including a port for accepting the removable battery pack.

13. The battery system, as recited in claim 12, wherein the power station port comprises an electrical and mechanical interface for coupling the removable battery pack to the power station.

14. The battery system, as recited in claim 12, wherein the power tool comprises an electrical and mechanical interface for coupling the removable battery pack to the power tool.

15. The battery system, as recited in claim 12, wherein the power station port comprises an electrical and mechanical interface for coupling the removable battery pack to the power station and wherein the power tool comprises an electrical and mechanical interface for coupling the removable battery pack to the power tool, wherein the power station interface is substantially identical to the power tool interface.

16. The battery system, as recited in claim 12, further comprising a towed vehicle coupled to the vehicle, wherein the power station is electrically coupled to the towed vehicle to charge various loads of the towed vehicle or an internal battery of the towed vehicle.

17. The battery system, as recited in claim 16, wherein the towed vehicle is a trailer and wherein the power tool is a lawn mower carried by the trailer and wherein the power station is electrically coupled to the lawn mower to charge an internal battery of the lawn mower and/or a removable battery pack in the lawn mower port.

18. A battery-based residential power system, comprising:

a stationary home power station, comprising at least one port for accepting a removable battery pack, the home power station electrically coupled to a home electrical system that is coupled to a utility power system;

a vehicle power station, comprising at least one port for accepting a removable battery pack; and

a removable battery pack that is configured to be accepted by the home power station port and the vehicle power station port.

19. The battery-based residential power system, as recited in claim 18, wherein the removable battery pack is mated with the home power station and receives power from the home electrical system.

20. The battery-based residential power system, as recited in claim 18, wherein the home electrical system receives power from the utility power system.

21. The battery-based residential power system, as recited in claim 18, wherein the home electrical system receives power from a photovoltaic solar system.

22. The battery-based residential power system, as recited in claim 18, wherein the removable battery pack is mated with the home power station and provides power to the home electrical system.

23. The battery-based residential power system, as recited in claim 18, wherein the home power station is electrically coupled to the vehicle power station and the home power station provides power to the vehicle power station.

24. The battery-based residential power system, as recited in claim 18, wherein a removable battery pack in the home power station provides power to the vehicle power station.

25. The battery-based residential power system, as recited in claim 18, wherein the home electrical system provides power to the vehicle power station.

26. The battery-based residential power system, as recited in claim 18, wherein the home power station is electrically coupled to the vehicle power station and the vehicle power station provides power to the home power station.

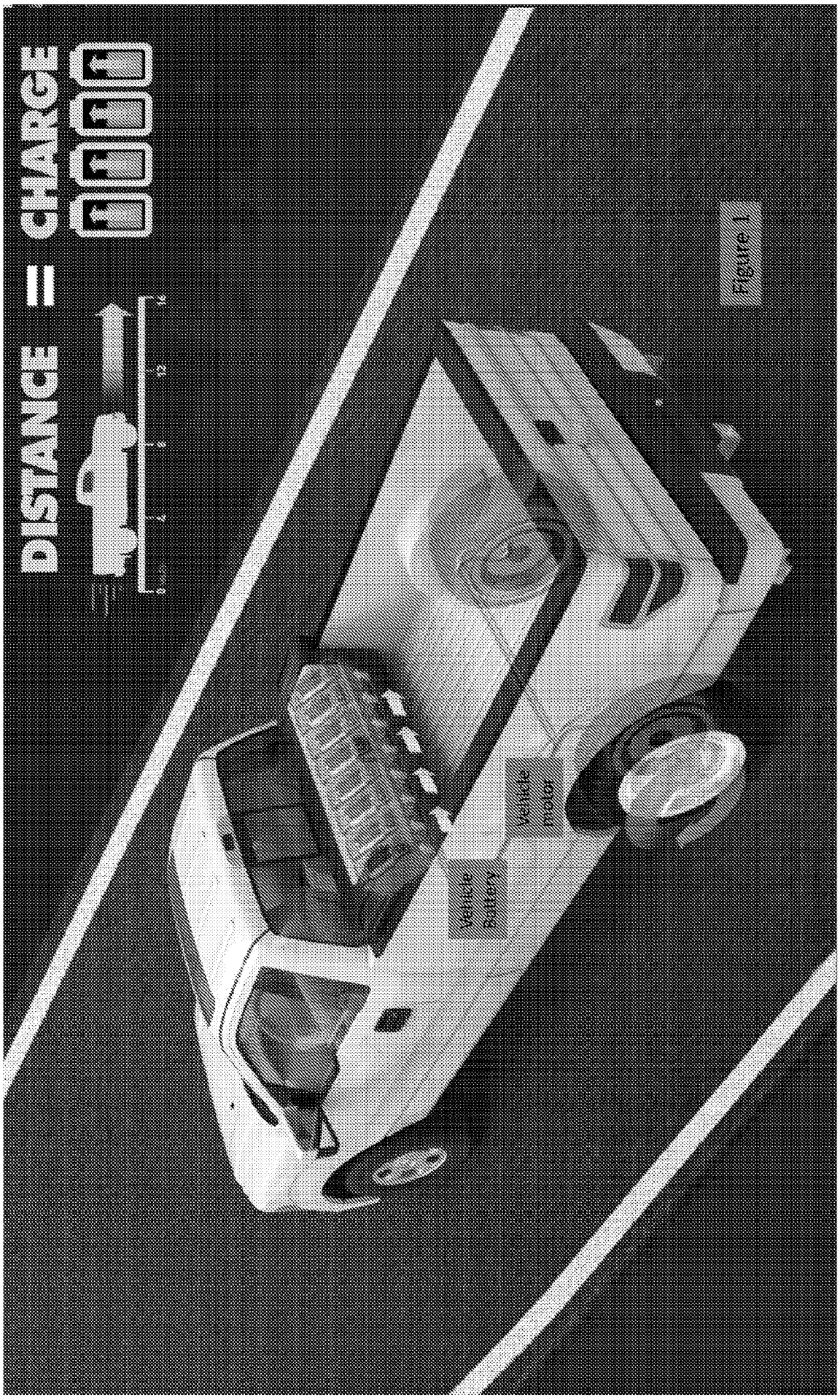


Figure 1

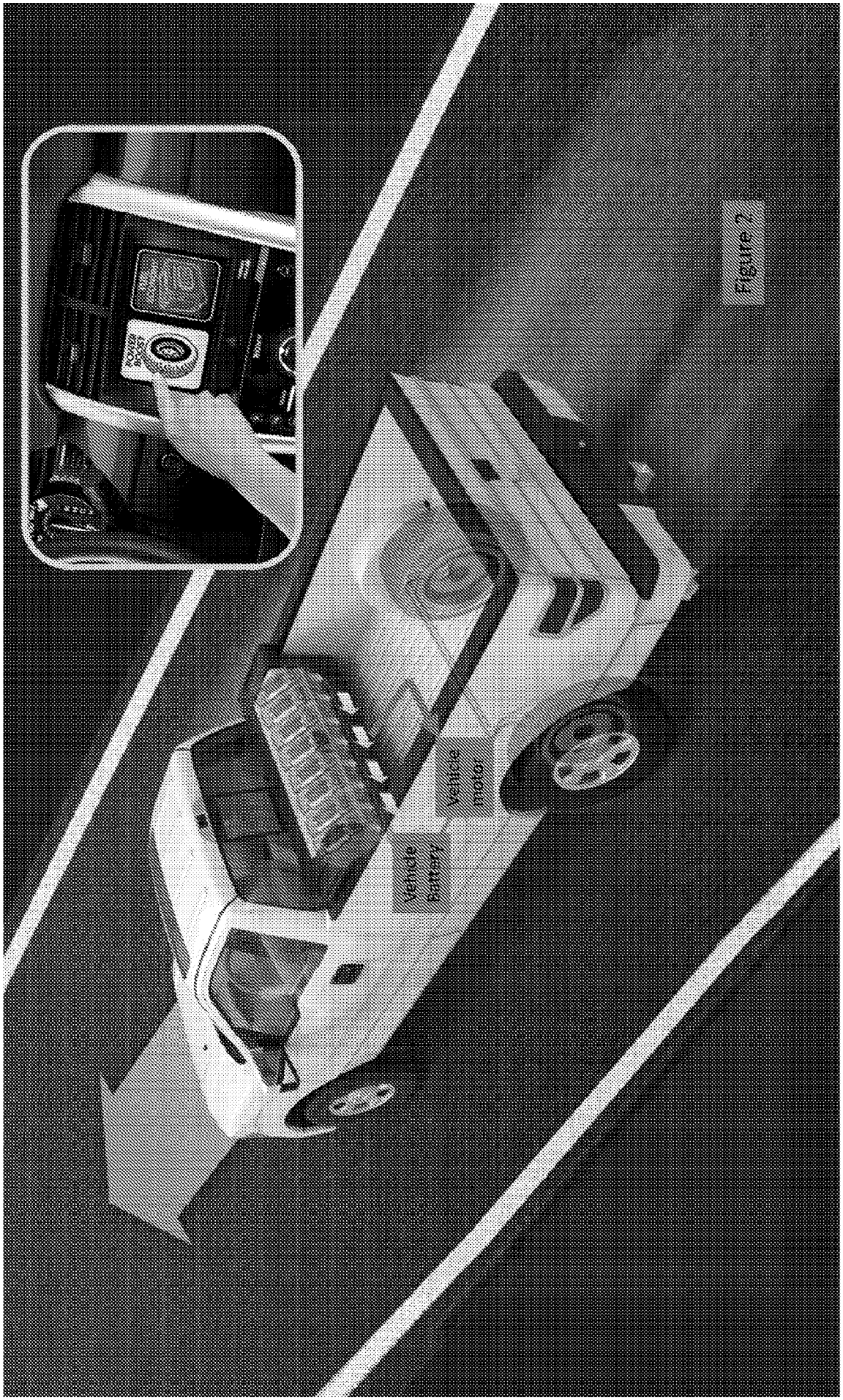


Figure 2

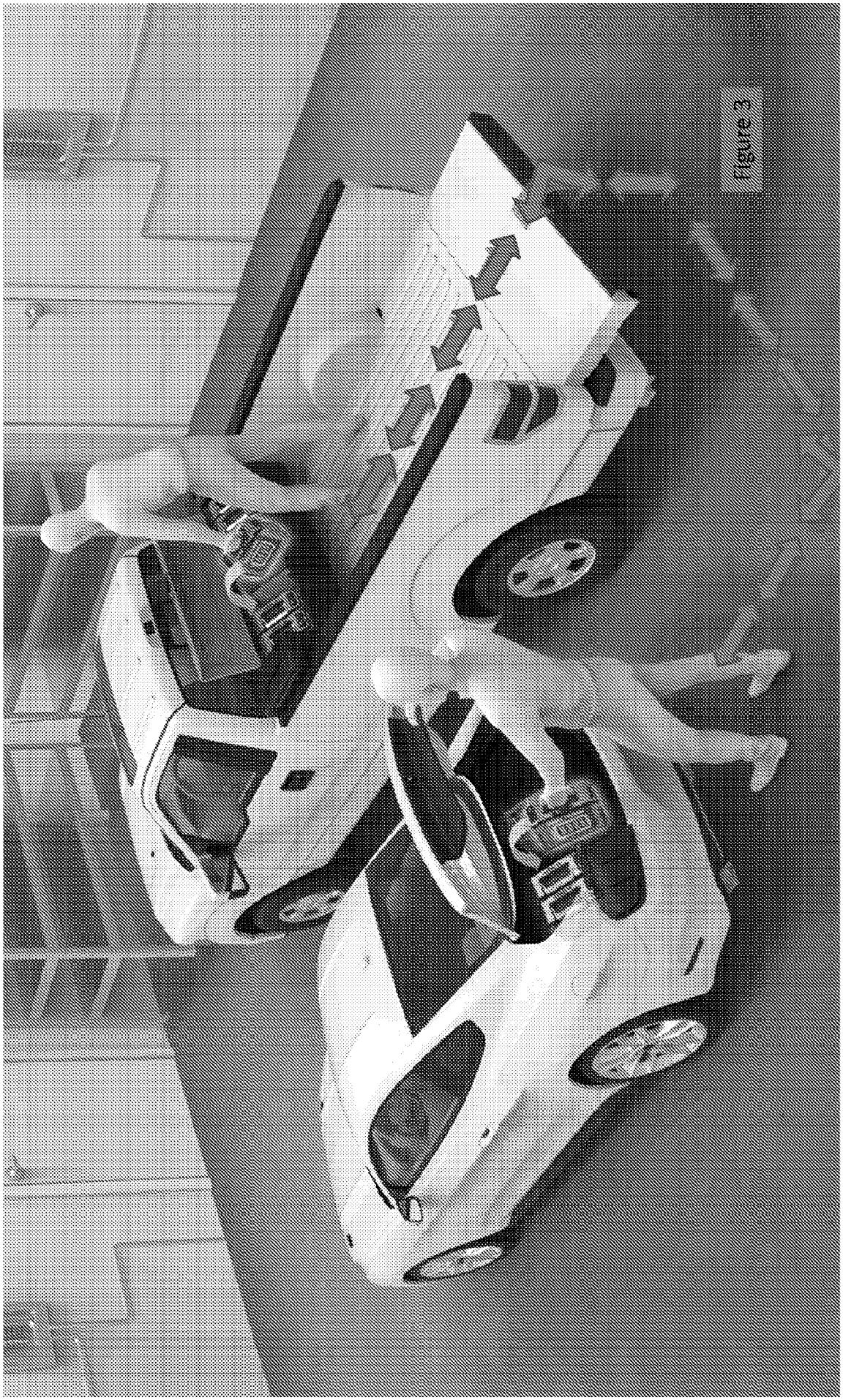


Figure 3

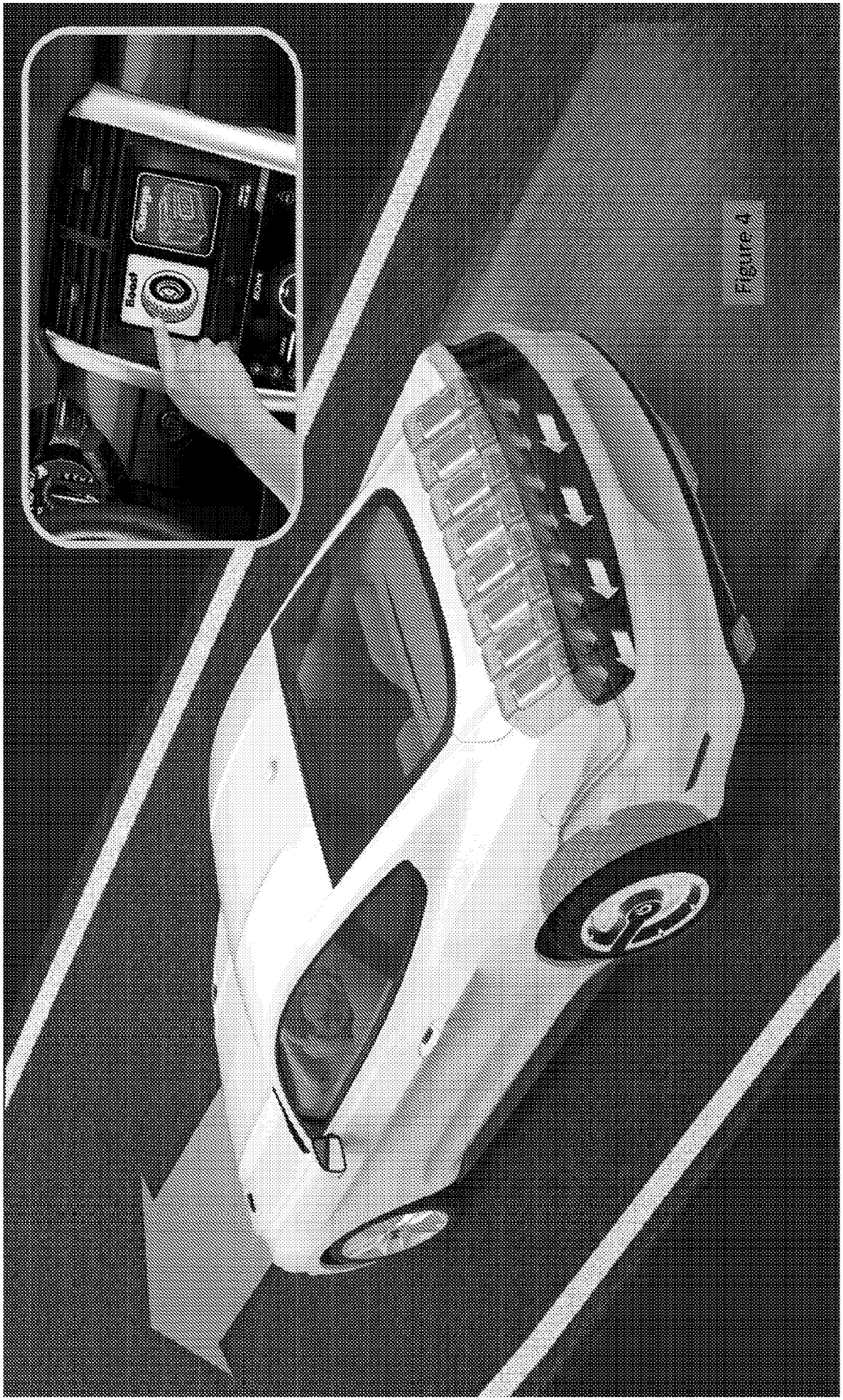


Figure 4

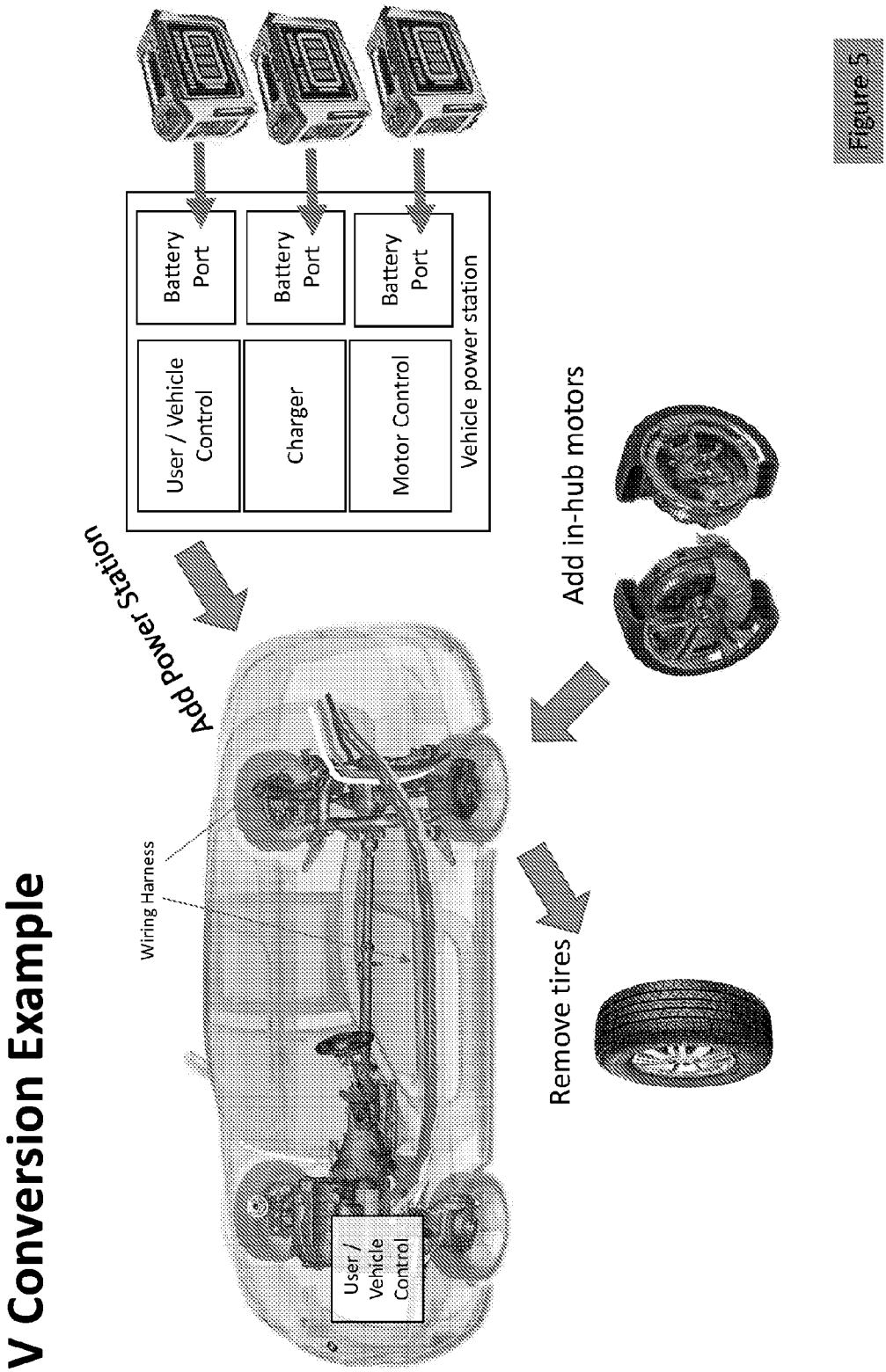

HEV Conversion Example
Add Power Station
Battery Port
Battery Port
Battery Port
User / Vehicle Control
Charger
Motor Control
Vehicle power station
Add in-hub motors
Remove tires
Wiring Harness
User / Vehicle Control

Figure 5

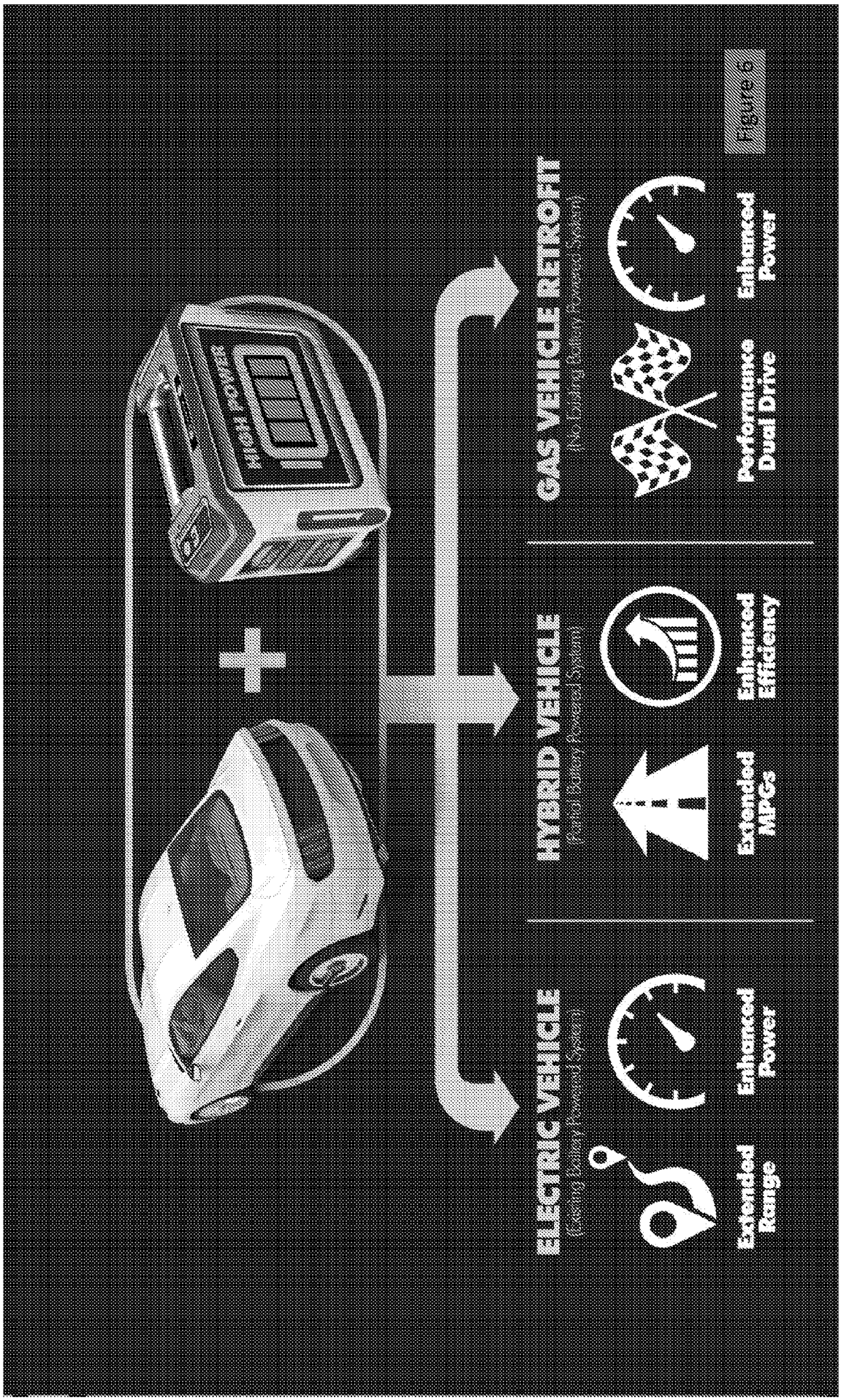

ELECTRIC VEHICLE
(Existing Battery Powered System)
Extended Range
Enhanced Power
HYBRID VEHICLE
(Added Battery Powered System)
Extended MPGs
Enhanced Efficiency
GAS VEHICLE RETROFIT
(Existing Battery Powered System)
Performance Dual Drive
Enhanced Power

Figure 6

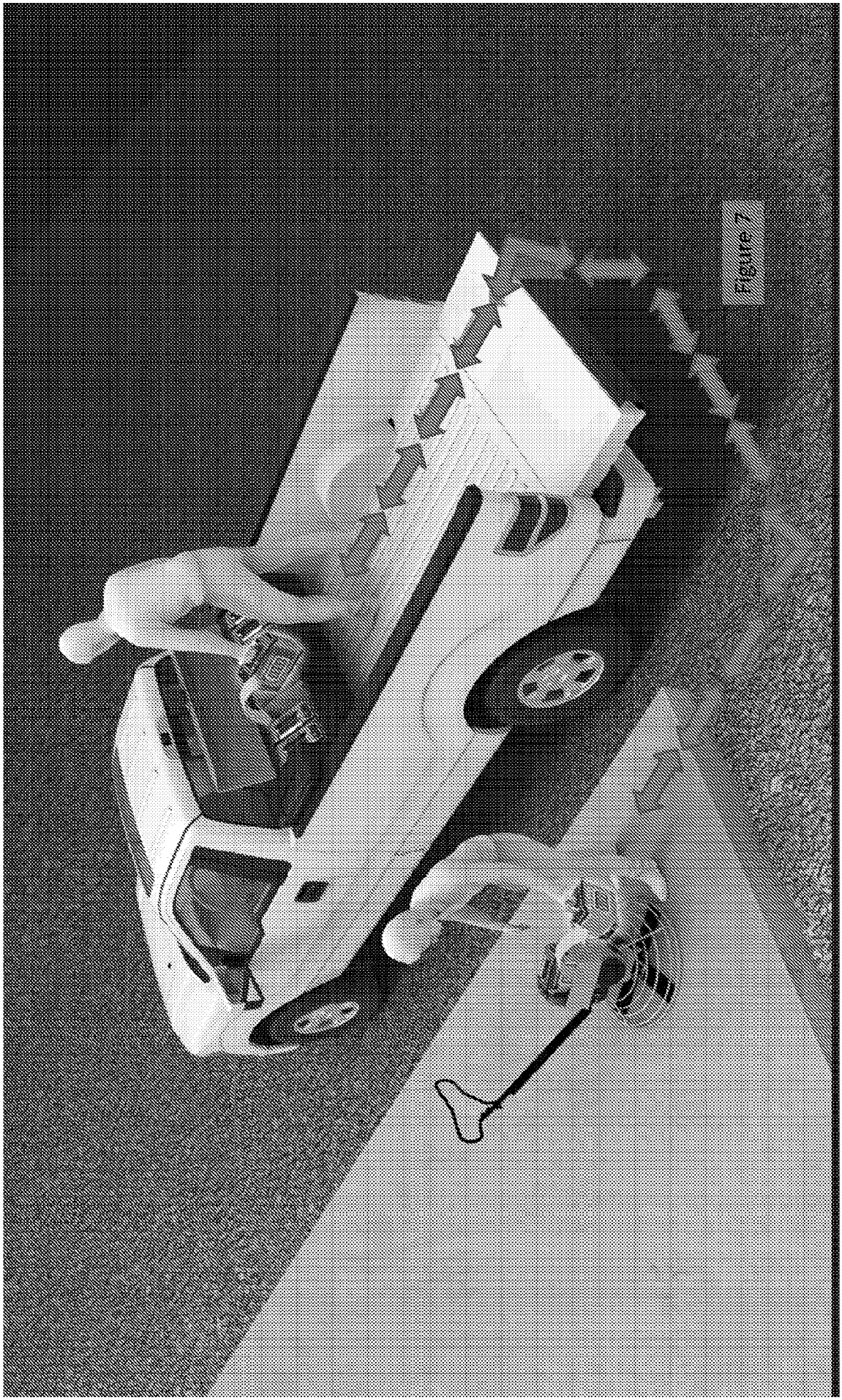


Figure 7

Figure 8

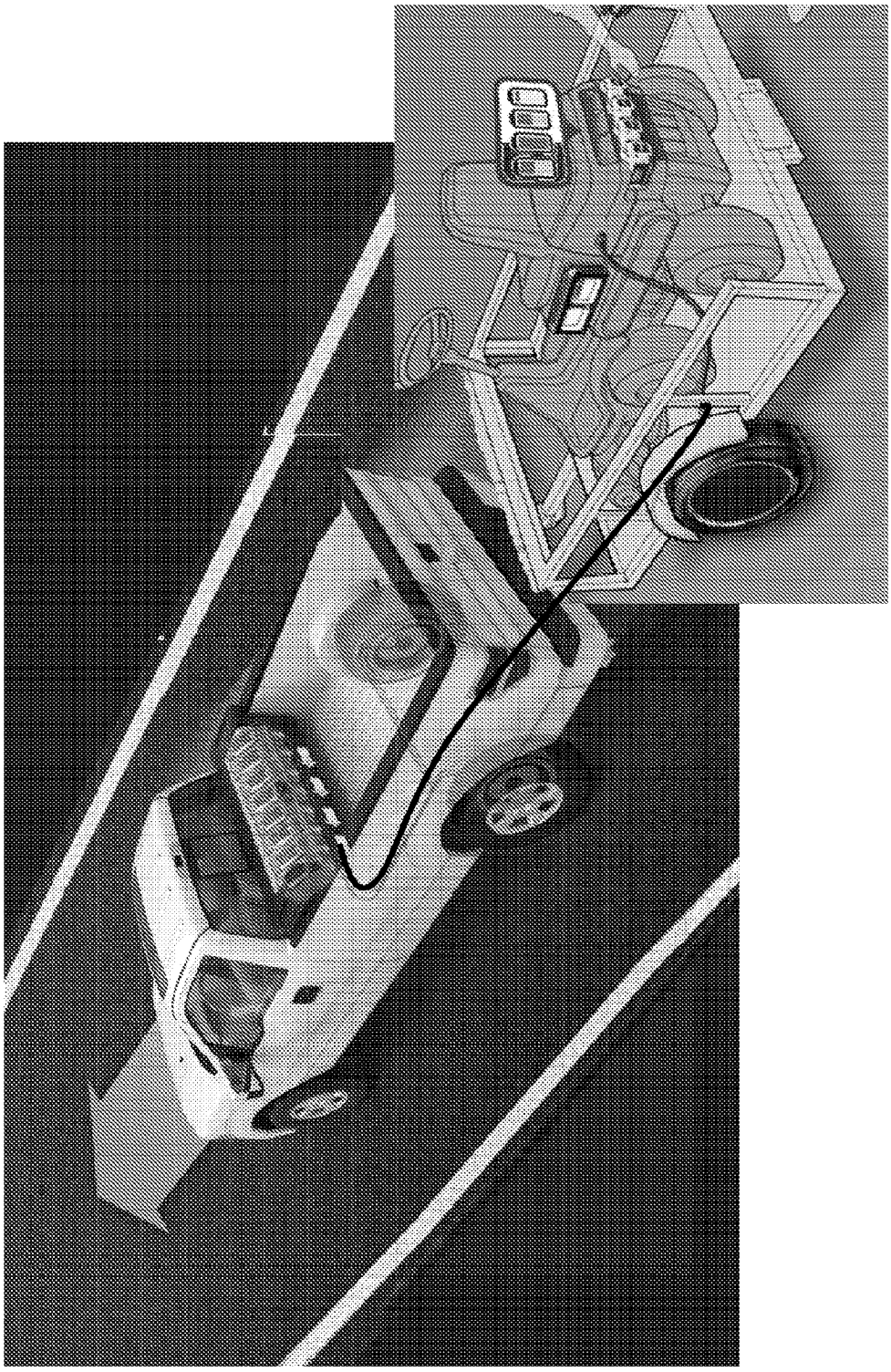


Figure 9

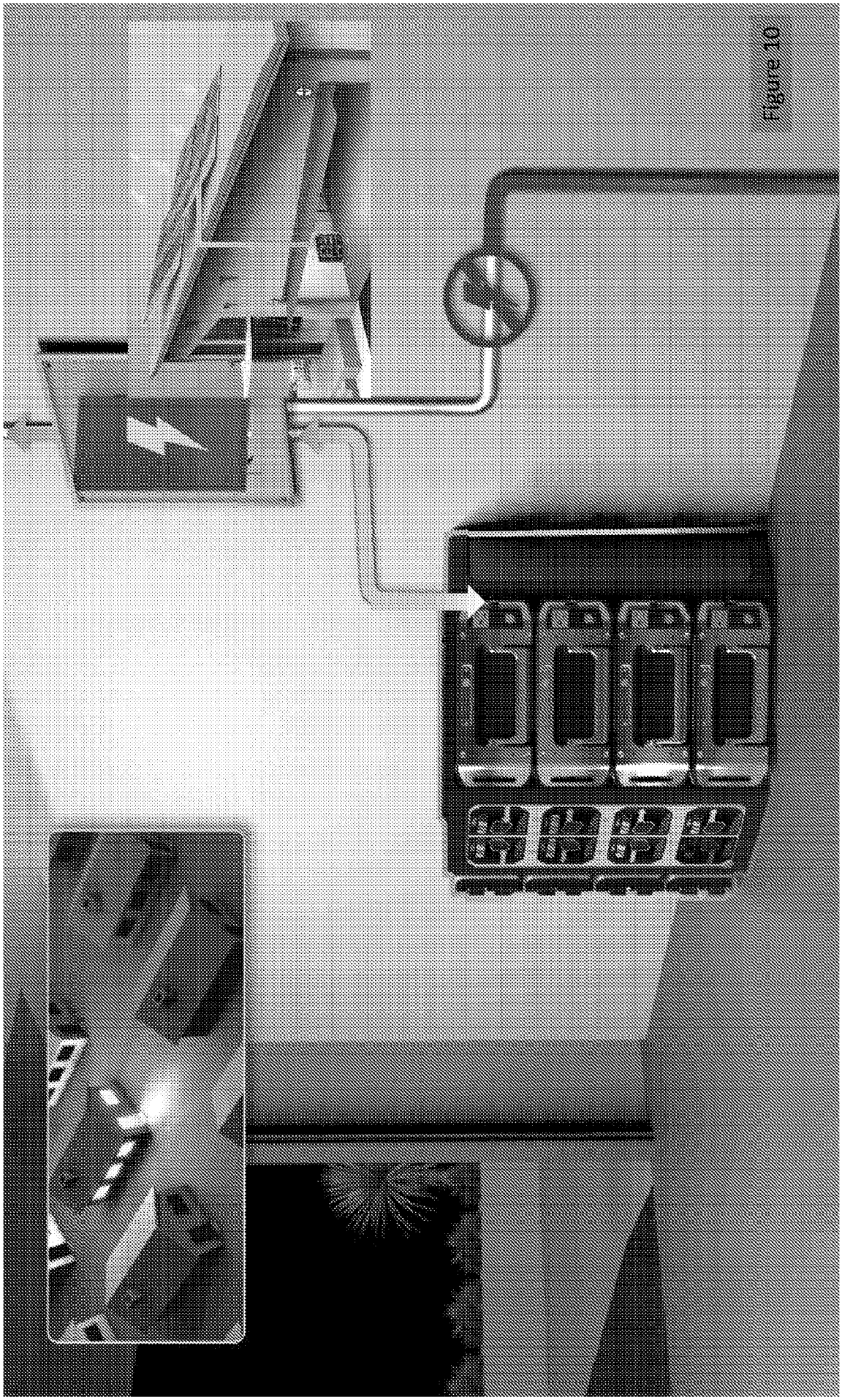
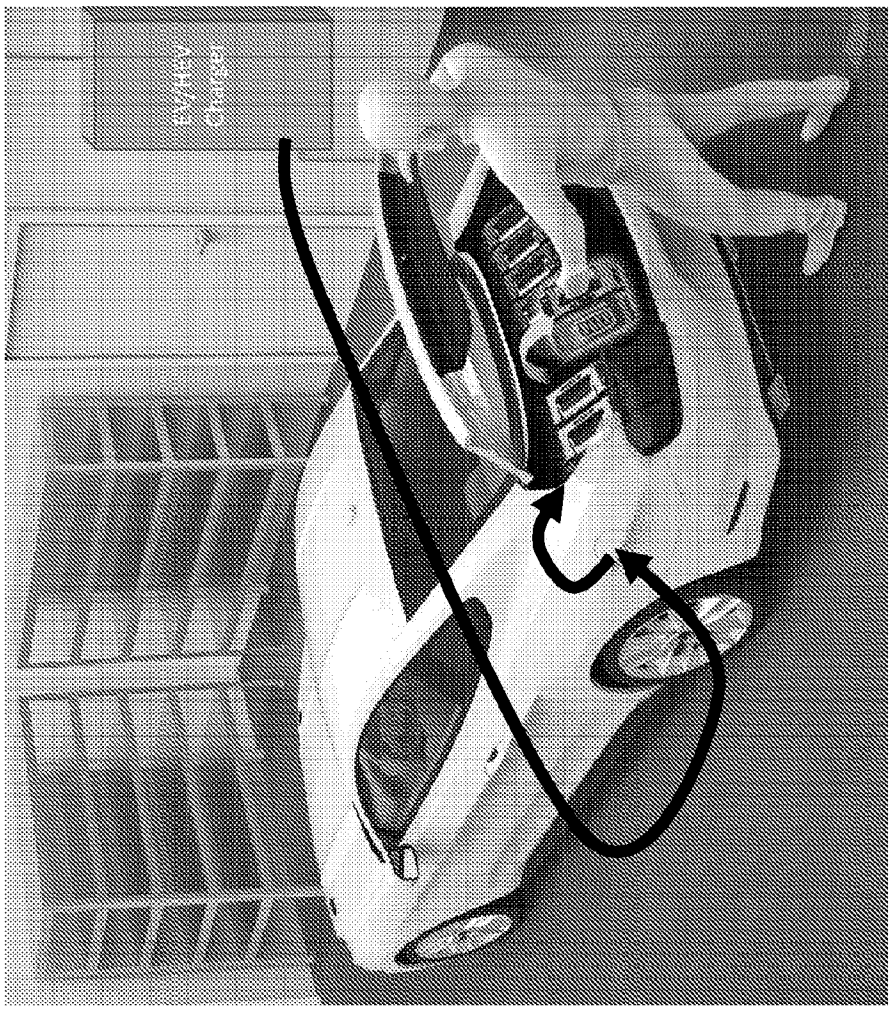


Figure 10

Figure 11



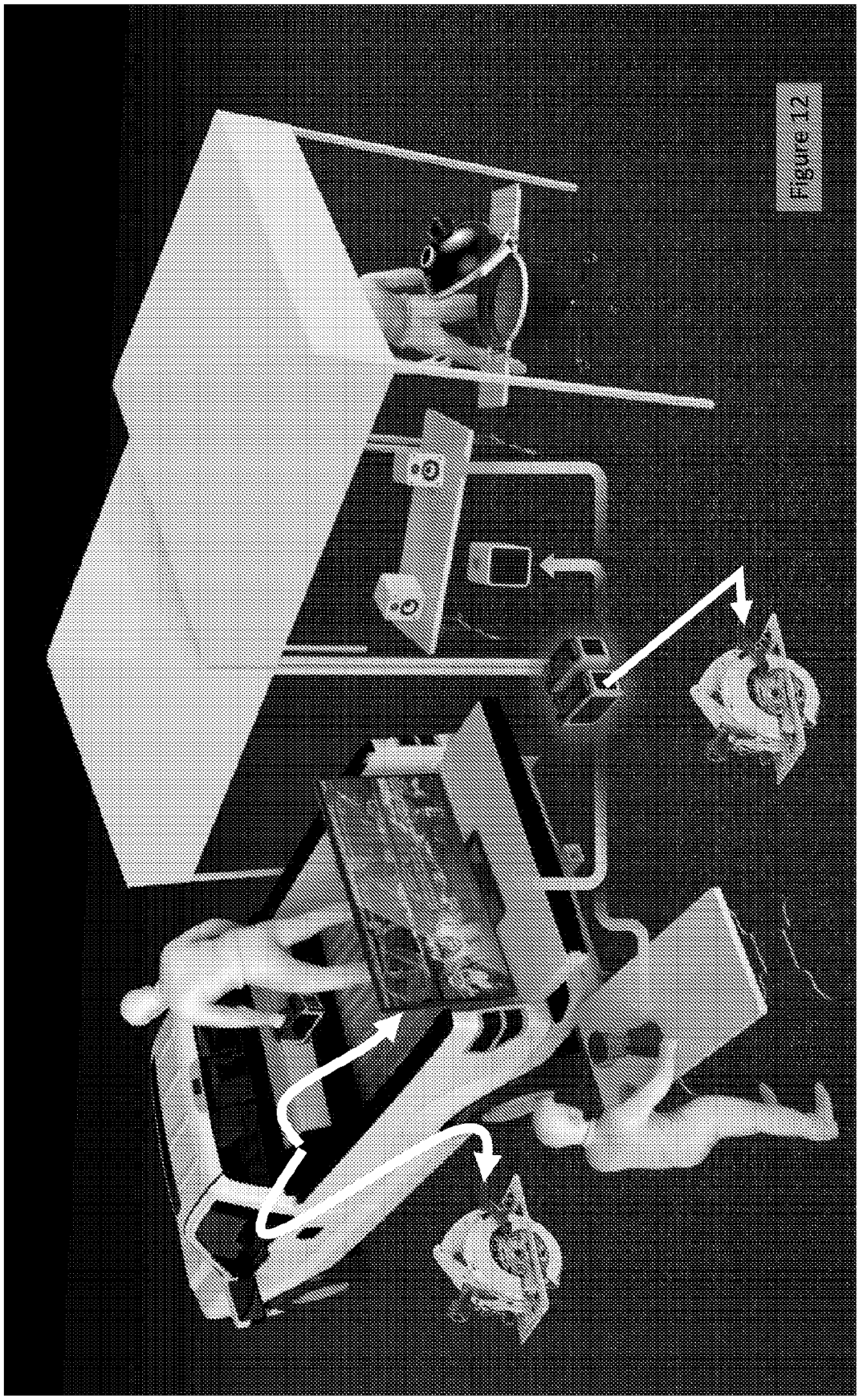


Figure 12