(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 December 2018 (20.12.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/232401 A1

(51) International Patent Classification:
G06Q 10/00 (2012.01)

(21) International Application Number:
PCT/US2018/038086

(22) International Filing Date:
18 June 2018 (18.06.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/520,598 16 June 2017 (16.06.2017) US

(71) Applicant: **CONTINENTAL AUTOMOTIVE SYSTEMS, INC.** [US/US]; One Continental Drive, Auburn Hills, Michigan 48326 (US).

(72) Inventors: **RICHARDS, Thomas Patrick**; 520 S. Edgeworth Ave, Royal Oak, Michigan 48067 (US). **MCCLAIN, Jeremy J**; 224 Presidio Dr, Ortonville, Michigan 48462 (US). **TUGGLE, Jeremy W**; 47365 Nita Drive, Shelby Township, Michigan 48317 (US).

(74) Agent: **MACKIEWICZ, Christine M** et al.; One Continental Drive, Auburn Hills, Michigan 48326 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

(54) Title: BUSINESS MODES FOR A VEHICLE WITH CUSTOMIZABLE CHASSIS MODULES WITH INTEGRATED RELATED FUNCTIONS

(57) Abstract: A method of servicing a fleet of vehicle includes collecting data from individual components on a module for a vehicle; diagnosing a performance level for each of the components; comparing the performance level for each component to a component performance standard; determining service of that component is desired based on the comparison; determining a preferred service timing based upon fleet information, vehicle information, and the performance level; and instructing a controller on the vehicle to drive to a preset location at a preset time based on the preferred service timing.

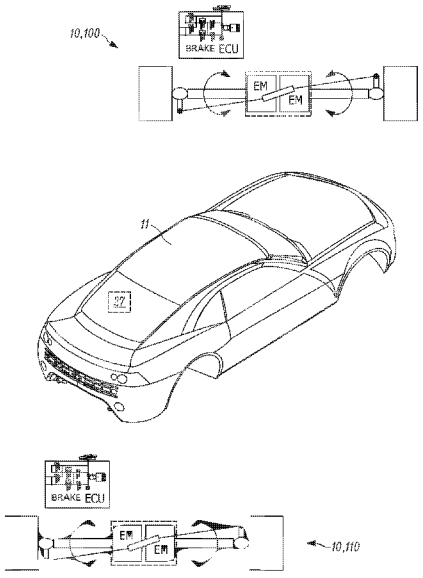

FIG. 1

WO 2018/232401 A1

[Continued on next page]

Declarations under Rule 4.17:

— *as to the identity of the inventor (Rule 4.17(i))*
— *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))*

Published:

— *with international search report (Art. 21(3))*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

BUSINESS MODES FOR A VEHICLE WITH CUSTOMIZABLE CHASSIS MODULES WITH INTEGRATED RELATED FUNCTIONS

TECHNICAL FIELD

[0001] The invention relates to a method of servicing automated driving systems for a motor vehicle, in particular for chassis, braking, steering and associated communications.

BACKGROUND

[0002] The increasing availability of technology has led to automotive vehicle becoming more automated. In particular, safety systems which assist in braking and steering in emergency situations make driving such vehicles safer. Further communications between vehicles, or vehicle and infrastructure is also becoming more popular to provide traffic and safety information to and/or from vehicles.

[0003] Vehicle-to-X communications is currently in a phase of development and standardization. This term is understood to mean in particular communication between vehicles (vehicle-to-vehicle communication) and communication between vehicles and infrastructure (vehicle-to-infrastructure communication).

[0004] With the increase in technology the driver interaction with the vehicle control systems is decreasing. With fully autonomous guidance the vehicle can maneuver itself independently in traffic and thus completely unburden the driver of the vehicle operation. As these systems become more independent the need to provide HMI and other controls available in the passenger compartment to the driver is less important.

[0005] The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

SUMMARY

[0006] A system of one or more computers can be configured to perform particular operations or actions by virtue of having software, firmware, hardware, or a combination of them installed on the system that in operation causes or cause the system to perform the actions. One or more computer programs can be configured to perform particular operations or actions by virtue of including instructions that, when executed by data processing apparatus, cause the apparatus to perform the actions.

[0007] One general aspect includes a method of servicing a fleet of vehicle including: collecting data from individual components on a module for a vehicle; diagnosing a performance level for each of the components; comparing the performance level for each component to a component performance standard; determining service of that component is desired based on the comparison; determining a preferred service timing based upon fleet information, vehicle information, and the performance level; and instructing a controller on the vehicle to drive to a preset location at a preset time based on the preferred service timing.

[0008] Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0010] Fig. 1 shows a schematic exemplary illustration of a first embodiment of a body module and end modules of the present invention;

[0011] Fig. 1A shows a schematic exemplary illustration of a first embodiment of a drive system for a module of the present invention;

[0012] Fig. 1B shows a schematic exemplary illustration of a second embodiment of a drive system for a module of the present invention;

[0013] Fig. 1C shows a schematic exemplary illustration of a third embodiment of a drive system for a module of the present invention;

[0014] Fig. 1D shows a schematic exemplary illustration of a fourth embodiment of a drive system for a module of the present invention;

[0015] Fig. 1E shows a schematic exemplary illustration of a fifth embodiment of a drive system for a module of the present invention;

[0016] Fig. 1F shows a schematic exemplary illustration of a sixth embodiment of a drive system for a module of the present invention;

[0017] Fig. 2A shows a schematic exemplary illustration of a first embodiment of a brake actuation system for a module of the present invention;

[0018] Fig. 2A shows a schematic exemplary illustration of a second embodiment of a brake actuation system for a module of the present invention;

[0019] Fig. 3A shows a schematic exemplary illustration of a first embodiment of a wheel brake system for a module of the present invention;

[0020] Fig. 3B shows a schematic exemplary illustration of a second embodiment of a wheel brake system for a module of the present invention;

[0021] Fig. 3C shows a schematic exemplary illustration of a third embodiment of a wheel brake system for a module of the present invention;

[0022] Fig. 3D shows a schematic exemplary illustration of a fourth embodiment of a wheel brake system for a module of the present invention;

[0023] Fig. 4A shows a schematic exemplary illustration of a first embodiment of a suspension system for a module of the present invention;

[0024] Fig. 4B shows a schematic exemplary illustration of a second embodiment of a suspension system for a module of the present invention;

[0025] Fig. 4C shows a schematic exemplary illustration of a third embodiment of a suspension system for a module of the present invention;

[0026] Fig. 5A shows a schematic exemplary illustration of a first embodiment of a steering system for a module of the present invention;

[0027] Fig. 5B shows a schematic exemplary illustration of a second embodiment of a steering system for a module of the present invention;

[0028] Fig. 5C shows a schematic exemplary illustration of a thid embodiment of a steering system for a module of the present invention;

[0029] Fig. 6A shows a schematic exemplary illustration of a first embodiment of a communication system for a module of the present invention; and

[0030] Fig. 6B shows a schematic exemplary illustration of a second embodiment of a communication system for a module of the present invention; and

[0031] Fig 7 shows a schematic exemplary illustration of a method of servicing a fleet of vehicles according to the present invention.

DETAILED DESCRIPTION

[0032] The following description is merely exemplary in nature and is in no way intended to limit the disclosure, its application, or uses. For purposes of clarity, the same reference numbers will be used in the drawings to identify similar elements.

[0033] The Figures illustrate schematic views of exemplary end modules 10 or corner modules 110, which are able independently operable to brake and steer themselves. The end/corner module(s) 10, 110 each have drive systems 12, 112, brake systems 14, 114, suspensions systems 16, steering systems 18 and communication systems 20. The drive system 12, 112, brake systems 14, 114, suspensions systems 16, steering systems 18 and communications systems 20 may be combined with one another in various combinations to form an end module 10 or corner module 110 as described herein.

[0034] Both types of modules 10, 110 can be quickly and easily removably secured to a vehicle body module 11. For example, the modules 10, 110 may have a support frame 24 secured to the wheels 22. Components for the drive systems 12, 112, such as a drive controller 26 can be secured and supported on the frame 24,

e.g. mounted in the body module fastened by screws or rivets. The end/corner modules 10, 110 are able to provide drive, braking and steering to move a body module 11 which may be attached. In one embodiment the support frame is a space frame design. That is, the frame is tubular or extruded metal, and can be welded or bonded, including steel or aluminum or composite material.

[0035] The connection to the body module may be via traditional fasteners, e.g. bolts, nuts, etc. In another embodiment the means for and / or eccentric clamp devices. Additionally, if the end/corner module 10, 110 uses use central hydraulic brakes then we need hydraulic quick connectors may also be used. Alternately the hydraulic brakes are confined to an end module 10, 110 or even to a corner of a corner/end module 10, 110 and hydraulic connections to the body module 11 are not necessary.

[0036] The body module 11 may define wheel wells and a compartment to provide space for the modules 10, 110 and may be placed over the modules 10, 110 and secured into position, as in the embodiment shown. Alternately the end portions of the body 11 may be secured to the modules 10, 110 and when assembled joined to the central portion of the body 11 such that the body module 11 does not have to be raised and lowered to assemble with the modules 10, 110. Further, the body module 11 may define storage space that does not interfere with the packaging space for the modules 10, 110. Preferably such storage space could be accessed from the exterior of the vehicle for use by the passengers to store items.

[0037] Additionally, the body module 11 (or the portions of the module 11 secured to the end/corner modules 10, 110) have both headlights/tail lights and brake lights such that either end of the vehicle may act as the front or the rear of the vehicle, as discussed in detail below.

[0038] The frame 24 or suspension components (discussed below) may have connection points for quickly securing the module 10, 110 to a body module 11. Matching modules 10, 110 can be secured at each end of the body module 11, or at each of the four corners of the body module 11. In this manner, the assembled motor vehicle will have a lead module, located at the forward portion of the vehicle

and a follow module located at the rear portion of the vehicle. As both modules 10, 110 are the same either end of the vehicle may be the forward/lead module 10, 110 and may switch back and forth (or reverse vehicle direction) during operation of the vehicle.

[0039] The end/corner modules 10, 110 may operate with one another in a lead/follow manner such that the end/corner modules 10, 110 on the front act as the lead and the end/corner modules 10, 110 on the rear are connected and act in a follow mode. When the vehicle changes direction the new end/corner modules 10, 110 will be the front and take the lead, while the other(s) follow. In the lead/follow mode of operation, the lead end/corner modules 10, 110 will be providing all of the necessary wheel torque for vehicle propulsion while the follow end/corner modules 10, 110 will be either disconnected so that no additional drag is provided or will be operated in a neutral (0 torque control) mode. In the case of an end/corner module 10, 110 disconnect, a disconnect clutch (not shown) may be used to mechanically decouple the drive system 12, 112 from the wheels 22. In this way, drag losses from the drive system 12, 112would be minimized for the end/corner 10, 110 module in the follow mode.

[0040] The communication system 20 allows the lead end/corner module(s) 10, 110 to communicate instructions to the follow end/corner module(s) 10, 110 as needed for braking, power, etc. The drive controller determines the 'lead module' by the direction the vehicle moves . In an alternative mode of operation, both the end/corner modules 10, 110 on the front and the rear are all providing vehicle propulsion, i.e. the total required wheel torque is distributed among two axles or four wheel, etc. This mode of operation would primarily be used in a high wheel torque demand scenario such as driving up a hill, i.e. steep road grades. In yet another mode of operation, both the front and rear end/corner modules 10, 110 may be providing propulsion but not necessarily in equal levels to achieve optimum efficiency. In other words, the distribution of propulsion between front and rear may be determined based on best operating efficiency and consideration of vehicle stability events.

[0041] The end/corner module(s) 10, 110 will require sensor input to provide the autonomous instructions for driving, braking and steering themselves. Various cameras and sensors may be connected to a controller for determining the autonomous driving instructions. The sensors, cameras and controller may be mounted on and included in the end/corner module(s) 10, 110 or may be mounted on the body and communicate the various instructions to the necessary systems 12, 112, 14, 114, 16, 18 and 20 on the end/corner module(s) 10, 110. Redundant sensing and communication can be provided for safety between the autonomous controller and the drive 12, 112 brake 14, 114 and steering systems 16 of the end/corner module(s) 10, 110.

[0042] Fig 1A shows a first embodiment of a drive system 12A for an end module 10 where the drive system 12A includes an electric machine (EM) 28 with an integrated inverter 30 connected to drive a differential 35, which is connected to two wheel assemblies 22 through drive shafts 32. The inverter 30 may be connected to a high voltage DC link to provide power to the electric machine 28. Additional high voltage energy storage 34 may also be available. The electric machine 28, inverter 30, and additional energy storage 34 may all be supported by the frame 24. As indicated by the arrows 23 and 33 the wheels 22 and drive shafts 32 may be driven to rotate in either direction. The drive controller 26 (or vehicle controller 27) will decide either one drive module from front or rear while the other operates in a follow mode OR both front and rear end/corner modules 10, 110 operate to provide propulsion. The decision is made based on desired vehicle direction, total vehicle propulsion torque demand (i.e. higher the torque demand may require both front and rear to drive for example on a road grade/hill). The decision is also made based on operating efficiency of front vs. rear and in addition based on vehicle stability/ESP limits to prevent wheel slip for traction. The driving module decision may also be changed in the case of overheating or failure of one of the end/corner modules 10, 110.

[0043] Fig 1B shows a second embodiment of a drive system 12B for an end module 10 where the drive system 12B includes an electric machine 28 with an integrated inverter 30 connected through a reduction gear set 36 to drive a differential 35, which is connected to two wheel assemblies 22 through drive shafts 32. The

inverter 30 may be connected to a high voltage DC link to provide power to the electric machine 28. Additional high voltage energy storage 34 may also be available (not shown). The electric machine 28, inverter 30, and additional energy storage 34 may all be supported by the frame 24. As indicated by the arrows 23 and 33 the wheels 22 and drive shafts 32 may be driven to rotate in either direction.

[0044] Fig 1C shows a third embodiment of a drive system 12C for an end module 10 where the drive system 12C includes two electric machines 28 with an inverter 30 to drive two wheel assemblies 22 through drive shafts 32. The electric machines 28 may be two rotors in one stator. The inverter 30 may be connected to a high voltage DC link to provide power to the electric machine 28. Additional high voltage energy storage 34 may also be available. The electric machine 28, inverter 30, and additional energy storage 34 may all be supported by the frame 24. As indicated by the arrows 23 and 33 the wheels 22 and drive shafts 32 may be driven to rotate in either direction. The drive shafts 32 are each directly driven by one of the electric motors 28.

[0045] Fig 1D shows a fourth embodiment of a drive system 12D for corner modules 110 where the drive system 112D for each corner includes an electric machine 28 with an inverter 30 to drive the wheel assembly 22 through drive shaft 32. The inverter 30 may be connected to a high voltage DC link to provide power to the EM 28. Additional high voltage energy storage 34 may also be available. EM 28, inverter 30, and additional energy storage 34 may all be supported by the frame 24. As indicated by the arrows 23 and 33 the wheel 22 and drive shaft 32 may be driven to rotate in either direction. The EM 28 is connected to the wheel 22 through a gear reducer set 36 and drive shaft 32.

[0046] Fig 1E shows a fifth embodiment of a drive system 12E for corner modules 110 where the drive system 112E for each corner includes an electric machine 28 with an inverter 30 to drive the wheel assembly 22 through drive shaft 32. The inverter 30 may be connected to a high voltage DC link to provide power to the EM 28. Additional high voltage energy storage 34 may also be available. EM 28, inverter 30, and additional energy storage 34 may all be supported by the frame 24. As indicated by the arrows 23 and 33 the wheel 22 and drive shaft 32 may be

driven to rotate in either direction. Two corner modules 110 can be connected to one another through a clutch 38. The clutch 38 may be supported on the frame 24 for one of the corner modules 110, while the other corner module 110 may include the necessary linkage to connect the two drive systems 112E to one another.

[0047] Fig 1F shows a fourth embodiment of a drive system 12F for corner modules 110 where the drive system 112F for each corner includes an electric machine 28 with an inverter 30 to drive the wheel assembly 22. The inverter 30 may be connected to a high voltage DC link to provide power to the EM 28. Additional high voltage energy storage 34 may also be available (not shown). The EM 28, inverter 30, and additional energy storage 34 may all be supported by the frame 24. As indicated by the arrows 23 the wheel 22 may be driven to rotate in either direction. The wheel 22 is directly driven by one of the electric motors 28.

[0048] Fig. 2A shows a first schematic illustration of a brake system 14, 114 for end/corner module(s) 10, 110. The brake system 14, 114 has an electro-hydraulic actuation system 40A with a controller 42 and a fluid reservoir 44. The brake system 14, 114 is connected to a power supply and a wheel speed sensor for each wheel 22. An Electric Integrated Parking Brake (EiPB) 46 is included in the brake system 14, 114. For end modules 10, a second wheel brake 48 may also be included on the second wheel 22 of the end module 10. The second wheel brake 48 may be conventional or NWC style wheel brake(s).

[0049] In one embodiment each deceleration brake event is analyzed by the brake controller and then the brake controller decides what deceleration device e.g. EM regeneration, friction brake, EPB, etc., should be used to satisfy the deceleration request. For example, possibly only the EM regenerative braking is used primarily in order to extend range of the vehicle, and friction brakes are only additionally used if necessary to reach the required deceleration. Depending on speed and deceleration request only one module may be sufficient or both modules are used to complete the request.

[0050] Fig. 2B shows a second schematic illustration of a brake system 14B, 114B for end/corner module(s) 10, 110. The brake system 14, 114 has an electro-mechanical actuation system 40B with a controller 42. The brake system 14, 114 is connected to a power supply and a wheel speed sensor for each wheel 22. A wheel brake 48 may be conventional or NWC style wheel brake(s).

[0051] Fig. 3A shows a first schematic illustration of brakes 48A for a brake system 14, 114 for end/corner module(s) 10, 110. The brake system 14, 114 has an electro-hydraulic actuation system 40A with a controller 42 and a fluid reservoir 44. A wheel brake 48 may also be included on the each wheel 22. The wheel brake 48 may be a tall narrow system with NWC style wheel brake(s).

[0052] Fig. 3B shows a second schematic illustration of brakes 48A for a brake system 14, 114 for end/corner module(s) 10, 110. The brake system 14, 114 has an electro-hydraulic actuation system 40A with a controller 42 and a fluid reservoir 44. A wheel brake 48 may also be included on the each wheel 22. The wheel brake 48 may be a conventional rotor and caliper style wheel brake(s) 48B.

[0053] Fig. 3C shows a third schematic illustration of brakes 48C for a brake system 14, 114 for end/corner module(s) 10, 110. The brake system 14, 114 has an electro-mechanical actuation system 40B with a controller 42. A wheel brake 48 is included on the each wheel 22. The wheel brake 48 may be a tall narrow system with NWC style wheel brake(s).

[0054] Fig. 3D shows a fourth schematic illustration of brakes 48D for a brake system 14, 114 for end/corner module(s) 10, 110. The brake system 14, 114 has an electro-mechanical actuation system 40B with a controller 42. A wheel brake 48 is included on the each wheel 22. The wheel brake 48 may be a conventional rotor and caliper style wheel brake(s) 48B.

[0055] The modules 10, 110 proposed would total chassis and powertrain systems to be provided in customizable modules having all the necessary functions available for integration, including Brake systems, Suspension Systems, Powertrain (Electric Traction Drive), Telematics, Transportation Services, Power Distribution,

Tires and Tire Information Systems, Hoses, Tubes, Isolation devices as well as, axels , drive shafts, structural connections, and steering Components. This will allow the body module to focus customer/driver specific experience factors, while delegating responsibility for the propulsion and lateral actuation of a vehicle to the end/corner modules 10, 110. Additionally both modules may be identical and provide the same functions. This additionally satisfies any safety requirements relating to redundancy of components, such as brake system components.

[0056] Fig 4A shows a first embodiment of a suspension system 16A for an end/corner module 10, 110 where the suspension system 16A includes a torsion spring 50 and a horizontally mounted shock absorber 52 which are connected between the wheel 22 and the frame 24 with the EM 28 and other components mount thereon. Horizontal mounting of the shock absorber 52 provides for a low packaging profile for the end/corner module 10, 110 which may be helpful when assembling/disassembling and otherwise packaging the end/corner module(s) 10, 110 to the body 11 (not shown). Since the modules are connected to the body, they provide suspension for the body module and themselves

[0057] Fig 4B shows a second embodiment of a suspension system 16B for an end/corner module 10, 110 where the suspension system 16A includes a leaf spring 50B and a horizontally mounted shock absorber(s) 52 which are connected between the wheel 22 and the frame 24 with the EM 28 and other components mount thereon. The leaf spring 50B may be a single or divided leaf spring 50B. Horizontal mounting of the shock absorber(s) 52 provides for a low packaging profile for the end/corner module 10, 110 which may be helpful when assembling/disassembling and otherwise packaging the end/corner module(s) 10, 110 to the body 11 (not shown).

[0058] Fig 4C shows a third embodiment of a suspension system 16C for an end/corner module 10, 110 where the suspension system 16C includes horizontally mounted struts 54 which are connected between the wheel 22 and the frame 24 with the EM 28 and other components mount thereon. Horizontal mounting of the shock strut(s) 54 provides for a low packaging profile for the end/corner module 10, 110 which may be helpful when assembling/disassembling and otherwise

packaging the end/corner module(s) 10, 110 to the body 11 (not shown). The strut(s) 54 may include an air spring or coil spring 50C.

[0059] Fig 5A shows a first embodiment of a steering system 18A for an end/corner module 10, 110 where the steering system 16A includes individual el. actuators 56 connected to wheel 22 on an outboard side of the frame connection, such as a drive shaft 32. The actuator 56A allows each wheel to be steered individually. The actuators may each have their own control 40, or may have one controller 40 that communicates to the actuators 56A of the other wheels 22.

[0060] Fig 5B shows a second embodiment of a steering system 18B for an end module 10 where the steering system 16B includes a conventional el. actuator 56 mounted on an inboard side of the frame connection at the EM(s) 28. The actuator 56 is connected to the wheels 22 through linkages 58. The actuator 56 may also include a controller 40 (not shown).

[0061] Fig 5C shows a third embodiment of a steering system 18C for an end module 10 where the steering system 16C includes an el. actuator 56C mounted on an inboard side of the frame connection at the EM(s) 28. The actuator 56C is independent of drive direction of the wheels 22. The actuator 56C is connected to the wheels 22 through linkages 58. The actuator 56 may also include a controller 40 (not shown).

[0062] Fig 6A shows a first embodiment of a communication system 20A for an end/corner module(s) 10, 110 the communications system 20A can provide for sending and receiving information for two end modules 10, or four corner modules 110 mounted to one vehicle body 11. The vehicle controller 27 will decide either one drive module from front or rear while the other operates in a follow mode OR both front and rear end/corner modules 10, 110 operate to provide propulsion. The lead end/corner module(s) 10, 110 can direct the various systems of the follow end/corner module(s) 10, 110 with the necessary instructions for providing vehicle functions. For example, for a brake system 12 (electro-mechanical system 14B shown) the ECU 40 for the lead end/corner module(s) 10, 110 may determine the braking necessary and communicated to the ECU 40 for the follow end/corner module(s) 10, 110 the necessary braking instructions. Similarly, the drive systems

12, 112 and steering systems 18 (individual actuators 56A shown) may also provide communications between the end/corner module(s) 10, 110. The communication system can be a Controller Area Network (CAN) based or Ethernet based system running on 12 Volts or 48 Volts. The drive systems 12, 112, brake systems 14, 114, and steering systems 18 can have common or individual controllers 40 (individual shown). The communications system 20A connects the controllers 40 for each end/corner module 10, 110 to one another. Further, if necessary the communication system 20A may also be capable of handling communication between the end/corner module(s) 10, 110 and other vehicles or infrastructure, V to X communications. Preferably both drive modules as well as the body module are connected to the same CAN or Ethernet. With that they can exchange information and the connection to the infrastructure is accomplished via wireless communication, i.e. cellular.

[0063] Fig 6B shows a second embodiment of a communication system 20B for an end/corner module(s) 10, 110 the communications system 20B can provide for sending and receiving information for two end modules 10, or four corner modules 110 mounted to one vehicle body 11. The lead end/corner module(s) 10, 110 can direct the various systems of the follow end/corner module(s) 10, 110 with the necessary instructions for providing vehicle functions. For example, for a brake system 12 (electro-hydraulic system 14A shown) the ECU 40 for the lead end/corner module(s) 10, 110 may determine the braking necessary and communicated to the ECU 40 for the follow end/corner module(s) 10, 110 the necessary braking instructions. Similarly, the drive systems 12, 112 and steering systems 18 (drive independent conventional actuator 56C shown) may also provide communications between the end/corner module(s) 10, 110. The communication system can be a CAN based or Ethernet based system running on 12 Volts or 48 Volts. The drive systems 12, 112, brake systems 14, 114, and steering systems 18 can have common or individual controllers 40 (individual shown).

[0064] Therefore, an end/corner module 10, 110 can be built in a modular manner by selecting one of the drive systems 12, 112 one of the brake systems 14, 114 one of the suspensions systems 16, one of the steering systems 18 and one of the communication systems 20 and assembling them together on a frame 24 with the

wheel(s) 22. The end/corner module(s) 10, 110 will be independently operable from one another to autonomously drive, brake and steer themselves. One or more end/corner module(s) 10, 110 may be assembled onto a body 11 to create a vehicle that can be autonomously controlled by the end/corner module(s) 10, 110.

[0065] Referring to Figure 7, a method for servicing a fleet of vehicles having corner/end modules is described. Vehicles today have components designed and purchased separately through original equipment manufacturers (OEMs), or in some limited combination thereof. By offering the end module or corner module 10, 110 as a single comprehensive assembly, OEMs will now have the opportunity to order substantial functional components as a single 'bundle'. The critical chassis, powertrain and communications components can be included into modules that can implemented in different configurations. End modules 10 can include tires, wheels, brake actuation components, air suspension components, electric traction drive, steering actuators, linkages, along with the relevant sensors and control electronics. These modules 10 would be implemented on the front or rear of a vehicle. Corner modules 110 can include tires, wheels, brake actuation components, air suspension components, electric traction drive, steering actuators, linkages, along with the relevant sensors and control electronics. These modules 110 would be implemented for the corners of the vehicle.

[0066] Service could be by either swapping out worn components and or modules, outside of dealership as a convenience for end users. Data collected through various sensorics and or algorithms regarding the performance of components to improve their features and functions. Such customizable modules 10, 110 enables proactive preventive maintenance of components via prognostic capabilities and improves serviceability of components. Components may be serviced by replacing a module 10, 110 for service off line, while continuing to allow the vehicle to operate. By keeping the end module or corner module concept, there is considerably more flexibility and component interchangeability in the implementation.

[0067] The corner module and end module will allow for repair and replacement of complete modules in a very fast so that they can quickly be returned to service.

Due to flexibility the end and corner modules 10, 110 provide various levels of performance by swapping out components to achieve different results (swapping out a relatively weaker electric motor traction drive in favor of a relatively stronger one in order to achieve improved performance).

[0068] The method would also offer a service through OEMs or fleet owners to do preventive maintenance, by either swapping out worn components and or modules, outside of dealership as a convenience for end users. The system would offer data collected through various sensorics and or algorithms regarding the performance of our components to OEMs to improve their features and functions. The system would offer system designs including realization of functional safety features and functions for the application of these concepts to meet functional safety requirements for various levels of autonomous driving.

[0069] Data from the vehicle can be used to monitor vehicle for current, suspected, or predicted performance and maintenance. Therefore the system and method may provide a service which prognosticates and/or diagnoses to schedule repair or preventative maintenance. Based on the predicted or diagnosed purpose the system may schedule such service with the vehicle through a communication device. Such scheduling would be based on severity of the repair and/or maintenance required, predicted vehicle mileage, length of the repair and/or maintenance service time, etc. The prognosis and/or diagnosis is performed by the system and is based on the vehicle information and general vehicle and component performance information, and fleet management information.

[0070] Vehicles today have these components designed and purchased separately by OEMs, or in some limited combination thereof. By offering the end module or corner module solutions as a single comprehensive assembly, OEMs will now have the opportunity to order substantial functional components as a single 'bundle'. The integration of these components enables a method of servicing the vehicle that can offer new and novel features and services such as: prognostic services, data collection and distribution, in field preventive maintenance / repairs. In certain business cases, prognostic services could be used to increase availability (in field) of ride share applications.

[0071] Such servicing could depend on the business model of the OEM and/or fleet owner, we could offer these modules through traditional sales channels with OEMs, or as leases so that customers could pay for the usage while Service would be responsible for performance of upkeep. This type of leasing could be based on per unit vehicle numbers, per unit module numbers, vehicle mileage, or individual module mileage, etc.

[0072] The method 200 comprising a first step 202, of collecting data from individual components on a module for a vehicle. A second step 204 of diagnosing a performance level for each of the components. The performance level for each component is compared to a component performance standard, step 206, and determines service of that component is desired based on the comparison, step 208. A preferred service timing is determined based upon fleet information, vehicle information, and the performance level, step 210. A controller on the vehicle is instructed to drive to a preset location at a preset time based on the preferred service timing, step 212.

[0073] The payment for servicing of the fleet is based on at least one of: a monitored mileage for each module of the fleet, a monitored mileage for each vehicle of the fleet, size of the fleet, type of usage for the fleet, and component for which service is desired is replaced, step 214. Afterwards the vehicle is returned to fleet operation, step 216.

[0074] Although the above method is described for a vehicle 10 having corner or end modules 10, 110, this method of monitoring can also be applied to a vehicle having an entire chassis module where the body and passenger compartment can be moved to another chassis and sent back out while the chassis module is serviced, or simply to schedule servicing of the vehicle chassis module at a convenient time before the vehicle 10 returns to service.

[0075] The invention is not limited to the exemplary embodiment described above. To a far greater extent, other variants of the invention can be derived by persons skilled in the art without departing from the object of the invention. In particular, all individual features described in connection with the exemplary embodiment can

also be combined in other ways with each other without departing from the object of the invention.

Claims

What is claimed is:

1. A method of servicing a fleet of vehicle comprising:

collecting data from individual components on a module for a vehicle;

diagnosing a performance level for each of the components;

comparing the performance level for each component to a component performance standard;

determining service of that component is desired based on the comparison;

determining a preferred service timing based upon fleet information, vehicle information, and the performance level; and

instructing a controller on the vehicle to drive to a preset location at a preset time based on the preferred service timing.

2. The method of claim 1, further comprising leasing the servicing of the fleet on at least one of: a monitored mileage for each module of the fleet, a monitored mileage for each vehicle of the fleet, size of the fleet, type of usage for the fleet.

3. The method of claim 1, further comprising replacing the component for which service is desired.

4. The method of claim 3, wherein replacing the component further comprises replacing the module which contains the component for which service is desired.

5. The method of claim 1, wherein the fleet information comprises at least one of: number of vehicles in service, fleet size, availability of replacement component, availability of replacement module, current demand on the fleet vehicles, predicted demand on the fleet vehicles, and predicted servicing of components on other fleet vehicles.

6. The method of claim 1, wherein the vehicle information comprises at least one of: current demand on the vehicle, predicted demand on the vehicles, performance level of other components on the vehicle, predicted servicing of other components on the vehicle, mileage on the vehicle, and mileage on the individual modules of a vehicle

7. The method of claim 1, wherein the diagnosing a performance level for each component comprises at least one of: comparing the component performance to performance of the same component on other modules in the fleet, and to a standard performance level for that component for vehicles of a similar type, and to a standard performance level for that component for vehicles of similar usage.

8. The method of claim 1, wherein the component performance standard includes at least a first category for acceptable performance, a second category for degrading performance in which service will be desired within a predicted amount of time, and a third category for unacceptable performance in which service will be desired at the earliest opportunity.

9. The method of claim 1, wherein the component performance standard includes a fourth category of performance which is inoperable until service is performed.

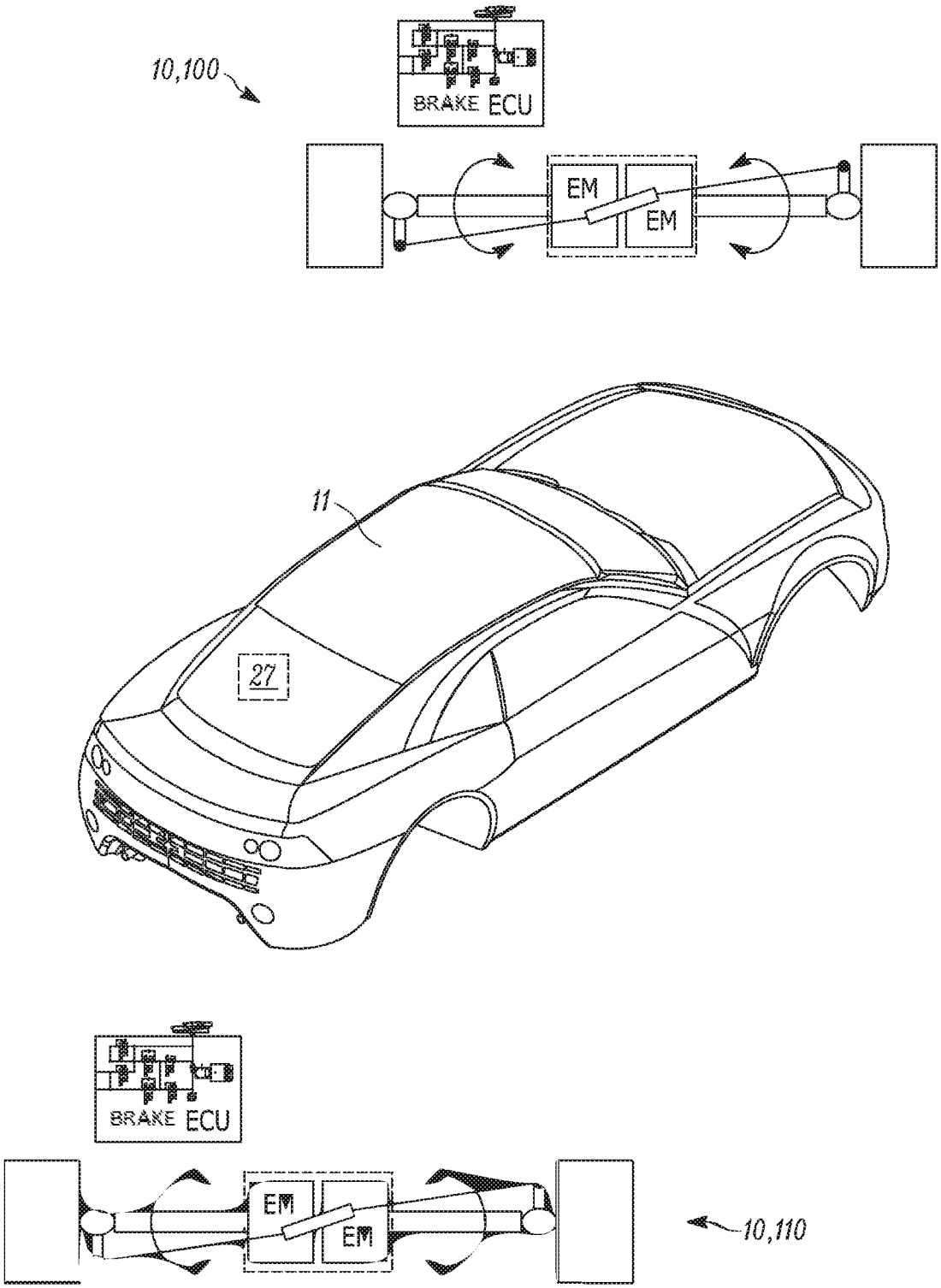

FIG. 1

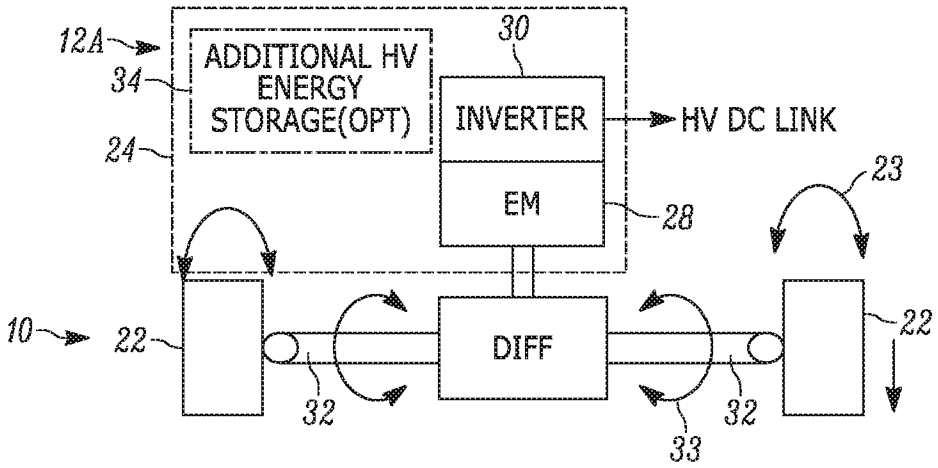
12A
ADDITIONAL HV ENERGY STORAGE(OPT)
34
30
INVERTER
HV DC LINK
24
EM
28
23
10
22
DIFF
22
32
32
33

FIG. 1A

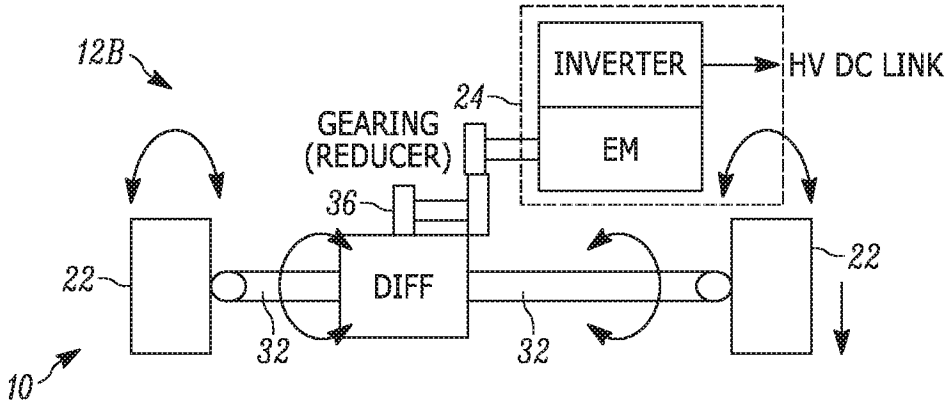
12B
INVERTER
HV DC LINK
24
GEARING (REDUCER)
EM
36
22
DIFF
22
32
32
10

FIG. 1B

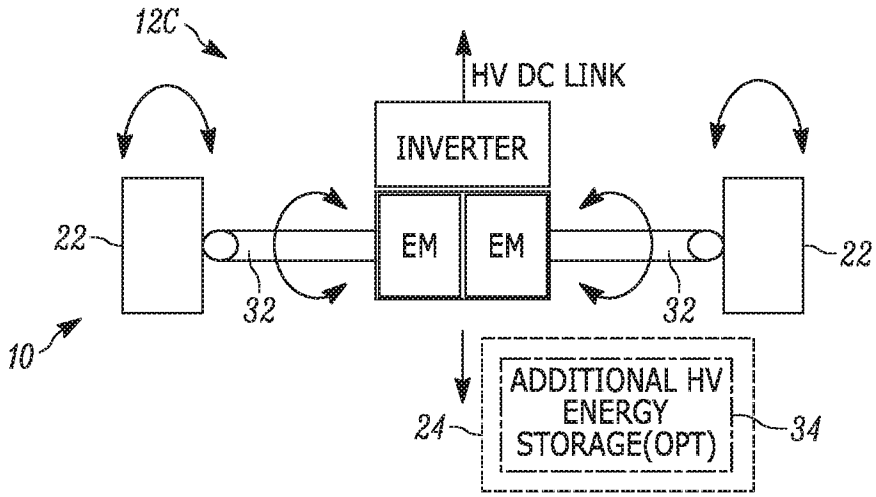
12C
HV DC LINK
INVERTER
EM
EM
22
22
32
32
10
ADDITIONAL HV ENERGY STORAGE(OPT)
24
34

FIG. 1C

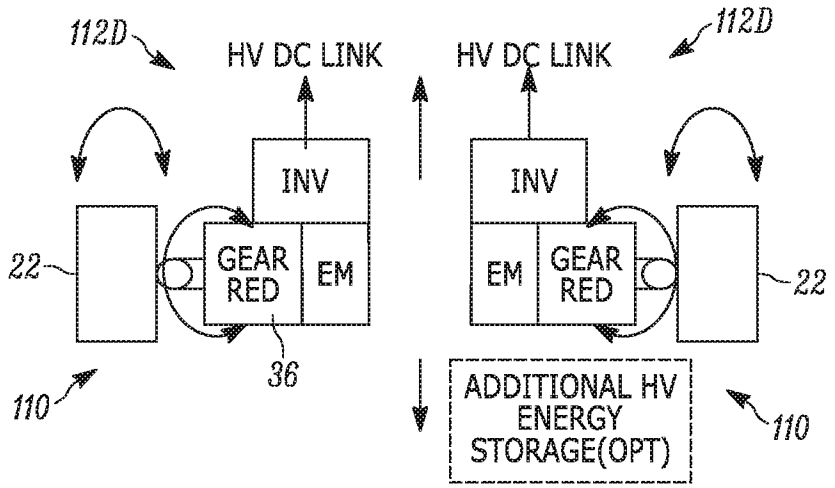
112D
HV DC LINK
HV DC LINK
112D
INV
INV
GEAR RED
EM
EM
GEAR RED
22
22
36
110
ADDITIONAL HV ENERGY STORAGE(OPT)
110

FIG. 1D

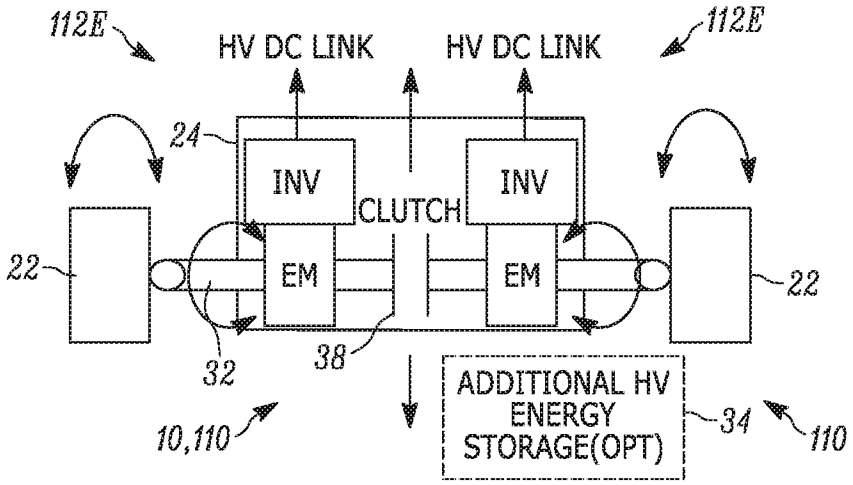
112E
HV DC LINK
HV DC LINK
112E
24
INV
CLUTCH
INV
22
EM
EM
22
32
38
ADDITIONAL HV ENERGY STORAGE(OPT)
34
110
10,110

FIG. 1E

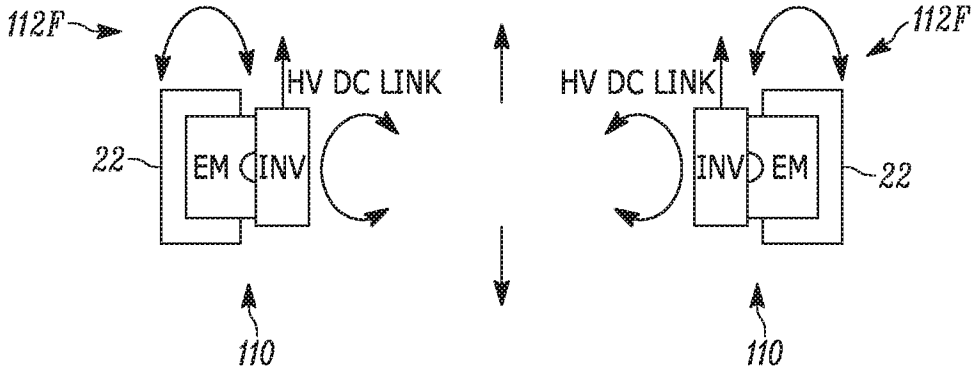
112F
HV DC LINK
HV DC LINK
112F
22
EM
INV
INV
EM
22
110
110

FIG. 1F

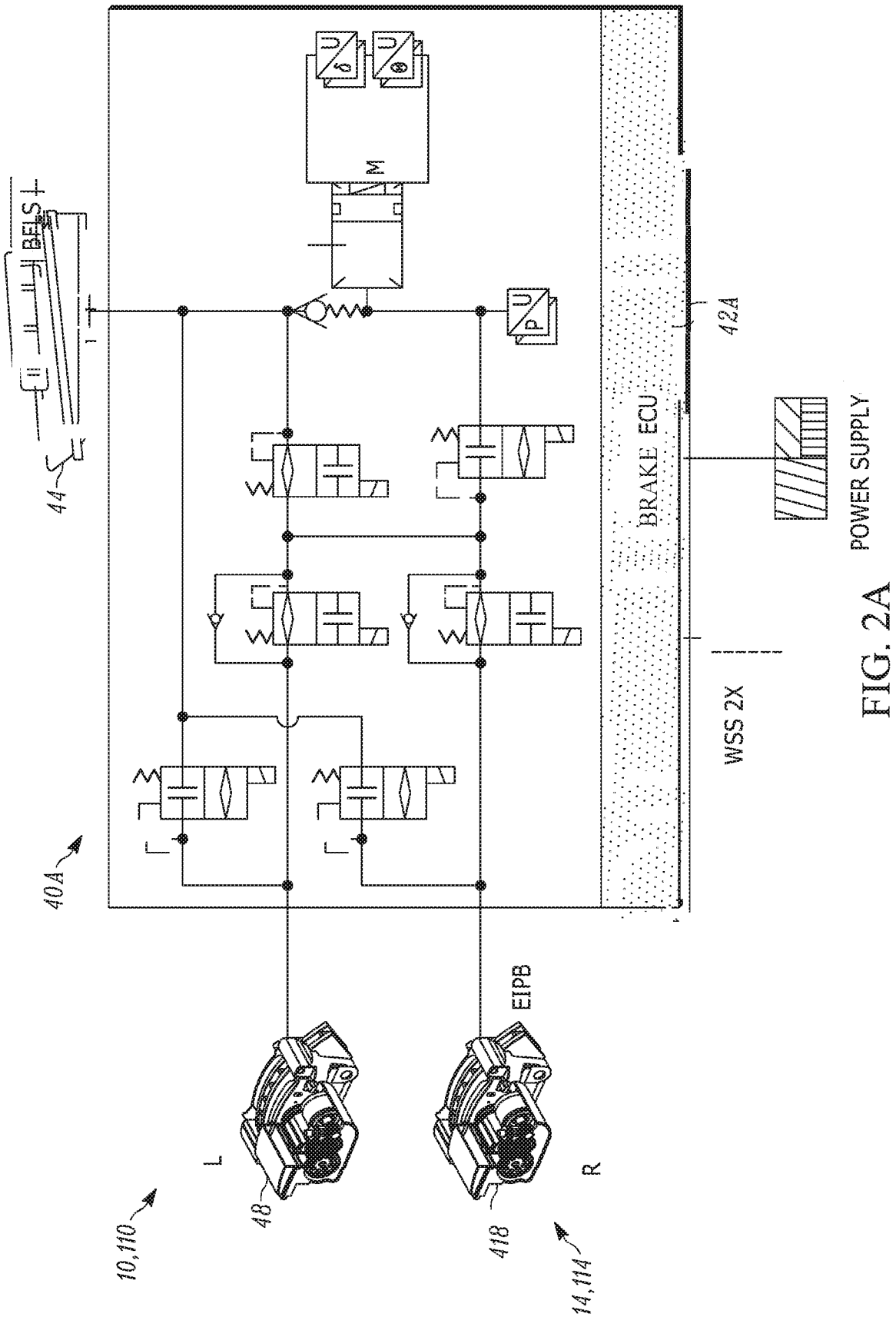
BFLS
44
40A
M
P
42A
BRAKE ECU
POWER SUPPLY
WSS 2X
EIPB
L
R
48
418
10,110
14,114

FIG. 2A

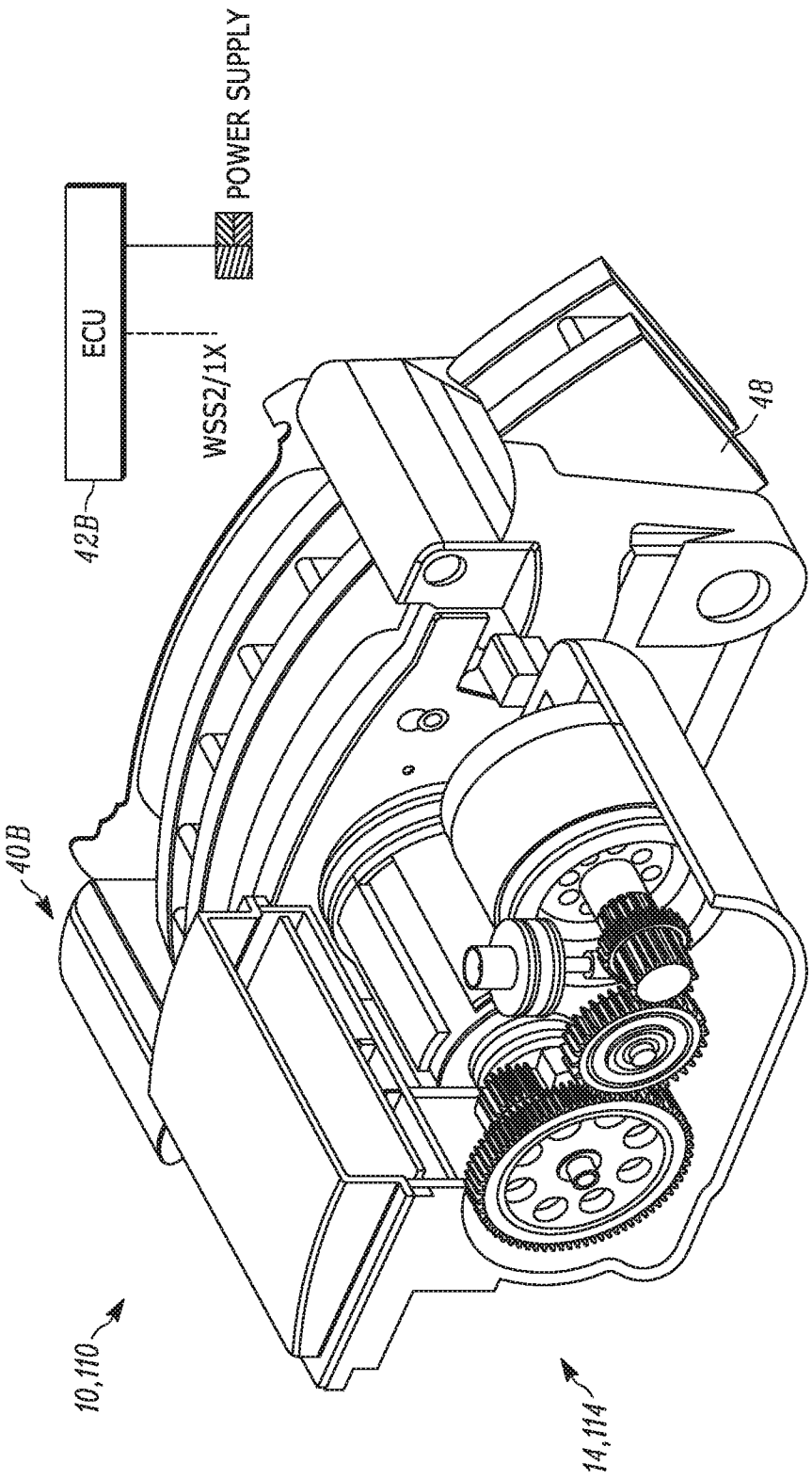

FIG. 2B

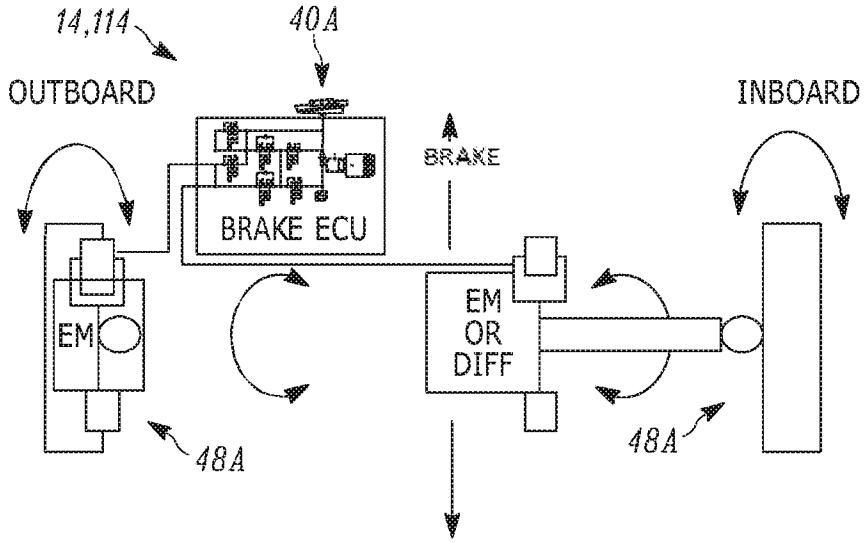
14,114
40A
OUTBOARD
INBOARD
BRAKE
BRAKE ECU
EM
EM
OR
DIFF
48A
48A

FIG. 3A

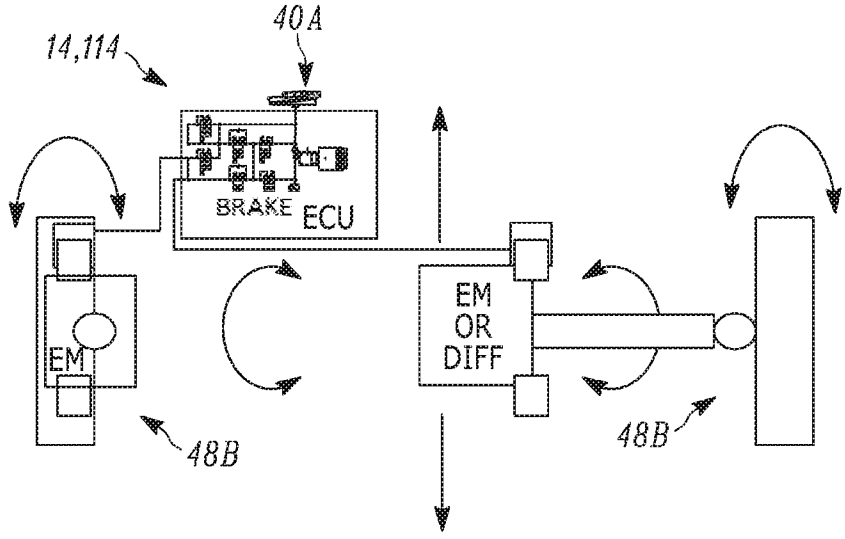
40A
14,114
BRAKE ECU
EM
EM
OR
DIFF
48B
48B

FIG. 3B

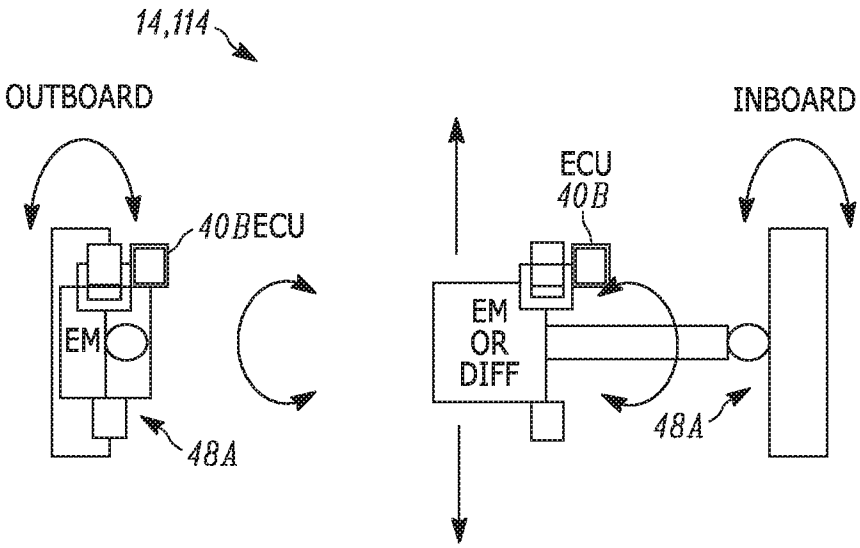
14,114
OUTBOARD
INBOARD
40BECU
EM
48A
ECU
40B
EM
OR
DIFF
48A

FIG. 3C

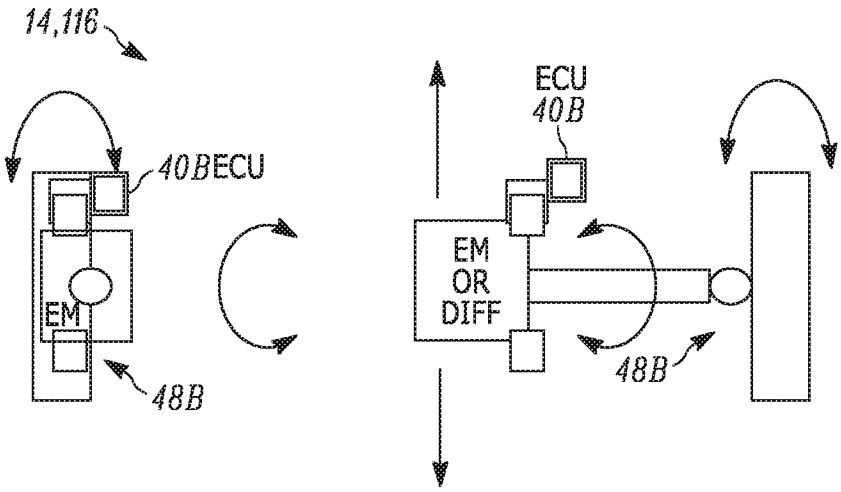
14,116
40BECU
EM
48B
ECU
40B
EM
OR
DIFF
48B

FIG. 3D

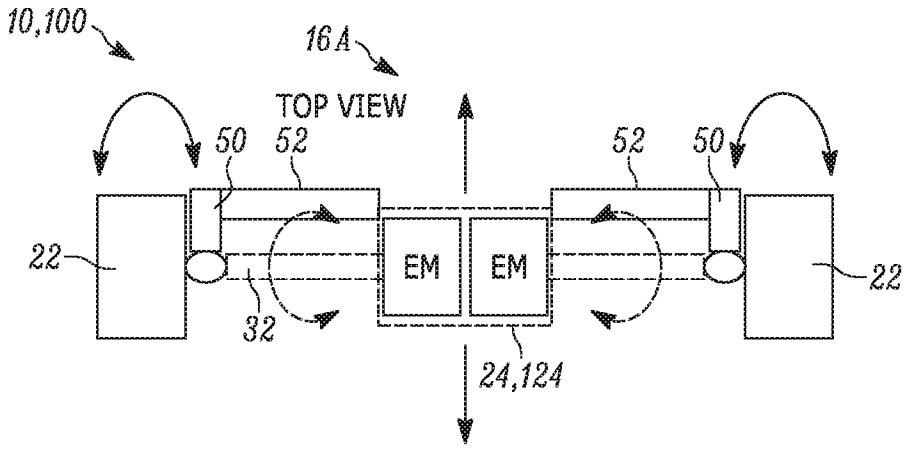

FIG. 4A

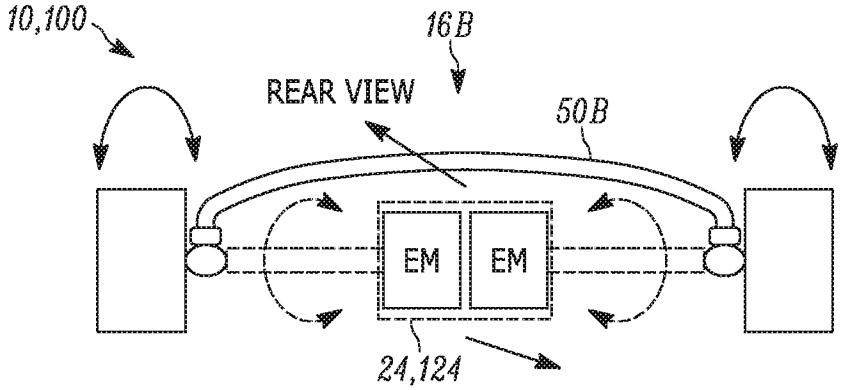

FIG. 4B

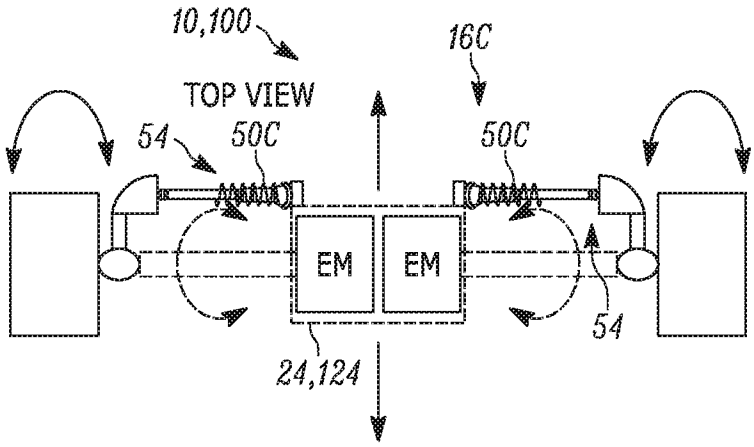

FIG. 4C

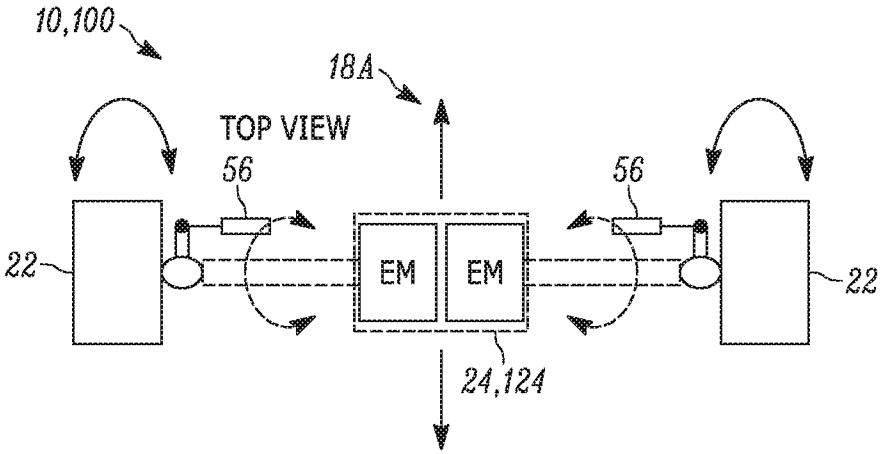

FIG. 5A

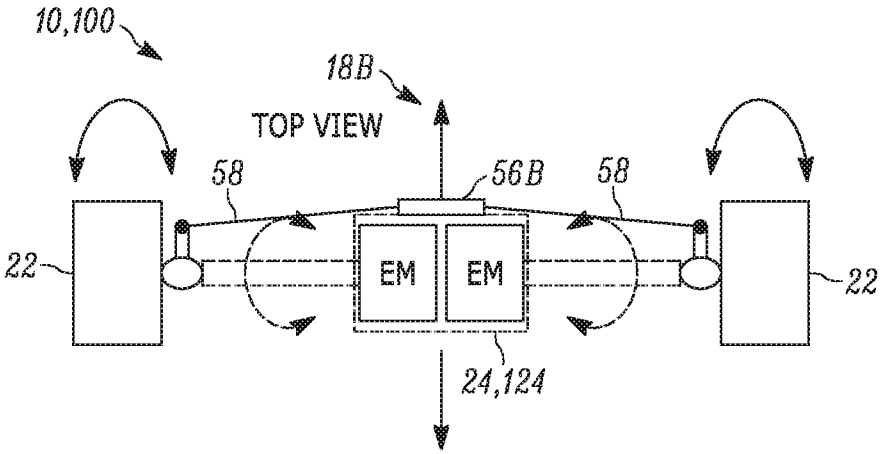

FIG. 5B

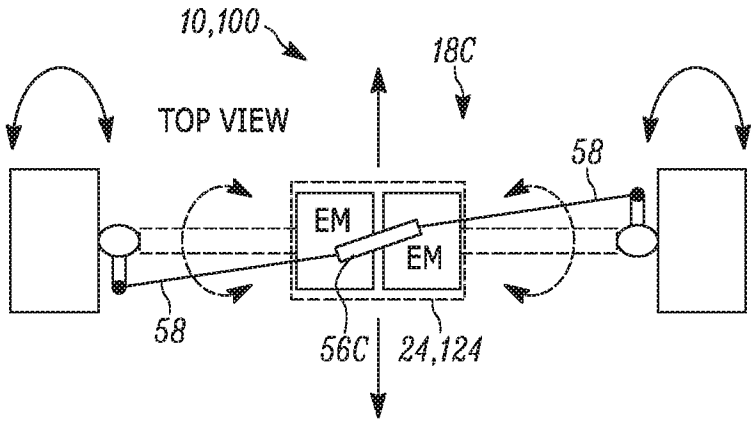

FIG. 5C

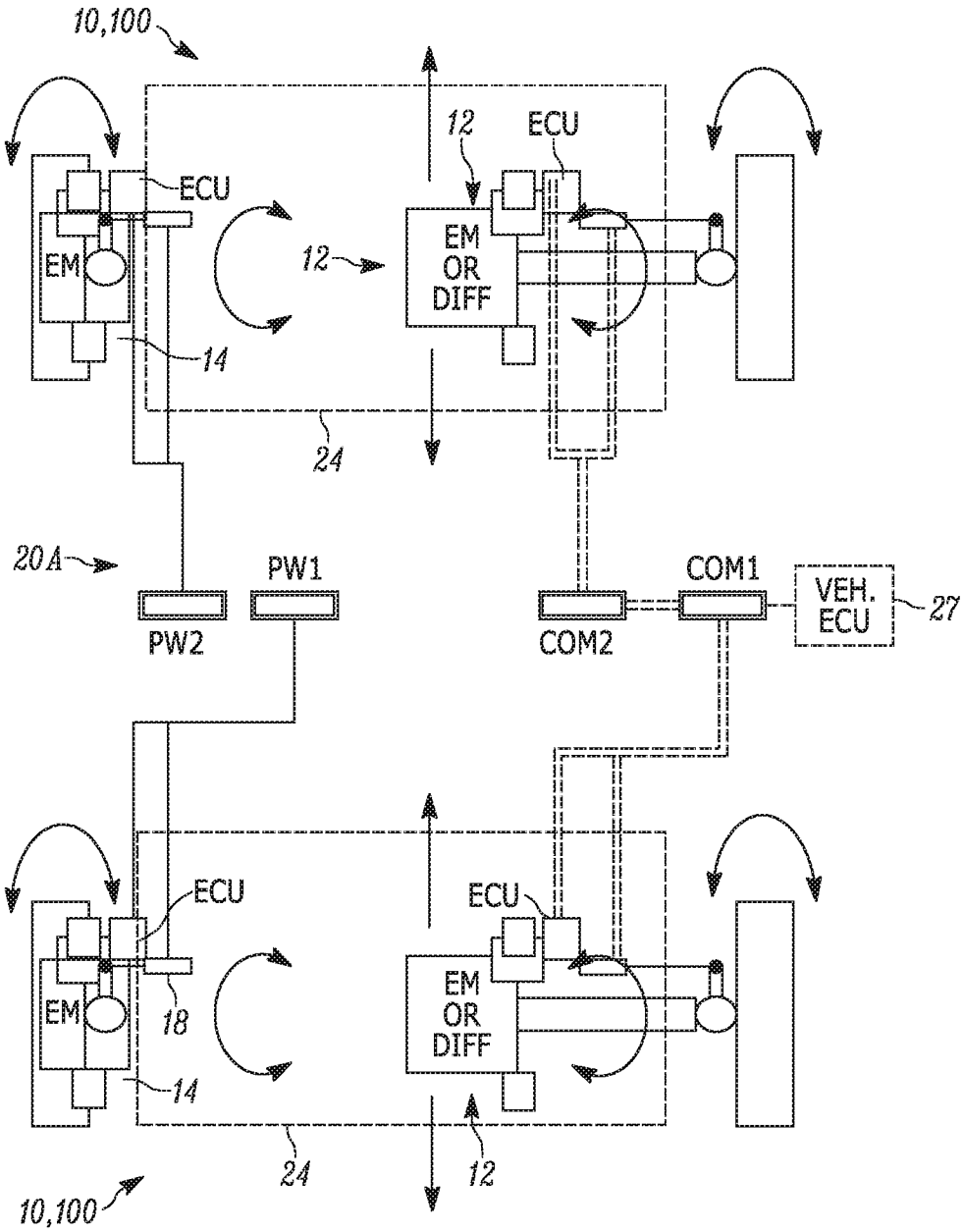
10,100
12
ECU
ECU
EM
12
EM
OR
DIFF
14
24
20A
PW1
PW2
COM1
COM2
VEH.
ECU
27
ECU
ECU
EM
18
EM
OR
DIFF
14
24
12
10,100

FIG. 6A

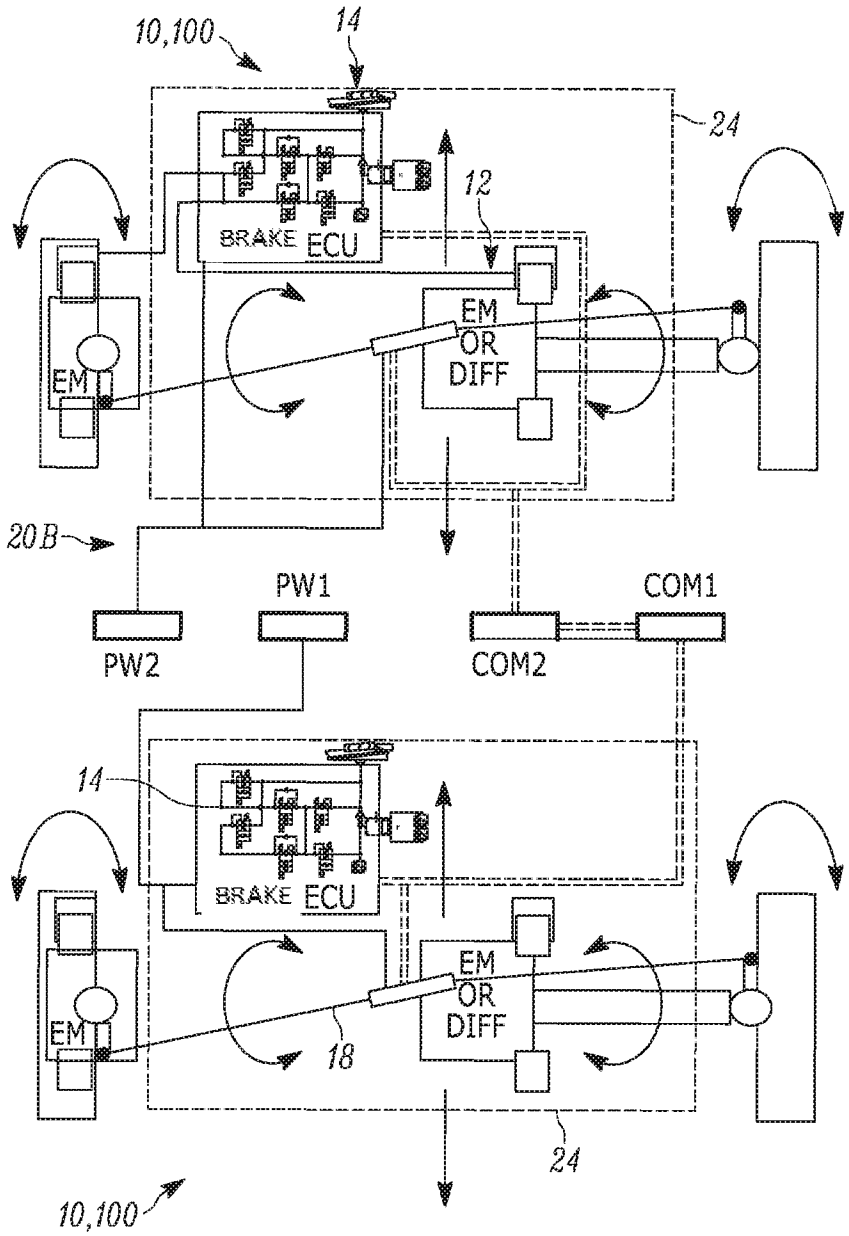
10,100
14
24
12
BRAKE ECU
EM
EM OR DIFF
20B
PW1
COM1
PW2
COM2
14
BRAKE ECU
EM
EM OR DIFF
18
24
10,100

FIG. 6B

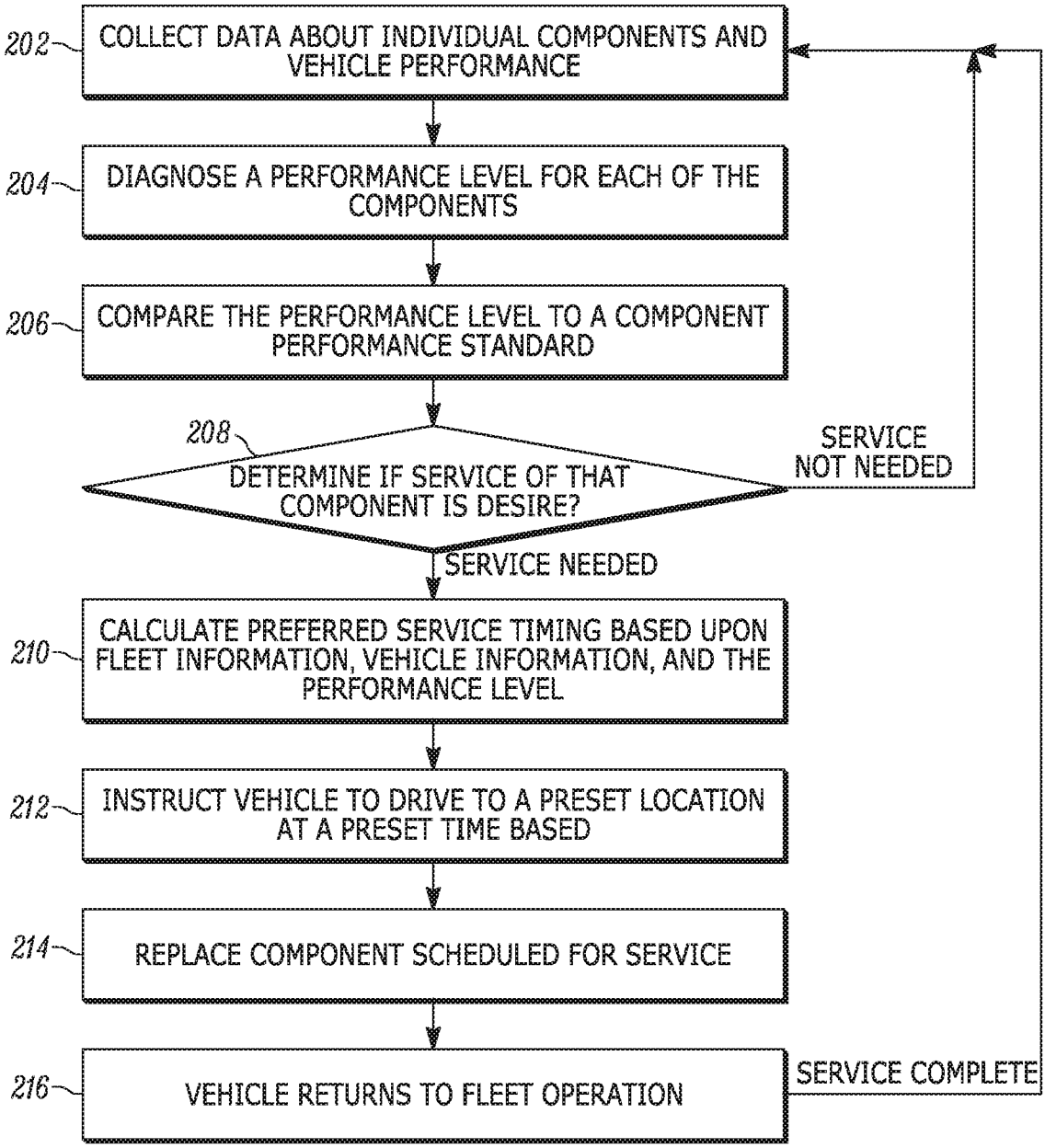
202
COLLECT DATA ABOUT INDIVIDUAL COMPONENTS AND VEHICLE PERFORMANCE
204
DIAGNOSE A PERFORMANCE LEVEL FOR EACH OF THE COMPONENTS
206
COMPARE THE PERFORMANCE LEVEL TO A COMPONENT PERFORMANCE STANDARD
208
DETERMINE IF SERVICE OF THAT COMPONENT IS DESIRE?
SERVICE NOT NEEDED
SERVICE NEEDED
210
CALCULATE PREFERRED SERVICE TIMING BASED UPON FLEET INFORMATION, VEHICLE INFORMATION, AND THE PERFORMANCE LEVEL
212
INSTRUCT VEHICLE TO DRIVE TO A PRESET LOCATION AT A PRESET TIME BASED
214
REPLACE COMPONENT SCHEDULED FOR SERVICE
216
VEHICLE RETURNS TO FLEET OPERATION
SERVICE COMPLETE

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2018/038086

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06Q10/00
ADD.

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)
G06Q

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2014/136414 A1 (ABHYANKER RAJ [US]) 15 May 2014 (2014-05-15) paragraphs [0183], [0184], [0188], [0637]; figures 1-57	1-9
X	WO 01/84506 A2 (GEN ELECTRIC [US]) 8 November 2001 (2001-11-08) figure 2	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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	Date of mailing of the international search report
2 October 2018	11/10/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Bîrlescu, V

2

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2018/038086

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014136414 A1	15-05-2014	NONE	
WO 0184506 A2	08-11-2001	AU 5931601 A	12-11-2001
		US 2002059075 A1	16-05-2002
		WO 0184506 A2	08-11-2001