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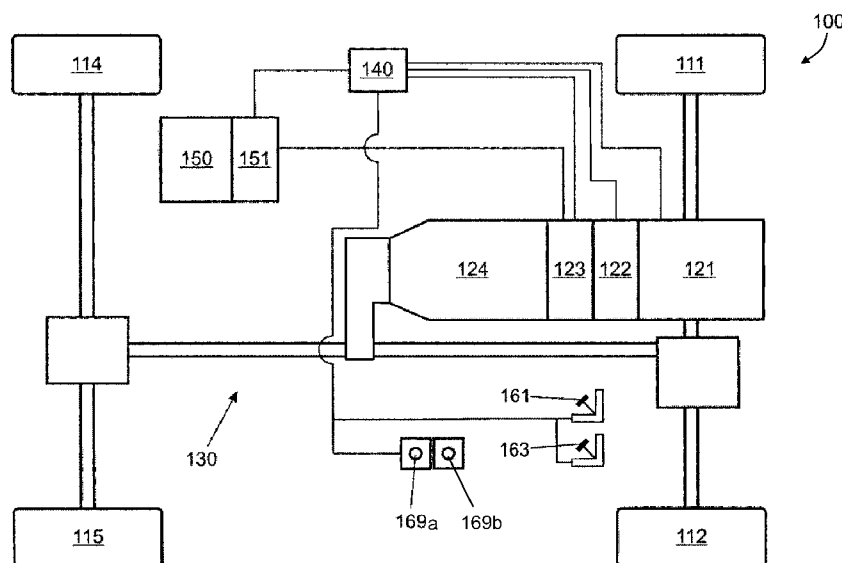


FIGURE 1

(57) Abstract: Aspects of the present invention relate to electric or hybrid vehicles (100) and their drive systems, and to methods, modules, controllers, apparatus and systems for controlling such drive systems. The vehicle (100) is operable in a first mode in which an internal combustion engine (121) and/or an electrical machine (123) provide a torque to the driveline (130) and in a second mode in which a torque from the driveline (130) is converted by the electrical machine (123) into electrical power to charge a battery (150). On removal of a torque demand by the accelerator (161), the vehicle (100) changes from the first mode to the second mode and the magnitude of the charge torque is adjustable dynamically in response to driver operation of the vehicle's paddle shifters (169a, 169b).

ELECTRIC DRIVE CONTROL

TECHNICAL FIELD

5 The present invention relates to electric drive control and particularly to apparatus, systems, control modules and methods for controlling the electric drive of an electric or hybrid electric vehicle. More specifically, although not exclusively, the present invention relates to the control of regenerative deceleration in electric and/or hybrid electric vehicles.

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BACKGROUND OF THE INVENTION

Electric vehicles, or electric drive vehicles, use one or more electric motors for propulsion. One type of electric vehicle that is becoming increasingly popular incorporates both an
15 electric motor and an internal combustion engine, which is commonly referred to as a hybrid electric vehicle, or a hybrid drive vehicle. The electric motor can be powered by any one of various energy storage devices, such as electrochemical batteries, fuel cells and the like.

Electric and hybrid vehicles present opportunities for more efficient use of the energy
20 consumed by the vehicle. For example, one common approach to improving energy efficiency is through regenerative braking, which involves converting the vehicle's momentum into mechanical energy in a flywheel or into electrical energy to charge the vehicle's electrical energy storage device when there is a demand for slowing the vehicle.

25 It is known to invoke regenerative deceleration or braking in various situations during vehicle operation, for example when the brake pedal is depressed or in the absence of an accelerator input by the driver and/or when the vehicle is coasting. The timing and extent to which such regenerative deceleration or braking occurs is, in the main, configured to optimise the energy efficiency of the vehicle and/or to maximise the useful life of the
30 electrical energy storage device.

It is a non-exclusive aim of the present invention to provide an electric drive control system and method that improves the use of regenerative deceleration or braking. It is a further non-exclusive aim of the present invention to provide an electric drive control system and
35 method that is more intuitive for the driver of a vehicle.

SUMMARY OF THE INVENTION

Aspects of the present invention relate to electric or hybrid vehicle drive systems, to methods, modules, controllers, apparatus and systems for controlling such drive systems and to computer program elements for executing such methods. Further aspects of the present invention relate to electric or hybrid drive vehicles incorporating such modules, controllers, apparatus, systems and/or computer program elements. For the avoidance of doubt, any of the features described herein apply equally to any aspect of the invention.

According to an aspect of the present invention there is provided an electric or hybrid drive apparatus or system comprising an electrical machine, a storage means that may be operatively connected to the electrical machine for storing electrical energy, a drive means or driveline for driving movement of a vehicle, a control means for controlling one or more elements of the apparatus or system and optionally an engine, the apparatus or system being operable in a first mode in which the engine and/or the electrical machine provide a torque, e.g. a drive torque, to the drive means or driveline and in a second mode in which a torque, e.g. a charge torque, from the drive means or driveline is converted by the electrical machine into electrical power to charge the storage means, wherein the magnitude of the torque converted in the second mode, e.g. the charge torque, is adjustable, e.g. dynamically and/or in response to a driver input via an optional input means, when the apparatus or system is in the second mode.

Providing control of the magnitude of charge torque enables the driver to slow the vehicle gently, in a manner similar to downshifting in conventional internal combustion engines, which is familiar to drivers. However, in the case of the present invention kinetic energy is converted into electrical energy, whereas conventional downshifting simply dissipates such kinetic energy through compression losses in the engine.

In some embodiments, the magnitude of the charge torque is continuously or step-wise adjustable, for example in response to a driver input via the optional input means, e.g. the input means may comprise a continuous or step-wise adjustment means. The input means may be operated or operable or activated or activatable manually and/or by hand, e.g. hand operated or operable, and/or orally or by voice, e.g. voice activated or activatable. In some embodiments, the input means comprises an actuation means or one or more actuators, such as a lever or one or more paddles, switches, dials or any other suitable input means. Preferably, the input means comprises a shift means or a shifter or selection means or selector, for example a paddle shift means or shifter or selection means or selector or a lever

shift means or shifter or selection means or selector or a gear shift means or shifter or selection means or selector.

5 In embodiments, the input means is operable to remove the charge torque or, for example, to disable the second mode. Additionally or alternatively, the magnitude of the charge torque is adjustable from a nil value to one or more, e.g. two or more, preferably a multiple or a plurality of different values.

10 The optional engine may comprise an internal combustion engine and/or may be operable to provide a torque to the drive means, for example when the apparatus or system is in the first mode and/or the second mode. The electrical machine may comprise or be operable as a motor, for example to convert electrical energy stored in the storage means into a torque, e.g. in the first mode. The electrical machine may further comprise or be operable as a generator, for example to convert a torque from the drive means or driveline into electrical
15 power to charge the storage means, e.g. in the second mode.

In some embodiments, the apparatus or system further comprises a transmission means or transmission, which may comprise a manual transmission, for example a sequential manual transmission, an automatic transmission, a semi-automatic transmission, a constant velocity
20 transmission or an electric variable or power sharing transmission. The transmission may, but need not, be between and/or operatively connect the electrical machine and/or the engine and/or the drive means or driveline. In embodiments, the transmission operatively connects the engine to the drive means or driveline. The transmission may be operable in two or more speed or gear ratios, for example a plurality of speed or gear ratios or an
25 infinitely variable speed or gear ratio. The speed or gear ratio may be selectable, for example via or using the or a further input means. Preferably, the speed or gear ratio is selectable sequentially, e.g. via or using the input means.

In embodiments, the input means comprises a shift means or shifter or selection means or selector, which may be operable to increase or decrease, in use, the speed or gear ratio of the transmission, for example when the engine operates to supply torque to the drive means or driveline and/or in the first and/or further modes. The shift means or shifter or selection means or selector may additionally or alternatively be operable to adjust, e.g. dynamically, the magnitude of the charge torque. The input means may comprise a first shift means or
30 shifter or selection means or selector that is operable to increase the speed or gear ratio and/or a second shift means or shifter or selection means or selector that is operable to decrease the speed or gear ratio, for example wherein the first shift means or shifter or
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selection means or selector is operable to decrease the magnitude of the charge torque and/or the second shift means or shifter or selection means or selector is operable to increase the magnitude of the charge torque. Additionally or alternatively, the input means may comprise a shift means or shifter or selection means or selector that is operable by a first actuation, e.g. an actuation in a first direction or by a first movement, to increase the speed or gear ratio and/or by a second actuation, e.g. an actuation in a second direction or by a second movement, to decrease the speed or gear ratio, for example wherein the second actuation or direction or movement is different or opposite the first direction or movement. The first actuation or actuation in the first direction or by the first movement may decrease the magnitude of the charge torque and/or the second actuation or actuation in the second direction or by the second movement may increase the magnitude of the charge torque. The reverse of each of these configurations is also envisaged and indeed may be preferable in certain circumstances, as will be appreciated by the skilled person.

In embodiments, the input means may comprise an actuation means or actuator, for example a speed selector or a speed ratio selector. In embodiments, the input means may form part of or be independent or separate from another input means of the vehicle, for example a speed ratio selector such as the transmission shift means or shifter or selection means or selector. For example, the input means may comprise a dedicated regenerative deceleration means or actuation means or actuator, which is preferably manually or hand operated or operable. Alternatively, the input means may comprise or be incorporated in a further or different actuation means or actuator, such as an actuation means or actuator or speed selector associated with adaptive cruise control or some other function, which actuation means or actuator may comprise a pair of actuators, e.g. for increasing or decreasing, in use, the speed of the vehicle when the vehicle is in an adaptive cruise control mode. The input means may comprise a first actuation means or actuator that is operable to increase the speed of the vehicle when in the adaptive cruise control mode and/or a second actuation means or actuator that is operable to decrease the speed of the vehicle when in the adaptive cruise control mode, for example wherein the first actuation means or actuator is operable to decrease the magnitude of the charge torque and/or the second actuation means or actuator is operable to increase the magnitude of the charge torque. Additionally or alternatively, the input means may comprise an actuation means or actuator that is operable by a first actuation, e.g. an actuation in a first direction or by a first movement, to increase the speed of the vehicle when in the adaptive cruise control mode and/or by a second actuation, e.g. an actuation in a second direction or by a second movement, to decrease the speed of the vehicle when in the adaptive cruise control mode, for example wherein the second actuation or direction or movement is different or opposite the first

direction or movement. The first actuation or actuation in the first direction or by the first movement may decrease the magnitude of the charge torque and/or the second actuation or actuation in the second direction or by the second movement may increase the magnitude of the charge torque. The reverse of each of these configurations is also envisaged and indeed may be preferable in certain circumstances, as will be appreciated by the skilled person.

In embodiments, the control means is configured on removal or reduction of a torque demand to cause the apparatus or system to operate in the second mode. The removal or reduction of a torque demand may be determined or detected by a signal received by the control means. The torque demand may be determined or set by an accelerator means or accelerator, for example an accelerator pedal, e.g. wherein the removal or reduction of a torque demand comprises the removal or retraction of a position or condition, e.g. a demand position or condition, of the accelerator means or accelerator. In a specific class of embodiments, the removal or reduction of a torque demand comprises or corresponds to the removal or retraction, in use, of a driver's foot or foot position on or in relation to an accelerator pedal. The apparatus or system may further comprise the or an accelerator means or accelerator pedal.

The electrical machine may comprise an electric motor and/or generator. In some embodiments, the electrical machine comprises a motor-generator, for example a single power transducer, e.g. a crankshaft integrated motor-generator, which may be operable as either an electric motor or generator or in a first, motor mode and/or a second, generator mode. In other embodiments, the electrical machine may comprise an electric motor and an electric generator. The electric motor-generator or the electric motor and/or the electric generator may be operatively connected to the storage means.

In embodiments, the engine is arranged in parallel or in series or is coupled to the electrical machine or a shaft or prime mover thereof. The engine may be operatively connected or coupled to the transmission means or transmission, for example via the electrical machine or the shaft or prime mover thereof, or in parallel and/or independently of the electrical machine.

In embodiments, the apparatus or system is operable in one or more of a plurality of modes, for example which may include a coast charge mode and any combination of one or more of an electric drive or EV mode, a hybrid drive or HEV mode, an engine or ICE mode and/or a parallel charge mode, and optionally a parallel coast mode and/or a braking mode. The

coast charge mode may comprise a configuration in which the electric machine alone provides a torque, e.g. a negative or charge torque, to the drive means or driveline, for example to decelerate the vehicle and/or to charge the storage means. The electric drive or EV mode may comprise a configuration in which the electric machine or motor alone provides a torque, e.g. a positive or drive torque, to the drive means or driveline. The hybrid drive or HEV mode may comprise a configuration in which both the electric machine or motor and the engine provide a torque, e.g. a positive or drive torque, to the drive means or driveline. The engine or ICE mode may comprise a configuration in which the engine alone provides a torque, e.g. a positive or drive torque, to the drive means or driveline. The parallel charge mode may comprise a configuration in which the engine provides a torque, e.g. a positive or drive torque, to the drive means or driveline, while the electric machine provides a torque, e.g. a negative or charge torque, to the engine and/or to the drive means or driveline, for example to charge the storage means. The parallel coast mode may comprise a configuration in which neither the electric machine nor the engine provides substantially any torque to the drive means or driveline. The braking mode may comprise a configuration in which a brake means, e.g. a friction brake means, or mechanism or system or arrangement provides a deceleration force, e.g. a friction force, to the vehicle and/or the electric machine provides a torque, e.g. a negative or charge torque, to the drive means or driveline, for example to decelerate the vehicle and/or to charge the storage means, e.g. together with or in place of the deceleration or friction force of the brake means.

The apparatus or system may be operable to control a vehicle in which it is comprised or incorporated to assume a mode of operation, e.g. one of the aforementioned modes of operation, in which each of a plurality of actuators of the vehicle or apparatus or system is controlled to assume a prescribed operational state. In some embodiments, when the storage means is fully charged the apparatus or system is configured to remove the charge torque, for example to change, e.g. automatically, into the parallel coast mode. However, it is also envisaged that the apparatus or system might be configured to provide a comparable compression loss deceleration, for example by application of the vehicle brakes. In some embodiments, the apparatus or system might be configured to redirect the charge power to one or more units of the vehicle that require an electric demand, for example an electric air conditioning unit, e.g. if there is a demand for air conditioning.

The apparatus or system may further comprise a clutch means or clutch, e.g. for selectively engaging and/or disengaging the engine from the drive means or driveline and/or the electric machine or motor. In embodiments, the clutch means or clutch is between and/or operatively connects or couples the engine and the drive means or driveline and/or the

transmission means or transmission. In embodiments, the clutch means or clutch is between and/or operatively connects or couples the engine and the electric machine or motor, e.g. a shaft or prime mover thereof. In some embodiments, the clutch is open or disengaged in one or more, e.g. each, of the electric drive or EV mode, the coast charge mode, the parallel coast mode and/or the braking mode. Additionally or alternatively, the clutch may be closed or engaged in one or more of the hybrid drive or HEV mode, the engine or ICE mode and/or the parallel charge mode.

In some embodiments, the apparatus or system comprises an electric motor, an electric generator and an engine, for example wherein the electric motor or a shaft or prime mover thereof is operatively connected or coupled to the drive means or driveline and/or the engine and electric generator may be operatively connected or coupled to the electric motor or shaft or prime mover thereof, e.g. via the or a transmission means or transmission. The transmission means or transmission may comprise a planetary transmission or gear arrangement or gear set, for example in which a sun gear thereof is operatively connected or coupled to the electric generator and/or a planetary gear carrier thereof is operatively connected or coupled to the engine and/or a ring gear thereof is operatively connected or coupled to the electric motor.

The engine preferably comprises an internal combustion engine, for example a piston engine, such as a two-stroke or four-stroke or six-stroke engine, or a rotary engine, such as a Wankel rotary engine, or any other suitable engine or engine design. The engine may be fuelled by any suitable fuel including, but not limited to petroleum, petroleum spirit, petroleum diesel, biodiesel, liquefied petroleum gas.

The storage means may comprise any suitable energy storage means, such as one or more batteries and/or battery cells, e.g. electrochemical cells such as lithium-ion or nickel-metal hydride or lead-acid batteries or cells, and/or fuel cells, e.g. hydrogen fuel cells, and/or capacitors, e.g. ultracapacitors.

According to an aspect of the present invention there is provided a method of controlling an electric or hybrid drive vehicle, the method comprising the steps of:

- a) detecting a removal or reduction of demanded torque;
- b) in response to the removal or reduction of a demanded torque, applying a negative or decelerating torque, e.g. a charge torque, to a drive means or driveline of the vehicle and generating electrical power using the torque or charge torque; and

- c) adjusting, e.g. dynamically, the magnitude of the torque or charge torque in response to a driver input.

In some embodiments, the method may further comprise causing the vehicle to change from a first mode or a first operating mode, e.g. in which an engine and/or electrical machine provide a torque to the drive means or driveline of the vehicle, to a second mode or a second operating mode, for example in which a torque from the drive means or driveline of the vehicle is converted, e.g. by the electrical machine, into electrical power, such as to charge a storage means.

In some embodiments, the magnitude of the negative or decelerating or charge torque may be adjusted continuously or by a step-wise adjustment. The driver input may be detected by an input means, which may comprise a continuous or step-wise and/or manual or hand operated or operable adjustment means, which may comprise an actuation means or one or more actuators, such as a lever or one or more paddles, switches, dials or any other suitable input means. Preferably, the driver input is detected by or with reference to an actuation of an actuation means or actuator, such as a shift means or a shifter or selection means or selector of the vehicle, for example a paddle shift means or shifter or selection means or selector or a lever shift means or shifter or selection means or selector or a gear shift means or shifter or selection means or selector. The actuation means or actuator may correspond to a speed or gear ratio shift means or shifter or selection means or selector, e.g. a transmission speed or gear ratio shift means or shifter or selection means or selector, or to a dedicated regenerative deceleration or off-run actuation means or actuator or to an actuation means or one or more actuators associated with an adaptive cruise control function or some other function.

In embodiments, the adjustment step comprises removing the negative or decelerating or charge torque. Additionally or alternatively, the adjustment step comprises adjusting the magnitude of the negative or decelerating or charge torque between a nil value and one of one or more, e.g. two or more, preferably multiple or a plurality of different negative or decelerating or charge torque values.

In embodiments, the removal or reduction of demanded torque may be detected by or with reference to an accelerator means or accelerator, for example an accelerator pedal, or by or with reference to a position or condition thereof. In a specific class of embodiments, the removal or reduction of a demanded torque comprises or corresponds to the removal or retraction of a driver's foot or foot position on or in relation to an accelerator pedal.

A further aspect of the invention provides a computer program element comprising computer readable program code means for causing a processor to execute a procedure to implement the aforementioned method. A yet further aspect of the invention provides the computer
5 program element embodied on a computer readable medium.

A yet further aspect of the invention provides a computer readable medium having a program stored thereon, where the program is arranged to make a computer execute a procedure to implement the aforementioned method.

10 Another aspect of the invention provides a control means or controller, e.g. for use in a system and/or apparatus as described above. The control means or controller may be configured to adjust, e.g. dynamically, the magnitude of the charge torque in response to a driver input, for example via an input means to which the controller is operatively connected
15 in use, e.g. when the apparatus or system is in the second mode. In some embodiments, the controller is operable to detect a removal or reduction of a torque demand and, e.g. in response thereto, the control means or controller may be configured to cause a hybrid drive apparatus or system in which the controller is comprised or incorporated to operate in the second mode. Additionally or alternatively, the control means or controller may comprise a
20 computer program element and/or a computer readable medium as described above.

Another aspect of the invention provides a vehicle, for example an electric or hybrid vehicle, which vehicle may comprise or incorporate a system and/or apparatus and/or computer program element and/or computer readable medium and/or control means or controller as
25 described above.

Within the scope of this application it is expressly envisaged that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features
30 thereof, may be taken independently or in any combination. Features described in connection with one aspect or embodiment of the invention are applicable to all aspects or embodiments, unless such features are incompatible.

35 BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

5 Figure 1 is a schematic illustration of a hybrid electric vehicle according to an embodiment of the present invention;

Figure 2 is a flow chart illustrating the operation of a control system for controlling the hybrid electric vehicle of Figure 1; and

10 Figure 3 is a schematic illustration of a hybrid electric vehicle according to a further embodiment of the present invention.

15 DETAILED DESCRIPTION

Figure 1 shows a hybrid electric vehicle (HEV) 100 according to an embodiment of the present invention. The vehicle 100 has an internal combustion engine (ICE) 121 releasably coupled to a crankshaft integrated motor/generator (CIMG) 123 by means of a clutch 122. The CIMG 123 is coupled to a transmission 124, which is in turn coupled to the driveline 130 of the vehicle 100. The vehicle 100 is operable to provide drive torque to the transmission 124 by means of the engine 121 alone in an ICE mode, the CIMG 123 alone in an EV mode
20 or the engine 121 and CIMG 123 in parallel in an HEV mode.

In this embodiment, the transmission 124 is a paddle-shift operated semi-automatic transmission. However, it is to be understood that in some embodiments the transmission
25 124 may be an automatic transmission, a sequential manual transmission, a constant velocity transmission, an electric variable or power sharing transmission or any other suitable transmission.

30 It is to be understood that embodiments of the present invention are suitable for use with vehicles in which the transmission 124 is arranged to drive only a pair of front wheels 111, 112 or only a pair of rear wheels 114, 115, i.e. front wheel drive or rear wheel drive vehicles in addition to all wheel drive or selectable two wheel drive/four wheel drive vehicles. Embodiments of the invention are also suitable for vehicles having less than four wheels or
35 more than four wheels.

The vehicle 100 has a battery 150 connected to an inverter 151 that generates a three-phase electrical supply that is supplied to the CIMG 123 when the CIMG 123 is operated in a first mode, as a motor. The battery 150 is arranged to receive charge from the CIMG 123 when the CIMG 123 is operated in a second mode, as a generator.

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The vehicle 100 has a controller 140 configured to control the vehicle 100 to operate in one of a plurality of modes, including the aforementioned modes. The vehicle 100 also has an accelerator pedal 161, a brake pedal 163 and a pair of transmission speed ratio selectors in the form of paddle shifters 169a, 169b mounted to the steering wheel (not shown) of the vehicle 100. When the vehicle 100 is in the ICE mode or in the HEV mode, a first paddle shifter 169a is operable to increase the speed ratio of the transmission 124, while a second paddle shifter 169b is operable to decrease the speed ratio of the transmission 124.

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In addition to the aforementioned ICE, EV and HEV modes, the vehicle 100 is also arranged to operate in one of a parallel charge mode, a coast charge mode, a parallel coast mode and a brake mode. In the parallel charge mode the engine 121 applies a positive or drive torque whilst the CIMG 123 applies a negative or charge torque whereby charge is generated by the CIMG 123 to charge the battery 150, whether the vehicle 100 is stationary or moving. In the coast charge mode the clutch 122 is open, the engine 121 is switched off and the CIMG 123 applies a selectable negative or charge torque whereby charge is generated by the CIMG 123 to charge the battery 150 and the vehicle 100 decelerates. In the parallel coast mode the clutch 122 is open, the engine 121 is switched off and the CIMG 123 applies substantially no torque. In the brake mode, which is typically initiated by the application of the brake pedal 163, the clutch 122 is open, the engine 121 is switched off and a friction braking mechanism (not shown) is applied, which may be done in conjunction with the CIMG 123 applying a negative or charge torque to charge the battery 150 according to a relationship determined and/or controlled by the controller 140.

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In accordance with an embodiment of the present invention, the paddle shifters 169a, 169b are also operable to increase or decrease the magnitude of charge torque applied by the CIMG 123 when the vehicle 100 is in the coast charge mode and to change the vehicle 100 mode from the coast charge mode to the parallel coast mode. More specifically, in this embodiment actuation of the first paddle shifter 169a one or more times decreases the magnitude of charge torque applied by the CIMG 123 by a corresponding number of steps, thereby simulating an 'up-shift' in a conventional ICE vehicle whereby the decelerating torque resulting from compression losses would decrease. Similarly, actuation of the second paddle shifter 169b one or more times increases the magnitude of charge torque applied by

the CIMG 123, thereby simulating a 'down-shift' in a conventional ICE vehicle whereby the decelerating torque resulting from compression losses would increase. In this embodiment, continuous actuation (ie: actuation for more than a set period of time, for example a second or more) of either of the first and second paddle shifter 169a, 169b causes the vehicle 100 to
5 change the vehicle mode from the coast charge mode to the parallel coast mode.

In use, the accelerator pedal 161 is depressed and provides positive or drive torque to the driveline of the vehicle 100 with the vehicle 100 in one of the ICE, EV and HEV modes. In accordance with the flow chart 200 illustrated in Figure 2, if the driver releases the
10 accelerator pedal 161, indicating a desire for the vehicle 100 to coast, the vehicle 100 is configured to change modes automatically to the coast charge mode (provided the battery 150 is not fully charged). In order to provide the driver with the same overrun feel as a vehicle with a conventional internal combustion engine, the CIMG 123 produces charge torque to simulate internal combustion engine pumping losses (including efficiency losses).
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In this embodiment, the magnitude of charge torque applied by the CIMG 123 is determined based on the negative torque estimated to correspond to compression losses of the engine 121 in the speed or gear ratio in use at the time the accelerator pedal 161 was released. The driver is then able to simulate a 'down-shift' or 'up-shift' to control the degree of
20 deceleration using the first and second paddle shifters 169a, 169b as described above. As illustrated in Figure 2, if the driver wishes to increase the rate of deceleration, this can be done either by pulling the "-" paddle to simulate a 'down-shift' as explained above or by pressing the brake pedal 163, which applies combined friction and regenerative braking. In this embodiment, if the driver prefers to remove the charge torque, simulating the
25 transmission of a traditional ICE vehicle in a neutral condition, this can be achieved by a continuous actuation of either of the first and second paddle shifter 169a, 169b which causes the vehicle 100 to change into the parallel coast mode. If the driver wishes to reduce the rate of deceleration, this can be done either by pulling the "+" paddle to simulate an 'up-shift' as explained above or by pressing the accelerator pedal 161, which applies a positive torque
30 to the driveline.

In this embodiment, when the battery 150 is fully charged the vehicle 100 changes automatically to the parallel coast mode. However, it is also envisaged that the vehicle 100 might be configured to provide a comparable compression loss deceleration by application of
35 either the vehicle brakes or even operating the ICE in the traditional fashion, although the latter is not preferable as it would reduce the efficiency of the vehicle 100. In another embodiment, the vehicle 100 might be configured to redirect the charge power to one or

more units of the vehicle that require an electric demand, for example an electric air conditioning unit, e.g. if there is a demand for air conditioning.

Referring now to Figure 3, there is shown a vehicle 300 according to a further embodiment, which is similar to the vehicle 100 according to the first embodiment in Figure 1 wherein like references depict like features that will not be described further herein. The vehicle 300 according to this embodiment differs from the vehicle 100 according to the first embodiment in that the transmission 124 is replaced by an automatic transmission 324, the paddle shifters 169a, 169b are replaced with first and second adaptive cruise control buttons 369a, 369b and a coast charge bypass selector 369. In use, the driver is able to simulate a 'down-shift' or 'up-shift' to control the degree of deceleration using the first and second adaptive cruise control buttons 369a, 369b in a similar way to the operation of the paddle shifters 169a, 169b as described above. If the driver prefers to remove such charge torque, simulating the transmission of a traditional ICE vehicle in a neutral condition, this can be achieved by operating the coast charge bypass selector 369 to prevent operation of the vehicle in the coast charge mode.

Embodiments of the invention have the advantage that a HEV may be controlled such that driver enjoyment may be enhanced because vehicle operations may be conducted in a manner that is more likely to meet driver expectations. That is, because the driver is able to select the level of decelerating torque applied during the coast regeneration mode, the vehicle 100 operates in a manner that is more intuitive.

There may be provided a vehicle or electric drive system comprising an electrical machine, a storage means for storing electrical energy, a drive means for driving movement of a vehicle, a control means for controlling one or more elements of the system and input means for receiving a driver input, the system being operable in a first mode in which the electrical machine provides a drive torque to the drive means and in a second mode in which a charge torque from the drive means is converted by the electrical machine into electrical power to charge the storage means, the magnitude of the charge torque converted in the second mode being adjustable dynamically in response to a driver input via the input means when the system is in the second mode, wherein the input means comprises a speed selector or speed ratio selector. This may be combined with elements of embodiments as described hereinbefore, such as paddles, cruise control, and so on.

It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application. Further aspects of the present invention will now be set out in the accompanying numbered paragraphs:

5 Embodiments of the present invention may be understood by reference to the following numbered paragraphs.

- 10 1. A hybrid drive system comprising an engine, an electrical machine, a battery for storing electrical energy, a driveline for driving movement of a vehicle, a controller for controlling one or more elements of the system and a driver actuator for receiving a driver input, the system being operable in a first mode in which said engine or said electrical machine or both provide a drive torque to said driveline and in a second mode in which a charge torque from said driveline is converted by said electrical machine into electrical power to charge said battery, wherein the magnitude of said charge torque is adjustable dynamically in response to a driver input via said driver actuator when the system is in said second mode, wherein said driver actuator comprises a speed selector or speed ratio selector.
- 20 2. A hybrid drive system according to paragraph 1, wherein said driver actuator comprises or is incorporated in a speed ratio selector for selecting the speed ratio of a transmission of a vehicle in which the system is incorporated in use.
- 25 3. A hybrid drive system according to paragraph 2, wherein said speed ratio selector is operable by a first actuation to increase the speed ratio of said transmission, and by a second actuation to decrease the speed ratio of said transmission, wherein when the system is in said second mode said first actuation decreases said magnitude of said charge torque and said second actuation increases said magnitude of said charge torque.
- 30 4. A hybrid drive system according to paragraph 3, wherein said speed ratio selector comprises first and second actuators for providing said first and second actuation respectively.
- 35 5. A hybrid drive system according to paragraph 2, wherein said speed ratio selector comprises one or more paddle shifters.

6. A hybrid drive system according to paragraph 1, wherein said driver actuator comprises an adaptive cruise control speed selector for adjusting, in use, the speed of a vehicle in which the system is incorporated when said vehicle is in an adaptive cruise control mode.
- 5 7. A hybrid drive system according to paragraph 6, wherein said speed selector comprises a first actuator operable to increase the speed of said vehicle and a second actuator operable to decrease said speed of said vehicle when said vehicle is in said adaptive cruise control mode, wherein when said system is in said second mode said
- 10 first actuator is operable to decrease said magnitude of said charge torque and said second actuator is operable to increase said magnitude of said charge torque.
8. An electric drive system comprising an electrical machine, a battery for storing electrical energy, a driveline for driving movement of a vehicle, a controller controlling
- 15 one or more elements of the system and a driver actuator for receiving a driver input, the system being operable in a first mode in which power from said battery is converted by said electrical machine into a drive torque provided to said driveline and in a second mode in which a charge torque from said driveline is converted by said electrical machine into electrical power to charge said battery, the magnitude of said
- 20 charge torque being adjustable dynamically in response to a driver input via said driver actuator, wherein said driver actuator comprises a speed selector or speed ratio selector.
9. A hybrid drive system according to paragraph 8, wherein said driver actuator
- 25 comprises or is incorporated in a speed ratio selector for selecting the speed ratio of a transmission of a vehicle in which the system is incorporated in use.
10. A hybrid drive system according to paragraph 8, wherein said driver actuator comprises an adaptive cruise control speed selector for adjusting, in use, the speed of
- 30 a vehicle in which the system is incorporated when said vehicle is in an adaptive cruise control mode.
11. A method of controlling an electric or hybrid drive vehicle, the method comprising the steps of:
- 35 a) detecting a removal or reduction of demanded torque;
- b) in response to said removal or reduction of demanded torque, applying a negative or decelerating charge torque to a drive means of said vehicle and generating electrical power using said charge torque; and

c) adjusting dynamically the magnitude of said charge torque in response to a driver input via a speed selector or a speed ratio selector of the vehicle.

5 12. A method according to paragraph 11, wherein said driver input is detected using a transmission speed ratio selector of the vehicle.

13. A method according to paragraph 11, wherein the driver input is detected using an adaptive cruise control speed selector of the vehicle.

10 14. A method according to paragraph 11, wherein said adjustment step comprises removing said charge torque.

15 15. A method according to paragraph 11, wherein said removal or reduction of demanded torque is detected by or with reference to a position or condition of an accelerator pedal.

20 16. A method according to paragraph 15, wherein said removal or reduction of demanded torque comprises or corresponds to a removal or retraction of a driver's foot or foot position on or in relation to said accelerator pedal.

17. A computer readable medium having a program stored thereon, where the program is arranged to make a computer execute a procedure to implement a method according to paragraph 11.

25 18. A controller for use in an electric or hybrid drive system, the controller having a program stored thereon, where the program is arranged to make a computer execute a procedure to implement a method according to paragraph 11.

19. A vehicle comprising or incorporating a system according to paragraph 1.

30 20. A vehicle comprising or incorporating a system according to paragraph 8.

CLAIMS:

1. A hybrid drive system comprising an engine, an electrical machine, a storage means
for storing electrical energy, a drive means for driving movement of a vehicle, a control
5 means for controlling one or more elements of the system and input means for
receiving a driver input, the system being operable in a first mode in which the engine
and/or the electrical machine provide a drive torque to the drive means and in a
second mode in which a charge torque from the drive means is converted by the
electrical machine into electrical power to charge the storage means, the magnitude of
10 the charge torque converted in the second mode being adjustable dynamically in
response to a driver input via the input means when the system is in the second mode,
wherein the input means comprises a speed selector or speed ratio selector.
2. A hybrid drive system according to claim 1, wherein the input means comprises a
15 speed ratio selector for selecting, in use, the speed ratio of a transmission of a vehicle
in which the system is incorporated.
3. A hybrid drive system according to claim 2, wherein the speed ratio selector is
operable by a first actuation to increase the speed ratio and by a second actuation to
20 decrease the speed ratio, wherein the first actuation decreases the magnitude of the
charge torque and the second actuation increases the magnitude of the charge torque.
4. A hybrid drive system according to claim 3, wherein the speed ratio selector comprises
first and second actuators for providing the first and second actuation respectively.
- 25 5. A hybrid drive system according to any one of claims 2 to 4, wherein the speed ratio
selector comprises one or more paddle shifters.
6. A hybrid drive system according to claim 1, wherein the input means comprises an
30 adaptive cruise control speed selector for adjusting, in use, the speed of a vehicle in
which the system is incorporated when the vehicle is in an adaptive cruise control
mode.
7. A hybrid drive system according to claim 6, wherein the speed selector is operable, in
35 use, by a first actuation to increase the vehicle speed and by a second actuation to
decrease the vehicle speed, wherein the first actuation decreases the magnitude of the
charge torque and the second actuation increases the magnitude of the charge torque.

8. A hybrid drive system according to claim 7, wherein the speed selector comprises first and second actuators for providing the first and second actuation respectively.
- 5 9. A method of controlling an electric or hybrid drive vehicle, the method comprising the steps of:
 - a) detecting a removal or reduction of demanded torque;
 - b) in response to the removal or reduction of a demanded torque, applying a negative or decelerating charge torque to a drive means of the vehicle and generating electrical power using the charge torque; and
 - 10 c) adjusting dynamically the magnitude of the charge torque in response to a driver input via a speed selector or a speed ratio selector of the vehicle.
- 15 10. A method according to claim 9, wherein the driver input is detected using a transmission speed ratio selector of the vehicle.
11. A method according to claim 9, wherein the driver input is detected using an adaptive cruise control speed selector of the vehicle.
- 20 12. A method according to any one of claims 9 to 11, wherein the adjustment step comprises removing the charge torque.
- 25 13. A method according to any one of claims 9 to 12, wherein the removal or reduction of demanded torque is detected by or with reference to the position or condition of an accelerator pedal.
- 30 14. A method according to claim 13, wherein the removal or reduction of a demanded torque comprises or corresponds to the removal or retraction of a driver's foot or foot position on or in relation to the accelerator pedal.
- 35 15. A computer program element comprising computer readable program code means for causing a processor to execute a procedure to implement a method according to any one of claims 9 to 14.
16. A computer program element according to claim 15 embodied on a computer readable medium.
17. A computer readable medium having a program stored thereon, where the program is arranged to make a computer execute a procedure to implement a method according to any one of claims 9 to 14.

18. A controller for use in a system according to any one of claims 1 to 8 configured to adjust the magnitude of the torque converted when the hybrid drive system is in the second mode in response to a driver input via an input means to which the controller is
5 operatively connected in use.
19. A controller for use in a system according to any one of claims 1 to 8, the controller comprising a computer program element according to claim 15 or a computer readable medium according to claim 17.
10
20. A vehicle comprising or incorporating a system according to any one of claims 1 to 8 or a computer program element according to claim 15 or a computer readable medium according to claim 17 or a controller according to claim 18 or claim 19.

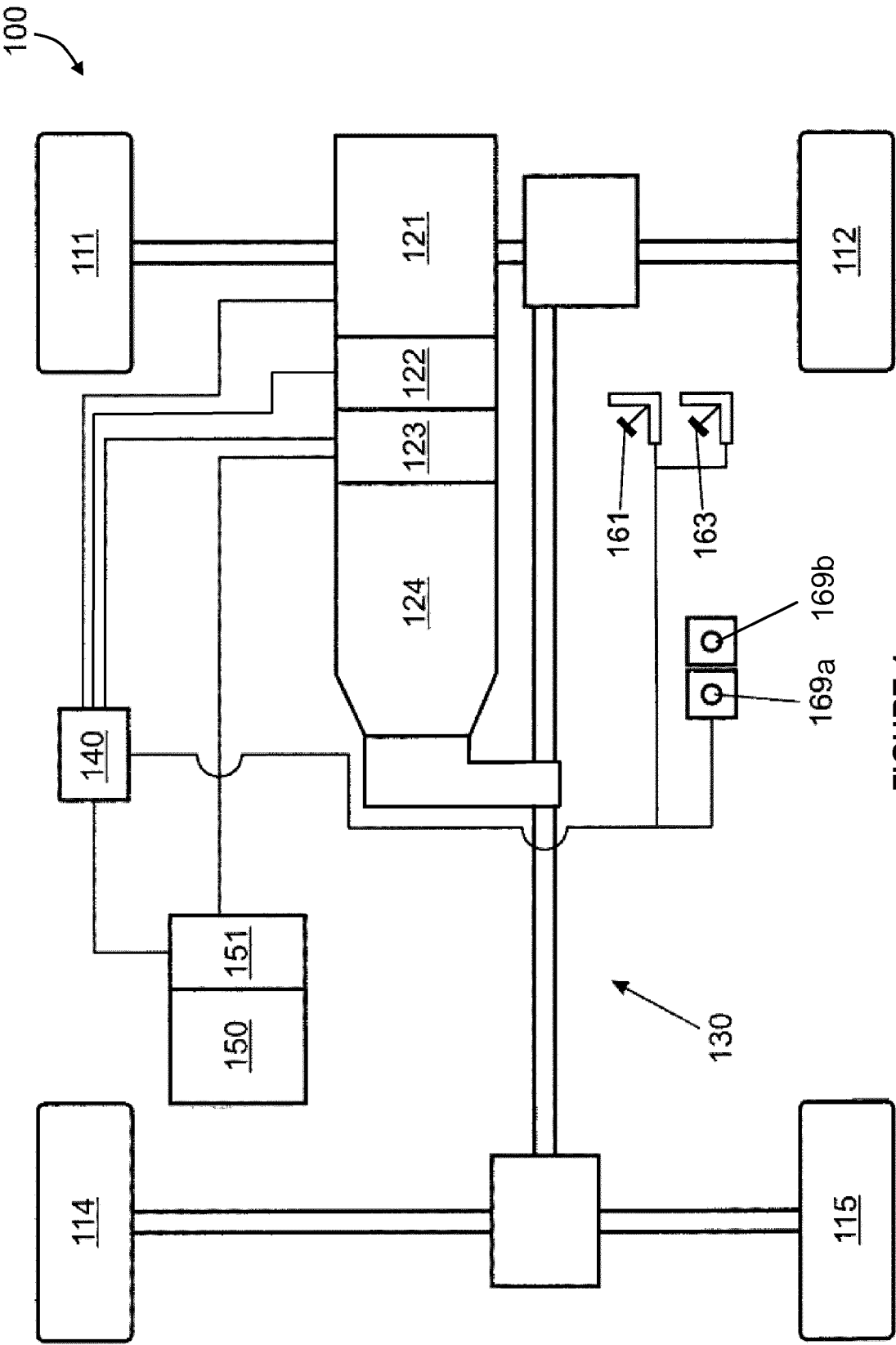


FIGURE 1

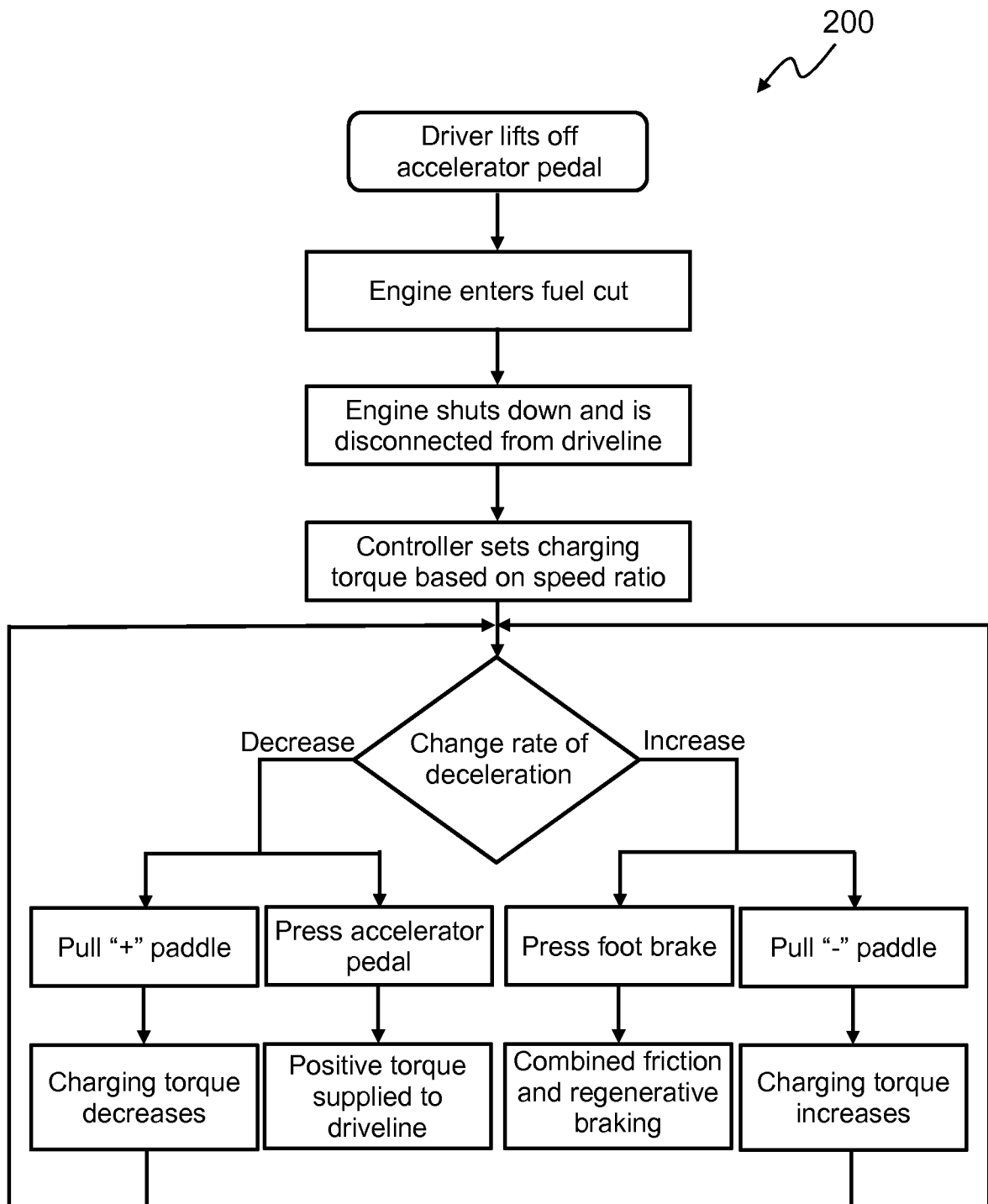
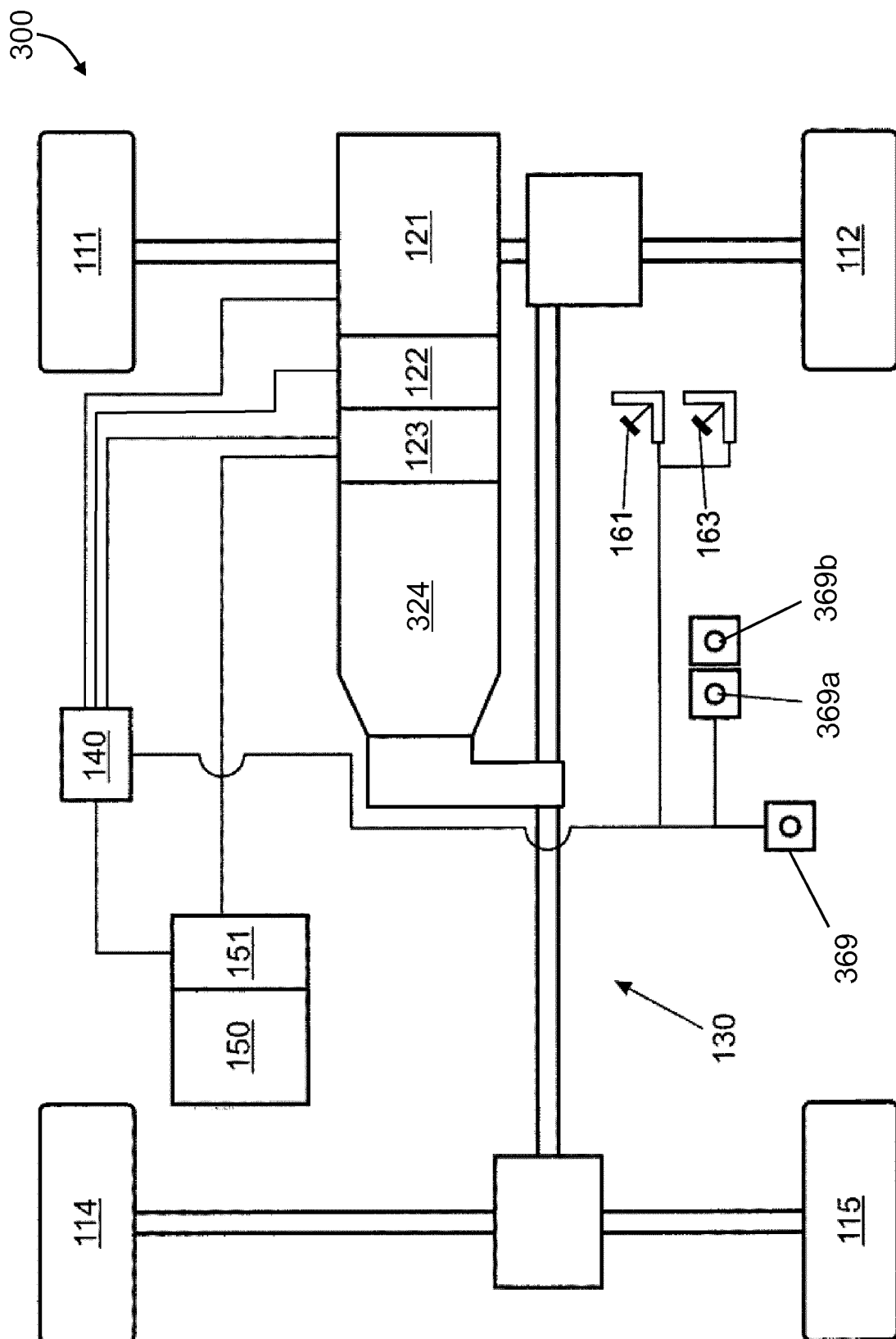


FIGURE 2



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/067561

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60W30/18
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)
B60W B60K

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 10 2007 035424 A1 (PORSCHE AG [DE]) 29 January 2009 (2009-01-29) paragraph [0002] - paragraph [0020] -----	1-20
X	DE 10 2013 002166 A1 (AUDI AG [DE]) 6 February 2014 (2014-02-06) paragraph [0008] - paragraph [0053]; figure 1 -----	1-20
X	DE 10 2010 004846 A1 (VOLKSWAGEN AG [DE]) 10 March 2011 (2011-03-10) paragraph [0008] - paragraph [0038]; figures 1,2 -----	1-20
A	FR 2 990 388 A3 (RENAULT SA [FR]) 15 November 2013 (2013-11-15) page 1, line 19 - page 14, line 7; figures 1-4 ----- -/--	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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"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

9 September 2015

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18/09/2015

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/067561

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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