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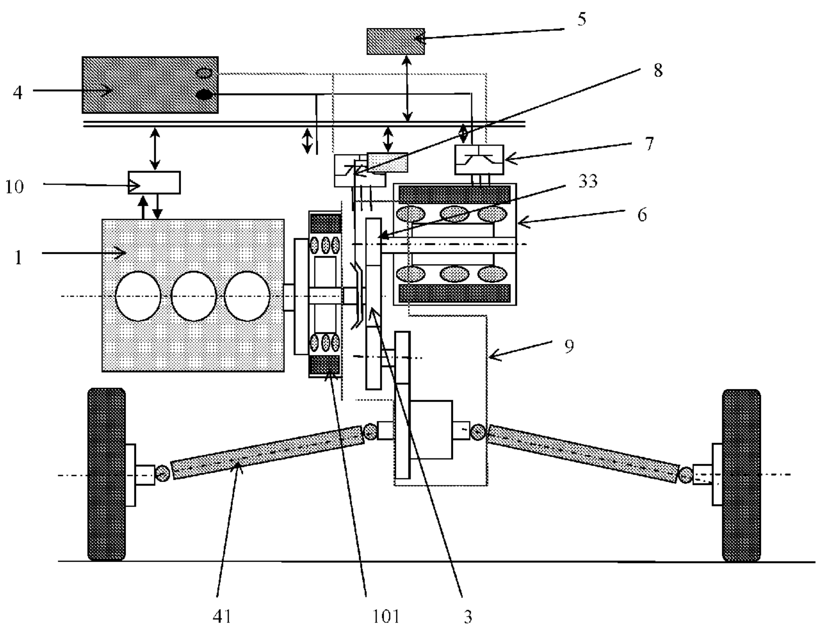

FIG. 1

(57) Abstract: The present disclosure relates to a powertrain (100) of a hybrid vehicle, comprising an input gear (3) mounted to an input shaft (19) of an engine (1) through a bearing, wherein the engine (1) is connected to an axial flux machine assembly (101). A motor gear (33) is connected to an electric motor shaft (29) of a traction motor (6) and geared to the input gear (3). A lay shaft (35) of a transmission module (9) is geared to the input gear (3) and a differential unit (36) and a shifter sleeve (30) is connected coaxially to the input shaft (19), wherein upon actuation of the shifter sleeve (30) by an actuator (8), the shifter sleeve (30) selectively engages the input gear (3).

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POWERTRAIN FOR A HYBRID VEHICLE AND METHOD THEREFORE

TECHNICAL FIELD

The present disclosure relates to transmission system in hybrid vehicles, In particular, embodiments of the present disclosure relates to clutch less transmission of hybrid vehicles.

BACKGROUND OF THE DISCLOSURE

Generally, vehicles or automobiles comprises of a powertrain consisting of three basic components i.e. power plant (engine), transmission and drive train of the vehicle. The power generated from the power plant (engine) is transferred to the transmission and then to the drive shaft affixed to the wheels of the vehicle. The transmission system consists of hydraulic actuators which operate at precise operating pressures and assists during gear engagement or disengagement. Upon conventional use, these hydraulic actuators gets heated up, and hence there is a necessity of a separate hydraulic cooling arrangement to be installed in the transmission for maintaining required operating conditions for the hydraulic actuator.

In hybrid vehicles, there are two separate power plants, one being a conventional internal combustion engine and the other being an electric motor. The electric motor is powered by a series of batteries placed in the vehicle. The batteries can be recharged by the internal combustion engine upon demand. Hence for hybrid vehicles, controlling and regulating the power from the power plants to achieve the desired vehicle occupant comfort in an efficient and cost effective manner becomes complicated. This is due to the fact that two hydraulic actuators have to be installed for the two separate power plants, to synchronise and transfer power to the wheels. This increases the space requirement for the vehicle and in turn increases the cost of the vehicle itself and brings in a change in the ergonomics of the vehicle. Also, the increased number of components adds weight to the vehicle, hampering the performance of the vehicle.

However, the problem of effective transfer of the power to the wheels of a hybrid vehicle has been overcome by utilising dual/twin clutch transmission system. In the dual clutch transmission system, each of the power transmission assembly is connected to each of the input shafts of the power plants and consequently drives one output shaft so that each of the clutch and gears can be shifted and clutched independently. In this manner, uninterrupted power transfer is made possible along with high mechanical efficiency of transmission. This also significantly increases fuel economy of the vehicle.

A clutch assembly of this type is disclosed in US Patent application no. US2009000896. The integrated starter generator and input clutch assembly for hybrid vehicles are disclosed in the document US2009000896. The document comprises a first and second sources of rotary power along with first and second transmission input shafts. A clutch hub is drivably connected to the first and second power sources. A first and second clutches is secured to the clutch hub for alternately closing and opening a drive connection between the first and second transmission input shafts and clutch hub. Further, a radial flux machine is used in the hybrid vehicle to facilitate cranking of the engine. However, in the document US2009000896, hydraulically actuated clutch assembly is used which adds weight due to the addition of components in the transmission module. This hampers the performance of the vehicle due to added weight and also increases the cost of the hybrid vehicle.

While, the conventional transmission system for a hybrid vehicle enables smooth and effective transfer of power, the system becomes cumbersome and complex due to the addition of performance components such as dual clutch, drive shafts etc.. Economically, manufacturing costs of the vehicle is also gradually increased, maintenance and serviceability of the vehicle becomes tedious and a costly affair.

In the light of the foregoing discussion, there is a need for a transmission which is simple in design, cost effective and at the same time overcome the limitations stated above.

SUMMARY OF THE DISCLOSURE

The limitations of the prior art are overcome and additional advantages are provided through the present disclosure. Additional features and advantages are realized through the techniques of the present disclosure. Other embodiments and aspects of the disclosure are described in detail herein and are considered a part of the claimed disclosure.

In one non-limiting embodiment of the present disclosure there is provided a powertrain of a hybrid vehicle, comprising an input gear mounted to an input shaft of an engine, wherein the engine is connected to an axial flux machine assembly. A motor gear connected to a motor shaft of a traction motor and geared to the input gear. A lay shaft of a transmission module geared to the input gear and a differential unit and a shifter sleeve connected coaxially to the input shaft, wherein upon actuation of the shifter sleeve by an actuator the shifter sleeve selectively engages the input gear.

In one embodiment of the present disclosure, the the axial flux machine assembly, comprises at least one rotor sandwiched in between two stators and coaxially coupled to flywheel, wherein the flywheel is mounted coaxially to the engine and the transmission module, such that one end of the flywheel is connected to crankshaft of the engine and other end of the flywheel is connected to a lay shaft of the transmission module and at least one damper connected in between the input shaft and the flywheel wherein the at least one damper dampens torsional vibrations generated during operation of the powertrain.

In one embodiment of the present disclosure, the flywheel is connected to the crankshaft using a coupler and a coupler bush to prevent axial movement of the flywheel.

In one embodiment of the present disclosure, an actuator upon receiving signals from an Electronic Control Unit operates the shifter sleeve to selectively engage the input gear.

In one embodiment of the present disclosure, the shifter sleeve upon selectively engaging with the input gear, the power is transferred from engine to the lay shaft or from traction motor to the lay shaft or both.

In one embodiment of the present disclosure, the actuator is selected from group comprising electro-mechanical, hydraulic and pneumatic actuators.

In one embodiment of the present disclosure, a method of assembling a powertrain of a hybrid vehicle is provided. The method comprises acts of mounting an input gear to an input shaft of an engine wherein the engine is connected to an axial flux machine assembly. Connecting a motor gear to a drive shaft of a traction motor, wherein the motor gear is geared to the input gear. Gearing a lay shaft of a transmission module to the input gear and connecting coaxially a shifter sleeve to the input shaft, wherein upon actuation of the shifter sleeve by an actuator the shifter sleeve selectively engages with the input gear.

In one embodiment of the present disclosure, a method of operating a powertrain of a hybrid vehicle is provided, said method comprises acts of operating a shifter sleeve connected to an input shaft by an actuator, upon receiving signals from an electronic control unit (ECU), wherein the shifter sleeve selectively engages an input gear with the input bearing shaft to transfer power from engine to a lay shaft or from a traction motor to the lay shaft or both.

In one embodiment of the present disclosure, the shifter sleeve upon selectively engaging with the input gear operates the hybrid vehicle in battery mode, engine mode, series mode, parallel mode and regeneration mode.

BREIF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are therefore, not to be considered limiting of its scope. The disclosure will be described with additional specificity and detail through use of the accompanying drawings.

Figure 1 illustrates powertrain of a hybrid vehicle of the present disclosure.

Figure 2 illustrates axial flux machine assembly with flywheel mounted coaxially to the crankshaft axis of the present disclosure.

Figure 3 illustrates sectional view of the powertrain of the hybrid vehicle of the present disclosure.

Figure 4 illustrates shafts layout within the transmission module of the present disclosure.

Figure 5 illustrates the shaft layout in the transmission when only traction motor is in operation of the present disclosure.

Figure 6 illustrates the cranking of the engine with the help of Integrated Starter Generator (ISG).

Figure 7 illustrates the shaft layout in the transmission module when only the engine is running to drive the wheels.

Figure 8 illustrates the shaft layout in the transmission module when both engine and traction motor is driving the wheels.

Figure 9 illustrates the shaft layout in the transmission module during series mode operation of the powertrain (100).

Figure 10 illustrates power flow when only traction motor is driving the wheels.

Figure 11 illustrates power flow when only Engine is running.

Figure 12 illustrates power flow when both engine and electric motor are driving the wheels.

Figure 13 illustrates power flow during series mode operation of the powertrain (100).

Figure 14 illustrates power flow during regeneration mode operation of the powertrain (100).

Figure 15 illustrates power flow during engine mode operation of the powertrain (100).

The figures depict embodiments of the disclosure for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles of the disclosure described herein.

DETAILED DESCRIPTION OF THE DISCLOSURE

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the figures, can be arranged, substituted, combined, and designed in a wide variety of different configurations, all of which are explicitly contemplated and make part of this disclosure.

Figure 1 illustrates hybrid powertrain (100) having an engine (1) mounted to an axial flux machine assembly (101) (also known as integrated-started generator) and geared to an input gear (3) placed in-between the engine (1) and transmission module (9). The engine bay consists of rotating and stationary components. The battery pack (4) is connected to the traction motor controller (7) which receives and distributes the current and also helps in charging of the battery pack (4). The traction motor (6) is connected to the motor shaft (29) which in-turn is connected to the input gear (3) via the motor gear (33). The engine (1) is coupled coaxially to the axial flux machine assembly (101). Further, the engine (1) is coupled to the transmission module (9) by gearing a lay shaft (35) of the transmission module (9) to the input gear (3). Similarly, the traction motor (6) is also coupled to the transmission module (9) of the vehicle via gearing the motor gear (33) to the input gear (3). An electro mechanical actuator (8) is provided which aids in switching to a variety of modes namely electric mode, parallel mode, series mode etc. An engine management system (EMS) (10) controls the speed and torque delivered by the engine (1), when the engine (1) is involved in charging the battery pack (4) or when engine (1) is driving the vehicle or both.

Figure 2 illustrates axial flux machine assembly (101) mounting scheme with flywheel (15) mounted coaxial to the crankshaft axis (18). In conventional flywheel mounting systems, the flywheel (15) was bolted onto the engine (1). In the present disclosure, the flywheel (15) is mounted coaxially to the crankshaft axis (18). The flywheel (15) is mounted by the aid of coupler (23) and coupler bush (24) to allow rotary motion of the flywheel (15). A crankshaft flange (25) is also coupled with the flywheel (15) to transfer torque from the crankshaft (2) of the engine (1) to the flywheel (15). A damper (20) is used on the other end of the flywheel (15) to connect the input shaft (19). Further, the damper (20) dampens the torsional vibrations generated during operation of the vehicle. Coupler (23) acts as an extension to the crankshaft (2) of the engine (1) along the axis of the crankshaft (18). A resolver rotor (16) is assembled to the coupler (23) using a key. In one embodiment of the present disclosure, other possibilities to mount the resolver rotor (16) can be bolting, gluing, etc. An ISG rotor (22) is bolted to the crankshaft flange (25) sandwiching the coupler (23). Resolver rotor (16) is assembled to the Coupler (23) while the Resolver stator (26) is assembled to the Stator holder plate (21). The resolver wires are routed through the Stator holder plate (21) through the transmission module front half (27). Resolver rotor (16) and resolver stator (26) is used to detect and convey the position of the ISG rotor (22) during different operations of the powertrain (100). Flywheel (15) has a splined shaft to transmit the torque from the engine (1) received from the crankshaft flange (25), to the input shaft (19). The flywheel (15) slides over the internal splines provided on the coupler (23) assembly, to facilitate easy arrangement of the flywheel (15) into the coupler (23) assembly. Flywheel (15) is supported by the coupler bush (24) at one end of the spline and by the inner race of coupler (23) at the other end of the spline on the flywheel (15). The coupler bush (24) restricts the axial movement of flywheel (15) in one direction, while the shim collar (17) restricts the other side along the crankshaft axis (18). The entire parts are housed within a transaxle bell housing (11) on the side of an electric traction motor (6) side and an engine adapter (12) on the engine (1) side.

The axial flux machine assembly (101) also referred as Integrated Starter Generator (ISG). In an embodiment of the present disclosure, the axial flux machine assembly (101) can be replaced with other types of electric machines.

Figure 3 illustrates cut sectional view of the hybrid electric power train (100) showing axial flux machine assembly (101) mounted to the engine (1) on one side and motor shaft (29) on the other side via motor gear (33). The transmission front half (27) comprises of the flywheel (15) mounted to the coupler (23) (shown in figure 2) by way of coupler bush (24) (shown in figure 2) and an ISG rotor (22) mounted over the coupler (23) assembly. The transmission rear half (28) has all the necessary parts which aid in transmitting the power from the electric traction motor (6) to the transmission module (9) for vehicle movement. Integration of the engine (1), axial flux machine assembly (101) and the traction motor (6) to transmission module (9) helps in transmission of power from either of the drivers through a single gearing system. A shifting mechanism is also employed at the transmission rear half (28) which helps in shifting of the gears within the transmission module (9) whenever an actuator (8) is actuated for operations of only the traction motor (6) or engine (1) or both. An actuator (8) is fixed to the shifter sleeve (30) and this shifter sleeve (30) is connected to the shifter rod (31) which facilitates in gear engagement or dis-engagement whenever the actuator (32) is actuated. In one embodiment of the present disclosure, the actuator (8) can be an electromechanical actuator, hydraulic actuator or a pneumatic actuator.

Figure 4 illustrates shafts layout within the transmission module (9). The motor shaft (29) has a motor gear (33) geared to an input gear (3). The input gear (3) is mounted to the input shaft (19) through a bearing. A shifter sleeve (30) and a shifter hub (37) are mounted on the input shaft (19), and are coaxially placed with the input gear (3). In one embodiment of the present disclosure, a rolling element (34) is provided in-between the input shaft (19) and the input gear (3). Further, a lay shaft (35) is geared to the input gear (3) to transmit torque from the input gear (3) to the differential unit (36) and then to the wheels of the vehicle (shown in figure 1).

Figure 5 and 10 illustrates the shaft layout in the transmission module (9) and power flow when only traction motor (6) is operating. In this mode the actuator (8) is deactivated and motor (6) is kept operational whereas, the engine (1) is in off condition. Traction Motor (6) is connected to the motor shaft (29) through the splines provided in the motor shaft (29). The motor shaft (29) and motor gear (33) are integrated together. Differential Unit (36) is connected to the wheels using an Axle (not shown). Traction motor (6) is rotated to transmit the torque to the motor shaft (29) and the motor gear (33). At this stage, the actuator (8) is in the retracted position such that the shifter sleeve (30) and the synchro cone (40) are not engaged with the input gear (3). Hence, the motor gear (33) transmits the torque to the lay shaft (35) directly, by rolling over the input shaft (19) without transmitting the torque to the input shaft (19). Thus, the torque is transmitted to the Differential unit (36) through lay shaft (35) from the traction motor (6), which is then transferred to the wheels of the vehicle by axles (41). This shaft layout and gearing is active only when traction motor (6) option is selected.

Figure 6 illustrates the cranking of the engine (1) with the help of axial flux machine assembly (101). The control algorithm embedded in an electronic control unit (5) commands the axial flux machine assembly (101) to start the engine (1). The electrical energy is converted to mechanical energy to crank the engine (1). ISG stators (13 & 14) (shown in figure 2) are excited by passage of electric current from the battery pack (4) (not shown). Due to this excitation, the stators (13 & 14) induces magnetic field around the magnetic ISG rotor (22), thereby rotating the rotor (22). This torque generated by the rotor (22) (shown in figure 2) of the axial flux machine assembly (101) is transmitted to the crankshaft (2) through the coupler (23) thereby cranking the engine (1).

Figures 7 and 11 illustrates the shaft layout in the transmission module (9) when only the engine (1) (shown in figure 1) is running and power flow when only engine (1) is running. In this mode the actuator (8) (not shown) is kept activated and the traction motor (6) is kept off while the engine (1) is kept running. In one embodiment of the present disclosure, this mode of operation is applicable only when the vehicle has already gained some speed, and not applicable to start the vehicle from a halt. When the vehicle is running in engine mode, the electronic control unit (ECU) (5) commands the actuator (8) (shown in figure 3) to actuate the shifter sleeve (30) to engage input shaft (19) with input gear (3). At this stage, the speeds of the motor shaft (29) and input shaft (19) are measured by sensors. The control algorithm embedded in an electronic control unit (5) synchronizes the speeds of the input shaft (19) such that its speed matches almost to that of the input gear (3). When the speed difference is small enough, the control algorithm commands the actuator (8) to move the shifter sleeve (30) through the shifter shaft (38), shifter rod (31), syncro cone (40) and shifter yoke (39) (shown in figure 3). This achieves a clutch-less engagement of gears within the transmission module (9). Further, in one embodiment of the present disclosure the spring ball arrangement in the shifter hub (37) locks itself with the shifter sleeve (30) by means of a spring ball mechanism. This way a positive locking is achieved between the shafts. The torque from the lay shaft (35) of the transmission module (9) is transferred to the differential (36). The axles (41) (shown in figure 1) then transfer the torque from the differential (36) to the wheels of the vehicle. Further, in one embodiment of the present disclosure, upon running the engine (1) the rotor (22) of the axial flux machine assembly (101) linked to the flywheel (15) also rotates. Upon rotation of the rotor (22) (shown in figure 2) electrical energy is generated, which is then transferred to the battery (4) for charging. Also, in another embodiment of the present disclosure the torque from the input gear (3) is also transferred to the traction motor (6) through motor gear (33), as the motor gear is geared to the input gear (3). Hence, the traction motor (6) generates electrical energy, which is then transferred to the battery (4) for charging.

Figures 8 and 12 illustrate the shaft layout in the transmission module (9) when both engine (1) and traction motor (6) are running and power flow is from both engine (1) and traction motor (6). In this mode of operation of the vehicle, the shifter sleeve (30) is actuated by the actuator (8) to engage input shaft (19) with the input gear (3). Further, the speeds of the motor shaft (29) and input shaft (19) are measured by sensors. The control algorithm embedded in an electronic control unit (5) synchronizes the speeds of the input shaft (19) such that its speed matches almost to that of the input gear (3). When the speed difference is small enough, the control algorithm commands the actuator to move the shifter sleeve (30) through the shifter shaft (38), shifter rod (31), syncro cone (40) and shifter yoke (39). This achieves a clutch-less engagement of gears within the transmission module (9). The spring ball arrangement in the shifter hub (37) locks itself with the shifter sleeve (30) by means of a spring ball mechanism. This way a positive locking is achieved between the shafts. Torque from the traction motor (6) to the input gear (3) flows identical as in Pure Electric mode, while the Engine (1) is cranked by the axial flux machine assembly (101). Torque is transmitted from the Engine (1) to the Input shaft (19) through crankshaft (2), coupler (23), flywheel (15), and damper (20). Further, all the torque i.e. torque from traction motor (6) and torque from the input shaft (19) is supplied to the input gear (3) and is amalgamated to a single torque for further transmission to the wheels through lay shaft (35) and differential unit (36).

Figures 9 and 13 illustrate the shaft layout in the transmission module (9) during series mode and power flow in series mode. In this mode the actuator (8) (shown in figure 3) is deactivated and the engine (1) is kept in running condition and simultaneously the traction motor (6) is also activated. Torque from the engine (1) is transmitted to the ISG Rotor (22) (shown in figure 2) through the crankshaft (2) and coupler (23) (shown in figure 2). The control algorithm embedded in an electronic control unit (5) commands the axial flux machine assembly (101) to generate and hence mechanical energy is converted to electrical energy to charge the battery (4). Electrical energy from the battery (4) (shown in figure 1) & electrical energy generated by the axial flux machine assembly (101) support running of the traction motor (6). The torque from the traction motor (6) is transferred to the wheels of the vehicle as transferred in pure electric mode.

Figure 14 illustrates power flow during regeneration mode operation of the powertrain (100). When the vehicle is required to slow down or come to a halt, the motor (6) converts the kinetic energy of the wheels into useful electrical energy for charging the battery (4) through the traction motor controller (7). This is achieved by transferring the torque of the lay shaft (35) linked to the running wheels, to the motor gear (33) through the input gear (3).

Figure 15 illustrates power flow during engine mode operation of the powertrain (100). In this mode, the engine (1) runs the axial flux machine assembly (101) and thereby induces electrical energy. This electrical energy is transferred to the battery (4), thereby charging it. Also, the actuator (8) (shown in figure 1 and 3) is disengaged there by no power is transferred from the engine (1) to the wheels. Hence, the engine (1) only drives the axial flux machine assembly (101). The axial flux machine assembly (101) generates electrical energy which is charges the battery (4). The electrical energy stored in the battery (4) is transferred to the traction motor (6). Hence, the traction motor (6) drives the vehicle.

As various changes could be made in the above without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

REFERRAL NUMERALS

100	Powertrain	19	Input shaft
101	Axial flux machine assembly	20	Damper

1	Engine	21	Stator holder plate
2	Crankshaft	22	ISG rotor
3	Input Gear	23	Coupler
4	Battery pack	24	Coupler bush
5	Electronic control unit (ECU)	25	Crankshaft flange
6	Traction motor	26	Resolver stator
7	Traction motor controller	27	Transmission front half
8	Actuator	28	Transmission rear half
9	Transmission module	29	Electric motor shaft
10	Engine management system (EMS)	30	Shifter sleeve
11	Transaxle bell housing	31	Shifter rod
12	Engine adapter	33	Motor gear
13	Engine Side ISG stator	34	Rolling element
14	Transmission side ISG stator	35	Lay shaft
15	Flywheel	36	Differential unit
16	Resolver rotor	37	Shifter hub
17	Shim collar	38	Shifter shaft
18	Crankshaft axis	39	Shifter yoke
19	Input shaft	40	Syncro cone
20	Damper	41	Axles
21	Stator holder plate		

We claim:

1. A powertrain (100) of a hybrid vehicle, comprising:

   an input gear (3) mounted to an input shaft (19) of an engine (1) through bearing, wherein the engine (1) is connected to an axial flux machine assembly (101);

   a motor gear (33) connected to an electric motor shaft (29) of a traction motor (6) and geared to the input gear (3);

   a lay shaft (35) of a transmission module (9) geared to the input gear (3) and a differential unit (36); and

   a shifter sleeve (30) connected coaxially to the input shaft (19), wherein upon actuation of the shifter sleeve (30) by an actuator (8), the shifter sleeve (30) selectively engages the input gear (3).

2. The powertrain (100) as claimed in claim 1, wherein the axial flux machine assembly (101), comprises:

   at least one rotor (7) sandwiched in between two stators (13) and coaxially coupled to flywheel (15), wherein the at least one flywheel (15) is mounted coaxially to the engine (1) and the transmission module (9), such that one end of the flywheel (15) is connected to crankshaft (18) of the engine (1) and other end of the flywheel (8) is connected to a lay shaft (35) of the transmission module (9); and

   at least one damper (20) connected in between the input shaft (19) and the flywheel (15) wherein the at least one damper (20) dampens torsional vibrations generated during operation of the powertrain (100).

3. The powertrain (100) as claimed in claim 2, wherein the flywheel (15) is connected to the crankshaft (18) using a coupler (23) and a coupler bush (24) to prevent axial movement of the flywheel (15).

4. The powertrain (100) as claimed in claim 1, wherein the actuator (8) receives signal from an Electronic Control Unit (5)(30) to selectively engage the shifter sleeve and the input gear (3).

5. The powertrain (100) as claimed in claim 1, wherein, power is transferred from at least one of engine (1) to the lay shaft (35) and traction motor (6) to the lay shaft (35) when the shifter sleeve (30) engages with the input gear (3).

6. The powertrain (100) as claimed in claim 1, wherein the actuator (8) is selected from group comprising electro-mechanical, hydraulic and pneumatic actuators.

7. A method of assembling a powertrain (100) of a hybrid vehicle, said method comprises acts of:

   mounting an input gear (3) to an input shaft (19) of an engine (1) wherein the engine (1) is connected to an axial flux machine assembly (101);

   connecting a motor gear (33) to a drive shaft (29) of a traction motor (6), wherein the motor gear (33) is geared to the input gear (3);

   gearing a lay shaft (35) of a transmission module (9) to the input gear (3); and

   connecting coaxially a shifter sleeve (30) to the input shaft (19), wherein upon actuation of the shifter sleeve (30) by an actuator (8) the shifter sleeve (30) selectively engages with the input gear (3).

8. A method of operating a powertrain (100) of a hybrid vehicle, said method comprises acts of:

   operating a shifter sleeve (30) connected to an input shaft (19) by an actuator (8), upon receiving signals from an electronic control unit (ECU) (5), wherein the shifter sleeve (30) selectively engages an input gear (3) with the input shaft (19) to transfer power from engine (1) to a lay shaft (35) or from a traction motor (6) to the lay shaft (35) or both.

9. The method as claimed in claim 8, wherein the shifter sleeve (30) upon selectively engaging with the input gear (3) operates the hybrid vehicle in battery mode, engine mode, series mode, parallel mode and regeneration mode.

AMENDED CLAIMS

received by the International Bureau on 05 September 2014 (05.09.14)

1. A powertrain (100) of a hybrid vehicle, comprising:

an input gear (3) mounted to an input shaft (19) of an engine (1) through bearing, wherein the engine (1) is connected to an axial flux machine assembly (101);

a motor gear (33) connected to an electric motor shaft (29) of a traction motor (6) and geared to the input gear (3);

a lay shaft (35) of a transmission module (9) geared to the input gear (3) and a differential unit (36); and

a shifter sleeve (30) connected coaxially to the input shaft (19), wherein upon actuation of a synchro cone (40) by an actuator (8) through a shifter sleeve (30), the shifter sleeve (30) selectively engages the input gear (3).

2. The powertrain (100) as claimed in claim 1, wherein the axial flux machine assembly (101), comprises:

at least one rotor (7) sandwiched in between two stators (13) and coaxially coupled to flywheel (15), wherein the at least one flywheel (15) is mounted coaxially to the engine (1) and the transmission module (9), such that one end of the flywheel (15) is connected to crankshaft (18) of the engine (1) and other end of the flywheel (8) is connected to a lay shaft (35) of the transmission module (9); and

at least one damper (20) connected in between the input shaft (19) and the flywheel (15) wherein the at least one damper (20) dampens torsional vibrations generated during operation of the powertrain (100).

3. The powertrain (100) as claimed in claim 2, wherein the flywheel (15) is connected to the crankshaft (18) using a coupler (23) and a coupler bush (24) to prevent axial movement of the flywheel (15).

4. The powertrain (100) as claimed in claim 1, wherein the actuator (8) receives signal from an Electronic Control Unit (5)(30) to selectively engage the shifter sleeve and the input gear (3).

5. The powertrain (100) as claimed in claim 1, wherein, power is transferred from at least one of engine (1) to the lay shaft (35) and traction motor (6) to the lay shaft (35) when the shifter sleeve (30) engages with the input gear (3).

6. The powertrain (100) as claimed in claim 1, wherein the actuator (8) is selected from group comprising electro-mechanical, hydraulic and pneumatic actuators.

7. The powertrain (100) as claimed in claim 1, wherein the engine output shaft is connected to the axial flux machine assembly (101) connected with the flywheel (15), the torsional damper (20) being mounted on the flywheel (15).

8. A method of assembling a powertrain (100) of a hybrid vehicle, said method comprises acts of:

   mounting an input gear (3) to an input shaft (19) of an engine (1) wherein the engine (1) is connected to an axial flux machine assembly (101);

   connecting a motor gear (33) to a drive shaft (29) of a traction motor (6), wherein the motor gear (33) is geared to the input gear (3);

   gearing a lay shaft (35) of a transmission module (9) to the input gear (3); and

   connecting coaxially a shifter sleeve (30) to the input shaft (19), wherein upon actuation of the shifter sleeve (30) by an actuator (8) the shifter sleeve (30) selectively engages with the input gear (3).

9. A method of operating a powertrain (100) of a hybrid vehicle, said method comprises acts of:

   operating a shifter sleeve (30) connected to an input shaft (19) by an actuator (8), upon receiving signals from an electronic control unit (ECU) (5), wherein the shifter sleeve (30) selectively engages an input gear (3) with the input shaft (19) to transfer power from engine (1) to a lay shaft (35) or from a traction motor (6) to the lay shaft (35) or both.

10. The method as claimed in claim 9, wherein the shifter sleeve (30) upon selectively engaging with the input gear (3) operates the hybrid vehicle in battery mode, engine mode, series mode, parallel mode and regeneration mode.

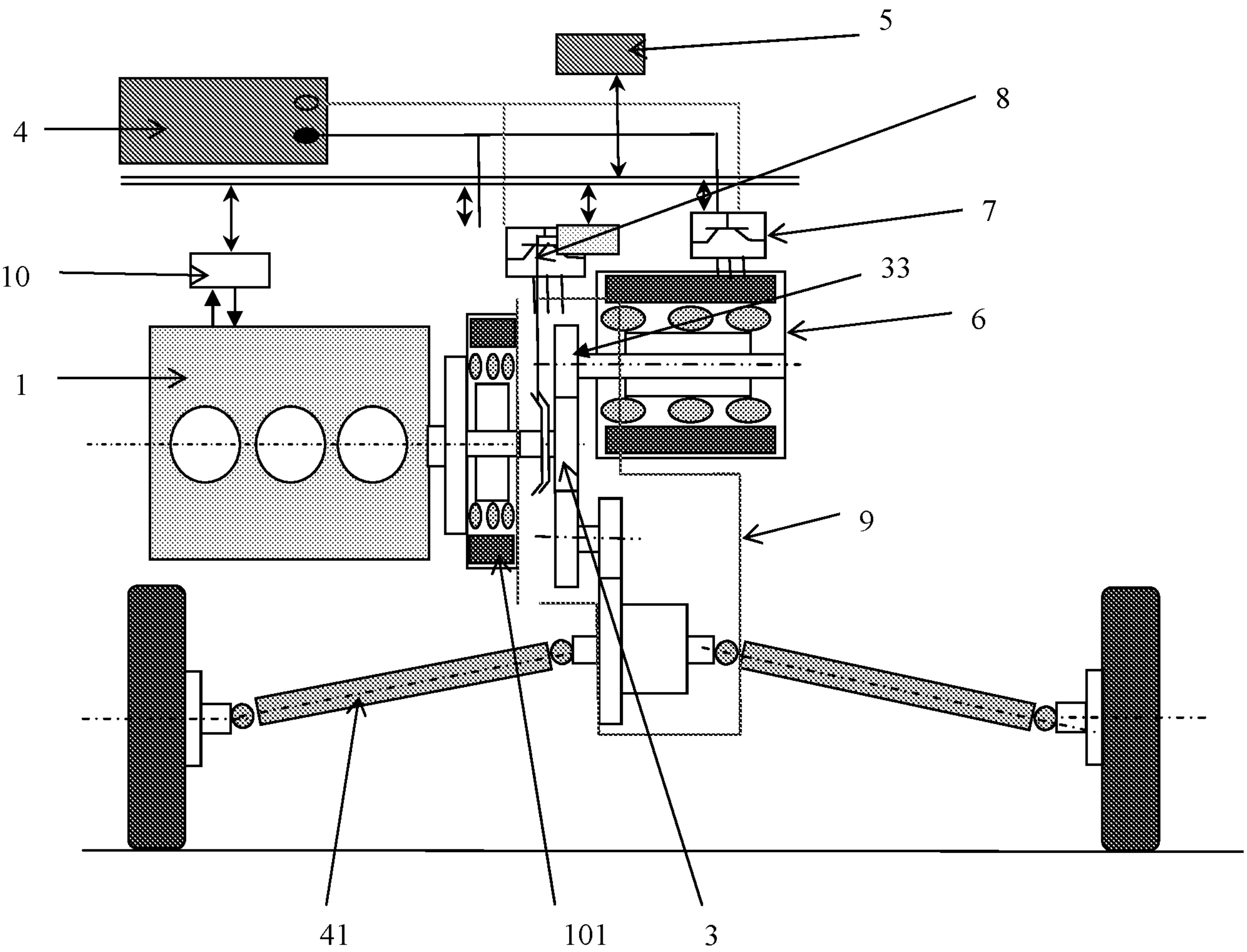

FIG. 1

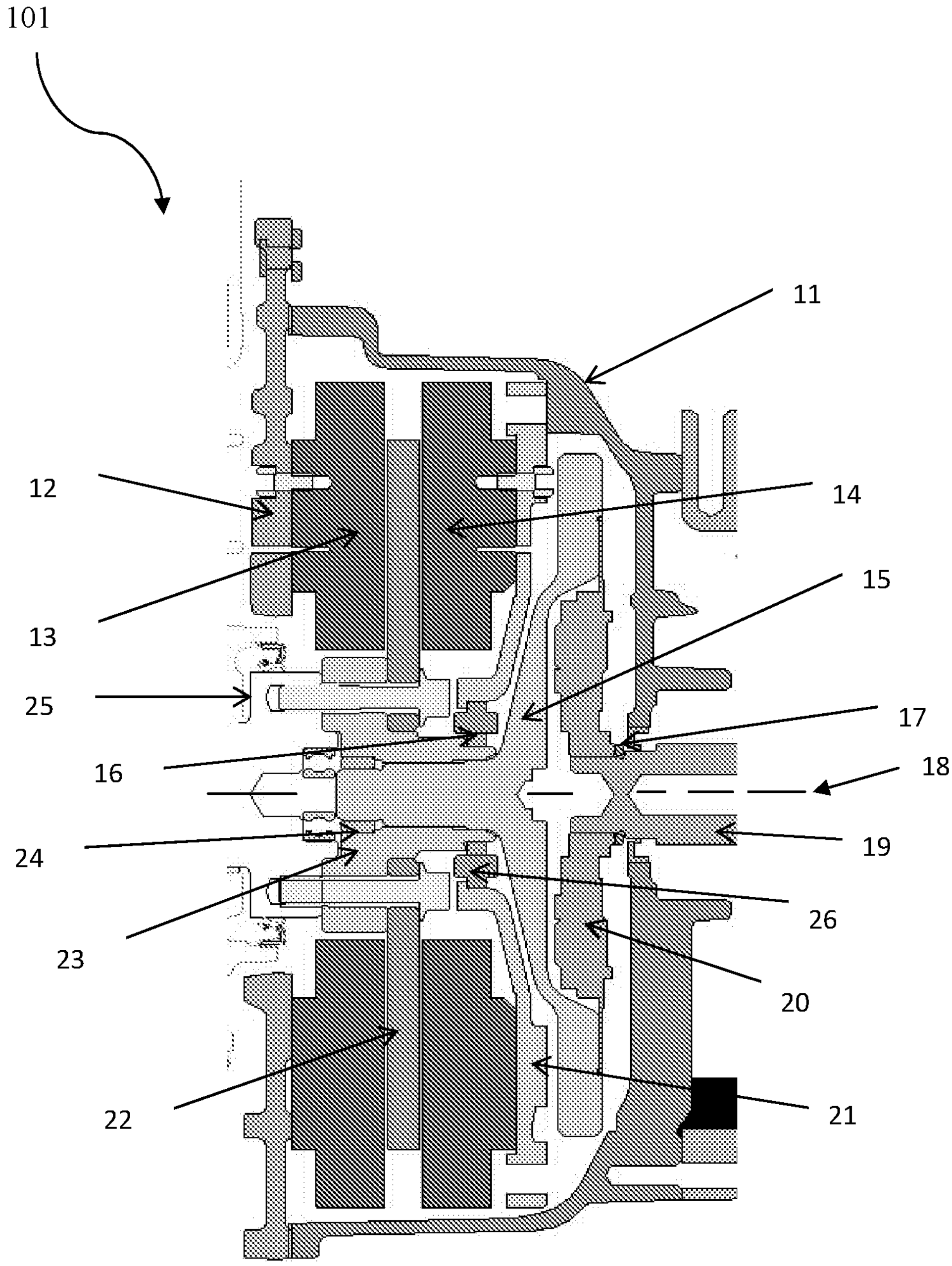

FIG. 2

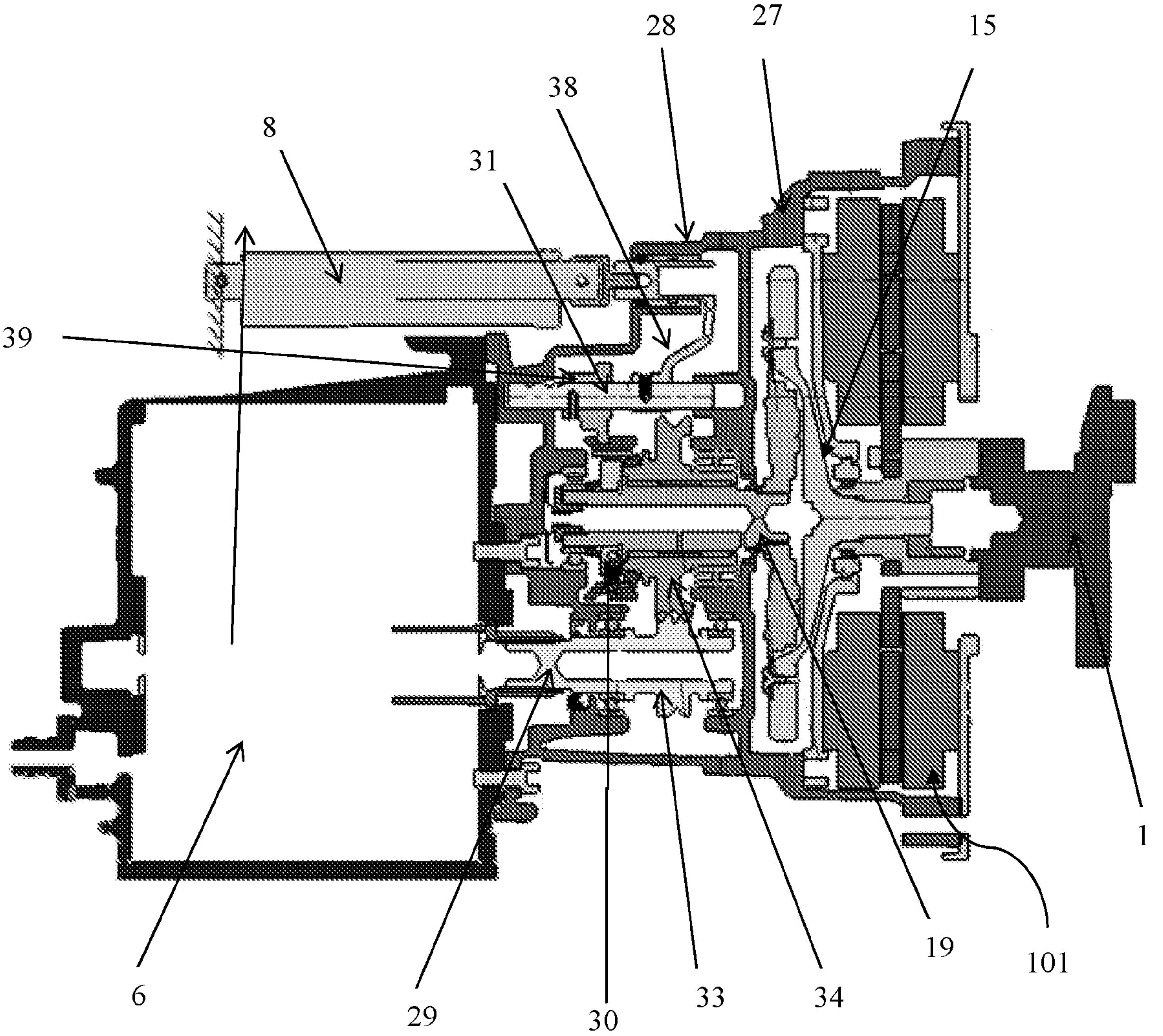

FIG. 3

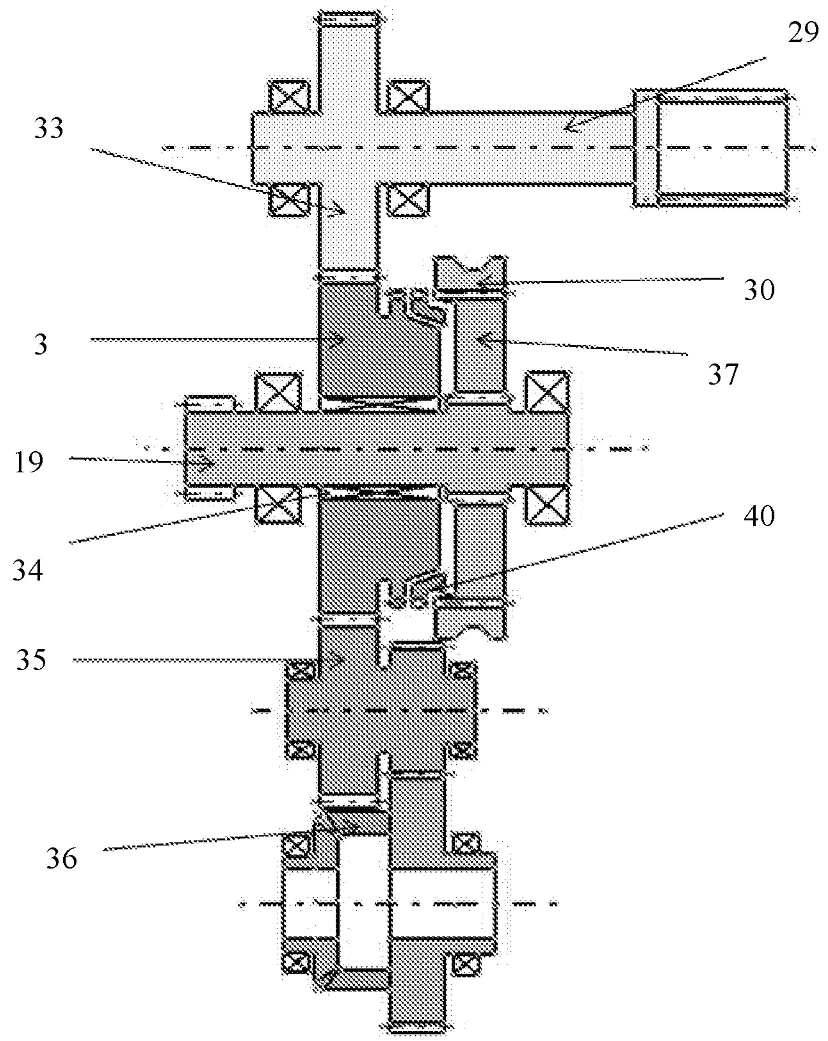

FIG. 4

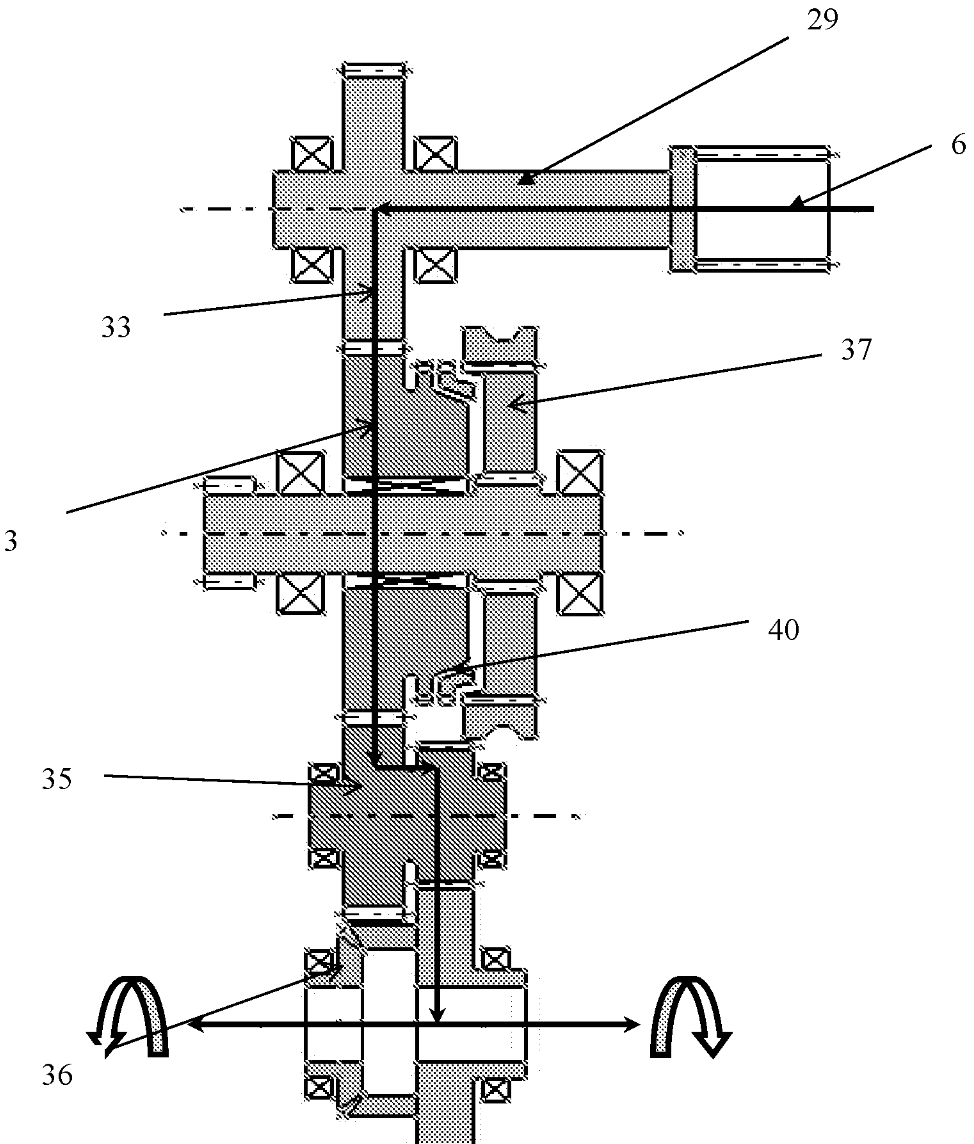

FIG. 5

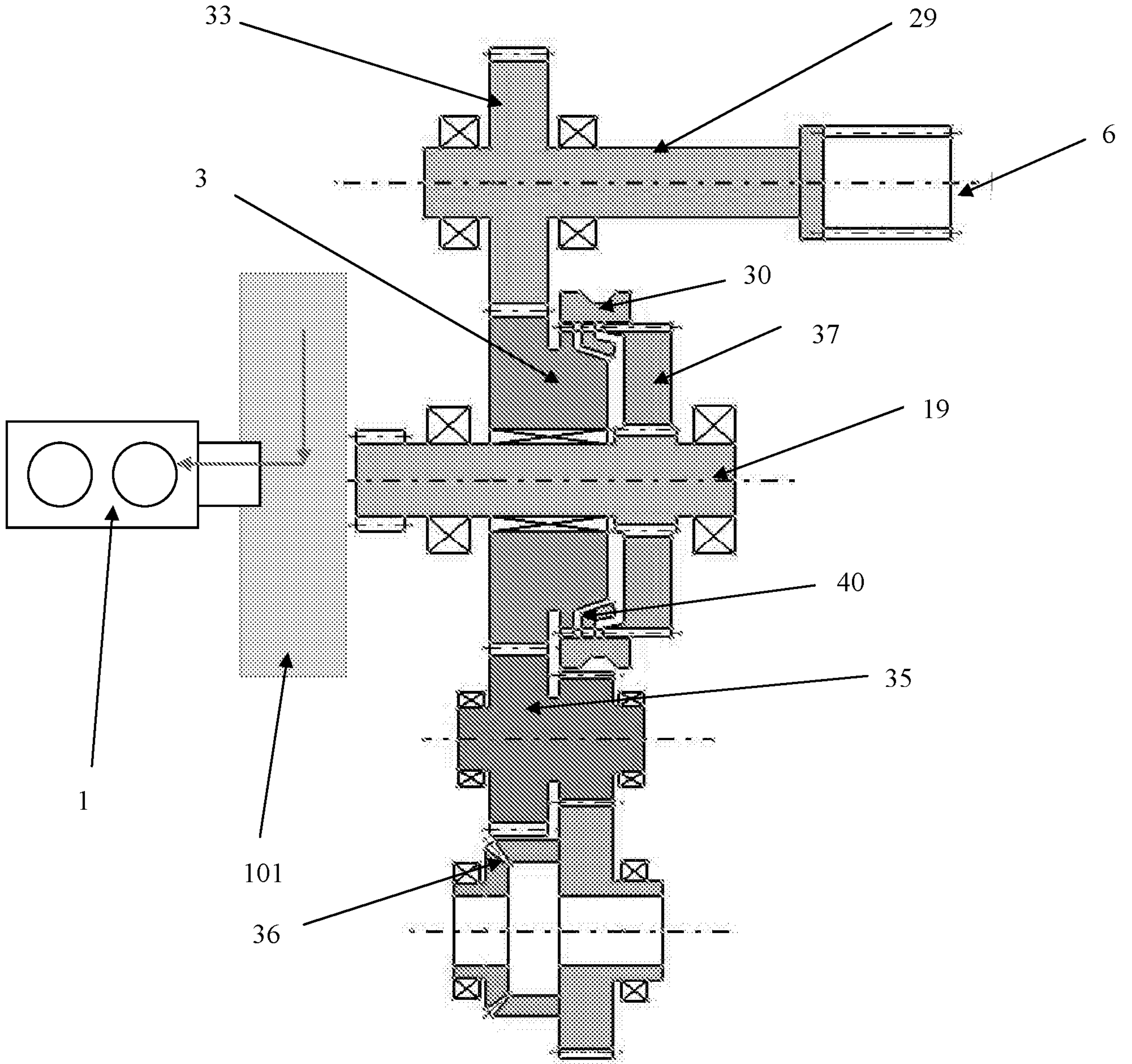

FIG. 6

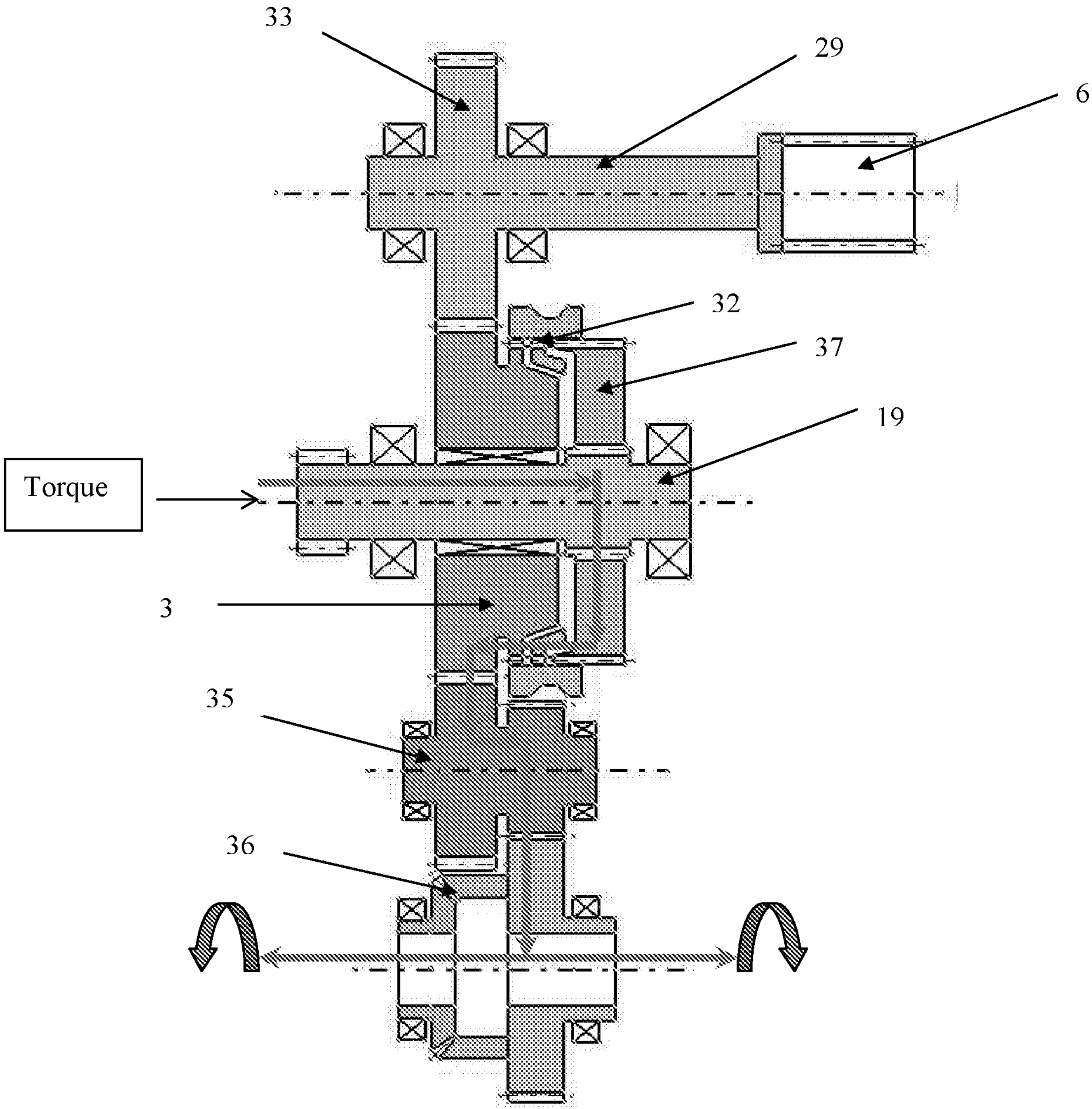

FIG. 7

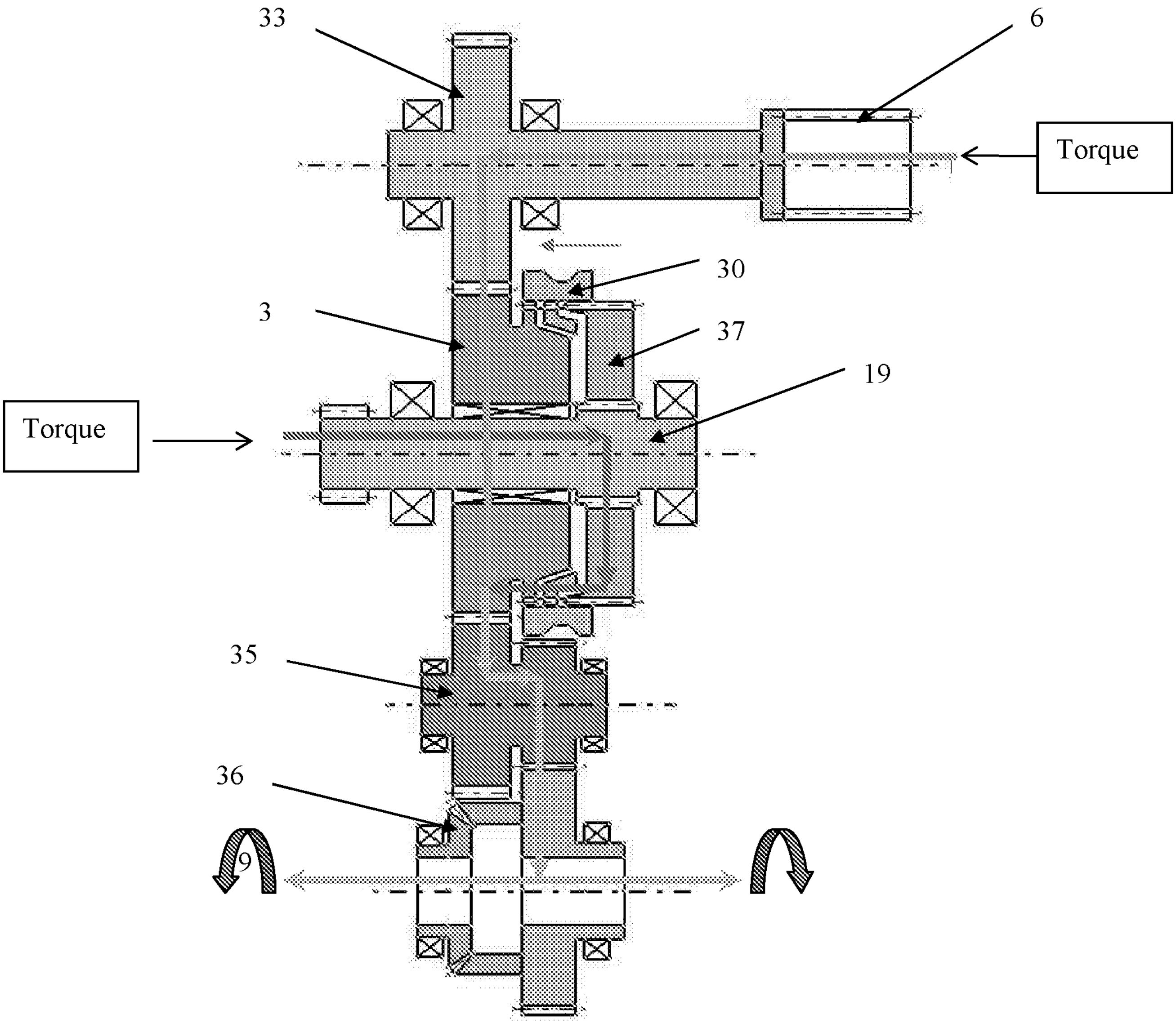

FIG. 8

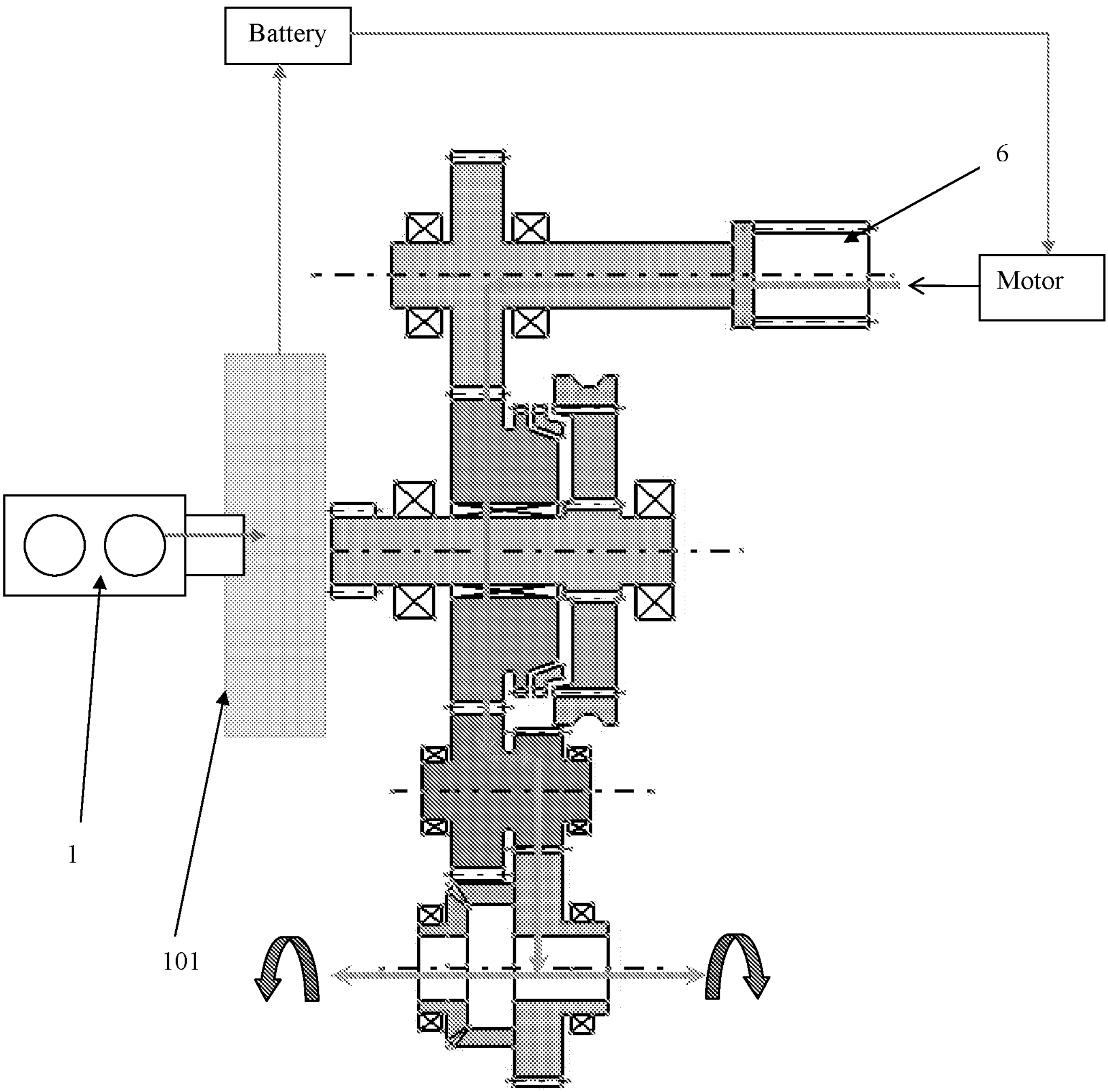

FIG. 9

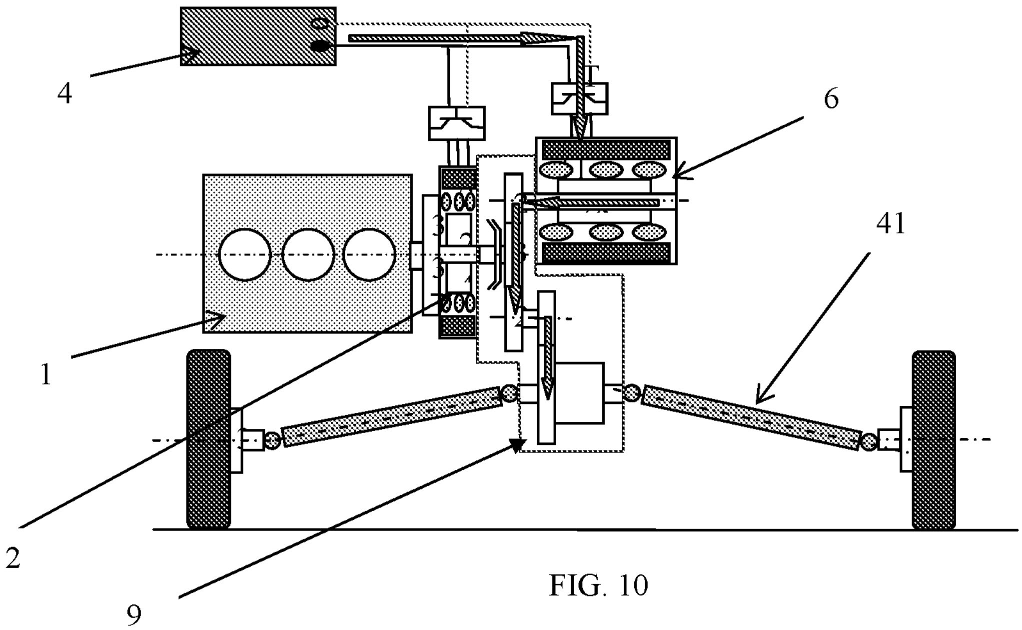

FIG. 10

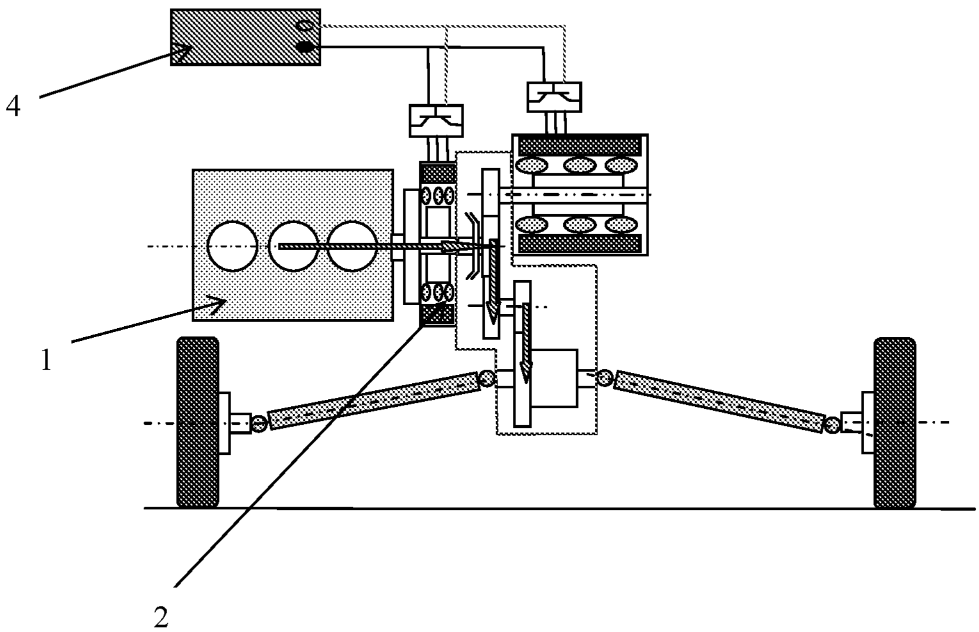

FIG. 11

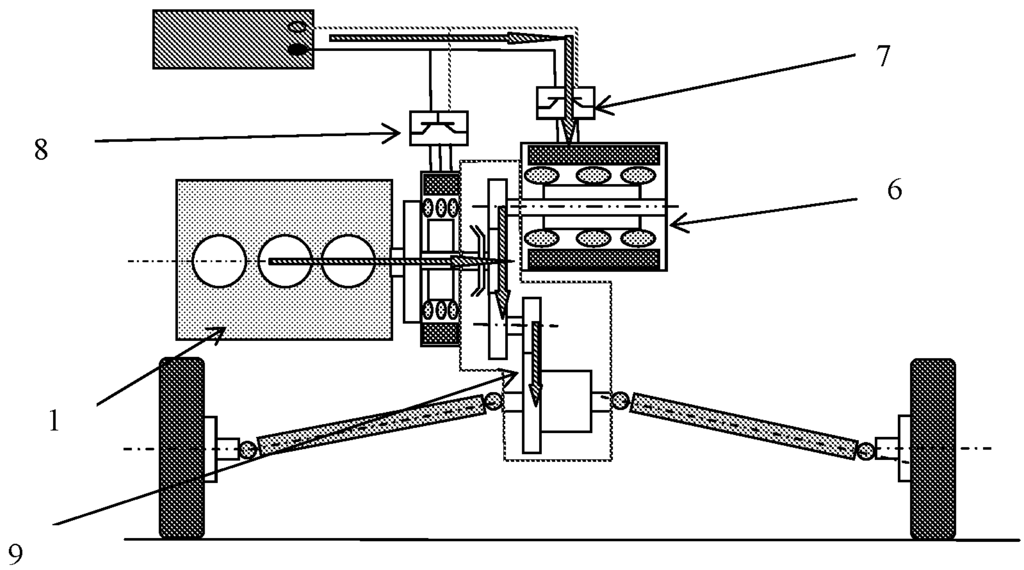

FIG. 12

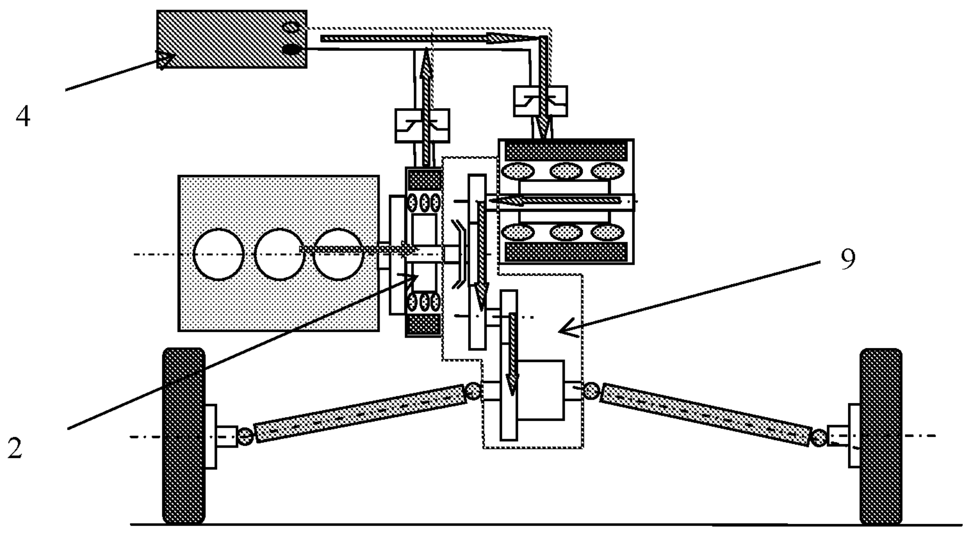

FIG. 13

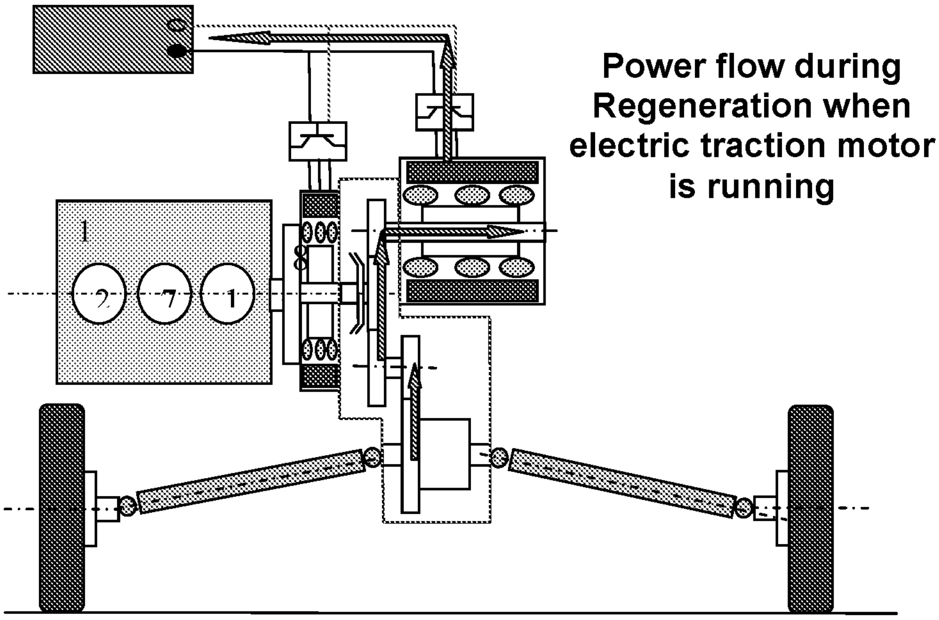
Power flow during
Regeneration when
electric traction motor
is running
1
8
2
7
1

FIG. 14

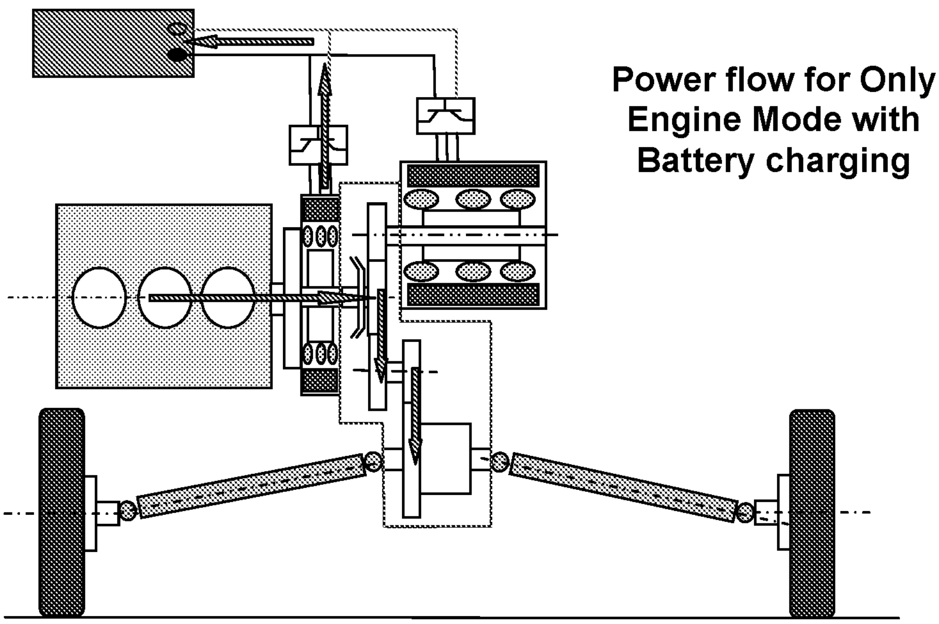
Power flow for Only
Engine Mode with
Battery charging

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2014/060075

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60K6/26 B60K6/387 B60K6/442
ADD. F16F15/14

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)
B60K F16F

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 Y	EP 1 876 050 A2 (HONDA MOTOR CO LTD [JP]) 9 January 2008 (2008-01-09) paragraphs [0016] - [0056], [0099]; figures 1,7	1,2,4-9 3
X	US 2008/156550 A1 (WEI TSENG-TEH [TW] ET AL) 3 July 2008 (2008-07-03) paragraphs [0050] - [0052], [0066] - [0068]; claim 13; figures 1-3,8	1-9
A	FR 2 973 299 A1 (RENAULT SA [FR]) 5 October 2012 (2012-10-05) page 3, line 33 - page 4, line 2; figure 1	1,7
A	WO 2011/015112 A1 (YE YUJING [CN]; YE SHAN [CN]; YE PENG [CN]; YE CHANGBIN [CN]; YE CHANG) 10 February 2011 (2011-02-10) abstract; figures 1-4	1,7

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"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
25 June 2014	07/07/2014

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	Wurzer, Oliver

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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			KR	20020095661	A	28-12-2002
			US	2002189569	A1	19-12-2002