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(54) Title: AN ELECTRIC DRIVE AND ASSIST ASSEMBLY

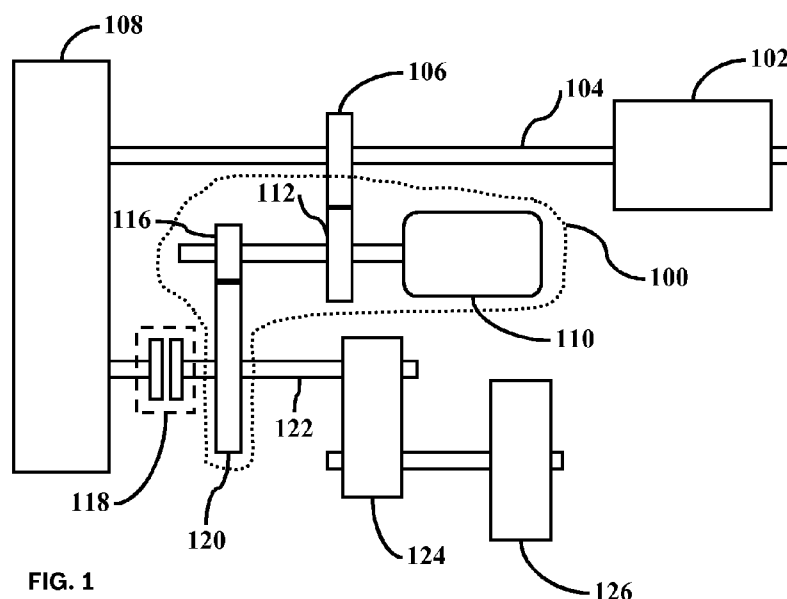


FIG. 1

(57) Abstract: The various embodiment of the present disclosure provide an electric drive and assist assembly 100 for a vehicle, which already comprises an Internal Combustion Engine (ICE)/ engine 102, a transmission 108 and a final drive unit 124. The trans-
mission 108 is coupled to the engine 102 and the final drive unit 124 by a primary shaft 104 and a secondary shaft 122 respectively. The electric drive and assist assembly 100 comprises an Electric Machine (EM) 110 coupled to the primary shaft 104 by at least one first engaging means 112 and electrically connected to a battery (not shown). The electric drive and assist assembly 100 further com-
prises at least one engaging means 116, 120 coupling the EM 110 to the secondary shaft 122.

Description**TITLE****AN ELECTRIC DRIVE AND ASSIST ASSEMBLY****Field of the invention:**

The present disclosure relates to an electric drive and assist assembly for a vehicle equipped with Internal Combustion Engine (ICE).

Background of the invention:

According to a patent literature US 8,191,660 a vehicle hybrid apparatus is provided. The vehicle hybrid apparatus provides a combined electrical unit that provides three functions that are starter motor, generator, and auxiliary drive motor. The apparatus attaches to a vehicle in typical starter motor location, with starter motor mounts being used. The pinion gear of the combined electrical unit is continuously engaged with the existing flywheel of the existing fuel engine. Electrical components of the apparatus are connected to existing automobile components and, together, these decide which function, whether starter motor, generator, or drive motor is employed.

Brief description of the accompanying drawings:

An embodiment of the disclosure is described with reference to the following accompanying drawings,

Fig. 1 illustrates a block diagram of first architecture of an electric drive and assist assembly for a vehicle, according to an embodiment of the present disclosure,

Fig. 2 illustrates a second architecture of the electric drive and assist assembly, according to an embodiment of the present disclosure,

Fig. 3 illustrates a third architecture of the electric drive and assist assembly, according to an embodiment of the present disclosure,

Fig. 4 illustrates a fourth architecture of the electric drive and assist assembly, according to an embodiment of the present disclosure,

Fig. 5 illustrates an Electronic Control Unit (ECU) for controlling the electric drive and assist assembly, according to an embodiment of the present disclosure, and

Fig. 6 illustrates a method for electrically driving and assisting a vehicle, according to an embodiment of the present disclosure.

Detailed description of the embodiments:

Fig. 1 illustrates a block diagram of first architecture of an electric drive and assist assembly for a vehicle, according to an embodiment of the present disclosure. The electric drive and assist assembly 100 is provided for a vehicle which already comprises an Internal Combustion Engine (ICE)/ engine 102, a transmission 108 and a final drive unit 124. The transmission 108 is coupled to the engine 102 and the final drive unit 124 by a primary shaft 104 and a secondary shaft 122 respectively. The electric drive and assist assembly 100 further comprises an Electric Machine (EM) 110 coupled to the primary shaft 104 by at least one first engaging means 112 and electrically connected to a battery (not shown). The EM 110 is optionally coupled to the primary shaft 104 via an additional at least one torque transmitting means (not shown in Fig. 1). The electric drive and assist assembly 100 furthermore comprises at least one second engaging means 116, 120 coupling the EM 110 to the secondary shaft 122. Still further, the EM 110 is optionally coupled through an additional at least one torque transmitting means (not shown in Fig. 1) to the secondary shaft 122.

The transmission 108 is selected from a group comprising but not limited to a Continuously Variable Transmission (CVT), an Infinite Variable Transmission (IVT), an automatic transmission, a semi-automatic transmission, a manual transmission and the like.

The transmission 108 is coupled to engine 102, which runs on fuel such as gasoline, petrol, diesel, flexi-fuel, etc. The primary shaft 104 is a crankshaft, which couples the engine 102 and the transmission 108 as known in the art. The transmission 108 is further coupled to the secondary shaft 122 on which the one or more wheels 126 of the vehicle is connected. The one or more wheels 126 are mounted to the secondary shaft 122 either directly or through a final drive unit 124. The final drive unit 124 comprises reduction gears/differentials for suitable or appropriate speed or torque transmission or distribution to the one or more wheels 126. The final drive unit 124 is coupled to the transmission 108 by the torque transmitting means 118. The torque transmitting means 118 comprises a clutch, which is controlled by actuating means comprising mechanical, electronic, hydraulic, pneumatic, electromechanical/ electromagnetic and the like. Hereinafter, the term "torque transmitting means" will be referred by term "clutch".

The EM 110 is selected in a manner such that, it is able to drive and assist the vehicle, and is also able to run as a generator for charging the battery (not shown in the Fig. 1). Hence, based on the type of EM 110 selected, a corresponding battery with appropriate properties and characteristics is used in place of or replaces existing battery in the vehicle. The EM 110 is mounted in place of the starter motor. Alternatively, the EM 110 is mounted in such a way that it engages with that component 106, which the starter motor used to engage with. The component 106 is generally a flywheel, but is allowed to be other than flywheel, which is mounted to the primary shaft 104 such as a gear or cogwheel and the like.

The first architecture comprises only a first engaging means 112 and the second engaging means 116, 120 for coupling the EM 110 to the primary shaft 104 and the secondary shaft 122 respectively. The EM 110 is mounted to the at least one intermediate shaft (not shown with a reference numeral). The at least one intermediate shaft is also axis of rotation for the first engaging means 112 and the second engaging means 116. Thus, the primary shaft 104, at least one intermediate shaft, and the secondary shaft 122 are coupled to each other. The electric drive and assist assembly 100 in Fig. 1 does not use any clutch. The first architecture is also allowed to be operated in electric mode, dual/hybrid mode and engine mode.

Fig. 2 illustrates a second architecture of the electric drive and assist assembly, according to an embodiment of the present disclosure. The EM 110 is coupled to the secondary shaft 122 through at least one torque transmitting means 114. The EM 110, first engaging means 112 and the second engaging means 116 are mounted to an at least one intermediate shaft (not shown with reference numeral), i.e. on the same axis.

The clutch 114 is assembled in between the first engaging means 112 and the second engaging means 116 on the at least one intermediate shaft. The EM 110 is coupled with the primary shaft 104 by at least one first engaging means 112. The first engaging means 112 comprises a gear or cogwheel, similar to the component 106 for transmitting the torque between the EM 110 and the engine 102. The coupling between the primary shaft 104 and the EM 110 is also possible by means of belt or chain on respective components 106 such as pulleys, sprockets, at least one reduction gear and the like.

According to an embodiment of the present disclosure, the EM 110 is selectively operated as any one of a traction motor, a starter motor, a generator and an assist motor. Alternatively, multiple modes of operating the EM 110 independently or in combination with the engine 102 are possible. The mode of running the vehicle comprises an electric mode, a dual/hybrid mode and an engine mode. The electric mode refers to starting of the engine 102 and assisting the engine 102.

Further, the mode of running the vehicle is decided automatically by a processor or controller (Electronic Control Unit) which monitors various operating parameters of the vehicle. Alternatively, a driver of the vehicle manually selects the mode of operation based on need. The operating parameters comprises but not limited to engine torque, engine speed, vehicle speed, Brake Specific Fuel Consumption (BSFC), temperature and the like. The temperature is further any one or combination of selected from a group comprising an EM temperature, battery temperature, ambient temperature, engine temperature, exhaust temperature and the like. At least one or combination of two or more operating parameters is taken for automatically switching between various modes of operating the vehicle.

In the electric mode, the EM 110 is operated as a traction motor or drive motor to help the vehicle to take-off from rest position or zero engine speed condition. For operating in the electric mode, the clutch 114 is actuated/closed thereby coupling the EM 110 to the secondary shaft 122 by the at least one second engaging means 116, 120. The second engaging means 116, 120 is similar to the first engaging means 112 and comprises gears, which mesh directly, or through belt or chain on pulleys and sprockets respectively. The clutch 118 is open or deactivated in the electric mode. The EM 110 drives the wheels 126 of the vehicle directly. The EM 110, is active and drives the vehicle until a condition is met, i.e. a specific predetermined threshold value for at least one of various operating parameter is reached, such as but not limited to reaching

to a specific speed. Once the condition is met, the EM 110 switches to dual mode. The EM 110 also assists in start-stop conditions during the vehicle drive.

In another embodiment, in the electric mode the EM 110 drives at least one wheel 126 along with cranking the engine 102. The engine 102 is brought to a condition of driving the vehicle for taking over as the drive source. The EM 110 is then starts assisting the engine 102 in the dual/hybrid mode. Alternatively, the EM 110 is operated as generator.

In the dual mode, the EM 110 and the engine 102 both operate together. The EM 110, which cranked and started the engine 102 in the electric mode, now supports the engine 102. The EM 110 keeps assisting the engine 102 until a second threshold value of the at least one operating parameter is reached. The clutch 114 is deactivated or opened, thereby coupling the EM 110 to the primary shaft 104 only. The clutch 118 is actuated or is closed. Alternatively, the EM 110 is still connected to secondary shaft 122 by actuating the clutch 114. Similar to the electric mode, the dual mode is active until another condition is met, i.e. a specific second threshold value for at least one of the various operating parameter is reached. After which, the vehicle switches to engine mode.

The operating parameter considered during the first threshold verification is same or different than the operating parameter considered during the verification of the second condition.

In the engine mode, the EM 110 operates as a generator and charges the battery. The EM 110 is driven by the engine 102 through the first engaging means 112, where the clutch 114 is deactivated or opened.

According to an embodiment of the present disclosure, the electric drive and assist, assembly 100 is retro fit to existing vehicle. Further, the electric drive and assist assembly 100 is preferred for a two-wheeler such as scooter, motorcycle, moped and the like, but is also capable to be used in other vehicles such as three wheelers such as auto-rickshaws, four wheeler such as cars and the like.

Fig. 3 illustrates a third architecture of the electric drive and assist assembly, according to an embodiment of the present disclosure. In the third architecture/ configuration/ topology, a clutch 115 is used to couple the EM 110 to the first engaging means 112. Thus, the EM 110 is not always connected to either the primary shaft 104 or the secondary shaft 122, but selectively coupled based on requirement. The EM 110 is also allowed to be optionally coupled to the first engaging means 112 on the at least

one intermediate shaft through the clutch 115. The clutch 115 is placed between the EM 110 and the first engaging means 112. The EM 110 is selectively coupled and decoupled based on the requirement. Otherwise, the functionality of the third architecture is same as that of Fig. 2.

In another embodiment, the motor 110 is coupled to the first engaging means 112 through the clutch 115. The first engaging means 112 is directly connected to the second engaging means 116 without the clutch 114.

In accordance to another embodiment, the EM 110 is coupled to the primary shaft 104 and to the secondary shaft 122 by respective at least one torque transmitting means 115 and 114.

Fig. 4 illustrates a fourth architecture of the electric drive and assist assembly, according to an embodiment of the present disclosure. The EM 110 is connected to the at least one intermediate shaft, but on the other end as compared to the architecture in Fig. 2. The EM 110 is able to drive the wheels 126 directly through the second engaging means 116, 120 while the clutch 114 is decoupled. Alternatively, the clutch 114 is coupled and the EM 110 drives both the wheels 126 and the engine 102. The clutch 118 is also controlled based on the operating requirement. In the fourth architecture, the EM 110 is also allowed to be optionally coupled through a clutch 115 (not shown in Fig. 4). The EM 110 is also operator as a generator based on the requirement.

Fig. 5 illustrates an Electronic Control Unit (ECU) for controlling the electric drive and assist assembly, according to an embodiment of the present disclosure. The ECU 500 is a processor or controller adapted to receive input signals 502 from sensors monitoring plurality of operating parameters. The sensors are existing sensors installed in the vehicle. The operating parameter comprises engine speed, EM speed, vehicle speed, engine torque, charge of battery, Brake Specific Fuel Consumption (BSFC), temperature and the like. The ECU 500 then compares at least one operating parameter value with a respective pre-stored threshold value. The ECU 500 takes the comparison result as input and controls the at least one torque transmitting means 114, 115, 118 and the EM 110 based on an operating strategy.

The operating strategy signifies, selectively and conditionally operating the EM 110 as any one selected from a group comprising traction motor, a starter motor, a generator and an assist motor.

For example: The ECU 500 checks speed of the vehicle with a speed sensor and if it is less than a specified first threshold value, the EM 110 is operated as a traction motor. The EM 110 starts the engine 102 and as well as helps the vehicle to take off from zero speed. The EM 110 also acts as a starter motor where it just starts the engine 102. If the speed reaches or becomes more than the first threshold value, then the EM 110 is operated as an assist motor. The EM 110 supports the engine 102. Now, if a second threshold of the operating parameters is reached, then the EM 110 is operated as a generator and the vehicle is run solely by the engine 102. To make the vehicle more efficient, the ECU 500 also controls the EM 110 as a starter motor. For controlling the EM 110, the ECU 500 controls the clutches 114, 115 and 118..., along with controlling battery.

The ECU 500 is used for controlling the electric drive and assist assembly 100 as described in the above paragraphs but not limited to aforementioned four architectures.

According to an embodiment of the present disclosure, the ECU 500 is an existing controller of the vehicle. Alternatively, the ECU 500 is a separate controller/processor, which communicates with the one or more existing ECUs of the vehicle.

Fig. 6 illustrates a method for electrically driving and assisting a vehicle, according to an embodiment of the present disclosure. The method for electrically driving and assisting a vehicle with an Internal Combustion Engine (ICE) as a prime mover is provided. The electric drive and assist assembly 100 is connected to the existing powertrain of the vehicle. The method comprises the step 602 comprises measuring operating parameters comprising engine speed, EM speed, vehicle speed, engine torque, charge of battery, Brake Specific Fuel Consumption (BSFC), temperature and the like. The step 604 comprises comparing at least one of the operating parameter with at least one pre-stored respective threshold values. The threshold value comprises a first threshold and a second threshold. The step 606 comprises controlling at least one torque transmitting means coupled with the EM 110 based on comparison with the at least one threshold value.

According to an embodiment of the present disclosure, selectively operating the EM 110 based on the comparison result comprises operating the EM 110 as a traction motor, a starter motor, a generator and an assist motor. The operating strategy is different in the region of operation comprising before first threshold, between first threshold and second threshold, and beyond second threshold. The EM 110 is operated differently during the vehicle run. For example: Before the first threshold, the EM 110 is operated as traction motor. Between the first threshold and the second

threshold, the EM 110 is operated as assist motor. Beyond the second threshold, the EM 110 is operated as generator. The EM 110 is also operated as conventional starter motor for only starting the engine 102. By the electric drive and assist assembly 100 the EM 110 is selectively operated which results in operating the engine 102 in optimal BSFC region. The above mentioned operating strategy is not fixed and is changed based on desired requirement.

According to an embodiment of the present disclosure, a hybrid architecture/ topology or configuration for a vehicle is provided. The hybrid architecture comprises a single EM 110 strategically coupled to the engine 102. The hybrid architecture provides maximum fuel economy benefits and efficiency. The architecture enables the engine 102 restart with the aid of energy recovered during the vehicle braking or deceleration, which is stored in the battery by operating the EM 110 as generator. Any electrical load demand is taken care by the EM 110 turned generator beyond hybrid operation range. The waste energy is utilized through regeneration during braking. A dedicated starter motor is eliminated from the vehicle. Further, a dedicated alternator/magneto is also eliminated from the vehicle. A comparatively bigger battery such as 48 V battery is used instead of 12 V battery. Any external charging system, which are generally used, is also possible to be eliminated due to the dual mode operation. The engine 102 is operated in best BSFC region by loading engine 102 through EM 110 as generator accordingly. Each mode of driving the vehicle is active either independently or in combination with other mode of driving.

According to an embodiment of the present disclosure, the electric drive and assist assembly 100 provides a parallel drivetrain or supplementary drivetrain, which operates either independently or in combination with existing drivetrain of the vehicle.

It should be understood that embodiments explained in the description above are only illustrative and do not limit the scope of this invention. Many such embodiments and other modifications and changes in the embodiment explained in the description are envisaged. The scope of the invention is only limited by the scope of the claims.

We claim:

1. An electric drive and assist assembly 100 for a vehicle, said vehicle comprising an Internal Combustion Engine (ICE) (102), a transmission (108) and final drive unit (124), said transmission (108) coupled to said ICE (102) and said final drive unit (124) by a primary shaft (104) and a secondary shaft (122) respectively, said electric drive and assist assembly 100 comprises:
an Electric Machine (EM) (110) coupled to said primary shaft (104) by at least one first engaging means (112), and
at least one second engaging means (116, 120) coupling said EM (110) to said secondary shaft (122).
2. The assembly (100) as claimed in claim 1, wherein said EM (110) is coupled to said primary shaft (104) through at least one torque transmitting means (115).
3. The assembly (100) as claimed in claim 1, wherein said EM (110) is coupled to said secondary shaft (122) through at least one torque transmitting means (114).
4. The assembly (100) as claimed in claim 1, wherein said EM (110) is coupled to said primary shaft (104) and to said secondary shaft (122) by respective at least one torque transmitting means (115, 114).
5. The assembly (100) as claimed in claim 1, wherein said EM (110) is selectively operated as any one selected from a group comprising a traction motor, a starter motor, a generator and a drive assist motor.
6. The assembly (100) as claimed in claim 1, wherein said at least one first engaging means (112) and second engaging means (116, 120) are selected from a group comprising a reduction gear, pulleys connected by a belt and sprockets connected by chain.

7. An Electronic Control Unit (ECU) (500) for controlling an electric drive and assist assembly (100) for a vehicle, said vehicle comprising an engine (102), said ECU (500) is adapted to:
receive at least one operating parameter comprising engine speed, EM speed, vehicle speed, engine torque, charge of battery, Brake Specific Fuel Consumption (BSFC), at least one temperature;
compare said at least one operating parameter value with a respective pre-stored threshold value; and
control coupling of said EM (110) with at least one of a primary shaft and a secondary shaft to operate as a traction motor, a starter motor, a generator and a drive assist motor based on said comparison result.
8. A method for electrically driving and assisting a vehicle with an Internal Combustion Engine (ICE) (102), said method comprises the steps of:
measuring operating parameters comprising engine speed, EM speed, vehicle speed, engine torque, charge of battery, Brake Specific Fuel Consumption (BSFC), temperature;
comparing at least one of said operating parameter with at least one pre-stored respective threshold values comprising a first threshold and a second threshold, and
controlling the coupling of said EM (110) with at least one of a primary shaft and a secondary shaft to operate as a traction motor, a starter motor, a generator and a drive assist motor based on said comparison result.
9. The method as claimed in claim 8, wherein said operating strategy is different in the region of operation comprising before first threshold, between first threshold and second threshold, and beyond second threshold.
10. The method as claimed in claim 8, wherein controlling said EM (110) results in operating said engine (102) in optimal BSFC region.

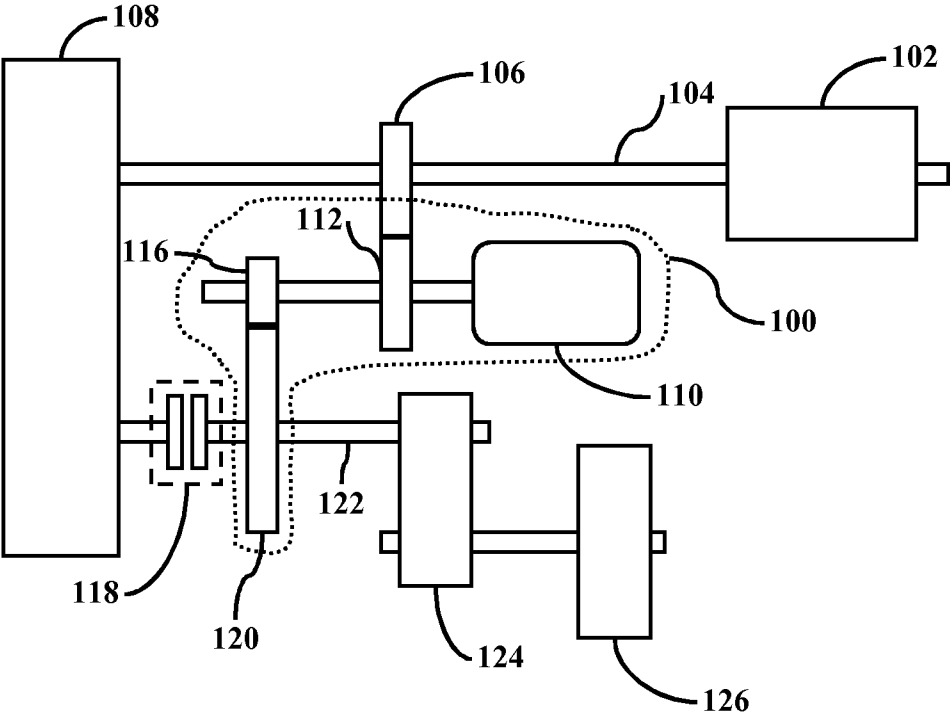


FIG. 1

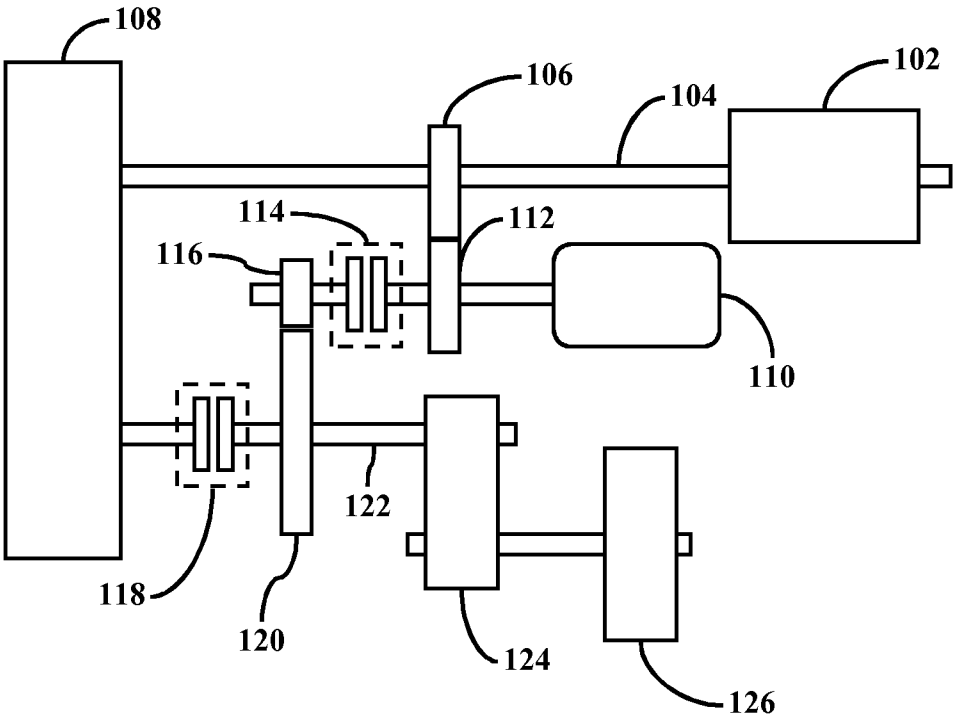


FIG. 2

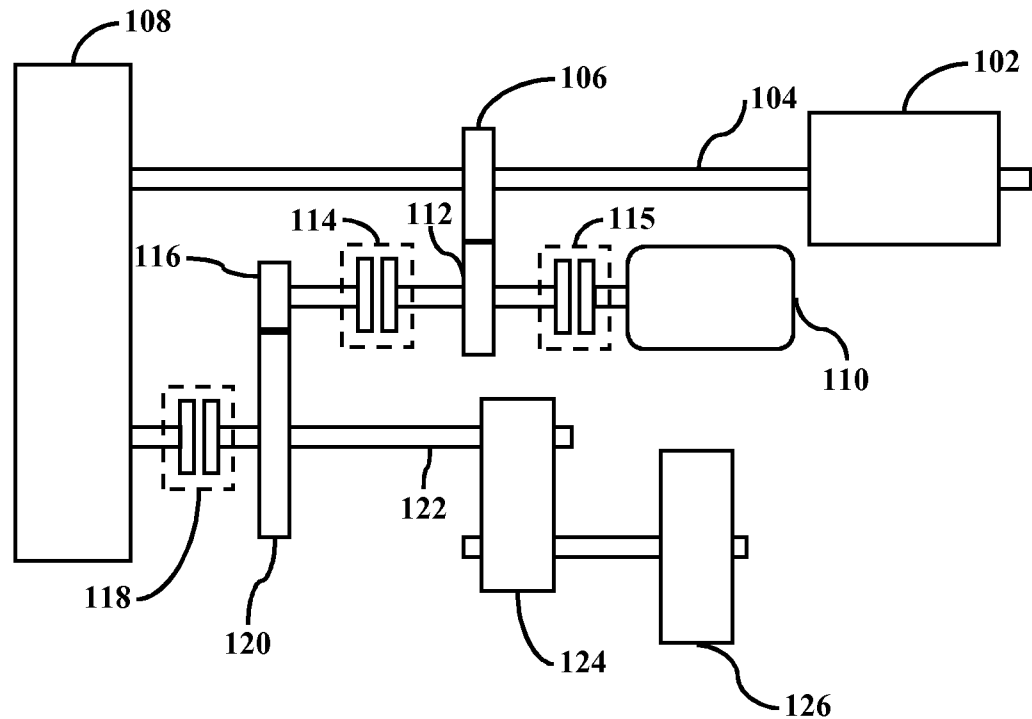


FIG. 3

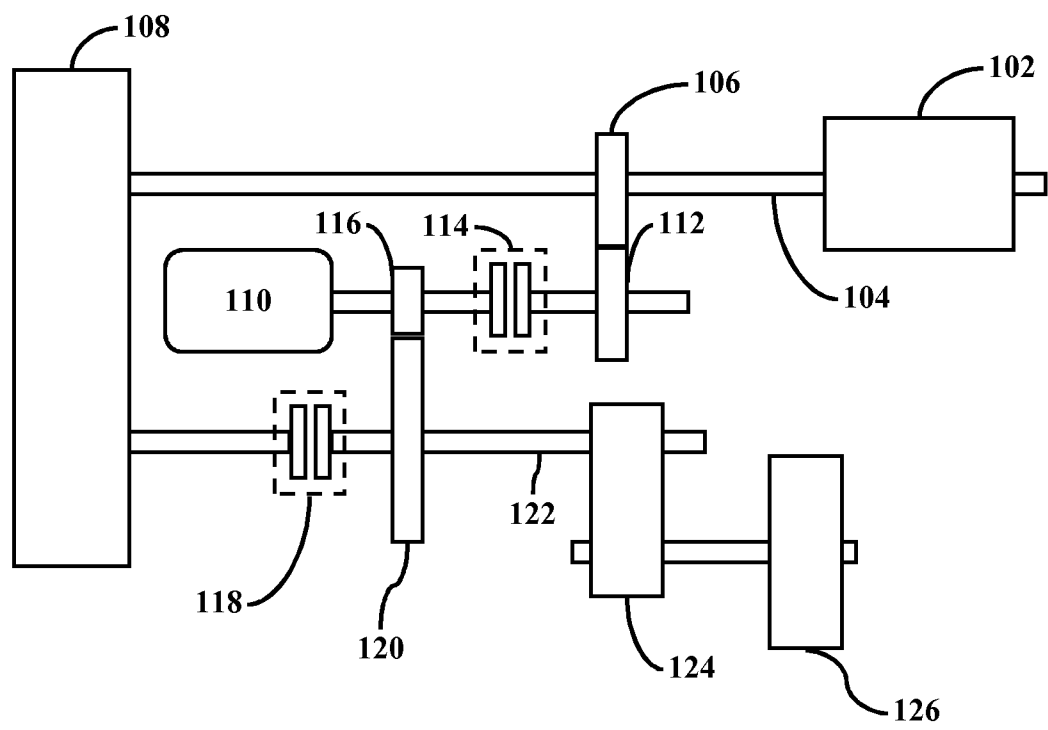


FIG. 4

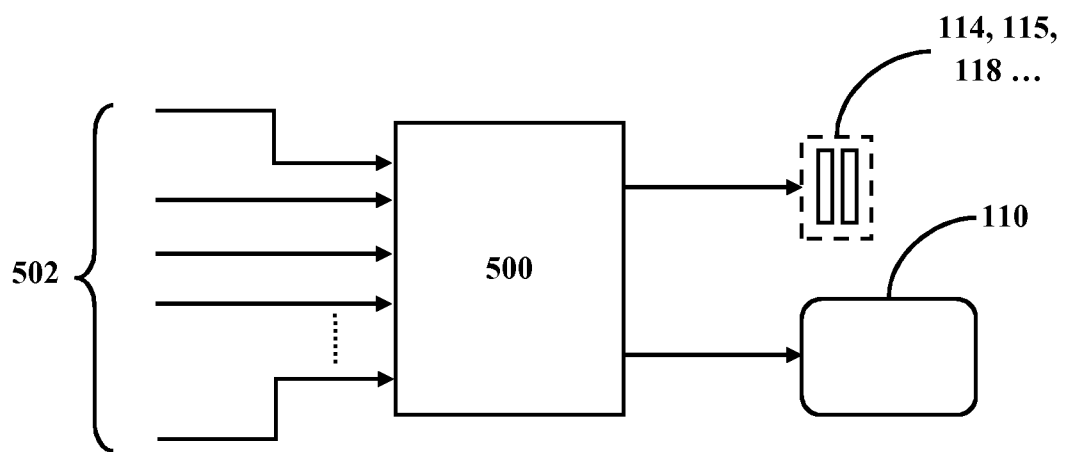


FIG. 5

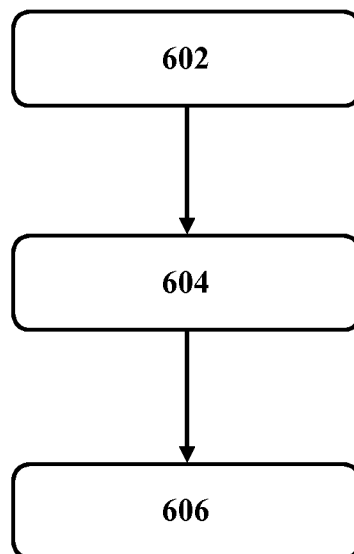


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
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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)
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, 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	EP 2 008 854 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 31 December 2008 (2008-12-31)	1-6
Y	paragraphs [0008], [0011], [0018] - [0037]	1
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	paragraphs [0065] - [0069], [0080], [0083], [0112] - [0122]; figures 1,7-13	
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A	US 2013/096759 A1 (BRETON LEO G [US] ET AL) 18 April 2013 (2013-04-18)	7-10
	paragraphs [0035], [0043]; figures 3,4	



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/057607

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