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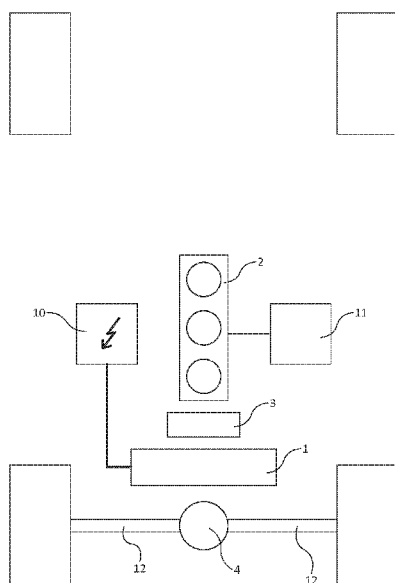


Fig.1

(57) Abstract: A powertrain for a hybrid vehicle with a primary drive output comprising at least one electric motor (1) coupled to a drive shaft for driving said drive shaft complemented by a combustion engine (2) capable of driving a drive axle (4), wherein the primary drive output comprises a combustion engine output with a gear ratio, such as an epicyclic gearing or compound epicyclic arrangement (3), located between its output and the input of at least one electric motor which drive a final gear ratio onto said drive axle.



Hybrid power train arrangement for a vehicle

The present invention relates to a hybrid power train arrangement for a vehicle, said power train having a primary drive output comprising at least one electric motor coupled to a drive shaft for driving said drive shaft complemented by a combustion engine coupled to said drive shaft for driving said drive shaft, said primary drive output being capable of driving a drive axle of the vehicle, wherein a first gear ratio is located between an output of said combustion engine and an input of said at least one electric motor and said at least one electric motor drives said drive axle over a final gear ratio.

In typical motor vehicle drive train arrangements, a combustion engine, which is typically most fuel efficient at a steady engine speed in the low end of its power band, drives one or more drive axles through a multi-gearbox. The multi-gearbox has multiple reduction gears to multiply input torque to optimally utilize the power band of the combustion engine delivered to its output. Gear selection is based on providing sufficient tractive force for either reaching or maintaining a certain vehicle speed. For fuel economy, it is desirable for a combustion engine to operate in a relatively high gear using low engine speed and/or at steady vehicle speeds. A typical electric motor can offer its maximum torque from standstill until a specified output speed at which it provides maximum power. Above this output speed, torque declines as power output stagnates as a function of power and rotation.

Typical hybrid drive train arrangements combine the characteristics of a combustion engines and an electric motor whereby at least one electric motor supplements a combustion engine driving at least one drive axle in a predetermined speed range, particularly where torque output from the combustion engine is limited, such as in lower revolutions and in between shifts. The duration at which an electric motor can assist depends on the traction battery state of charge or until its preset torque drop-off point or thermal limitations are reached.

For better acceleration and road handling, especially through corners, vehicle mass is preferably kept as low as possible while maximizing total torque output, particularly so in high-performance vehicles where a multi-gearbox represents an even higher percentage of the total vehicle mass. This matters especially for a vehicle with a dual-clutch transmission which reduces shift time by preselecting the next available gear.

A typical multi-gearbox drive train layout introduces efficiency losses of approximately 10-25% from its combustion engine to its driven wheels due to friction that is largely converted into excess heat, which necessitates additional cooling capacity. In hybrid vehicles, at least one electric motor are typically placed upstream from the gearbox, which may partially or entirely negate overall energy efficiency gains. The added torque output from an electric motor necessitates a higher torque capacity of the multi-gearbox which typically adds further to its mass and thereby contributing to a higher vehicle mass, which in turn increases fuel consumption.

Paradoxically, motor vehicles with hybridized drive trains designed to reduce fuel consumption are without exception heavier than their non-hybrid equivalents as well as significantly costlier to develop. In conclusion, hybridization may increase fuel efficiency and acceleration but typically negatively affects other significant key performance indicators, such as overall vehicle mass.

Electric motors typically offer higher power densities than combustion engines, however, in order to attain comparable power and range, battery electric vehicles must carry large and relatively heavy batteries with an energy storage that is a fraction of the energy density available from liquid and gaseous fuels for use for combustion engines. Even when using the highest performance battery technologies, the mass of battery electric vehicles will inevitably be higher than combustion engine equipped equivalents.

The combustion engine of a typical motor vehicle drive train typically features a power band with engine speeds higher than wheel speeds, necessitating a final drive ratio with a significant reduction that is usually driven through a multi-gear box with 5 to 8 or more forward gears, most of which are reduction gears, to match power band to wheel speed and increase wheel torque at lower wheel speeds.

A typical hybrid drive train arrangement comprises a combustion engine with at least one electric motor that typically functions as a torque assist to augment acceleration at lower speeds and in between shifts. Electric motors can deliver significant torque to propel a vehicle from standstill to increase wheel speeds where a combustion engine is unable to. Furthermore, a combustion engine is typically more fuel efficient providing the bulk of its available torque

higher up in its power band, therefore it is desirable to combine the characteristics of both in a single drive train to benefit from the strengths of both while reducing the effects of the drawbacks of either.

5 A drive train arrangement as described in the opening paragraph is known from WO 2014/033569. This known drive train comprises a gearbox between the combustion engine and an electric motor, which is described as preferably having multiple planetary gearings, such as a typical automatic transmission, with the purpose of keeping the combustion engine in a certain range of its power band at any given vehicle speed. This arrangement provides torque in a similar fashion to a conventional drive train with an electric motor augmenting total torque
10 output through a secondary gearbox and final drive ratio onto a drive axle. Continued acceleration of the combustion engine through the proposed gears, stated as a preferred total of 6, only marginally improves fuel economy and does not specifically eliminate drive train losses, since changes in wheel speed necessitate shifts that invariably changes combustion
15 engine speed.

Furthermore, the axial length of this known drive train arrangement does not reduce the demand of the drive train on space in the vehicle, which could otherwise be appropriated for storage purposes or aerodynamic features to increase the down force when aiming for high
20 performance applications.

It is therefore, among others, an aim of the present invention to provide a hybrid drive train for a vehicle which can be more compact and relatively light-weight.

25 To that end, a hybrid drive train for a vehicle of the type as described in the opening paragraph is characterized in that said first gear ratio between said combustion engine and said electric motor comprises a star type epicyclic gearing with a reducing gear ratio and in that a crankshaft of said combustion engine and said input of said electric motor are driven in opposite directions of rotation. Said at least one electric motor may have an adequate total output to provide the
30 drive axle with sufficient torque to generate the necessary tractive force for a desired acceleration. This avoids the need of a multi-gear box. By using a star type epicyclic gearing instead, the present invention significantly reduces associated drive train losses, weight and required dimensions. The invention moreover improves torque output and fuel economy, while

generating sufficient torque in addition to the torque output of the combustion engine in order to enable an increased top speed compared to an equivalent drive train without any electric motor.

5 The preferred application for an electric motor in the proposed hybrid powertrain is to supply sufficient torque to propel the vehicle from standstill up to its top speed, or drive a vehicle in reverse, similarly to a battery-powered electric vehicle. The proposed hybrid drive train arrangement allows at least one electric motor, such as an axial flux or pancake motor, to deliver the bulk of torque for acceleration while a combustion engine fuelled by an energy
10 dense liquid or gas is then burned to sustain a given speed, thereby preserving traction battery state of charge while optimizing fuel consumption.

WO 2014/109064 describes a direct-drive drive train arrangement without a multi-gearbox where an electric motor drives a drive axle of the vehicle in lower wheel speeds while the
15 combustion engine is uncoupled from the drive axle yet coupled to an electric motor functioning as a generator to increase the battery state of charge. At speeds where fuel economy favours the combustion engine driving the drive axle, the combustion engine can be coupled to the drive axle to provide the vehicle with propulsion while the electric motor can be switched off and/or uncoupled to prevent a decrease in the state of charge of the traction
20 battery.

In unison with a combustion engine and its associated fuel tank capacity, the range of the vehicle can well exceed that which the battery capacity is able to provide, allowing a decrease in required battery capacity for a given range and thereby reducing battery size as well as mass,
25 which in turn lowers total vehicle weight and even production costs.

For example, WO 2016/079118 describes a direct-drive drive train arrangement characterized by a lack of a multi-gearbox between its combustion engine and final drive gear and drive axle. This arrangement has the notable absence of a gear ratio in between its combustion engine and
30 adjacent electric motor, whereby the associated combustion engine and electric motor top speeds relative to each other and resulting total torque output curve are likely or even inevitably not optimally tuned throughout the vehicle speed range.

There are several different reasons for which one might want to tune combustion engine speeds to one or more serial or parallel electric motors. One possible reason is for the maximum torque of both electric motors and combustion engine to coincide at a particular engine, motor and wheel speed. To achieve this, a fixed gear ratio, preferably in a type of epicyclic gear with minimal losses, is placed between the combustion engine output and at least one electric motor on its output axle with an optional brake on its reactionary to isolate the combustion engine from driving the vehicle, for example in order to allow operation similar to that of a battery electric vehicle. Therefore, in a preferred embodiment, the powertrain arrangement according to the invention is characterized in that said star type epicyclic gearing is provided with a brake on a reactionary member thereof, such as the carrier, to effect a neutral gear position between the combustion engine and the at least one electric motor.

In another preferred embodiment, the powertrain arrangement according to the invention is characterized in that said star type epicyclic gearing is provided with one or more sprag bearings to effect a neutral gear position in the opposite rotation of said crankshaft of the combustion engine.

In another preferred embodiment, the powertrain arrangement according to the invention is characterized in that a torque converter is located between said at least one electric motor and said drive axle. Said torque convertor may be embodied as a lock-up type converter.

In another preferred embodiment, the powertrain arrangement according to the invention is characterized in that a clutch is located between said at least one electric motor and said drive axle. Said clutch may conveniently be embodied as a sprag bearing.

In another preferred embodiment, the powertrain arrangement according to the invention is characterized in that a multi-gearbox is located between said at least one electric motor and said drive axle. Said multi-gear box is conveniently embodied as a dual-clutch or an automatic transmission.

In another preferred embodiment, the powertrain arrangement according to the invention is characterized in that an epicyclic type gearing is located between said at least one electric motor and said drive axle, which allows for direct drive, reverse, neutral, and one reduction

gear. Preferably, the epicyclic type gearing is of the star gear type, which comprises a casing with brakes on its planet carrier and its annulus, so as to allow the selection of its reactionary and output, a sprag bearing each between carrier and output, and annulus and output, in opposite rotating directions to alternate between its output engagement and a brake between any two members in order to operate in direct drive.

In another preferred embodiment, the powertrain arrangement according to the invention comprises a primary drive output complemented by a further drive output comprising at least one electric motor driving said drive axle parallel to the primary drive output through, for instance, a ring and pinion gear.

In another preferred embodiment, the powertrain arrangement according to the invention comprises a primary drive output complemented by a further drive output on said drive axle, wherein at least one electric motor are mounted to each half shaft, so as to allow each wheel to be driven individually.

In another preferred embodiment, the powertrain arrangement according to the invention comprises a primary drive output complemented by a further drive output which comprises an epicyclic gear ratio located between at least one electric motor and said drive axle.

In another preferred embodiment, the powertrain arrangement according to the invention comprises a primary drive output complemented by a further drive output comprising at least one electric motor driving a second or further drive axles.

In another preferred embodiment, the powertrain arrangement according to the invention comprises a primary drive output complemented by a further drive output comprising one or more gear ratios, such as an epicyclic gear ratio, located between said at least one electric motor and said drive axle.

In addition, it is preferred that each electric motor is able to operate as a generator where an inverter or a motor controller reverses the flow of electricity that allows said electric motor to increase the state of charge of the traction battery by extracting kinetic energy from the vehicle

in motion during braking events and/or absorb energy from the output shaft of an operational combustion engine.

Hence, the present invention proposes a full hybrid solution to achieve the following improvements over existing technologies:

- Minimized drive train losses through a simplified transmission layout and thereby increasing efficiency compared to typical multi-gearbox drive train arrangements.
- Dimensional downsizing and weight-reduction advantages through the simplification of the primary drive output and transmission for spatial advantages used for e.g. storage or aerodynamic purposes. Reduced mass through a simplified transmission compared to, for example, a 7-speed dual clutch gearbox typically used in performance vehicles.
- ICE/MGU rotational speed harmonization through a single fixed ratio epicyclic gear of any combination of combustion engine and electric motor according to specified vehicle design characteristics such as acceleration in a desired speed range anywhere from standstill till top speed, to achieve a desired or maximized top speed, specific optimized cruising, fuel and/or battery economy.
- Sufficient tractive force from standstill for spirited driving, in high performance applications up to the slip limit of the tires. Raising the drive traction limit and enabling torque vectoring capabilities through motor generator placement by extending the drive train to a secondary or further output axle.
- Regenerative braking and range extending capabilities by using the electric motor as generator to increase traction battery state of charge and thereby maximizing traction battery driving range, prevent complete discharge during propulsion and reduce combustion engine fuel consumption and emissions.
- Forward, reverse and neutral drive capabilities through at least one electric motor, combustion engine or any combination of both elements.
- Operating modes for flexibility between using the internal combustion engine for tractive force to the wheels and/or driving at least one electric motor to replenish state of charge of the traction battery and to drive with minimal or zero emissions or to maximize torque output or driving range on the available fuel and battery state of charge available at any moment.

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- Multiple drive axles or all-wheel drive for improved traction during acceleration, increasing the drive traction limit and enabling a higher rate of energy recovery from regenerative braking.
 - Full drive train utilization in any given hybrid drive mode where each electric motor can function independently as either a motor or generator so none is ever incapacitated.
- Electric park brake capabilities.

The invention will now be described in further detail with reference to a few specific embodiments and an accompanying drawing. In the drawing:

Figure 1 presents a schematic overview of a first embodiment of a hybrid drive train according to the invention;

Figure 2 presents a schematic overview of a second embodiment of a hybrid drive train according to the invention;

Figure 3 presents a schematic overview of a third embodiment of a hybrid drive train according to the invention;

Figure 4A-D show a perspective view, front view, side view and cross-section respectively of a star type epicyclic gearing as used in the drive train according to any of the embodiments of figures 1 to 3.

It should be noticed that the drawings are drafted purely schematically and not to scale. In particular, certain dimensions may have been exaggerated to a lesser or greater extent for sake of clarity and understanding. Corresponding parts have been identified with same reference numerals throughout the drawing.

With reference to figure 1, the invention relates to a hybrid powertrain arrangement with a primary drive output comprised of an internal combustion engine (2) and at least one electric motor (1) driving an axle (4) and a fixed ratio star type epicyclic gear arrangement (3) mounted with its input coming from the combustion engine crankshaft and output onto an axially placed shaft with at least one electric motor allows for the tuning of the operational rotational speed range of the combustion engine (2) output to the desired rotational speed and/or torque range of the adjacent first electric motor (1) to the resulting rotational speed of the output of the epicyclic gear. This star type gear ratio (3) is shown in greater detail in figure 4 and reflects the exact ratio of the respective maximum output rotations of each would ensure that one can always complement the other within a specified rotational speed range.

Tuning the rotational speed at which maximum torque is transmitted from the combustion engine (2) output to converge or coincide with that of the at least one downstream electric motor (1) ensures that at any overlapping rotational operating speeds the combined output results in a higher torque output onto the drive axle (4) than that of either. Tuning ratios can be selected to achieve a desired combined torque output curve.

Additionally, the electric motor is able to replace the function of a starter motor for the combustion engine to eliminate the need of such and where the omission of said starter motor results in weight savings compared to a typical combustion engine in a non-hybridized drive train arrangement.

To reach and maintain a higher vehicle top speed than either combustion engine (2) or at least one electric motor (1) is able to reach on their own, as well as for durability purposes, it may be preferred to match the maximum combustion engine output speed to within 80% of the maximum operational rotational speed of the at least one electric motor (1) to ensure longevity of the powertrain by preventing neither from reaching rotational speeds detrimental to the other.

Engine speeds may remain below its given peak torque output rate at a given wheel speed while at least one electric motor (1) sufficiently complements the combustion engine (2) for a total torque output needed for a given vehicle velocity of increase thereof. Alternatively, the combustion engine (2) may be assisted by at least one electric motor (1) to supply the desired torque output for maintaining or increasing a certain vehicle velocity in a given gear.

To isolate the combustion engine (2) from the powertrain, the epicyclic gear (3) has brake on its reactionary that through its release allows for the cessation of torque transfer downstream from said combustion engine, thereby allowing for e.g. warm-up and idling, either stationary or under vehicle motion, driving the vehicle in reverse through at least one electric motor (1) without forcing the crankshaft of said combustion engine to turn contrary to operating rotation and revving the engine higher at lower vehicle speeds.

Additionally, with a forward motion of the vehicle and the combustion engine (2) output isolated from transmitting torque through the powertrain, and the influence from the drive axle

(4), at least one electric motor (1) can serve as a generator or regenerative brake that feeds energy into the traction battery and/or absorbs torque when the vehicle is moving forward.

5 The fixed ratio epicyclic gear (3) may be outfitted with a sprag bearing, a bearing that rotates freely in one rotational direction and engages in the opposite, to allow the combustion engine (2) to switch off completely or turn at a lower speed output speed while the vehicle is driven without transferring torque downstream.

10 A torque converter (6) may be placed before the drive axle (4) to multiply torque received from the upstream combustion engine (2) and at least one electric motor (1) for the purpose of increasing tractive force at lower vehicle speeds. When said torque converter is equipped with a lock-up clutch, direct drive throughput can be established that eliminates losses at converging input and output speeds and/or allowing for regenerative braking on the at least one electric motor upstream (1).

15 A torque converter (6), with a lock-up clutch disengaged in case of lock-up type, or a clutch (7) allows for the upstream elements to be isolated from the rotation of the wheels, enabling the combustion engine (2), fixed ratio epicyclic gear (3) and electric motor (1) to form a contained unit that can run independently from any wheel speed whereby torque from the output of the combustion engine (2) is absorbed by at least one downstream electric motor (1) that operates
20 as a generator to increase the state of charge of the traction battery (10). Additionally, the combustion engine (2) may idle or rev independently of wheel speed.

25 To effect a swift acceleration to a higher wheel speed, said combustion engine and said at least one electric motor is preferably brought to a higher rotation speed while the clutch is open to enable a high combined torque potential before engaging the clutch plates of said clutch in a controlled manner.

30 Placing a multi-gearbox (8) in between the drive axle (4) and at least one electric motor (1) results in a more traditional drive train arrangement for torque multiplication through reduction gears for traction and acceleration at lower speeds while taking advantage of the fixed gear ratio tuning by a star type epicyclic gear between combustion engine (2) and electric motors (1) according to the invention. If said multi-gearbox does not incorporate a clutch, such

a clutch (7) and/or a torque converter (6) and/or an epicyclic gear (3) with a neutral position may be incorporated to allow for said combustion engine idling and revving as necessary for desired operation. Typically, the presence of a reverse gear is preferred in such a multi-gearbox to allow for the combustion engine (2), at least one electric motor (1) or a combination of the two to propel the vehicle rearwards.

An epicyclic type gearing (9) may be provided featuring brakes on multiple elements complemented with two sprag bearings on the outputs to achieve direct drive, reduction drive, neutral and reverse (or optionally a reduction achieved through a reversed reverse output). Due to the downstream location of epicyclic gear (9), the combustion engine (2) can be utilized to add traction as needed. To enable reverse traction from the combustion engine (2) while turning at its designated direction, the following elements need to be present: epicyclic gear (9) and the brake on epicyclic (3) to achieve neutral gear to isolate the combustion engine (2) when the wheel speed corresponds with an engine speed lower than its idling rotational speed or the vehicle is driven in the reverse gear by at least one electric motor (1).

Typically, epicyclic gears feature three distinct members in the form of a sun gear, planet carrier with planet gears and annulus or ring gear and are affected by five laws or transmission modes, namely neutral, reduction, direct drive, overdrive and reverse. Brakes can be present on its respective specified members to achieve the aforementioned drive modes.

Four out of five possible transmission modes may be achieved, namely reduction, direct drive, reverse and neutral, in a single epicyclic gear. This can be achieved through alternately engaging and/or disengaging brakes to switch between either the carrier being the output member for reduction, the annulus as the output member for reverse, locking any two members together for direct drive or fully disengage all brakes for a neutral gear position where no torque transfer occurs, and provides an additional forward gear with reduction ratio to increase torque output to the drive axle (4) by the factor of the gear ratio at lower vehicle speeds.

The brakes of the planet carrier and annulus may be attached the gear housing with the planet carrier and annulus both connected to the output shaft that drives the drive axle (4) through mutually opposing rotary engagement sprag bearings that each rotationally engage when their respective reactionary turns the responding output in the desired direction, allowing for

automatic engagement of one and free rotation of the other as brakes are applied to switch outputs to either the planet carrier or annulus.

Such an adaptable epicyclic gear arrangement, which is similar in function to, yet lower in complexity than, a Ravigneaux gear set, can provide the desired peak output torque at lower vehicle speeds, shortens axial length and reduces weight and drive train friction losses over a multi-gearbox.

A drive train can be characterized as a parallel hybrid arrangement where the combustion engine (2) and/or at least one electric motor (1) can drive the drive axle (4) or where at least one electric motor (1) may function as a generator to extract energy from superfluous torque from the output of said combustion engine or the kinetic energy from the motion of the vehicle through the axle (4) in order to increase the state of charge of the traction battery (10).

During circumstances where little to no torque to the drive axle (4) is needed for the propulsion of the vehicle to sustain its velocity, such as during a stationary hold, coasting downhill or through corners or when the vehicle is towed or pushed, the combustion engine (2) and at least one electric motor (1) may be disconnected from said axle through disengaging a clutch (7) or a neutral transmission of the epicyclic (9) to allow said combustion to drive said at least one electric motor in isolation in order to increase the state of charge in the traction battery, for instance at a rate of input common to at least one electric motor (1) and that of the combustion engine (2) at any associated speed. By limiting power output in favour of energy returns for storage in the traction battery, such interruptions in torque demand from at least one drive axle (4) can improve speed efficiency and fuel and energy economy, e.g. under circuit racing conditions.

In the described full hybrid drive train having a primary drive output with a combustion engine (2) and at least one electric motor (1), where each output generates sufficient torque and power for adequate vehicle operation, a traditional multi-gearbox (8) typically having four or more forward gears would be unnecessary. Engaging both outputs allows for much larger gaps in between gear ratios to achieve a more than adequate acceleration. While a single forward drive engagement may suffice, it may be preferred for the primary drive output to feature one

or more additional reduction gears for torque multiplication to complement the direct drive torque transfer.

5 A second embodiment of the invention as shown in figure 2, allows for a series hybrid mode with at least one additional electric motor (1) for an independent secondary and further drive output to the primary drive axle (4) and/or further drive axles (5). In a drive train, where the primary drive output can function in a harvesting or electric range extending mode in isolation from drive axle (4), at least one additional electric motor (1) enables a simultaneous harvesting or electric range extending mode with at least one electric motor powering the primary drive
10 axle (4) and/or further drive axles (5).

Providing that, in a series hybrid mode, the energy demand from the at least one electric motor (1) propelling the secondary and/or tertiary drive output of the vehicle is lower than the available charge rate from the primary drive output isolated from its drive axle (4), extended
15 electric drive with the capacity of the traction battery (10) is possible through intermittent charge cycles dependent on the availability of the content of the fuel tank (11) to supply the combustion engine (2) to replenish the state of charge of said traction battery, which can be desirably effected at an optimized charge rate for a determined speed, intensity, fuel flow, a minimized combustion engine and associated exhaust sound, fuel to stored electric energy
20 efficiency, or desired charge cycle on-time relative to electric drive time available from the traction battery (11).

The presence of at least one further drive axle (5) allows for additional torque and power output that effectively raises total vehicle drive traction or slip limit, where the maximum
25 propulsion of the vehicle is achieved only through the available torque output from all electric motors on the secondary and/or tertiary drive outputs in addition to that of the primary drive output.

Electric drive is preferred for city driving typically characterized by a fluctuating moderate
30 power demand with, when necessary or convenient, complemented by intermittent charge cycles in series hybrid mode as necessary to replenish the traction battery (10). Additionally, electric drive can allow for a predictable throttle response for the electric propulsion of the vehicle as well as minimal noise production for silent driving, which benefits driving in areas

where combustion engines are not allowed for propelling a vehicle or exhaust emissions are banned or otherwise undesirable.

By reversing the energy flow, any electric motor in the secondary or further drive output can function as a generator and provide regenerative braking and drive axle hold to establish the standstill of the vehicle. Through an epicyclic gear with a fixed reduction ratio tuning the electric motor operational speed to the maximum wheel speed of the vehicle, improves efficiency in absorbing energy during braking to increase battery state of charge, especially from the front wheels where during a braking event more of the kinetic energy potential from the vehicle in motion can be converted back into an increase in battery state of charge than that from the rear wheels.

Part of a third embodiment of the drive train according to the invention is shown in figure 3. In this embodiment a drive axle is provided with at least one further electric motor (1) connected to each half shaft (12) to drive each of its wheels individually. This enables torque vectoring by increasing, reducing or even reversing the applied torque to a driven wheel in such a manner as to enhance the manoeuvrability of the vehicle. An epicyclic gear (3) is located between said further electric motor and the corresponding half shaft (12), so as to allow each wheel to be driven individually through an appropriately selected gear ratio. Besides this typical suspension and placement of the electric motors (1) the remainder of this embodiment largely corresponds to that of either the embodiment of figure 1 or figure 2.

Although the invention has been describes hereinbefore with reference to merely a few specific embodiments, it will be clear that the invention is by no means limited to these examples. Instead many alternatives and variations are feasible for a skilled person without departing from the scope and spirit of the present invention.

Claims:

1. A hybrid powertrain arrangement for a vehicle, said powertrain having a primary drive output comprising at least one electric motor (1) coupled to a drive shaft for driving said drive shaft complemented by a combustion engine (2) coupled to said drive shaft for driving said drive shaft, said primary drive output being capable of driving a drive axle (4) of the vehicle, wherein a first gear ratio is located between an output of said combustion engine and an input of said at least one electric motor and said at least one electric motor drives said drive axle (4) over a final gear ratio, characterized in that said first gear ratio (3) between said combustion engine (2) and said electric motor (1) comprises a star type epicyclic gearing with a reducing gear ratio and in that a crankshaft of said combustion engine (2) and said input of said electric motor are driven in opposite directions of rotation.

2. A powertrain arrangement according to claim 1, characterized in that said star type epicyclic gearing (3) is provided with a brake on a reactionary member thereof, such as the carrier, to effect a neutral gear position between the combustion engine (2) and the at least one electric motor (1).

3. A powertrain arrangement according to claim 1, characterized in that said star type epicyclic gearing (3) is provided with one or more sprag bearings to effect a neutral gear position in the opposite rotation of said crankshaft of the combustion engine (2).

4. A powertrain arrangement according to any one of the foregoing claims, characterized in that a torque converter (6) is located between said at least one electric motor and said drive axle (4).

5. A powertrain arrangement according to any one of the foregoing claims, characterized in that a clutch (7) is located between said at least one electric motor and said drive axle (4), which clutch may be embodied as a sprag bearing.

6. A powertrain arrangement according to any one of the foregoing claims, characterized in that a multi-gearbox (8) is located between said at least one electric motor and said drive axle (4), which may be embodied as a dual-clutch or an automatic transmission.

7. A powertrain arrangement according to any one of claims 1, 2, 3, or 4, characterized in that an epicyclic type gearing (9) is located between said at least one electric motor (1) and said drive axle (4), which allows for direct drive, reverse, neutral, and one reduction gear, wherein
5 said epicyclic type gearing (9) is comprised of a casing with brakes on its planet carrier and its annulus, so as to allow the selection of its reactionary and output, a sprag bearing each between carrier and output, and annulus and output, in opposite rotating directions to alternate between its output engagement and a brake between any two members in order to operate in direct drive.

10 8. A powertrain arrangement according to any one of the foregoing claims, characterized in that said primary drive output is complemented by at least one further drive output that comprises at least one further electric motor.

15 9. A powertrain arrangement according to claim 8, characterized in that said further drive output drives said drive axle (4) parallel to the primary drive output, particularly through a ring and pinion gear.

20 10. A powertrain arrangement according to claim 8, characterized in that said one or more further electric motor (1) are mounted to each half shaft (12), so as to allow each wheel to be driven individually, particularly through an epicyclic gear ratio (3) located between said at least one further electric motor and the corresponding half shaft, so as to allow each wheel to be driven individually through a gear ratio.

25 11. A powertrain arrangement according to claim 8, characterized in that said further drive output comprises an epicyclic gear ratio (3) located between said one or more further electric motor and said drive axle (4).

30 12. A powertrain arrangement according to claim 8, characterized in that said one or more further electric motor (1) drive a second or further drive axle (5).

13. A powertrain arrangement according to claim 12, characterized in that said further drive output comprises one or more gear ratios (3), such as an epicyclic gear ratio, located between said at least one further electric motor (1) and said drive axle (5).

5 14. A powertrain arrangement according to any one of the foregoing claims, wherein all electric motors can operate as a generator, wherein an inverter or a motor controller reverses the flow of electricity which allows said at least one electric motor to increase the state of charge of a traction battery by extracting kinetic energy from the vehicle in motion during braking events and/or absorb energy from the output of the combustion engine.

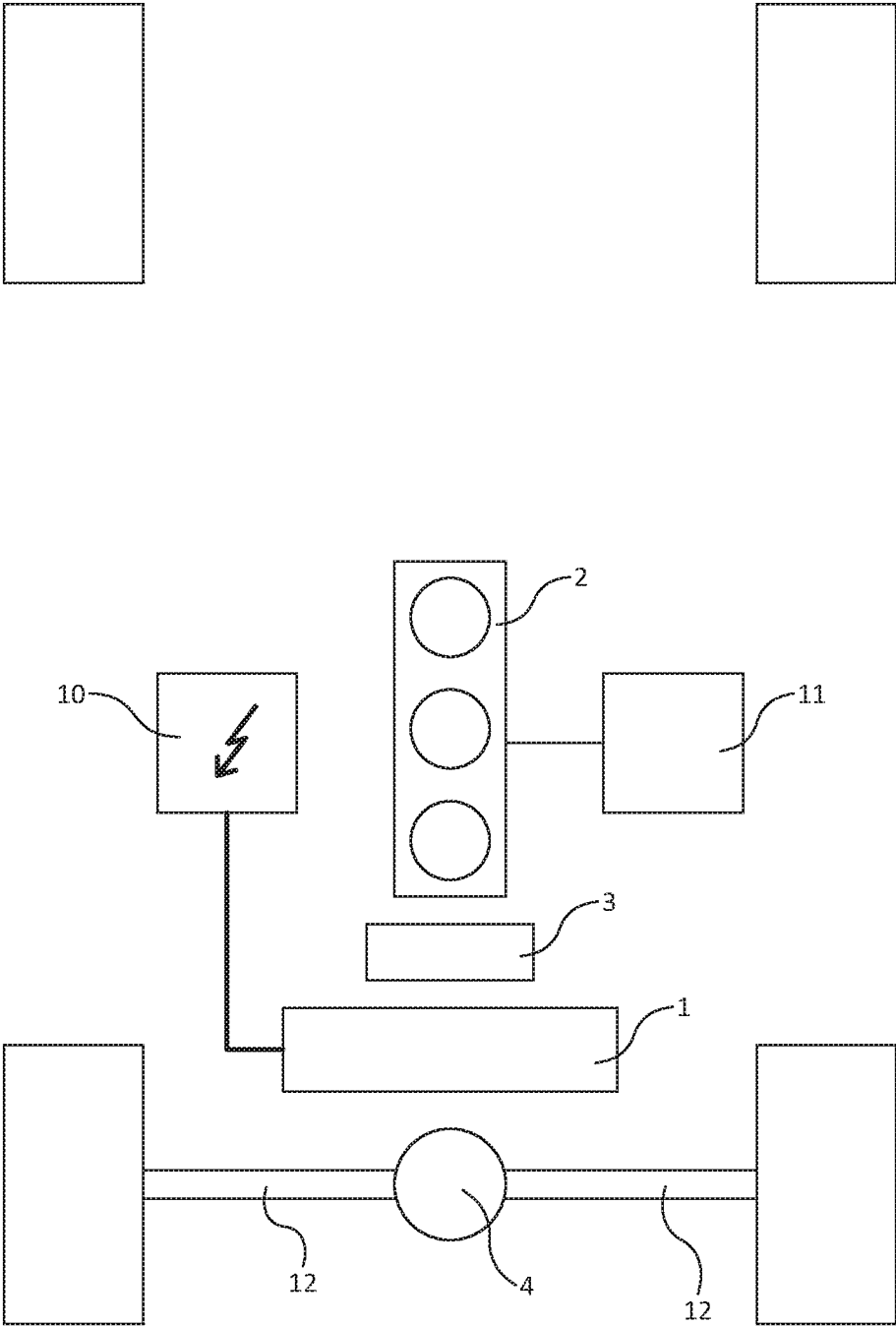


Fig.1

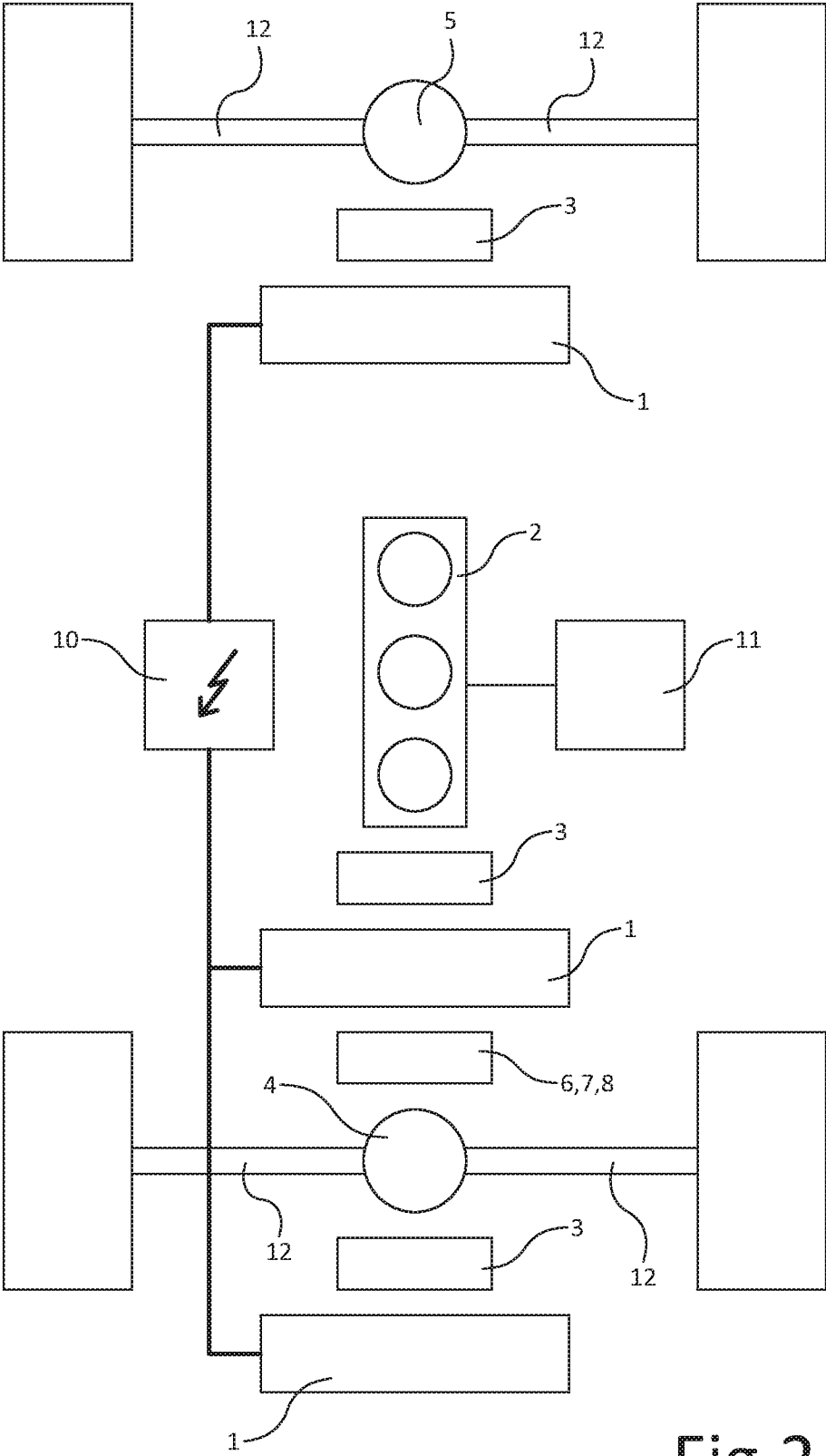


Fig.2

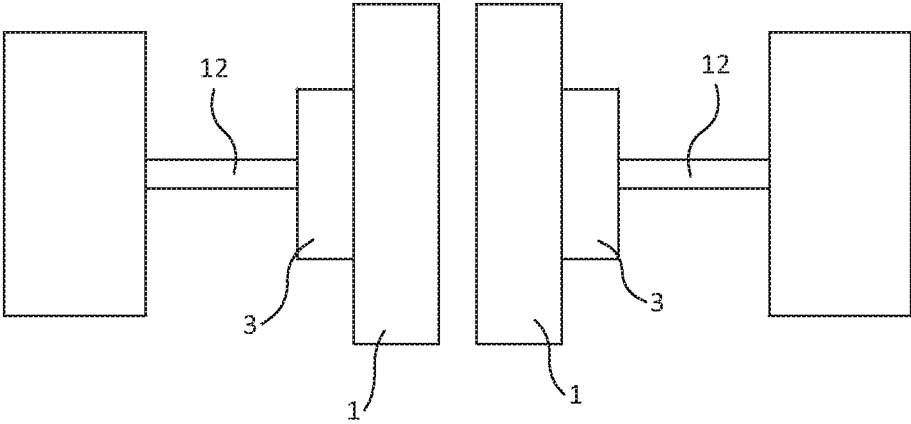


Fig.3

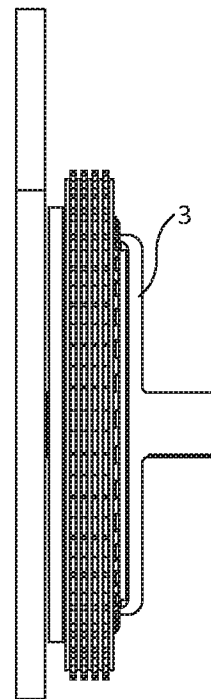
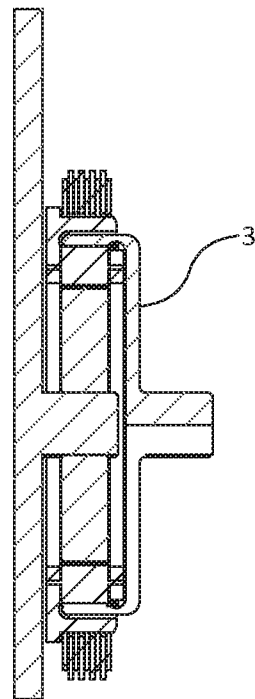
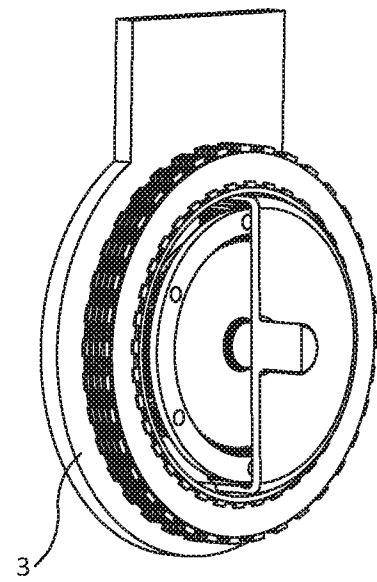
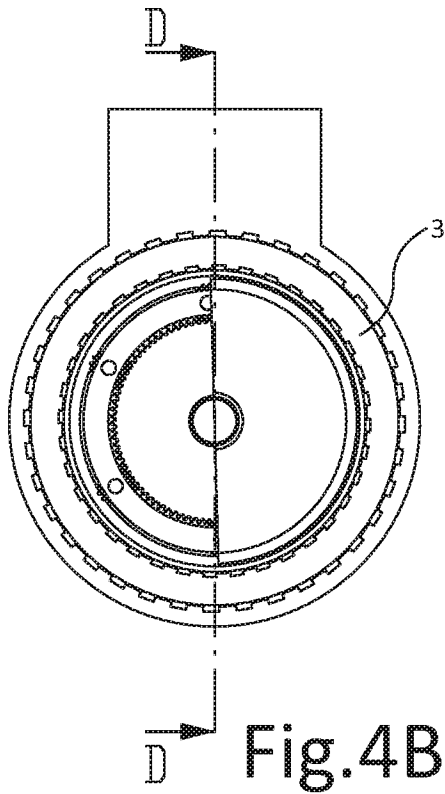


Fig. 4D

Fig. 4C