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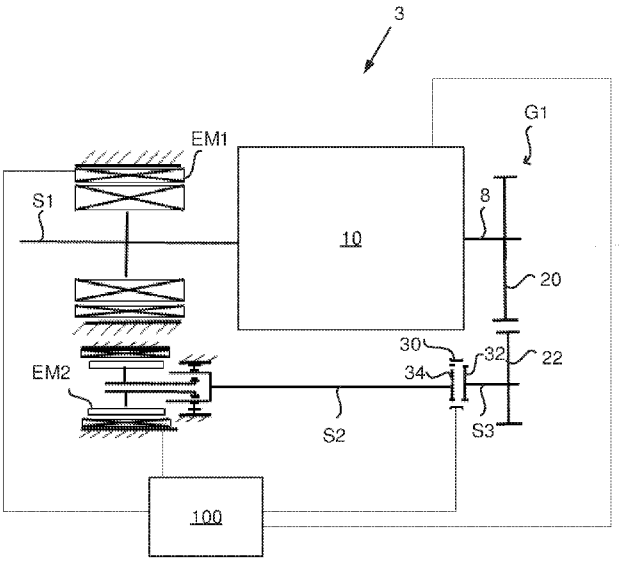

FIG. 2

(57) Abstract: The invention relates to a powertrain (3) for a vehicle (1), the powertrain (3) comprising: a first electrical machine (EM1) and a first shaft (S1) connected to the first electrical machine (EM1); a second electrical machine (EM2) and a second shaft (S2) connected to the second electrical machine (EM2); an output shaft (8); and a gearbox arrangement (10) connected to the output shaft (8), wherein the first shaft (S1) and the second shaft (S2) are arranged to be selectively connected to the output shaft (8), wherein the first shaft (S1) is connectable to the output shaft (8) via the gearbox arrangement (10), wherein the second shaft (S2) is configured to be connected to a power take off or an auxiliary component and wherein the first electrical machine (EM1) and the second electrical machine (EM2) are arranged to be controllable independently of each other. The invention further relates to a vehicle comprising a powertrain (3) and a method (100) of controlling a powertrain (3).

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A powertrain for a vehicle, an all-electric vehicle, and a method of controlling a powertrain

TECHNICAL FIELD

The present invention relates to a powertrain for a vehicle. The invention also relates to a vehicle comprising such a powertrain. More specifically, the present invention relates to a powertrain for an all-electric vehicle and an all-electric vehicle comprising such a powertrain.

BACKGROUND

Heavy vehicles, such as trucks and busses, which are propelled by means of internal combustion engines, may consume large amounts of fuel for propulsion. Fossil fuels, such as diesel or petrol, are expensive and non-renewable energy sources. Vehicles powered by fossil fuel also causes emissions that may contribute to climate change. In order to reduce the consumption and dependence on fossil fuels, hybrid powertrains have been developed. A hybrid powertrain typically combine the use of a main propulsion unit, such as an internal combustion engine, with a secondary propulsion unit, such as an electric motor driven by a battery.

To completely avoid using fossil fuels, all-electric vehicles have been developed. All-electric vehicles are propelled by means of at least one electrical machine/electric motor. Today there are different powertrain solutions for electric vehicles, from lightweight cars to medium/heavy sized trucks/busses. The required propulsion power from the electrical machine typically vary depending on the weight of the vehicle. Certain driving situations, such as for example starting from standstill, requires more torque and a sophisticated gearbox. Electric vehicles may also require power for driving connected Power Take Offs (PTO) or auxiliary components, such as air compressors or climate

systems. Electric vehicles may therefore comprise large electrical machines configured for providing the required power.

Document US 2011/0212803 A1 discloses a drive for an electric vehicle, comprising a first electric motor, a second electric motor and a planetary gear train coupling the first and second electric motors.

SUMMARY

Despite known solutions in the field, it would be desirable to develop a powertrain for an all-electric vehicle, which overcomes or alleviates at least some of the drawbacks of the prior art.

An object of the present invention is thus to achieve an advantageous powertrain, which allows multi-tasking. Another object of the present invention is to achieve a powertrain, which enables power shifting and improves operation of the vehicle. Another object of the present invention is to achieve a method, which improves operation of the vehicle

The herein mentioned objects are achieved by a powertrain, a vehicle, and a method according to the independent claims.

Hence, according to an aspect of the present invention, a powertrain for a vehicle is provided. The powertrain is configured to provide only electrical propulsion of the vehicle, the powertrain comprising: a first electrical machine and a first shaft connected to the first electrical machine; a second electrical machine and a second shaft connected to the second electrical machine; an output shaft; and a gearbox arrangement connected to the output shaft, wherein the first shaft and the second shaft are arranged to be selectively connected to the output shaft, wherein the first shaft is connectable to the output shaft via the

gearbox arrangement, and wherein the first electrical machine and the second electrical machine are arranged to be controllable independently of each other.

According to another aspect of the invention, a vehicle comprising such a powertrain is provided.

According to another aspect of the invention, a method of controlling a powertrain for a vehicle is provided.

A powertrain configured to provide only electrical propulsion of a vehicle comprises at least one electrical machine for propulsion. The powertrain may comprise multiple electrical machines, which are typically arranged in series and combined with transmission elements such as planetary gear set or gear sets and thereby affect each other. By means of the powertrain according to the present invention, where the first and second shafts are arranged to be selectively connected to the output shaft, the first electrical machine and the second electrical machine can be used independently of each other. This way, propulsion torque may be provided to the drive wheels of the vehicle from either the first electrical machine or the second electrical machine, and shifting gear can thereby be performed without torque interruption, also called power shifting. Thus, by being able to individually control the first electrical machine and the second electrical machine, the electrical machines can be controlled independently of each other to provide power to different functions/components at the same time or both electrical machines can be controlled to provide propulsion power at the same time. Thus, by means of the powertrain according to the invention, a multi-task powertrain is achieved, which means that the two electrical machines can be independently controlled with regard to speed and torque. As an example, the powertrain according to the invention allows one electrical machine to be used for power take off functions without affecting the other electrical machine, which enables use of power take off functions while the vehicle is at standstill. Furthermore, by having two electrical machines, which both can provide propulsion torque on the output shaft, each electrical machine

can be smaller and less powerful compared to when one single electrical machine should provide all power for propulsion and auxiliary components etc.

Further objects, advantages and novel features of the present invention will become apparent to one skilled in the art from the following details, and also by putting the invention into practice. Whereas the invention is described below, it should be noted that it is not restricted to the specific details described. Specialists having access to the teachings herein will recognise further applications, modifications and incorporations within other fields, which are within the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

For fuller understanding of the present invention and further objects and advantages of it, the detailed description set out below should be read together with the accompanying drawings, in which the same reference notations denote similar items in the various drawings, and in which:

Figure 1	schematically illustrates a vehicle according to an example;
Figure 2	schematically illustrates a powertrain according to an example;
Figure 3	schematically illustrates a powertrain according to an example;
Figure 4	schematically illustrates a powertrain according to an example;
Figure 5	schematically illustrates a powertrain according to an example;
Figure 6	schematically illustrates a powertrain according to an example; and

Figure 7 schematically illustrates a method of controlling a powertrain according to an example.

DETAILED DESCRIPTION

According to an aspect of the present disclosure, a powertrain for a vehicle is provided. The powertrain is configured to provide only electrical propulsion of the vehicle, the powertrain comprising: a first electrical machine and a first shaft connected to the first electrical machine; a second electrical machine and a second shaft connected to the second electrical machine; an output shaft; and a gearbox arrangement connected to the output shaft, wherein the first shaft and the second shaft are arranged to be selectively connected to the output shaft, wherein the first shaft is connectable to the output shaft via the gearbox arrangement, and wherein the first electrical machine and the second electrical machine are arranged to be controllable independently of each other. The first electrical machine and the second electrical machine being controllable independently of each other means that the two electrical machines may be individually controlled with regard to speed and torque, so that they do not affect one another.

The vehicle is suitably an all-electrical vehicle. An all-electrical vehicle may also be referred to as a battery electric vehicle (BEV), a pure electric vehicle, or an only-electric vehicle. Thus, an all-electric vehicle is propelled only by electric energy. In one example, the vehicle also comprises an internal combustion engine.

The powertrain may further comprise an energy storage unit, such as a battery/battery pack or an energy conversion unit, such as a fuel cell. The energy storage unit/energy conversion unit is configured to provide electric energy to, and thus drive, the first electrical machine and the second electrical machine. The powertrain may also comprise an inverter, configured to, for example,

convert direct current from the energy storage unit into alternating current for the electrical machines. The powertrain may further comprise power electronics and a control device arranged to control the first electrical machine and the second electrical machine. The control device may thus be configured to regulate the power supplied to the electrical machines. The first electrical machine and the second electrical machine may be configured to function as generators and thereby generate electric energy during vehicle braking. The inverter may thus be configured to convert alternating current from the electrical machines into direct current for the energy storage unit.

It is to be understood that the control device of the powertrain may be implemented as a separate entity or distributed in two or more physical entities. The control device may comprise one or more control units and/or computers. The control device may thus be implemented or realised by the control device comprising a processor and a memory, the memory comprising instructions, which when executed by the processor causes the control device to perform certain method steps to control the powertrain.

The first shaft may be connected to the gearbox arrangement. The first shaft may form part of an input shaft to the gearbox arrangement. The first electrical machine may be arranged in direct connection with the first shaft. The first electrical machine may be arranged to apply torque on the first shaft. The applied torque may thus be transferred through the gearbox arrangement to the output shaft. The gearbox arrangement may be configured so that the first shaft can be selectively connected to, or disconnected from, the output shaft. Suitably, the control device is configured to control the gearbox arrangement to connect/disconnect the first shaft and the output shaft and thereby enable transfer of torque through the gearbox arrangement or prevent torque transfer through the gearbox arrangement. The gearbox arrangement may comprise a plurality of gear pairs or gear units corresponding to a number of fixed gear steps. The gearbox arrangement may be configured in any way, and may comprise any number of gear steps, such as two or more gear steps or one or more gear

steps. Since the gearbox arrangement may comprise one or more gear steps, according to some embodiments, the gearbox arrangement is in some places herein referred to as a transmission/gearbox arrangement. Throughout this disclosure, the wording "gearbox arrangement" may be replaced with the wording "transmission/gearbox arrangement". Likewise, throughout this disclosure, the wording "transmission/gearbox arrangement" may be replaced with the wording "gearbox arrangement". The first shaft may be connectable to an auxiliary component of the vehicle, such as an air compressor, AC compressor or similar. Typically, a front end of the first shaft is connectable to an auxiliary component, and a rear end of the first shaft is connected to the gearbox arrangement. This way, in the event that the first shaft is disconnected from the output shaft, the first electrical machine can still provide power to the auxiliary component.

According to an example, the first electrical machine and the second electrical machine are differently configured. Thus, the first electrical machine may be configured with a performance/capacity different from the performance/capacity of the second electrical machine. As an example, the first electrical machine may be configured to have a high efficiency at high torque values and the second electrical machine may be configured to have a high efficiency at low torque values, or vice versa. By having two electrical machines of different types/performances, torque can be divided between the two electrical machines to optimise efficiency. Thus, the first electrical machine and the second electrical machine may be controlled to provide torque to increase/optimise efficiency of at least one of the electrical machines. The control device may thus be configured to control the first electrical machine and the second electrical machine to increase/optimise efficiency of at least one of the electrical machines.

According to an example, the first electrical machine and the second electrical machine are arranged adjacent each other. By arranging the first electrical machine and the second electrical machine adjacent each other a shorter powertrain is created with less packaging space. Furthermore, by arranging the

electrical machines close together, one inverter may be used for both electrical machines. The inverter may be mounted on the gearbox housing without cables, which thereby further reduces the packaging space. The first electrical machine and the second electrical machine may be coaxially arranged, having the same rotational axis. Alternatively, the first electrical machine and the second electrical machine may be arranged with different/individual/separate rotational axis. This means that the first electrical machine and the second electrical machine may be arranged so that their respective rotational axis are not aligned.

According to yet another example, the gearbox arrangement comprises a reduction gear connected to the first shaft. The reduction gear is configured to reduce the rotational speed of the first shaft. The reduction gear may comprise a planetary gear unit with a sun gear, planetary gears, a carrier and a ring gear. The sun gear may be connected to the first shaft and drives the planetary gears. The carrier may be connected to the rest of the gearbox arrangement and the ring gear may be connected to a gearbox housing. The reduction gear and the first electrical machine may be comprised in a first module. The first module can be used alone, and a powertrain may thus comprise only the first module and the output shaft. The reduction gear may then be connected to the output shaft and thereby to driving wheels of the vehicle. The first module may be configured for vehicles with a weight up to about 19 tons. The first module together with the rest of the gearbox arrangement, the output shaft and the second electrical machine may be referred to as a second module. The powertrain according to the present disclosure may thus comprise the second module. The second module may be configured for vehicles with a weight between 19-40 tons.

The second electrical machine may be arranged in direct connection with the second shaft. The second electrical machine may be configured to apply torque on the second shaft. According to an example, the second shaft is connectable to the output shaft via a first gear pair. The powertrain may thus comprise a first gear pair connecting the second shaft and the output shaft. According to an example, the second shaft is connectable to the output shaft via a first coupling

device. The powertrain may thus further comprise a first coupling device. When the first coupling device is engaged (closed) both electrical machines may provide propulsion power on the output shaft. When first coupling device is disengaged (open), the second electrical machine is disconnected from the output shaft and from the first electrical machine, which means that the two electrical machines can be separately controlled. According to an example, the second shaft is connectable to the output shaft via a first coupling device and a first gear pair. The first gear pair may comprise a first gear wheel fixedly arranged on the output shaft and the second gear wheel fixedly arranged on a third shaft of the powertrain. The third shaft and the output shaft may thus be arranged in parallel. A gear wheel fixedly arranged on the shaft will always rotate together with the shaft and with the same rotational speed as the shaft. The third shaft may be connectable to the second shaft by means of the first coupling device. Thus, when the first coupling device connects the second shaft and the third shaft, torque can be transferred from the second shaft to the output shaft or vice versa. However, when the first coupling device is in a position where the second shaft is disconnected from the third shaft, torque transfer from the second shaft to the output shaft, or vice versa, is prevented. When the second shaft is connected to the third shaft by means of the first coupling device, torque may be transferred to the output shaft and the second electrical machine may thus provide propulsion power to propel the vehicle. The first coupling device may comprise a displaceable coupling sleeve configured to interact with splines on a first coupling gear wheel on the third shaft and/or splines on a second coupling gear wheel on the second shaft. Alternatively, the first coupling device may comprise a disc clutch or similar. The control device may be configured to control the first coupling device and thereby control the torque transfer between the output shaft and the second shaft. Alternatively, the first gear pair comprises a first gear wheel fixedly arranged on the output shaft and a second gear wheel selectively lockable to the second shaft. The output shaft and the second shaft may thus be arranged in parallel. In this example, the second gear wheel may be mechanically locked to/disconnected from the second shaft by means of a displaceable coupling unit. Such coupling unit may comprise a coupling sleeve.

When the coupling unit locks the second gear wheel to the second shaft, torque may be transferred between the second shaft to the output shaft. When the coupling unit disconnects the second gear wheel and the second shaft, torque transfer between the second shaft and the output shaft is prevented. In this example, the first coupling device and the third shaft is not required.

According to an example, the gearbox arrangement comprises a first planetary gear unit connectable to the first shaft and the output shaft. The first planetary gear unit may be configured to provide three gear steps and may thus be referred to as a three speed transmission. The first planetary gear unit may be configured so that the first shaft can be selectively connected to or disconnected from the output shaft. In the event that the gearbox arrangement comprises a reduction gear connected to the first shaft, the first planetary gear may be connected to the reduction gear. The first planetary gear unit may comprise a first sun gear, first planetary gears, a first ring gear and a first carrier. The first sun gear may be directly connected to the reduction gear. In the event that the reduction gear comprises a planetary gear unit, the first sun gear may be directly connected to the carrier of the reduction gear. The first carrier may be arranged to be selectively connected to the output shaft and thereby connect or disconnect the first shaft and the output shaft.

The gearbox arrangement may further comprise a second planetary gear unit connectable to the first planetary gear unit. The second planetary gear unit may comprise a second sun gear, second planetary gears, a second ring gear and a second carrier. The second sun gear may be arranged to be selectively connected to the first carrier. The second carrier may be arranged to be selectively connected to the output shaft.

According to an example, the output shaft of the powertrain is connected to a cardan shaft. In another example, the powertrain comprises a transmission unit arranged to connect the output shaft with a rear wheel axis. The transmission

unit may comprise a differential at the rear wheel axis. This way, the powertrain may be used as an eAxle and the cardan shaft can be removed.

It is to be understood that upstream and downstream with regard to the arrangement of gear units relates to the direction of torque transfer from the electrical machines towards the output shaft. By gear units means any type of gear device, such as gear pairs, gear wheels, planetary gear units or similar.

According to another example of the present disclosure, the gearbox arrangement comprises a second gear pair connecting the second shaft and the output shaft. The second gear pair may comprise a third gear wheel fixedly arranged on an intermediate shaft of the gearbox arrangement and a fourth gear wheel selectively lockable to the second shaft. The third gear wheel may be arranged so that there is another gear unit downstream of the third gear wheel on the intermediate shaft, before the output shaft. Thus, by transferring torque via the second gear pair, the second electrical machine may affect the gear unit downstream of the third gear wheel. In one example, the third gear wheel is arranged between the first planetary gear unit and the second planetary gear unit of the gearbox arrangement. In another example, the third gear wheel is arranged upstream of the first planetary gear pair. The intermediate shaft may be connected to the first sun gear or the second sun gear. In the event that the third gear wheel is arranged between the first and the second planetary gear units, the intermediate shaft may be connected to the first carrier and the second sun gear. The fourth gear wheel may be mechanically locked to/disconnected from the second shaft by means of a coupling unit. The coupling unit may in one example consist of the first coupling device. Thus, the first coupling device may comprise a displaceable sleeve configured to interact with the first coupling gear wheel on the third shaft, the second coupling gear wheel on the second shaft, and/or a third coupling gear wheel connected to the fourth gear wheel of the second gear pair. When the first coupling device is in a first position connecting the second coupling gear wheel and the third coupling gear wheel, the fourth gear wheel is locked to the second shaft and thus rotates together with the

second shaft. Torque can thereby be transferred from the second shaft to the intermediate shaft and to the output shaft via the second gear pair. When the first coupling device is in a second position connecting the first coupling gear wheel and the second coupling gear wheel, the second shaft and the third shaft are connected and torque may be transferred from the second shaft to the output shaft via the first gear pair. When the first coupling device is in a neutral position, the second shaft is disconnected from the output shaft and the fourth gear wheel is disconnected from the second shaft. Thus, the fourth gear wheel is able to rotate in relation to the second shaft. In this neutral position, the second electrical machine may provide power without affecting the output shaft and thus without affecting the propulsion of the vehicle. By enabling connection of the second shaft and the output shaft, the second electrical machine can increase the total torque provided on the output shaft and thereby increase the traction force of the vehicle. This way, the first electrical machine can be less powerful. Alternatively, the powertrain is able to drive/propel heavier vehicles.

According to embodiments herein, the second shaft is configured to be connected to a power take off and/or an auxiliary component. Moreover, according to some embodiments, the second shaft is connected to a power take off and/or an auxiliary component. Such a power take off and/or an auxiliary component may be comprised in the powertrain as described herein. An auxiliary component, as referred to herein, may be a compressor, a pump or similar. The second shaft may be connected to a power take off or an auxiliary component at a front end of the second shaft and/or at a rear end of the second shaft. Since the first electrical machine and the second electrical machine are arranged to be individually controlled, without affecting each other, the second electrical machine can provide power to auxiliary components and power take offs during all driving situations, including starting from standstill, without affecting the propulsion of the vehicle or interrupting the powertrain. This may be specifically advantageous when the vehicle is operated in reverse. In such situation, the first electrical machine may be operated to apply a torque in opposite (reverse) direction on the first shaft and thereby on the output shaft.

The auxiliary component or power take off connected to the second shaft may, however, require to be driven in one specific direction, typically a forward direction. Thus, if the first electrical machine and the second electrical machine were not arranged to be controlled independently of each other, the auxiliary component/power take off could not be provided with power when the vehicle is reversing. The powertrain according to the present disclosure thus facilitates and improves the operation of the vehicle, with regard to propulsion and driving of auxiliaries and power take offs.

According to an aspect of the present disclosure, a vehicle is provided. The vehicle comprises a powertrain as disclosed herein. The vehicle may be heavy vehicle, such as a truck or bus. Typically, the vehicle is a commercial vehicle.

The present disclosure will now be further illustrated with reference to the appended figures.

Figure 1 schematically shows a side view of a vehicle 1 according to an example. The vehicle 1 is an all-electric vehicle and comprises a powertrain 3 connected with driving wheels 6 of the vehicle 1. Only two driving wheels 6 are illustrated in the figure, however, any number of driving wheels 6 may be driven by the powertrain 3 within the scope of the invention. The powertrain 3 may also be configured as an eAxle. The powertrain 3 will be further described in relation to Figures 2-6 below. The vehicle 1 may be a heavy vehicle, e.g. a truck or a bus. The vehicle 1 may alternatively be a passenger car.

Figure 2 schematically illustrates a powertrain 3 of a vehicle according to an example. The vehicle may be the vehicle 1 as disclosed in Figure 1. The powertrain 3 is configured to provide only electrical propulsion of the vehicle 1. The powertrain 3 comprises a first electrical machine EM1 and a first shaft S1 connected to the first electrical machine EM1; a second electrical machine EM2 and a second shaft S2 connected to the second electrical machine EM2. The powertrain 3 further comprises an output shaft 8 and a gearbox arrangement 10

connected to the output shaft 8. The first shaft S1 and the second shaft S2 are arranged to be selectively connected to the output shaft 8, wherein the first shaft S1 is connectable to the output shaft 8 via the gearbox arrangement 10. The first electrical machine EM1 and the second electrical machine EM2 are arranged to be controllable independently of each other.

The first electrical machine EM1 and the second electrical machine EM2 may be arranged with different rotational axis as shown in the figure or coaxially with the same rotational axis (not shown). Further, the second shaft S2 is arranged in parallel with the first shaft S1 and the output shaft 8. The output shaft 8 may be connected with the driving wheels 6 of the vehicle 1.

The gearbox arrangement 10 may be controlled to connect or disconnect the first shaft S1 and the output shaft 8. Typically, the first electrical machine EM1 is used to provide propulsion power to the driving wheels 6 of the vehicle 1 via the output shaft 8. However, the gearbox arrangement 10 may be controlled to disconnect the first shaft S1 and the output shaft 8, wherein the first electrical machine EM1 instead may be used to provide power to an auxiliary component (not shown) connected to the first shaft S1.

In this example, the powertrain 3 further comprises a first gear pair G1 connecting the second shaft S2 and the output shaft 8. The first gear pair G1 may comprise a first gear wheel 20 fixedly arranged on the output shaft 8 and a second gear wheel 22 connectable with the second shaft S2. As shown in the figure, the powertrain 3 may further comprise a third shaft S3, and the second gear wheel 22 may be fixedly arranged on the third shaft S3. The powertrain 3 may also comprise a first coupling device 30 arranged to selectively connect/disconnect the second shaft S2 and the third shaft S3. The first coupling device 30 may comprise a displaceable sleeve configured to interact with a first coupling gear wheel 32 on the third shaft S3 and/or a second coupling gear wheel 34 on the second shaft. Alternatively, the first coupling device 30 may comprise a disc clutch or similar. When the first coupling device 30 is in a

position where the second shaft S2 is connected with the third shaft S3, torque may be transferred between the second shaft S2 and the output shaft 8. Thus, the second electrical machine EM2 may provide propulsion power to the driving wheels 6 of the vehicle 1 via the first gear pair G1. When the first coupling device 30 is in a position where the second shaft S2 is disconnected from the third shaft S3, the second electrical machine EM2 may be used to provide power to a power take off or auxiliary component (not shown) connected to the second shaft S2.

The powertrain 3 may further comprise a control device 100. The control device 100 may be configured to control the first electrical machine EM1, the second electrical machine EM2, the gear arrangement 10 and the first coupling device 30. The control device 100 may be implemented as a separate entity or distributed in two or more physical entities. The control device 100 may comprise one or more control units and/or computers.

Figure 3 schematically illustrates a powertrain 3 of a vehicle according to an example. The vehicle may be the vehicle 1 as disclosed in Figure 1. The powertrain 3 is configured to provide only electrical propulsion of the vehicle 1. The powertrain 3 may be configured as disclosed in Figure 2.

In this example, the gearbox arrangement 10 comprises a reduction gear 12 connected to the first shaft S1. The reduction gear 12 is herein illustrated as a planetary gear unit with a sun gear, planetary gears, a carrier and a ring gear. However, this is only an example and the reduction gear 12 may be differently configured. Furthermore, in this example the gearbox arrangement 10 comprises a first planetary gear unit PG1 connectable to the first shaft S1 and the output shaft 8. The first planetary gear unit PG1 may be configured to provide three gear steps and may thus be referred to as a three speed transmission. The first planetary gear unit PG1 may be configured so that the first shaft S1 can be selectively connected to or disconnected from the output shaft 8. The first planetary gear unit PG1 may be connected to the reduction gear 12. The first planetary gear unit PG1 may comprise a first sun gear 13, first planetary

gears 14, a first ring gear 15 and a first carrier 16. The first sun gear 13 may be directly connected to the reduction gear 12. In the event that the reduction gear 12 comprises a planetary gear unit, the first sun gear 13 may be directly connected to the carrier of the reduction gear 12. The first carrier 16 may be arranged to be selectively connected to the output shaft 8 and thereby connect or disconnect the first shaft S1 and the output shaft 8.

Figure 4 schematically illustrates a powertrain 3 of a vehicle according to an example. The vehicle may be the vehicle 1 as disclosed in Figure 1. The powertrain 3 is configured to provide only electrical propulsion of the vehicle 1. The powertrain 3 may be configured as disclosed in Figure 2. For simplicity, the control device 100 is not illustrated in this figure, it is however to be understood that the powertrain 3 in this example also comprises the control device 100.

In this example, the gearbox arrangement 10 may comprise a first planetary gear unit PG1 and a second planetary gear unit PG2. The first planetary gear unit PG1 and the second planetary gear unit PG2 may be connectable to the first shaft S1 and the output shaft 8. The first planetary gear unit PG1 may comprise a first sun gear 13, first planetary gears 14, a first ring gear 15 and a first carrier 16. The first sun gear 13 may be directly connected to the first shaft S1. The second planetary gear unit PG2 is connected to the first planetary gear unit PG1. The second planetary gear unit PG2 may comprise a second sun gear 40, second planetary gears 42, a second ring gear 44 and a second carrier 46. The second sun gear 40 may be arranged to be selectively connected to the first carrier 16 of the first planetary gear unit PG1. The second carrier 46 may be arranged to be selectively connected to the output shaft 8. Thus, by controlling the first planetary gear unit PG1 and the second planetary gear unit PG2, the first shaft S1 may be connected to/disconnected from the output shaft 8.

Figure 5 schematically illustrates a powertrain 3 of a vehicle according to an example. The vehicle may be the vehicle 1 as disclosed in Figure 1. The powertrain 3 is configured to provide only electrical propulsion of the vehicle 1.

The powertrain 3 may be configured as disclosed in Figure 2 or Figure 3. For simplicity, the control device 100 is not illustrated in this figure, it is however to be understood that the powertrain 3 in this example also comprises the control device 100 as disclosed in Figure 2 and Figure 3.

In this example, the powertrain 3 comprises a transmission unit 50 arranged to connect the output shaft 8 with a rear wheel axis 7 of the vehicle 1. The transmission unit 50 is thus arranged on connection with the output shaft 8, for example via the first gear wheel 20 of the first gear pair G1. The transmission unit 50 is further arranged in connection with the rear wheel axis 7. The transmission unit 50 may comprise a differential 52 at the rear wheel axis 7.

Figure 6 schematically illustrates a powertrain 3 of a vehicle according to an example. The vehicle may be the vehicle 1 as disclosed in Figure 1. The powertrain 3 is configured to provide only electrical propulsion of the vehicle 1. The powertrain 3 may be configured as disclosed in Figure 2, Figure 3 or Figure 4. For simplicity, the control device 100 is not illustrated in this figure, it is however to be understood that the powertrain 3 in this example also comprises the control device 100 as disclosed in Figure 2 and Figure 3.

The powertrain 3 is here illustrated with the gearbox arrangement 10 comprising a first planetary gear unit PG1 and a second planetary gear unit PG2. The first planetary gear unit PG1 may comprise a first sun gear 13, first planetary gears 14, a first ring gear 15 and a first carrier 16. The first sun gear 13 may be directly connected to the first shaft S1. The second planetary gear unit PG2 is connected to the first planetary gear unit PG1. The second planetary gear unit PG2 may comprise a second sun gear 40, second planetary gears 42, a second ring gear 44 and a second carrier 46. The second sun gear 40 may be arranged to be selectively connected to the first carrier 16 of the first planetary gear unit PG1. The second carrier 46 may be arranged to be selectively connected to the output shaft 8.

Furthermore, in this example, the gearbox arrangement 10 comprises a second gear pair G2 connecting the second shaft S2 and the output shaft 8. The gearbox arrangement 10 comprises an intermediate shaft 9 connecting the first planetary gear unit PG1 and the second planetary gear unit PG2. The intermediate shaft 9 thus selectively connects the first carrier 16 and the second sun gear 40. The second gear pair G2 may comprise a third gear wheel 24 fixedly arranged on the intermediate shaft 9 and a fourth gear wheel 26 selectively lockable to the second shaft S2. The third gear wheel 24 may thus be arranged between the first planetary gear unit PG1 and the second planetary gear unit PG2. The fourth gear wheel 26 may be mechanically locked to/disconnected from the second shaft S2 by means of the first coupling device 30. Thus, the first coupling device 30 may comprise a displaceable sleeve configured to interact with the first coupling gear wheel 32 on the third shaft S3, the second coupling gear wheel 34 on the second shaft S2, and/or a third coupling gear wheel 36 connected to the fourth gear wheel 26 of the second gear pair G2. When the first coupling device 30 connects the second coupling gear wheel 34 and the third coupling gear wheel 36, the fourth gear wheel 26 is locked to the second shaft S2 and thus rotates together with the second shaft S2. Torque can thereby be transferred from the second shaft S2 to the intermediate shaft 9 and to the output shaft 8 via the second gear pair G2. When the first coupling device 30 connects the first coupling gear wheel 32 and the second coupling gear wheel 34, the second shaft S2 and the third shaft S3 are connected and torque may be transferred from the second shaft S2 to the output shaft 8 via the first gear pair G1. When the first coupling device 30 is in a neutral position, the second shaft S2 is disconnected from the output shaft 8 and the fourth gear wheel 26 is disconnected from the second shaft S2.

Figure 7 schematically illustrates a method 200 of controlling a powertrain for a vehicle. The vehicle may be a vehicle 1 according to the embodiments illustrated in Figure 1 and the powertrain may be a powertrain 3 according to any of the embodiments illustrated in Figure 2 – Figure 6. Therefore, below, simultaneous reference is made to Figure 1 – Figure 7. The method 200 is a method 200 of

controlling a powertrain 3 for a vehicle 1, the powertrain 3 being configured to provide only electrical propulsion of the vehicle 1. The powertrain 3 comprises a first electrical machine EM1 and a first shaft S1 connected to the first electrical machine EM1. The powertrain 3 further comprises a second electrical machine EM2 and a second shaft S2 connected to the second electrical machine EM2. The powertrain 3 further comprises an output shaft 8 and a transmission/gearbox arrangement 10 connected to the output shaft 8, wherein the first shaft S1 and the second shaft S2 are arranged to be selectively connected to the output shaft 8.

The method 200 comprises the steps of:

- connecting 110 the first shaft S1 to the output shaft 8 via the transmission/gearbox arrangement 10,
- connecting 120 the second shaft S2 to a power take off and/or an auxiliary component, and
- controlling 130 the first electrical machine EM1 and the second electrical machine EM2 independently of each other.

Since the method comprises the step of controlling 130 the first electrical machine EM1 and the second electrical machine EM2 independently of each other, the second electrical machine EM2 can provide power to auxiliary components and power take offs during all driving situations, including starting from standstill, without affecting the propulsion of the vehicle 1 or interrupting the powertrain 3. This may be specifically advantageous when the vehicle 1 is operated in reverse. In such situation, the first electrical machine EM1 may be operated to apply a torque in opposite (reverse) direction on the first shaft S1 and thereby on the output shaft 8. The auxiliary component or power take off connected to the second shaft S2 may, however, require to be driven in one specific direction, typically a forward direction. Thus, if the first electrical machine EM1 and the second electrical machine EM2 were not arranged to be controlled independently of each other, the auxiliary component/power take off could not be provided with power when the vehicle 1 is reversing. The method 200 according to the present disclosure thus facilitates and improves the

operation of the vehicle 1, especially with regard to propulsion and driving of auxiliaries and power take offs.

The foregoing description of the examples is provided for illustrative and descriptive purposes. It is not intended to be exhaustive or to restrict the invention to the variants described. Many modifications and variations will obviously be apparent to one skilled in the art. The examples have been chosen and described in order best to explain the principles of the invention and its practical applications and hence make it possible for specialists to understand the invention for various examples and with the various modifications appropriate to the intended use.

Claims

1. A powertrain (3) for a vehicle (1), the powertrain (3) being configured to provide only electrical propulsion of the vehicle (1), the powertrain (3) comprising:

a first electrical machine (EM1) and a first shaft (S1) connected to the first electrical machine (EM1);

a second electrical machine (EM2) and a second shaft (S2) connected to the second electrical machine (EM2);

an output shaft (8); and

a transmission/gearbox arrangement (10) connected to the output shaft (8),

wherein the first shaft (S1) and the second shaft (S2) are arranged to be selectively connected to the output shaft (8), wherein the first shaft (S1) is connectable to the output shaft (8) via the transmission/gearbox arrangement (10), and wherein the first electrical machine (EM1) and the second electrical machine (EM2) are arranged to be controllable independently of each other,

characterized in that the second shaft (S2) is configured to be connected to a power take off and/or an auxiliary component.

2. The powertrain (3) according to claim 1, wherein the first electrical machine (EM1) and the second electrical machine (EM2) are differently configured.

3. The powertrain (3) according to any one of the preceding claims, wherein the first electrical machine (EM1) and the second electrical machine (EM2) are arranged with different rotational axis or with the same rotational axis.

4. The powertrain (3) according to any one of the preceding claims, wherein the transmission/gearbox arrangement (10) comprises a reduction gear (12) connected to the first shaft (S1).

5. The powertrain (3) according to any one of the preceding claims, wherein the second shaft (S2) is connectable to the output shaft (8) via a first gear pair (G1).

6. The powertrain (3) according to any one of the preceding claims, wherein the transmission/gearbox arrangement (10) comprises a first planetary gear unit (PG1) connectable to the first shaft (S1) and the output shaft (8).

7. The powertrain (3) according to claim 6, wherein the transmission/gearbox arrangement (10) comprises a second planetary gear unit (PG2) connectable to the first planetary gear unit (PG1).

8. The powertrain according to any one of the preceding claims, wherein the powertrain (3) further comprises:

a transmission unit (50) arranged to connect the output shaft (8) with a rear wheel axis (7) of the vehicle (1).

9. The powertrain (3) according to any one of the preceding claims, wherein the transmission/gearbox arrangement (10) comprises a second gear pair (G2) connecting the second shaft (S2) and the output shaft (8).

10. The powertrain (3) according to any one of the preceding claims, further comprising:

a control device (100) configured to control the first electrical machine (EM1) and the second electrical machine (EM2) independently of each other.

11. A vehicle (1), comprising a powertrain (3) according to any one of the preceding claims.

12. The vehicle (1) according to claim 11, wherein the vehicle (1) is a commercial vehicle.

13. A method (100) of controlling a powertrain (3) for a vehicle (1), the powertrain (3) being configured to provide only electrical propulsion of the vehicle (1), the powertrain (3) comprising:

a first electrical machine (EM1) and a first shaft (S1) connected to the first electrical machine (EM1);

a second electrical machine (EM2) and a second shaft (S2) connected to the second electrical machine (EM2);

an output shaft (8); and

a transmission/gearbox arrangement (10) connected to the output shaft (8),

wherein the first shaft (S1) and the second shaft (S2) are arranged to be selectively connected to the output shaft (8),

and wherein the method (100) comprises:

- connecting (110) the first shaft (S1) to the output shaft (8) via the transmission/gearbox arrangement (10),
- connecting (120) the second shaft (S2) to a power take off and/or an auxiliary component, and
- controlling (130) the first electrical machine (EM1) and the second electrical machine (EM2) independently of each other.

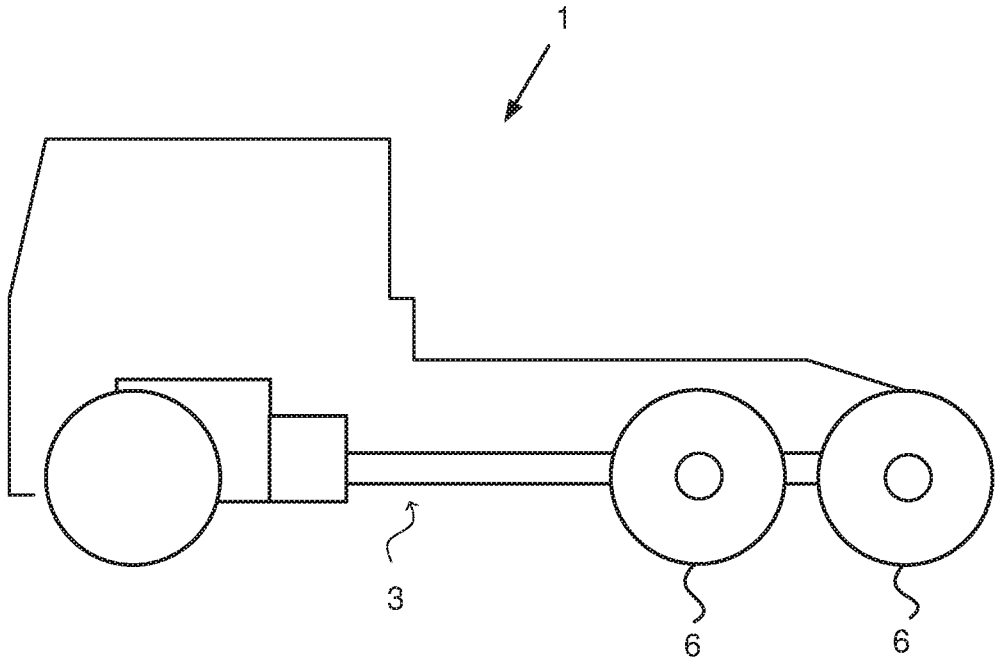


FIG. 1

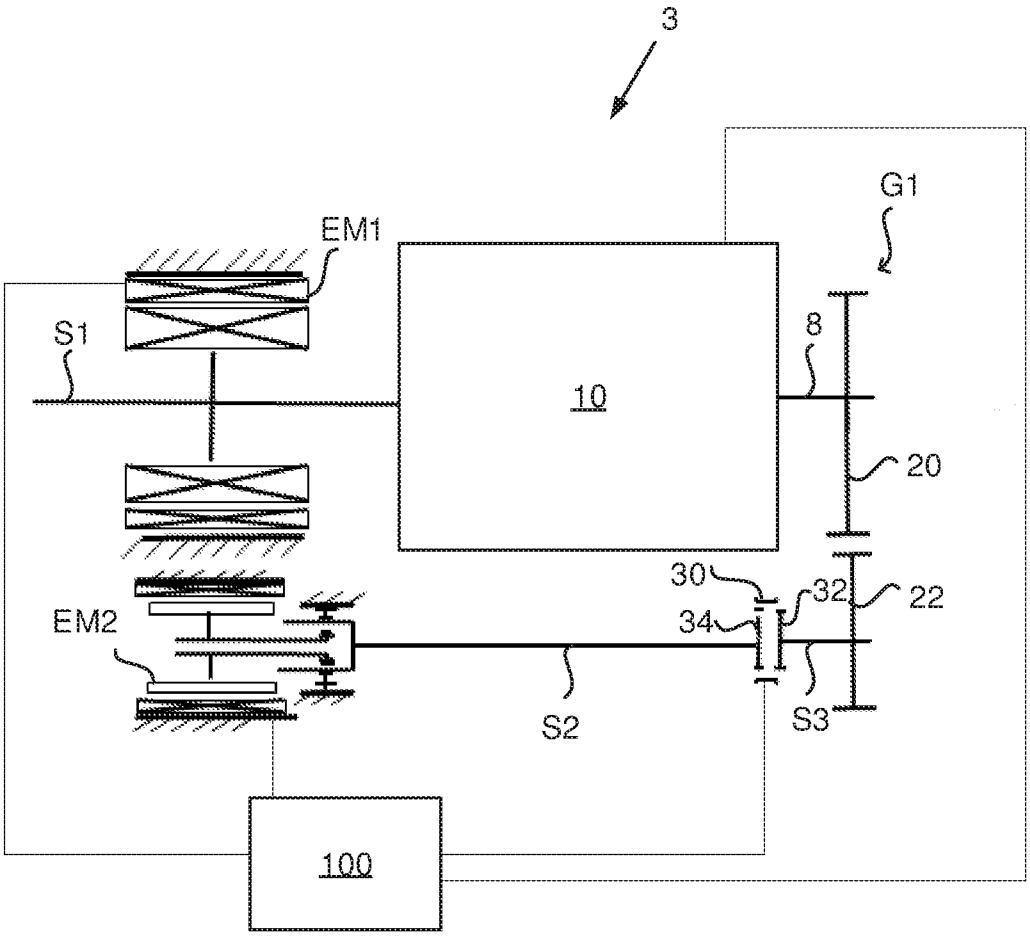


FIG. 2

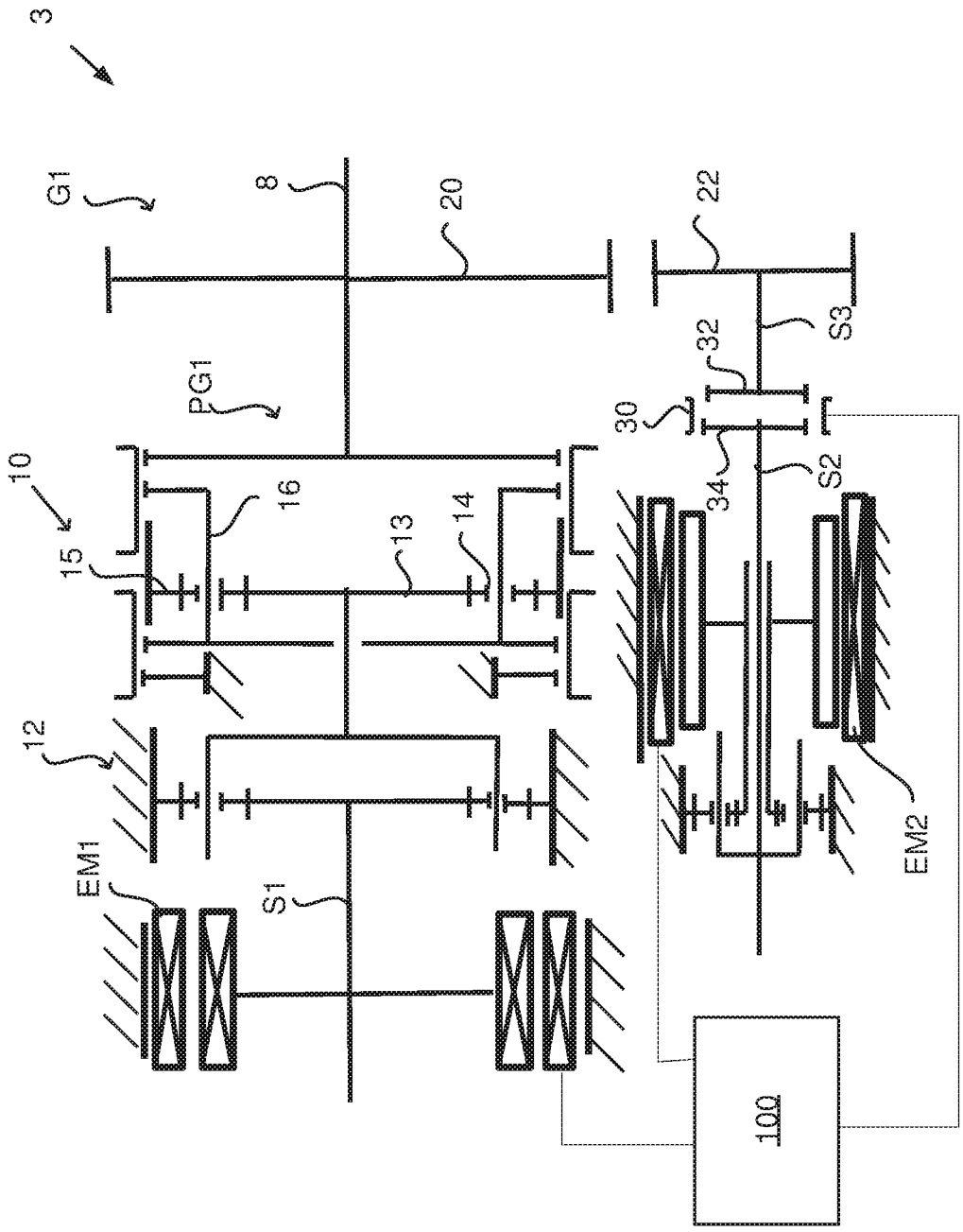


Fig. 3

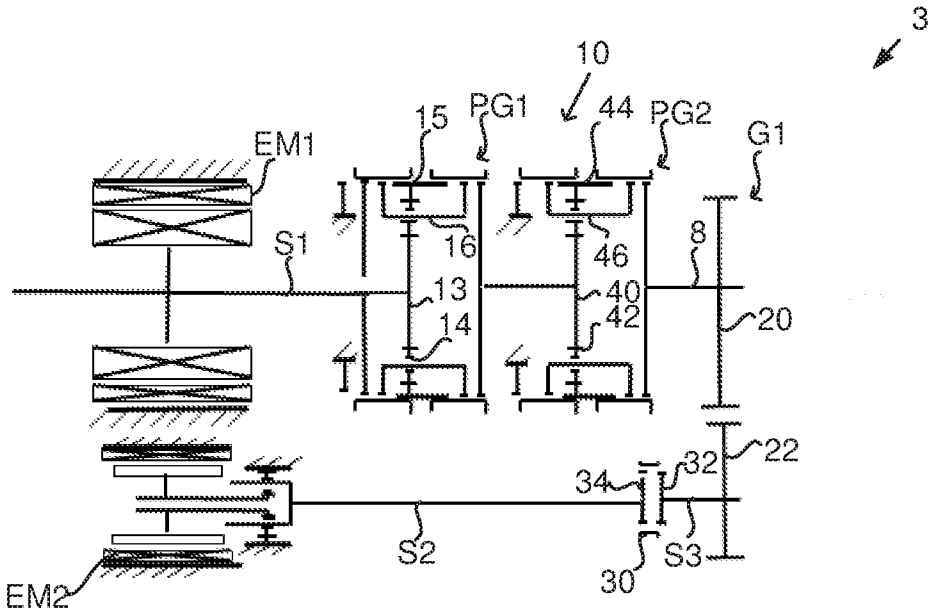
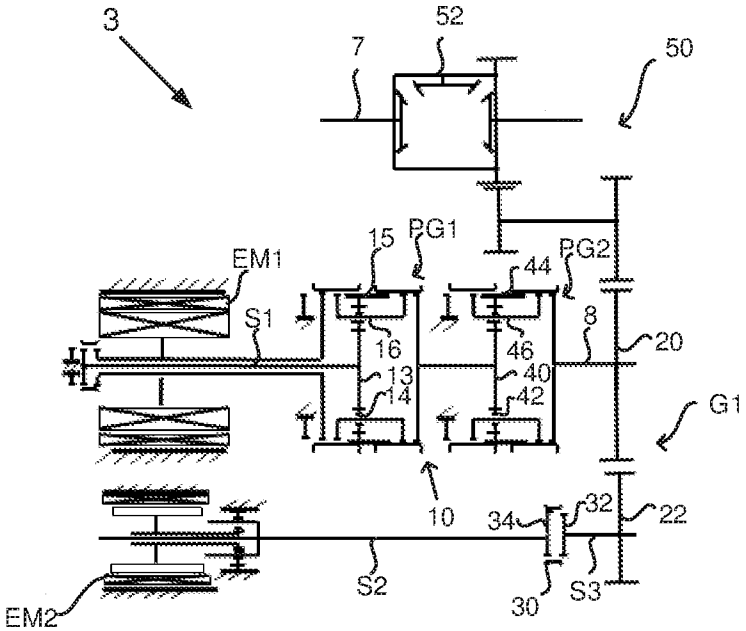

3
10
15
PG1
44
PG2
G1
EM1
S1
16
46
8
13
40
20
14
42
22
32
34
S2
S3
30
EM2

FIG. 4


3
52
7
50
15
PG1
EM1
44
PG2
S1
8
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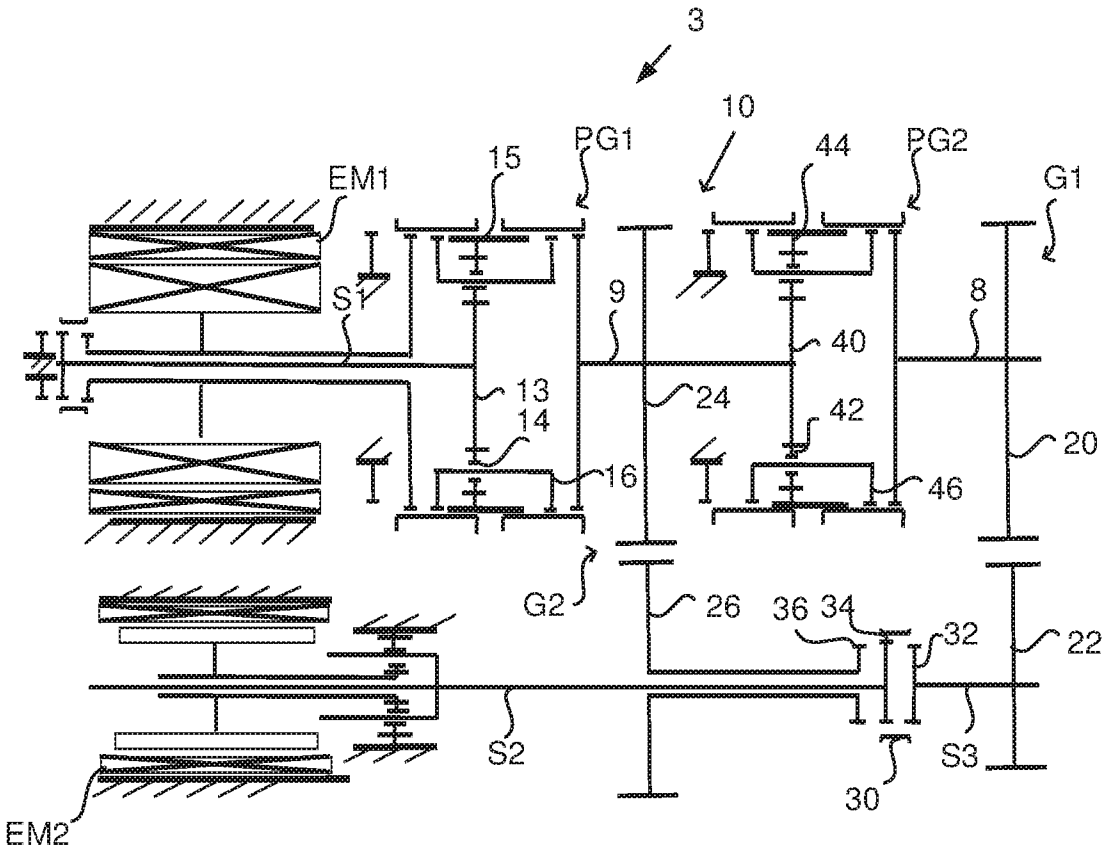
13
40
14
42
G1
10
34
32
22
S2
30
S3
EM2

FIG. 5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15
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PG2
G1
EM1
S1
9
8
40
13
14
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20
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G2
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36
34
32
22
S2
S3
30
EM2

FIG. 6

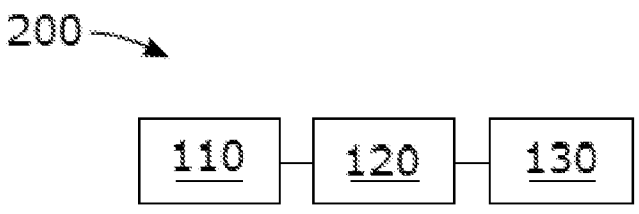
200
110
120
130

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2020/050209

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B60K, B60L, B60W, F16H

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

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20180222484 A1 (SHIVELY JASON ET AL), 9 August 2018 (2018-08-09); paragraphs [0002], [0030]-[0031], [0033], [0038]-[0039], [0044]; figures 1, 3, 9,11-13	1-13
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A	DE 102010031156 A1 (ZAHNRADFABRIK FRIEDRICHSHAFEN), 12 January 2012 (2012-01-12); abstract; paragraphs [0015]-[0017]; figure 1; claims 1-3	1-13
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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

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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
09-04-2020	09-04-2020

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Tomas Lund Telephone No. + 46 8 782 28 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2020/050209

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Continuation of: second sheet

International Patent Classification (IPC)

B60K 1/02 (2006.01)
B60K 17/04 (2006.01)
B60K 17/28 (2006.01)
B60L 15/20 (2006.01)
B60K 6/365 (2007.10)
B60K 25/00 (2006.01)
B60L 50/60 (2019.01)
B60W 10/30 (2006.01)

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DE	102015215393	A1	29/09/2016	NONE			
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DE	102015206190	A1	13/10/2016	NONE			
EP	3098103	A1	30/11/2016	CN	106274464	B	10/09/2019
				US	10144309	B2	04/12/2018
				US	20160347203	A1	01/12/2016
EP	3388274	A1	17/10/2018	CN	105416049	A	23/03/2016
				WO	2017096635	A1	15/06/2017
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				DE	102009036992	A1	17/02/2011
				JP	2011038637	A	24/02/2011