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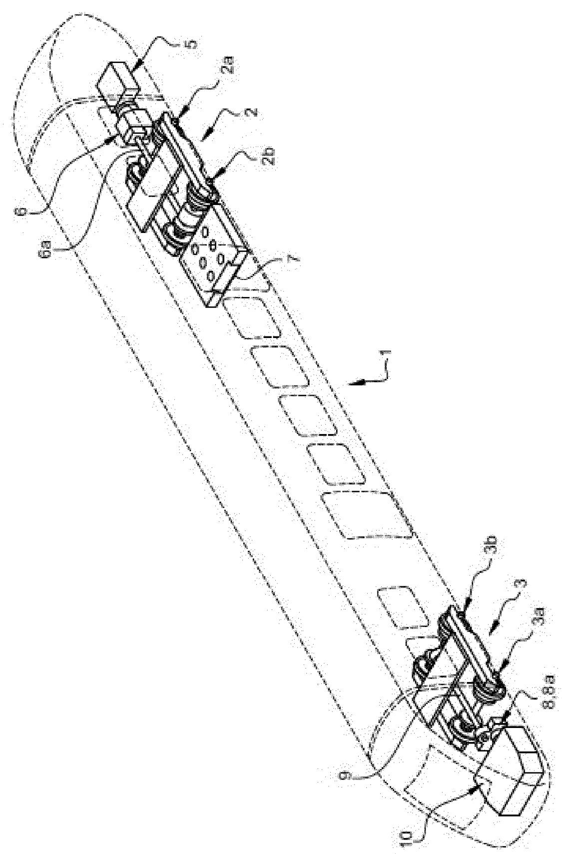
(54) SELF-PROPELLED RAILWAY VEHICLE COMPRISING A HYBRID MOTORIZATION AND CONTROL METHOD FOR SAID SELF-PROPELLED RAILWAY VEHICLE

(57) The invention relates to a self-propelled railway vehicle comprising a first and a second bogie in which there is assembled at least one body and each of which comprises at least one axle, with each bogie being associated with a respective drive train, a control system for controlling the operation of the drive trains in such a way that a torque is provided to either of the axles, with one of the drive trains being a thermal drive train comprising a heat engine (5), a hydraulic or mechanical gearbox (6), and a universal joint (6a) connecting the drive axle (2b) of the first bogie (2) to the hydraulic or mechanical gearbox (6). According to the invention, the other drive train is an electric drive train comprising a permanent magnet asynchronous or synchronous electric motor (8), a reduction gear (8a), a universal joint (9) connecting the drive axle (3b) of the second bogie (3) to the reduction gear (8a), an electrical energy storage system (10), and an AC/DC converter for powering the electric motor (8) and thereby providing torque to the axle (3b) of the second bogie (3), with said control system also being configured to control the braking of the vehicle and/or the recharging of the electrical energy storage system (10) by means of said electric motor (8) and the axle of the second bogie (3).

[Fig. 3]



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Description

TECHNICAL FIELD

[0001] The present invention relates to the general technical field of self-propelled railway vehicles (hereinafter also referred to as trains) and, more particularly, to the technical field of motorization and the auxiliary energy generation of said vehicles.

[0002] These self-propelled railway vehicles comprise, for example, a body or car supported by two bogies. Each of the bogies comprises of one, two, or three axles, one of which, for example the inner axle when there are several, is motorized.

[0003] The invention also relates to self-propelled railway vehicles comprise, where appropriate, several cars supported by as many bogies as required.

[0004] The invention more particularly relates to the motorization and to the drive trains, as well as to the onboard auxiliary energy production of these self-propelled railway vehicles. For the purposes of this document, a self-propelled railway vehicle is understood to mean an autonomous railway vehicle that does not have a power supply system by external means such as a catenary, a sliding skid or other means.

PRIOR ART

[0005] There are known, for example, self-propelled railway vehicles comprising, for example, two end bogies as well as two thermal drive trains, each comprising a diesel heat engine. Indeed, the self-propelled railway vehicles in question are mechanically propelled in the sense that the transmission of the torque on the drive axles is performed by means of a universal joint and a reduction gear from the body of said vehicle where diesel engines coupled to gearboxes are located. The latter are generally equipped with a hydraulic variator, a clutch and a retarding system to ensure dissipative braking in the gearbox oil in order to brake said vehicle without wear.

[0006] Current transport policy strongly encourages mobility with a smaller ecological footprint. However, current transport operators or carriers still have at their disposal rolling stock with mechanical diesel drive (i.e., torque is transmitted to the wheels from the vehicle body by means of a universal joint and axle-bridge system), which is currently operating at the halfway point of its service life. Ideally, therefore, it would be desirable to replace existing stock with new stock integrating new technologies comprising batteries and/or fuel cells. However, replacing existing rolling stock that has not yet reached the end of its service life would generate considerable economic losses. Not only would this make no economic sense, but it would also make no ecological sense considering the cost of manufacturing new stock when the existing stock still has a potential service life.

[0007] In addition, existing rolling stock is not always adapted to be renewed or motorized again with these new technologies, insofar as their designs may be old. This lack of adaptation is linked, for example, to restrictions of occupied volume, these new technologies being too bulky and/or heavy on the one hand, or because the latter do not make it possible to guarantee efficiencies identical to current efficiencies, namely in terms of passengers carried and/or autonomy. There is also the notion of safety which, when not taken into account from the outset, can make the adaptation of vehicles impossible, as their use would be too dangerous.

[0008] Diesel engine technology has evolved considerably in recent years to drastically reduce polluting emissions on the one hand, and to limit fuel consumption on the other. These new engines also make it possible to reduce the use of fossil fuels by means of adding biofuels from agriculture or recycling circuits in varying proportions. Replacing the existing diesel engine with this new, more efficient diesel engine is therefore an interesting approach, but it is not enough. Indeed, the railway rolling stock thus transformed will not be suitable for circulating in so-called zero-emission areas, which are implemented in particular in stations and in the vicinity of cities or other inhabited areas on the one hand, and which will not allow the recovery of braking energy which is another source of energy savings and maintenance cost reduction on the other hand.

[0009] Hybridization, i.e., the integration of an electric motor in a bogie, of an existing rolling stock with mechanical and/or hydraulic diesel propulsion, is also confronted with the need to integrate an electric drive train and electric energy storage equipment in a stock that was not originally intended for this purpose. The integration of an electric motor on an existing bogie will entail an in-depth overhaul of the latter with a long and costly validation campaign to be carried out again for said bogie and for the train or railway vehicle thus modified. Such a conversion of existing rolling stock would generate unacceptable cost overruns for operators.

[0010] At present, railway rolling stock is made up of identical drive trains throughout the train. At present, hybridization is generally only envisaged in stock where the drive trains are already electric, i.e., the torques communicated to the drive axles are produced by electric motors which are in turn installed on the bogies.

DISCLOSURE OF THE INVENTION

[0011] Accordingly, the object of the invention intends to alleviate the drawbacks of the prior art by proposing a hybridization of the existing mechanical/hydraulic diesel propulsion self-propelled railway vehicles, in order to reduce polluting emissions, decrease their consumption, reduce their maintenance cost, and guarantee their operation until the end of their useful life.

[0012] Another object of the present invention intends to propose a hybridization of the existing self-propelled railway vehicles, which does not adversely affect the efficiency, in particular from the point of view of the autonomy and the transported load of said vehicles.

[0013] Another object of the invention intends to propose a hybridization of the existing automotive railway vehicles favoring energy savings by means of the recovery of braking energy.

[0014] Another object of the invention intends to propose a new control method for controlling the electric and thermal drive trains of self-propelled railway vehicles optimized by means of hybridization of their motorization.

[0015] Another object of the invention intends to propose a reform of the principles of generation and storage of the auxiliary energy on board the train to replace all alternators and other low voltage batteries with static converters, power electronics (inverter and isolator) directly powered by the electrical energy storage equipment added to perform the hybridization.

[0016] The objects assigned to the invention are achieved with the aid of a self-propelled railway vehicle comprising at least one first and one second bogie in which there is assembled at least one body and each of which comprises at least one axle, with each end bogie being associated with a respective drive train, a control system for controlling the operation of the drive trains in such a way that a torque is provided to either of the axles, with one of the drive trains being a thermal drive train comprising a heat engine, a hydraulic or mechanical gearbox, and a universal joint connecting the axle of the first bogie to the hydraulic or mechanical gearbox, characterized in that the at least other drive train is an electric drive train comprising a permanent magnet asynchronous or synchronous electric motor, a reduction gear, a universal joint connecting the axle of the second end bogie to the reduction gear, an electrical energy storage system, and an AC/DC converter for powering the electric motor and thereby providing torque to the axle of the second bogie, with said control system also being configured to control the braking of the vehicle and/or the recharging of the electrical energy storage system by means of said electric motor and the axle of the second bogie.

[0017] According to one embodiment, the heat engine is a flat heat engine that can operate with biofuel and complies with the latest regulations in terms of polluting emissions. This heat engine advantageously has a height of less than 800 mm so as not to modify the lower limit of the railway gauge. According to one embodiment, this heat engine provides advantageously a power of more than 315 kW, whereas the conventional heat engine it replaces only provides a power of 257 kW.

[0018] According to one embodiment, the electric drive train comprises a hydrostatic drive system associated with a gearbox and with a clutch system for driving the electric motor in a clutched state and thereby providing electrical energy to the vehicle when such vehicle is stopped and when the heat engine is active.

[0019] According to one embodiment, the railway vehicle comprises a single body or car and two axles per bogie, with the drive axle of each of the bogies being made up of the axle assembled on the inner side of the end bogies.

[0020] According to another embodiment, the railway vehicle at least one non-motorized central bogie and a double body or car, a first part of which is assembled on the first end bogie and on the central bogie, and a second part of which is assembled on the second end bogie and on the central bogie, being the drive axle of each of the end bogies made up of the axle assembled on the inner side of the end bogies

[0021] The objects assigned to the invention are also achieved with the aid of a control method for the thermal and electric drive trains of the self-propelled railway vehicle described above, characterized in that it comprises control instructions, each corresponding to a specific operating mode of the drive trains, each of said instructions being selected manually by the driver of said railway vehicle or automatically by the control system, said operating modes comprising:

- a mode A in which the vehicle is parked and not electrically powered, with the heat engine and electric motor being inactive,
- a mode B in which the vehicle is stopped in preconditioning or in service maintenance,
- a mode C in which the vehicle makes a short stop at the station in zero-emission mode,
- a mode D in which the vehicle travels in low drive or coasts in zero-emission mode,
- a mode E in which the vehicle travels in full drive,
- a mode F in which the vehicle is braking, and
- a mode G in which the vehicle travels in low drive or in neutral but without braking and performs recharging of the electrical energy storage system.

[0022] According to an exemplary implementation of the control method, mode B corresponds to the activation of the heat engine and of the hydrostatic drive system for driving the electric motor and thereby recharging the electrical energy storage system, without requiring a power source outside said vehicle.

[0023] According to an exemplary implementation of the control method, mode C corresponds to the inactivation of the heat engine when said vehicle is stopped, during said mode C all the auxiliary equipment onboard said vehicle remains active. This makes it possible to maintain the same level of comfort for the passengers while at the same time preventing pollution and acoustic emissions of the heat engine.

[0024] According to an exemplary implementation of the control method, mode D corresponds to the inactivation of the heat engine and to the activation of the electric motor powered by the energy storage system to provide a torque to the axle which it motorizes in order to move said vehicle, the accessories and electrical devices of said vehicle being powered by the energy storage system by means of static power electronics converters. In this mode D, the tractive effort is less than 50% of the maximum effort that can be provided.

[0025] According to an exemplary implementation of the control method, mode E corresponds to the activation of the heat engine and of the electric motor to provide a maximum torque to the axles of the first and second bogies. The heat engine is thereby controlled at its rated speed and the electric motor offsets the demanded power variation, related to the route and/or the load, against or as a support for the heat engine.

[0026] According to an exemplary implementation of the control method, mode F corresponds to the activation or to the inactivation of the heat engine and to the activation of the electric motor which works to recharge the energy storage system and thereby generates a braking force on the axle of the second bogie. In this mode F, the dynamic braking can also be obtained by means of the "retarding" function of the gearbox on the side of the diesel heat engine, in the event of not being able to use the electric drive train in braking mode by means of energy recovery.

[0027] According to an exemplary implementation of the control method, mode G corresponds to the activation of the heat engine and to the activation of the electric motor which works to recharge the energy storage system and thereby generates a braking force on the drive axle of the second bogie, said heat engine being controlled to provide a complementary torque to the drive axle of the first bogie, in such a way that the braking force is offset and the travelling speed of said vehicle is kept constant.

[0028] The objects assigned to the invention are also achieved with the aid of a computer program product comprising program code instructions stored on a computer-readable support, for putting into practice the steps of the method according to any one of claims 6 to 12, when said program is executed by a computer.

[0029] Self-propelled railway vehicles according to the invention have the significant and unexpected advantage of maintaining the efficiency of the currently existing non-transformed stock, even improving such efficiency by up to 10%, while at the same time meeting the standards and regulatory and environmental restrictions. Furthermore, there is no need for the infrastructures used for the existing stock to be developed or for a power source outside the train.

[0030] Another significant advantage of the self-propelled railway vehicle according to the invention resides in the use of a less polluting heat engine that accepts biofuels. This makes it possible to considerably reduce the emissions of CO_2 and other harmful particles.

[0031] Another advantage of the self-propelled railway vehicles according to the invention resides in the conservation in the new electric drive train of a part of the elements of the thermal drive train as it was before the hybridization. Indeed, the transformation of a thermal drive train into an electric drive train only takes place upstream of the universal joint connecting the drive axle to the reduction gear. The universal joint and all its connection interfaces remain unchanged, both in terms of their shapes and their locations. This therefore contributes to facilitating operations for transforming existing rolling railway vehicles and to reducing the costs associated with such a transformation or hybridization.

[0032] Therefore, it is possible to circulate or park in zero-emission areas in which only the electric drive train is active as well as the auxiliary elements powered by the energy storage system added on board the train. Accordingly, decreased acoustic and polluting emissions in urban areas are also obtained.

[0033] Another significant advantage of the self-propelled railway vehicles according to the invention is the result of a new control method of the drive trains in which the recharging phases of the electrical energy storage system are optimized. Therefore, it is possible to perform recharging when the self-propelled railway vehicle is in running phase in braking mode and in running phase out of braking mode.

[0034] This new control method is also significant in that it makes it possible to manage a different effort between the axles operated respectively by the thermal drive train and the electric drive train, and this being done in a manner that it is completely transparent for the driver.

[0035] Another advantage of the self-propelled railway vehicle according to the invention resides in an optimized management of the braking phases to prioritize the recovery of the deceleration energy by the axle propelled by means of the electric drive train. Conserving an original gearbox makes it possible to implement the "retarding" function by dissipation in the oil, in particular in the case of not being able to use the electric drive train chain to slow down the train.

[0036] Another advantage of the self-propelled railway vehicles according to the invention resides in the use of a hydrostatic drive system which makes it possible to drive the electric motor by the heat engine for purposes of recharging the electrical energy storage system when said vehicle is stopped. The self-propelled railway vehicle can thereby continue to be autonomous even for recharging the electrical energy storage system.

[0037] Another advantage of the self-propelled railway vehicles according to the invention resides in the use of power electronics converters for powering the onboard auxiliary elements, which offer improved energy efficiency without polluting emissions and with lower noise levels. As a result, the overall efficiency of the vehicle's onboard auxiliary energy generation system increases significantly from 60% to 95%. Accordingly, passenger comfort is also improved.

[0038] Another advantage linked to the control method for the railway vehicle according to the invention resides in the possibility of running the heat engine at its rated speed, in particular in mode G, for a longer duration. The problems associated with fouling of the heat engine encountered if the load is low are thereby reduced.

DESCRIPTION OF THE DRAWINGS

[0039] Other features and advantages of the present invention will become clearer from the following description, given by making reference to the attached drawings, provided by way of non-limiting examples, in which:

Figure 1 is a perspective view of an embodiment of a railway vehicle of the prior art.

Figure 2 is a bottom view of the railway vehicle of Figure 1.

Figure 3 is a perspective view of an embodiment of a railway vehicle according to the invention,

Figure 4 is a bottom view of the railway vehicle of Figure 3,

Figure 5 depicts an enlarged scaled part A of Figure 4,

Figure 6 depicts an enlarged scaled part B of Figure 4,

Figure 7 schematically illustrates an example of the hydrostatic drive system of the railway vehicle according to the invention, and

Figures 8, 9 and 10 illustrate different embodiments of the railway vehicle according to the invention.

DETAILED DISCLOSURE OF THE INVENTION

[0040] The same numerical or alphanumerical reference is assigned to structurally and functionally identical elements present in several different figures.

[0041] Figure 1 is a perspective view of an embodiment of a railway vehicle of the prior art comprising a body 1 supported by a first motorized bogie 2 and a second motorized bogie 3. The latter are motorized by means of a heat engine 5, which operates in a range of 600 to 1800 rpm, and a hydraulic or mechanical gearbox 6. A fuel, diesel, tank 7 is arranged under the body 1 in the vicinity of the second bogie 3 and makes it possible to power the two heat engines 5.

[0042] Figure 2 is a bottom view of the railway vehicle of Figure 1. Each of the gearboxes 6 transmits a torque respectively to the drive axle 2b and 3b of the first and second bogies 2 and 3 by means of a universal joint 6a.

[0043] Figure 3 is a perspective view of an embodiment of a railway vehicle according to the invention. One of the drive trains, in this case the one located on the side of the second bogie 3, is an electric drive train. This electric drive train comprises a permanent magnet asynchronous or synchronous electric motor 8, and a reduction gear 8a associated with said electric motor 8, the operating range of which is comprised between 0 and 4800 rpm.

[0044] The electric drive train also comprises a universal joint 9 connecting the drive axle 3b of the second bogie 3 to the reduction gear 8a.

[0045] The electric drive train also comprises an electrical energy storage system 10 and a second AC/DC converter, for powering the electric motor 8 and thereby providing a torque to the motorized axle 3b of the second bogie 3.

[0046] The control system of the railway vehicle is advantageously configured for controlling the braking of said vehicle and/or the recharging of the electrical energy storage system 10 by means of the electric motor 8 and the drive axle 3b of the second bogie 3.

[0047] Figure 4 is a bottom view of the railway vehicle of Figure 3. The heat engine 5 in the vehicle according to the invention is a flat heat engine that can operate with biofuel and complies with the latest regulations in terms of polluting emissions.

[0048] Figure 5 depicts an enlarged scaled part A of Figure 4, which illustrates the side of the second bogie 3 in further detail, and Figure 6 depicts an enlarged scaled part B of Figure 4, which illustrates the side of the first bogie 2 in further detail.

[0049] The universal joint 9 of the electric drive train is advantageously identical to the universal joint 6a of the thermal drive train. The connection interface between the reduction gear 8a and the universal joint 9, on one hand, and the connection interface between the hydraulic or mechanical gearbox 6 and the universal joint 6a are located in the same position with respect to the body 1, thereby largely facilitating hybridization of the railway vehicle, namely the replacement of a thermal drive train with an electric drive train.

[0050] According to one embodiment, the electric drive train comprises a hydrostatic drive system 11 associated with a fixed ratio gear system 12 and with a clutch system 13 for driving the electric motor 8 in a clutched state, and thereby providing electrical energy to the vehicle when such vehicle is stopped and when the heat engine 5 is active. This operating mode corresponds to a parked vehicle with an emergency brake activated.

[0051] In this operating mode, the mechanical attachment between the heat engine 5 and the hydraulic or mechanical gearbox 6, which directly drives the drive axle 2b, is uncoupled as a result of a first clutch 5a in an unclutched state. The first clutch 5a is advantageously integrated in the hydraulic or mechanical gearbox 6.

[0052] Moreover, the mechanical attachment between the electric motor 8 (or the reduction gear 8a) and another fixed ratio gear system 14 which directly drives the drive axle 3b, is uncoupled as a result of a second clutch 8b in an unclutched state. The unclutched states are indicated by means of crosses in Figure 7. No torque is then transmitted to the drive axles 2b and 3b.

[0053] The hydrostatic drive system 11 also comprises a hydrostatic pump 5b controlled by means of the heat engine 5 and which makes it possible to drive a hydrostatic motor 5c, which is mechanically attached to the fixed ratio gear system 12, by means of the clutch system 13.

[0054] Figures 8, 9, and 10 illustrate different embodiments of the railway vehicle according to the invention. In that sense, Figure 8 illustrates a self-propelled railway vehicle comprising a single body 1 supported by the first motorized bogie 2 and the second motorized bogie 3. Therefore, the latter constitute end bogies. Each of the bogies 2 and 3 advantageously comprises two axles.

[0055] Figure 9 illustrates another embodiment of the railway vehicle, comprising a double body with part 1a and part 1b, the first bogie 2, the second bogie 3, and a central bogie 4. Therefore, the railway vehicle comprises a non-motorized central bogie 4 and a double body or car, a first part 1a of which is assembled on the first end bogie 2 and on the central bogie 4, and a second part 1b of which is assembled on the second end bogie 3 and on the central bogie 4.

[0056] Figure 10 illustrates another embodiment of the railway vehicle, comprising a double body with part 1a and part 1b, the first bogie 2, the second bogie 3, and two central bogies 4a and 4b. Each of the parts 1a and 1b of the body is then supported, respectively, by the first bogie 2 and a central bogie 4a and by the second bogie 3 and the other central bogie 4b.

[0057] Other configuration examples of the railway vehicle can be envisaged in the context of the present invention.

[0058] Moreover, the invention relates to a hybridization method for a self-propelled railway vehicle comprising at least two thermal drive trains, each associated with a bogie of said railway vehicle, replacing at least one of the thermal drive trains with an electric drive train upstream of the universal joint, making it possible to transmit a torque to the drive axle, and replacing, in at least another thermal drive train, the existing heat engine with a more efficient heat engine.

[0059] This hybridization method also comprises a step of optimizing the control method for said electric and thermal drive trains.

[0060] Indeed, the control method for the thermal and electric drive trains of the self-propelled railway vehicle described above comprises control instructions, each corresponding to a specific operating mode A, B, C, D, E, F, and G of the drive trains, each of said instructions being selected manually by the driver of said railway vehicle or automatically by the control system. Therefore, the operating modes comprise mode A in which the vehicle is parked and not electrically powered, with the heat engine and electric motor being inactive.

[0061] Mode B, in which the vehicle is stopped in preconditioning or in service maintenance, corresponds to the activation of the heat engine 5 and of the hydrostatic drive system for driving the electric motor 8 and thereby recharging the electrical energy storage system 10, if needed, according to the state of charge of the electrical energy storage system 10, without requiring a power source outside said vehicle and, therefore, a particular infrastructure.

[0062] Mode C, in which the vehicle makes a short stop at the station in zero-emission mode, corresponds to the inactivation of the heat engine 5 when said vehicle is stopped, during which stop all the auxiliary equipment onboard said vehicle remains active.

[0063] Mode D, in which the vehicle travels in low drive or coasts in zero-emission mode, corresponds to the inactivation of the heat engine 5 and to the activation of the electric motor 8 powered by the electrical energy storage system 10 to provide a torque to the axle 3b which it motorizes in order to move said vehicle, the accessories and electrical devices of said vehicle being powered by the electrical energy storage system 10 by means of static power electronics converters. In this mode D, the tractive effort is less than 50% of the maximum effort that can be provided to the rolling stock in question.

[0064] Mode E, in which the vehicle travels in full drive, corresponds to the activation of the heat engine 5 and of the electric motor 8 to provide a maximum torque to the drive axles 2b and 3b of the first and second bogies 2 and 3. The heat engine 5 is thereby controlled at its rated speed and the electric motor 8 offsets the demanded power variation, related to the route and/or the load, against or as a support for the heat engine 5.

[0065] Mode F, in which the vehicle is braking, corresponds to the activation or to the inactivation of the heat engine 5 and to the activation of the electric motor 8 which works to recharge the electrical energy storage system 10 and thereby generates a braking force on the axle of the second bogie. In this mode F, the dynamic braking can also be obtained by means of the "retarding" function of the gearbox 6 on the side of the diesel heat engine, in the event of not being able to use the electric drive train in braking mode by means of energy recovery.

[0066] Mode G, in which the vehicle travels in low drive or in neutral but without braking and performs recharging of the electrical energy storage system 10, corresponds to the activation of the heat engine 5 and to the activation of the electric motor 8 which works while braking to recharge the energy storage system 10 and thereby generates a braking force on the drive axle 3b of the second bogie 3. The electric motor 8 thereby provides an effort against the tractive effort generated by the heat engine 5. The heat engine 5 is then controlled to provide a complementary torque to the drive axle 2b of the first bogie 2, in such a way that the braking force is offset and the travelling speed of said vehicle is kept constant.

[0067] It is evident that the present description is not limited to the examples explicitly described, but also comprises other embodiments. Therefore, a described technical feature and a described method step can be replaced respectively with an equivalent technical feature or an equivalent method step, without departing from the context of the present invention as defined by the claims.

Claims

1. Self-propelled railway vehicle comprising at least one first and one second bogie (2, 3) in which there is assembled at least one body (1) and each of which comprises at least one axle (2b, 3b), with each of the first and second bogies (2, 3) being associated with a respective drive train, a control system for controlling the operation of the drive trains in such a way that a torque is provided to either of the axles (2, 3b), with one of the drive trains being a thermal drive train comprising a heat engine (5), a hydraulic or mechanical gearbox (6), and a universal joint (6a) connecting the drive axle (2b) of the first bogie (2) to the hydraulic or mechanical gearbox (6), **characterized in that** the at least other drive train is an electric drive train comprising a permanent magnet asynchronous or synchronous electric motor (8), a reduction gear (8a), a universal joint (9) connecting the drive axle (3b) of the second bogie (3) to the reduction gear (8a), an electrical energy storage system (10), and an AC/DC converter for powering the electric motor (8) and thereby providing torque to the axle (3b) of the second bogie (3), with said control system also being configured to control the braking of the vehicle and/or the recharging of the electrical energy storage system (10) by means of said electric motor (8) and the axle (3b) of the second bogie (3).

2. Self-propelled railway vehicle according to claim 1, wherein the heat engine (5) is a flat heat engine that can operate with biofuel and complies with the latest regulations in terms of polluting emissions.

3. Self-propelled railway vehicle according to claim 1 or 2, wherein the electric drive train comprises a hydrostatic drive system (11) associated with a fixed ratio gear system (12) and with a clutch system (13) for driving the electric motor (8) in a clutched state and thereby providing electrical energy to the vehicle when such vehicle is stopped and the heat engine (5) is active.

4. Self-propelled railway vehicle according to any one of claims 1 to 3, wherein it comprises a single body or car (1) and two axles (2a, 2b) or (3a, 3b) per bogie, with the drive axle (2b, 3b) of each of the bogies (2, 3) being made up of the axle assembled on the inner side of the bogies (2, 3).

5. Self-propelled railway vehicle according to any one of claims 1 to 3, wherein it comprises at least one non-motorized central bogie (4) and a double body or car (1), a first part (1a) of which is assembled on the first end bogie (2) and on the central bogie (4), and a second part (1b) of which is assembled on the second end bogie (3) and on the central bogie (4), with the drive axle (2b, 3b) of each of the end bogies (2, 3) being made up of the axle assembled on the inner side of the end bogies (2, 3).

6. Control method for the thermal and electric drive trains of the self-propelled railway vehicle according to any one of claims 1 to 5, **characterized in that** it comprises control instructions, each corresponding to a specific operating mode of the drive trains, each of said instructions being selected manually by the driver of said railway vehicle or automatically by the control system, said operating modes comprising:

   - a mode A in which the vehicle is parked and not electrically powered, with the heat engine (5) and electric motor (8) being inactive,
   - a mode B in which the vehicle is stopped in pre-conditioning or in service maintenance,
   - a mode C in which the vehicle makes a short stop at the station in zero-emission mode,
   - a mode D in which the vehicle travels in low drive or coasts in zero-emission mode,
   - a mode E in which the vehicle travels in full drive,
   - a mode F in which the vehicle is braking, and
   - a mode G in which the vehicle travels in low drive or in neutral but without braking and performs recharging by means of recovery of the electrical energy storage system.

7. Control method for the thermal and electric drive trains according to claim 6 and for the self-propelled railway vehicle according to claim 3, wherein mode B corresponds to the activation of the heat engine (5) and of the hydrostatic drive system for driving the electric motor (8) and thereby recharging the electrical energy storage system (10), without requiring a power source outside said vehicle.

8. Control method for the thermal and electric drive trains of the self-propelled railway vehicle according to claim 6 or 7, wherein mode C corresponds to the inactivation of the heat engine (5) when said vehicle is stopped, during said mode C all the auxiliary equipment onboard said vehicle remains active.

9. Control method for the thermal and electric drive trains of the self-propelled railway vehicle according to any one of claims 6 to 8, wherein mode D corresponds to the inactivation of the heat engine (5) and to the activation of the electric motor (8) powered by the energy storage system (10) to provide a torque to the axle (3b) which it motorizes in order to move said vehicle, the accessories and electrical devices

of said vehicle being powered by the energy storage system (10) by means of static power electronics converters.

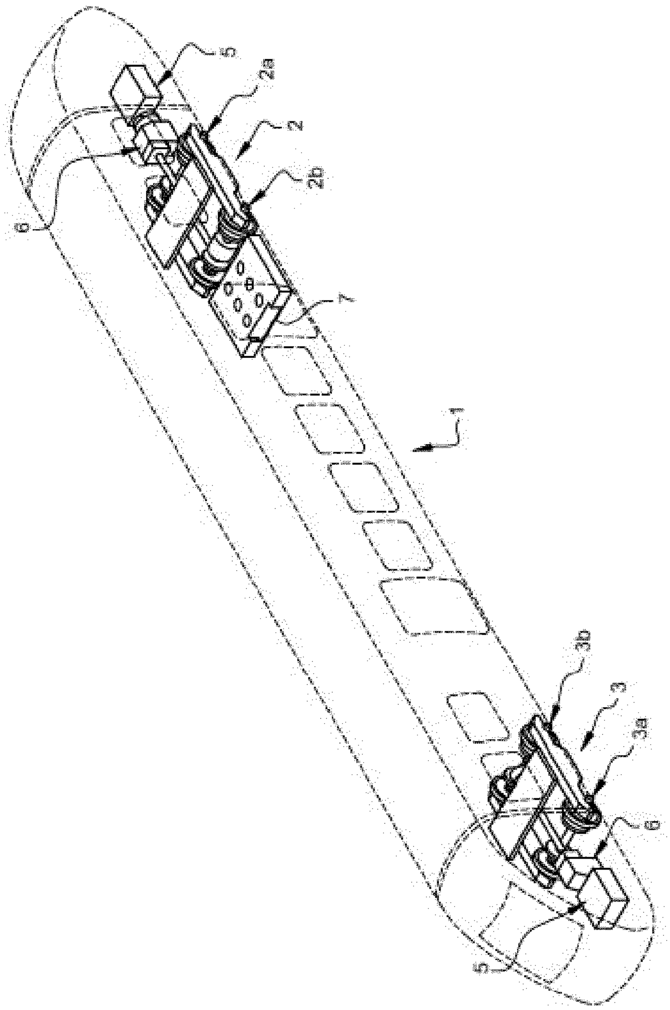
10. Control method for the thermal and electric drive trains of the self-propelled railway vehicle according to any one of claims 6 to 9, wherein mode E corresponds to the activation of the heat engine (5) and of the electric motor (8) to provide a maximum torque to the axles (2b, 3b) of the first and second bogies (2, 3).

11. Control method for the thermal and electric drive trains of the self-propelled railway vehicle according to any one of claims 6 to 10, wherein mode F corresponds to the activation or to the inactivation of the heat engine (5) and to the activation of the electric motor (8) which works to recharge the energy storage system (10) and thereby generates a braking force on the axle (3b) of the second bogie (3).

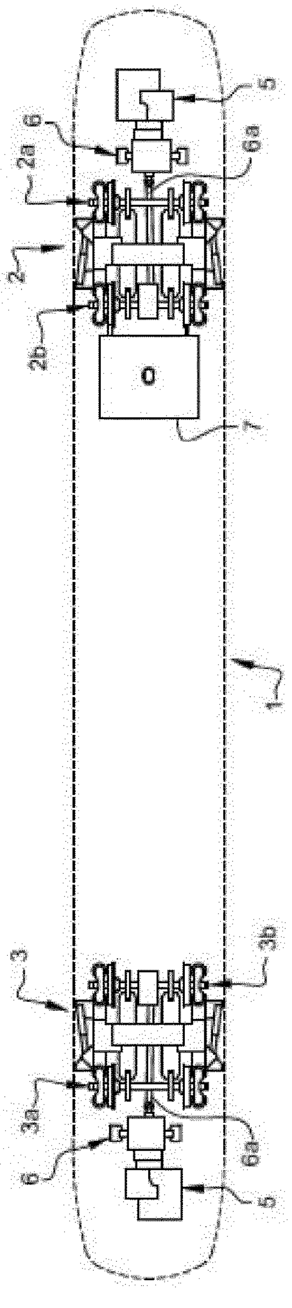
12. Control method for the thermal and electric drive trains of the self-propelled railway vehicle according to any one of claims 6 to 11, wherein mode G corresponds to the activation of the heat engine (5) and to the activation of the electric motor (10) which works to recharge the energy storage system (10) and thereby generates a braking force on the drive axle (3b) of the second bogie (3), said heat engine (5) being controlled to provide a complementary torque to the drive axle (2b) of the first bogie (2), in such a way that the braking force is offset and the travelling speed of said vehicle is kept constant.

13. Computer program product comprising program code instructions stored on a computer-readable support, for putting into practice the steps of the method according to any one of claims 6 to 12, when said program is executed by a computer.

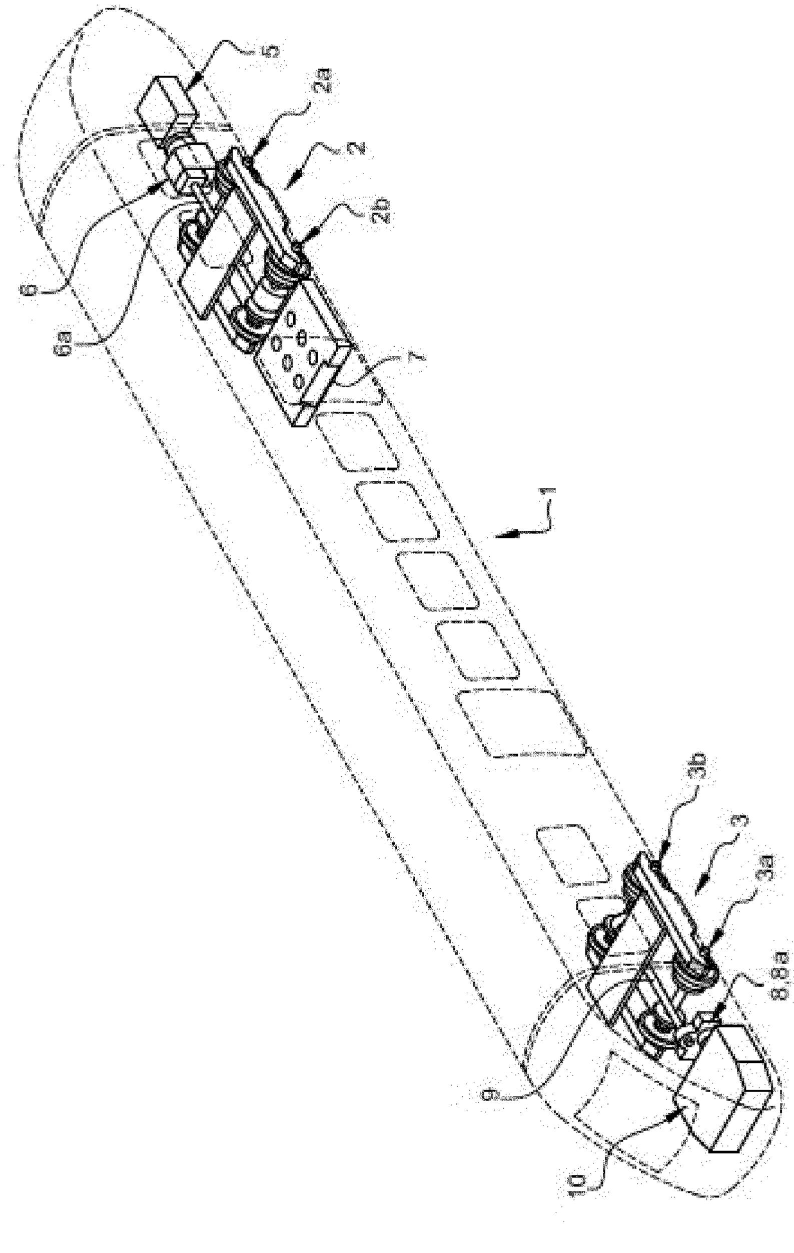
[Fig. 1]



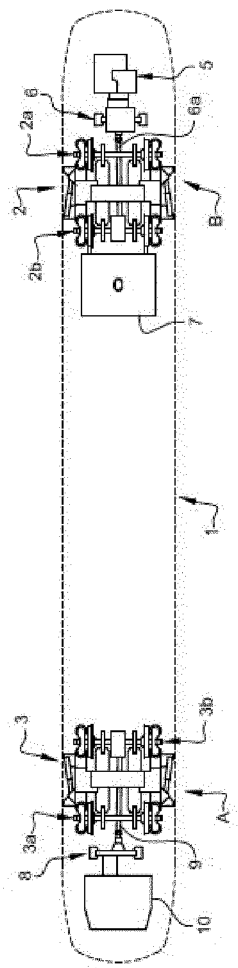
[Fig. 2]



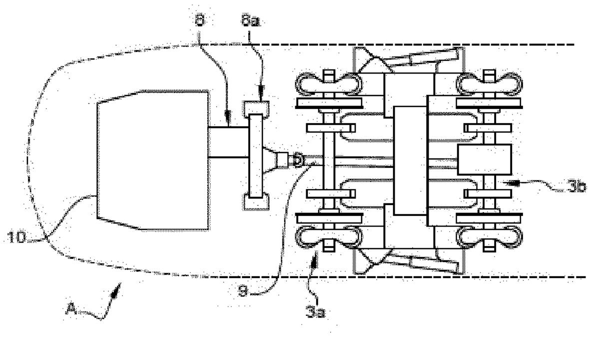
[Fig. 3]



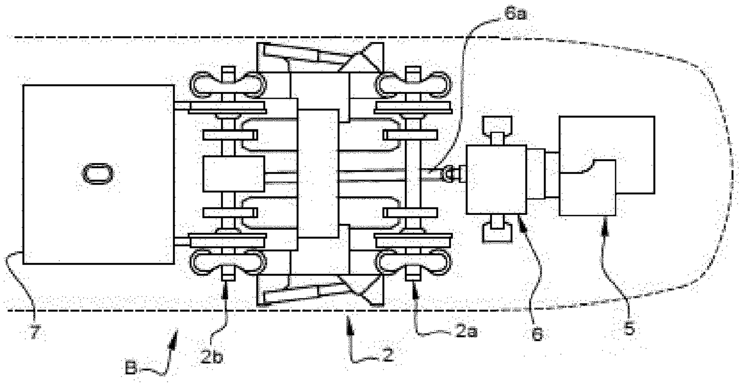
[Fig. 4]



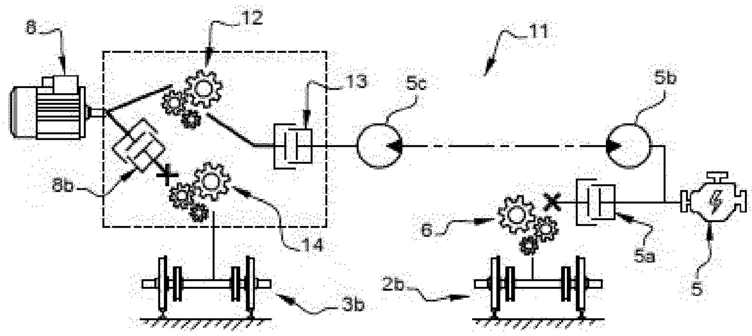
[Fig. 5]



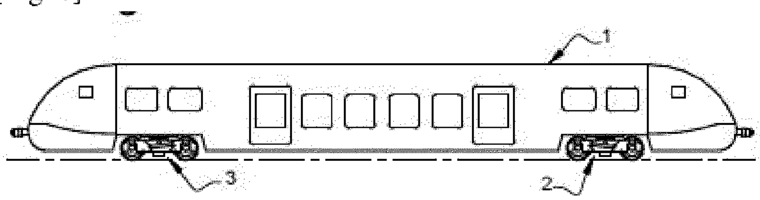
[Fig. 6]



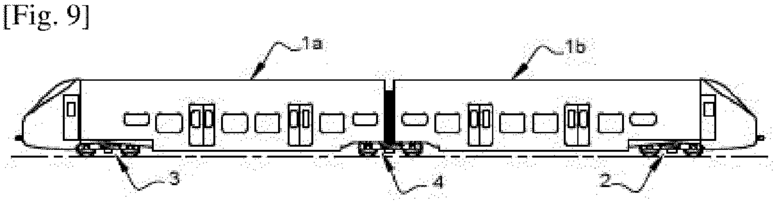
[Fig. 7]



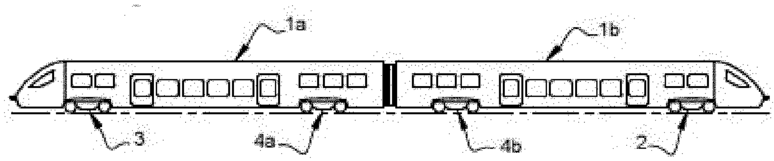
[Fig. 8]



[Fig. 9]



[Fig. 10]



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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 8489

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 August 2023	Awad, Philippe

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