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(54) COMPACT DRIVE UNIT FOR TRACTION VEHICLES

KOMPAKTANTRIEBSEINHEIT FÜR ZUGFAHRZEUGE

UNITÉ D'ENTRAÎNEMENT COMPACTE POUR VÉHICULES À TRACTION

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EP-A2- 1 386 815	**CN-B- 103 633 775**
DE-A1- 19 805 679	**DE-A1-102014 117 570**
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Description

Technical field

[0001] This invention concerns a traction vehicle with a compact drive unit connected to wheel a bogie of the traction vehicle. It concerns for example rail vehicles such as trams, light rail vehicles, metros, electric units (EMUs) and train sets. The drive unit of the traction vehicle combines high-speed electric drive with appropriate gearbox and it allows design of drive units with significantly reduced volume and weight.

Background and summary of the invention

[0002] The invention concerns a traction vehicle as proposed in the independent claims 1 or 2. The traction vehicle comprises a compact traction drive unit and is intended for rail vehicles, which often demand a full low-floor arrangement of the vehicle. Existing solutions of drive units for traction vehicles can be divided into wheel drives and axle/wheelset drives.

[0003] Wheel drives are aimed particularly to low-floor design for urban passenger transport. These drives are used with or without a gearbox, i.e. with a low-speed electric motor directly connected to the wheel. Gearless wheel drives typically employ multi-pole electrical motors connected to the wheel directly or by means of a mechanical coupling element which allows mechanical disconnection of the motor shaft from the wheel (specifically under fault conditions). The electric motor usually uses permanent magnets in order to achieve both maximum power density and efficiency. The above mentioned solutions are known e.g. from EP 1 867 543, EP 0 918 676 and they were reported in many non-patent literature publications, e.g. F. Demmelmayr, M. Troyer and M. Schroedl, "Advantages of PM-machines compared to induction machines in terms of efficiency and sensorless control in traction applications," IECON 2011 - 37th Annual Conference on IEEE Industrial Electronics Society, Melbourne, VIC, 2011, pp. 2762-2768. doi: 10.1109/IECON.2011.6119749 or Z. Huang, X. Huang, J. Zhang, Y. Fang and Q. Lu, "Design of an interior permanent magnet synchronous traction motor for high speed railway applications," Power Electronics, Machines and Drives (PEMD 2012), 6th IET International Conference on, Bristol, 2012, pp. 1-6. doi: 10.1049/cp.2012.0253.

[0004] The gearless wheel drives (such as EP 1 867 543) are competitive in the drives approximately up to 50 kW. In higher power applications, where this invention is intended for, their weights and volumes make impossible direct mounting to the wheel. Their maximum output power is generally limited by wheel diameter and vehicle speed. The same constraint applies to gearless axle drives (such as EP 0 918 676, WO 2006051046 or J. Germishuizen, A. Jockel, T. Hoffmann, M. Teichmann, L. Lowenstein and F. v. Wangelin, "SyntegraTM - next generation traction drive system, total integration of traction, bogie and braking technology," International Symposium on Power Electronics, Electrical Drives, Automation and Motion, 2006. SPEEDAM 2006., Taormina, 2006, pp. 1073-1077), where the limit is given by the wheel gauge. One of the biggest disadvantages of mentioned solutions is a direct coupling between the motor and the wheel or axle resulting in large unsprung masses.

[0005] Wheelset drives are dominant in applications where higher power transmission to the axle is required, especially for locomotives, EMUs and metro trainsets. These drive units can be designed directly within bogie or vehicle concepts. In WO9629224, the drive unit for a low-floor vehicle is proposed. It drives two wheels by means of a single longitudinally mounted motor outside the bogie. The gearboxes are connected to both output shafts of the motor. The brake is integrated in the drivetrain between the motor and the wheels. Similar solution of one-sided drive for two single wheels is described in DE 199 45 464. In both cases, the motor is proposed as a low-speed one and therefore its weight and dimensions are treated as disadvantages.

[0006] The US 511 97 36 describes a bogie concept which is characterized by the longitudinally placed motor of each wheel which is connected to the associated wheel by interposition of a homokinetic flexible coupling shaft and comprises a reduction gear unit. The motor and reduction units do not create a compact closed unit and the presence of the homokinetic coupling shaft signifies that the motor belongs among low-speed ones and therefore its dimensions are large to achieve the rated power of the proposed drive unit.

[0007] The US 8 978 563 introduces a bogie drive concept allowing partly low-floor design of the rail vehicle. Longitudinally placed electric motor inside the bogie has output shafts on both motor ends. The shafts are connected by means of a gearbox to axles suspended in the bogie. The concept allows two possible motor designs as well. However, the full low-floor concept is not possible here and the dimensions of the electric motor are larger due to its low-speed concept. The drive does not include the brake directly but it is placed outside the bogie separately.

[0008] The concept of a drive driving two axles of the bogie is presented in US 4 130 065, where the electric motor is placed longitudinally outside the bogie between the two drive axles.

[0009] The advantage of this design is that the two ends of the rotor shaft stubs are equipped with the drive pinions. To save the weight, the stator of the electric traction motor is made without housing. For this reason, the stator lamination stack clamped between pressure plates is provided at its back with clamping elements which compress the stator lamination stack. Even if the weight is particularly saved, it is not sufficient in comparison to the solution proposed in presented invention, where the high-speed electric motor concept allows significant reduction of the weight of the whole drive unit by using high speeds to transmit desired power.

[0010] Among investigated solutions, patents related directly to drive units exist. These patents deal with various connections of the motor to the driven wheel/axle but in general each of presented solutions incorporates a part or design aspect, which makes the usage of a high-speed motor impossible, therefore they lead to physically larger and significantly heavier solutions than presented invention. This fact applies especially to patents DE 100 50 757, EP 1 386 815 and EP 0 698 540.

[0011] In case of DE 10050757, the power transmission from the motor to the axle is ensured through cardan-like element and the alignment imperfections between the gearbox and the axle is performed through inclinable tooth coupling. Such a solution is not suitable for higher speeds because of its dimensions and therefore it makes usage of a high-speed electrical motor impossible. The main advantage of presented invention (which is reduction of weight and volume) cannot be achieved through the solution described in DE 100 50 757.

[0012] A very similar disadvantage applies to patent EP 0 698 540. In this case, the power transmission from the gearbox to the axle is performed through hollow cardan coupling, which forms a very heavy and large part. In comparison to presented invention, the EP 0 698 540 forms heavier and larger alternative.

[0013] The EP 1 386 815 presumes relatively low output power of the electric motor (approximately 40 kW) and utilizes one stage gearbox. The device is applicable to the wheel drive only, whilst our solution is predominantly intended for the axle drive and allows design of higher power drive. The one stage gearbox in EP 1 386 815 does not allow utilization of high-speed electrical motor. The important benefit of our solution is passive cooling system which uses the whole drive unit housing and all integrated components for motor heat dissipation.

[0014] A device presented in DE 10 2014 117570 comprises an electrical machine, a transmission gear and a differential gear, wherein the electrical machine has a hollow shaft formed on the motor shaft. The achievable transmission ratio is according to the description 3 to 4 in case of first gear and 2 to 3 in case of second gear. Thus, the total gear ratio is typically between 6 and 12 only. The internal combustion engine is a part of the drive. The drive is intended for hybrid vehicles with axle drivetrain. The electric motor operates in the speed range up to 12 000 rpm, with the rated voltage of 48 V and max. power around 60 kW. The design of the unit explicitly considers usage of a motor with hollow shaft and coaxial layout of the components with the motor. The layout of all components of this solution prevents its usage in low-floor traction (rail) vehicles.

[0015] A device presented in US 5 751 081 comprises an electrical motor, a differential gear mechanism and a planetary gear type reduction gear, wherein one of the output shafts penetrates the rotor of the electrical motor. The achievable transmission ratio according to the description is approximately up to 10 only. The design of the unit uses an electric motor with hollow shaft and coaxial layout of the components with the motor. The device combines electrical machine, reduction gears and a differential gear mechanism; therefore, it has two output shafts to be connected to two independent running wheels. The device is suitable for small passenger cars, where the differential gear mechanism is a must, or similar road vehicles. The layout of all components of this solution prevents its usage in low-floor traction (rail) vehicles.

[0016] A device presented in DE 198 05 679 is a wheel hub drive comprising an electrical motor and transmission gears, wherein the electrical motor has a hollow rotor shaft. The transmission gears are strictly formed by planetary gears. The achievable transmission ratio is typically between 6 and 12 only. The design of the device explicitly considers usage of a motor with hollow shaft and coaxial layout of the components with the motor. The device is determined to be mounted directly by means of bearings to a wheel, or it can be a part of a wheel hub. The construction design and layout of all components prevents its usage as axle/wheelset drive. Moreover, achievable maximum power of this device is relatively low.

[0017] A device presented in CN 103 633 775 comprises driving motor and a differential gear mechanism and a planetary gear, or fixed shaft gear reducer. In case of configuration with a differential gear mechanism, the rotor of the motor includes either the differential gear mechanism inside the rotor, or it is formed by a hollow shaft penetrated by one of the output shafts which are connected to the output of the differential gear mechanism. In case of the configuration with fixed shaft reducer, there is one-stage planetary gear transmission which has a limited transmission ratio. In all cases above, the usage of high-speed electrical motor (over 6 000 rpm) is unfeasible because of limited transmission ratio.

[0018] Document GB 1 438 620 and corresponding document US 4 148 262 describe a drive unit for railway vehicles, using a low-speed electric motor. The drive unit is located in the bogie between the wheels so it is prevented from using in full low-floor vehicles. It discloses the electric motor connected to a gearbox via coupling.

[0019] Document JP 2003-339101 describes an oil heating system for automotive application used in an electric drive unit with gearbox. To solve the problem of high viscose cold oil causing high friction and additional load of the motor, it proposes to preheat the oil before the start of the drive unit. To solve this problem, it uses some of stator coils immersed in the oil so that the oil is purposely heated and its viscosity lowered. The heated oil from motor coils is pumped through the drive unit using functional apparatus (oil pump). Accordingly, it implicitly further discloses use of necessary oil ducts, temperature sensors and protections. Proposed solution therefore accommodates many additional parts, making it more expensive, complicated and possibly less reliable.

[0020] European patent application EP 0 054 135 describes a rail vehicle drive unit placed inside the bogie so it is prevented from using in full low-floor vehicles. The document discloses arrangement of disc brakes, shafts, gears and other parts of the drive unit. However, the document is silent about arrangement of the housing and any oil management.

[0021] European patent application EP 0 457 106 also describes a rail vehicle drive unit placed inside the bogie so it is prevented from using in full low-floor vehicles. The document discloses arrangement of disc brakes, shafts, gears and other parts of the drive unit. However, the document is silent about arrangement of the housing and any oil management.

[0022] Generally, the bearing and gearing lubrication in the traction drive gearboxes, especially of rail vehicles, is performed by means of gear wading in the oil pool and throwing of oil from the wading gears to bearings by auxiliary collecting and distribution channels. Based on available technical data, the maximum speed of the input shaft of the gearbox is nowadays approximately 5 200 rpm. Protective seal of the inner space of the gearbox against dust, water and oil leakage is performed by labyrinth sealing, or by shaft sealing rings.

[0023] Cooling of lubricant is performed by means of passive cooling via the housing of the gearbox.

[0024] In modern traction drives, the manufacturers use ac electrical motors, most popular are induction and permanent magnet motors which are generally known and they were reported in many non-patent literature publications as described above.

[0025] These electrical motors have maximum speeds up to 5 200 rpm (extremely up to 6 000 rpm). They are usually cooled by an independent fan or by a fan placed on the shaft of the motor. The liquid cooling is often used as well.

[0026] Existing solutions of traction drive units are designed for lower speeds of electrical motors (approx. up to 5 200 rpm). To assure the transmission of the power from such motor to the axle or wheel, the corresponding design leads from transmitted torque point of view to relatively robust solutions characterized by large volumes of drive units and their considerable weight. The idea of high-speed drive (i.e. with the electrical motor speed over 6 000 rpm), which could enable essential reduction of dimensions and weight of the drive unit, is generally known in the theory. It comes from the equation for mechanical power $P_m = T_\omega$, where P_m is a mechanical power at the rotor output, T is a torque and ω is a mechanical rotor speed. Therefore, if the rotor speed is significantly increased and the output power is kept constant, then the output torque substantially decreases. Thus, all mechanical components result smaller in volume and weight. However, there is no existing reliable design solution available for traction applications up to now.

[0027] With the subject-matter of each of the independent claims 1 and 2 a traction vehicle is provided with a robust design solution of the compact drive unit, which allows significant reduction of the volume and the weight of the traction unit due to significant increase of the traction motor speed (typically over 9 000 rpm) while keeping the same traction vehicle characteristics. Although, higher speeds of traction motor require usage of high-speed stages of the gearbox to reduce the speed to rated output speeds of the axle/wheel, the torques transmitted by high-speed stages of the gearbox are significantly lower, which principally decreases demands on gear train dimensions. Moreover, the proposed compact unit, due to significant reduction of dimensions of particular parts of the drive, enables the integration of the drive into a single compact housing. This integration into the one housing together with unique construction design of high-speed electrical motor makes possible to improve the heat transfer from particular components and to use passive cooling of the electrical motor, which is a significant advantage compared to the existing solutions. As explained above, the proposed invention significantly overcomes currently known designs and arrangements of drives for traction vehicles. It allows significant reduction of weight and volume of the drive unit and, based on that, integration of the drive unit into the single compact housing, which further enables the use of passively cooled electrical motor and significantly simplifies and reduces the cost of drive assembling.

[0028] The proposed solution requires preheating of the lubricant of high-speed stage of the gearbox during extremely low ambient temperatures, which can typically go down to -40 °C. This is, as described in detail below, solved by design arrangement of the drive and by the usage of thermal sources available in the integrated body of the drive unit, i.e. without any further external equipment. In comparison with existing designs of traction drives employing low-speed gearboxes having no extreme demands on gearing and bearing lubrication or preheating of lubricant, the required preheating in this invention is not any significant disadvantage.

Brief description of drawings

[0029] The invention is further explained by means of the drawings. Fig. 1 describes basic configuration and cooperation of particular components of invented compact traction drive unit. Fig. 2 describes the functionality of optional additional gearbox stages and alternative position of the brake.

Description of the preferred embodiments

[0030] Fig. 1 describes invented compact traction drive unit. The device is mounted on the outside of the wheel 9 of a traction rail vehicle. It is composed of a high-speed electrical motor 1 with passive cooling. The motor 1 has typically rated rotor speed over 9 000 rpm. The high-speed electrical motor 1 can be designed as an induction motor, a synchronous motor, a reluctance motor, an electronically commutated (brush-less dc) motor or a direct-current motor. Considering requirements for extremely small volume, high efficiency and reliability, the permanent magnet motor is going to be the most suitable solution.

[0031] The electrical motor 1 is supplied by a power electronics converter 2. Typically, it is a voltage-source inverter. The power electronics converter 2 can also be a current-source inverter.

[0032] From the Fig. 1 it is apparent that a gearbox connected at the drive-end of the motor shaft is divided into two stages: high-speed 11, and low-speed. The rotor of the electrical motor 1 is supported by three rolling-element bearings 3 along with pinion gear 4 of the input spur/helical gear 5 and all together create rotor assembly 14. The location of the middle rolling-element bearing 3 at the motor shaft improves the dynamic stability of the rotor. It also simplifies drive unit assembly. The shaft 6 of the gear is a part of the following bevel gear 7 and simultaneously it can be connected to the brake 13. The coupling of the brake 13 to the shaft 6 of the high-speed gearbox stage 11 allows important reduction of the dimensions of the brake 13. Alternatively (as shown in Fig. 2), the brake 13 can be connected to the rotor assembly 14 which will further reduce the brake dimensions.

[0033] Output shaft of the bevel gear 7 can be connected either directly or by using the coupling 12 to the wheel 9 from the other side of the wheel 9 respective to the axle 8. In case the higher transmission ratio is required, the output shaft of the bevel gear 7 can be connected to additional gears 10 (as shown in Fig. 2), where the output shaft of these additional gears 10 is connected to the wheel 9 from the other side of the wheel 9 respective to the axle 8 directly or by using the coupling 12. The brake 13 can also be connected to the output of the low-speed gearbox stage. However, this position leads to the larger dimensions and weight of the invented compact traction drive unit.

[0034] Due to significant reduction of both dimensions and weight of particular components of invented drive unit, all the drive unit components can be embedded into one compact housing. This solution significantly decreases the assembly cost and time. However, it is important that at least electrical motor 1 and high-speed gearbox stage 11 are embedded into common compact housing. The integration of the drive unit components into the single housing together with unique construction design of the high-speed motor 1 result in better heat dissipation from all components and it allows a passive cooling of the electrical motor 1 and the whole drive unit. This is very important advantage of the presented invention in comparison to existing traction drive technologies.

[0035] The proposed two-stage solution of the gearbox requires preheating of the lubricant of the high-speed gearbox stage 11 under extremely low ambient temperatures (typically down to -40 °C) before running the gearbox. Due to integration of the drive unit components into one housing, the proposed invention uses preheating of the lubricant of the gearbox 11 by means of the losses of the electrical motor 1. Thus, the power electronics converter 2 feeds the current into the stator winding of the motor 1 which causes production of the heat due to existing losses in the motor 1 (the resistive losses play the major role in this phenomenon). The produced losses, respectively resulting heat is distributed inside the drive unit using the conduction via both drive components and the housing and it preheats in this way the lubricant of the gearbox 11 before its running. Thus, the invented concept does not require any additional device (external thermal source, etc.) and it is very robust and reliable.

[0036] This invention allows significant reduction of drive units volume and weight while demanded traction power/tractive effort is kept. If the electrical motor 1 has the rated speed around 9 000 rpm and the rated power close to 100 kW (typical application for light traction rail vehicles), our conservative calculation shows that the drive unit volume and weight will decrease at least by 25 % while keeping the same traction rail vehicle characteristics. This invention allows manufacturing of the traction drive unit in a single compact housing. It results in better heat dissipation from the drive components, it is not necessary to use a fan for the drive cooling (passive cooling of the whole drive forms the important advantage in comparison to competitive solutions) and the single drive housing also cuts the assembly cost and time.

Claims

1. A traction rail vehicle comprising a compact drive unit mounted on the outside of the wheel (9) of a traction rail vehicle, the drive unit comprising an electrical motor (1) supplied by a power electronics converter (2), a gearbox and a mechanical coupling to a wheel (9) which is mounted to one end of an axle (8), wherein the electrical motor (1) is a high-speed electrical motor with speed over 9000 rpm, its rotor is supported by bearings (3) along with pinion gear (4) of the input spur/helical gear (5) of the high-speed gearbox stage (11) and all together create a rotor assembly (14), whose axis of rotation is perpendicular to the axis of rotation of the wheel (9),
the output shaft (6) of the gear (5) is a part of the following bevel gear (7), output shaft of the bevel gear (7) is connected either directly or by using the coupling (12) to the wheel (9) from the other side of the wheel (9) respective to the axle (8),
wherein at least the electrical motor (1) and the high-speed gearbox stage (11) are embedded in a single compact housing, wherein the power electronics converter is arranged to feed the current into the stator winding of the electrical motor (1) which causes production of the heat due to existing losses in the electrical motor (1), wherein the resulting heat is distributed inside the drive unit using the conduction via both drive components and the housing for preheating of the lubricant of the high-speed gearbox stage (11) before running the gearbox under extremely low ambient temperatures.

2. A traction rail vehicle comprising a compact drive unit mounted on the outside of the wheel (9) of a traction rail vehicle, the drive unit comprising an electrical motor (1) supplied by a power electronics converter (2), a gearbox and a mechanical coupling to a wheel (9) which is mounted to one end of an axle (8), wherein the electrical motor (1) is a high-speed electrical motor with speed over 9000 rpm, its rotor is supported by bearings (3) along with pinion gear (4) of the input spur/helical gear (5) of the high-speed gearbox stage (11) and all together create a rotor assembly (14), whose axis of rotation is perpendicular to the axis of rotation of the wheel (9),
the output shaft (6) of the gear (5) is a part of the following bevel gear (7), output shaft of the bevel gear (7) is connected to additional gears (10) which is either directly or by using the coupling (12) connected to the wheel (9) from the other side of the wheel (9) respective to the axle (8),
wherein at least the electrical motor (1) and the high-speed gearbox stage (11) are embedded in a single compact housing, wherein the power electronics converter is arranged to feed the current into the stator winding of the electrical motor (1) which causes production of the heat due to existing losses in the electrical motor (1), wherein the resulting heat is distributed inside the drive unit using the conduction via both drive components and the housing for preheating of the lubricant of the high-speed gearbox stage (11) before running the gearbox under extremely low ambient temperatures.

3. The traction rail vehicle according to any preceding claim **characterized by that** the electrical motor (1) is with passive cooling.

4. The traction rail vehicle according to any preceding claim **characterized by that** the rotor assembly (14) is supported by at least three bearings (3).

5. The traction rail vehicle according to any preceding claim **characterized by that** the shaft (6) is connected to a brake (13).

6. The traction rail vehicle according to claims 1 to 4 **characterized by that** the rotor assembly (14) is connected to a brake (13).

7. The traction rail vehicle according to claims 1 to 4 **characterized by that** the output of the low-speed gearbox stage is connected to a brake (13).

8. The traction rail vehicle according to claims 2 to 7 **characterized by that** the additional gear (10) is designed as a bevel gear, a spur/helical gear, or an epicyclic gear set.

Patentansprüche

1. Traktionsfähiges Schienenfahrzeug bestehend aus kompakter Antriebseinheit, die auf der äußeren Seite des Rads (9) des Schienenfahrzeugs installiert ist, die Antriebseinheit besteht aus Elektromotor (1), der über einen elektronischen Leistungsumrichter (2) eingespeist wird, Getriebe und mechanischer Kupplung zum Rad (9), die auf einem Ende der Achse (8) montiert ist, wobei der Elektromotor (1) ein hochtouriger Motor mit der Drehzahl von mehr als 9000 U/min ist, sein Rotor ist in Lagern (3) gemeinsam mit dem Ritzel (4) des Eingangsgetriebes mit schrägverzahnten Stirnrädern (5) eingelagert, wobei dieses Eingangsgetriebe ein Bestandteil des hochtourigen Getriebes (11) ist, wobei alles gemeinsam eine Zusammenstellung des Rotors (14) darstellt, dessen Rotationsachse senkrecht zu der des Rads (9) steht,
die Ausgangswelle (6) des Getriebes (5) ist ein Bestandteil des folgenden Kegelgetriebes (7), die Ausgangswelle des Kegelgetriebes (7) ist entweder direkt oder über die Kupplung (12) von der äußeren Seite des Rads (9) mit dem Rad (9) oder mit der Achse (8) verbunden,
wobei mindestens der Elektromotor (1) und das hochtourige Getriebe (11) in einem kompakten Gehäuse installiert sind und der elektronische Leistungsumrichter speist die Statorwindung des Elektromotors (1) mit dem elektrischen Strom ein, was zur Wärmeentstehung durch die Verluste des Elektromotors (1) führt, wobei die entstehende Wärme innerhalb des Antriebs durch die Wärmeleitung über die Antriebskomponenten und das Gehäuse zur Vorwärmung des Schmierstoffes im hochtourigen Getriebe (11) genutzt wird, wenn das Getriebe (11) bei extrem niedrigen Umgebungstemperaturen anlaufen soll.

2. Traktionsfähiges Schienenfahrzeug bestehend aus kompakter Antriebseinheit, die auf der äußeren Seite des Rads (9) des Schienenfahrzeugs installiert ist, die Antriebseinheit besteht aus Elektromotor (1), der über einen elektronischen Leistungsumrichter (2) eingespeist wird, Getriebe und mechanischer Kupplung zum Rad (9), die auf einem Ende der Achse (8) montiert ist, wobei der Elektromotor (1) ein hochtouriger Motor mit der Drehzahl von mehr als 9000 U/min ist, sein Rotor ist in Lagern (3) gemeinsam mit dem Ritzel (4) des Eingangsgetriebes mit schrägverzahnten Stirnrädern (5) eingelagert, wobei dieses Eingangsgetriebe ein Bestandteil des hochtourigen Getriebes (11) ist, wobei alles gemeinsam eine Zusammenstellung des Rotors (14) darstellt, dessen Rotationsachse senkrecht zu der des Rads (9) steht,
die Ausgangswelle (6) des Getriebes (5) ist ein Bestandteil des folgenden Kegelgetriebes (7), die Aus-

gangswelle des Kegelgetriebes (7) ist mit Zusatzgetriebe (10) verbunden, wobei diese Verbindung entweder direkt oder über die Kupplung (12) realisiert wird, die von der äußeren Seite des Rads (9) mit dem Rad (9) oder mit der Achse (8) verbunden ist, wobei mindestens der Elektromotor (1) und das hochtourige Getriebe (11) in einem kompakten Gehäuse installiert sind und der elektronische Leistungsumrichter speist die Statorwindung des Elektromotors (1) mit dem elektrischen Strom ein, was zur Wärmeentstehung durch die Verluste des Elektromotors (1) führt, wobei die entstehende Wärme innerhalb des Antriebs durch die Wärmeleitung über die Antriebskomponenten und das Gehäuse zur Vorwärmung des Schmierstoffes im hochtourigen Getriebe (11) genutzt wird, wenn das Getriebe (11) bei extrem niedrigen Umgebungstemperaturen anlaufen soll.

3. Traktionsfähiges Schienenfahrzeug nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** der Elektromotor (1) passiv gekühlt wird.

4. Traktionsfähiges Schienenfahrzeug nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** die Zusammenstellung des Rotors (14) in mindestens drei Lagern (3) gelagert ist.

5. Traktionsfähiges Schienenfahrzeug nach einem der vorherigen Ansprüche, **dadurch gekennzeichnet, dass** die Welle (6) mit der Bremse (13) verbunden ist.

6. Traktionsfähiges Schienenfahrzeug nach Ansprüchen 1 bis 4, **dadurch gekennzeichnet, dass** die Zusammenstellung des Rotors (14) mit der Bremse (13) verbunden ist.

7. Traktionsfähiges Schienenfahrzeug nach Ansprüchen 1 bis 4, **dadurch gekennzeichnet, dass** der Ausgang der niedertourigen Stufe des Getriebes mit der Bremse (13) verbunden ist.

8. Traktionsfähiges Schienenfahrzeug nach Ansprüchen 2 bis 7, **dadurch gekennzeichnet, dass** das Zusatzgetriebe (10) als Kegelgetriebe, Getriebe mit schrägverzahnten Stirnrädern oder Planetengetriebe konstruiert ist.

Revendications

1. Véhicule de traction sur rail comprenant une unité d'entraînement compacte montée sur le côté extérieur de la roue (9) du véhicule de traction sur rail, cette unité d'entraînement comprenant un moteur électrique (1) alimenté par un convertisseur électronique de puissance (2), une boîte de vitesses et un couplage mécanique avec la roue (9), qui est monté sur une extrémité de l'essieu (8), le moteur électrique étant (1) un moteur électrique grande vitesse à la vitesse de plus de 9 000 tr/min, dont le rotor est placé dans des roulements (3) ensemble avec le pignon (4) d'engrenage d'entrée (5) à denture frontale oblique de l'étage grande vitesse (11) de la boîte de vitesses et conjointement ceux-ci créent l'ensemble rotor (14), dont l'axe de rotation est perpendiculaire à l'axe de rotation de la roue (9),
l'arbre de sortie (6) de l'engrenage (5) fait partie de l'engrenage conique suivant (7), l'arbre de sortie de l'engrenage conique (7) étant connecté soit directement soit à l'aide d'un accouplement (12) à la roue (9) de l'autre côté de la roue (9) par rapport à l'essieu (8),
dans lequel au moins le moteur électrique (1) et l'étage grande vitesse (11) de la boîte à vitesses sont placés dans une seule boîte compacte commune, le convertisseur électronique de puissance étant arrangé de façon à fournir le courant dans l'enroulement de stator du moteur électrique (1), ce qui cause la production de la chaleur en conséquence des pertes existantes dans le moteur électrique (1), la chaleur résultante distribuée à l'intérieur de l'unité d'entraînement à l'aide de la conduite tant par les composants de l'entraînement que par la boîte, étant utilisée pour le préchauffage du lubrifiant de l'étage grande vitesse (11) de la boîte à vitesses préalablement à la mise en marche de la boîte à vitesses lors des températures ambiantes extrêmement basses.

2. Véhicule de traction sur rail comprenant une unité d'entraînement compacte montée sur le côté extérieur de la roue (9) du véhicule de traction sur rail, cette unité d'entraînement comprenant un moteur électrique (1) alimenté par un convertisseur électronique de puissance (2), une boîte de vitesses et un couplage mécanique avec la roue (9), qui est monté sur une extrémité de l'essieu (8), le moteur électrique étant (1) un moteur électrique grande vitesse à la vitesse de plus de 9 000 tr/min, dont le rotor est placé dans des roulements (3) ensemble avec le pignon (4) d'engrenage d'entrée (5) à denture frontale oblique de l'étage grande vitesse (11) de la boîte de vitesses et conjointement ceux-ci créent l'ensemble rotor (14), dont l'axe de rotation est perpendiculaire à l'axe de rotation de la roue (9),
l'arbre de sortie (6) de l'engrenage (5) fait partie de l'engrenage conique suivant (7), l'arbre de sortie de l'engrenage conique (7) étant connecté à des engrenages additionnels (10), lesquels sont soit directement soit à l'aide d'un accouplement (12) connectés à la roue (9) de l'autre côté de la roue (9) par rapport à l'essieu (8),
dans lequel au moins le moteur électrique (1) et l'étage grande vitesse (11) de la boîte à vitesses sont placés dans une seule boîte compacte commune, le

convertisseur électronique de puissance étant arrangé de façon à fournir le courant dans l'enroulement de stator du moteur électrique (1), ce qui cause la production de la chaleur en conséquence des pertes existantes dans le moteur électrique (1), la chaleur résultante distribuée à l'intérieur de l'unité d'entraînement à l'aide de la conduite tant par les composants de l'entraînement que par la boîte, étant utilisée pour le préchauffage du lubrifiant de l'étage grande vitesse (11) de la boîte à vitesses préalablement à la mise en marche de la boîte à vitesses lors des températures ambiantes extrêmement basses.

3. Véhicule de traction sur rail selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le moteur électrique (1) est refroidi passivement.

4. Véhicule de traction sur rail selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'ensemble rotor (14) est placé au moins dans trois paliers (3).

5. Véhicule de traction sur rail selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'arbre (6) est connecté au frein (13).

6. Véhicule de traction sur rail selon les revendications 1 à 4, **caractérisé en ce que** l'ensemble rotor (14) est connecté au frein (13).

7. Véhicule de traction sur rail selon les revendications 1 à 4, **caractérisé en ce que** la sortie de l'étage petite vitesse de la boîte à vitesses est connectée au frein (13).

8. Véhicule de traction sur rail selon les revendications 2 à 7, **caractérisé en ce que** les engrenages additionnels (10) sont conçus comme un engrenage conique, un engrenage à denture frontale oblique ou un jeu d'engrenages épicycloïdaux.

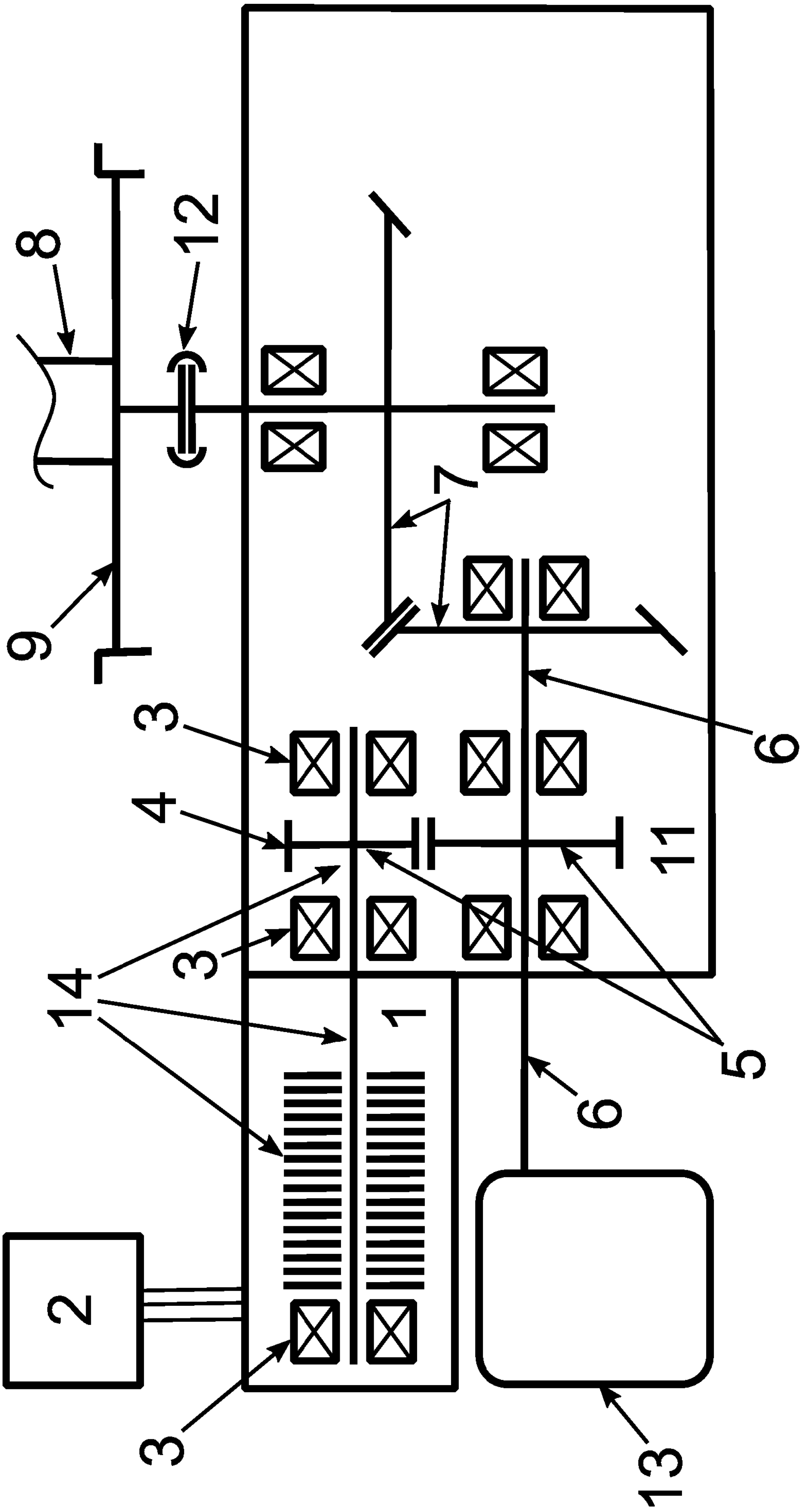

Fig. 1

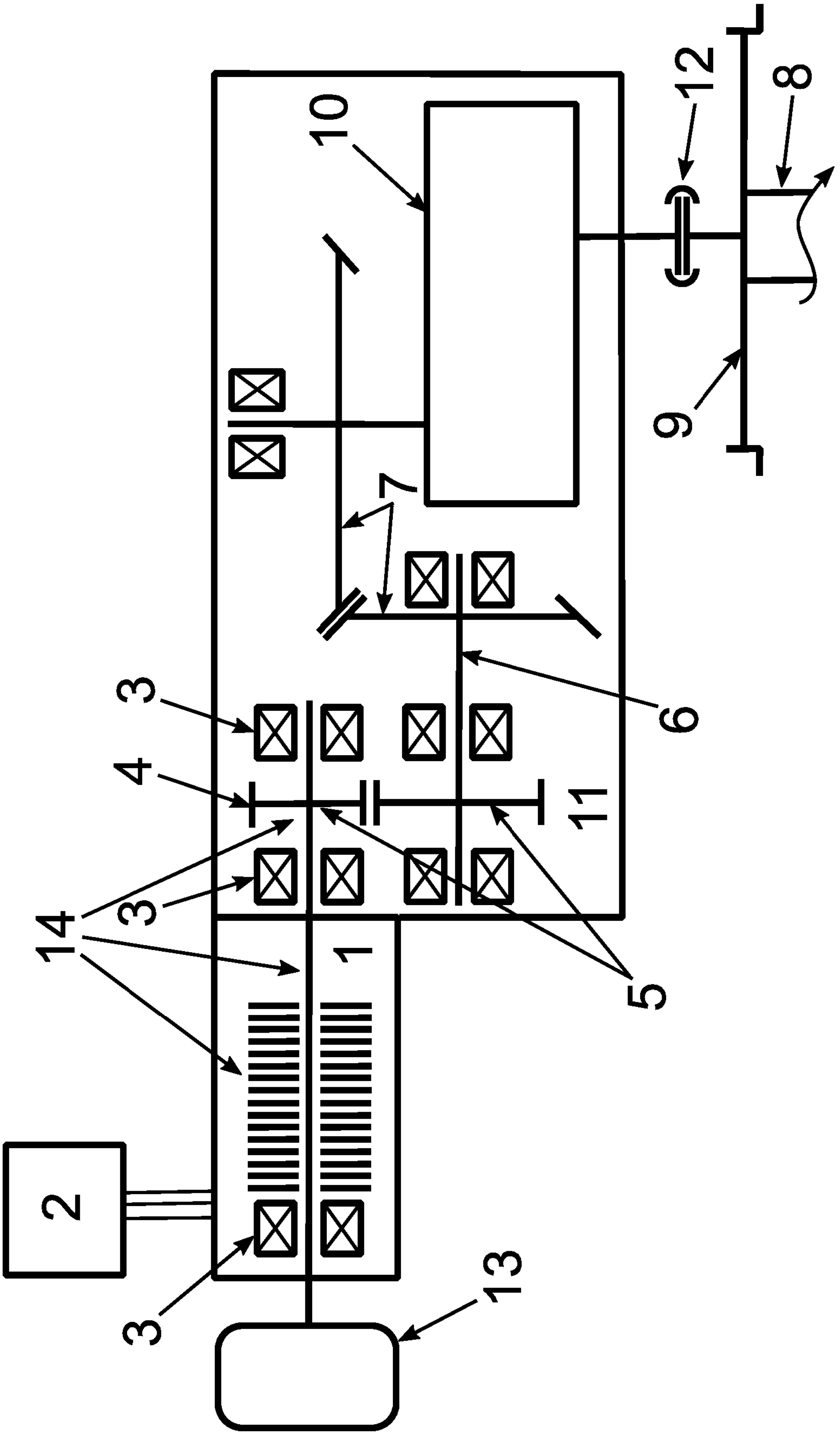

Fig. 2

REFERENCES CITED IN THE DESCRIPTION

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