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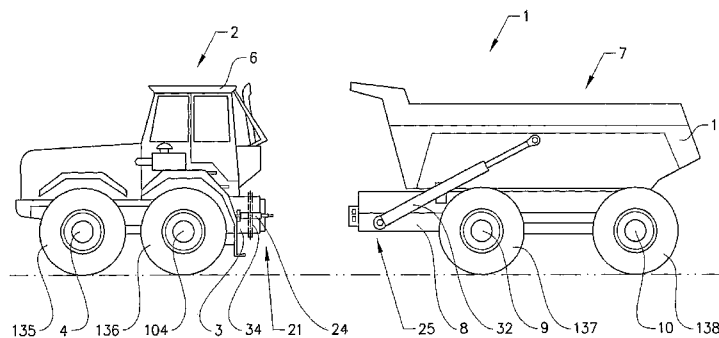


FIG. 2

(57) Abstract: The invention relates to a work machine (1) comprising a front section (2) with a front frame (3), a first set of ground engaging members (135, 136) and a power source for propelling the work machine, a rear section (7) with a rear frame (8), a second set of ground engaging members (137, 138) and a load-carrying container (11). The rear section (7) comprises an electric drive system adapted for driving at least one ground engaging member of said second set. The rear section (7) is detachably connected to the front section (2). The power source of the front section (2) is adapted to power the electric drive system in the rear section (7) in an attached state of the front and rear sections (2, 7). Said electric drive system is adapted for driving said at least one ground engaging member of said second set for self-propelling of the rear section (7) in a detached state.

Work Machine

FIELD OF THE INVENTION AND PRIOR ART

5 The present invention relates to a work machine comprising a front section with a front frame, a first set of ground engaging members and a power source for propelling the work machine, a rear section with a rear frame, a second set of ground engaging members and a
10 load-carrying container.

The invention will below be described for an articulated hauler. This should however be regarded as a non-limiting example. The invention may be realized
15 in other types of work machines, such as dump trucks or other construction equipment having a tractor unit and a trailer unit which are pivotally connected to each other. The expression "work machine" is also intended to comprise heavy vehicles to be used on regular roads,
20 such as trucks having a front section (tractor or semi-trailer tractor unit) and a rear section (trailer or semi-trailer unit) pulled by the front section.

Further terms frequently used for work machines are
25 "earth-moving machinery", "off-road work machines", "construction equipment" and "forest machines". The term "ground engaging members" may comprise wheels, caterpillar tracks etc.

30 In connection with transportation of heavy loads, e.g. in contracting work, a work machine of the type of an articulated hauler is frequently used. Such vehicles may be operated with large and heavy loads in areas where there are no roads, for example for transports in

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connection with road or tunnel building, sand pits, mines, forestry and similar environments. Thus, an articulated hauler is frequently used in rough terrain with various slippery ground.

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The front frame carries a power source in the form of an internal combustion engine and a load-carrying container is arranged on the rear frame of an articulated hauler. An articulated hauler is further defined by a first
10 pivot joint arranged to allow the front frame and the rear frame to pivot in relation to each other around an imaginary longitudinal axis, that is an axis that runs in the longitudinal direction of the vehicle. Travelling on uneven ground is substantially improved by virtue of
15 such a joint.

The articulated hauler further has a second, vertical pivot joint between the front frame and the rear frame and a pair of hydraulic cylinders for steering the work
20 machine via pivoting the front frame relative to the rear frame about the vertical pivot axis. It is emphasized that a frame-steered work machine is adapted for an optimized off road performance with regard to any vehicle with Ackerman steering (front wheel
25 steering). More specifically, the articulated steering creates conditions for using much larger (both with regard to diameter and width) front wheels than with so-called Ackermann steering. Further, articulated steering creates conditions for 100% lock in the front
30 axle differential (which is not possible with Ackermann steering), which is essential when operating on slippery ground.

Further, an articulated hauler normally has six wheels. The front section comprises a front wheel axle and the rear section comprises a pair of bogie axles. A powertrain is adapted to drive the three wheel axles.
5 Thus, the articulated hauler may be operated with all (6) wheel drive.

Each axle is provided with a differential gear and a (transverse) differential lock. Further, one
10 longitudinal differential lock is provided on the transmission shaft between the front axle and the bogie axles and a further longitudinal differential lock is provided on the transmission shaft between the bogie axles. The differential locks are preferably engaged
15 when there is a risk of the wheels slipping. According to an alternative design, any of the differential locks may be replaced by a device allowing limited slip.

SUMMARY OF THE INVENTION

20 One object of the invention is to achieve a work machine, which creates conditions for a more flexible operation.

This object is achieved by the work machine defined in
25 claim 1. Thus, it is achieved in that the rear section comprises an electric drive system adapted for driving at least one ground engaging member of said second set, that the rear section is detachably connected to the front section, that the power source of the front
30 section is adapted to power the electric drive system in the rear section in an attached state of the front and rear sections, and that said electric drive system is adapted for driving said at least one ground

engaging member of said second set for self-propelling of the rear section in a detached state.

Thus, the invention is particularly directed to a hybrid electric work machine.

Thus, the rear section can be maneuvered after disconnection. In other words, the invention creates conditions for detaching the rear section and self-propelling the rear section short distances.

Preferably, a control system is adapted for remote control of the rear section in order to maneuver it in the detached state. The control system is preferably adapted for communication between a remote unit and the detached rear section via radio waves.

According to an example, the electric drive system comprises at least one electric motor. The electric motor creates conditions for an infinitely variable torque distribution between the wheels which is advantageous when operating in severe terrain conditions.

According to a preferred embodiment, the power source comprises an electric machine for providing electric power. Preferably, the power source comprises means for generating mechanical power and the electric machine is operatively connected to the mechanical power generating means for converting the mechanical power to electric power. Especially, the means for generating mechanical power is constituted by an internal combustion engine and the electric machine forms a generator. Alternatively, the electric machine may be

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adapted to generate electric power directly (for example a fuel cell).

Further, torque may be infinitely variably supplied to the rear wheels in order to support the front wheel drive in certain (slippery) conditions.

Further preferred embodiment and advantages thereof emerge from the description below, the figures and the claims.

BRIEF DESCRIPTION OF FIGURES

The invention will be described in greater detail below with reference to the embodiment shown in the accompanying drawings, in which

FIG 1 shows a work machine according to a first embodiment in an attached state in a side view;

FIG 2 shows the work machine in figure 1 in a detached state in a side view; and

FIG 3 schematically shows an exemplary powertrain of the work machine.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig 1 shows an articulated hauler (also called frame-steered dumper) 1 in a side view. The articulated hauler comprises a front vehicle section 2 (pull unit or tractor) comprising a front frame 3, a front wheel axle 4, a rear wheel axle 104 and a cab 6 for a driver. Each axle 4, 104 comprises a left ground engagement element 135, 136 and a right ground engagement element 235, 236 (see figure 3) in the form of wheels. The articulated hauler 1 also comprises a rear vehicle section 7 (trailer) comprising rear wheels

137,237,138,238 (see figure 3) and a tiltable container 11.

5 A first pivot joint 25 is adapted in order to allow the front frame 3 and the rear frame 8 to be pivoted relative to one another about an imaginary longitudinal axis, that is to say an axis which extends in the longitudinal direction of the vehicle 1.

10 The front frame 3 is connected to the rear frame 8 via a second joint 21 which allows the front frame 3 and the rear frame 8 to be pivoted relative to one another about a vertical axis 34 for steering (turning) the vehicle. Actuators in the form of a pair of hydraulic
15 cylinders 24 are arranged on respective sides of the rotary joint 21 for steering the vehicle. The hydraulic cylinders are controlled by the driver of the vehicle via a wheel and/or a joystick (not shown).

20 The container 11 is connected to the rear frame 8 via an articulation (not shown) at a rear portion of the rear frame 8. A pair of tilting cylinders 32 are connected to the rear frame 8 with a first end and connected to the platform body 11 with a second end.

25 The tilting cylinders 32 are positioned one on each side of the central axis of the vehicle in its longitudinal direction. The platform body 11 is therefore tilted in relation to the rear frame 8 on activation of the tilting cylinders 32.

30

Figure 2 shows the work machine 1 in a detached state, wherein the rear section 7 is detached from the front section 2. The vehicle turning system, comprising the hydraulic cylinders 24 and the second joint 21, is

preferably arranged on the front section 2 in the detached state. The hydraulic cylinders are preferably automatically released and reconnected, respectively between the front and rear sections in operation.

5

Figure 3 schematically shows a powertrain according to a first embodiment of the present invention. The powertrain comprises a power source 140. The power source 140 comprises means for generating mechanical power 105 and an electric machine 142 operatively connected to the mechanical power generating means 105 for converting the mechanical power to electric power. The mechanical power generating means 105 comprises an internal combustion engine in the form of a diesel engine.

15

The powertrain further comprises means 141 for mechanical transmission of power from the internal combustion engine 105 to the ground engaging members 135,136,235,236 of said section. The mechanical power transmission means 141 comprises a gear box 144 and the axle 4 adapted to drive the front wheels 135,235. The mechanical power transmission means 141 preferably comprises a combined gear box 144 and transmission unit for transmitting power from the internal combustion engine 105 to a pair of transverse drive shafts 147,149. The transmission unit may comprise a toothed wheel gearing, bevel gears and cardan shaft, belt drive or chain drive or other transmission member for performing said power transmission. The transmission unit further preferably comprises a differential gear adapted to transmit power to said pair of ground engaging members and a differential lock 145 adapted to

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lock the pair of transverse drive shafts 147,149 together.

The rear axle 104 of the front section 2 comprises a differential gear 162 adapted to transmit power to said pair of wheels 136,236 and a differential lock 164 adapted to lock a pair of transverse drive shafts 166,168 together. The front axle 4 is mechanically connected to the rear axle 104 for power transmission via a drive shaft 170, such as a cardan shaft.

At least one electric motor 146,148,150,152 is adapted for driving at least one ground engaging member 137,237,138,238 in the rear section, preferably via a reduction gear. More specifically, a plurality of electric motors 146,148,150,152 are adapted for driving one of said ground engaging members 137,237,138,238 each. Thus, four electric motors are arranged, one at each wheel.

The work machine further comprises means 151 for electrical transmission of power from the electric machine 142 to said at least one electric motor 146,148,150,152. The work machine further comprises a power electronic unit 152 adapted to distribute electric power to the respective electric motors 146,148,150,152. The dotted lines in figure 3 indicate lines for transmission of electric current.

Both the front and the rear section 2,7 requires electrical mating contacts (not shown) for enabling attaching and detaching the front and the rear section 2,7. The electrical contacts are preferably automatically released and reconnected, respectively

between the front and rear sections in operation. The electrical contacts are preferably positioned within the boundaries of the first pivot joint 25.

5 Further, the work machine comprises at least one electric power storing means 154, which is operatively connected to said at least one electric motor 146,148,150,152. The electric power storing means 154 is operatively connected to the power electronic unit
10 152. Said at least one electric power storing means 154 is preferably positioned between two spaced, elongated frame members in the rear section which extend in a longitudinal direction of the work machine.

15 The electric motors 146,148,150,152 are adapted for both driving and braking the driving wheels 137,237,138,238.

According to an alternative to the described first
20 embodiment, in addition to the mechanical drive of the front wheels 135,235, at least one electric motor is adapted to drive the front wheels 135,235. Preferably, one electric motor is adapted to drive an individual wheel 135,235.

25

Further, the work machine comprises a control system (not shown) for controlling the power distribution. The control system comprises a control unit with software for controlling the power distribution. Thus, the
30 control unit is connected to the energy storage means 154 for controlling transfer of power to and from the energy storage means according to an established control strategy, see further below.

10

The control unit is commonly known as an Electronic Control Unit (ECU), a Central Processing Unit (CPU) or an Electronic Control Module (ECM) for an electronic control of the vehicle operation. In a preferred
5 embodiment, the control unit comprises a microprocessor. The control unit comprises a memory, which in turn comprises a computer program with computer program segments, or a program code, for implementing the control method when the program is run. This
10 computer program can be transmitted to the control unit in various ways via a transmission signal, for example by downloading from another computer, via wire and/or wirelessly, or by installation in a memory circuit. In particular, the transmission signal can be transmitted
15 via the Internet.

Regarding steering of the front vehicle section 2 in the detached state, the front wheel axle 4 is preferably steered, such as via so-called Ackerman-steering.
20 Further, the front section 2 may be provided with a front wheel steering lock, wherein, in the attached state, the front wheel steering can be locked. Thus, the work machine is frame-steered in the attached state, see description above.

25

The invention is not to be regarded as being limited to the illustrative embodiments described above, but a number of further variants and modifications are conceivable within the scope of the patent claims
30 below.

As an alternative to the described first embodiment, the rear section of the work machine comprises at least two axles, and that each axle is adapted to drive a

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ground engaging member at each side of the work machine. One single electric motor may be adapted to drive each axle. Thus, a single electric motor is adapted to drive each pair of wheels.

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Within the scope of the invention, the power source can be designed in many different ways. Preferably, it is adapted to provide electricity. One option is to use a fuel cell for providing electricity. A further solution
10 is to use a gas turbine provided with an electric generator. The source of electric power can also be a free-piston engine provided with an electric generator.

The electricity for propelling the work machine can
15 come from a variety of sources, such as stored energy devices relying on chemical conversions (batteries), stored electrical charge devices (capacitors), stored energy devices relying on mechanical stored energy (e.g. flywheels, pressure accumulators) and energy
20 conversion products.

According to an alternative to that the rear wheels
136,236 of the front section 2 are mechanically driven via power transmission from the engine 105, they may be
25 electrically driven via electric motors in a similar manner as has been described above for the wheels of the rear section.

According to an alternative design to the trailer
30 embodiment shown in figure 1 and 2, the front and rear wheels may be movably arranged in the longitudinal direction of the work machine. Especially, the front wheels may be adapted to be arranged close to the rear wheels, below a rear part of the container, in a first

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state and below a front part of the container in a second state. The rear section can be equipped with swing arms or any other system to reposition the wheels, after disconnection, in order to balance the vessel. For example, the front and rear wheels may be repositioned relative to one another via electrical means. Said electrical means is preferably operatively connected to the electrical drive system for receiving electrical power therefrom.

10

According to an alternative design to the trailer embodiment shown in figure 1 and 2, the front section may only be provided with a single pair of drive wheels. The front section may comprise a gyroscope self-balancing system for balancing the front section in the detached state.

15

CLAIMS

1. A work machine (1) comprising
- 5 - a front section (2) with a front frame (3), a first set of ground engaging members (135,235,136,236) and a power source (140) for propelling the work machine,
- a rear section (7) with a rear frame (8), a second set of ground engaging members (137,237,138,238) and a
- 10 load-carrying container (11), **characterized in**
- that the rear section (7) comprises an electric drive system (151) adapted for driving at least one ground engaging member of said second set,
- that the rear section (7) is detachably connected to
- 15 the front section (2),
- that the power source of the front section (2) is adapted to power the electric drive system in the rear section (7) in an attached state of the front and rear sections (2,7), and
- 20 - that said electric drive system is adapted for driving said at least one ground engaging member of said second set for self-propelling of the rear section (7) in a detached state.
- 25 2. The work machine according to claim 1, *characterized in* that the electric drive system (151) comprises at least one electric motor (146,148,150,152).
- 30 3. The work machine according to claim 2, *characterized in* that the electric drive system (151) comprises at least one electric power storing means (154), which is operatively connected to said at least one electric motor.

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4. The work machine according to claim 2 or 3, characterized in that the work machine comprises at least two electric motors (146,148,150,152) and that each electric motor is adapted to drive an individual ground engaging member.

5. The work machine according to any preceding claim, characterized in that the power source (140) comprises means for generating mechanical power (105).

10

6. The work machine according to claim 5, characterized in that the means for generating mechanical power comprises an internal combustion engine (105).

7. The work machine according to claim 6, characterized in that the front section comprises means (141) for mechanical transmission of power from the mechanical power generating means to the first set of ground engaging members.

20

8. The work machine according to any preceding claim, characterized in that the power source (140) comprises an electric machine (142) for providing electric power.

9. The work machine according any one of claims 5-7 and claim 8, characterized in that electric machine (142) is operatively connected to the means for generating mechanical power for converting the mechanical power to electric power.

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10. The work machine according to claim 8 or 9, characterized in that the work machine comprises means (151) for electrical transmission of power from the

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electric machine (142) to said at least one electric motor (146,148,150,152).

11. The work machine according to any preceding claim,
5 *characterized in* that the work machine comprises at least one pivot joint (21,25) between the front section (2) and the rear section (7) allowing the front section to pivot with regard to the rear section in the attached state.

10

12. The work machine according to claim 10 and 11,
characterized in that the electrical transmission means (151) comprises a line for transmission of electric power to the electric motor and that the electric power
15 transmission line extends through the pivot joint (21,25).

13. The work machine according to claim 11 or 12,
characterized in that the work machine comprises a
20 first pivot joint (21) adapted to allow the front section to pivot with regard to the rear section about an axis extending in a longitudinal direction of the work machine.

25 14. The work machine according to any of claims 11-13,
characterized in that the work machine comprises a second pivot joint (25) adapted to allow the front section to pivot with regard to the rear section about an axis extending in a vertical direction of the work
30 machine.

15. The work machine according to claim 14,
characterized in that the work machine comprises means (24) for steering the work machine via pivoting the

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front section relative to the rear section about the vertical pivot axis.

16. The work machine according to claim 15,
5 *characterized in* that the steering means (24) comprises a hydraulic actuator arranged on each side of the second pivot joint.

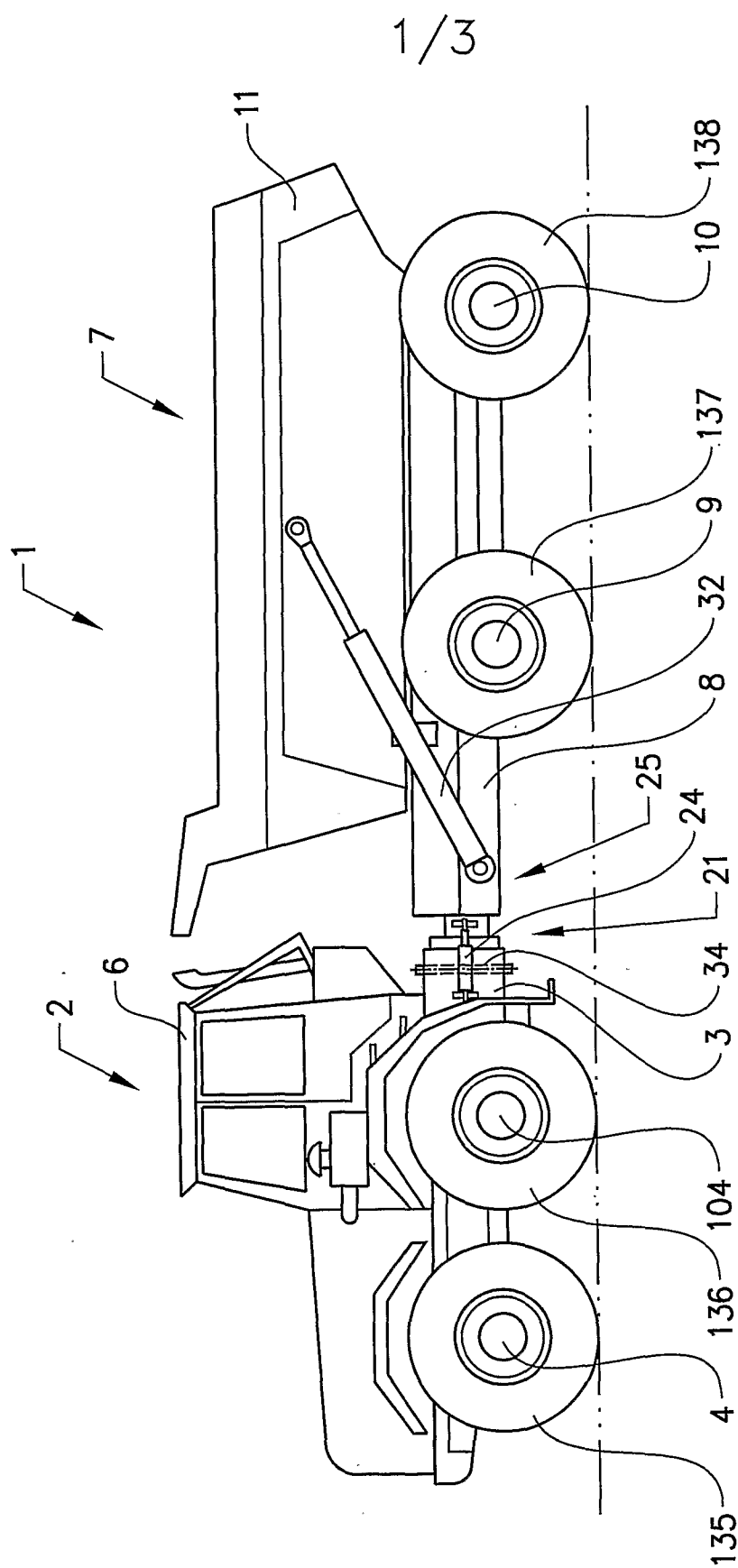


FIG. 1

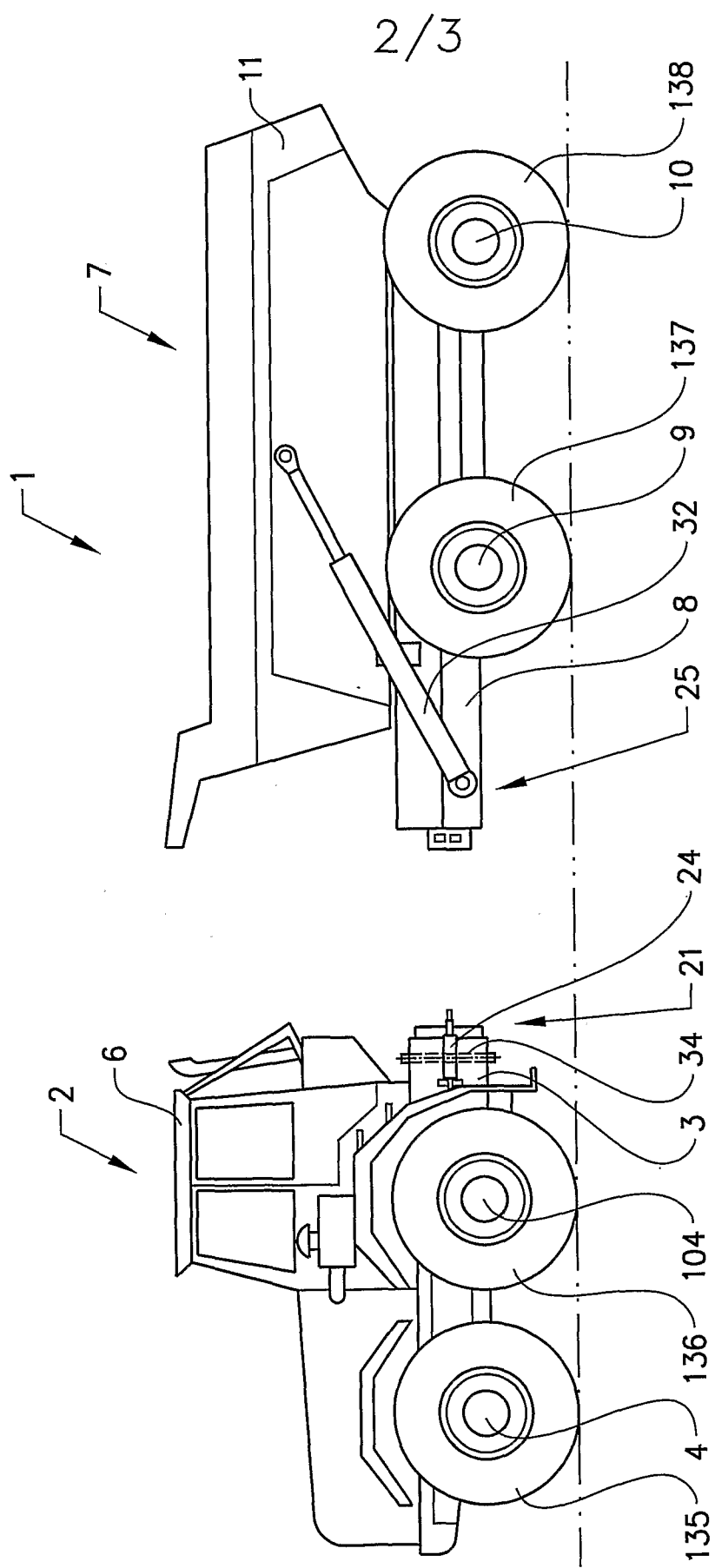
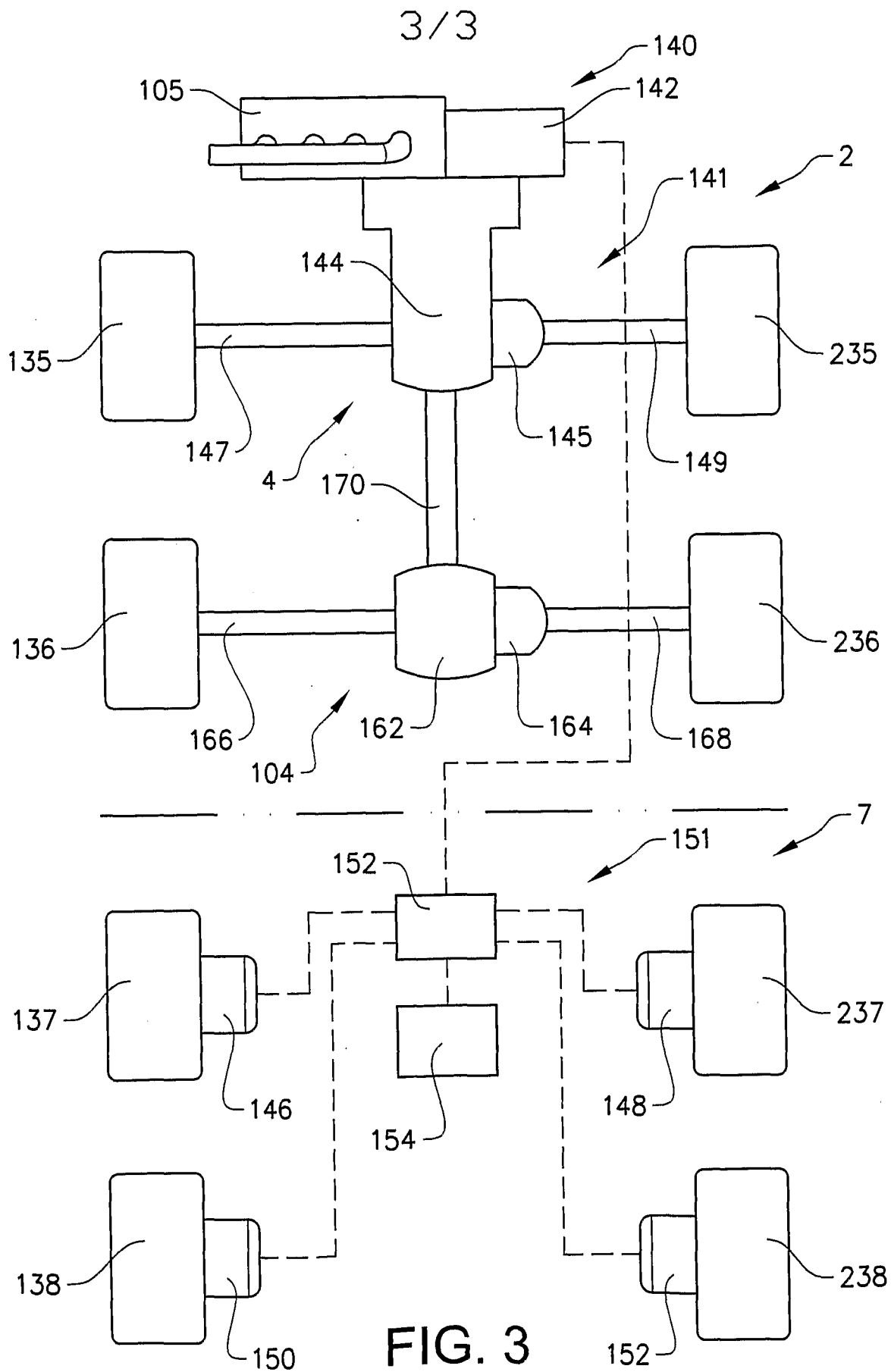


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2009/000111

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: B62D, B60K, B60W

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, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20040226760 A1 (LOH ET AL), 18 November 2004 (18.11.2004), figure 3, abstract --	1-16
P,A	EP 1918180 A1 (RHEINMETALL LANDSYSTEME GMBH), 7 May 2008 (07.05.2008), figure 1, abstract -- -----	1-16



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See patent family annex.

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Date of the actual completion of the international search

2 June 2009

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Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE2009/000111

US 20040226760 A1 18/11/2004 NONE

EP 1918180 A1 07/05/2008 DE 102006052274 A 08/05/2008