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(54) **COMPACTOR DEVICE SYSTEM AND METHOD FOR OPERATING A COMPACTOR DEVICE SYSTEM**

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Description

[0001] The present invention relates to a compactor device system. Furthermore, the present invention relates to a method for operating a compactor device system and a compactor vehicle.

[0002] Asphalt concrete is used to surface roads, parking lots or airports. Once a layer of asphalt concrete has been provided on the prepared surface, it is to be compacted such that the finished road has the desired performance characteristics in terms of durability in turn affecting tire wear, road noise and so on.

[0003] Typically a road roller, being a compactor vehicle, comprising a compactor device system like a compactor drum, needs to pass several times over a single spot on the surface in order to achieve the desired compaction. In order to reduce the number of cycles of passing over the same spot an unbalanced mass, or multiple unbalanced masses, are commonly provided in a compactor drum of the road roller such that forces caused by the rotation of the unbalanced masses contribute to the compaction in addition to the weight of the road roller. Even in case an unbalanced mass is being used, multiple passes of the road roller over a single spot are needed to obtain the desired compaction. The direction of movement of the road roller conventionally changes from forward to backward between two succeeding passes of the road roller over a single spot.

[0004] When changing a movement direction from of the road roller the rotation of the unbalanced mass needs conventionally to be stopped since during the process of change of direction the asphalt concrete, the road roller is standing on, would be compacted more strongly than a section of the asphalt concrete compacted by the road roller while having normal operational speed.

[0005] Not only is this process time-consuming but the rotational energy of the unbalanced mass(es) is being lost in the process of changing the movement direction and in order to accelerate the unbalanced mass for reactivation of the compacting action further energy is being needed.

[0006] Furthermore, the acceleration of the road roller during the change of travel direction from forward to backward consumes energy as well and during deceleration of the road roller during this process energy is being lost.

[0007] In addition, common road rollers have two compacting drums provided with an unbalanced mass each and comprise between the front compactor drum and the aft compactor drum a steering joint allowing to tilt the rotational axis of the front compactor drum and the rotational axis of the aft compactor drum with respect to each other essential in a plane parallel to the ground allowing a steering of the road roller.

[0008] Due to the forces implied by the unbalanced masses the wear of the steering joint is increased resulting in high maintenance cost or high cost for production due to the dimensions of the steering joint.

[0009] Still further there is a need to measure in a sim-

ple and cost-effective way, preferably during use of a compactor device system, the compaction of the respective ground or ground covering, such as the usual asphalt concrete to allow assessment whether the ground or ground covering, in particular the asphalt concrete has been compacted according to specifications or/and to allow that a desired compaction is achieved.

[0010] Further, it would be favorable if the intensity of a compacting action of a compacting tool could be adapted to respective needs, e.g. for achieving a desired compaction of respective ground or ground covering, such as asphalt concrete.

[0011] Document WO 2017/184036 A1 discloses the subject matter of the preamble of the independent claims.

The prior art compactor device system, according to a first disclosed concept, has a compactor drum rotatable about a drum axis and a first unbalanced mass comprising a first shaft having a first eccentricity and a second unbalanced mass comprising a second shaft having a second eccentricity. The first and second unbalanced masses are provided within the compactor drum. The first unbalanced mass is rotatable about a first rotational axis and the second unbalanced mass is rotatable about a second rotational axis. The first and second rotational axes extend parallel to the drum axis on diametrically opposed sides of the drum axis. A drive is operable to drive the first unbalanced mass by means of a first transmission loop and to drive the second unbalanced mass by means of a second transmission loop. A (first) phase shifting arrangement is adapted to alter the path of the first transmission loop for shifting the phase of rotation of the first unbalanced mass. According to a second disclosed concept, there is also second phase shifting arrangement which is adapted to alter the path of the second transmission loop for shifting the phase of rotation of the second unbalanced mass.

[0012] A device for generating mechanical vibration is known from US 6,717,379 B1. The creation of mechanical vibration is made with a system of two or more rotating eccentrics. Each eccentric is rotated by an individually controlled motor and the angle position of each eccentric is read by an angle sensor. With a control and monitoring system, the rotation frequency, direction of rotation and phase position of each eccentric can be controlled. By choosing a number of eccentrics, mass of the eccentrics, rotation frequency, direction of rotation and phase position, a force vector diagram of suitable form, in space and time, can be generated. The device is intended primarily for use in appliances for dynamic compaction of various materials.

[0013] A compaction roller vibratory mechanism is known from EP 2 147 725 A1. A vibratory mechanism of a drum of a compaction roller consists of an outer eccentric weight, an inner eccentric weight, a friction clutch, and a hydraulic connection of hydromotors. The eccentric weights are pivoted and coaxially mounted against each other on unidentified shafts connected with the hydromotors. Sensors of a mutual angular displacement of ec-

centric weights are situated on shafts associated to the eccentric weights. A control unit together with related components is adapted to act on the hydraulic connection of the hydromotors to allow a slipping movement of the friction clutch, thereby achieving a mutual displacement of one eccentric weight against the order.

[0014] The document DE 10 2011 195 899 A1 discloses a compaction device driven by an electric motor, having a rechargeable storage unit for electrical power, and a vibration-damped guide device. Also a method for compaction control is disclosed which derives an degree of compaction on basis of determining the power of the electric motor.

[0015] An adjustable vibration cylinder for a road roller is known from US 3,192,839 corresponding to DE-AS 1 267 623. A vibrating arrangement has two inertia or unbalancing weights which are driven with the same speed in opposite directions.

[0016] A working device for generating a working movement is known from DE 10 2011 102 553 A1. The known device has a drive train with an internal combustion engine and with a motion conversion device for converting a rotational movement of the internal combustion engine into a working movement. A load device is coupled to the drive train for exerting a load on the drive train on demand for avoiding an oversupply of energy and for avoiding that the speed of the internal combustion engine increases beyond an allowed value. According to a mentioned embodiment the load device comprises an energy buffer or storage for storing energy which is withdrawn from the drive train, and the load device is adapted to pass stored energy back into the drive train by means of an electric motor. As an alternative to an realization of the energy buffer or storage using electric capacitors the possibility of a fly wheel storage is mentioned, e.g. of a kind using the rotor of the electric motor as fly wheel.

[0017] US 2015/152606 A1 discloses a soil compaction machine in the form of a vibration compactor, which comprises a vibration exciter for generating different kinds of exciter vibration having a first and a second imbalance shaft, which are arranged in parallel to one another. Each imbalance shaft is driven via a separate motor, so that the rotational velocity, the rotational direction, and the phase relation of each of the imbalance shafts can be changed separately.

[0018] The object of the present invention is therefore to provide a compactor device system and a method for using a compactor device system reducing energy consumption during operation of the compactor device system.

[0019] For achieving this object, the present invention provides the compactor device system defined in claim 1 and the method for operating a compactor device system defined in claim 8. Preferred embodiments of the invention are defined in the dependent claims and are indicated to the skilled reader in the following description.

[0020] The invention and preferred embodiments thereof achieve further advantages, such as to provide

a compactor device system which allows to accelerate the operation of the compactor device system, to provide a compactor device system having a relatively simple structure, to provide a compactor device system and a method for using a compactor device system allowing a variation of the intensity of a compacting action of a compacting tool of the compactor device system, and to provide a compactor vehicle and a method of operating a compactor vehicle resulting in reduced structural stress of the compactor vehicle during its use. An additional object of the present invention is the provision of a simple and cost-effective method of measuring ground compaction.

[0021] According to the present invention, there is provided a compactor device system comprising a compacting tool; a first driving means; a first unbalanced mass rotatable by the first driving means at a first rotation frequency; a second driving means; a second unbalanced mass rotatable by the second driving means at a second rotation frequency. Each of the first and second unbalanced mass, when rotated by the respective driving means, is adapted to apply a respective oscillating force on the compacting tool. A control unit is adapted to control the first rotation frequency and the second rotation frequency, such that the first rotation frequency equals the second rotation frequency; and is further adapted to control a relative phase between a rotation of the first unbalanced mass and a rotation of the second unbalanced mass. The control unit is further adapted to drive the compactor device system in a compacting mode by setting the relative phase to such a value, that forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass both contribute to a compacting action of the compacting tool. According to the present disclosure, the first unbalanced mass and the second unbalanced mass are operable as a flywheel energy storage in at least one operation mode of the compactor device system. In this respect it is provided that the flywheel energy storage is adapted to store a rotational energy of the rotating first unbalanced mass and a rotational energy of the second rotating unbalanced mass. As provided according to the invention, the compactor device system has have a recuperation arrangement which is adapted to store energy generated by regenerative braking in the flywheel energy storage and to withdraw energy stored in the flywheel energy storage for driving or supporting at least one function of the compactor device system. Therefore, the energy consumption of the compactor device system can be reduced.

[0022] Preferably, the control unit is further adapted to drive the compactor device system in a non-compacting mode by setting the relative phase to such a value, that forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass add destructively for achieving minimum or no compacting action of the compacting tool, wherein the first unbalanced mass and the second unbalanced mass are

operable as said flywheel energy storage at least in the non-compacting mode.

[0023] According to a preferred embodiment, the compacting tool comprises a compactor drum which is arranged to be rotatable about a drum axis and is adapted to directly contact the object or surface to be compacted, wherein the recuperation arrangement with the compactor drum and the flywheel energy storage are operable to rotationally drive or accelerate at least one of the first unbalanced mass and the second unbalanced mass on basis of rotational energy of the compactor drum and to rotationally drive or accelerate the compactor drum on basis of energy stored in the flywheel energy storage.

[0024] In the compactor device system or the method (see below) according to the present disclosure, the first rotation frequency equals the second rotation frequency means equality of the absolute value of the rotation frequencies and the rotational direction. During the process of switching from one of the non-compacting mode and the compacting mode to the other one of the non-compacting mode and the compacting mode, the first rotation frequency is not equal the second rotation frequency.

[0025] According to a preferred embodiment, the compacting tool comprises a compactor drum which is arranged to be rotatable about a drum axis and is adapted to directly contact the object or surface to be compacted, wherein the first unbalanced mass and the second unbalanced mass are arranged concentrically within the compactor drum and rotatable about said drum axis which is common rotational axis of the compactor drum and the first and second unbalanced masses. Therewith a compactor device system having a relatively simple structure is provided.

[0026] Preferably the control unit is further adapted to drive the compactor device system in the compacting mode by setting the relative phase to an intermediate value, preferably a selected one of plural intermediate values or within an intermediate value range, between the/a first value, which provides that forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass add constructively for achieving maximum compacting action of the compacting tool and the/a second value, which provides that forces created by rotation of the second unbalanced mass add destructively for achieving minimum or no compacting action of the compacting tool, such that for the intermediate value being set forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass contribute to compacting action of the compacting tool. Therewith a compacting action with a reduced intensity of the compacting action with respect to the maximum compacting action and preferably a variability of this reduced intensity can be achieved.

[0027] Generally it is proposed that the control unit is adapted to change the rotation frequency of at least one of the first unbalanced mass and the second unbalanced mass such that the value of the relative phase changes

from a value having been set to another value to be set, preferably to switch from one of the non-compacting mode and the compacting mode to the other one of the non-compacting mode and the compacting mode or to change the intensity of the compacting action of the compacting tool.

[0028] The compactor device system described herein can further comprise a third driving means, wherein the compacting tool is a compactor drum adapted to directly contact the object or surface to be compacted, and wherein the compacting tool is rotatable by the third driving means; a third regenerative braking device adapted to convert rotational energy of the compacting tool into recuperation energy, in particular into electrical recuperation energy; wherein the compactor device system is adapted to store recuperation energy obtained from converting rotational energy of the compacting tool in the flywheel energy storage by accelerating the a first unbalanced mass using the first driving means and the second unbalanced mass using the second driving means in the non-compacting mode.

[0029] Such a system further reduces significantly the energy consumption resulting in the possibility of using a smaller combustion engine, compared with a conventional compactor device system, for powering the compactor device system, reducing costs and overall emissions.

[0030] In a particular preferred embodiment the compactor device system can further comprise a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass into recuperation energy, in particular into electrical recuperation energy; or/and a second regenerative braking device adapted to convert rotational energy of the second unbalanced mass into recuperation energy, in particular into electrical recuperation energy; and preferably a storage device adapted to store the recuperation energy; wherein the compactor device system is adapted to accelerate the compacting tool using recuperation energy obtained from the first or/and second regenerative braking device, which has preferably been stored in the storage device.

[0031] In such a compactor device system well known and reliable means can be used to gain recuperation energy from the unbalanced masses and to use it for driving or accelerating of the compacting tool or accelerate one of the unbalanced masses. One form of recuperation energy is potential energy stored in compressed air or any other compressible fluid. The conversion of the rotation energy of an unbalanced mass into this form of recuperation energy can be done by driving directly a pump, e. g. switchable by a clutch, increasing a pressure in a tank. The high pressure fluid stored in the tank can be used to drive one of the unbalanced masses e.g. by using the pump as a turbine, driven by the high pressure fluid. Thus the pump can be a regenerative braking device or/and a driving means. In preferred embodiments regenerative braking devices provide electrical power which can be stored using a battery like a lithium ion polymer battery,

a capacitor or a super capacitor and so on.

[0032] The compactor device system may further comprise at least one of: a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass into recuperation energy, in particular into electrical recuperation energy, wherein preferably the first regenerative braking device is comprised by the first driving means; a second regenerative braking device adapted to convert rotational energy of the second unbalanced mass into recuperation energy, in particular into electrical recuperation energy, wherein preferably the second regenerative braking device is comprised by the second driving means; and a third regenerative braking device adapted to convert kinetic energy, preferably rotational energy, of the compacting tool into recuperation energy, in particular into electrical recuperation energy, wherein preferably the third regenerative braking device is comprised by a third driving means of the compactor device system adapted to drive the compacting tool.

[0033] In case one, a plurality or all of the regenerative braking devices are provided, it is possible to reuse energy obtained from the regenerative braking device(s) to accelerate one or both of the unbalanced masses or/and the compacting tool in case one or both of the unbalanced masses or/and the compacting tool needs to be accelerated. Such systems are most versatile in case the kinetic energy is converted into electrical energy, referred to as electrical recuperation energy, since the energy transfer from a regenerative braking device to a storage means, or from a storage means to a drive means can be performed by conventional cables and power electronics. The provision of such systems is well known in the field of hybrid vehicles and further details are omitted since those systems form part of the general knowledge of a person skilled in the art.

[0034] It is preferred that at least one, preferably all of the first driving means and the second driving means, and preferably in addition a third driving means of the compactor device system adapted to drive the compacting tool, is an electric driving means, e.g. a respective electric motor, which preferably is adapted to be a regenerative braking device by being adapted to be used as a generator in a generator mode. In such a compactor device system simple and reliable driving means like electrical motors are used which require essentially no or only minor modifications in order to be used as a regenerative braking device.

[0035] It is envisioned in the compactor device system at least one of the first driving means, the second driving means and the third driving means of the compactor device is a corresponding first, second or third regenerative braking device, adapted to convert the corresponding kinetic energy of the first unbalanced mass or the second unbalanced mass or the compacting tool into recuperation energy, preferably into electrical recuperation energy, wherein preferably the compactor device system is adapted to supply the recuperation energy to a flywheel energy storage, preferably comprising a first unbalanced

mass and the second unbalanced mass.

[0036] In such a compactor device system according to an aspect of the present disclosure is possible to switch from the compacting mode to the non-compacting mode, and vice versa, by at least decelerating one of the first or second unbalanced masses in order to change the relative phase between the rotations of these masses. The compactor device system discussed above is adapted to reuse energy obtainable in such a deceleration.

[0037] It is most convenient in the above case, that the first, second or third regenerative braking device are formed by a corresponding electric motor adapted to be used as an electric generator, since recuperation energy obtained by the regenerative braking device can be distributed to another driving means or storage of electrical energy like a capacitor or battery without any further energy-form conversion accompanied by losses.

[0038] The compactor device system can comprise a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass into recuperation energy, in particular into electrical recuperation energy; and a storage device for recuperation energy. In case further regenerative braking devices are provided, the storage device is preferably adapted to store the recuperation energy provided by those regenerative braking devices as well.

[0039] Such a compactor device system has particular means for obtaining recuperation energy and for storage of recuperation energy allowing reduction of total energy use due to energy storage and the possibility to reuse of the stored energy.

[0040] In a compactor device system at least one, preferably all of the driving means can be an electrical driving means like an electric motor. Therefore it is preferable that the storage device is a capacitor, supercapacitor or a battery.

[0041] In particular is preferred that the storage device is part of a AC/AC-converter, in particular of a variable-frequency drive, of the compactor device system, adapted to drive at least one, preferably all driving means, wherein each driving means is preferably an electric driving means, e.g. an electric motor.

[0042] Since most AC/AC-converters already comprise a storage device in the DC part of the AC/AC-converter, such a storage device can either be used directly for storing electrical recuperation energy obtained from a regenerative braking device, like an electric motor adapted to be driven as a generator, or such a storage device can be provided with an enlarged capacity compared to conventional AC/AC-converters, allowing a simple implementation of the storage device.

[0043] Furthermore it is particularly preferred that the AC/AC-converter comprises, preferably for each driving means, an AC-power input-side, e.g. an first rectifier/inverter-unit, an intermediate section preferably formed as a DC-section or DC-link, and an AC-power output-side, e.g. a second rectifier/inverter-unit, wherein the AC-power output-side is adapted to receive AC-power and to

transfer DC-power to the storage device, preferably via parts of the DC-section, the storage device being preferably formed by a capacitor, supercapacitor or a battery of the intermediate section, and the storage device can be part of the AC/AC-converter, e.g. of the DC-section or DC-link.

[0044] In such a compactor device system the electrical energy to be stored in the storage device is provided in the appropriate DC form already by the AC/AC-converter and no conversion loss introducing additional rectifier, associated with the storage device and rectifying an output of the AC/AC-converter needs to be provided.

[0045] It is preferred that the first unbalanced mass and the second unbalanced mass are arranged coaxially, preferably concentrically, in particular as concentric drums rotatably connected to the compacting tool, wherein the compacting tool preferably is formed as a compactor drum adapted to directly contact the object or surface to be compacted, wherein in particular the first unbalanced mass is a first unbalanced drum, the second unbalanced mass is a second unbalanced drum, and wherein the compactor drum, the first unbalanced drum and the second unbalanced drum are arranged concentrically. This arrangement of the first and second unbalanced mass and of preferably the compacting tool provides a compact arrangement of those elements resulting in a small and space efficient compactor device system.

[0046] In a preferred embodiment one, in particular only one, of the first driving means and the second driving means and preferably of a third driving means of the compactor device system adapted to drive the compacting tool, is hydraulically powered, and preferably formed as a hydraulic motor. This embodiment allows the use of well-known and reliable driving means for the compactor device system increasing its reliability.

[0047] In the compactor device system the control unit is adapted to switch from one of the/a non-compacting mode and the/a compacting mode to the other one of the non-compacting mode and the compacting mode or/and is adapted to change the intensity of the action of the compacting tool by being adapted to carry out a step of changing the relative phase, wherein preferably the step of changing the relative phase comprises commanding a first step of changing the rotation frequency of the first unbalanced mass, followed by commanding a second step of changing the rotation frequency of the first unbalanced mass or/and the rotation frequency of the second unbalanced mass, wherein after the first step of changing the rotation frequency of the first unbalanced mass and the second step of changing the rotation frequency of the first unbalanced mass or/and the rotation frequency of the second unbalanced mass, the thus obtained rotational frequency of the first unbalanced mass is equal to the thus obtained rotational frequency of the second unbalanced mass.

[0048] Such a compactor device system allows to switch between the compacting mode and non-compacting mode with a simple control scheme, since the rota-

tional frequency of the first unbalanced mass and the rotational frequency, present before the step of changing the relative phase has started, may be different from the thus obtained rotational frequency of the first unbalanced mass and the thus obtained rotational frequency of the second unbalanced mass, present once the step of changing the relative phase has been carried out.

[0049] In the above-described compactor device system is preferred that it further comprises a first regenerative braking device; and preferably further an energy management system; wherein the compactor device system is adapted to carry out the first step of changing the rotation frequency of the first unbalanced mass by decelerating the rotation of the first unbalanced mass by converting rotational energy of the first unbalanced mass into recuperation energy, in particular into electrical recuperation energy, using the first regenerative braking device; and wherein preferably the energy management system is adapted to store the recuperation energy obtained during decelerating the rotation of the first unbalanced mass by the first regenerative braking device. Such a system allows to store energy, which would be conventionally lost during switching from between the non-compacting mode and the compacting mode.

[0050] In such a system it is preferred that the compactor device system is adapted to carry out the second step of changing the rotation frequency of the first unbalanced mass by accelerating, in particular using a recuperation energy, which is preferably stored in the energy management system, the rotation of the first unbalanced mass by means of the first driving means, preferably until the first rotation frequency is reached by the first unbalanced mass.

[0051] Energy does not need to be stored outside the energy management system, but can be stored in an internal capacitor, battery or similar, and thus less successive steps of storing and withdrawing of energy are carried out in order to finish the step of switching between the non-compacting mode and the compacting mode, wherein each additional step of storing and withdrawing of energy would lead to energy losses. Of course, an external energy storage may be provided, if desired.

[0052] The present invention further provides a method for operating a compactor device system, preferably a compactor device system as described above, the compactor device system comprising a compacting tool; a first driving means; a first unbalanced mass rotatable by the first driving means at a first rotation frequency; a second driving means; a second unbalanced mass rotatable by the second driving means at a second rotation frequency; wherein each of the first and second unbalanced mass, when rotated by the respective driving means, is adapted to apply a respective oscillating force to the compacting tool; a control unit adapted to control the first rotation frequency and the second rotation frequency, such that the first rotation frequency equals the second rotation frequency; and further adapted to control a relative phase between a rotation of the first unbalanced

mass and a rotation of the second unbalanced mass. The method comprises the steps of: rotating the first unbalanced mass at a first rotation frequency, rotating the second unbalanced mass at a second rotation frequency; controlling the first rotation frequency to be equal to the second rotation frequency; driving the compactor device system in a compacting mode by setting the relative phase to such a value that forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass both contribute to a compacting action of the compacting tool. According to the present disclosure, the first unbalanced mass and the second unbalanced mass are operated as a flywheel energy storage in at least one operation mode of the compactor device system, wherein the flywheel energy storage stores a rotational energy of the rotating first unbalanced mass and a rotational energy of the second rotating unbalanced mass. The method comprises the step to store energy generated by regenerative braking in the flywheel energy storage and the step to withdraw energy from the flywheel energy storage for driving or supporting at least one function of the compactor device system. This method provides advantages corresponding to those of the compactor device system according to the present invention.

[0053] Preferably, the compactor device system is driven in a non-compacting mode by setting the relative phase to such a value that forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass add destructively for achieving minimum or no compacting action of the compacting tool, wherein the first unbalanced mass and the second unbalanced mass are operable as said flywheel energy storage at least in the non-compacting mode.

[0054] The compacting tool may comprise a compactor drum which is arranged to be rotatable about a drum axis and is adapted to directly contact the object or surface to be compacted. In this case the method may comprise to rotationally drive or accelerate at least one of the first unbalanced mass and the second unbalanced mass on basis of rotational energy of the compactor drum and may comprise to rotationally drive or accelerate the compactor drum on basis of energy stored in the flywheel energy storage.

[0055] The method may comprise to drive the compactor device system in the compacting mode by setting the relative phase to an intermediate value, preferably a selected one of plural intermediate values or within an intermediate value range, between the/a first value, which provides that forces created by rotation of the first unbalanced mass and forces created by rotation of the second unbalanced mass add constructively for achieving maximum compacting action of the compacting tool and the/a second value, which provides that forces created by rotation of the second unbalanced mass add destructively for achieving minimum or no compacting action of the compacting tool, such that for the intermediate value being set forces created by rotation of the first unbalanced

mass and forces created by rotation of the second unbalanced mass contribute to compacting action of the compacting tool. Therewith a compacting action with a reduced intensity of the compacting action with respect to the maximum compacting action and preferably a variability of this reduced intensity can be achieved.

[0056] Generally the method may comprise to change the rotation frequency of at least one of the first unbalanced mass and the second unbalanced mass such that the value of the relative phase changes from a value having been set to another value to be set, preferably to switch from one of the non-compacting mode and the compacting mode to the other one of the non-compacting mode and the compacting mode or to change the intensity of the compacting action of the compacting tool.

[0057] In a particularly preferred embodiment of the method the compactor device system is further comprising a third driving means, wherein the compacting tool is a compactor drum adapted to directly contact the object or surface to be compacted, and a third regenerative braking device adapted to convert rotational energy of the compacting tool into recuperation energy, in particular into electrical recuperation energy; wherein in the non-compacting mode the first unbalanced mass and the second unbalanced mass form a flywheel energy storage adapted to store a rotational energy of the rotating first unbalanced mass and a rotational energy of the second rotating unbalanced mass, the method further comprising the steps of: rotating the compacting tool by the third driving means; obtaining recuperation energy from the third regenerative braking device by converting rotational energy of the compacting tool into recuperation energy; preferably storing the recuperation energy in a storage device of the compactor device system; supplying the recuperation energy to supply the flywheel energy storage. The method discussed above allows to reuse energy obtained in a deceleration of the compacting tool, and e.g. a whole vehicle applying the method.

[0058] In a further preferred embodiment the compactor device system is further comprising a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass into recuperation energy, in particular into electrical recuperation energy; a second regenerative braking device adapted to convert rotational energy of the second unbalanced mass into recuperation energy, in particular into electrical recuperation energy; the method further comprising the steps of: rotating the first unbalanced mass and the second unbalanced mass in the non-compacting mode; obtaining first recuperation energy from the first regenerative braking device by converting rotational energy of the first unbalanced mass into recuperation energy; obtaining second recuperation energy from the second regenerative braking device by converting rotational energy of the second unbalanced mass into recuperation energy; preferably storing the first recuperation energy or/and the second recuperation energy in a storage device of the compactor device system; accelerating the compacting tool using first and second

recuperation energy, e.g. by means of a third driving means of the compactor device system.

[0059] Such a method uses well known and reliable means in order to gain recuperation energy from the unbalanced masses and uses it for driving or accelerating of the compacting tool.

[0060] The present invention also provides a compactor vehicle comprising: a first compactor device system, as described above, adapted to generate a first oscillating force acting on at least some of mounting elements of the compactor vehicle for the first compactor device system; a second compactor device system, as described above, adapted to generate a second oscillating force acting on at least some of mounting elements of the compactor vehicle for the second compactor device system; and a master control unit adapted to control a relative orientation of the first and second oscillating force, preferably adapted to control the relative orientation of the first and second oscillating force such that the first and second oscillating force are parallel.

[0061] By controlling the relative orientation of the first and second oscillating force is possible to control the force acting on components of the compactor vehicle due to the interaction of the forces caused by the first and second compactor device system, in particular it is possible to reduce the stress significantly when the oscillating forces are parallel, i.e. directed in the same direction, wherein this common direction may vary with time, e.g. rotate.

[0062] Embodiments of the present invention will be described in the following with reference to the enclosed figures, with

Fig. 1 showing a schematic drawing of a compactor vehicle according to the invention with two compactor device systems according to the invention;

Fig. 2 showing a schematic cross section of a compactor device system according to the invention;

Fig. 3 showing a schematic circuit diagram of power electronics used in an embodiment of a compactor device systems according to the invention;

Fig. 4 showing in a schematic drawing a step of changing the relative phase between the rotation of a first unbalanced mass and the rotation of a second unbalanced mass resulting in a change from a compacting mode, left side, to a non-compacting mode, right side;

Fig. 5 is a schematic circuit diagram of an AC/AC converter;

Fig.6 showing in a schematic drawing a deceleration of a compacting tool and storing the recuperation energy in a flywheel energy storage, the compactor device system being in the non-compacting mode,

the compacting tool rotates on the left side and is not rotating on the right side;

Fig.7 showing in a schematic drawing an acceleration of a compacting tool and withdrawing of energy from a flywheel energy storage, the compactor device system being in the non-compacting mode, the compacting tool does not rotate on the left side and is rotating on the right side;

Fig. 8 showing a schematic drawing of a compactor vehicle according to the invention with two non-correctly synchronized compactor device systems, the compactor device systems being embodiments of the invention; and

Fig. 9 showing a schematic drawing of the compactor vehicle of Fig. 8 with the two compactor device systems being correctly synchronized according to a further aspect of the invention.

[0063] Fig. 1 shows a compactor vehicle 20, e.g. a road roller, comprising a first compactor device system 22 and a second compactor device system 24 as well as a master control unit 26 adapted to control the concurrence of the first 22 and second 24 device system as will be described below. The first 22 and second 24 compactor device system can essentially show the same features and thus, only the first compactor device system 22 will be described in details.

[0064] The compactor device system 22 comprises a compacting tool 28, which can be a compactor drum 30 as commonly used in road rollers. Within the compacting tool 28 a first unbalanced mass 32 rotatable by a first driving means 34 and a second unbalanced mass 36 rotatable by a second driving means 38. The first and second driving means 34 and 38 may be supported on a first holding element 40 such that the first unbalanced mass 32 and the second unbalanced mass 36 are supported via the corresponding first and second driving means 34 and 38 on the first holding element 40. The first holding element 40 can be connected to a frame of the compactor vehicle 20.

[0065] Furthermore, the first unbalanced mass 32 can be rotatably supported by a first bearing element 42 and a second holding element 46 and the second unbalanced mass 36 can be supported by a second bearing element 44 on the second holding element 46, which can be connected to a frame of the compactor vehicle 20. In addition, the compacting tool 28 can be rotatably supported by a third bearing element 52 on the second holding element 46. Each of the first, second and third bearing elements 42, 44 and 52 can be a rolling element bearing. Each of the first and second driving means 34 and 38 can be an electric motor with a toroidal construction, like the torque motor, or each of the first and second driving means 34 and 38 can comprise external teeth provided on the outer surface of the first and/or second unbalanced mass,

meshing with a gear supported on the first holding element 40 and driven by an electric motor with a drivetrain supported by the first holding element 40. The first and second driving means 34 and 38 may comprise bearing elements in order to support the corresponding first or second unbalanced mass 32 and 36 rotatably on the first holding element 40.

[0066] In a preferred embodiment, the first unbalanced mass 32 comprises a mass bearing section 32A, a bearing section 32B and a driven section 32C, wherein preferably each of these sections is axially symmetric, in particular with regard to the same axis, represented by a dot dash line in Fig. 2. The mass bearing section 32A bears an eccentric section 32D or a section having a different density, formed for example by introduction of more dense material than the surrounding material, both sections can be essentially extend along an extension direction of the first unbalanced mass 32. It is to be noted that the eccentric section 32D is not shown in the schematic cross-section of Fig. 2.

[0067] In a further preferred embodiment, the second unbalanced mass 36 is provided within a cavity 32K of the first unbalanced mass 32. The second unbalanced mass 36 comprises a mass bearing section 36A, a bearing section 36B and a driven section 36C. The mass bearing section 36A bears an eccentric section 36D or a section having a different density, formed for example by introduction of more dense material than the surrounding material, both sections can be essentially extend along an extension direction of the second unbalanced mass 36. The second unbalanced mass 36 and its parts have preferably the same functions or/and forms or/and arrangement as the corresponding sections 32, 32A to 32D of the first unbalanced mass 32 and therefore a further description is omitted.

[0068] The bearing section 32B preferably is connected via the first bearing element 42 to the second holding element 46 and the driven section 32C is preferably connected via the first driving means 34 to the first holding element 40. The bearing section 36B preferably is connected via the second bearing element 44 to the second holding element 46 and the driven section 36C is preferably connected via the second driving means 38 to the first holding element 40.

[0069] The compactor device system 22 comprises a control unit, which may be part of the master control unit 26, but may also be provided separately from the master control unit 26. The control unit is adapted to control a relative phase between a rotation of the first unbalanced mass 32 and the second unbalanced mass 36.

[0070] In a preferred embodiment, the first unbalanced mass 32 and the second unbalanced mass 36 are arranged coaxially, preferably concentrically as shown in figure 1. The provision of eccentric sections 32D and 36D does not prevent in the context of this application that the first unbalanced mass 32 and the second unbalanced mass 36 are arranged coaxially or concentrically. In case the compacting tool 28 is formed as a compactor drum

30, it is preferred that the first unbalanced mass 32, the second unbalanced mass 36 and the compactor drum 30 are arranged coaxially, preferably concentrically as shown in Figs. 1 and 2. Those unbalanced masses 32 and 36 can have essentially the shape of a drum and can be labeled as unbalanced drums.

[0071] The absolute phase of the rotation of the first/second unbalanced mass is the rotation angle acquired over time during the rotation of the first/second unbalanced mass, such that if the unbalanced mass rotates once about 360° , the total phase is 2π . In case the unbalanced mass rotates two times about 360° , the total phase is 4π , and so on. The total phase of the first unbalanced mass can be expressed as

$$\varphi_{\text{total } 1} = \omega_1 t + \varphi_1$$

wherein ω_1 is the rotation frequency of the first unbalanced mass 32 (first rotational frequency), t is the time, and φ_1 is the offset angle of the first unbalanced mass 32 at $t = 0$. The total phase of the second unbalanced mass can be similarly expressed

$$\varphi_{\text{total } 2} = \omega_2 t + \varphi_2$$

wherein ω_2 is the rotation frequency of the second unbalanced mass 36 (second rotational frequency), t is the time, and φ_2 is the offset angle of the second unbalanced mass 36 at $t = 0$.

[0072] $\varphi_{\text{total } 1}$ and $\varphi_{\text{total } 2}$ can be regarded as the angular position of eccentric sections 32D and 36D with respect to a given reference angular position of a rotation about the rotational axis 48. Therefore, the relative phase $\Delta\varphi$ between a rotation of the first unbalanced mass 32 and rotation of the second unbalanced mass 36 can be expressed for $\omega_1 = \omega_2$ as

$$\Delta\varphi = \varphi_{\text{total } 1} - \varphi_{\text{total } 2} = \varphi_1 - \varphi_2$$

$\Delta\varphi$ represents the relative angular position between the eccentric sections 32D and 36D, being 0° in Fig. 1 for the first compactor device 22 and being 180° for the second compactor device system 24. The control unit 50 can receive the absolute angle of the first unbalanced mass 32 and the absolute angle second unbalanced mass 36 from respective rotary encoders mounted on the first unbalanced mass and the second unbalanced mass (not shown in the figures) with respect to a predetermined reference position of the corresponding mass. The control unit 50 can be adapted to control the first rotation frequency and the second rotation frequency on the basis of the absolute angles measured and a timing signal, which is preferably generated by the control unit 50.

[0073] Within a control margin, $\omega_1 = \omega_2$ is being obtained by such a control process. Since the first and sec-

ond rotation frequencies are constant due to a control of the control unit 50 and the absolute angular positions of the first unbalanced mass 32 and the second unbalanced mass 36 are obtained from respective rotary encoders and provided to the control unit 50, the control unit 50 can be adapted to calculate the relative phase between the rotation of the first unbalanced mass 32 and the rotation of second unbalanced mass 36 and furthermore, the control unit 50 can be adapted to control this relative phase, preferably using PID algorithm.

[0074] Since oscillating forces are created by rotation of the first and second unbalanced masses and 32 and 36, the above arguments not only apply for the rotational position of the eccentric sections 32D and 36D, but also for the direction of forces created by the rotation of the first and second unbalanced masses and 32 and 36. These forces are acting on the ground to be compacted via the compacting tool 28.

[0075] Furthermore, for $\Delta\varphi = 0^\circ$ the eccentric section 32D and 36D are aligned with respect to each other as shown in Fig. 1 for the first compactor device system 22. Thus, for $\Delta\varphi = 0^\circ$ the forces created by the first unbalanced mass and the second unbalanced mass 32 and 36, being essentially centrifugal forces, point in the direction of the respective eccentric section 32D and 36D. This directions 32E and 36E are parallel to each other, and therefore the forces created by rotation of the first unbalanced mass 32 and the second unbalanced mass 36 add for $\Delta\varphi = 0^\circ$ constructively all the time, in particular when facing the direction of the object or surface to be compacted. Thus, the compactor device system 22 is a compacting mode when the control unit 50 sets the relative phase $\Delta\varphi$ to 0 (0 being a first value of the relative phase) and keeps (controls) this value constant.

[0076] When the control value $\Delta\varphi$ to be controlled by the control unit 50 is set to 180° by the control unit, the direction 32E of the force created by rotation of the first unbalanced mass 32 and the direction 36E of the force created by rotation of the second unbalanced mass 36 are anti-parallel, point in opposite directions, such that the force created by the rotation of the first unbalanced mass 32 and the force created by rotation of the second unbalanced mass 36 add destructively (cancel each other out at least partially). An essentially complete cancellation of these forces can be achieved for $\Delta\varphi = 180^\circ$ by a correct choice of the ratio of the masses m_1 , m_2 of the eccentric sections 32D, 36D. In case the eccentric sections are being modelled by point-masses m_1 and m_2 rotating with respective rotational frequencies ω_1 and ω_2 at respective radiuses r_1 , r_2 (for convenience represented by the same arrows as directions 32E, 36E), the respective centrifugal forces F_1 created by the first unbalanced mass 32 and F_2 created by the second unbalanced mass 36 can be calculated to be

$$F_1 = m_1\omega_1^2r_1 \text{ and } F_2 = m_2\omega_2^2r_2$$

[0077] And therefore, the ratio of the masses can be expressed for $\omega_1 = \omega_2$ as

$$\frac{m_1}{m_2} = \frac{L_2}{L_1}$$

when a cancellation of forces is to be achieved. Such a ratio of masses and radiuses can be chosen as starting point for optimizing positioning, weight and shaping of the eccentric sections.

[0078] $\Delta\varphi = 180^\circ$ can be regarded as a second value for the relative phase. The control unit 50 can receive different target values from an operator of the compactor device system inputting a requested $\Delta\varphi$, for example being 0° or 180° , alternatively the operator can select a compacting mode, resulting in the control unit 50 setting $\Delta\varphi$ to 0° , or a non-compacting mode, resulting in the control unit 50 setting $\Delta\varphi$ to 180° , such that the control unit 50 is adapted to switch from compacting mode to the non-compacting mode and vice versa.

[0079] In the context of a road roller equipped with the compactor device system 22, the compacting mode is being used when the road roller travels on the road surface to be compacted. However, the process of compacting the road surface comprises passing multiple times by the road roller over the surface to be compacted. Therefore, between passes, the driving direction of the road roller needs to change. This process comprises bringing the road roller to a halt and changing its moving direction from forward to backward. In particular at the instant of standing, a continuation of the compacting mode is not desired since the compacting tool would create a dent in the surface to be compacted. In modern road rollers a rotation of an unbalanced mass or masses is being stopped during the change of direction between two different passes over the surface to be compacted by the road roller in order to avoid non-uniform compaction. Such an approach requires time for the deceleration and reacceleration of the unbalanced mass(es) during change of direction of the road roller and results in loss of energy.

[0080] According to the present invention the compactor vehicle 20 using a compactor device system according to the invention switches the compactor device system from the compacting mode to the non-compacting mode in the process of changing the direction from forward to backward. This change uses only a minor amount of energy when changing the relative phase between the rotation of the first unbalanced mass 32 and the rotation of the second unbalanced mass 36, since introduction of significant changes in the rotation frequency of the first unbalanced mass 32 and second unbalanced mass 36 is avoided while the combined forces created by the rotation of the unbalanced masses is essentially zero which reduces the compacting action of the road roller.

[0081] Once the road roller has changed the direction, the compacting mode is being reengaged by changing

the relative phase of the rotation of the first unbalanced mass 32 and second unbalanced mass 36, again requiring only a minor amount of energy since no significant change in the rotation frequency of the first unbalanced mass 32 and the rotation of the second unbalanced mass 36 needs to be introduced during re-engaging of the compacting mode.

[0082] Therefore, the process of changing the direction of movement of road roller during the compacting process requires less energy. In addition, the process of changing the relative phase between a rotation of the first unbalanced mass and the rotation of the second unbalanced mass, carried out twice in the above process, has been found by the inventors to be much faster compared with bringing a rotating unbalanced mass to a hold and then accelerating the unbalanced mass to a desired rotation frequency within the parameters, used for rotation of unbalanced mass in compacting device systems. Thus, the compactor device system according to the invention enables faster change of direction of the compactor vehicle 20 in the process of compacting a surface.

[0083] The above-described compactor device system 22 can be operated by a method comprising the steps of rotating the first unbalanced mass 32 at first rotation frequency ω_1 , rotating the second unbalanced mass 36 at a second rotation frequency ω_2 . This is indicated by the solid arrows on the first unbalanced mass 32 and the second unbalanced mass 36 in Fig. 4. The method further comprises the steps of: controlling the first rotation frequency ω_1 to be equal to the second rotation frequency ω_2 and driving the compactor device system 22 in the compacting mode by setting the relative phase to a first value, preferably, setting the relative phase to 0° , driving the compactor device system in the non-compacting mode by setting the relative phase to a second value, preferably by setting the relative phase to 180° , Fig. 4, right side (rotation of the unbalanced masses is not indicated further), and mode switching from one of the non-compacting mode and the compacting mode to the other one of the non-compacting mode and the compacting mode. The switching from the non-compacting mode to the compacting mode is indicated in Fig. 4, left side, by arrows A and B showing the position change of the eccentric sections 32D and 36D. The position change of the eccentric sections 32D and 36D during mode switching from the non-compacting mode to the compacting mode is preferably induced by controlling of the first and second driving means 34 and 38, in particular by decelerating one of the first 32 and second 36 unbalanced masses and accelerating this unbalanced mass e.g. under the control of PID algorithm, such that the relative phase is 180° after the acceleration.

[0084] The mode switching from the compacting mode to the non-compacting mode can be carried out essentially in the same manner, however, after the acceleration of the previously decelerated unbalanced mass the relative phase is 0° .

[0085] It is to be noted that in the non-compacting mode

the first unbalanced mass 32 and second unbalanced mass 36 preferably form part of a flywheel energy storage storing rotational energy of the rotating first unbalanced mass 32 and the second unbalanced mass 36 without energy dissipation due to work done by the oscillating force resulting from rotation of the first unbalanced mass 32 and of the second unbalanced mass 36. Energy is only being lost by friction of the first unbalanced mass 32 and a second unbalanced mass 36 and by work been done by forces due to residual unbalance of the combination of the first unbalanced mass 32 and second unbalanced mass 36 in the non-compacting mode.

[0086] In a particularly preferred embodiment the compactor device system 22 comprises further a third driving means 54 driving the compactor tool 28 or drum 30 which is adapted to directly contact object or surface to be compacted. The third driving means 54 can drive the compactor drum 30 by rotating the compactor drum 30. Furthermore, the compactor device system 22 preferably comprises a third regenerative braking device which is adapted to convert rotational energy of the compacting tool 28 into recuperation energy, in particular into electrical recuperation energy.

[0087] In a particularly preferred embodiment the third driving means 54 comprises an electric motor adapted to be used as an electric generator in a generator mode such that the third regenerative braking device can be part of the third driving means and the conversion of rotational energy of the compacting tool is being performed by the electric motor used as an electric generator. The compactor device system 22 is adapted to store the recuperation energy obtained from the third regenerative braking device in the flywheel energy storage by using the energy obtained by the third regenerative braking device to accelerate the first unbalanced mass 32 and the second unbalanced mass 36 by the corresponding first and second driving means while the compactor device system is the non-compacting mode. The compactor device system 22 can comprise a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass 32 into recuperation energy, in particular into electrical recuperation energy and/or comprise a second regenerative braking device adapted to convert rotational energy of the second unbalanced mass 36 into recuperation energy, in particular into electrical recuperation energy.

[0088] The first regenerative braking device can be formed by the first driving means 34 comprising an electric motor, which can function as generator in a generator mode and in the generator mode rotational energy of the first unbalanced mass can be converted by the into electrical energy. In the same manner the second regenerative braking device can be formed by the second driving means 38 comprising an electric motor, which can function as generator in a generator mode and in the generator mode rotational energy of the second unbalanced mass can be converted by the into electrical energy. The use of electric motors adapted to be used generators as

regenerative braking device is as well known in the art and thus a detailed description is omitted here.

[0089] In case the compactor device system 22 or the compactor vehicle 20 is equipped with a regenerative braking device, e.g. comprised or formed by the third driving means 54, the compactor device system is preferably adapted to supply energy obtained from the regenerative braking device or any other energy to be stored to the flywheel energy storage. Such a process is shown in Fig. 6: The initial rotation of the first unbalanced mass 32, the second unbalanced mass 36 and the compacting tool 28 is indicated by the solid arrows on these elements on the left side of Fig. 6. The compacting tool 28 / compacting drum 30 is decelerated as indicated by arrow C' using the third driving means 54 as a regenerative braking device. The recuperation energy obtained from this process is used to accelerate the first unbalanced mass 32 and the second unbalanced mass 36 by the corresponding first 34 and second 38 driving means. Preferably the rotation frequency of the first unbalanced mass 32 and the rotation frequency of the second unbalanced mass 36 are kept to be equal during the acceleration of the first unbalanced mass 32 and the second unbalanced mass 36, such that the compactor device system 22 remains in the non-compacting mode. In Fig. 6, right side, the compacting tool 28 is not rotating and the rotation frequency of the first 32 and second 36 unbalanced mass is increased compared to the left side of Fig. 6.

[0090] The compactor device system is preferably adapted to withdraw energy stored in the flywheel energy storage. Such a process is shown in Fig. 7, wherein the initial rotation state of the first unbalanced mass 32, the second unbalanced mass 36 and the compacting tool 28 in Fig. 7, left side corresponds to the final rotation state of the first unbalanced mass 32, the second unbalanced mass 36 and the compacting tool 28 in Fig. 6, right side and the final rotation state of the first unbalanced mass 32, the second unbalanced mass 36 and the compacting tool 28 in Fig. 7, right side corresponds to the initial rotation state of the first unbalanced mass 32, the second unbalanced mass 36 and the compacting tool 28 in Fig. 6, left side. In Fig. 7, the compactor device system 22 is in the non-compacting mode. Starting in Fig. 7, left side, in order to withdraw energy stored in the flywheel energy storage, the first unbalanced mass 32 and the second unbalanced mass 36 are decelerated by the corresponding first 34 and second 38 driving means as indicated by arrows A" and B", wherein preferably the rotation frequency of the first unbalanced mass 32 and the rotation frequency of the second unbalanced mass 36 are kept equal during this process. The recuperation energy obtained from this process is used to accelerate the compacting tool 28/ compacting drum 30 by means of the third driving means 54 as indicated by arrow C".

[0091] In order to manage the energy flow to the first, second and third driving means 34, 38 and 54; the energy flow from the first, second and third regenerative braking

devices; and by means of coupling of the first driving means 34 and the first regenerative braking device to the first unbalanced mass 32 and the second driving means 38 and the second regenerative braking device to the second unbalanced mass 36, also the energy flow to and from the flywheel energy storage, the compactor device system 22 preferably comprises an energy storage device for storing the recuperation energy from the regenerative braking devices, wherein the energy storage device can be a capacitor, a battery or a super capacitor.

[0092] In a preferred embodiment, in order to power the compactor device system 22, an engine, preferably a combustion engine 56, is provided in the compactor device system 22. The engine can be mounted on the frame of the compactor vehicle 20 and can drive a generator 58 of the compactor device system 22, preferably also mounted on the frame of the compactor vehicle 20. The drivetrain is indicated symbolically by a line in Fig. 1. Depending on the rotational speed of the engine 56, the output voltage and output frequency of the generator 50, which preferably is a three-phase generator, varies. In order to be able to use the output of the generator 58 as a power source for the first, second and search driving means, the output voltage and output frequency of the generator 58 is preferably adjusted by means of an AC/AC converter 60 which is in a preferred embodiment a variable frequency drive. In Fig. 2, the connection of the AC/AC converter 60 to the first, second and search driving means is symbolically represented by a line.

[0093] In a preferred embodiment, the AC/AC-converter 60 comprises first rectifier/inverter-unit 62, which rectifies the input power from the generator 58 and provides DC power to a DC-link 64 of the AC/AC converter 60, which in turn transfers DC power to a second rectifier/inverter-unit 66 of the AC/AC converter. The second rectifier/inverter-unit 66 inverts DC power into AC power and provides the AC power as an output e.g. to one of the driving means. The second rectifier/inverter-unit 66 is preferably adapted to receive AC power as an input of the AC/AC converter 60, e.g. from a regenerative braking device which can be comprised in a driving means. In such an embodiment, the second rectifier/inverter-unit 66 is adapted to rectify the received AC power and to provide DC power to the DC-link 64, which is adapted to receive DC power from the second rectifier/inverter-unit 66. In a preferred embodiment, the first rectifier/inverter-unit 62 is adapted to receive DC power from the DC-link 64, to invert the received DC power in AC power and to provide this AC power as an output of the AC/AC converter 60.

[0094] The DC-link 64 can comprise an energy storage C like a capacitor, a super capacitor or a battery, see e.g. the embodiment of Fig. 3. Preferably, the capacity of the energy storage C is increased, compared to a conventional AC/AC converter, in order to store energy obtained from a regenerative braking device without the need for transferring the energy through first rectifier/inverter-unit 62 for inversion and storage, since the addi-

tional transfer through first rectifier/inverter-unit 62 introduces additional energy losses.

[0095] In such a system, in the process described with respect to Fig. 4, when during mode switching from one of the non-compacting mode and the compacting mode to the other one of these modes, one of the first 32 and second 36 unbalanced masses is decelerated, an associated regenerative braking device can be used for deceleration, the obtained electrical recuperation energy can be provided to the second rectifier/inverter-unit 66, rectified, and stored in the energy storage C of the DC-link 64. When the above mentioned one of the first 32 and second 36 unbalanced masses is accelerated in order to complete the mode switching, the energy stored in the energy storage C of the DC-link 64 can be provided to the second rectifier/inverter-unit 66 and used as an input power of the driving means accelerating the mass to be accelerated. Thus, the process of switching from one of the non-compacting mode and the compacting mode to the other one of these modes can be carried out more energy efficient due to use of recuperation energy obtained during this switching.

[0096] Similarly, in the process described with respect to Figs. 6 and 7, the recuperation energy obtained from any, any combination or all, of the regenerative braking devices can be provided to the second rectifier/inverter-unit 66, rectified into DC-power, and stored in the energy storage C of the DC-link 64 before being inverted into AC-power and provided, via the second rectifier/inverter-unit 66, to any, any combination or all of the driving means.

[0097] Please note that the first written/inverter 62 can be replaced by a rectifier in case no energy transfer from the DC-link 64 via the first rectifier/inverter-unit 62 is needed. In a preferred embodiment instead of the single second rectifier/inverter-unit being connected to the DC-link 64 a plurality of second rectifier/inverter-units 66-1 to 66-3 are connected in parallel to the DC-link 64 via a first conducting bar 68 and a second conducting bar 70. Still only one first rectifier/inverter-unit 62 connected to the DC-link 64, not shown in Fig. 3, can be used, e.g. by connection to the first conducting bar 68 and the second conducting bar 70. Preferably, each of the second rectifier/inverter-units 66-1 to 66-3 comprises multiple circuit legs 72A to 72C, wherein the number of circuit legs corresponds to the number of phases of the driving means/regenerative braking device, the second rectifier/inverter-unit is connected to. Each of the circuit legs 72A to 72C connects the first conducting bar 68 with the second conducting bar 70 and comprises a first S1A; S1B; S1C and second switch S2A; S2B; S2C, connected in series; and a tab LA, LB, LB is connected between the first and second switch. Each of the tabs LA, LB, LB is connected to the corresponding phase terminal of the corresponding driving means/regenerative braking device. Each of the switches is connected in parallel with a diode, D1A, D2A; D1B, D2B; D1C, D2C as shown in Fig. 3.

[0098] Please note that each of the second inverter/rectifies 66-1, 66-2, 66-3 can show essentially the same setup and thus, the internal elements of the second inverter/converter 66-2 and 66-3 have not been provided with reference signs. The DC-link is also called the DC section in the art.

[0099] The switching of the switches S1A; S1B; S1C; S2A; S2B; S2C can be operated/performed by the associate motor controller 74-1, 74-2, 74-3 in order to control the corresponding energy flow in the second inverter/rectifier 66-1, 66-2, 66-3. Each of the motor controllers 74-1, 74-2, 74-3 is preferably controlled by the control unit 50.

[0100] The control unit is adapted to switch from the non-compacting mode to the compacting mode and vice versa by changing the above mentioned relative phase, wherein preferably the step of changing the relative phase comprises a first step of changing the rotation frequency of the first unbalanced mass, followed by a second step of changing the rotation frequency of the first unbalanced mass or/and the rotation frequency of the second unbalanced mass, wherein after the first step of changing the rotation frequency of the first unbalanced mass and the second step of changing the rotation frequency of the second unbalanced mass for the thus obtained rotational frequency ω_1' of the first unbalanced mass and the thus obtained rotational frequency ω_2' of the second unbalanced mass are equal, but may be different from the initial first and second rotational frequencies ω_1 and ω_2 .

[0101] The AC/AC converter 60 can be regarded as an embodiment of an energy management system of compactor device system.

[0102] The above-described compactor device system 22 allows to carry out the step of change the rotational frequency of the first unbalanced mass by the step of the decelerating the rotation of the first unbalanced mass by converting rotational energy of the first unbalanced mass into electrical recuperation energy using the first regenerative braking device. The electrical recuperation energy obtained in this step can be stored. In addition, the step of changing the rotation frequency of the first unbalanced mass can comprise a step of accelerating the rotation of the first unbalanced mass using the stored recuperation energy by means of the first driving means, preferably until the first rotation frequency, the step of change the rotational frequency has started from, is reached by the frequency of the rotation of the first unbalanced mass. Once the rotation frequency of the first unbalanced mass has been reduced and preferably the energy obtained from the corresponding regenerative braking device is stored, the relative angle between the first unbalanced mass and second unbalanced mass is changing over time, the first unbalanced mass needs to be accelerated in a step of acceleration in order to enter one of the compacting mode and the non-compacting mode, in particular using the stored recuperation energy by means of the first driving means 34, preferably until

the first rotation frequency is reached at which the process of the acceleration has started. However, in case the rotation frequency of the second unbalanced mass has changed, e.g. due to friction, the first unbalanced mass needs to be accelerated or changed until the rotation frequency of the second unbalanced mass is reached by the first unbalanced mass.

[0103] In addition, when the compactor device system 22 further comprises the third driving means 54 and the compactor device 28 is a compactor drum 30 and wherein the third driving means 54 is an electric motor capable to be driven as a generator, such that the third driving means comprises a third regenerative braking device, and when in the non-compacting mode the first unbalanced mass 32 and the second unbalanced mass 36 are adapted to form a flywheel energy storage, the method can further comprise the steps of rotating the compacting tool 28 by the third driving means 54, obtaining recuperation energy from the third regenerative braking device by converting rotational energy of the compactor drum 30 into recuperation energy, preferably during the process of braking of the movement of the compactor device system by braking the compactor drum 30 and supplying the recuperation energy to the flywheel energy storage. The flywheel energy storage is present in the non-compacting mode. The supplied recuperation energy is being stored in the flywheel energy storage by accelerating the first unbalanced mass 32 and the second unbalanced mass 36 while keeping the relative phase between the rotation of the first unbalanced mass 32 and the second unbalanced mass 26 constant, such that the non-compacting mode is maintained.

[0104] Preferably, when the compactor device system 22 comprises the first regenerative braking device and the second regenerative braking device, in order to accelerate the compacting device 28, preferably the compactor drum 30, the method further can comprise the step of obtaining recuperation energy from the flywheel energy storage, by obtaining first recuperation energy from the first regenerative braking device by decelerating the first unbalanced mass 32 thus converting its rotational energy into recuperation energy, preferably electrical recuperation energy and obtaining second recuperation energy, preferably second electrical recuperation energy using the second regenerative braking device by decelerating the second unbalanced mass and thus converting rotational energy of the second unbalanced mass 34 into recuperation energy while keeping the relative phase between the rotation of the first unbalanced mass 32 and the second unbalanced mass 26 constant. The electrical energy obtained can be used to accelerate the compacting tool, wherein the recuperation energy is preferably store the DC-Link 64, e.g. in the energy storage C, of the AC/AC converter 60.

[0105] It is possible, that the deceleration of the compacting tool 28 starts, while the compactor device system 22 is in the compacting mode. In this case it is possible to change the relative phase during the above described

acceleration of the first unbalanced mass 32 and the second unbalanced mass 26, such that, when the compacting tool 28 stops, the relative phase reaches a value such that the compactor device system 22 is in the non-compacting mode. This process can be controlled by the control unit 50.

[0106] In addition, it is possible, that the acceleration of the compacting tool 28 starts, while the compactor device system 22 is in the non-compacting mode. However, it is possible to change the relative phase during the above described deceleration of the first unbalanced mass 32 and the second unbalanced mass 26, such that, when the compacting tool 28 reaches an operation velocity, the relative phase reaches a value such that the compactor device system 22 is in the compacting mode. This process can be controlled by the control unit 50.

[0107] The inventors have realized that the compactor vehicle 20, usually comprising two compactor device systems 22 and 24 is facing significant stress on the frame of the compactor vehicle 20, in particular on a joint 76 of the frame used for steering the compactor vehicle 20, in case the forces created by the first compactor device system and the second compactor device system are not synchronized correctly.

[0108] It is to be noted that even though in the preferred embodiment the first and second compactor device system of the compactor vehicle is a compactor device system as described above, this aspect of the present invention also applies to compactor device systems adapted to generate an oscillating force without the possibility of entering the non-compacting mode. This may be the case for compactor device systems comprising a single unbalanced mass without any further means for creating a force countering the force created single unbalanced mass.

[0109] According to the invention the compactor vehicle 20 comprises a master control unit 26 which is adapted to control a relative orientation of the first and second oscillating force, created respectively by the first and second compactor device system, preferably such that the first and second oscillating force are parallel. This is achieved when the force vector F22 of the oscillating force created by the first compactor device system and the force vector F24 of the oscillating force created by the second compactor device system as a function of the time rotate with the same velocity in the same direction and point essentially the same direction, as can be seen for example in Fig. 9.

[0110] This state can be achieved for example by using rotary encoders providing a position information of each of the unbalanced masses in the first and second compactor device system as an input to master control unit 26. The master control unit 26 can provide control signals to control the rotational frequencies of all unbalanced masses, e.g. to be a common base frequency, and to control the absolute angular position of the unbalanced masses of the first and second compactor device systems, such that the force vectors F22 and F24 are parallel

and thus point in the same direction. The force vectors F22 and F24 can be calculated based on the directions of the centrifugal forces of the unbalanced masses in the first and second compactor device system.

[0111] In Fig. 8 an example is shown creating maximum stress on the frame of the compactor vehicle 20 due to first and second oscillating force vectors F22 and F24 pointing in different directions.

[0112] In case compactor device system 22 and 24 are compactor device systems according to the invention as described above, the master control unit 26 can command for each of the compactor device systems 22 and 24, the control unit of the respective compactor device system 22 and 24 to control the absolute phase of the first and second unbalanced masses of the corresponding compactor device system, to control the corresponding rotational frequencies of the first and second unbalanced mass, such that a common base frequency for both compactor device systems 22 and 24 exists. In particular, the absolute phases of the rotation of first unbalanced masses and the rotational frequencies of the first unbalanced masses of both compactor device system 22 and 24 are controlled to be equal and the absolute phases of the rotation of the first unbalanced masses and the rotational frequencies of the second unbalanced masses of both compactor device system 22 and 24 are controlled to be equal, such that the unbalanced masses of the compactor device system 22 and 24 move in unison resulting in parallel vectors of the forces created by the compactor device systems 22 and 24.

[0113] In each of the embodiments it is preferred that each of the driving means is an electrical driving means, preferably an electric motor adapted to function as a generator in a generator mode such that the regenerative braking device can be part of the driving means. However, is possible that the third driving means 54 of the compactor device system 22 is hydraulically powered, for example is a hydraulic motor.

[0114] The inventors have realized that at a given velocity the energy dissipation from a compactor device system is caused by friction and work done by compacting a surface, e.g. a road surface. Thus, given the energy dissipation at known parameters like travel speed of the compactor vehicle, rotational frequencies of first and second unbalanced masses of the above described compactor device system(s) 22 and 24, the measured energy loss per time can be used as a measure for the compaction obtained of the ground/surface. The compaction of the ground can be obtained by measuring the compaction of the ground with conventional means after the compactor device system has compacted the ground. The obtained values can be compared with the energy loss per time obtained from the compactor device system during compacting of the ground. This data can be interpolated and the obtained mapping can be used to map the measured energy loss per time of the compactor device system to a compaction of the ground. The energy loss per time can be measured by monitoring the power consumed by

the compactor device system.

[0115] The intensity of the compacting action of the compacting tool or respective compacting tool may be varied between a maximum compacting action achieved by the constructive addition of the forces created by rotation of the first unbalanced mass 32 and the second unbalanced mass 36 for the relative phase $\Delta\varphi=0^\circ$ and the vanishing or minimum compacting action achieved by the destructive addition of the forces created by rotation of the first unbalanced mass 32 and the second unbalanced mass 36 for the relative phase $\Delta\varphi=180^\circ$. To this end the control unit is configured to set the relative phase to a relative phase value $\Delta\varphi$ fulfilling the relation $0^\circ < \Delta\varphi < 180^\circ$. Preferably, a selected one of plural different predefined discrete relative phase values fulfilling this relation may be set, or the set relative phase may be varied continuously between 0° and 180° or within at least one subrange between 0° and 180° . The above concepts and explanations for switching between the compacting mode for $\Delta\varphi=0^\circ$ and the non-compacting mode for $\Delta\varphi=180^\circ$ apply analogously.

[0116] Selecting or adapting the intensity of the compacting action and therewith the ground compaction effect achieved allows to appropriately operate the compactor device system on difficult grounds or e.g. bridges.

Claims

1. Compactor device system (22, 24) comprising
 - a compacting tool (28);
 - a first driving means (34);
 - a first unbalanced mass (32) rotatable by the first driving means (34) at a first rotation frequency (w_1);
 - a second driving means (38);
 - a second unbalanced mass (36) rotatable by the second driving means (38) at a second rotation frequency (w_2);
 - wherein each of the first and second unbalanced mass (32; 36), when rotated by the respective driving means, is adapted to apply a respective oscillating force on the compacting tool (28);
 - a control unit (50) adapted to control the first rotation frequency (w_1) and the second rotation frequency (w_2), such that the first rotation frequency (w_1) equals the second rotation frequency (w_2); and
 - further adapted to control a relative phase between a rotation of the first unbalanced mass (32) and a rotation of the second unbalanced mass (36);
 - wherein the control unit (50) is further adapted to drive the compactor device system (22, 24) in a compacting mode by setting the relative phase to such a value, that forces created by rotation of the first unbalanced mass (32) and

- forces created by rotation of the second unbalanced mass (36) both contribute to a compacting action of the compacting tool (28);
characterized in that the compactor device system (22, 24) has a recuperation arrangement which is adapted to operate the first unbalanced mass (32) and the second unbalanced mass (36) as a flywheel energy storage in at least one operation mode of the compactor device system, wherein the flywheel energy storage is adapted to store a rotational energy of the rotating first unbalanced mass (32) and a rotational energy of the second rotating unbalanced mass, wherein the recuperation arrangement which is further adapted to store energy generated by regenerative braking in the flywheel energy storage and to withdraw energy stored in the flywheel energy storage for driving or supporting at least one function of the compactor device system (22, 24).
2. Compactor device system (22, 24) according to claim 1, wherein the control unit (50) is further adapted to drive the compactor device system (22, 24) in a non-compacting mode by setting the relative phase to such a value, that forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) add destructively for achieving minimum or no compacting action of the compacting tool, wherein the first unbalanced mass (32) and the second unbalanced mass (36) are operable as said flywheel energy storage at least in the non-compacting mode.
 3. Compactor device system (22, 24) according to claim 1 or 2, wherein the compacting tool (28) comprises a compactor drum (30) which is arranged to be rotatable about a drum axis and is adapted to directly contact the object or surface to be compacted, wherein the recuperation arrangement with the compactor drum (30) and the flywheel energy storage are adapted to rotationally drive or accelerate at least one of the first unbalanced mass (32) and the second unbalanced mass (36) on basis of rotational energy of the compactor drum and to rotationally drive or accelerate the compactor drum on basis of energy stored in the flywheel energy storage.
 4. Compactor device system (22, 24) according to one of claims 1 to 3, wherein the control unit (50) is further adapted to drive the compactor device system (22, 24) in the compacting mode by setting the relative phase to an intermediate value, preferably a selected one of plural intermediate values or within an intermediate value range, between a first value, which provides that forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) add constructively for achieving maximum compacting action of the compacting tool (28) and a second value, which provides that forces created by rotation of the second unbalanced mass (36) add destructively for achieving minimum or no compacting action of the compacting tool, such that for the intermediate value being set forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) contribute to compacting action of the compacting tool (28).
 5. Compactor device system according to one of claims 1 to 4, wherein the control unit (50) is adapted to change the rotation frequency of at least one of the first unbalanced mass (32) and the second unbalanced mass (33) such that the value of the relative phase changes from a value having been set to another value to be set, preferably to switch from one of the non-compacting mode and the compacting mode to the other one of the non-compacting mode and the compacting mode or to change the intensity of the compacting action of the compacting tool (28).
 6. Compactor device system (22, 24) according to any one of claims 1 to 5, further comprising
 - a third driving means (54), wherein the compacting tool (28) is a compactor drum (30) adapted to directly contact the object or surface to be compacted, and wherein the compacting tool (28) is rotatable by the third driving means (54);
 - a third regenerative braking device adapted to convert rotational energy of the compacting tool (28) into recuperation energy, in particular into electrical recuperation energy;
 - wherein the compactor device system (22, 24) is adapted to store recuperation energy obtained from converting rotational energy of the compacting tool (28) in the flywheel energy storage by accelerating the first unbalanced mass (32) using the first driving means (34) and the second unbalanced mass (36) using the second driving means (38) in the non-compacting mode.
 7. Compactor device system (22, 24) according to any of the preceding claims, further comprising
 - a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass (32) into recuperation energy, in particular into electrical recuperation energy; or/and
 - a second regenerative braking device adapted to convert rotational energy of the second unbalanced mass (36) into recuperation energy, in particular into electrical recuperation energy; and preferably
 - a storage device (C) adapted to store the recuperation energy;

wherein the compactor device system (22, 24) is adapted to accelerate the compacting tool (28) using recuperation energy obtained from the first or/and second regenerative braking device, which has preferably been stored in the storage device (C). 5

8. Method for operating a compactor device system (22, 24), the compactor device system (22, 24) comprising

a compacting tool (28);
 a first driving means (34);
 a first unbalanced mass (32) rotatable by the first driving means (34) at a first rotation frequency (w_1);
 a second driving means (38);
 a second unbalanced mass (36) rotatable by the second driving means (38) at a second rotation frequency (w_2);
 wherein each of the first and second unbalanced mass (32; 36), when rotated by the respective driving means, is adapted to apply a respective oscillating force to the compacting tool (28);
 a control unit (50) adapted to control the first rotation frequency (ω_1) and the second rotation frequency (ω_2), such that the first rotation frequency (ω_1) equals the second rotation frequency (ω_2); and
 further adapted to control a relative phase between a rotation of the first unbalanced mass (32) and a rotation of the second unbalanced mass (36);
 the method comprising the steps of:

rotating the first unbalanced mass (32) at a first rotation frequency,
 rotating the second unbalanced mass (36) at a second rotation frequency;
 controlling the first rotation frequency (ω_1) to be equal to the second rotation frequency (ω_2);
 driving the compactor device system (22, 24) in a compacting mode by setting the relative phase to such a value that forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) both contribute to a compacting action of the compacting tool (28); **characterized in that** the first unbalanced mass (32) and the second unbalanced mass (36) are operated as a flywheel energy storage in at least one operation mode of the compactor device system, wherein the flywheel energy storage stores a rotational energy of the rotating first unbalanced mass (32) and a rotational energy of the second rotating unbalanced mass,

wherein the method comprises the step to store energy generated by regenerative braking in the flywheel energy storage and the step to withdraw energy from the flywheel energy storage for driving or supporting at least one function of the compactor device system (22, 24).

9. Method for operating a compactor device system (22, 24) according to claim 8, wherein the compactor device system (22, 24) is driven in a non-compacting mode by setting the relative phase to such a value that forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) add destructively for achieving minimum or no compacting action of the compacting tool, wherein the first unbalanced mass (32) and the second unbalanced mass (36) are operable as said flywheel energy storage at least in the non-compacting mode. 10
10. Method for operating a compactor device system (22, 24) according to claim 8 or 9, wherein the compacting tool (28) comprises a compactor drum (30) which is arranged to be rotatable about a drum axis and is adapted to directly contact the object or surface to be compacted, wherein the method comprises to rotationally drive or accelerate at least one of the first unbalanced mass (32) and the second unbalanced mass (36) on basis of rotational energy of the compactor drum and comprises to rotationally drive or accelerate the compactor drum on basis of energy stored in the flywheel energy storage. 20
11. Method of operating a compactor device system (22, 24) according to one of claims 8 to 10, comprising to drive the compactor device system (22, 24) in the compacting mode by setting the relative phase to an intermediate value, preferably a selected one of plural intermediate values or within an intermediate value range, between a first value, which provides that forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) add constructively for achieving maximum compacting action of the compacting tool (28) and a second value, which provides that forces created by rotation of the second unbalanced mass (36) add destructively for achieving minimum or no compacting action of the compacting tool, such that for the intermediate value being set forces created by rotation of the first unbalanced mass (32) and forces created by rotation of the second unbalanced mass (36) contribute to compacting action of the compacting tool (28). 25
12. Method for operating a compactor device system according to one of claims 8 to 11, comprising to change the rotation frequency of at least one of the 30

first unbalanced mass (32) and the second unbalanced mass (33) such that the value of the relative phase changes from a value having been set to another value to be set, preferably to switch from one of the non-compacting mode and the compacting mode to the other one of the non-compacting mode and the compacting mode or to change the intensity of the compacting action of the compacting tool (28).

13. Method for operating a compactor device system (22, 24) according to any of the claims 8 to 12, wherein the compactor device system (22, 24) is further comprising

a third driving means (54), wherein the compacting tool (28) is a compactor drum (30) adapted to directly contact the object or surface to be compacted, and
 a third regenerative braking device adapted to convert rotational energy of the compacting tool (28) into recuperation energy, in particular into electrical recuperation energy;
 wherein in the non-compacting mode the first unbalanced mass (32) and the second unbalanced mass (36) form a flywheel energy storage adapted to store a rotational energy of the rotating first unbalanced mass (32) and a rotational energy of the second rotating unbalanced mass, the method further comprising the steps of:

rotating the compacting tool (28) by the third driving means (54);
 obtaining recuperation energy from the third regenerative braking device by converting rotational energy of the compacting tool (28) into recuperation energy;
 preferably storing the recuperation energy in a storage device (C) of the compactor device system (22, 24);
 supplying the recuperation energy to supply the flywheel energy storage.

14. Method for operating a compactor device system (22, 24) according to any of the claims 8 to 13, wherein the compactor device system (22, 24) is further comprising

a first regenerative braking device adapted to convert rotational energy of the first unbalanced mass (32) into recuperation energy, in particular into electrical recuperation energy;
 a second regenerative braking device adapted to convert rotational energy of the second unbalanced mass (36) into recuperation energy, in particular into electrical recuperation energy;
 the method further comprising the steps of:

rotating the first unbalanced mass (32) and

the second unbalanced mass (36) in the non-compacting mode;
 obtaining first recuperation energy from the first regenerative braking device by converting rotational energy of the first unbalanced mass (32) into recuperation energy;
 obtaining second recuperation energy from the second regenerative braking device by converting rotational energy of the second unbalanced mass (36) into recuperation energy;
 preferably storing the first recuperation energy or/and the second recuperation energy in a storage device (C) of the compactor device system (22, 24);
 accelerating the compacting tool (28) using first and second recuperation energy.

15. Compactor vehicle comprising:

a first compactor device system (22, 24), according to any of the claims 1 to 7, adapted to generate a first oscillating force acting on at least some of mounting elements of the compactor vehicle for the first compactor device system (22, 24);
 a second compactor device system (22, 24), according to any of the claims 1 to 7, adapted to generate a second oscillating force acting on at least some of mounting elements of the compactor vehicle for the second compactor device system (22, 24); and
 a master control unit (26) adapted to control a relative orientation of the first and second oscillating force, preferably adapted to control the relative orientation of the first and second oscillating force such that the first and second oscillating force are parallel.

Patentansprüche

1. Verdichtervorrichtungssystem (22, 24), umfassend:

ein Verdichtungswerkzeug (28);
 ein erstes Antriebsmittel (34);
 eine erste Unwuchtmasse (32), welche durch das erste Antriebsmittel (34) mit einer ersten Rotationsfrequenz (w_1) rotierbar ist;
 ein zweites Antriebsmittel (38);
 eine zweite Unwuchtmasse (36), welche durch das zweite Antriebsmittel (38) mit einer zweiten Rotationsfrequenz (w_2) rotierbar ist;
 wobei jede der ersten und der zweiten Unwuchtmasse (32; 36), wenn sie von den jeweiligen Antriebsmitteln rotiert werden, dazu eingerichtet ist, eine jeweilige oszillierende Kraft auf dem Verdichtungswerkzeug (28) auszuüben;

eine Steuereinheit (50), welche dazu eingerichtet ist, die erste Rotationsfrequenz (w_1) und die zweite Rotationsfrequenz (w_2) derart zu steuern, dass die erste Rotationsfrequenz (w_1) der zweiten Rotationsfrequenz (w_2) entspricht; und ferner dazu eingerichtet ist, eine relative Phase zwischen einer Rotation der ersten Unwuchtmasse (32) und einer Rotation der zweiten Unwuchtmasse (36) zu steuern;

wobei die Steuereinheit (50) ferner dazu eingerichtet ist, das Verdichtervorrichtungssystem (22, 24) durch Einstellen der relativen Phase auf einen derartigen Wert in einem Verdichtungsmodus anzutreiben, dass sowohl durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte als auch durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte zu einer Verdichtungswirkung des Verdichtungswerkzeugs (28) beitragen;

dadurch gekennzeichnet, dass das Verdichtervorrichtungssystem (22, 24) eine Rückgewinnungsanordnung aufweist, welche dazu eingerichtet ist, die erste Unwuchtmasse (32) und die zweite Unwuchtmasse (36) als Schwungradenergiespeicher in wenigstens einem Betriebsmodus des Verdichtervorrichtungssystems zu betreiben, wobei der Schwungradenergiespeicher dazu eingerichtet ist, eine Rotationsenergie der rotierenden ersten Unwuchtmasse (32) und eine Rotationsenergie der zweiten rotierenden Unwuchtmasse zu speichern, wobei die Rückgewinnungsanordnung ferner dazu eingerichtet ist, Energie zu speichern, welche durch regeneratives Bremsen in dem Schwungradenergiespeicher erzeugt worden ist, und Energie zu entziehen, welche in dem Schwungradenergiespeicher gespeichert ist, zum Antreiben oder Unterstützen wenigstens einer Funktion des Verdichtervorrichtungssystems (22, 24).

2. Verdichtervorrichtungssystem (22, 24) nach Anspruch 1, wobei die Steuereinheit (50) ferner dazu eingerichtet ist, das Verdichtervorrichtungssystem (22, 24) in einem Nichtverdichtungsmodus durch Einstellen der relativen Phase auf einen derartigen Wert anzutreiben, dass durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte und durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte destruktiv zum Erreichen einer minimalen oder keiner Verdichtungswirkung des Verdichtungswerkzeugs beitragen, wobei die erste Unwuchtmasse (32) und die zweite Unwuchtmasse (36) wenigstens in dem Nichtverdichtungsmodus als der Schwungradenergiespeicher betriebsbereit sind.
3. Verdichtervorrichtungssystem (22, 24) nach Anspruch 1 oder 2, wobei das Verdichtungswerkzeug

(28) eine Verdichtertrommel (30) umfasst, welche derart angeordnet ist, dass sie um eine Trommelachse rotierbar ist und dazu eingerichtet ist, das/die zu verdichtende Objekt oder Fläche direkt zu kontaktieren, wobei die Rückgewinnungsanordnung mit der Verdichtertrommel (30) und dem Schwungradenergiespeicher dazu eingerichtet ist, wenigstens eine aus der ersten Unwuchtmasse (32) und der zweiten Unwuchtmasse (36) auf Grundlage einer Rotationsenergie der Verdichtertrommel rotierbar anzutreiben oder zu beschleunigen und die Verdichtertrommel auf Grundlage in dem Schwungradenergiespeicher gespeicherter Energie rotierbar anzutreiben.

4. Verdichtervorrichtungssystem (22, 24) nach einem der Ansprüche 1 bis 3, wobei die Steuereinheit (50) ferner dazu eingerichtet ist, das Verdichtervorrichtungssystem (22, 24) in dem Verdichtungsmodus durch Einstellen der relativen Phase auf einen Zwischenwert anzutreiben, welcher vorzugsweise ein Ausgewählter ist aus mehreren Zwischenwerten oder innerhalb eines Zwischenwertbereichs zwischen einem ersten Wert, welcher gewährleistet, dass durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte und durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte konstruktiv zum Erreichen einer maximalen Verdichtungswirkung des Verdichtungswerkzeugs (28) beitragen, und einem zweiten Wert liegt, welcher gewährleistet, dass durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte destruktiv zum Erreichen einer minimalen oder keiner Verdichtungswirkung des Verdichtungswerkzeugs beitragen, so dass für den eingestellten Zwischenwert durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte und durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte zur Verdichtungswirkung des Verdichtungswerkzeugs (28) beitragen.

5. Verdichtervorrichtungssystem nach einem der Ansprüche 1 bis 4, wobei die Steuereinheit (50) dazu eingerichtet ist, die Rotationsfrequenz wenigstens einer aus der ersten Unwuchtmasse (32) und der zweiten Unwuchtmasse (36) zu ändern, so dass sich der Wert der relativen Phase von einem Wert, welcher eingestellt worden ist, auf einen einzustellenden Wert ändert, vorzugsweise, um von einem Nichtverdichtungsmodus und dem Verdichtungsmodus zu dem anderen des Nichtverdichtungsmodus und des Verdichtungsmodus zu wechseln oder um die Intensität der Verdichtungswirkung des Verdichtungswerkzeugs (28) zu ändern.

6. Verdichtervorrichtungssystem (22, 24) nach einem der Ansprüche 1 bis 5, ferner umfassend:

ein drittes Antriebsmittel (54), wobei das Ver-

dichtungswerkzeug (28) eine Verdichtertrommel (30) ist, welche dazu eingerichtet ist, das/die zu verdichtende Objekt oder Fläche direkt zu kontaktieren, und wobei das Verdichtungswerkzeug (28) durch das dritte Antriebsmittel (54) 5 rotierbar ist;
 eine dritte regenerative Bremsvorrichtung, welche dazu eingerichtet ist, Rotationsenergie des Verdichtungswerkzeugs (28) in Rückgewinnungsenergie zu konvertieren, insbesondere in elektrische Rückgewinnungsenergie; 10
 wobei das Verdichtervorrichtungssystem (22, 24) dazu eingerichtet ist, Rückgewinnungsenergie zu speichern, welche aus einer Konvertierung von Rotationsenergie des Verdichtungswerkzeugs (28) in dem Schwungradenergiespeicher durch Beschleunigen der ersten Unwuchtmasse (32) unter Verwendung des ersten Antriebsmittels (34) und der zweiten Unwuchtmasse (36) unter Verwendung des zweiten Antriebsmittels (38) in dem Nichtverdichtungsmodus erhalten worden ist. 15 20

7. Verdichtervorrichtungssystem (22, 24) nach einem der vorhergehenden Ansprüche, ferner umfassend: 25

eine erste regenerative Bremsvorrichtung, welche dazu eingerichtet ist, Rotationsenergie der ersten Unwuchtmasse (32) in Rückgewinnungsenergie zu konvertieren, insbesondere in elektrische Rückgewinnungsenergie; oder/und eine zweite regenerative Bremsvorrichtung, welche dazu eingerichtet ist, Rotationsenergie der zweiten Unwuchtmasse (36) in Rückgewinnungsenergie zu konvertieren, insbesondere in elektrische Rückgewinnungsenergie; und vorzugsweise 30
 eine Speichervorrichtung (C), welche dazu eingerichtet ist, die Rückgewinnungsenergie zu speichern; 35
 wobei das Verdichtervorrichtungssystem (22, 24) dazu eingerichtet ist, das Verdichtungswerkzeug (28) unter Verwendung von Rückgewinnungsenergie zu beschleunigen, welche von der ersten oder/und der zweiten regenerativen Bremsvorrichtung erhalten worden ist und welche vorzugsweise in der Speichervorrichtung (C) gespeichert worden ist. 40 45

8. Verfahren zum Betreiben eines Verdichtervorrichtungssystems (22, 24), wobei das Verdichtervorrichtungssystems (22, 24) umfasst: 50

ein Verdichtungswerkzeug (28);
 ein erstes Antriebsmittel (34); 55
 eine erste Unwuchtmasse (32), welche durch das erste Antriebsmittel (34) mit einer ersten Rotationsfrequenz (ω_1) rotierbar ist;

ein zweites Antriebsmittel (38);
 eine zweite Unwuchtmasse (36), welche durch das zweite Antriebsmittel (38) mit einer zweiten Rotationsfrequenz (ω_2) rotierbar ist;
 wobei jede der ersten und der zweiten Unwuchtmasse (32; 36), wenn sie von den jeweiligen Antriebsmitteln rotiert werden, dazu eingerichtet ist, eine jeweilige oszillierende Kraft auf dem Verdichtungswerkzeug (28) auszuüben;
 eine Steuereinheit (50), welche dazu eingerichtet ist, die erste Rotationsfrequenz (ω_1) und die zweite Rotationsfrequenz (ω_2) derart zu steuern, dass die erste Rotationsfrequenz (ω_1) der zweiten Rotationsfrequenz (ω_2) entspricht; und ferner dazu eingerichtet ist, eine relative Phase zwischen einer Rotation der ersten Unwuchtmasse (32) und einer Rotation der zweiten Unwuchtmasse (36) zu steuern;
 wobei das Verfahren die Schritte umfasst:

Rotieren der ersten Unwuchtmasse (32) mit einer ersten Rotationsfrequenz,
 Rotieren der zweiten Unwuchtmasse (36) mit einer zweiten Rotationsfrequenz;
 Steuern der ersten Rotationsfrequenz (ω_1), um der zweiten Rotationsfrequenz (ω_2) zu entsprechen;
 Antreiben des Verdichtervorrichtungssystems (22, 24) in einem Verdichtungsmodus durch Einstellen der relativen Phase auf einen derartigen Wert, dass sowohl durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte als auch durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte zu einer Verdichtungswirkung des Verdichtungswerkzeugs (28) beitragen;
dadurch gekennzeichnet, dass die erste Unwuchtmasse (32) und die zweite Unwuchtmasse (36) in wenigstens einem Betriebsmodus des Verdichtervorrichtungssystems als Schwungradenergiespeicher betrieben werden, wobei der Schwungradenergiespeicher eine Rotationsenergie der ersten rotierenden Unwuchtmasse (32) und eine Rotationsenergie der zweiten rotierenden Unwuchtmasse speichert,
 wobei das Verfahren den Schritt zum Speichern von Energie, welche durch regeneratives Bremsen in dem Schwungradenergiespeicher erzeugt wird, und den Schritt zum Entziehen von Energie von dem Schwungradenergiespeicher zum Antreiben oder Unterstützen wenigstens einer Funktion des Verdichtervorrichtungssystems (22, 24) umfasst. 60 65

9. Verfahren zum Betreiben eines Verdichtervorrichtungssystems (22, 24) nach Anspruch 8, wobei das

Verdichtervorrichtungssystem (22, 24) in einem Nichtverdichtungsmodus durch Einstellen der relativen Phase auf einen derartigen Wert angetrieben wird, so dass durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte und durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte destruktiv zum Erreichen einer minimalen oder keiner Verdichtungswirkung des Verdichtungswerkzeugs beitragen, wobei die erste Unwuchtmasse (32) und die zweite Unwuchtmasse (36) wenigstens in dem Nichtverdichtungsmodus als der Schwungradenergiespeicher betriebsbereit sind.

10. Verfahren zum Betreiben eines Verdichtervorrichtungssystems (22, 24) nach Anspruch 8 oder 9, wobei das Verdichtungswerkzeug (28) eine Verdichtertrommel (30) umfasst, welche derart angeordnet ist, dass sie um eine Trommelachse rotierbar ist und dazu eingerichtet ist, das/die zu verdichtende Objekt oder Fläche direkt zu kontaktieren, wobei das Verfahren umfasst wenigstens eine der ersten Unwuchtmasse (32) und der zweiten Unwuchtmasse (36) auf Grundlage von Rotationsenergie der Verdichtertrommel rotierbar anzutreiben oder zu beschleunigen, und umfasst die Verdichtertrommel auf Grundlage von in dem Schwungradenergiespeicher gespeicherten Energie rotierbar anzutreiben oder zu beschleunigen.

11. Verfahren zum Betreiben eines Verdichtervorrichtungssystems (22, 24) nach einem der Ansprüche 8 bis 10, umfassend das Verdichtervorrichtungssystem (22, 24) in dem Verdichtungsmodus durch Einstellen der relativen Phase auf einen Zwischenwert anzutreiben, welcher vorzugsweise ein Ausgewählter ist aus mehreren Zwischenwerten oder innerhalb eines Zwischenwertbereichs zwischen einem ersten Wert, welcher gewährleistet, dass durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte und durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte konstruktiv zum Erreichen einer maximalen Verdichtungswirkung des Verdichtungswerkzeugs (28) beitragen, und einem zweiten Wert liegt, welcher gewährleistet, dass durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte destruktiv zum Erreichen einer minimalen oder keiner Verdichtungswirkung des Verdichtungswerkzeugs beitragen, so dass für den eingestellten Zwischenwert durch Rotation der ersten Unwuchtmasse (32) entstandene Kräfte und durch Rotation der zweiten Unwuchtmasse (36) entstandene Kräfte zur Verdichtungswirkung des Verdichtungswerkzeugs (28) beitragen.

12. Verfahren zum Betreiben eines Verdichtervorrichtungssystems nach einem der Ansprüche 8 bis 11, umfassend die Rotationsfrequenz wenigstens einer aus der ersten Unwuchtmasse (32) und der zweiten

Unwuchtmasse (33) zu ändern, so dass sich der Wert der relativen Phase von einem Wert, welcher eingestellt worden ist, auf einen einzustellenden Wert ändert, vorzugsweise, um von einem Nichtverdichtungsmodus und dem Verdichtungsmodus zu dem anderen des Nichtverdichtungsmodus und des Verdichtungsmodus zu wechseln oder um die Intensität der Verdichtungswirkung des Verdichtungswerkzeugs (28) zu ändern.

13. Verfahren zum Betreiben eines Verdichtervorrichtungssystems (22, 24) nach einem der Ansprüche 8 bis 12, wobei das Verdichtervorrichtungssystem (22, 24) ferner umfasst:

ein drittes Antriebsmittel (54), wobei das Verdichtungswerkzeug (28) eine Verdichtertrommel (30) ist, welche dazu eingerichtet ist, das/die zu verdichtende Objekt oder Fläche direkt zu kontaktieren, und

eine dritte regenerative Bremsvorrichtung, welche dazu eingerichtet ist, Rotationsenergie des Verdichtungswerkzeugs (28) in Rückgewinnungsenergie zu konvertieren, insbesondere in elektrische Rückgewinnungsenergie;

wobei die erste Unwuchtmasse (32) und die zweite Unwuchtmasse (36) in dem Nichtverdichtungsmodus einen Schwungradenergiespeicher bilden, welcher dazu eingerichtet ist, eine Rotationsenergie der rotierenden ersten Unwuchtmasse (32) und eine Rotationsenergie der zweiten rotierenden Unwuchtmasse zu speichern,

wobei das Verfahren ferner die Schritte umfasst:

Rotieren des Verdichtungswerkzeugs (28) durch das dritte Antriebsmittel (54);

Erhalten von Rückgewinnungsenergie von der dritten regenerativen Bremsvorrichtung durch Konvertieren von Rotationsenergie des Verdichtungswerkzeugs (28) in Rückgewinnungsenergie;

vorzugsweise Speichern der Rückgewinnungsenergie in einer Speichervorrichtung (C) des Verdichtervorrichtungssystems (22, 24);

Bereitstellen der Rückgewinnungsenergie zum Bereitstellen des Schwungradenergiespeichers.

14. Verfahren zum Betreiben eines Verdichtervorrichtungssystems (22, 24) nach einem der Ansprüche 8 bis 13, wobei das Verdichtervorrichtungssystem (22, 24) ferner umfasst:

eine erste regenerative Bremsvorrichtung, welche dazu eingerichtet ist, Rotationsenergie der ersten Unwuchtmasse (32) in Rückgewin-

nungsenergie zu konvertieren, insbesondere in elektrische Rückgewinnungsenergie;
eine zweite regenerative Bremsvorrichtung, welche dazu eingerichtet ist, Rotationsenergie der zweiten Unwuchtmasse (36) in Rückgewinnungsenergie zu konvertieren, insbesondere in elektrische Rückgewinnungsenergie;
wobei das Verfahren ferner die Schritte umfasst:

Rotieren der ersten Unwuchtmasse (32) und der zweiten Unwuchtmasse (36) in dem Nichtverdichtungsmodus;
Erhalten von erster Rückgewinnungsenergie von der ersten regenerativen Bremsvorrichtung durch Konvertieren von Rotationsenergie der ersten Unwuchtmasse (32) in Rückgewinnungsenergie;
Erhalten von zweiter Rückgewinnungsenergie von der zweiten regenerativen Bremsvorrichtung durch Konvertieren von Rotationsenergie der zweiten Unwuchtmasse (36) in Rückgewinnungsenergie;
vorzugsweise Speichern der ersten Rückgewinnungsenergie oder/und der zweiten Rückgewinnungsenergie in einer Speichervorrichtung (C) des Verdichtervorrichtungssystems (22, 24);
Beschleunigen des Verdichtungswerkzeugs (28) unter Verwendung der ersten und der zweiten Rückgewinnungsenergie.

15. Verdichterfahrzeug, umfassend:

ein erstes Verdichtervorrichtungssystem (22, 24) nach einem der Ansprüche 1 bis 7, welches dazu eingerichtet ist, eine erste oszillierende Kraft zu erzeugen, welche auf wenigstens einige von Befestigungselementen des Verdichterfahrzeugs für das erste Verdichtervorrichtungssystem (22, 24) wirkt;
ein zweites Verdichtervorrichtungssystem (22, 24) nach einem der Ansprüche 1 bis 7, welches dazu eingerichtet ist, eine zweite oszillierende Kraft zu erzeugen, welche auf wenigstens einige von Befestigungselementen des Verdichterfahrzeugs für das zweite Verdichtervorrichtungssystem (22, 24) wirkt; und
eine Master-Steuereinheit (26), welche dazu eingerichtet ist, eine relative Orientierung der ersten und der zweiten oszillierenden Kraft zu steuern, und vorzugsweise dazu eingerichtet ist, die relative Orientierung der ersten und der zweiten oszillierenden Kraft derart zu steuern, dass die erste und die zweite oszillierende Kraft parallel sind.

Revendications

1. Système de dispositif compacteur (22, 24) comprenant

un outil de compactage (28) ;
des premiers moyens d'entraînement (34) ;
une première masse déséquilibrée (32) pouvant être mise en rotation par les premiers moyens d'entraînement (34) à une première fréquence de rotation (w_1) ;
des deuxièmes moyens d'entraînement (38) ;
une seconde masse déséquilibrée (36) pouvant être mise en rotation par les deuxièmes moyens d'entraînement (38) à une seconde fréquence de rotation (w_2) ; dans lequel chacune des première et seconde masses déséquilibrées (32 ; 36), lorsqu'elles sont tournées par les moyens d'entraînement respectifs, est adaptée pour appliquer une force oscillante respective sur l'outil de compactage (28) ;
une unité de commande (50) adaptée pour commander la première fréquence de rotation (w_1) et la seconde fréquence de rotation (w_2), de telle sorte que la première fréquence de rotation (w_1) est égale à la seconde fréquence de rotation (w_2); et adaptée en outre pour commander une phase relative entre une rotation de la première masse déséquilibrée (32) et une rotation de la seconde masse déséquilibrée (36) ;
dans lequel l'unité de commande (50) est en outre adaptée pour entraîner le système de dispositif compacteur (22, 24) dans un mode de compactage en établissant la phase relative à une valeur telle que des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) contribuent ensemble à une action de compactage de l'outil de compactage (28) ;
caractérisé en ce que le système de dispositif compacteur (22, 24) a un équipement de récupération qui est adapté pour faire fonctionner la première masse déséquilibrée (32) et la seconde masse déséquilibrée (36) en tant que stockage d'énergie à volant d'inertie dans au moins un mode de fonctionnement du système de dispositif compacteur, dans lequel le stockage d'énergie à volant d'inertie est adapté pour stocker une énergie de rotation de la première masse déséquilibrée (32) rotative et une énergie de rotation de la seconde masse déséquilibrée rotative, dans lequel l'équipement de récupération est en outre adapté pour stocker de l'énergie générée par un freinage régénératif dans le stockage d'énergie à volant d'inertie et pour extraire de l'énergie stockée dans le stockage d'énergie à volant d'inertie pour entraîner ou

- supporter au moins une fonction du système de dispositif compacteur (22, 24).
2. Système de dispositif compacteur (22, 24) selon la revendication 1, dans lequel l'unité de commande (50) est en outre adaptée pour entraîner le système de dispositif compacteur (22, 24) dans un mode de non-compactage en établissant la phase relative à une valeur telle que des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) s'additionnent de manière destructive pour obtenir une action de compactage minimal ou de non-compactage de l'outil de compactage, dans lequel la première masse déséquilibrée (32) et la seconde masse déséquilibrée (36) peuvent fonctionner en tant que ledit stockage d'énergie à volant d'inertie au moins dans le mode de non-compactage.
 3. Système de dispositif compacteur (22, 24) selon la revendication 1 ou 2, dans lequel l'outil de compactage (28) comprend un tambour compacteur (30) qui est agencé pour pouvoir tourner autour d'un axe de tambour et est adapté pour entrer directement en contact avec l'objet ou la surface à compacter, dans lequel l'équipement de récupération avec le tambour compacteur (30) et le stockage d'énergie à volant d'inertie sont adaptés pour entraîner ou accélérer en rotation au moins l'une de la première masse déséquilibrée (32) et de la seconde masse déséquilibrée (36) sur la base d'une énergie de rotation du tambour compacteur et entraîner ou accélérer en rotation le tambour compacteur sur la base d'une énergie stockée dans le stockage d'énergie à volant d'inertie.
 4. Système de dispositif compacteur (22, 24) selon l'une quelconque des revendications 1 à 3, dans lequel l'unité de commande (50) est en outre adaptée pour entraîner le système de dispositif compacteur (22, 24) dans le mode de compactage en établissant la phase relative à une valeur intermédiaire, de préférence l'une sélectionnée parmi plusieurs valeurs intermédiaires ou dans une plage de valeurs intermédiaires, entre une première valeur, qui assure que des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) s'additionnent de manière constructive pour obtenir une action de compactage maximal de l'outil de compactage (28) et une seconde valeur, qui assure que des forces créées par rotation de la seconde masse déséquilibrée (36) s'additionnent de manière destructive pour obtenir une action de compactage minimal ou de non-compactage de l'outil de compactage, de telle sorte que, pour la valeur intermédiaire qui est établie, des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36)
 5. Système de dispositif compacteur selon l'une des revendications 1 à 4, dans lequel l'unité de commande (50) est adaptée pour changer la fréquence de rotation d'au moins l'une de la première masse déséquilibrée (32) et de la seconde masse déséquilibrée (33) de telle sorte que la valeur de la phase relative change d'une valeur ayant été établie en une autre valeur à établir, de préférence pour passer de l'un du mode de non-compactage et du mode de compactage à l'autre du mode de non-compactage et du mode de compactage ou pour changer l'intensité de l'action de compactage de l'outil de compactage (28).
 6. Système de dispositif compacteur (22, 24) selon l'une quelconque des revendications 1 à 5, comprenant en outre
 - des troisièmes moyens d'entraînement (54), dans lequel l'outil de compactage (28) est un tambour compacteur (30) adapté pour entrer directement en contact avec l'objet ou la surface à compacter, et dans lequel l'outil de compactage (28) peut être mis en rotation par les troisièmes moyens d'entraînement (54) ;
 - un troisième dispositif de freinage régénératif adapté pour convertir de l'énergie de rotation de l'outil de compactage (28) en énergie de récupération, en particulier en énergie électrique de récupération ;
 - dans lequel le système de dispositif compacteur (22, 24) est adapté pour stocker de l'énergie de récupération obtenue en convertissant de l'énergie de rotation de l'outil de compactage (28) dans le stockage d'énergie à volant d'inertie en accélérant la première masse déséquilibrée (32) en utilisant les premiers moyens d'entraînement (34) et la seconde masse déséquilibrée (36) en utilisant les deuxièmes moyens d'entraînement (38) dans le mode de non-compactage.
 7. Système de dispositif compacteur (22, 24) selon l'une quelconque des revendications précédentes, comprenant en outre
 - un premier dispositif de freinage régénératif adapté pour convertir de l'énergie de rotation de la première masse déséquilibrée (32) en énergie de récupération, en particulier en énergie électrique de récupération ; ou/et
 - un deuxième dispositif de freinage régénératif adapté pour convertir de l'énergie de rotation de la seconde masse déséquilibrée (36) en énergie de récupération, en particulier en énergie électrique de récupération ; et de préférence un dis-

positif de stockage (C) adapté pour stocker l'énergie de récupération ;
 dans lequel le système de dispositif compacteur (22, 24) est adapté pour accélérer l'outil de compactage (28) en utilisant de l'énergie de récupération obtenue auprès du premier ou/et du deuxième dispositif de freinage régénératif, qui a de préférence été stockée dans le dispositif de stockage (C).

8. Procédé de fonctionnement d'un système de dispositif compacteur (22, 24), le système de dispositif compacteur (22, 24) comprenant

un outil de compactage (28) ;
 des premiers moyens d'entraînement (34) ;
 une première masse déséquilibrée (32) pouvant être mise en rotation par les premiers moyens d'entraînement (34) à une première fréquence de rotation (w_1) ;
 des deuxièmes moyens d'entraînement (38) ;
 une seconde masse déséquilibrée (36) pouvant être mise en rotation par les deuxièmes moyens d'entraînement (38) à une seconde fréquence de rotation (w_2) ; dans lequel chacune des première et seconde masses déséquilibrées (32 ; 36), lorsqu'elles sont tournées par les moyens d'entraînement respectifs, est adaptée pour appliquer une force oscillante respective sur l'outil de compactage (28) ;
 une unité de commande (50) adaptée pour commander la première fréquence de rotation (ω_1) et la seconde fréquence de rotation (ω_2), de telle sorte que la première fréquence de rotation (ω_1) est égale à la seconde fréquence de rotation (ω_2) ; et adaptée en outre pour commander une phase relative entre une rotation de la première masse déséquilibrée (32) et une rotation de la seconde masse déséquilibrée (36) ;
 le procédé comprenant les étapes consistant à :

faire tourner la première masse déséquilibrée (32) à une première fréquence de rotation,
 faire tourner la seconde masse déséquilibrée (36) à une seconde fréquence de rotation ;
 commander la première fréquence de rotation (ω_1) pour qu'elle soit égale à la seconde fréquence de rotation (ω_2) ;
 entraîner le système de dispositif compacteur (22, 24) dans un mode de compactage en établissant la phase relative à une valeur telle que des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) contribuent ensemble à une action de compactage de

l'outil de compactage (28) ; **caractérisé en ce que** la première masse déséquilibrée (32) et la seconde masse déséquilibrée (36) fonctionnent comme un stockage d'énergie à volant d'inertie dans au moins un mode de fonctionnement du système de dispositif compacteur, dans lequel le stockage d'énergie à volant d'inertie stocke une énergie de rotation de la première masse déséquilibrée (32) rotative et une énergie de rotation de la seconde masse déséquilibrée rotative,
 dans lequel le procédé comprend l'étape de stockage d'énergie générée par un freinage régénératif dans le stockage d'énergie à volant d'inertie et l'étape d'extraction d'énergie depuis le stockage d'énergie à volant d'inertie pour entraîner ou supporter au moins une fonction du système de dispositif compacteur (22, 24).

9. Procédé de fonctionnement d'un système de dispositif compacteur (22, 24) selon la revendication 8, dans lequel le système de dispositif compacteur (22, 24) est entraîné dans un mode de non-compactage en établissant la phase relative à une valeur telle que des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) s'additionnent de manière destructive pour obtenir une action de compactage minimal ou de non-compactage de l'outil de compactage, dans lequel la première masse déséquilibrée (32) et la seconde masse déséquilibrée (36) peuvent fonctionner en tant que ledit stockage d'énergie à volant d'inertie au moins dans le mode de non-compactage.
10. Procédé de fonctionnement d'un système de dispositif compacteur (22, 24) selon la revendication 8 ou 9, dans lequel l'outil de compactage (28) comprend un tambour compacteur (30) qui est agencé pour pouvoir tourner autour d'un axe de tambour et est adapté pour entrer directement en contact avec l'objet ou la surface à compacter, dans lequel le procédé comprend l'entraînement ou l'accélération en rotation d'au moins l'une de la première masse déséquilibrée (32) et de la seconde masse déséquilibrée (36) sur la base d'une énergie de rotation du tambour compacteur et comprend l'entraînement ou l'accélération en rotation du tambour compacteur sur la base d'une énergie stockée dans le stockage d'énergie à volant d'inertie.
11. Procédé de fonctionnement d'un système de dispositif compacteur (22, 24) selon l'une des revendications 8 à 10, comprenant l'entraînement du système de dispositif compacteur (22, 24) dans le mode de compactage en établissant la phase relative à une

valeur intermédiaire, de préférence l'une sélectionnée parmi plusieurs valeurs intermédiaires ou dans une plage de valeurs intermédiaires, entre une première valeur, qui assure que des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) s'additionnent de manière constructive pour obtenir une action de compactage maximal de l'outil de compactage (28) et une seconde valeur, qui assure que des forces créées par rotation de la seconde masse déséquilibrée (36) s'additionnent de manière destructive pour obtenir une action de compactage minimal ou de non-compactage de l'outil de compactage, de sorte que, pour la valeur intermédiaire qui est établie, des forces créées par rotation de la première masse déséquilibrée (32) et des forces créées par rotation de la seconde masse déséquilibrée (36) contribuent à une action de compactage de l'outil de compactage (28).

12. Procédé de fonctionnement d'un système de dispositif compacteur selon l'une des revendications 8 à 11, comprenant le changement de la fréquence de rotation d'au moins l'une de la première masse déséquilibrée (32) et de la seconde masse déséquilibrée (33) de telle sorte que la valeur de la phase relative change d'une valeur ayant été établie en une autre valeur à établir, de préférence pour passer de l'un du mode de non-compactage et du mode de compactage à l'autre du mode de non-compactage et du mode de compactage ou pour changer l'intensité de l'action de compactage de l'outil de compactage (28).

13. Procédé de fonctionnement d'un système de dispositif compacteur (22, 24) selon l'une quelconque des revendications 8 à 12, dans lequel le système de dispositif compacteur (22, 24) comprend en outre

des troisièmes moyens d'entraînement (54), dans lequel l'outil de compactage (28) est un tambour compacteur (30) adapté pour entrer directement en contact avec l'objet ou la surface à compacter, et

un troisième dispositif de freinage régénératif adapté pour convertir de l'énergie de rotation de l'outil de compactage (28) en énergie de récupération, en particulier en énergie électrique de récupération ;

dans lequel dans le mode de non-compactage, la première masse déséquilibrée (32) et la seconde masse déséquilibrée (36) forment un stockage d'énergie à volant d'inertie adapté pour stocker une énergie de rotation de la première masse déséquilibrée (32) rotative et une énergie de rotation de la seconde masse déséquilibrée rotative,

le procédé comprenant en outre les étapes con-

sistant à :

faire tourner l'outil de compactage (28) par les troisièmes moyens d'entraînement (54) ;

obtenir de l'énergie de récupération à partir du troisième dispositif de freinage régénératif en convertissant de l'énergie de rotation de l'outil de compactage (28) en énergie de récupération ;

stocker de préférence l'énergie de récupération dans un dispositif de stockage (C) du système de dispositif compacteur (22, 24) ; fournir l'énergie de récupération pour fournir le stockage d'énergie à volant d'inertie.

14. Procédé de fonctionnement d'un système de dispositif compacteur (22, 24) selon l'une quelconque des revendications 8 à 13, dans lequel le système de dispositif compacteur (22, 24) comprend en outre

un premier dispositif de freinage régénératif adapté pour convertir de l'énergie de rotation de la première masse déséquilibrée (32) en énergie de récupération, en particulier en énergie électrique de récupération ;

un deuxième dispositif de freinage régénératif adapté pour convertir de l'énergie de rotation de la seconde masse déséquilibrée (36) en énergie de récupération, en particulier en énergie électrique de récupération ;

le procédé comprenant en outre les étapes consistant à :

faire tourner la première masse déséquilibrée (32) et la seconde masse déséquilibrée (36) dans le mode de non-compactage ;

obtenir une première énergie de récupération à partir du premier dispositif de freinage régénératif en convertissant de l'énergie de rotation de la première masse déséquilibrée (32) en énergie de récupération ;

obtenir une seconde énergie de récupération à partir du deuxième dispositif de freinage régénératif en convertissant de l'énergie de rotation de la seconde masse déséquilibrée (36) en énergie de récupération ;

stocker de préférence la première énergie de récupération ou/et la seconde énergie de récupération dans un dispositif de stockage (C) du système de dispositif compacteur (22, 24) ;

accélérer l'outil de compactage (28) en utilisant une première et une seconde énergie de récupération.

15. Véhicule compacteur comprenant :

un premier système de dispositif compacteur (22, 24), selon l'une quelconque des revendications 1 à 7, adapté pour générer une première force oscillante agissant sur au moins certains d'éléments de montage du véhicule compacteur pour le premier système de dispositif compacteur (22, 24) ; 5

un second système de dispositif compacteur (22, 24), selon l'une quelconque des revendications 1 à 7, adapté pour générer une seconde force oscillante agissant sur au moins certains d'éléments de montage du véhicule compacteur pour le second système de dispositif compacteur (22, 24) ; et 10

une unité de commande principale (26) adaptée pour commander une orientation relative de la première et de la seconde force oscillante, de préférence adaptée pour commander l'orientation relative de la première et de la seconde force oscillante de telle sorte que la première et la seconde force oscillante sont parallèles. 15 20

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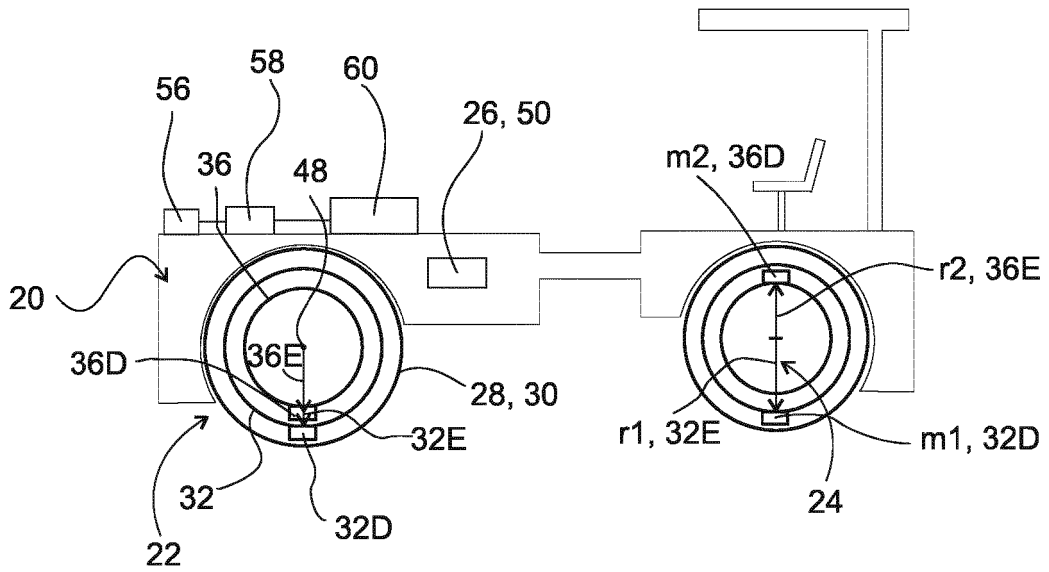


Fig. 1

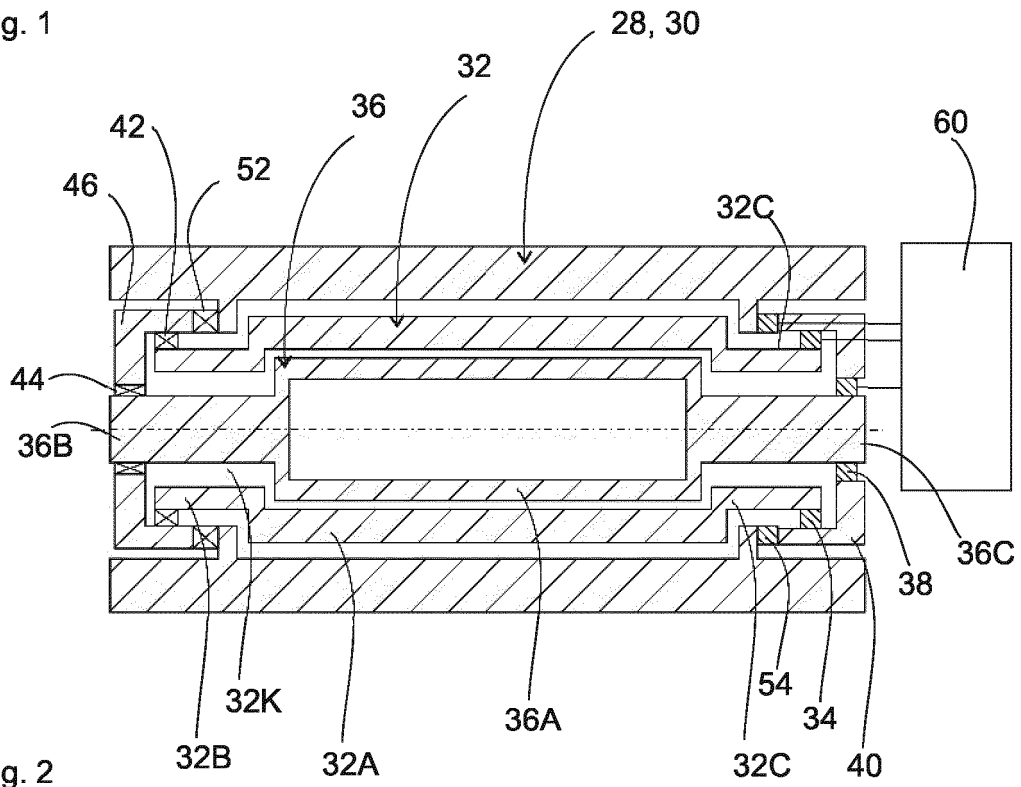


Fig. 2

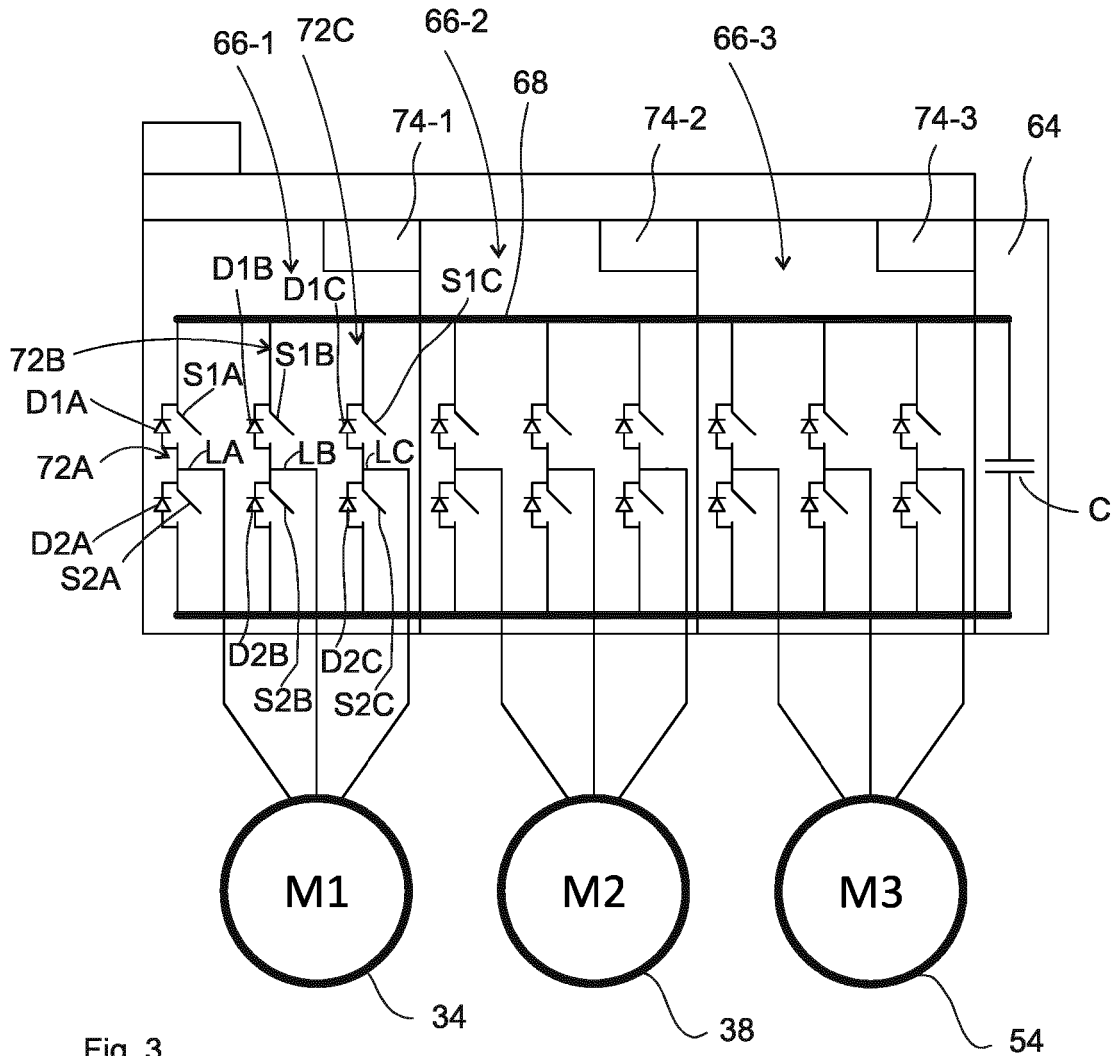


Fig. 3

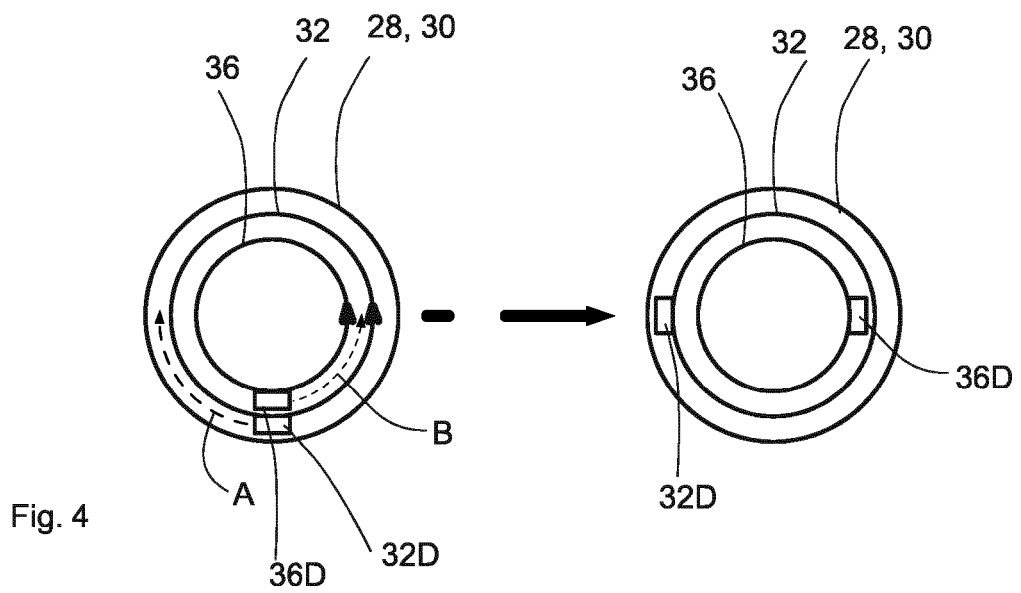


Fig. 4

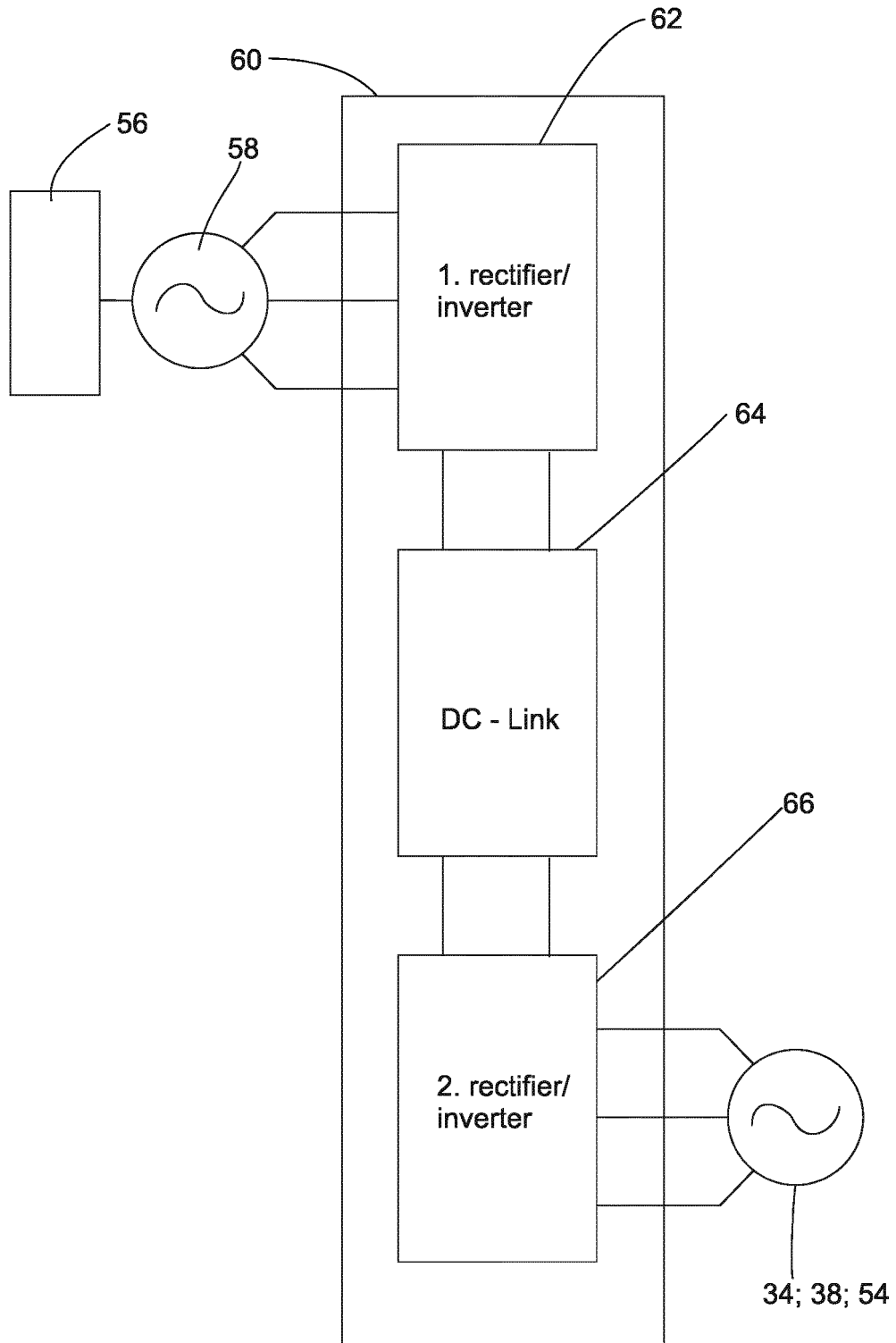


Fig. 5

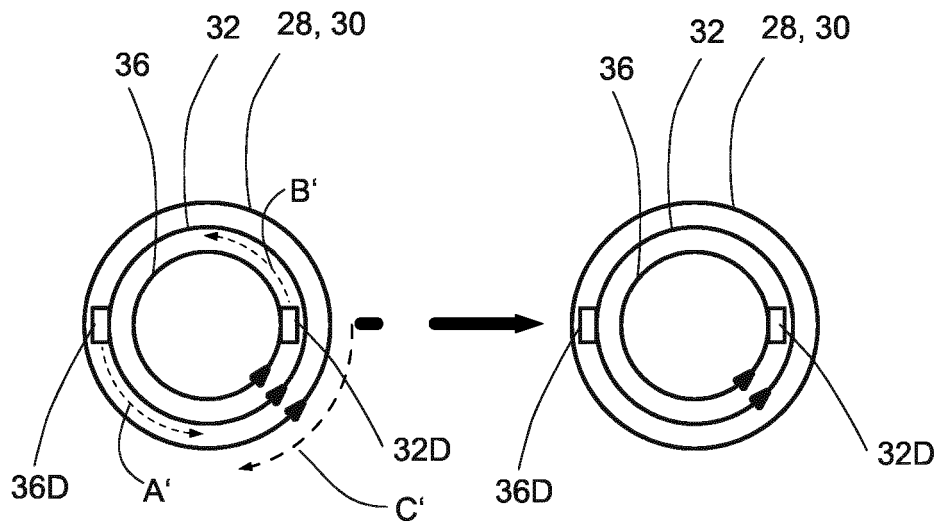


Fig. 6

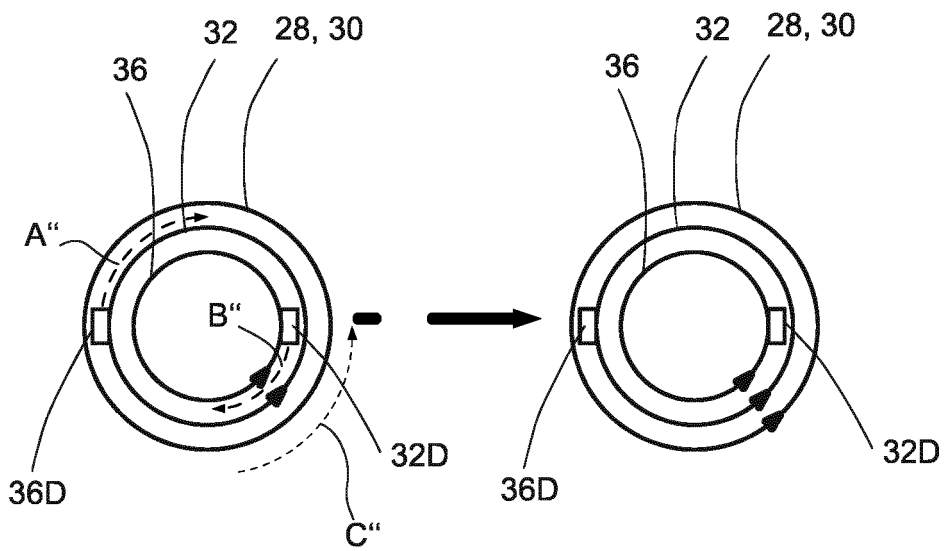


Fig. 7

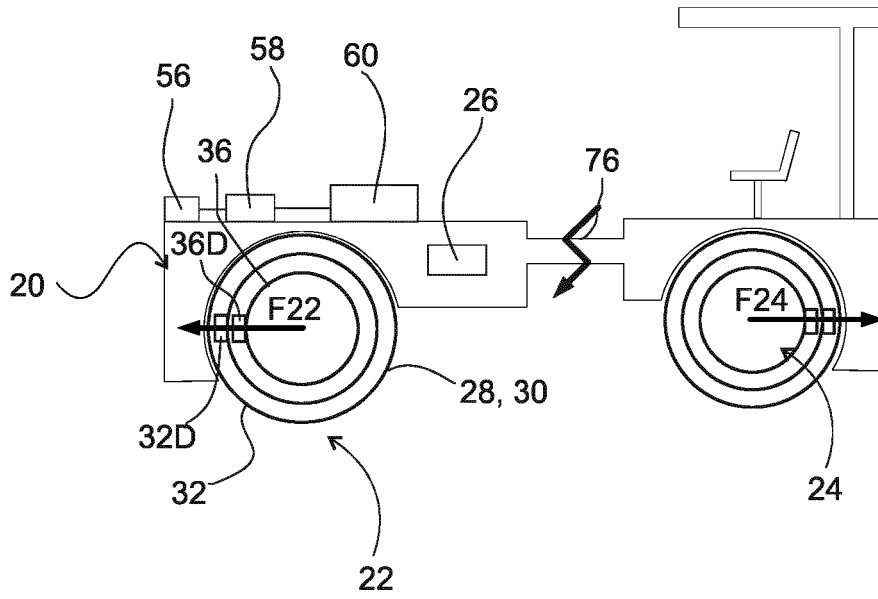


Fig. 8

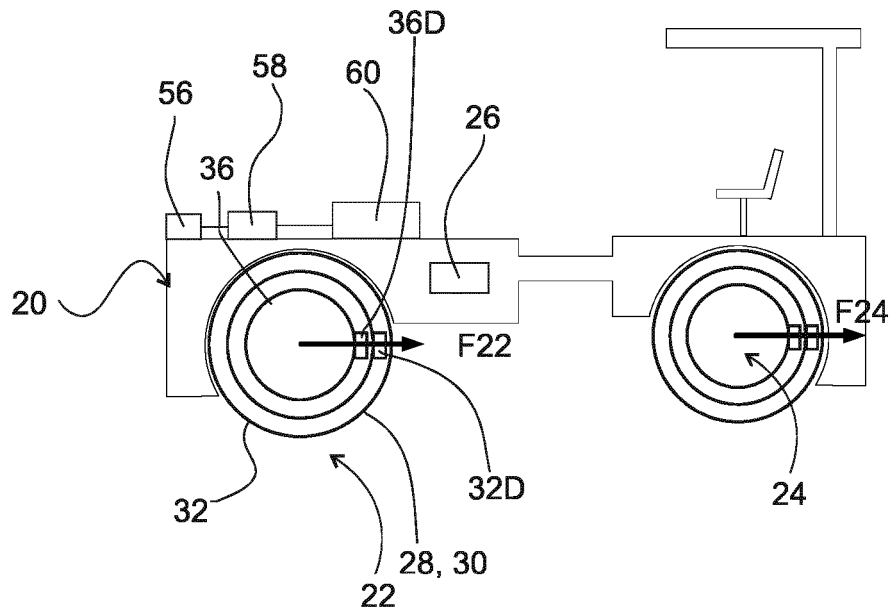


Fig. 9

REFERENCES CITED IN THE DESCRIPTION

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