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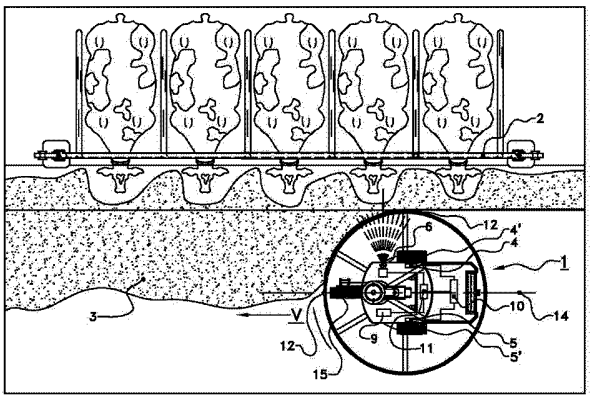
(54) **Vehicle for displacing feed lying on a floor in a sideward displacement direction.**

(57) The invention relates to a vehicle (1) for displacing feed, comprising a frame with wheels having a plurality of elongate tread portions and grooves, a motor for moving the vehicle in a moving direction (V), a material displacer to displace the material, when the vehicle moves in the moving direction, over the floor towards a first side with respect to said moving direction. At least a majority of the tread portions is arranged such that they extend, when in contact with the floor, in a direction that makes a sharp angle with the forward direction opposite said first side. Thus, diagonal tread portions (101) are predominantly directed to one side to counteract a reaction force of the feed being displaced sidewardly by the vehicle.



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Vehicle for displacing feed lying on a floor in a sideward displacement direction

TECHNICAL FIELD

The invention relates to a vehicle for displacing feed lying on a floor in a sideward displacement direction.

PRIOR ART

Such vehicles are known. For example, a vehicle for cleaning a stable floor is described in EP-A-0 943 235. Furthermore, Austrian Gebrauchsmuster AT-6016-U discloses a device that is movable along a guide means for displacing feed substantially transverse to the direction of travel.

Also known are vehicles that distribute feed and simultaneously displace feed substantially transversely to the direction of travel. EP2007191 describes a vehicle that is capable, without guide means, of displacing feed substantially transversely to the direction of travel.

In the context of the present invention, the term sideward or transverse is used to indicate that the feed is moved in a direction mainly transverse/perpendicular to the direction of movement of the vehicle. The nett movement of feed may be in a diagonal forward direction with respect to the direction of movement of the vehicle, but the intended displacement direction should not be along the direction of travel of the vehicle, but to a sideward or transverse direction.

A problem with the known devices is that often the displacement of feed or other material and/or the vehicle navigation is deteriorated.

BRIEF DESCRIPTION

It is an object to provide a vehicle, in particular a vehicle according to the preamble of claim 1, with an improved material displacement and/or navigation capability.

This object is achieved by a vehicle according to claim 1, in particular a vehicle for displacing material such as feed, comprising a frame with a plurality of wheels having a tread pattern with a plurality of elongate tread portions and grooves, a motor device operably coupled to at least one of the wheels for moving the vehicle over a floor in a moving direction, a material displacer coupled to the

frame, and arranged to displace the material, when the vehicle moves in the moving direction, over the floor towards a first side with respect to said moving direction, wherein at least a majority of the tread portions of all wheels combined is arranged such that they extend, when and at least for the part in contact with the floor, in a direction that makes a sharp angle with the forward direction opposite said first side.

It was found that with such a vehicle, both navigation precision and e.g. feed displacement capability improved. Without the applicant wishing to be tied to an explanation, it is believed that the total grip of the vehicle is increased by the tread as described. It is noted that material such as feed displaced will exert a reaction force on the vehicle. Since the feed is displaced towards a side of the vehicle, the reaction force will be directed from that side, which force has to be compensated by the frictional force from the wheels, i.e. the treads. In principle, there will also be a reaction force aimed in the direction of movement, in particular forwardly. Therefore, the total reaction force will often make an obtuse angle with the forward direction. This force can be compared to forces to be exerted by a car's wheel/tread in a curve, but it is usually an undesired force which is tried to be minimized or cancelled, mostly by providing a tread pattern that is mirror symmetrical in a vertical plane along the forward direction for either each tire, or at least for the car/vehicle as a whole. However, in the present invention, this reaction force is actually tried to be increased on purpose.

To improve a wheel's, or: a tread's, ability to compensate such a force, the tread has been arranged as described in this invention. Upon moving of the vehicle in the moving direction, the tread patterns of the plurality of wheels, in interaction with the floor, together generate a force acting on the vehicle having a component in the direction of said sideward displacement direction, thus compensating offsets affecting navigation or displacement to a larger part than known vehicles.

In the present application, the tread portions may be linear, curvilinear as well as discontinuous. The tread portions extend along their direction of largest extent. For example an oblong tread portion, having a length and a width, extends along the direction of its length. The term "majority" means that, in the case of tread portions of substantially equal length, more than half of the relevant tread portions extend in the indicated direction, or quadrant, i.e. it is an

absolute majority. Herein, the relevant tread portions are those that do not extend parallel to or perpendicular to the direction of movement. Since the exact directions of all tread portions, when in contact with the floor, need not be strictly the same, they may vary as long as that direction fulfills the requirement as described and claimed. If the tread portions are of unequal length, or of equal length for that matter, "majority" means that the sum of the individual lengths of all tread portions that extend in the indicated direction, or quadrant, is higher than the sum of the lengths of the tread portions extending in the direction, or quadrant, mirrored with respect to the moving direction. When looking in the moving direction, more tread portion imprints will point away from the first side of the moving direction, i.e. the side towards which the material is displaced, than will point towards that first side. This will ensure that a larger force can be exerted to compensate the reaction force from the material displaced. Importantly, the mirror symmetry of the tread pattern as imprinted on the floor is broken in the present invention. Herein, it is important to realise that the displacing of the material is intended to be to one side. In cases where there is an equal probability for the material to be displaced to either of two opposite sides, it is not advantageous to select a first side with a main orientation for the tread portions. However, in the present invention, there is a single main side for displacement of the material, and thus the possibility to select a tread design that is asymmetrical for all of the vehicle. Note that it is believed that a design that is asymmetrical for an individual wheel, but mirror symmetrical (of course in a plane along the moving direction) for the vehicle as a whole would still not lead to the advantage of the present invention. Contrarily, the design for all wheels combined, i.e. for all treads as a whole, should be arranged according to the present invention.

Herein, as in all of the application, the only tread portions considered are those that come into contact with the floor during normal rolling of the wheel(s), and they are sometimes called the "relevant" tread portions herein. Any tread part on a rim of a curved outer wheel surface, that does not come in contact with the floor, does not count in this invention as a tread portion. Furthermore, the term wheel includes the combination of a, mostly metal, rimmed true wheel and a tire, as well as wheel that is a unitary piece of material.

Advantages and preferred embodiments will be described in the dependent claims, as well as in what follows.

For example, the sharp angle mentioned above is advantageously between 45 and 90°, preferably between 45 and 75°, most preferably about 60°, i.e. ±5°. It has been found that with such angles, a good balance is struck between grip in the forward, moving direction and resisting sideward displacement resulting from the reaction force by displaced material, i.e an improved navigation that requires less correction or resetting. Herein, the angle relates to the average angle of the relevant tread portions, wherein "average" relates to the direction of largest extent. If for all of the relevant tread portions, i.e. 'slanted' or 'diagonal' in the indicated quadrant, this angle is the same, the angle is of course clear and unambiguous, but if this angle varies somewhat, "average" relates to the average angle of all relevant tread portions. Note that the tread pattern may comprise a number of different tread portions, including a mixture of axial, tangential (circumferential) and diagonal tread portions. However, the former two will not be considered further in the present invention.

The tread pattern may comprise a number of different tread portions, including a mixture of axial, tangential and diagonal tread portions, but may also comprise only diagonal tread portions. In particular embodiments, the tread portions comprise or consist of mutually parallel tread portions. This ensures that the behaviour of the wheel, such as relating to grip, can be made sufficiently constant. Advantageously, for all of the circumference of the wheel, at least three tread portions, that are separated by a groove, are in contact with the floor. More in particular the tread portions comprise straight, linear tread portions, and even more in particular consist of straight, linear tread portions. This ensures even better the constant behaviour as to grip etc., which is advantageous in respect of navigational accuracy.

In some vehicles according to the present invention, the tread portions, and in particular each one thereof, extend over the entire width of the tread, more in particular of the wheel. This ensures that the tread, i.e. outer surface of the wheel that is in contact with the floor, has a grip providing tread portion that is as constant as possible. A very simple and robust embodiment therefore has a tread surface consisting of parallel lugs and grooves, each extending all across the tread from one shoulder to the other. An even simpler version consisting of a wheel with a solid outer layer having the above tread pattern, that is simply a cylindrical portion cut straight off a (much) longer cylinder

having such a pattern of lugs and grooves. According to an embodiment the plurality of wheels comprise an outer layer formed of a solid, flexible material, for instance polyurethane (PUR) wherein or whereon the tread pattern is formed. Providing a solid outer layer of a flexible material, allows for substantial deformation of the outer layer due to contact with the floor, which in combination with the tread pattern can generate a force acting on the vehicle having a component in the direction of the sideward displacement direction. This will be explained in more detail below. According to an embodiment, the wheel comprises a non-pneumatic tire.

In embodiments, the grooved tread portions have a depth (d) and the raised tread portions have a width (w), wherein the width (w) is smaller than 3 times the depth (d), preferably smaller than 2 times the depth (d). In an embodiment, the width and the depth are substantially equal to each other. In a further embodiment, the width is smaller than the depth. Such dimensions allow the raised tread portions to deform in a direction perpendicular to the diagonal direction of the tread portions, thereby generating a force having a component in the direction of said sideward displacement direction.

With certain vehicle according to the invention, at least two, and preferably all, of the plurality of wheels have a mutually translationally identical tread pattern. As was already indicated above, it is the total tread of all the wheels combined that determines the behaviour of the vehicle. Then, the wheels all comprise an identical tread pattern. And still only one type of wheel is needed, thus keeping stock to a minimum.

It will be understood that there may be wheels present on the vehicle with a tread pattern that doesn't substantially contribute to the a sideward force, in particular those with a wheel-wise mirrorsymmetrical tread pattern. Also, there even may be wheels present on the vehicle with a tread pattern that on its own generate a force in the opposite direction, i.e. away from the (sideward) displacement direction, as long as the plurality of wheels together, in particular the mentioned and claimed majority of the relevant tread portions, result in a force having a component in the direction of the sideward displacement direction. There may also be wheels provided without a tread pattern, such as "slicks". However, in particular in a barn environment, this is not advantageous with respect to grip and navigational accuracy.

The vehicle is not particularly limited, and may relate to an operator controlled vehicle. An advantage here would still be that that operator need perform fewer and smaller navigational corrections. However, advantageously, the vehicle is an autonomous unmanned vehicle. For such vehicles, having good grip will also result in good navigation accuracy. For navigation systems that use counting revolutions of one or more wheels, this will be obvious. But even for wheel-independent navigation systems, fewer corrections will be required, which will make the system faster and still more accurate, or at least simpler, as it either needs fewer calibration moments or beacons and/or less time and energy to perform corrections in the path. In particular, the vehicle comprises a navigation system arranged to count a number of revolutions of at least one of the wheels and to measure a steering direction of the vehicle, and that is arranged to navigate the vehicle based on said number and said steering direction. However, other navigation systems such as floor-strip followers, ultrasound or gps based systems are not excluded, while for further details reference is made to the navigation systems known in the art.

Furthermore, the type of material displacer is not particularly limited, and could be a snow plough or street dirt displacer. Importantly, however, it should be a material displacer that is intended to displace the material substantially sidewardly in only one sideward direction, such as by a unidirectionally rotating brush or a simple slide. After all, if both sideward directions are (equally) possible, the advantage of compensation for a reaction force from a certain direction would be diminished (or lost). In most cases, a snow plough or street dirt displacer displaces the snow, the street dirt respectively, to one side, *viz.* to the right in lefthand-drive countries, and vice versa.

In some other advantageous embodiments, the material displacer comprises feed displacing means for displacing feed substantially sidewardly, in particular a feed slide. Herein, it is noted that such feed displacers are used primarily along feed fences or other feeding places. Although the direction of displacing the feed is not particularly limited, it is easy to limit is to one direction, if need be adapting the route to be followed by the vehicle. In a particularly advantageous embodiment, the feed displacer comprises a circular element freely rotatable for frictional drive with the ground and/or the feed, such as more in particular used in the Lely Juno™ or the Lely Vector™. The latter systems use a

more or less frustroconical skirt or sleeve, that rotates when in contact with feed, or with the ground, to thereby push feed to one side, such as to the feed fence. More details are described in a.o. NL-1031605 and NL-1034771.

In embodiments, the vehicle according to the invention comprises two wheels that are separately drivable by separate drive means, a distance determining device for determining the distance from the vehicle to a wall portion, a torque difference adjusting device for adjusting the torque difference between the wheels, a control unit for controlling the vehicle and moving it in a direction of travel, or movement. These embodiments are suitable for following a wall, such as even a feed fence, in order to navigate. Further navigation details, such as what to do when a wall ends, can be entered in the control unit. The control unit is programmed in such a way that during operation the vehicle will maintain a distance determined by the distance determining device to the wall portion, which distance is preferably fixed and greater than or equal to a predetermined minimum distance to the wall portion.

In such case, the two wheels that are separately drivable are non-swivel or non-steerable wheels. Rather, the steering may be brought about by having a difference in rotational speed. Additional wheels may be provided. However, alternative or additional steering means may be provided. According to an embodiment the vehicle comprises a further wheel. The further wheel may be positioned before or behind the wheels that are separately drivable by the separate drive means, at a lateral position in between these two wheels. The further wheel may be a swivel wheel or a steerable wheel.

The swivel-wheel may be driven or non-driven. The swivel wheel may be with or without tread pattern.

Alternatively, the vehicle may be provided with one or more steerable wheels and one or more non-swivel wheels (similar to a private car).

SHORT DESCRIPTION OF THE DRAWINGS

Embodiments will now be described, by way of example only, with reference to the accompanying schematic drawings in which corresponding reference symbols indicate corresponding parts, and in which:

- Figure 1 is a schematic side view of the vehicle,

- Figure 2 is a schematic plan view of the unmanned vehicle according to an embodiment, and

- Fig.'s 3a – 3e schematically show a top view of vehicles according to different embodiments,

- Fig. 4 shows a perspective view of a wheel,

- Fig. 5 shows the tread pattern of the wheel shown in Fig. 4 in an unrolled state, and

- Fig. 6 shows a cross sectional view of the tread pattern.

DETAILED DESCRIPTION

Embodiments will be described with reference to the Figures.

First, with reference to Figures 1 and 2, an embodiment of a vehicle for displacing feed lying on a floor in a substantially sideward displacement direction with respect to a (forward) moving direction of the vehicle will be described. Of course, other types of vehicles for displacing feed lying on a floor in a substantially sideward displacement direction with respect to a (forward) moving direction of the vehicle are conceivable as well. The embodiments relate in particular to vehicles which are arranged to displace feed in one predetermined sideward displacement direction (left or right) with respect to a moving direction and not in two sideward displacement directions (left and right).

Figures 1 and 2 show an unmanned autonomous vehicle 1 for displacing feed 3 lying on a floor substantially sidewardly to a feeding gate 2. The feed 3, that may be solid, liquid or a mixture thereof, has been deposited at the feeding gate 2 in a manner known per se, for example with the aid of a tractor. It will be obvious that the present invention will also be applicable to other installations for supplying feed to animals, so that the feeding gate shown in Figure 2 is only one of the many examples of a wall portion in the vicinity of which feed can be deposited.

The term "wall portion" refers to partition elements, either or not having an open structure, it being possible for the wall portion to assume many different, curved, rectilinear, angular, etc. shapes.

Autonomously movable vehicles for performing many different functions, as well as the control of such vehicles, are known per se and will therefore not be described here in detail. Automatic charging of the energy supply

of the vehicle and automatic loading and unloading of other materials into and from, respectively, containers present on the vehicle, are known as well. It will suffice to refer to the following patent documents: US-2966256, DE-1109441, DE-1183301, EP-0382693, DE-4425924, US-5309592, EP-0142594, DE-4444508, GB-2313190, US-5109566, GB-2313191, US-3273038, NL-7416427, US-5341540, US-5646494, EP-0943235, EP-1369010, EP-1369012 en EP-1368017.

The vehicle 1 comprises two wheels 4', 5' that are separately drivable by separate drive means 4, 5. The vehicle 1 is further provided with a distance determining device 6, in the embodiment shown an ultrasonic sensor, for determining the distance from the vehicle 1 to the feeding gate 2. It will be obvious that all sensors known in the technique, such as for example the sensors mentioned in the patent documents enumerated above, can be used for the purpose of distance determination. The unmanned vehicle 1 can be provided with an external, protective covering 7 provided with apertures 8, so that the ultrasonic sensor 6 is enabled to detect the feeding gate 2.

The vehicle 1 as shown further comprises a front wheel 15. Front wheel 15 may be a swivel wheel.

In order to prevent material, such as feed and the like, from accumulating in the interior of the unmanned vehicle 1 via the apertures 8, the bottom of the unmanned vehicle 1 is at least partially open.

The unmanned vehicle 1 further comprises an orientation determining device 9, in the embodiment shown a gyroscope, for determining the orientation of the centre line 14 of the vehicle 1 relative to the feeding gate 2. It will be obvious that all sensors known in the technique, such as for example the sensors mentioned in the patent documents enumerated above, can be used for the purpose of orientation determination, such as an electronic compass or a camera with image recognition equipment.

The unmanned vehicle 1 is also provided with a torque difference determining device for determining the torque difference between the wheels 4', 5'. Such a torque difference determining device, which uses data from the drive means 4, 5, is known per se. Such a torque difference determining device can also be used for detecting skid of one of the wheels, after which detection it is possible to perform a correct action (such as reducing the number of revolutions per minute, alarming an operator).

The unmanned vehicle 1 is further provided with a control unit 11 for controlling the unmanned vehicle 1 and moving it in a direction of travel V, also referred to as a moving direction of forward moving direction. It is of course not excluded that the vehicle can be controlled to move in a rearward direction. From the positioning of the sensors and feed displacing means (described in more detail below), the moving direction V will be clear.

The control unit 11 is connected, via electric wires, or in a wireless manner if desired, with the distance determining device 6, the orientation determining device 9, the torque difference determining device 10, and the drives 4, 5 of the wheels 4', 5', for the purpose of exchanging data.

For displacing feed 3 substantially transverse to the direction of travel V of the unmanned vehicle, the unmanned vehicle 1 is provided with feed displacing means 12. Such feed displacing means can be constituted by e.g. an obliquely disposed slide, or by a conveyor belt. However, according to the embodiment shown, these feed displacing means 12 are preferably constituted by a freely rotatable circular element 12, whose outer circumference constitutes the outer circumference of the unmanned vehicle 1. When, during operation of the unmanned vehicle 1, the circular element 12, which may be for example a ring or a disc, comes into contact with the feed and/or floor, said element 12 is rotated automatically, in other words the circular element 12 is feed or floor driven.

An extremely reproducible displacement of the feed is obtained if the circular element 12 is tilted through an angle α in such a way that, at least almost in the direction of travel V of the vehicle 1, it is located closest to the floor. In dependence on the feed to be displaced, the angle α enclosed by the circular element 12 and the floor, can be adjustable. If desired, the angle α is adjustable, during operation of the vehicle 1, by tilting means known per se (not shown in the drawing), such as a cylinder, that are controlled by the control unit 11.

When the feed is deposited on the floor, and when the animals present at the feeding gate are eating the feed, the feed is accumulated over different distances to the feeding gate to different heights. In order that the animals are always able to reach in a simple manner a desired amount of feed it is ensured, by making the unmanned vehicle move regularly along the feeding gate 2, that feed is displaced to the feeding gate, as schematically shown in Figure 2. In order that the unmanned vehicle 1 is correctly controlled, the control unit 11 is

programmed in such a way that during operation the vehicle 1 will maintain a distance determined by the distance determining device 6 to the feeding gate 2, which distance is greater than or equal to a pre-determined minimum distance to the feeding gate, and that during operation the centre line 14 of the vehicle will maintain an orientation determined by the orientation determining device 9 relative to the feeding gate 2, which orientation is at least almost equal to a pre-determined orientation, and that during operation the drivable wheels 4', 5' of the unmanned vehicle 1 will show a torque difference determined by the torque difference determining device 10, which torque difference is smaller than or equal to a pre-determined maximum torque. This means that the unmanned vehicle will always maintain a correct orientation relative to the feeding gate 2, that the unmanned vehicle 1 will not come within the minimum distance to the feeding gate 2, and that it is ensured that the feed will not accumulate too much, because, in case of the unmanned vehicle 1 moving through a too large amount of feed, the torque difference would become too great.

The control unit 11 is programmed in such a way that, for controlling the unmanned vehicle 1, priority is given to the distance determined by the distance determining means 6 in combination with the pre-determined minimum distance.

The pre-determined distance may be adjustable during operation. The adjustment may, for example, depend on the point of time of the day, the period of time elapsed since the unmanned vehicle was present at the same position, the sort of animals or the individual animals present at the feeding gate. In a preferred embodiment of an unmanned vehicle, also the pre-determined maximum torque difference and/or the pre-determined orientation are/is adjustable during operation.

The unmanned autonomous vehicle 1 is provided with a (non-shown) energy supply that is chargeable via sidewardly disposed charging strips 13 that are capable of being brought into contact with a charging device. Other ways of charging the energy supply, such as inductive means, are mentioned inter alia in the abovementioned patent documents.

Although not shown in the figures, the unmanned vehicle 1 may additionally be adapted to supply feed. For this purpose, the unmanned vehicle 1 may be provided with a storage container for containing feed, and with a discharge

device for discharging feed to the floor. The storage container is preferably provided with a mixing device for mixing feed. In this case it is advantageous if the control unit controls the operation of the discharge device on the basis of data from the distance determining device and/or the torque difference determining device and/or the speed of the vehicle and/or the weight decrease of the storage container. This enables inter alia the supply of a uniform amount of feed. When, for example, at a particular distance to the feeding gate the torque difference comes below a particular value (for example mentioned in a table stored in a memory of the control unit), the amount of feed has come below a particular value. On the basis of these data, the discharge device can deposit a particular amount of feed on that place of the floor. Alternatively or additionally, the unmanned vehicle 1 may be provided with a signalling device (for example a transmitting aerial with a suitable controlling transmission circuit) for supplying a signal (for example for drawing the attention of an owner and/or operator of the unmanned vehicle), the control unit controlling the operation of the signalling device on the basis of data from the distance determining device and/or the torque difference determining device. The invention is based on the insight that the magnitude of the torque difference depends on the amount of feed present on the floor through which the unmanned vehicle moves, and this torque difference can thus be used advantageously together with the determined distance and orientation for a correct control of the unmanned vehicle.

Fig. 2 and Fig. 3a show a top view of the vehicle 1 and therefore also show the upper parts of the wheels 4', 5'. As shown schematically, the outer circumference of the wheels 4', 5'are provided with tread portions 100 which comprise diagonal tread portions 101 directed to one side. It will be understood that the diagonal tread portions will be directed differently in the lower part of the wheels 4', 5'. Furthermore it is noted that the figures show the tread patterns schematically, not taking into account the curve of the wheel.

The diagonal tread portions 101 as shown in Fig. 3a have a direction of largest extent that subtends a sharp angle β with a plane that is perpendicular to an axis of rotation of the respective wheel. Angle β is preferably in the range of 35° - 75°, for instance 60°.

Angle β is preferably chosen in relation to a width W of the wheel to ensure that along each cross-section of the wheel comprising the axis of rotation,

at least two, but preferably at least three diagonal tread portions 101 are crossed. This it to ensure that there are always at least two or three diagonal tread portions 101 in contact with the floor.

The diagonal tread portions may be formed by grooved tread portions 101, leaving raised tread portions 102 in between the grooved tread portions 101. This has the effect that, upon moving of the vehicle 1 in the moving direction, the treads 100 of the plurality of wheels 4', 5' in interaction with the floor, together generate a force acting on the vehicle 1 having a component in the direction of said sideward displacement direction. In other words, the vehicle 1 is biased towards the feeding gate 2 or wall portion.

For instance, in case the vehicle is for displacing feed to the right of the vehicle with respect to the moving direction of the vehicle, the feed will exert a reaction force pushing the vehicle to the left. The diagonal tread portions are provided to cause a tread force being exerted on the vehicle to the right, thereby counteracting the reaction force of the feed.

Fig. 3a shows in more detail that two wheels 4', 5' are provided with diagonal tread portions 101, while a front wheel 15 is provided with a different tread not comprising diagonal tread portions and which will thus not substantially contribute to the component of the force acting on the vehicle 1 in the sideward displacement direction. Alternatively, the front wheel 15 may comprise diagonal tread portions as well, or may not comprise any tread pattern at all.

Also shown in the figures is that the diagonal tread portions 101 extend over the entire width of the wheel. Alternatively, the diagonal tread portions 101 may extend over only a part of the width of the wheel, for instance over the centre 80% of the width of the wheel.

More clearly indicated in Fig.'s 3b – 3e is a total resulting force F_T exerted by the floor via the wheels on the vehicle 1, having a component in the sideward displacement direction, showing that upon moving of the vehicle 1 in the moving direction, the tread patterns 100 of the plurality of wheels 4', 5' in interaction with the floor, together generate a force acting on the vehicle 1 having a component in the direction of said sideward displacement direction.

Fig. 3b shows an embodiment in which the vehicle 1 comprises a front wheel 15 without diagonal tread portions, one wheel 4' without a tread pattern and one wheel 5' with a tread pattern which, upon moving of the vehicle 1 in the

moving direction, in interaction with the floor, generates a force acting on the vehicle 1 having a component in the direction of said sideward displacement direction.

Fig. 3c shows an embodiment similar to Fig. 3b, with the difference that instead of one wheel 4' without a tread pattern, wheel 4' comprises a tread pattern which, upon moving of the vehicle 1 in the moving direction, in interaction with the floor, generates a force acting on the vehicle 1 having a component in a direction opposite of said sideward displacement direction.

However, as the tread pattern of wheel 4' is less dense than the tread of wheel 5', upon moving of the vehicle 1 in the moving direction, the tread pattern of the plurality of wheels 4', 5' in interaction with the floor, together generate a force acting on the vehicle 1 having a component in the direction of said sideward displacement direction.

Fig. 3d shows a further alternative in which the diagonal tread portions comprise first diagonal tread portions 101' in a first diagonal direction and second diagonal tread portions 101'' in a second diagonal direction, the first and second diagonal directions being opposite with respect to each other, wherein the number of first diagonal tread portions 101' exceeds the number of second diagonal tread portions 101''.

The number of first diagonal tread portions may for instance be at least 50% higher, but preferably more than 100% higher than the number of second diagonal tread portions.

Fig. 3e further shows that the wheels comprising the diagonal tread portions may further comprise non-diagonal tread portions.

Fig. 4 schematically shows a wheel which can advantageous be used in the embodiments described above. The wheel 4' shown has an outer circumferential surface that is provided with a tread pattern 100, such that upon moving of the vehicle 1 the tread patterns 100 of the wheels 4' in interaction with the floor, generates a force acting on the wheel 4' (and thus on the vehicle the wheel is attached to) having a component in a sideward direction.

The wheel has a diameter D and a width W. The diameter D may be 300 mm and the width W may be 90 mm.

The tread pattern 100 is formed by a plurality of diagonal grooved tread portions 101 extending over the entire width W of the outer circumferential

surface of the wheel. In between the grooved tread portions 101 are diagonal raised tread portions 102 which also extend over the entire width W of the outer circumferential surface.

The wheel 4' is formed by a rim 110 on which a tire 111 is mounted. The tire is a solid tire 111, i.e. it is not pneumatic tire.

Fig. 5 schematically shows the tread pattern 100 of the wheel 4' shown in Fig. 4 in an unrolled state, showing the alternating grooved tread portions 101 and raised tread portions 102. Fig. 5 is shown such that the figure also corresponds to a foot print of the wheel 4' seen from above.

Also depicted is a force F_T (traction) which is generated when a part of a raised tread portion 102 is in contact with the floor as a result of the fact that the wheel 4' is driven. As a result, the raised tread portion 102 will deform as it has some flexibility, in particular in a direction perpendicular to the diagonal direction of the grooved tread portions 101 surrounding the raised tread portion 102. This will result in a force F_S. As shown, the resulting force F_R acting on the wheel 4', and thus on the vehicle the wheel 4' is attached to, has a component in the direction of said sideward displacement direction.

Fig. 6 schematically shows a cross sectional view of part of the wheel 4' in a direction perpendicular to direction of largest extent of the diagonal tread portions 101. Fig. 6 shows that the diagonal grooved tread portions 101 have a depth d with respect to the raised tread portions 102. The raised tread portions 102 have a width w. So, the closest distance between two adjacent grooved tread portions 101 is equal to w and the height of the raised tread portions 102 is equal to d.

The grooves may have any suitable cross sectional shape, such as rectangular or rounded as shown in Fig. 6. The bottom may be rounded having a radius of 3 mm, providing a groove with a width of 6 mm. The transition from the raised surface to the groove may be rounded having a radius of 0,5 mm.

The groove may also have a shape creating an undercut area into the diagonal raised tread portion 102, providing the diagonal raised tread portion 102 with improved flexibility in a direction perpendicular to the diagonal direction of the grooves 101.

The width w is at least smaller than 3 times the depth (d), preferably smaller than 2 times the depth (d) The width and the depth may be substantially equal to each other. The width w may also be smaller than the depth d.

Such dimensions allow the raised tread portions to be flexible in a direction perpendicular to the diagonal direction of the tread portions. The raised tread portions 102 will deform in this direction upon interaction with the floor, resulting in a reaction force. This reaction force has a component in the sideward direction. This results in a resulting force F_R having a component in the direction of said sideward displacement direction.

The ration between the width w and the depth d should be chosen in dependence on the weight of the vehicle, the flexibility of the outer material of the wheel and the expected force exerted by the displacement of feed.

The tread pattern may be formed by taking a wheel having an outer circumferential surface without a tread pattern and removing material to create grooved tread portions. Removing material may be done by milling. Alternatively the tread pattern may be formed by taking a wheel having an outer circumferential surface without tread pattern and adding material forming raised tread portion.

Of course, alternative embodiments may be conceived, other than the embodiments shown in the figures. For instance, the treads may be asymmetrical treads, having a different tread pattern on the inside of the wheel than on the outside of the wheel and/or may be directional treads, i.e. treads which behave differently in a forward moving direction than in a backward moving direction.

Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims

.

CONCLUSIES

1. Voertuig (1) voor het verplaatsen van materiaal, zoals voer, omvattend:

- een frame met meerdere wielen die een loopvlakpatroon hebben met meerdere langwerpige loopvlakdelen en groeven,

- een motorinrichting werkzaam gekoppeld aan ten minste één van de wielen voor het over een vloer bewegen van het voertuig in een bewegingsrichting (V),

- een materiaalverplaatser welke gekoppeld is aan het frame, en ingericht is voor het verplaatsen van het materiaal, als het voertuig in de bewegingsrichting beweegt, over de vloer naar een eerste zijde ten opzichte van de bewegingsrichting,

met het kenmerk dat ten minste een meerderheid van de loopvlakdelen is ingericht zodat wanneer deze in contact zijn met de vloer, deze zich uitstrekken in een richting die een scherpe hoek maakt met de voorwaartse richting tegengesteld aan de eerste zijde.

2. Voertuig (1) volgens conclusie 1, waarin de scherpe hoek tussen 45 en 90° ligt, bij voorkeur tussen 45 en 75° ligt, en met meeste voorkeur ongeveer 60° is.

3. Voertuig (1) volgens conclusie 1 of 2, waarin de loopvlakdelen onderling parallelle loopvlakdelen omvatten, in het bijzonder rechte, lineair loopvlakdelen, en meer in het bijzonder bestaan uit rechte, lineaire loopvlakdelen.

4. Voertuig volgens een van de voorgaande conclusies, waarbij de loopvlakdelen, en in het bijzonder elk daarvan, zich uitstrekken over de gehele breedte van het loopvlak, meer in het bijzonder van het wiel.

5. Voertuig volgens een van de voorgaande conclusies, waarbij de gegroefde loopvlakdelen (101) een diepte (d) hebben en de verhoogde loopvlakdelen (102) een breedte (w), waarbij de breedte (w) kleiner is dan driemaal de diepte (d), bij voorkeur kleiner dan tweemaal de diepte (d).

6. Voertuig volgens een van de voorgaande conclusies, waarbij ten minste twee, en bij voorkeur alle, van de meerdere wielen een onderling onder translatie identiek loopvlakpatroon hebben.

7. Voertuig volgens een van de voorgaande conclusies, waarbij het voertuig (1) een autonoom onbemand voertuig is.

8. Voertuig (1) volgens een van de voorgaande conclusies, waarbij de materiaalverplaatser voerverplaatsingsmiddelen (12) omvat voor het in hoofdzaak zijwaarts verplaatsen van voer, met name een voerschuif of een vrij draaibaar rond element welke middels wrijving met de grond en/of het voer wordt aangedreven.

9. Voertuig volgens een van de voorgaande conclusies, omvattend:

- twee wielen (4', 5') welke afzonderlijk aandrijfbaar zijn door afzonderlijke aandrijfmiddelen (4, 5),

- een afstandsbepalingsinrichting (6) voor het bepalen van de afstand van het voertuig tot een muurdeel,

- een torsieverschilaanpassingsinrichting (10) voor het aanpassen van het torsieverschil tussen de wielen (4', 5'),

- een besturingseenheid (11) voor het besturen van het voertuig en het bewegen van het voertuig in een voortbewegingsrichting.

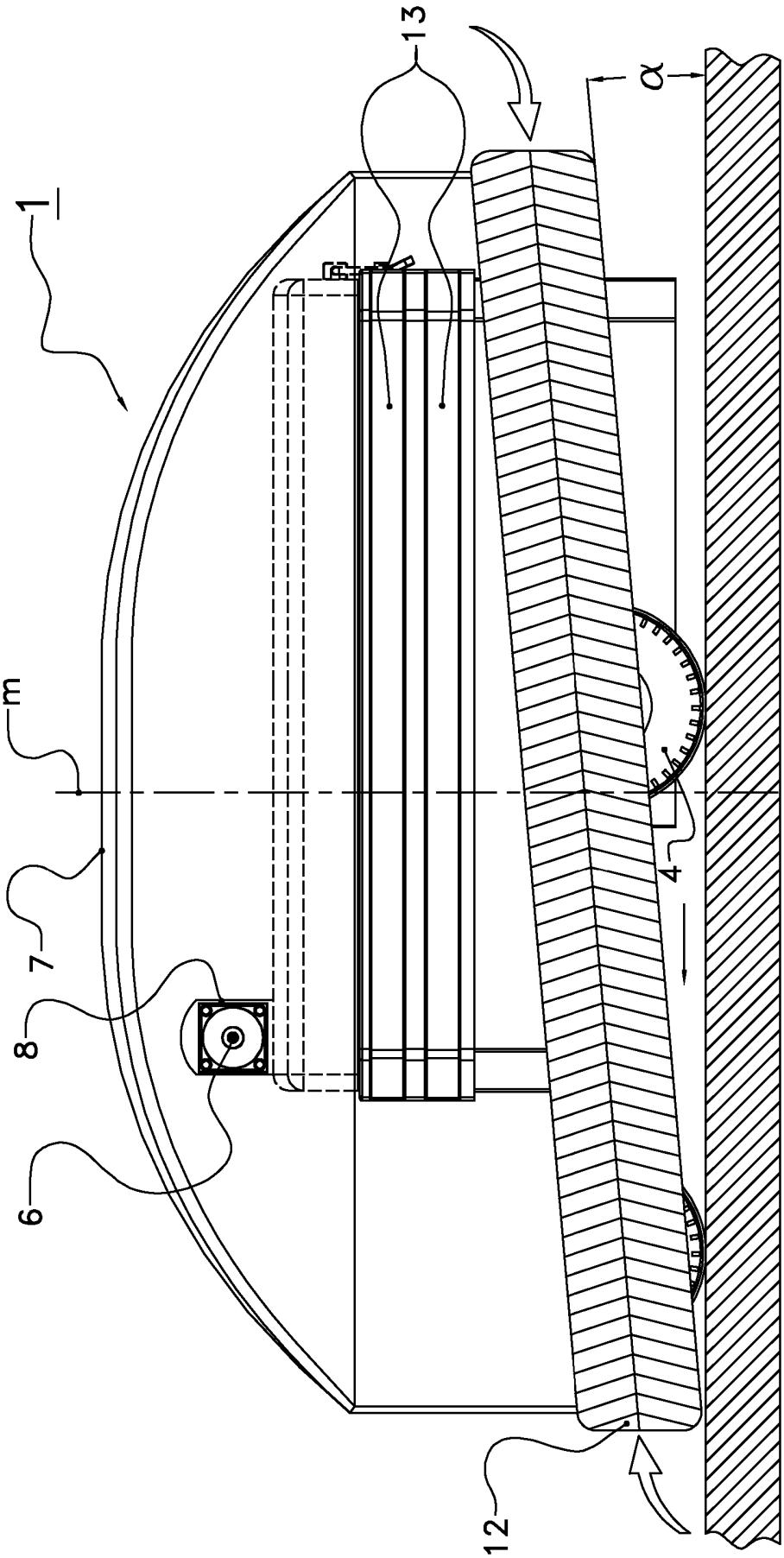

FIG. 1

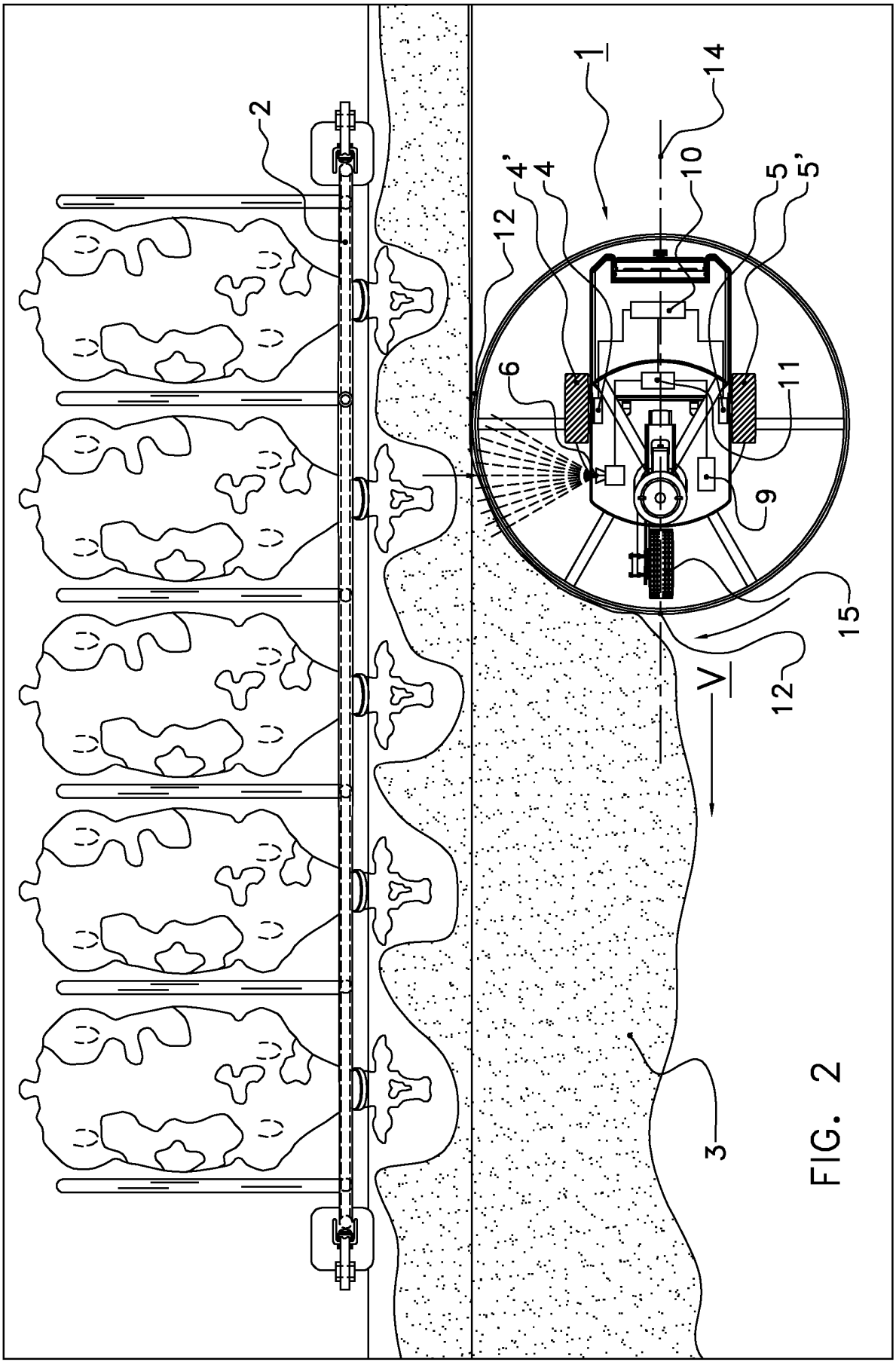

FIG. 2

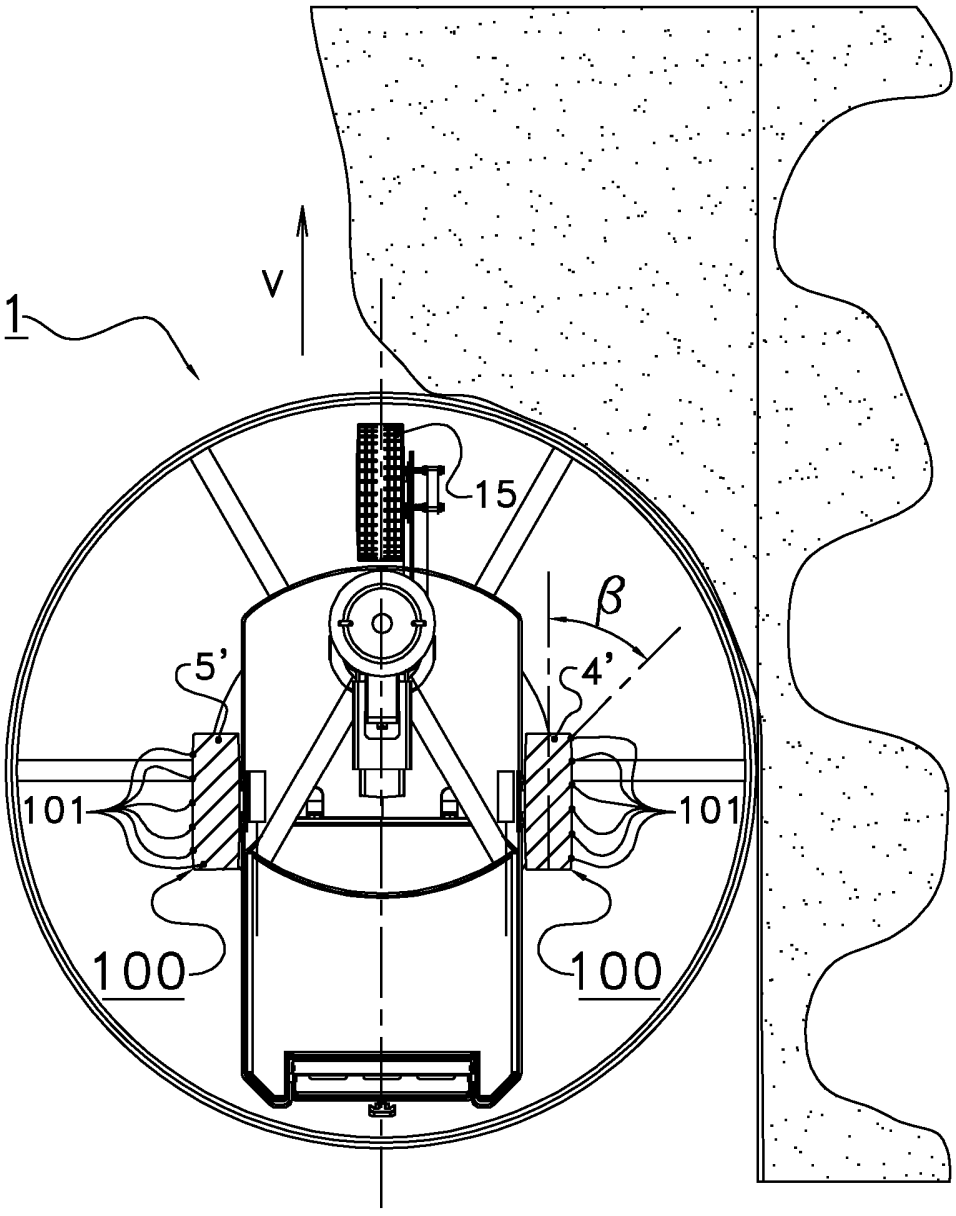

FIG. 3A

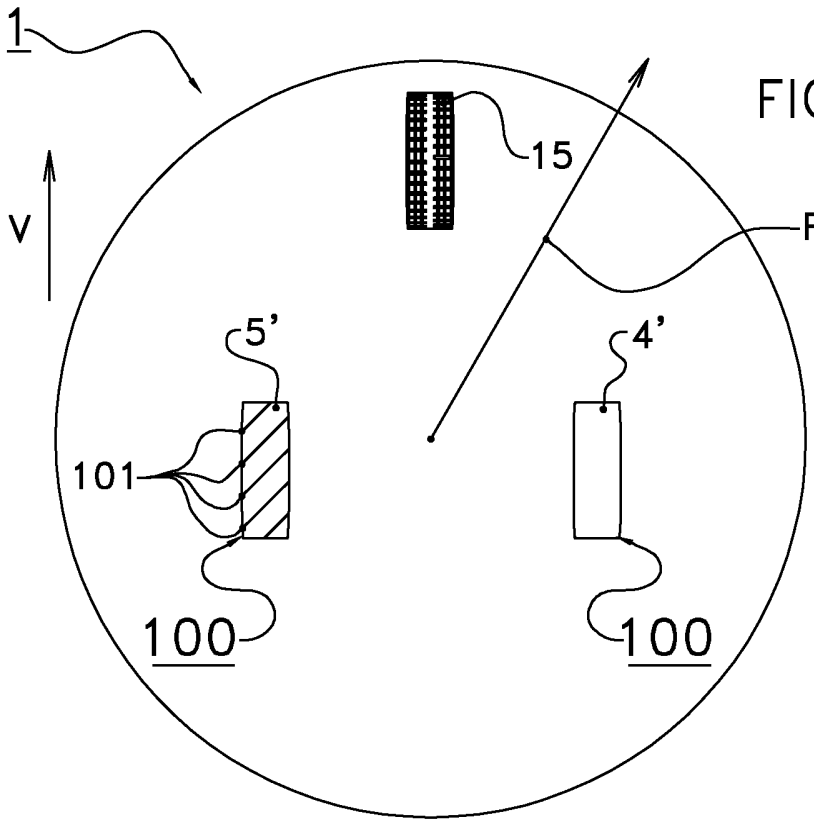

FIG. 3B

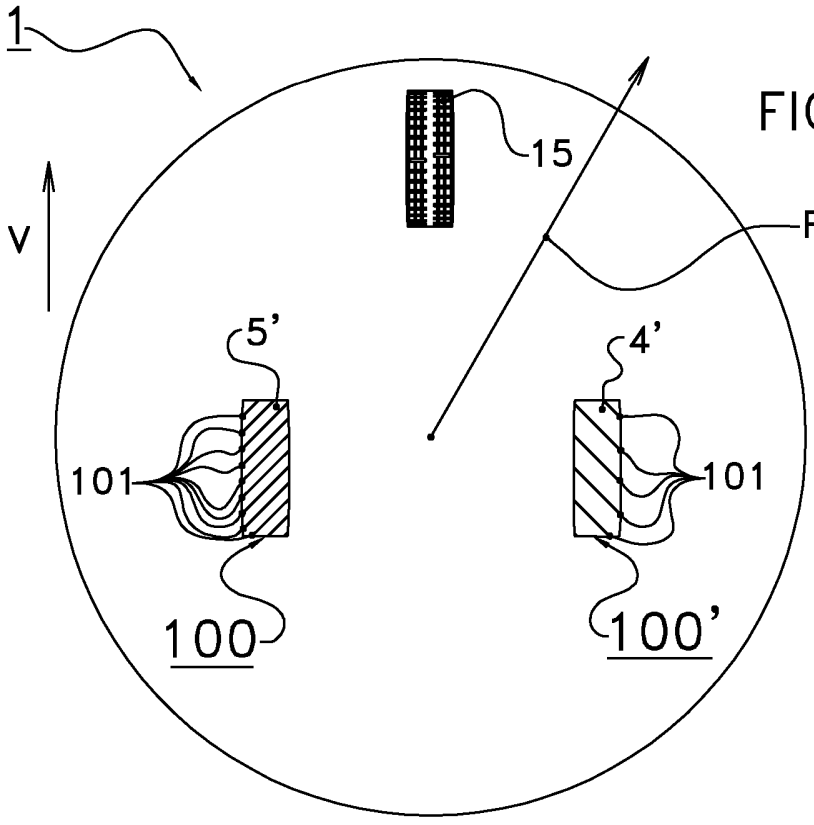

FIG. 3C

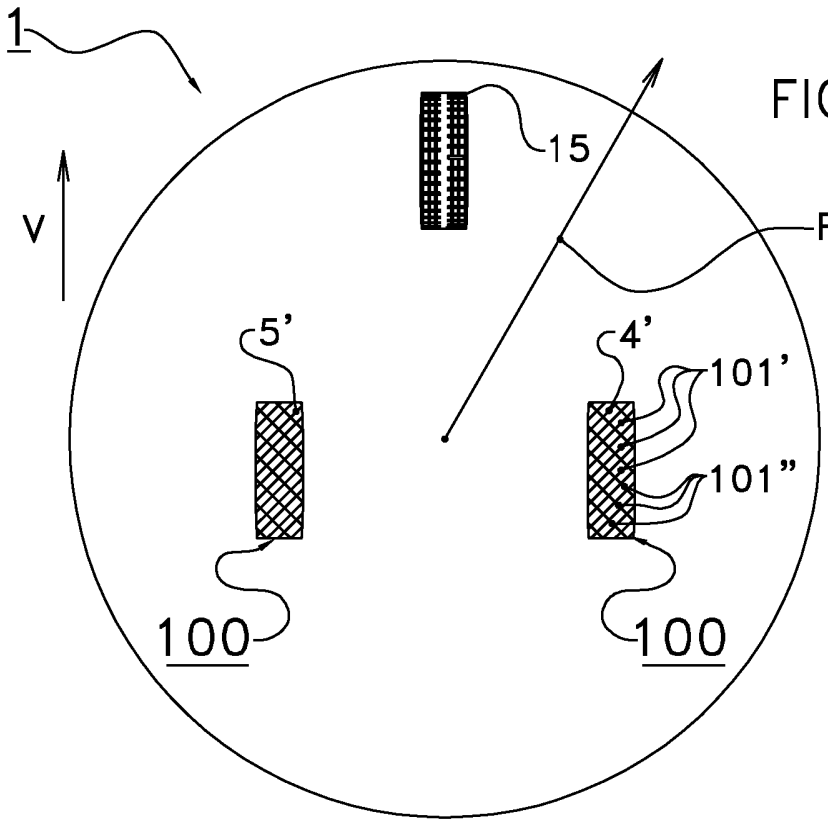

FIG. 3D

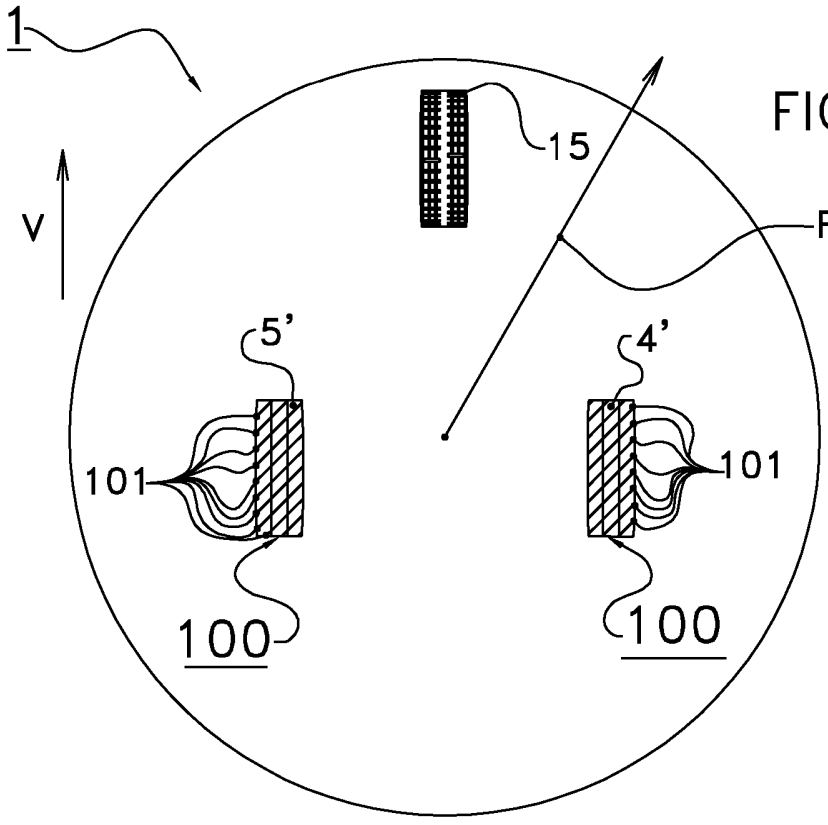

FIG. 3E

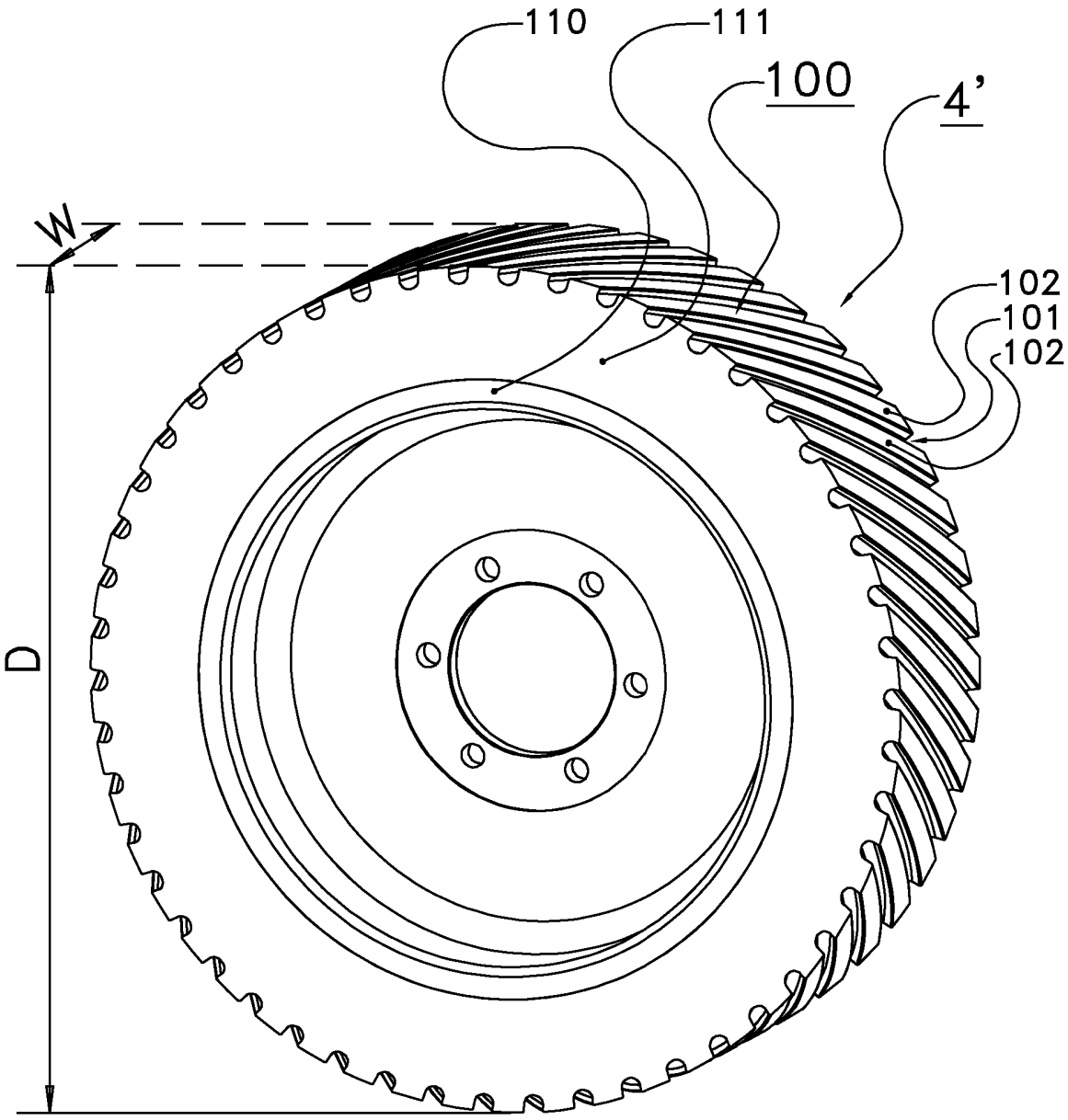

FIG. 4

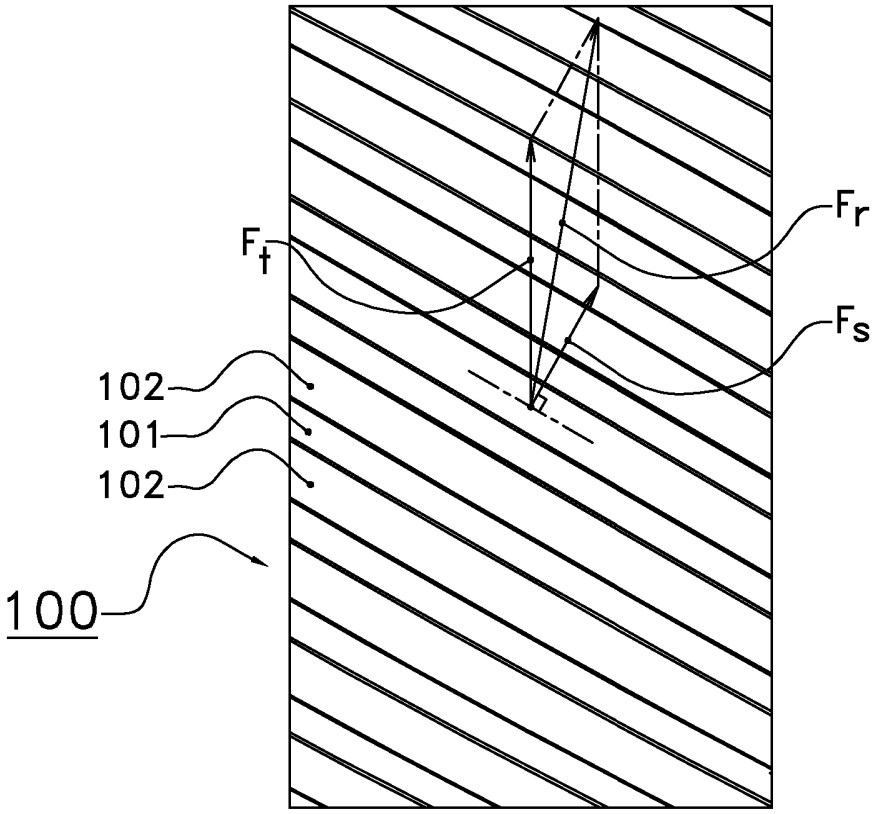

FIG. 5

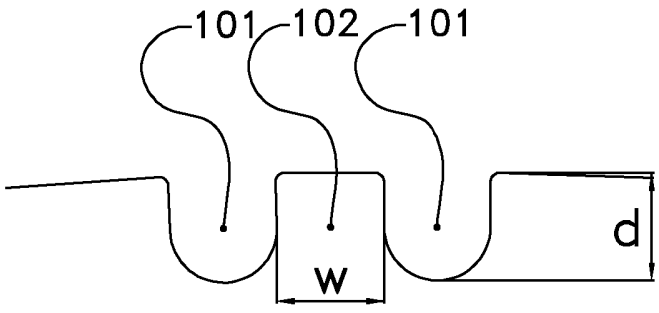

FIG.6

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	D4723/NLP
Nederlands aanvraag nr. **2010499**	Indieningsdatum **21-03-2013**
	Ingeroepen voorrangsdatum
Aanvrager (Naam) **Lely Patent N.V.**	
Datum van het verzoek voor een onderzoek van internationaal type **22-06-2013**	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr. **SN 60278**

I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)

Volgens de internationale classificatie (IPC)

A01K1/01 **A01K1/10** **A01K5/02**
E01H5/06

II. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimumdocumentatie

Classificatiesysteem	Classificatiesymbolen		
IPC	**A01K**	**E01H**	**B60C**

Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

III. ☐	**GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES**	(opmerkingen op aanvullingsblad)
IV. ☐	**GEBREK AAN EENHEID VAN UITVINDING**	(opmerkingen op aanvullingsblad)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2010499

A. CLASSIFICATIE VAN HET ONDERWERP
INV. A01K1/01 A01K1/10 A01K5/02 E01H5/06
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHTE GEBIEDEN VAN DE TECHNIEK

Onderzochte miminum documentatie (classificatie gevolgd door classificatiesymbolen)
A01K E01H B60C

Onderzochte andere documentatie dan de mimimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)
EPO-Internal, WPI Data

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie °	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
A,D	EP 2 007 191 B1 (MAASLAND NV [NL]) 9 september 2009 (2009-09-09) in de aanvraag genoemd * het gehele document *	1,7-9

A	DE 299 04 151 U1 (SALZ WILLI [DE]) 20 mei 1999 (1999-05-20) * bladzijde 2, alineas 2, 3 * * bladzijde 4, alinea 3; figuur 1 *	1-6

☐ Verdere documenten worden vermeld in het vervolg van vak C.

☒ Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

° Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvrage vermeld

"E" eerdere octrooi(aanvrage), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwarend is voor de octrooiaanvrage, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid	Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type
20 november 2013	
Naam en adres van de instantie European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	**De bevoegde ambtenaar** von Arx, Vik

Formulier PCT/ISA/201 (tweede blad) (Januari 2004)

ONDERZOEKSRAPPORT BETREFFENDE HET RESULTAAT VAN HET ONDERZOEK NAAR DE STAND VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar de stand van de techniek
NL 2010499

In het rapport genoemd octrooigeschrift	Datum van publicatie	Overeenkomend(e) geschrift(en)		Datum van publicatie
EP 2007191	B1 09-09-2009	AT	442037 T	15-09-2009
		CA	2645372 A1	25-10-2007
		DK	2007191 T3	07-12-2009
		EP	2007191 A1	31-12-2008
		ES	2333180 T3	17-02-2010
		JP	5054095 B2	24-10-2012
		JP	2009534737 A	24-09-2009
		NL	1031605 C2	19-10-2007
		US	2009069968 A1	12-03-2009
		WO	2007120036 A1	25-10-2007
DE 29904151	U1 20-05-1999	GEEN		

OCTROOICENTRUM NEDERLAND

WRITTEN OPINION

File No.	Filing date *(day/month/year)*	Priority date *(day/month/year)*	Application No.
SN60278	21.03.2013		NL2010499

International Patent Classification (IPC)
INV. A01K1/01 A01K1/10 A01K5/02 E01H5/06

Applicant
Lely Patent N.V.

This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the application
- ☐ Box No. VIII Certain observations on the application

	Examiner
	von Arx, Vik

Application number

WRITTEN OPINION

NL2010499

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.

2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:

   a. type of material:

   ☐ a sequence listing

   ☐ table(s) related to the sequence listing

   b. format of material:

   ☐ on paper

   ☐ in electronic form

   c. time of filing/furnishing:

   ☐ contained in the application as filed.

   ☐ filed together with the application in electronic form.

   ☐ furnished subsequently for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes:	Claims	1-9
	No:	Claims	
Inventive step	Yes:	Claims	1-9
	No:	Claims	
Industrial applicability	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Reference is made to the following document:

D1: EP 2 007 191 B1 (MAASLAND NV [NL]) 9 September 2009 (2009-09-09) cited in the appliaction

Document D1 is regarded as being the prior art closest to the subject-matter of claim 1, and discloses a vehicle according to the preamble of independent claim 1.

The subject-matter of claim 1 therefore differs from this known vehicle in that least a majority of the tread portions of all wheels combined is arranged such that they extend, when in contact with the floor, in a direction that makes a sharp angle with the forward direction opposite a first side with respect to said moving direction and is therefore new.

The problem to be solved by the present invention may be regarded as to provide a vehicle, in particular a vehicle according to the preamble of claim 1, with an improved material displacement and/or navigation capability.

The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step for the following reasons:
The prior published documents, cited in the search report and in the description, either taken individually or in combination do not disclose, suggest or reasonably lead the person skilled in the art to consider the installation of diagonal tread portions as claimed on the wheels of the known device.
The person skilled in the art would not be able to combine all the features of claim 1 and as such arrive at the claimed vehicle without an inventive activity.

Claims 2 to 9 are dependent on claim 1 and as such also meet the requirements of novelty and inventive step.