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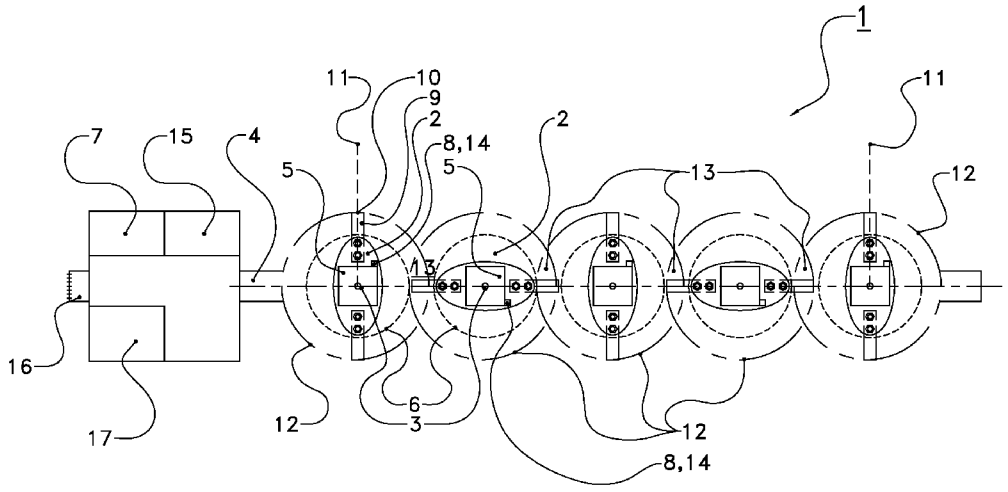


FIG. 1

(57) Abstract: A mower (1) having a plurality of mowing members (2), each mowing member (2) mounted rotatably about a vertical rotation axis (3) to a support (4), and each mowing member (2) having an electric drive motor (5) couplable thereto and arranged to drive the mowing member (2) to rotate along a circular trajectory (6) coaxial to the vertical rotation axis (3) and the mower (1) further having at least one control device (7) arranged to control at least one of the electric drive motors (5) move the mowing member (2) to a pre-defined position on its circular trajectory (6).

[Continued on next page]

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Mower

The invention relates to a mower comprising a support to which a plurality of mowing members are mounted rotatably about vertical rotation axes and each mowing member defining a rotation area surrounding its vertical rotation axis.

Such mowers are known in the art, as e.g. from EP0126518 or US8327612, in which the mowing members include a series of knife holders with mowing knives which are mounted by side on a frame and which knife holders are rotated about vertical center lines by means of a drive mechanism couple to a power take-off or another external drive device. The knife holders being fastened in rotationally fixed manner on associated hubs or output shafts which are driven by the drive mechanism. Known drive arrangements include a common drive shaft with suitable (conical) gear wheels to drive each knife holder. Alternatively it is known to use a gear train.

Rotation of the knives severs the crop (such as e.g. grass) by the impact on it. Typically the mower is also moved in a general forward direction, over a field containing the crop by being pulled by (or carried on) a tractor or is self-driven or is part of an autonomous vehicle.

Alternatively, mowing member may have a blade carrier to which the mowing blades are integrally formed. For example the member may be in the form of an elongated member mounted to the support, and including mowing blades in the form of sharpened edges at end positions with respect to the center of the member. Such blades are generally used in mulching mowers.

Mowing a crop is done by the combined action of moving the mower forward e.g. by pulling it by a tractor and the mowing members rotating. During mowing it is possible that the mowing members encounter obstacles, such as e.g. rocks or tree stumps or waste or the like. This may cause blockage of the rotational movement of the mowing member, which in turn causes an overload of the drive mechanism. The mower is pulled forward past the obstacle. Such a collision may cause damage to multiple parts of the mower, e.g. to one or more mowing members, to the central drive system, to the mowing knives and may lead to expensive and difficult repairs.

Solutions to prevent or reduce damage to the mower caused by such encounters with foreign or obstacles have been found in providing means which disconnect the mowing member from the central drive e.g. by a one way clutch as described in US5581985. Or by mowing member or part thereof to break off the frame

as described in US4497161 or EP0774202. These solutions prevent expensive and difficult repairs of the central drive.

It is an object of the invention to provide an alternative and improved solution to prevent or reduce damage caused by collisions of a mowing member with an foreign object or obstacle without disconnecting or breaking-off mowing members from the drive mechanism.

This object is realized by providing a mower comprising

- a plurality of mowing members, each mowing member mounted rotatably about a vertical rotation axis to a support ,
- each mowing member comprising an electric drive motor couplable thereto and arranged to drive the mowing member to rotate along a circular trajectory

coaxial to the vertical rotation axis and wherein,

the mower further comprises at least one control device arranged to control at least one of the electric drive motors move the mowing member to a pre-defined position on its circular trajectory.

By providing a control device arranged to control the motor move the mowing member to a pre-defined position on its circular trajectory.

The rotation of the mowing element and thus also the stopping of the mowing member may be done in a controlled. In the event of a mower member hitting an obstacle it may be arrested by the obstacle, and the invention than provides a means to move the mowing member to a pre-defined position. Preventing further damage to the mowing member. Also by controlling movement of the mowing member to a pre-defined position, a series of pre-defined positions may be defined on the circular trajectory allowing for complete control of the movement of the mowing element.

According to an aspect of the invention the control device includes a position location device to determine the actual position of the mowing member on the circular trajectory and the control device is arranged to control the motor to move the mowing member from the actual location to the pre-defined position.

By providing in combination with the electric motor, the control device including a position location and arranging the control device to control the motor to move the mowing member from the actual location to the pre-defined position, an efficient manner to control where the mowing member is, is provided.

According to an aspect of the invention the pre-defined position is the position in which the the mowing member may be stopped on its circular trajectory.

By pre-defining the stop position of a mowing member, the mowing member may be brought to a stop in a controlled manner.

According to an aspect of the invention each mowing member comprising at least one mowing blade having a free outer end, which blade in normal operating circumstances projects radially outwardly including a radial center line which radial center line extends from the rotation axis outward and the free outer end following a circular blade trajectory, and

wherein each mowing member is mounted to the frame adjacent to another mowing member such that the respective blade trajectories define an overlap area between them, and wherein a pre-defined stop position is chosen such is such that the radial line of the blade of the stopped mowing member does not intersect the overlap area.

Normal operating circumstances are when the mower is in operation and there are no collisions of foreign objects with the mowing members and/or with the mowing blades. Under these circumstances the blade projects outwardly along a radial line which extends from the vertical axis outwardly and the tip of the blade is at the maximum distance from the vertical axis about which the mowing member rotates.

In order to achieve a proper mowing without gaps of unmowed crop, it is important that the mowing circles overlap. A mowing circle is the area covered by a rotating mowing blade. In order for the mowing circles to overlap, the mowing members are mounted to the frame adjacent each other creating an overlap of the blade trajectories.

In order to prevent collision between a rotating blade and a stationary blade of neighboring mowing members, it is necessary park the stationary blade outside the overlap area. Otherwise a moving blade of a neighboring mowing member will collide with the stationary blade. The invention solves this by selecting a so-called 'safe position' for the blade that was stopped. The safe position is the pre-defined stop position in which the radial line of the blade of the stopped mowing member does not intersect the overlap area.

According to an aspect of the invention the position location device comprises an encoder. Encoders can convert the angular position or motion of a shaft or axle to an analog or digital code. The encoder can be used to determine this for the shaft driving the mowing member.

According to an aspect of the invention the mower includes at least one capacitor electrically connected to the motor and the control device is arranged to stop rotation of the at least one mowing member by controlling the capacitor to inject DC current into the motor to be stopped.

An effective manner of stopping the rotation of an electric motor is by DC injection which involves injection DC current into the rotor of the motor. The DC current creates a stationary magnetic field which applies a static torque to the rotor slowing it down to a stop. Injecting the DC current in relation to the rotation position of the mowing member may be used to effectuate stopping of the mowing member in the pre-defined stop position.

The invention will now be further explained using the drawing figures which show exemplary and non-limiting embodiments, in which:

Figures 1 is a diagrammatic top view of an embodiment of the mower according to the invention.

Figure 1 shows mower 1 having a plurality of mowing members 2, each mowing member 2 mounted rotatably about a vertical rotation axis 3 to a support 4, and each mowing member 2 having an electric drive motor 5 drive the mowing member to rotate along circular trajectory 6. The circular trajectory 6 is coaxial to the vertical rotation axis 3. The mowing member as shown is of a general oblong shape. Alternatively the mowing member could be circular. The mower 1 further is equipped with at least one control device 7 arranged to control at least one of the electric drive motors 5 to control rotation of the mowing member to rotate the mowing member into a pre-defined position with respect to its circular trajectory. The motor can rotate the mowing member, and stop the member in a position. When mowing members are driven to rotate, according to the invention the positions of the blades of all the mowing members can be controlled. In one rotation the knives will pass 360 degrees of a circle. Thus the positions of the blades of each mowing member can also be controlled relative to each other. In a conventional mower this is done by a mechanically by using a gear train. In the mower of the invention this is achieved by motor control and the control device controlling the positions of all the mowing members/blades by controlling each motor. In this manner the position and the speed as well as the direction of rotation of the mowing members/blades may be controlled. Also synchronization of the mowing members by controlling the motors of each mowing member is possible.

The control device 7 is shown to be present on the frame 4 of the mower 1, near the coupling member 16 which will allow the motor to be coupled to a vehicle (not shown) and power to be lead onto the mower. The vehicle usually is a tractor and the mower 1 is in de form of a cutter bar which is coupled to a three-point hitch to be pulled by the tractor across a field of crop to be mowed. Alternatively the mower may be

part of a self-driving vehicle with a person driving the vehicle, or even an autonomously moving vehicle for which no person operating/driving it is necessary. Power to drive the motors and feed the control device may be provided by battery 17 provided on the mower or by power cables (not shown) passing through coupling member 16 from a battery on the vehicle or from a so-called power take-off (PTO) generator.

The control device is provided with suitable electronics to be connected to the motors of the mower in order to control their rotation. E.g. the control device may receive and send sensor and/or control signals to and from each motor.

The electric drive motors may be of the brushless motor type, e.g. an AC motor with a stator having wound coils and being supplied with an AC current and a rotor rotatably positioned inside the stator. The rotor driving an output shaft which in turn drives the mowing member. The rotor may be in the form of permanent magnets or electrical windings. The rotation of such a motor may be controlled by using a Variable Frequency Drive (VFD) which uses motor input frequency of the AC current and voltage to control the AC motor speed and torque. Different types of VFD control exist, of which the so-called vector control is the most common. Types of vector control are Direct Torque Control (DTC) and Field Oriented Control (FOC). The frequency of the current determines how fast the magnetic field will change and thus how fast the rotor (and output shaft) will rotate. This involves calculating the motor's magnetic flux and torque based on the measured voltage and current of the motor.

Significant aspects of vector control application are that speed or position must be determined (either measured or estimated), and that torque and flux can be changed reasonably fast, i.e. generally in less than 5-10 milliseconds. Typically the control algorithm has to be calculated at least every millisecond.

Defining a pre-defined position on the circular trajectory may be done by defining a point on the mower member, which upon rotation of the member describes a circular trajectory. After all the mowing member rotates about a central axis causing any point on the mowing member to follow a circle. The trajectory can be seen as an collection of coordinate points (P) on the circumference of the circle. These coordinates can be calculated because for any point P on the circle at distance r from the origin the formula $x^2 + y^2 = r^2$ holds.

The mower 1 further includes a position location device 8 which is part of the control device to determine the actual position of the mowing member on the circular trajectory 6 and the control device 7 is arranged to control the motor to move the mowing member from the actual location to the pre-defined position.

As shown in figure 1 the position location device 8 is provided on the motor 5 of each mowing member. Suitable data transmission hardware and software are provided for the data gathered by the position location devices 8 to sent to the control device 7, received by the control device and used to control the motor.

As shown in figure 1 the mower the position location device 8 is an encoder 14, mounted onto the motor. The encoder when mounted onto the motor as shown in figure 1 is typically an add-on encoder which once mounted can detect the angular position or motion of a shaft or axle and convert it into an analog or digital signal code, which is then transmitted to the control device. In the embodiment as shown, the encoder can be used to determine this for the shaft driving the mowing member.

Alternatively the encoder may be used to determine angular position or motion of the rotor of an electric motor relative to the stator and may be a position sensor inside the motor. These values can be used to determine the position of a mowing blade, after all the position of the mowing blade relative to the motor is known or may be derived from the dimensions form the mower, blade, mowing member and motor. Position encoders are available in a large variety and may be operate mechanically, optically, magnetic or capacitively. According to the invention the term encoder must also be seen using Field Oriented Control instead of a position sensor, in which the magnitude and position of the rotor flux are determined in order to control the motor.

The pre-defined position may be chosen to be the position in which the mowing member is to be stopped on its circular trajectory.

Each mowing member 2 has at least one mowing blade 9 having a free outer end 10, which blade 9 in normal operating circumstances projects radially outwardly including a radial center line 11 which radial center line 11 extends from the rotation axis 3 outward and the free outer end 10 following a circular blade trajectory 12, and

each mowing member 2 is mounted to the frame 4 adjacent to another mowing member 4 such that the respective blade trajectories 12 define an overlap area 13 between them, and wherein a pre-defined stop position is chosen such is such that the radial line of the blade of the stopped mowing member does not intersect the overlap area.

In figure 1 the mowing members are shown in a manner in which the blades 9, 10 will never hit each other.

In order to stop the electric motor 5, a capacitor 15 is provided with suitable connections to each motor. These connections may be the same as the ones that provided the motors with electricity. The control device is arranged to stop rotation of the at least one mowing member by controlling the capacitor 15 to inject DC current into the motor to be stopped.

Claims

1. A mower comprising

- a plurality of mowing members, each mowing member mounted rotatably about a vertical rotation axis to a support ,
- each mowing member comprising an electric drive motor couplable thereto and arranged to drive the mowing member to rotate along a circular trajectory coaxial to the vertical rotation axis and wherein,

the mower further comprises at least one control device arranged to control at least one of the electric drive motors move the mowing member to a pre-defined position on its circular trajectory.

2. The mower of claim 1 wherein the control device includes a position location device to determine the actual position of the mowing member on the circular trajectory and the control device is arranged to control the motor to move the mowing member from the actual location to the pre-defined position.

3. The mower of any of the claims 1 or 2 wherein the pre-defined position is the position in which the the mowing member may be stopped on its circular trajectory.

4. The mower of 3 wherein

- each mowing member comprising at least one mowing blade having a free outer end, which blade in normal operating circumstances projects radially outwardly including a radial center line which radial center line extends from the rotation axis outward and the free outer end following a circular blade trajectory, and

wherein each mowing member is mounted to the frame adjacent to another mowing member such that the respective blade trajectories define an overlap area between them, and wherein a pre-defined stop position is chosen such is such that the radial line of the blade of the stopped mowing member does not intersect the overlap area.

5. The mower of any of the preceding claims 2-4 wherein the position location device comprises an encoder.

6. The mower of any of preceding claims wherein the mower includes at least one capacitor electrically connected to the motor and the control device is arranged to stop rotation of the at least one mowing member by controlling the capacitor to inject DC current into the motor to be stopped.

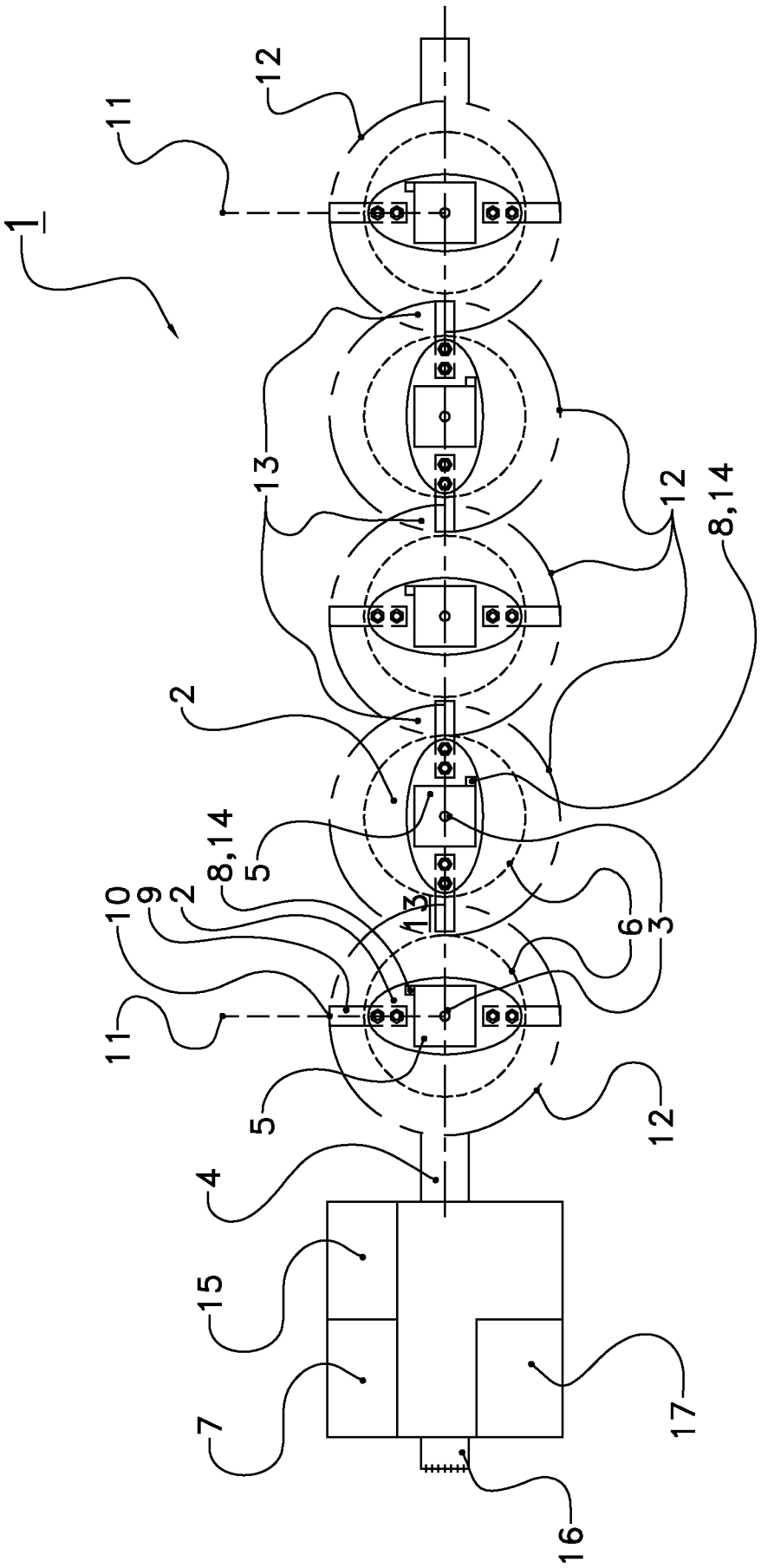


FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2017/050365

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01D34/66 A01D34/78 A01D34/82
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 3 025 569 A1 (BRAUN MASCHB GMBH [DE]) 1 June 2016 (2016-06-01) paragraph [0005] - paragraph [0008] paragraph [0010] paragraph [0020] - paragraph [0027] figures 1-3	1-4

X	US 2013/152535 A1 (ROBERGE MARTIN J [CA]) 20 June 2013 (2013-06-20)	1,3
Y	paragraph [0027] - paragraph [0028]	6
A	paragraph [0030] paragraph [0032] - paragraph [0036] figures 3-6, 10	2,4

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2006/059879 A1 (EDMOND BRIAN W [CA]) 23 March 2006 (2006-03-23) paragraphs [0033], [0049], [0051], [0052] paragraph [0056] - paragraph [0058] paragraph [0062] figure 1	6 1
X	US 6 591 593 B1 (BRANDON DENNIS [US] ET AL) 15 July 2003 (2003-07-15) column 6, line 10 - line 32 column 7, line 19 - line 50 column 8, line 63 - column 9, line 6 column 11, line 67 - column 12, line 58 figure 1	1,2,5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2017/050365

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