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(71) Applicant(s)
Maasland N.V.

(72) Inventor(s)
Olaf Van Der Lely; Alexander Van Der Lely; Maarten Koorn

(74) Agent/Attorney
PHILLIPS ORMONDE and FITZPATRICK,367 Collins Street,MELBOURNE VIC 3000

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(71) Applicant *(for all designated States except US)*: MAASLAND N.V. [NL/NL]; Weverskade 10, NL–3155 PD Maasland (NL).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: VAN DER LELY, Olaf [NL/CH]; Weinbergstrasse 11, CH–6300 Zug (CH). VAN DER LELY, Alexander [NL/NL]; Jan Witkampstraat 44, NL–3065 NA Rotterdam (NL). KOORN, Maarten [NL/NL]; H. Wielengastraat 5, NL–3123 CP Schiedam (NL).

(74) Agent: MULDER, Herman; Weverskade 10, NL–3155 PD Maasland (NL).

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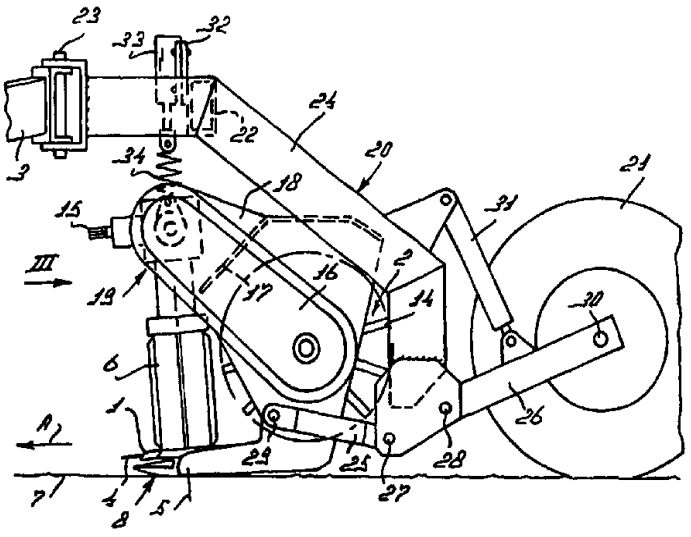

(57) Abstract

The invention relates to an agricultural machine, such as a mowing implement, provided with one or more mowing members (1) for mowing a crop, which agricultural machine comprises means for determining the soil conditions and/or determining and/or forecasting the behaviour of at least part of the agricultural machine caused by the soil conditions and/or the crop present on the ground. The invention also relates to a method of using an agricultural machine, such as a mowing implement.

AN AGRICULTURAL MACHINE AND A METHOD OF USING SAME

The invention relates to an agricultural machine such as a mowing implement, provided with one or more mowing members for mowing crop. The invention also relates to a method of using an agricultural machine, such as a mowing implement.

This discussion of documents, acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed in Australia before the priority date of each claim of this application.

An agricultural machine of this type is a so-called drawn mowing implement provided with a resilient supporting beam suspended in a mobile main frame and extending substantially horizontally and perpendicular to the direction of travel, on which supporting beam there is disposed a row of knives which are arranged in side by side relationship and which are rotatable in opposite directions about upwardly orientated respective shafts. Via said supporting beam part of the weight of that row rests on the ground. Prior to mowing, the ground pressure of the supporting beam can be adjusted at a predetermined ground pressure by means of manually controlled multiple adjustment. In this manner the operation of the agricultural machine can be adapted to the soil conditions. The multiple adjustment cannot be operated from the tractor.

According to one aspect of this invention there is provided an agricultural machine, such as a mowing implement, including one or more mowing members for mowing crop, wherein the agricultural machine includes means for determining the soil conditions and/or determining and/or forecasting the behaviour of at least part of the agricultural machine caused by the soil conditions and/or the crop present on the ground.

In this manner it is possible to adapt the agricultural machine during mowing e.g. to the change in the soil conditions. This will result in an improved mowing process; it

will be possible to move the agricultural machine at a higher speed; the agricultural machine will be less subject to wear or damage and there will be inflicted e.g. less harm to the soil or the crop.

The invention is based on the insight that the soil conditions are not equal in every place of a parcel, so that presetting only once of e.g. the ground pressure of the agricultural machine prior to mowing a parcel does not give an optimal result.

With a soft ground e.g. a too great ground pressure is disadvantageous, because in that case the supporting beam threatens to sink in the ground and to damage the roots of the crop, while in the situation of a hard ground e.g. a too small ground pressure results in that the subframe will bounce so that the mowing process will be irregular. Also in the situation of a bumpy ground a greater ground pressure will be favourable. By means of the invention it will be possible continuously to adjust an optimum during mowing for the purpose of mowing at a minimal ground pressure and at a minimal bouncing movement.

The invention also relates to determining the resistance which the agricultural machine encounters during moving over the ground and, in the case that the agricultural machine is designed as a mowing implement, also to determining the speed of rotation of the mowing members during mowing, for the purpose of improving e.g. the mowing results on the basis of these determinations.

According to another aspect of the invention there is provided an agricultural machine including one or more mowing members for mowing crop, a security system for determining or forecasting at least the horizontal friction between at least art of the agricultural machine and the ground and/or crop.

According to further still another aspect of this invention there is provided an agricultural machine including one or more mowing members for mowing crop, a monitoring system for determining the number of revolutions of the one or more mowing members

According to further still another aspect of this invention there is provided a method of using an agricultural machine provided with one or more mowing members for mowing crop, wherein during mowing, the soil conditions in front of the agricultural machine or under the agricultural machine, or the behaviour of at least part of the agricultural machine because of the soil conditions is determined or forecast continuously or at intervals.

According to further still another aspect of this invention there is provided a method of using an agricultural machine provided with one or more mowing members for mowing crop, wherein, during mowing, at least the horizontal resistance of the agricultural machine relative to the ground and/or crop is determined continuously or at intervals.

According to further still another aspect of this invention there is provided a method of using an agricultural machine provided with one or more mowing members for mowing crop, wherein the number of revolutions of at least one mowing member is determined.

In what follows the invention is explained in further detail on the basis of non-restricting exemplary embodiments and with reference to the accompanying drawings, in which:

Figure 1 is a plan view of a first embodiment of the invention;

Figure 2 is a side view of part of a drawn mower according to the invention;

Figure 3 is a front view of the part of the implement shown in Figure 2, partially showing the interior thereof, and

Figure 4 is a plan view of a second embodiment of the invention.

In the figures, showing the embodiment schematically, corresponding parts are indicated by the same reference numerals.

Figure 1 shows a tractor 36 with a drawn mower 37 and a front mower 38 suspended from the tractor. In what follows the invention is set out in further detail on the basis of a drawn mower, although the principles of the invention are also applicable to e.g. the front mower.

Figure 2 shows schematically a combined mower-crusher implement with mowing members 1 and the rotor 2 of the crusher. The fastening arm 3, by means of which the drawn implement can be connected to a tractor, is only partially shown. The agricultural machine may also be designed without a crusher.

There are shown a number of mowing members 1 arranged in side by side relationship and extending at least substantially horizontally and perpendicular to the direction of travel (arrow A), which mowing members are all provided with two knives 4. The juxtaposed mowing members 1 rotate each time in opposite directions about respective upwardly orientated shafts 5, the knives 4 following a path overlapping that of the mowing members 1 located immediately next thereto. Each shaft 5 inclines forward somewhat in the direction of travel (arrow A), as shown in particular in Figure 2. The outer mowing member 1 located on either side of the agricultural machine is provided with a crop guide member 6 which rotates together with said mowing member.

As shown in particular in Figure 2, the mowing members 1 are disposed above a supporting beam 8 which, in the shown operative position of the agricultural machine, rests on the ground and extends at least substantially horizontally and perpendicular to the direction of travel (arrow A). Under each mowing member 1 the supporting beam 8 is provided with a guide shoe 10 which is partially circular at the front side. Inside the supporting beam 8 there are drive means for driving the mowing members 1 in rotation, which drive means comprise e.g. a drive rod 11 (see Figure 3)

extending through the supporting beam in longitudinal direction.

In this embodiment the drive rod 11 is driven near its two ends by a (non-visible) shaft, which is co-axial to the respective shaft 5 and extends through the crop guide member, which (non-visible) shaft is driven itself by a shaft 9 passing through the frame beam 12 extending at least substantially parallel to the supporting beam 8 and at some distance above the mowing members, which shaft 9 is driven itself by the shaft 15 to be connected to the power take-off shaft of the tractor. Alternatively it is possible for the drive rod 11 to be driven only at one end.

The crusher device 2 comprises a cylindrical shaft 13 rotatable about its axis and extending between the supporting beam 8 and the frame beam 12 at least substantially parallel to these beams 8 and 12, on which shaft 13 projecting crushing pins 14 are disposed. The cylindrical shaft 13 is driven in rotation near one of its two ends by the shaft 9 by means of a (non-visible) transmission included in a gear box 16, which transmission is arranged at the respective side of the agricultural machine and which transmission may be constituted by a chain running over a gear wheel disposed on the respective shaft 9 and the cylindrical shaft 13. The crusher device is partially surrounded by a cap 17 extending at least substantially parallel to the cylindrical shaft 13.

By means of a plate element 18 on either side of the agricultural machine the supporting beam 8 and the frame beam 12 are joined together to form a subframe 19 retaining at least substantially its shape. This subframe 19 is fastened to a carrier frame 20 which is capable of being moved over the ground 7 by means of a wheel 21 on either side of the agricultural machine and which is supported at one side by these wheels 21 and at the other side by the fastening arm 3 coupled to the tractor. The carrier frame 20 retains at least substantially its shape and comprises a frame beam 22 extending at least substantially parallel to the frame beam 12, to which frame beam 22 the fastening arm 3 is pivotably fastened about an upwardly orientated shaft 23. On either side of the agricultural machine there is provided a respect-

ive frame arm 24 which is rigidly secured to the frame beam 22 and which extends obliquely rearwards and downwards relative to the direction of travel (arrow A). At the other free end of this frame arm 24 a respective end of arms 25, 26 respectively is freely pivotably disposed about pivot shafts 27, 28 respectively extending substantially horizontally and parallel to the frame beam 22. In the shown operative position of the agricultural machine, the arm 25 extends substantially horizontally, while its other end is fastened, freely pivotably about a pivot shaft 29 extending at least substantially parallel to the pivot shaft 27, to the plate element 18 of the subframe 19 and ensures in this manner that the subframe is adjustable at least substantially only in height. With its other end the arm 26 is fitted to the hub of the wheel 21 so as to be freely pivotable about the wheel axle 30. The position of the arm 26 relative to the ground 7 is adjustable by means of the adjusting element 31, in this embodiment constituted by a hydraulic cylinder, which is fastened with one end to the arm 26 and with its other end to the frame arm 24. The adjusting element may be designed so as to be capable of being operated from the tractor and may serve to bring the agricultural machine from the shown operative position into the transport position in which the supporting beam 8, e.g. during transport by public road is lifted with sufficient clearance from the ground 7.

The vertical support between the subframe 19 and the carrier frame 20 is designed as an adjustable one; in this embodiment there are disposed for that purpose two adjustable fastening members 32 with mutual interspace. Although different alternatives are possible, in this embodiment each fastening member 32 consists of an adjusting element 33, such as a hydraulic cylinder, which is rigidly fastened to the frame beam 22, and a spring element of which one end is rigidly secured to the adjusting element 33 while the other end is rigidly secured to the frame beam 12, the spring element being constituted in this situation by a helical tension spring 34. Preferably the spring element has a spring constant which is approximately constant over a considerable part of the difference in length which the

spring element undergoes during operation. As an alternative, a progressive spring constant may be applied as well. Instead of a helical tension spring, there may also be applied another type of spring, such as an air spring. Because of its simplicity and sturdiness a helical tension spring is preferred.

By extending the adjusting element 33 to a greater or a lesser extent, the weight distribution of the subframe 9 over the supporting beam 8 and the carrier frame 20 can be controlled, so that the supporting beam presses to a greater or a lesser extent on the ground 7. The spring element ensures that the supporting beam is capable of following e.g. unevennesses of the ground 7. Adjustment of the adjusting element preferably takes place automatically when the agricultural machine is moved forward, so that the pressure at which the subframe 19 rests on by the ground 7 via the supporting beam 8 is adapted to changing conditions. For that purpose, in this embodiment a sensor 35 is fastened to the subframe 19, in this situation to the frame beam 12. The sensor 35 belongs to a recording system and is used for detecting vibrations of the subframe 19 during mowing, for determining on the basis thereof whether adjustment of the ground pressure for the subframe 19 is necessary. For that purpose, in this embodiment the sensor 35 is an acceleration meter. This acceleration meter supplies a signal to a calculation device or an evaluation device comparing this signal, or a signal derived or converted therefrom, e.g. with a reference value and in case of a deviation therefrom, whilst observing possibly a predetermined threshold value, activates the control device for the adjusting element, for the purpose of adapting the ground pressure in the desired manner. The signal emanating from the acceleration meter is e.g. filtered, to which end there is provided a signal filtering device for e.g. filtering out slower motions due to following unevennesses of the ground hardly influencing, if at all, the mowing process. Instead of or in addition to the acceleration meter 35, e.g. a strain gauge may be used as sensor, which strain gauge detects deformations in a portion of the subframe 19, which deformations are generated e.g. by

a bouncing movement of the subframe 19. An other alternative to the acceleration meter is e.g. a sound recording microphone with the aid of which an identifiable sound pattern which is characteristic for a too great or too small ground pressure can be recorded. A further alternative is e.g. a ground identification system, such as a picture identification system, e.g. a video camera, which ground identification system determines the type of soil (e.g. soft or hard or marshy or dry) and on the basis of which the ground pressure is adapted during mowing.

Instead of fitting the sensor 35 to the subframe, said sensor may also be disposed elsewhere, e.g. more in front of the subframe 19 relative to the direction of travel, e.g. on the fastening arm 3, so that changing conditions can be anticipated. In front of the subframe 19 there may also be used an auxiliary element which rests on the ground and whose behaviour is measured, while on the basis of this measurement the ground pressure of the subframe 19 is adapted.

As an alternative to or in addition to the fully automatic system there may be arranged, e.g. in the driver's cabin of the tractor, an electronic unit, e.g. a keyboard, on which the driver, during mowing, can input a desired ground pressure, e.g. when he notices that the ground structure changes, or when he receives a relevant signal from the signalling device. The electronic unit may be combined with an indicating device for indicating the adjusted ground pressure or a position representing same. For example, in the situation of a combination of automatic and manual operation, the driver may optionally switch between these two positions.

As an alternative to the adjusting element 33 the adjusting element 31 may also be used for adjusting the ground pressure during mowing. In this situation, of course, the spring element 34 is fastened directly to the frame beam 22. The adjusting element will be activated by the control device on the basis of e.g. the signal emanating from the sensor 35. The adjusting element 33 may also be provided between the arm 25 and the frame arm 24.

As an alternative to the mowing members 1 it is e.g. possible to apply the invention to a so-called cage

mower which, e.g. by means of a supporting roller beside the mowing cage, rests at least partially on the ground.

The agricultural machine furthermore comprises a monitoring system for the number of revolutions of the mowing members 1. For that purpose each guide shoe 10 is provided with a (non-visible) light-sensitive element, such as a diode, signalizing the passage of a knife 4. In an evaluation device the number of revolutions can be deduced from the registered passages. The evaluation device may e.g. be coupled to an indicating or warning device. The number of revolutions may e.g. also be measured on the basis of the number of revolutions of the drive shaft 9 or that of the drive shaft passing through the crop guide member 6.

The mower 39 shown in Figure 4 is a so-called trailed mower. The most significant difference from the drawn mowers shown in Figures 1 to 3 is the suspension of the mower 39 by the intermediary of a coupling trestle 44 to the three-point trestle 42 of the tractor 36. The mower 39 comprises an upwardly orientated pivot shaft 40. A supporting arm 41 extends between this pivot shaft 40 and the mower 39. Spaced apart from the pivot shaft 40, a deflection mechanism 43 extends between the three-point trestle 42 and the supporting arm 41. Said deflection mechanism 43 comprises in a manner known per se two coupling arms located above each other and slidable under spring action, one of which being pivotably connected to the supporting arm 41 and the other one being fastened to the coupling trestle 44. In the situation of a too great torque on the deflection mechanism, e.g. due to the fact that the mower meets with an obstacle, the coupling arms move away from each other, thus enabling the mower to pivot away. At a growing friction between the mower 39 (in particular the guide shoes 10; see Figure 2) and the ground, the force exerted on the deflection mechanism 43 will increase while generating a transformation therein. This transformation or movement of the two coupling arms relative to each other is determined by a (non-shown) sensor of a security system and is a measure for the ground resistance. At a too great resistance the mower 39 will pivot about the pivot shaft 40. The resistance having been found too great, an

adjustment may be carried out e.g. by decreasing the ground pressure or by reducing the driving speed. In Figure 2 it is also possible to measure the resistance at the coupling trestle 44 with the aid of a strain gauge fitted thereto.

The invention is not restricted to the embodiments described and shown in the foregoing. For example, an embodiment based on the combination of one or more features of one embodiment with one or more features of the other embodiment shown or described here is possible, as well as similar combinations made of more than two embodiments shown or described here.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An agricultural machine, such as a mowing implement, including one or more mowing members for mowing crop, wherein the agricultural machine includes means for determining the soil conditions and/or determining and/or forecasting the behaviour of at least part of the agricultural machine caused by the soil conditions and/or the crop present on the ground.

2. An agricultural machine as claimed in claim 1, including a subframe and a carrier frame partially carrying the subframe, the latter including the mowing members, while the behaviour of the subframe can be determined or forecast by means of a recording system belonging to the means.

3. An agricultural machine as claimed in claim 2, wherein the recording system includes sensor means.

4. An agricultural machine as claimed in claim 3, wherein the sensor means are sensitive to one or more vibrations in the agricultural machine.

5. An agricultural machine as claimed in claim 3 or 4, wherein the sensor means include one or more acceleration meters.

6. An agricultural machine as claimed in claim 3, 4 or 5, including filtering means for filtering out undesired signals supplied by the sensor means.

7. An agricultural machine as claimed in any one claims 3 to 6, wherein the sensor means are at least partially provided on the subframe.

8. An agricultural machine as claimed in any one of the preceding claims including a security system for determining or forecasting at least the horizontal friction between at least part of the agricultural machine and the ground and/or crop.

9. An agricultural machine including one or more mowing members for mowing crop, a security system for determining or forecasting at least the horizontal friction between at least part of the agricultural machine and the ground and/or the crop.

10. An agricultural machine as claimed in claim 8 or 9, wherein the security system includes means which are sensitive to movement between two parts of the agricultural machine.

11. An agricultural machine as claimed in claim 10, wherein at least one of these two parts belongs to a break-back device of the agricultural machine.

12. An agricultural machine as claimed in any one of the preceding claims, including a supporting member by means of which at least part of the weight of the agricultural machine can rest on the ground during mowing.

13. An agricultural machine as claimed in claim 12, including ground pressure adjusting means with the aid of which the degree of supporting via the supporting member can be adjusted.

14. An agricultural machine as claimed in claim 13, wherein the ground pressure adjusting means include at least one adjustable fastening member between the subframe and the carrier frame.

15. An agricultural machine as claimed in claim 12 or 13, including control means which are connected to the security system and/or the recording system, in a manner in which they receive signals therefrom, and are suitable for controlling the ground pressure adjusting means on the basis of the security system or the recording system.

16. An agricultural machine as claimed in claim 13, 14 or 15, including an imputing device for controlling manually, but preferably automatically, a desired adjustment of the ground pressure adjustment means while the agricultural machine is moved forward.

17. An agricultural machine as claimed in any one of the preceding claims, including a monitoring system for determining the number of revolutions of one or more mowing members.

18. An agricultural machine including one or more mowing members for mowing crop, a monitoring system for determining the number of revolutions of the one or more mowing members.

19. An agricultural machine as claimed in claim 17 or 18, wherein the monitoring system includes measuring means for recording the passage of a knife of a mowing member.

20. An agricultural machine as claimed in claim 17 or 18 or 19, including control means which are connected to the monitoring system, in a manner in which they receive signals therefrom, which control means are capable of adjusting the number of revolutions on the basis of signals emanating from the monitoring system.

21. An agricultural machine as claimed in any one of the preceding claims, wherein the recording system or the security system or the monitoring system includes indicating means.

22. A recording system as defined in one or more of claims 1 to 21, for being applied in an agricultural machine.

23. A method of using an agricultural machine provided with one or more mowing members for mowing crop, wherein during mowing, the soil conditions in front of the agricultural machine or under the agricultural machine, or the behaviour of at least part of the agricultural machine because of the soil conditions is determined or forecast continuously or at intervals.

24. A method of using an agricultural machine provided with one or more mowing members for mowing crop, wherein during mowing, at least the horizontal resistance of the agricultural machine relative to the ground and/or the crop is determined continuously or at intervals.

25. A method as claimed in claim 23 or 24, wherein the agricultural machine rests at least partially on the ground by means of a supporting member, and the degree of supporting by the supporting member is adjusted depending on the determination or forecast.

26. A method of using an agricultural machine provided with one or more mowing members for mowing crop, wherein the number of revolutions of at least one mowing member is determined.

27. A method as claimed in any one of claims 23 to 26, wherein the determination or forecast is compared with a reference value and, in case of a deviation therefrom, whilst observing possibly a predetermined threshold value, there is taken a measure for reducing the deviation.

28. An implement or a method as described in the foregoing or shown in the drawings.

DATED: 13 July 2000

PHILLIPS ORMONDE & FITZPATRICK

Attorneys for:

MAASLAND N.V

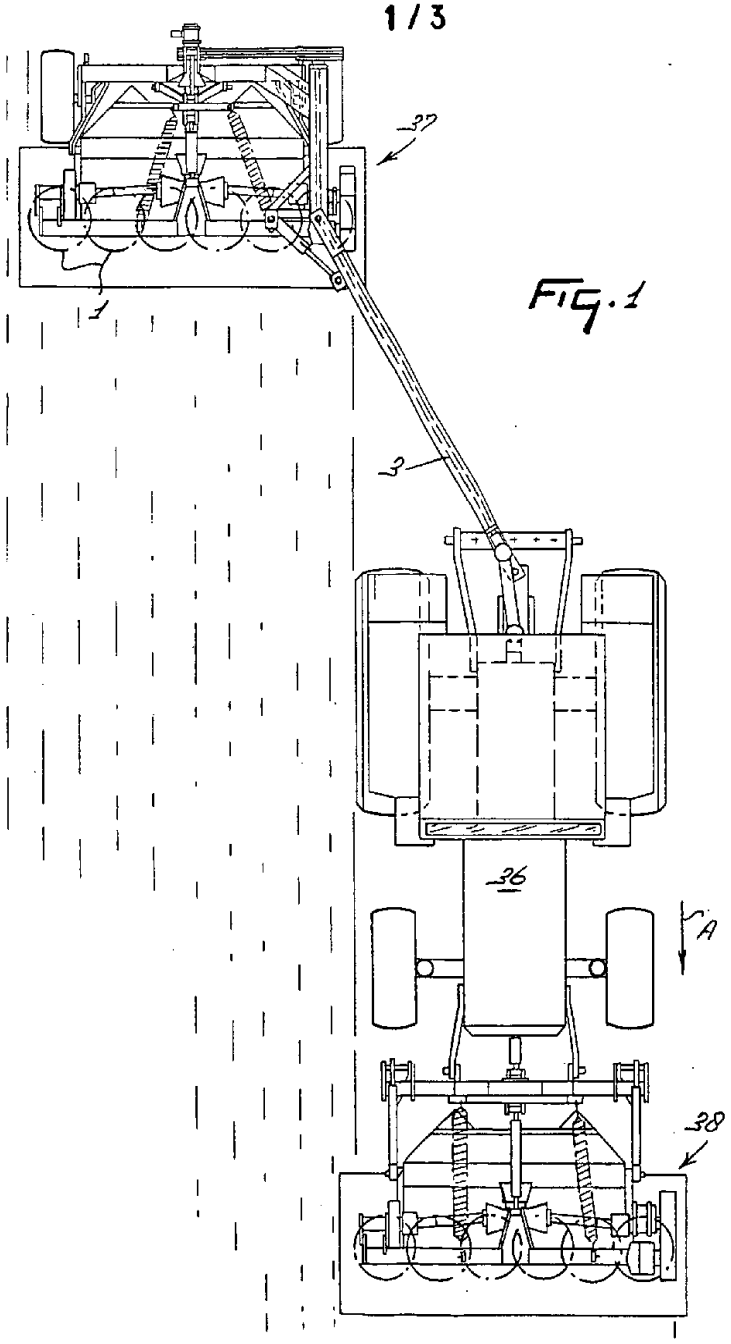

FIG. 1

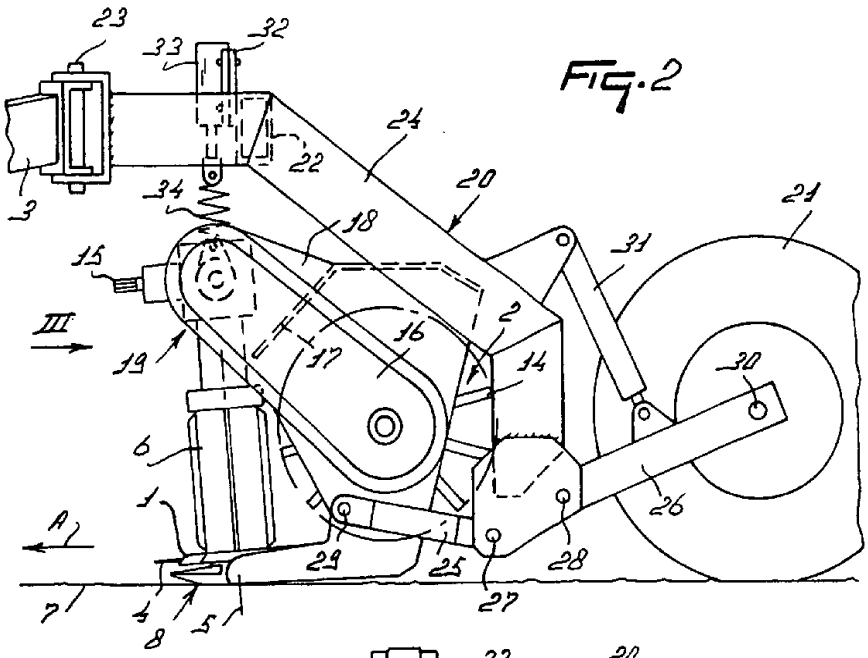
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FIG. 2

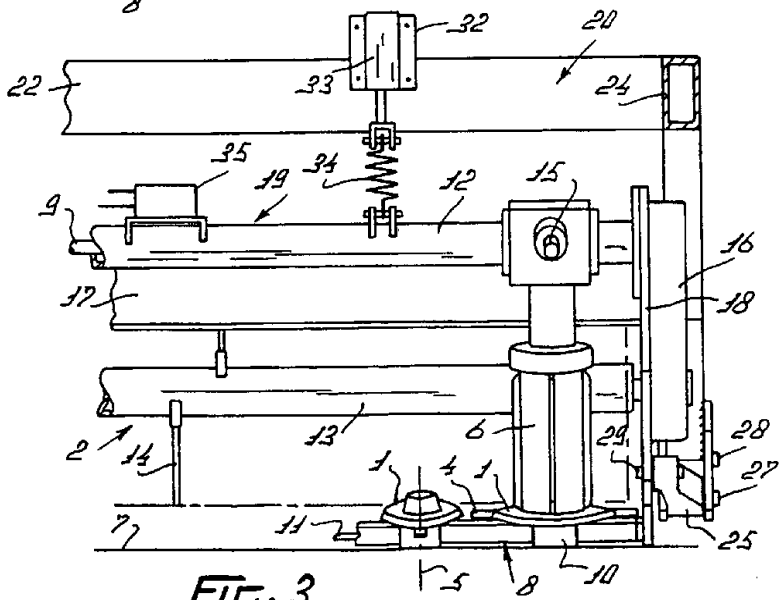
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FIG. 3

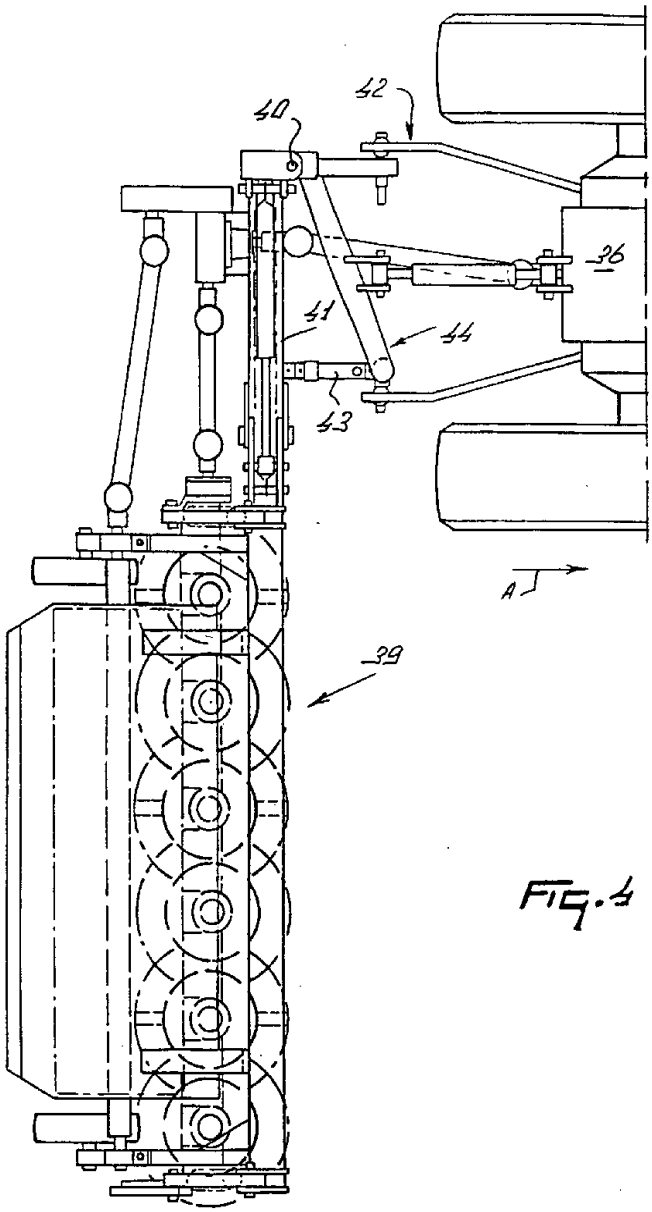

FIG. 4