(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 January 2011 (13.01.2011)

PCT

(10) International Publication Number
WO 2011/005449 A1

(51) International Patent Classification:
A01B 63/114 (2006.01) *E02F 3/84* (2006.01)
A01C 5/06 (2006.01)

(21) International Application Number:
PCT/US2010/039028

(22) International Filing Date:
17 June 2010 (17.06.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/489,261 22 June 2009 (22.06.2009) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) Title: TRENCHING DEVICE AND SYSTEM

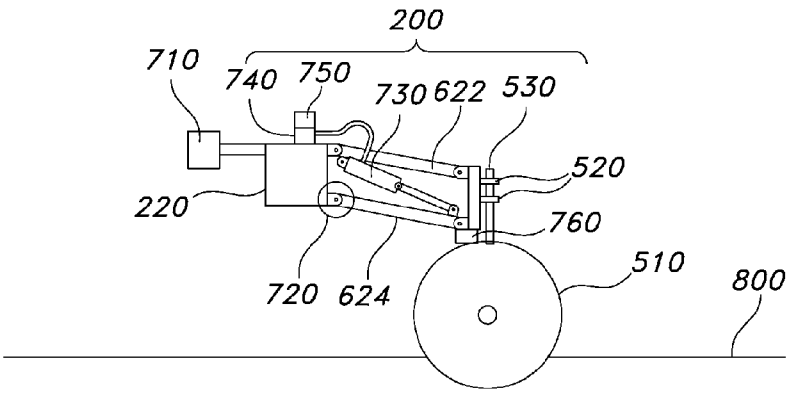

FIG. 4

(57) Abstract: A device for trenching and a system of controlling trenching at a constant depth and at a speed of more than 12 miles per hour.

WO 2011/005449 A1

TRENCHING DEVICE AND SYSTEM

FIELD OF THE INVENTION

The present invention relates to agricultural implements used for in soil banding of fertilizer or seeds.

BACKGROUND OF THE INVENTION

Modern agriculture requires large amounts of fertilizer to be spread over high acreage fields in the quickest, most efficient manner. Two methods are used to spread fertilizer: broadcast and in soil banding.

In soil banding has several advantages. First, in soil banding is often the preferred method because it targets fertilizer near the seed and unlike broadcast fertilizer, in soil banding does not waste fertilizer by placing it away from the seed and in spots where it can fertilize weeds instead of crops. Second, in soil banding can be used in reduced-till or no-till systems. Third, when in soil banding is used instead of tilling, there is reduced soil erosion, better moisture conservation, reduced weed growth, reduced operating cost, and better seed germination and crop establishment.

In soil banding can be accomplished by opening the soil with openers such as discs, knives, sweeps, double discs and single angle discs. The disc or blade is attached to a frame which is pulled behind a tractor to make a furrow in the soil where application material such as fertilizer or seeds can be placed.

In soil banding relies on downward pressure on the disc or blade to achieve a band depth in the soil surface. Pressure is commonly applied to the disc or blade by a single spring or a hydraulic cylinder. This method of in soil banding limits the ground speed of the agricultural machine to less than 10 miles per hour because sufficient time is needed to enable the spring or hydraulic cylinder to adjust to the soil conditions such as uneven terrain, varying soil density, and friction between the disc or blade and the soil. While in soil banding has the advantage over broadcast methods because in soil banding is a targeted approach, broadcast methods are quicker to apply to the soil without dynamic repositioning in real time. The problem is to compete with broadcast methods, equipment using trenching methods need to travel much faster (speeds greater that 12 mph) than equipment currently does and still maintain a precise placement of product at the desired depth.

What is needed therefore is a trenching device and system that utilizes in soil banding techniques, yet can deliver constant band depths at speeds greater than 12 mph. It is to such a device and system that the present invention is primarily directed.

SUMMARY OF THE INVENTION

Briefly described, in preferred form, the present invention is a device for trenching and a system of controlling trenching at a constant depth and at a speed of more than 12 miles per hour.

The control system to be used on such a furrow opener can include a height sensing assembly along the main frame of the banding device to determine the absolute implement-to-ground dimension at each row location, a depth sensing assembly to determine the furrow depth in the soil, an actuator or cylinder to apply a varying load to the row unit, a processor to provide a real-time calculation of the dimension requirements, a pressure regulator/driver to control the length of the actuator or cylinder, and a soil condition sensing assembly.

These and other objects, features, and advantages of the present invention will become more apparent upon reading the following specification in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view of farm equipment with a trenching device according to a preferred embodiment of the present invention.

Fig. 2 is a view of an implement with a trenching device according to a preferred embodiment of the present invention.

Fig. 3 is a top view of a trenching device according to a preferred embodiment of the present invention.

Fig. 4 is a side, close-up view of an individual unit of a trenching device according to a preferred embodiment of the present invention.

Fig. 5 is a view of a farm implement with a trenching device according to another embodiment of the present invention.

Fig. 6 is flow chart describing the control system of the trenching device.

DETAILED DESCRIPTION

While the invention is susceptible to various modifications and alternative forms, a specific embodiment thereof has been shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims. Exemplary embodiments of the present invention are shown in the **Figs. 1-5**.

A device for trenching soil comprising a furrow opening assembly that maintains a near constant depth into the soil when traversing the soil at speeds of **12** miles per hour or greater. **Fig. 1** shows a tractor **101** pulling the trenching device **102** across the soil **103**. The trenching device **102** maintains a near constant depth of +/- 10% as it is being pulled behind the tractor **101**. A near constant depth is very important because it allows for the precise placement of application material **207** at the proper depth in the furrow.

Fig. 2 shows a farm implement **201** that has a horizontal member **205** used to attach a frame **204** to a plurality of row units **202**. Optionally attached to the frame is an application device **206** such

as a tube or chute that connects on one end to a container **203** of application material **207** and on the other end, the application device **206** is connected to the furrow opener assembly **202**. The application material **207** exits the application device behind the furrow opener assembly **202**.

The soil **103** that is opened by the furrow opening assembly has a variety of densities. For instance, the soil **103** could be very sandy and easy to open the soil with the furrow opening assembly through. Or the soil **103** could be very thick like clay which makes it very difficult to open with the furrow opening assembly. The furrow opening assembly would also have difficulty opening hard soil **103** that is densely packed together or rocky soil that has a lot of unevenness and rocks.

The soil level is uneven. The soil level itself has often has hills and valleys like the terrain in general. Vegetation left behind from prior plantings can also cause peaks in the soil **103**. Very rarely will the soil level be perfectly flat.

An automated adjustment system can dynamically adjust the force the furrow opening assembly applies to the soil to provide the near constant depth into the soil, as the soil varies in densities and level. **Fig. 3** shows a closer top view of a farm implement **301** with a plurality of row units **202** attached to a frame **204**, which is a straight member made of a durable material connecting a plurality of row units **204** in a straight line. Each row unit **202** has an automated adjustment system **316** and a furrow opening assembly **312**. The furrow opening assembly **312** contains a furrow opener **308**. A furrow opener **308** can include as discs, knives, sweeps, double discs and single angle discs for use to open the soil. In the present embodiment, the furrow opener **308** is a disc. An automated adjustment system **316** can be used to adjust the downward force on the furrow opener assembly **312** to control the depth that the furrow opener **308** will cut into the soil. The control assembly **316** can include six basic functional blocks for each row unit: a height sensing assembly **303**; a depth sensing assembly **304**; an actuator **305**; an actuator control **306**; a processor **307**; and a soil condition sensing assembly **309**.

Fig. 4 shows a detailed drawing of both the automated adjustment system **316** and the furrow opening assembly **312**. The furrow opening assembly **312** can be attached to the frame **204** by an arm **313**. The arm **313** includes an actuator **305** and two stabilizing members **311**. One stabilizing member **311** can be above the actuator **305** and one stabilizing member **311** is below the actuator **305**. The stabilizing members **311** can be connected to the right face of frame **204** on end and can be connected on the other end to the furrow opening assembly **312**, which can include furrow handle **314** extending horizontal from the arm **313** and attached on the top end of the vertical member **315** that has the furrow opener **308** at the other end. A furrow opener system is connected to the automated adjustment system **316** by the arm **313**, which includes the stabilizing members **311** that are generally horizontal and attached can move up and down relative to the ground **317**.

An automated adjustment system **316** can be used to adjust the downward force on the furrow opener **308** to control the depth that the furrow opener **308** will cut into the ground **317**. The automated adjustment system **316** can include six basic functional blocks for each row unit: a height sensing assembly **303**; a depth sensing assembly **304**; an actuator **305**; a processor **307**; an actuator control **306**; and a soil condition sensing assembly **309**.

The actuator **305** can be mounted to the furrow opening assembly **312** on one end and the frame **204** on one end. The actuator **305** is a mechanical device used to exert downward force on the furrow opening assembly **312**. Some examples of actuators include but are not limited to a spring, a pneumatic or hydraulic cylinder, or other force-driven device such as a motor. The actuator control **306** can be mounted on top of the frame **306** or on top of the actuator **305**. The actuator control **306** controls how much downward force the actuator **305** will exert on the furrow opening assembly **312**. The actuator control **306** receives its instructions from a processor **307**.

The processor **307** can be attached above the actuator control **306**, on the frame **204**, or any location within close enough proximity to the actuator control **306**, the height sensing assembly **303**; the depth sensing assembly **304**; and the soil condition sensing assembly **309** to use a hard wire. The processor **307** can also use a wireless connection to communicate with the actuator control **306**, the height sensing assembly **303**; the depth sensing assembly **304**; and the soil condition sensing assembly **309**. The processor **307** can use the output from the height sensing assembly **303** and soil condition sensing assembly **309** to calculate the proper fertilizer depth and compare it with the output of the depth sensing assembly **304**. If the proper depth is not being maintained, the processor **307** will send information to the actuator control **306** to adjust the down force exerted by the actuator **305**. The processor **307** can also query the height sending assembly **303**, depth sensing assembly **304**, and soil condition sensing assembly **309**.

The height sensing assembly **303**, the depth sensing assembly **304** and the soil condition sensing assembly **309** can have specialized jobs. A height sensing assembly **303** can be used to determine the height of the frame from the ground. The depth sensing assembly **304** can be used to determine how deep a furrow the furrow opener would be making in the soil. The output of the depth sensing assembly **304** can be sent into a processor **307**. A soil condition sensing assembly **309** would supply information regarding the effect of current ground speed and soil density, or compaction, on the row unit.

The height sensing assembly **303** can be attached to left face of the frame **204**. The depth sensing assembly **304** can be attached to the frame **204** or to the lower stabilizing member **311**. The soil condition sensing assembly **309** would be attached to the lower stabilizing member **311**.

In another embodiment, the stabilizing members **311** can be unnecessary and the actuator **305** connects directly from the frame to the furrow opener.

In another embodiment of **Fig. 4**, one processor **307** for each of the row units **202** on the frame **204** can be unnecessary. Instead, as in **Fig. 5**, one processor **307** can be located anywhere because the processor wirelessly sends and receives information between itself and the row unit **202**.

In **Fig. 6**, in box **601**, the processor queries the sensing assemblies. Then in box **602** the sensing assemblies get input from their surroundings. Next, in box **603** the sensing assemblies send input to the processors. In box **604**, the processor determines if the depth is correct using input from sensing assemblies. If no, then in box **605** the processor sends messages to the actuator control. Then in box **607** the actuator control adjusts the actuator and the process starts over at box **601**. If yes, then in box **606**, nothing is done and the process starts again at box **601**.

CLAIMS

What is claimed is:

1. A device for trenching soil comprising a furrow opening assembly that maintains a near constant depth into the soil when traversing the soil at speeds of 12 miles per hour or greater.

2. The device for trenching soil of Claim 1, wherein the soil incorporates a variety of densities.

3. The device for trenching soil of Claim 1, wherein the soil level is uneven.

4. The device for trenching soil of Claim 1, further comprising an automated adjustment system that can dynamically adjust the force the furrow opening assembly applies to the soil to provide the near constant depth into the soil, as the soil varies in densities and level.

5. A device for trenching soil comprising:

a tractor for traversing the soil;

a furrow opening assembly attached to a frame pulled by the tractor, the furrow opening assembly maintaining a near constant furrow depth into the soil; and

an automated adjustment system that can dynamically adjust the force the furrow opening assembly applies to the soil to provide the near constant depth into the soil, as the soil varies in densities and level, and as the tractor traverses the soil at speeds of 12 miles per hour or greater.

6. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises an actuator control assembly for applying the dynamically changing force on the furrow opening assembly, to maintain the near constant furrow depth into the soil depending on changing soil densities and level.

7. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a height sensing assembly for real-time determination of the distance between the frame and the varying soil level.

8. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a depth sensing assembly for real-time determination of the furrow depth into the soil.

9. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a soil condition sensing assembly for real-time determination of the varying character of the soil.

10. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from the soil condition sensing assembly.

11. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from the depth sensing assembly.

12. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from the height sensing assembly.

13. The device for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from automated adjustment system.

14. The device for trenching soil of Claim 5, wherein the processor sends and receives information through a wire.

15. The device for trenching soil of Claim 5, wherein the processor sends and receives information wirelessly.

16. A method for trenching soil comprising a furrow opening assembly that maintains a near constant depth into the soil when traversing the soil at speeds of 12 miles per hour or greater.

17. The method for trenching soil of Claim 1, wherein the soil incorporates a variety of densities.

18. The method for trenching soil of Claim 1, wherein the soil level is uneven.

19. The method for trenching soil of Claim 1, further comprising an automated adjustment system that can dynamically adjust the force the furrow opening assembly applies to the soil to provide the near constant depth into the soil, as the soil varies in densities and level.

20. A method for trenching soil comprising:

a tractor for traversing the soil;

a furrow opening assembly attached to a frame pulled by the tractor, the furrow opening assembly maintaining a near constant furrow depth into the soil; and

an automated adjustment system that can dynamically adjust the force the furrow opening assembly applies to the soil to provide the near constant depth into the soil, as the soil varies in densities and level, and as the tractor traverses the soil at speeds of 12 miles per hour or greater.

21. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises an actuator control assembly for applying the dynamically changing force on the furrow opening assembly, to maintain the near constant furrow depth into the soil depending on changing soil densities and level.

22. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a height sensing assembly for real-time determination of the distance between the frame and the varying soil level.

23. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a depth sensing assembly for real-time determination of the furrow depth into the soil.

24. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a soil condition sensing assembly for real-time determination of the varying character of the soil.

25. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from the soil condition sensing assembly.

26. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from the depth sensing assembly.

27. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from the height sensing assembly.

28. The method for trenching soil of Claim 5, wherein the automated adjustment system comprises a processor for sending, receiving, or sending and receiving information to and from automated adjustment system.

29. The method for trenching soil of Claim 5, wherein the processor sends and receives information through a wire.

30. The method for trenching soil of Claim 5, wherein the processor sends and receives information wirelessly.

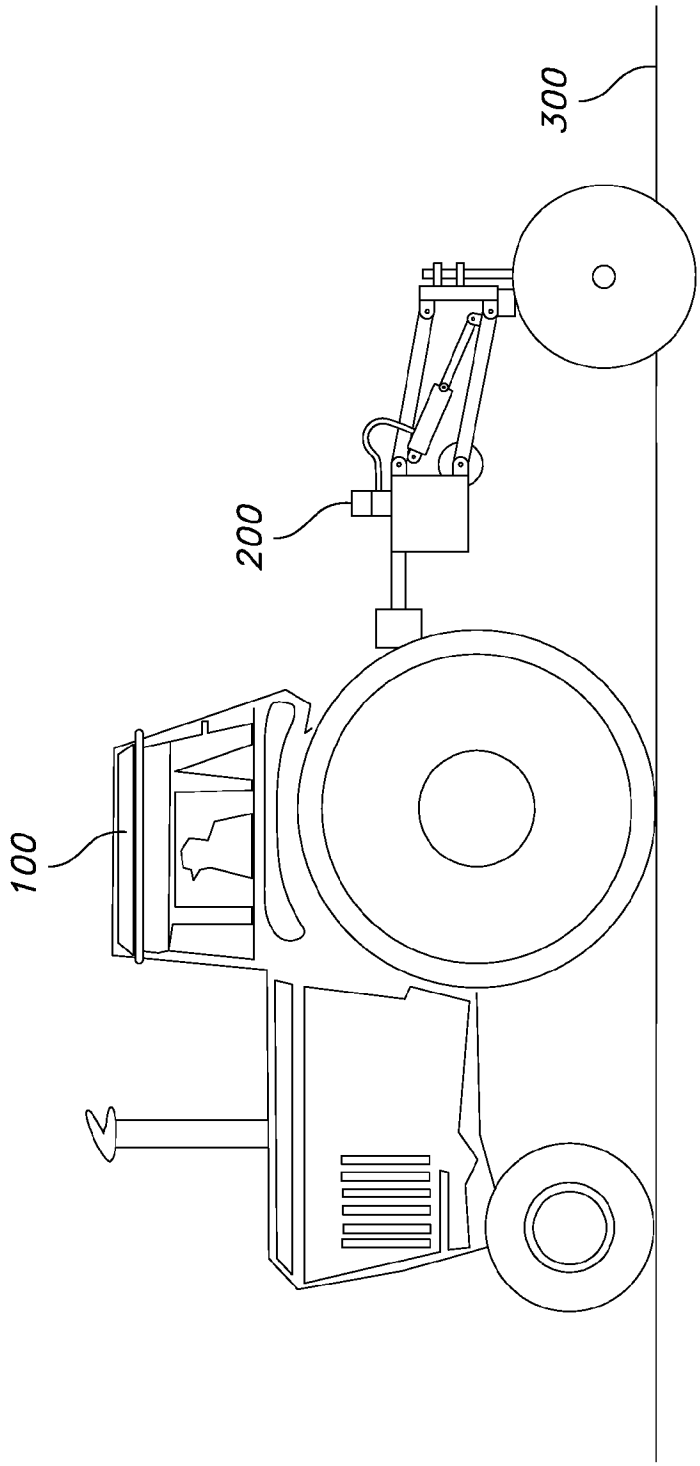

FIG. 1

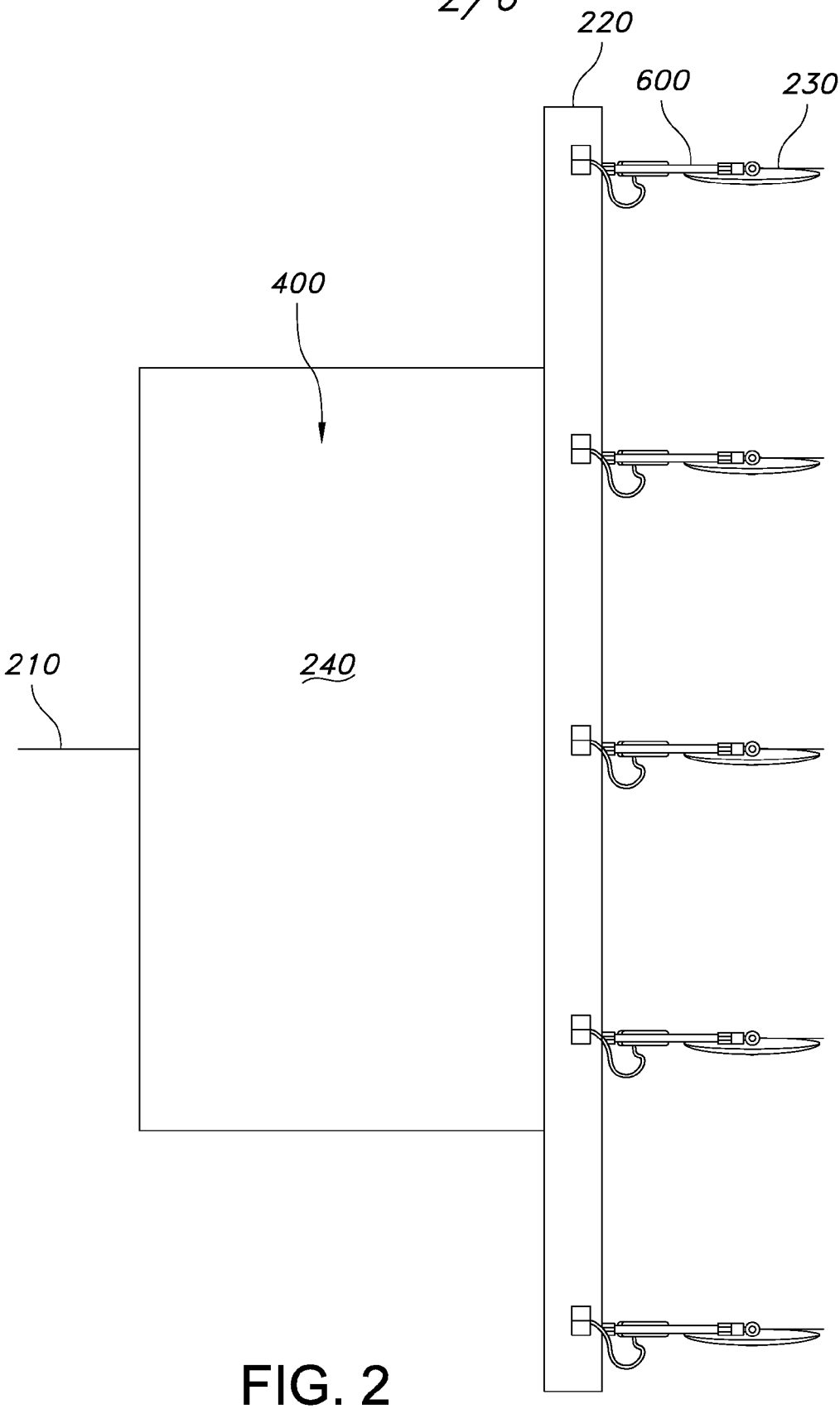

FIG. 2

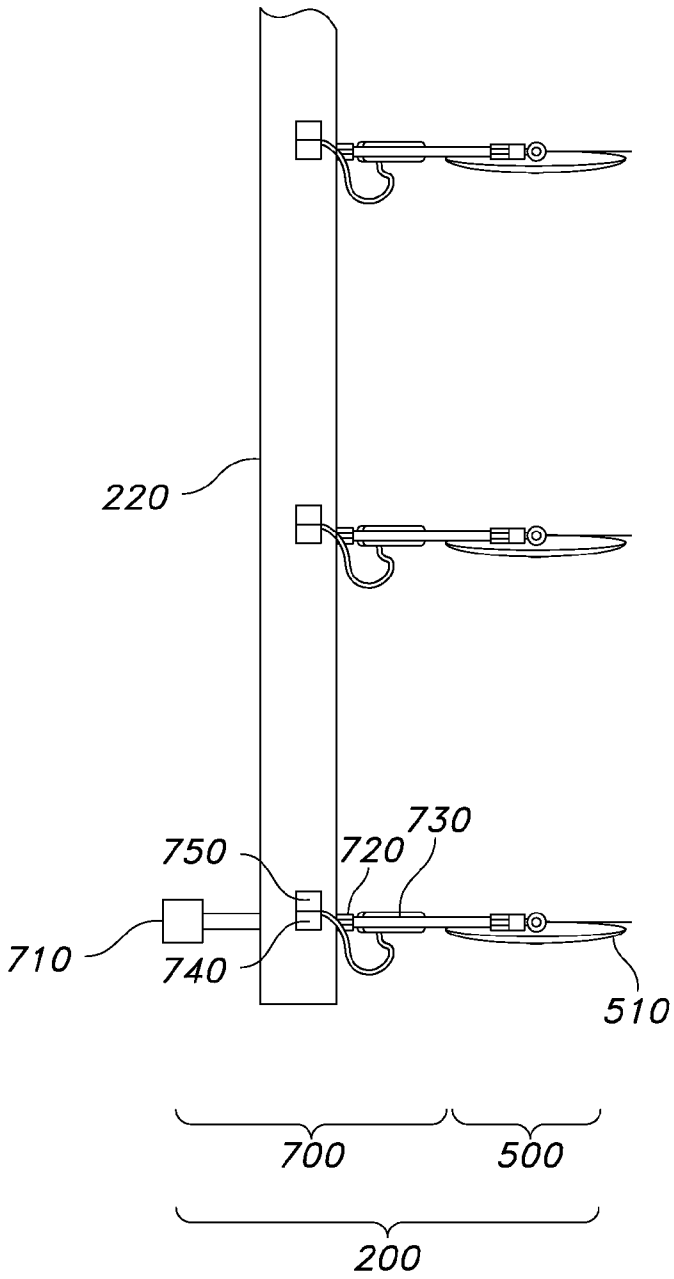

FIG. 3

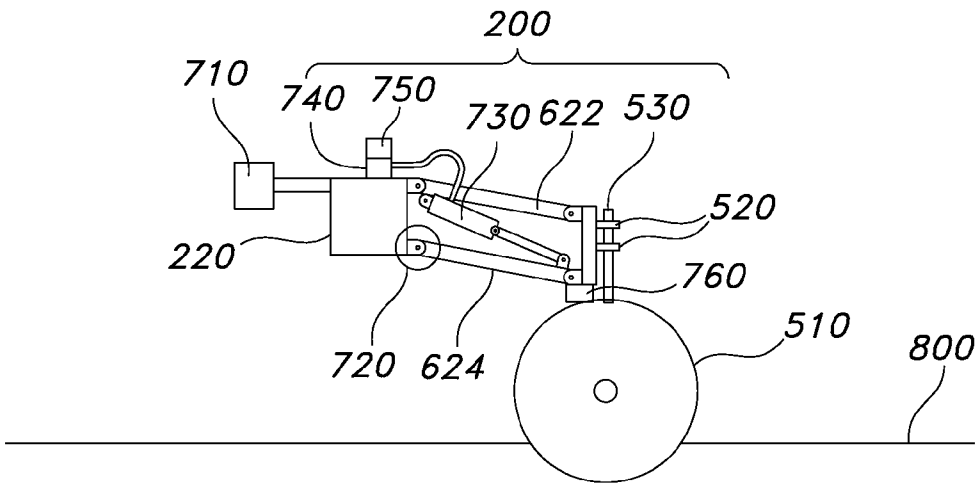

FIG. 4

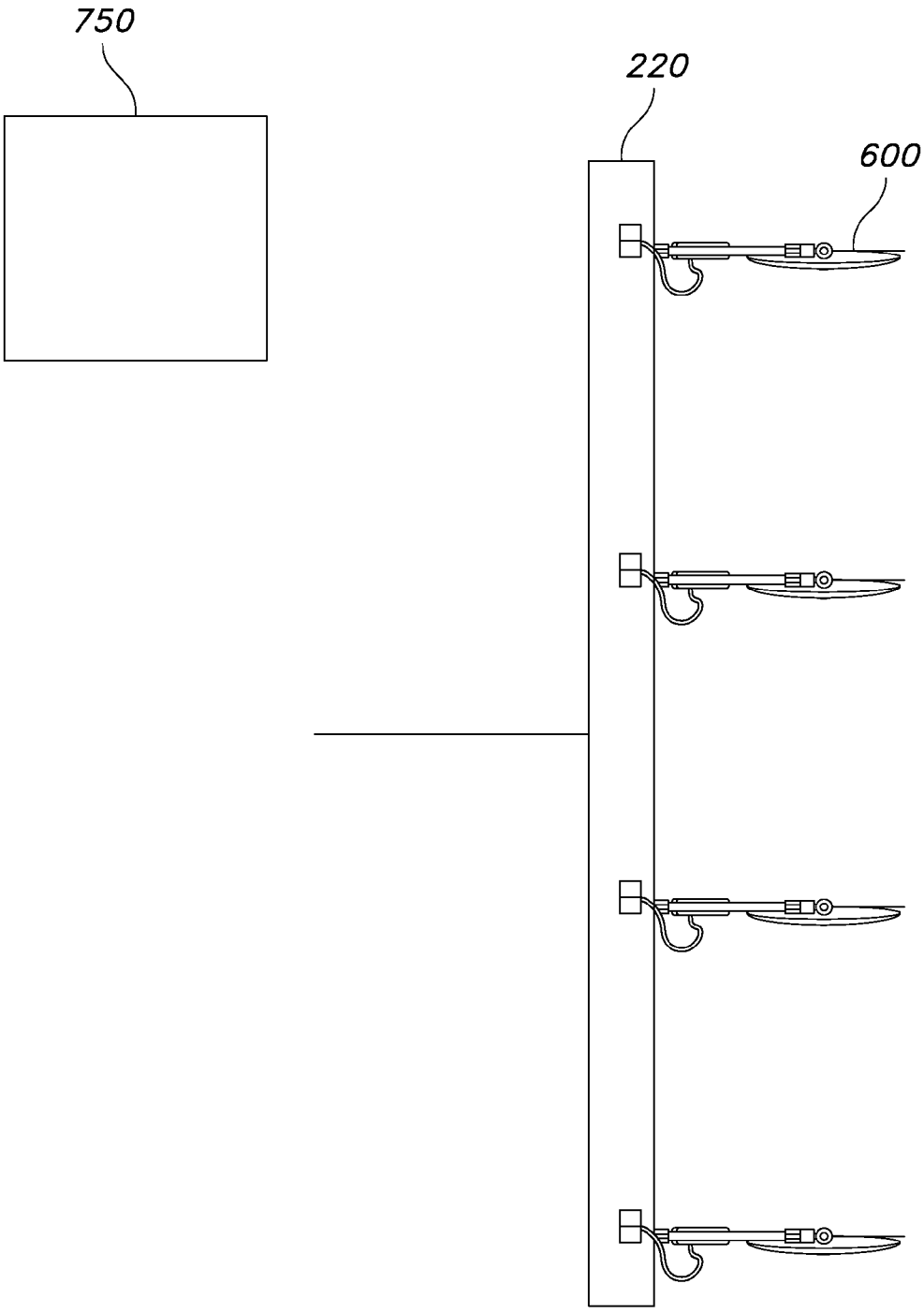

FIG. 5

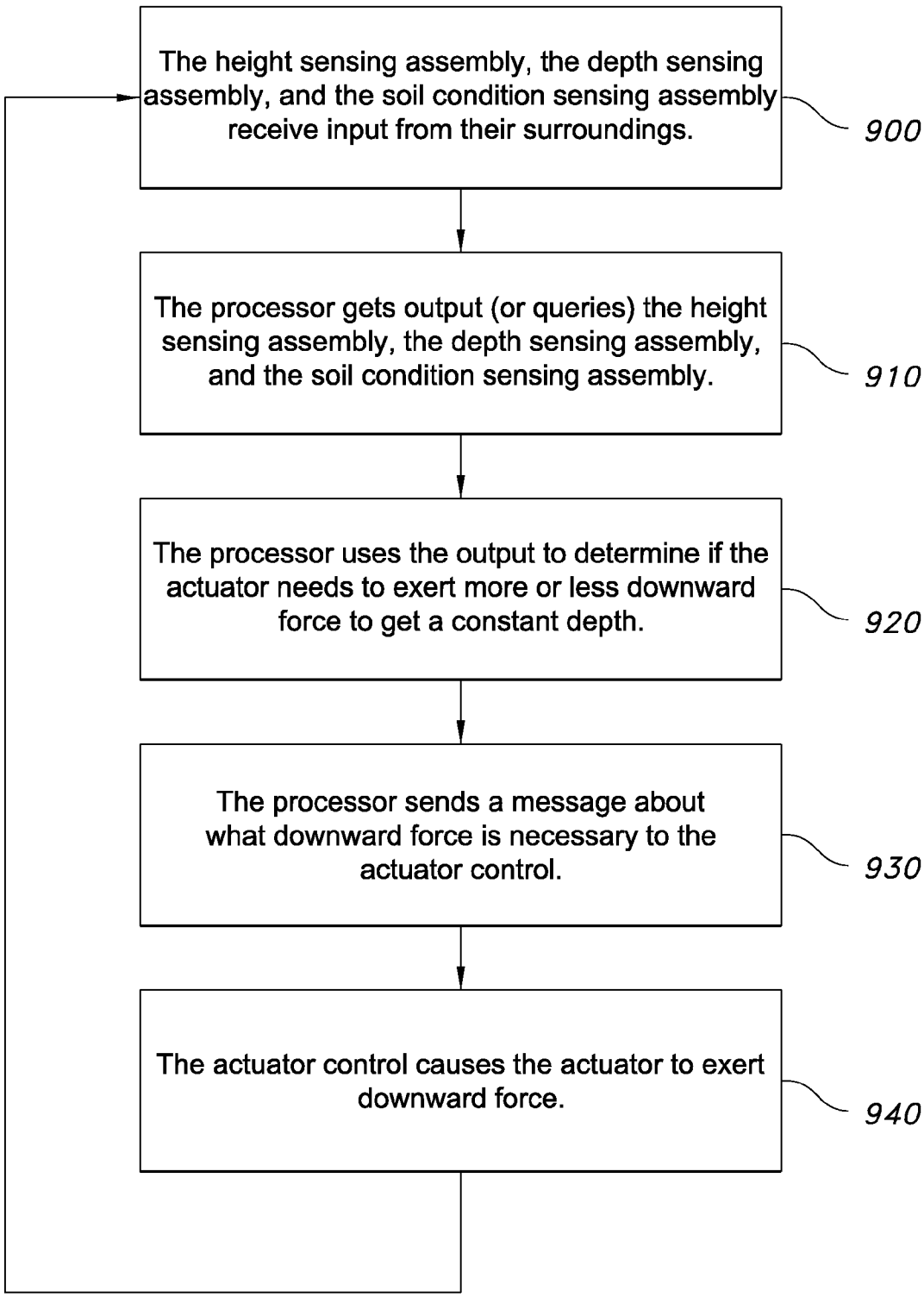
The height sensing assembly, the depth sensing assembly, and the soil condition sensing assembly receive input from their surroundings.
900
The processor gets output (or queries) the height sensing assembly, the depth sensing assembly, and the soil condition sensing assembly.
910
The processor uses the output to determine if the actuator needs to exert more or less downward force to get a constant depth.
920
The processor sends a message about what downward force is necessary to the actuator control.
930
The actuator control causes the actuator to exert downward force.
940

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/039028

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01B63/114 A01C5/06 E02F3/84
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)
A01B A01C E02F

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 practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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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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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 September 2010	29/09/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Laurer, Michael

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/039028

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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