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ABSTRACT OF THE DISCLOSURE

A work vehicle includes a commodity container and an actuator system with a plurality of actuators. The work vehicle includes a delivery system with a plurality of tubes. Furthermore, the work vehicle includes a metering system with a plurality of metering rollers that are configured to be individually actuated by respective ones of the plurality of actuators to meter out a commodity from the commodity container to respective ones of the plurality of tubes. The plurality of metering rollers are arranged substantially parallel to each other. The plurality of metering rollers are disposed in a staggered arrangement.

**ORIGINAL COMPLETE SPECIFICATION
STANDARD PATENT**

Invention Title

Commodity metering system for work vehicle with rollers in staggered arrangement

The following statement is a full description of this invention, including the best method of performing it known to me/us:-

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] Not applicable.

STATEMENT OF FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

FIELD OF THE DISCLOSURE

[0003] This disclosure relates to work vehicles and implements, and more specifically, to a commodity metering system for a work vehicle with metering rollers that are disposed in a staggered arrangement.

BACKGROUND OF THE DISCLOSURE

[0004] Seeding work vehicles, such as air carts/seeder and other seeding devices, are configured for applying seed, fertilizer, and/or other particulate commodities to a field. The work vehicle may be operatively connected to tilling equipment for applying the commodity under the surface of the soil.

[0005] Seeding work vehicles typically include one or more tanks and a metering system that meters out a predetermined quantity of the commodity from the tank as the work vehicle moves across the field. The metering system may include a plurality of metering elements, such as metering rollers that are configured to meter out the commodity from the tank.

[0006] It may be desirable to increase the number of metering rollers to thereby increase the amount of commodity that is delivered to the soil in a single pass of the work vehicle. However, there may be space constraints that limit the number of metering rollers that can be included on the work vehicle.

SUMMARY OF THE DISCLOSURE

[0007] This disclosure provides an improved commodity metering system and/or delivery system for a work vehicle. This disclosure also provides methods for operating the same.

[0008] In one aspect, the disclosure provides a work vehicle with a commodity metering system having a commodity container and an actuator system with a plurality of actuators. The work vehicle includes a delivery system with a plurality of tubes. Furthermore, the work vehicle includes a metering system with a plurality of metering rollers that are configured to be individually actuated by respective ones of the plurality of actuators to meter out a commodity from the commodity container to respective ones of the plurality of tubes. The plurality of metering rollers are arranged substantially parallel to each other. The plurality of metering rollers are staggered in a vertical direction and staggered in a horizontal direction.

1 [0009] In another aspect, a work vehicle is disclosed that includes a commodity container
2 and an actuator system with a first actuator and a second actuator. The work vehicle
3 includes a delivery system with at least one tube a metering system with at least one
4 metering unit. The metering unit includes a housing, a passage defined through the
5 housing and configured to receive a commodity from the commodity container, and a first
6 metering roller and a second metering roller at least partly disposed within the passage of
7 the housing. The first metering roller is configured to be driven in rotation by the first
8 actuator for metering the commodity through the passage to the delivery system. The
9 second metering roller is configured to be driven in rotation by the second actuator for
10 metering the commodity through the passage to the delivery system.

11 [0010] In an additional aspect, the disclosure provides a work vehicle with a commodity
12 container and a metering system with a plurality of metering rollers arranged in a first row
13 and a second row. The first row is spaced apart at a vertical distance from the second row.
14 The first row is offset horizontally with respect to the second row. The work vehicle also
15 includes an actuator system with a plurality of actuators configured to individually actuate
16 respective ones of the plurality of metering rollers. Moreover, the work vehicle includes a
17 delivery system with a plurality of tubes, each configured to receive a commodity metered
18 from the commodity container by respective ones of the plurality of metering rollers. The
19 plurality of tubes are arranged in a third row and a fourth row. The third row is spaced apart
20 at a vertical distance from the fourth row, and the third row is offset horizontally with respect
21 to the fourth row. The plurality of tubes are substantially parallel to the plurality of metering
22 rollers.

23 [0011] The details of one or more embodiments are set forth in the accompanying
24 drawings and the description below. Other features and advantages will become apparent
25 from the description, the drawings, and the claims.

26 BRIEF DESCRIPTION OF THE DRAWINGS

27 [0012] FIG. 1 is a side view of a work vehicle according to example embodiments of the
28 present disclosure;

29 [0013] FIG. 2 is a section view of a metering system and a delivery system of the work
30 vehicle taken along the line 2-2 of FIG. 1 according to example embodiments;

31 [0014] FIG. 3 is a section view of the metering system and the delivery system of the work
32 vehicle taken along the line 3-3 of FIG. 1 according to example embodiments;

33 [0015] FIG. 4 is an end view of a metering unit of the metering system of FIG. 2; and

34 [0016] FIG. 5 is a section view of the metering unit of FIG. 4.

35 [0017] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0018] The following describes one or more example embodiments of a commodity metering system for a work vehicle (e.g., an air cart, commodity cart, etc.), its control system(s), and the methods for operating the same, as shown in the accompanying figures of the drawings described briefly above. Various modifications to the example embodiments may be contemplated by one of skill in the art.

[0019] As used herein, unless otherwise limited or modified, lists with elements that are separated by conjunctive terms (e.g., "and") and that are also preceded by the phrase "one or more of" or "at least one of" indicate configurations or arrangements that potentially include individual elements of the list, or any combination thereof. For example, "at least one of A, B, and C" or "one or more of A, B, and C" indicates the possibilities of only A, only B, only C, or any combination of two or more of A, B, and C (e.g., A and B; B and C; A and C; or A, B, and C).

[0020] Furthermore, in detailing the disclosure, terms of direction, such as "forward," "rear," "front," "back," "lateral," "horizontal," and "vertical" may be used. Such terms are defined, at least in part, with respect to the direction in which the work vehicle or implement travels during use. The term "forward" and the abbreviated term "fore" (and any derivatives and variations) refer to a direction corresponding to the direction of travel of the work vehicle, while the term "aft" (and derivatives and variations) refer to an opposing direction. The term "fore-aft axis" may also reference an axis extending in fore and aft directions. By comparison, the term "lateral axis" may refer to an axis that is perpendicular to the fore-aft axis and extends in a horizontal plane; that is, a plane containing both the fore-aft and lateral axes. The term "vertical," as appearing herein, refers to an axis or a direction orthogonal to the horizontal plane containing the fore-aft and lateral axes.

[0021] The following describes one or more example implementations of the disclosed work vehicle for metering and delivering a commodity to the soil, as shown in the accompanying figures of the drawings described briefly above. The work vehicle may include a metering system with a plurality of metering elements. The metering elements may comprise metering rollers in some embodiments. The metering rollers may actuate (rotate) independent of each other and at variable output speeds in some embodiments. The work vehicle may also include a control system configured to control the actuation of the metering rollers individually and independently.

[0022] The metering rollers may be spaced apart and arranged substantially parallel to each other. In some embodiments, the rollers may be substantially parallel to the primary axis of the work vehicle (i.e., parallel to the direction of travel). Also, in some embodiments, the rollers may be disposed in a staggered arrangement. The rollers may be staggered

1 vertically and horizontally in some embodiments. For example, the rollers may be arranged
2 into rows that are spaced apart vertically and that are offset horizontally.

3 **[0023]** The work vehicle may also include a delivery system with a plurality of tubes. Air
4 may move through the tubes. The tubes may receive commodity that is metered out from
5 the metering rollers, and the commodity may travel along the tubes within the airstream
6 toward a row unit for planting in the soil. At least part of the tubes may be arranged
7 substantially parallel to each other (e.g., parallel to the primary axis of the work vehicle)
8 and substantially parallel to the metering rollers. In some embodiments, the tubes of the
9 delivery system may be disposed in a staggered arrangement. The tubes may be
10 staggered vertically and horizontally in some embodiments. For example, a part of the
11 tubes may be arranged into rows that are spaced apart vertically and that are offset
12 horizontally.

13 **[0024]** Furthermore, at least two of the metering rollers may be housed in a common
14 housing. The housing may define an inlet that receives the commodity from a commodity
15 container. The housing may also define a plurality of outlets. Commodity that enters the
16 housing through the inlet may be metered by the metering rollers and provided to
17 respective ones of the outlets. The outlets may provide the metered commodity to
18 respective ones of the tubes of the delivery system. Then, the tubes may deliver the
19 commodity to the row units for planting in the soil.

20 **[0025]** Accordingly, the work vehicle may provide the commodity to the soil in a controlled
21 and accurate manner. Furthermore, the arrangement of the metering rollers and/or the
22 tubes of the delivery system may be compact and well-organized.

23 **[0026]** Figure 1 illustrates a work vehicle 100 according to example embodiments of the
24 present disclosure. In the illustrated embodiment, the work vehicle 100 may be towed by
25 another vehicle, such as a tractor (not shown). In other embodiments, the work vehicle 100
26 of the present disclosure may be a self-propelled vehicle. In some embodiments, the work
27 vehicle 100 may be an air cart or air drill that contains a bulk amount of a commodity, that
28 meters out the commodity from the bulk amount, and that moves the metered commodity
29 away from the work vehicle 100 for planting in the ground. The work vehicle 100 shown in
30 FIG. 1 is merely an example embodiment of the present disclosure. One or more features
31 of the present disclosure may be included on a different work vehicle, such as a planter, a
32 commodity cart, or other work vehicle without departing from the scope of the present
33 disclosure.

34 **[0027]** A longitudinal axis 118 (i.e., primary axis) is indicated in FIG. 1 for reference
35 purposes. The longitudinal axis 118 may be substantially parallel to a direction of travel of
36 the work vehicle 100. Thus, the longitudinal axis 118 may be parallel to a fore-aft axis of

1 the work vehicle 100. A lateral axis 124 is also indicated in FIG. 1. The lateral axis 124 may
2 be perpendicular to the longitudinal axis 118 and may extend between opposite lateral
3 sides of the work vehicle 100. Furthermore, a vertical axis 126 is indicated in FIG. 1 for
4 reference purposes.

5 **[0028]** The work vehicle 100 may be configured for delivering the commodity to one or
6 more row units 101. Each row unit 101 may include features for respectively tilling the soil,
7 opening a furrow in the soil, depositing the commodity into the furrow, and closing the
8 furrow. In some embodiments, the row units 101 may be connected together by a row unit
9 frame 102 that extends substantially along the lateral axis 124. There may be a plurality of
10 row units 101 spaced apart and arranged in series on the row unit frame 102 along the
11 lateral axis 124. Thus, although only one row unit 101 is shown in FIG. 1, it will be
12 appreciated that similar row units 101 may be included and disposed in series along the
13 lateral axis 124. The row unit frame 102 may be connected to the work vehicle 100 via a
14 rear tow bar 111. The row unit frame 102 may also be connected to the towing vehicle
15 (e.g., tractor) via a forward tow bar 109. Accordingly, the row units 101 may be disposed
16 between the work vehicle 100 and the towing vehicle with respect to the longitudinal axis
17 118. However, the row units 101 may be disposed behind the work vehicle 100 in some
18 embodiments and/or the row units 101 may be directly connected to the work vehicle 100
19 (i.e., directly connected to the frame of the work vehicle 100) without departing from the
20 scope of the present disclosure.

21 **[0029]** As shown in FIG. 1, the work vehicle 100 may include a frame 110 (i.e., chassis)
22 and a plurality of wheels 112. The frame 110 may be assembled from rigid beams, bars,
23 brackets, or other structures and may support the components described in detail below.
24 The wheels 112 may support the frame 110 on terrain and enable movement of the vehicle
25 100 across the terrain. As shown, the frame 110 may extend between a front end 114 and
26 a rear end 116 of the work vehicle 100. The tow bar 111 may extend from the frame 110
27 at the front end 114 for attaching the work vehicle 100 to the row unit frame 102.

28 **[0030]** The work vehicle 100 may further include one or more commodity containers 128
29 (tanks, vessels, etc.). The containers 128 may be supported on the frame 110. The
30 commodity containers 128 may contain seed, fertilizer, and/or another particulate or
31 granular commodity. There may be any number of containers 128. In the illustrated
32 embodiment, for example, there are three commodity containers 128.

33 **[0031]** Additionally, the work vehicle 100 may include at least one metering system 130.
34 The metering system 130 may be a volumetric metering system. The metering system 130
35 may be configured to receive commodity from the commodity container 128 and may meter
36 commodity to a downstream component. In some embodiments, the metering system 130

1 may be supported by the frame 110 and may be disposed generally underneath the
2 commodity container(s) 128. The work vehicle 100 may include individual metering
3 systems 130 for different commodity containers 128 in some embodiments. One
4 representative metering system 130 is shown in FIG. 2 and 3 according to example
5 embodiments. During operation, particles of the commodity within one of the containers
6 128 may move vertically downward toward the metering system 130. The metering system
7 130 may operate to meter out the commodity from the container 128 at a controlled rate
8 as the vehicle 100 moves across the field.

9 **[0032]** The work vehicle 100 may also include a delivery system 132. The delivery system
10 132 may include a plurality of delivery tubes 133 (i.e., lines, pipes, etc.). The tubes 133
11 may include rigid segments as well as flexible segments. The tubes 133 may be supported
12 by the frame 110 and may extend from the work vehicle 100 substantially along the
13 longitudinal axis 118. The tubes 133 may conduct a flow of air from the rear end 116 to the
14 front end 114 and away from the work vehicle 100. Airflow within the tubes 133 may be
15 generated by a fan or other source mounted on the vehicle 100. The tubes 133 may be
16 fluidly connected to the metering system 130 such that particles of the commodity (metered
17 out by the metering system 130) may be received by the tubes 133. In some embodiments,
18 the particles may move vertically downward into the tubes 133. Once in the tubes 133, the
19 air stream therein may propel the metered particles away from the work vehicle 100 and
20 toward the row units 101.

21 **[0033]** The tubes 133 may also be attached to and in fluid communication with a
22 downstream manifold 129. In some embodiments, the manifold 129 may be supported by
23 the row unit frame 102 (i.e., remote from the work vehicle 100), although it will be
24 appreciated that the manifold 129 may be supported directly on the frame 110 of the work
25 vehicle 100 or other location. As shown in FIG. 1, a first tube 134 of the plurality of plurality
26 of tubes 133 may be connected to the manifold 129, and the manifold 129 may be
27 connected to a plurality of different branch lines 131, which extend to different row units
28 101 along the lateral axis 124. Thus, commodity delivered by the first tube 134 from the
29 work vehicle 100 may be directed between a plurality of different row units 101 for delivery
30 to the soil.

31 **[0034]** Moreover, the work vehicle 100 may include a control system 140. The control
32 system 140 may include and/or communicate with various components of a computerized
33 device, such as a processor, a data storage device, a user interface, etc. The control
34 system 140 may be in communication with and may be configured for controlling the
35 metering system 130, the delivery system 132, and/or other components of the work
36 vehicle 100. The control system 140 may be wholly supported on the work vehicle 100, or

1 the control system 140 may include components that are remote from the vehicle 100. The
2 control system 140 may be in electronic, hydraulic, pneumatic, mechanical, or other
3 communication with the metering system 130, the delivery system 132, etc.

4 **[0035]** During operation of the work vehicle 100 (e.g., when towed by a tractor or other
5 towing vehicle), the control system 140 may control the metering system 130 (e.g., by
6 controlled actuation of one or more motors or other actuators), which allows a controlled
7 quantity of particles to pass into the delivery system 132 at a predetermined rate. The
8 metered commodity may flow through the delivery system 132 to the manifold 129, which
9 may distribute the commodity to the different row units 101 for planting the commodity
10 within different rows in the soil.

11 **[0036]** Referring now to FIGS. 2-5, the metering system 130, the delivery system 132, and
12 the control system 140 will be discussed in greater detail according to example
13 embodiments. It will be appreciated that certain parts of the work vehicle 100 are hidden
14 for clarity.

15 **[0037]** The metering system 130 may include a plurality of metering units. In the illustrated
16 embodiment, there is a first metering unit 135, a second metering unit 136, a third metering
17 unit 137, and a fourth metering unit 138. The metering units 135, 136, 137, 138 may be
18 removably and replaceably supported by the frame 110 of the work vehicle 100. In some
19 embodiments, the work vehicle 100 may have different configurations, wherein the number
20 of metering units, the spacing between metering units, the arrangement of the metering
21 units, etc. is different in each configuration. Thus, it will be appreciated that the illustrated
22 configuration (having four, evenly spaced metering units 135, 136, 137, 138) is merely one
23 example. Other example configurations of the work vehicle 100 may include a single
24 metering unit. Additional example configurations may include five or more metering units.

25 **[0038]** The first metering unit 135 is shown isolated in FIGS. 4 and 5 as a representative
26 example. It will be appreciated that the second, third, and fourth metering units 136, 137,
27 138 may be substantially similar.

28 **[0039]** The metering unit 135 may include a housing 158. The housing 158 may include a
29 plurality of rigid walls that are arranged to define an interior passage 142. (In FIGS. 2 and
30 4, a cover 144 of the housing 158 is included that hides the passage 142; however, in
31 FIGS. 3 and 5, the cover 144 is not shown such that the passage 142 is revealed.) The
32 passage 142 may be defined through the housing 158 and may be configured to receive
33 commodity from the commodity container 128.

34 **[0040]** As shown in FIGS. 4 and 5, the housing 158 may include a flange 117 that is
35 disposed at an upper region of the housing 158. As will be discussed, flange 117 may
36 interconnect the metering unit 135 with other metering units, may facilitate installation of

1 the metering unit 135 on the work vehicle 100, and/or may ensure that the metering unit
2 135 is oriented correctly when installed.

3 **[0041]** As shown in FIG. 5, the passage 142 may include an inlet 146, an intermediate
4 section 148, and a plurality of outlets 150, 152. The outlets may include a first outlet 150
5 and a second outlet 152; however, it will be appreciated that there may be any number of
6 outlets.

7 **[0042]** The inlet 146 may be defined by a funnel-shaped inlet wall 147. The inlet 146 of
8 the passage 142 may be in communication with the commodity container 128 to receive
9 commodity therefrom.

10 **[0043]** The intermediate section 148 may be defined by an intermediate wall 149. At least
11 a portion of the intermediate wall 149 may taper outward from the inlet 146. The
12 intermediate wall 149 may also include a divider structure 151, which divides the
13 intermediate section 148 of the passage 142 into a first branch 153 and a second branch
14 155. The first branch 153 may be in communication with the first outlet 150 and the second
15 branch 155 may be in communication with the second outlet 152.

16 **[0044]** The metering unit 135 may additionally include a shut off valve 160. The shut off
17 valve 160 may be a rotational valve that is supported for rotation about an axis 162. The
18 shut off valve 160 may be moveably attached to the housing 158 and disposed proximate
19 a transition between the inlet 146 and the intermediate section 148 of the passage 142.
20 The rotational axis 162 of the shut off valve 160 may extend substantially parallel to the
21 longitudinal axis 118 of the work vehicle 100 in some embodiments. The shut off valve 160
22 may rotate about the axis 162 between a first, open and second, closed position. In the
23 open position, commodity within the inlet 146 may move into the intermediate section 148
24 of the passage 142. In the closed position, the shut off valve 160 may prevent movement
25 of the commodity from the inlet 146 to the intermediate section 148. As shown in FIGS. 4
26 and 5, the shut off valve 160 may include an arm 157. The arm 157 may be disposed on
27 an axial end of the valve 160 and may extend radially away from the axis 162. Rotation of
28 the arm 157 about the axis 162 may move the shut off valve 160 between the open and
29 closed positions. Also, as shown in FIG. 2, the metering system 130 may include a shut off
30 coupling member 156. The coupling member 156 may be a rigid bar that is fixed to the
31 arms 157 of the different shut off valves 160. Accordingly, moving the coupling member
32 156 may simultaneously move the connected shut off valves 160 between the open
33 position and the closed position.

34 **[0045]** Furthermore, the metering unit 135 may include a plurality of metering elements
35 189. There may be any number of metering elements 189. As shown in the embodiment
36 of FIGS. 4 and 5, for example, the plurality of metering elements 189 may include a first

1 metering roller 190 and a second metering roller 191. However, it will be appreciated that
2 the metering elements 189 may include any number of rollers.

3 **[0046]** The first and second metering rollers 190, 191 may be substantially similar. Both
4 the first and second metering rollers 190, 191 may be substantially cylindrical. In some
5 embodiments, the metering rollers 190, 191 may include a plurality of projections that
6 project radially such that the metering rollers 190, 191 are fluted. The metering rollers 190,
7 191 may also be configured as an auger or configured otherwise in some embodiments of
8 the present disclosure.

9 **[0047]** The first and second metering rollers 190, 191 may be moveably attached to the
10 housing 158 and supported for rotation within the interior passage 142 about respective
11 axes. Specifically, the first metering roller 190 may be supported for rotation about a first
12 axis of rotation 164, and the second metering roller 191 may be supported for rotation
13 about a second axis of rotation 166. The first and second metering rollers 190, 191 may
14 be disposed within the intermediate section 148 of the metering unit 135 with the divider
15 structure 151 disposed between the first and second metering rollers 190, 191. Also, the
16 housing 158 may include a first cradle 171 that is rounded and that partially receives an
17 underside of the first metering roller 190. Likewise, the housing 158 may include a second
18 cradle 173 that is rounded and that partially receives an underside of the second metering
19 roller 191. The first metering roller 190 may also be disposed within the passage 142,
20 between the intermediate section 148 and the first outlet 150. Specifically, the first outlet
21 150 may be defined between the first cradle 171 and an outer wall 175 of the housing 158.
22 The second metering roller 191 may be disposed within the passage 142, between the
23 intermediate section 148 and the second outlet 152. Specifically, the second outlet 152
24 may be defined between the second cradle 173 and the divider structure 151.

25 **[0048]** Additionally, the first and second metering rollers 190, 191 may be disposed within
26 the passage 142, downstream of the shut off valve 160. As such, moving the shut off valve
27 160 to the closed position may cut off the supply of the commodity from the commodity
28 container 128 from moving toward the rollers 190, 191. Conversely, moving the shut off
29 valve 160 to the open position may allow the commodity to move from the commodity
30 container 128 toward the first and second metering rollers 190, 191.

31 **[0049]** The axes 164, 166 of the metering rollers 190, 191 may be substantially parallel to
32 each other. Also, in some embodiments, the first and second axes 164, 166 may be parallel
33 to the longitudinal axis 118 (i.e., parallel to the primary axis of the work vehicle 100 and the
34 travel direction). The axes 164, 166 may be spaced apart at a horizontal distance 168 in
35 some embodiments. Also, the axes 164, 166 may be spaced apart at a vertical distance
36 170 in some embodiments.

1 [0050] The first and second metering rollers 190, 191 may rotate to provide volumetric
2 metering of the commodity within the intermediate section 148 of the passage 142. During
3 operation, particles of commodity may move from the container 128 toward the metering
4 rollers 190, 191. A first portion of the commodity within the intermediate section 148 may
5 be divided from a second portion of the commodity, for example, by the divider structure
6 151. The first metering roller 190 may rotate to meter the first portion of the commodity
7 from the intermediate section 148 to the first outlet 150. The second metering roller 191
8 may rotate to meter the second portion of the commodity from the intermediate section 148
9 to the second outlet 152. Accordingly, controlled amounts of the commodity may be output
10 from the first and second outlets 150, 152 toward the delivery system 132.

11 [0051] As shown in FIG. 4, the metering system 130 may also include a plurality of
12 actuators, such as a first actuator 180 and a second actuator 181. The actuators 180, 181
13 may be of any suitable type, such as electric motors in some embodiments. However, it
14 will be appreciated that the actuators may be a hydraulic actuators or other types without
15 departing from the scope of the present disclosure. In some embodiments, the metering
16 rollers 190, 191 may include respective and independent actuators 180, 181. In other
17 words, the first actuator 180 may be operatively connected to the first metering roller 190
18 for drivingly rotating the first metering roller 190 about the axis of rotation 164, and the
19 second actuator 181 may be operatively connected to the second metering roller 191 for
20 drivingly rotating the second metering roller 191 about the axis of rotation 166. As such,
21 the metering rollers 190, 191 may be individually and independently actuated relative to
22 the other. In some operating situations, the metering rollers 190, 191 may operate
23 simultaneously, but at different individual speeds. In other situations, one of the metering
24 rollers 190, 191 may operate while the other is stationary.

25 [0052] The actuators 180, 181 may be operatively connected to the control system 140.
26 The control system 140 may include a processor 200. The processor 200 may comprise
27 hardware, software, and/or firmware components configured to enable communications
28 and/or interaction with the actuators 180, 181. The control system 140 may also include a
29 memory element (e.g., RAM memory, flash memory, EPROM memory, EEPROM memory,
30 registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium
31 known in the art). In this regard, the memory element can be coupled to the processor 200
32 such that the processor 200 can read information from, and write information to, the
33 memory element. In the alternative, the memory element may be integral to the processor
34 200. As an example, the processor 200 and the memory element may reside in an ASIC.
35 The control system 140 may further include a user interface (U/I) with buttons, dials,
36 displays, speakers, and/or other components which a user may manually input commands

1 and/or receive output. Depending on the embodiment, the processor 200 may be
2 implemented or realized with a general purpose processor, a content addressable memory,
3 a digital signal processor, an application specific integrated circuit, a field programmable
4 gate array, any suitable programmable logic device, discrete gate or transistor logic,
5 processing core, discrete hardware components, or any combination thereof, designed to
6 perform the functions described herein. The processor 200 may also be implemented as a
7 combination of computing devices, e.g., a plurality of processing cores, a combination of a
8 digital signal processor and a microprocessor, a plurality of microprocessors, one or more
9 microprocessors in conjunction with a digital signal processor core, or any other such
10 configuration. In practice, the processor 200 includes processing logic that may be
11 configured to carry out the functions, techniques, and processing tasks associated with the
12 operation of the control system 140. Furthermore, the steps of a method or algorithm
13 described in connection with the embodiments disclosed herein may be embodied directly
14 in hardware, in firmware, in a software module executed by the processor 200, or in any
15 practical combination thereof.

16 **[0053]** During operation, the processor 200 may receive one or more input signals from
17 one or more sensors. The input signals may relate to a variable condition detected by the
18 sensor(s) (e.g., the ground speed of the work vehicle 100, the turn radius of the work
19 vehicle 100 as it turns within the field, etc.). The processor 200 may rely on the input signals
20 as well as predetermined computer logic to generate and output control commands for the
21 first and second actuators 180, 181. Thus, as the ground speed of the vehicle 100 changes,
22 the actuators 180, 181 may change the angular speed of the metering rollers 190, 191
23 accordingly. Likewise, as the work vehicle 100 turns within the field, the control system 140
24 may rotate the metering roller 190 faster than the second metering roller 191 or vice versa
25 to accommodate for the turn. It will be appreciated that the control system 140 may
26 independently control the actuators 180, 181 in additional ways as well without departing
27 from the scope of the present disclosure.

28 **[0054]** As shown in FIGS. 2 and 3, the first metering unit 135 may be arranged on the
29 work vehicle 100 in a horizontal row or series with the second metering unit 136, the third
30 metering unit 137, and the fourth metering unit 138. The housings 158 of the metering units
31 135, 136, 137, 138 may be arranged in a row that extends horizontally and substantially
32 parallel to the lateral axis 124. The housing 158 of one of the units 135, 136, 137, 138 may
33 abut against a neighboring housing 158 in this arrangement and may be interconnected
34 therewith. In some embodiments, the flange 117 of one metering unit may be connected
35 to a neighboring metering unit and/or surrounding support structure.

1 [0055] In this arrangement, the housings 158 may be configured to receive commodity
2 from a common source (i.e., the same commodity container 128). Also, the housings 158
3 may collectively house the plurality of metering rollers of the metering system 130. In the
4 embodiment of FIGS. 2 and 3, for example, the housing 158 of the first metering unit 135
5 may house a roller group consisting of the first and second metering rollers 190, 191.
6 Similarly, the housing 158 of the second metering unit 136 may house a group consisting
7 of the third metering roller 192 and a fourth metering roller 193. Likewise, the housing 158
8 of the third metering unit 137 may house a group consisting of the fifth metering roller 194
9 and a sixth metering roller 195. Additionally, the housing 158 of the fourth metering unit
10 138 may house a group consisting of a seventh metering roller 196 and an eighth metering
11 roller 197.

12 [0056] Furthermore, in some embodiments, the first, third, fifth, and seventh metering
13 rollers 190, 192, 194, 196 may be aligned and arranged in a horizontally-extending upper
14 row 198. Stated differently, the axes of rotation of these rollers 190, 192, 194, 196 may be
15 aligned along the lateral axis 124. Additionally, the second, fourth, sixth, and eighth
16 metering roller 191, 193, 195, 197 may be aligned and arranged in a horizontally-extending
17 lower row 199. The upper row 198 may be offset from vertical alignment with the lower row
18 199 (i.e., staggered and spaced apart) at a distance equal to the horizontal distance 168.
19 Also, the upper row 198 may be offset from horizontal alignment with the lower row 199
20 (i.e., staggered and spaced apart) at a distance equal to the vertical distance 170.

21 [0057] FIGS. 2 and 3 illustrate the delivery system 132 according to example
22 embodiments. As stated above, the delivery system 132 may include a plurality of tubes
23 133. In some embodiments, the plurality of tubes 133 may include a first tube 201, a second
24 tube 202, a third tube 203, a fourth tube 204, a fifth tube 205, a sixth tube 206, a seventh
25 tube 207, an eighth tube 208, a ninth tube 209, a tenth tube 210, an eleventh tube 211, a
26 twelfth tube 212, a thirteenth tube 213, a fourteenth tube 214, a fifteenth tube 215, and a
27 sixteenth tube 216. As shown, each of these tubes 201-216 may include a segment that is
28 fixed to the frame 110 of the work vehicle 100 below the metering system 130. The
29 longitudinal axis of these segments of the tubes 201-216 may be substantially parallel to
30 each other and may be substantially parallel to longitudinal axis 118. As such, in some
31 embodiments, the tubes 201-216 may be substantially parallel to the metering rollers 190-
32 197.

33 [0058] The tubes 201-216 may also be fluidly connected (in fluid communication) with the
34 metering system 130. For example, a first chute 220 may connect the first tube 201 to the
35 second outlet 152 of the first metering unit 135, and a second chute 222 may connect the
36 second tube 202 to the second outlet 152 as well. In some embodiments, the delivery

1 system 132 may include a valve 230 that may be disposed within the first chute 220 and/or
2 the second chute 222 and that may move to control flow of the commodity therethrough.
3 For example, in some embodiments, the valve 230 may be a flap that is rotationally
4 supported at a branch between the first and second chute 220, 222. The valve 230 may
5 rotate to open and shut the chutes 220, 222 to control flow.

6 **[0059]** A third chute 224 may connect the third tube 203 to the first outlet 150 of the first
7 metering unit 135, and a fourth chute 226 may connect the fourth tube 204 to the first outlet
8 150 as well. The third chute 224 and the fourth chute 226 may include a respective valve
9 230 as well. Furthermore, the remaining tubes 205-216 may be similarly connected to the
10 second, third, and fourth metering units 136, 137, 138.

11 **[0060]** Accordingly, the tubes 201-216 may be organized into groups. Each group of tubes
12 201-216 may be configured to receive commodity metered out from a single one of the
13 plurality of metering rollers 190-197. For example, as shown in FIG. 3, the first tube 201
14 and the second tube 202 may be paired together in such a group 240 and may receive
15 commodity metered out from the second metering roller 191. Similarly, the third tube 203
16 and fourth tube 204 may be paired into a group 241 and may receive commodity metered
17 out from the first metering roller 190. The remaining tubes 205-216 may be similarly paired
18 into groups as well.

19 **[0061]** As mentioned above, once the commodity is metered into the delivery system 132,
20 the tubes 201-216 may propel the commodity away from the work vehicle 100. For
21 example, commodity from the second metering roller 191 may move into the first tube 201.
22 Then, the commodity in the first tube 201 may be propelled toward the manifold 129 (FIG.
23 1), which may split this amount of commodity between the branch lines 131 for delivery to
24 the different row units 101. On the other hand, commodity from the second metering roller
25 191 may also move into the second tube 202, and this amount may move to a different
26 manifold 129 for delivery to a different group of row units 101. Likewise, the other tubes
27 203-216 may move commodity to different manifolds 129 for delivery to the remaining row
28 units 101.

29 **[0062]** It will be appreciated, however, that commodity delivery to the tubes 201-216 may
30 be cut off in various ways. For example, the valves 230 may be moved to cut off flow to
31 respective tubes 201-216. Also, the shut off valves 160 may be moved to cut off flow further
32 upstream as discussed above. Additionally, the control system 140 may turn off the
33 actuators 180, 181 to cut off supply of the commodity as discussed above.

34 **[0063]** The plurality of tubes 201-216 of the delivery system 132 may be arranged in a
35 compact manner. For example, the first, third, fifth, seventh, ninth, eleventh, thirteenth, and
36 fifteenth tube 201, 203, 205, 207, 209, 211, 213, 215 may be aligned and arranged in a

1 horizontally-extending upper row 250. Additionally, the second, fourth, sixth, eighth, tenth,
2 twelfth, fourteenth, and sixteenth tube 202, 204, 206, 208, 210, 212, 214, 216 may be
3 aligned and arranged in a horizontally-extending lower row 252. The upper row 250 may
4 be offset from vertical alignment with the lower row 252 (i.e., staggered and spaced apart)
5 at a distance equal to a horizontal distance 254. Moreover, the upper row 250 may be
6 offset from horizontal alignment with the lower row 252 (i.e., staggered and spaced apart)
7 at a distance equal to a vertical distance 256.

8 **[0064]** In summary, the metering system 130 and delivery system 132 may be compact
9 and well-organized despite the large number of components and given the limited amount
10 of space. Accordingly, the work vehicle 100 may deliver a controlled amount of commodity
11 to a large number of row units 101 for efficient planting operations.

12 **[0065]** Also, the following examples are provided, which are numbered for easier
13 reference.

14 **[0066]** 1. A work vehicle comprising: a commodity container; an actuator system with a
15 plurality of actuators; a delivery system with a plurality of tubes; and a metering system
16 with a plurality of metering rollers that are configured to be individually actuated by
17 respective ones of the plurality of actuators to meter out a commodity from the commodity
18 container to respective ones of the plurality of tubes, the plurality of metering rollers
19 arranged substantially parallel to each other, the plurality of metering rollers being
20 staggered in a vertical direction and staggered in a horizontal direction.

21 **[0067]** 2. The work vehicle of example 1, wherein the metering rollers are arranged in a
22 first row and a second row, the first row being spaced apart at a vertical distance from the
23 second row, the first row being offset horizontally with respect to the second row.

24 **[0068]** 3. The work vehicle of example 1, wherein at least one of the plurality of tubes is
25 operatively connected to a downstream manifold, the downstream manifold configured to
26 direct the commodity between a plurality of row units for delivery to ground.

27 **[0069]** 4. The work vehicle of example 1, wherein the plurality of tubes includes at least
28 one group of tubes each configured to receive commodity metered out from a single one
29 of the plurality of metering rollers.

30 **[0070]** 5. The work vehicle of example 1, wherein the plurality of tubes are arranged
31 substantially parallel to each other, the plurality of tubes being staggered in the vertical
32 direction and staggered in the horizontal direction.

33 **[0071]** 6. The work vehicle of example 5, wherein the plurality of tubes are arranged
34 substantially parallel to the plurality of metering rollers.

1 [0072] 7. The work vehicle of example 1, further comprising a frame that supports the
2 metering system; and further comprising a housing that houses a group of the plurality of
3 metering rollers; wherein the housing is removably attached to the frame.

4 [0073] 8. The work vehicle of example 7, wherein the housing is one of a plurality of
5 housings the house different groups of the plurality of metering rollers; wherein the plurality
6 of housings are arranged in a row that extends in the horizontal direction; and wherein the
7 group includes a first roller and a second roller that are spaced apart at a vertical distance;
8 and wherein the first roller and the second roller are spaced apart at a horizontal distance.

9 [0074] 9. The work vehicle of example 8, wherein at least one of the plurality of housings
10 includes an interior, the first and second rollers being supported for rotation within the
11 interior; further comprising a shut-off valve that is disposed within the interior, the shut-off
12 valve having a first position and a second position; the shut-off valve, in the first position,
13 configured to prevent the commodity from moving from the commodity container to the first
14 and second metering rollers; and the shut-off valve, in the second position, configured to
15 allow the commodity to move from the commodity container to the first and second
16 metering rollers.

17 [0075] 10. The work vehicle of example 9, wherein the first roller is configured to rotate
18 about a first axis of rotation to meter out the commodity from the commodity container;
19 wherein the second roller is configured to rotate about a second axis of rotation to meter
20 out the commodity from the commodity container; wherein the shut-off valve is configured
21 to rotate about a third axis of rotation when moving between the first position and the
22 second position; and wherein the first, second and third axes of rotation are substantially
23 parallel.

24 [0076] 11. The work vehicle of example 1, further comprising a control system configured
25 to generate control signals for the plurality of actuators to selectively actuate individual
26 ones of the plurality of metering rollers.

27 [0077] 12. A work vehicle comprising: a commodity container; an actuator system with a
28 first actuator and a second actuator; a delivery system with at least one tube; and a
29 metering system with at least one metering unit that includes a housing, a passage defined
30 through the housing and configured to receive a commodity from the commodity container,
31 and a first metering roller and a second metering roller at least partly disposed within the
32 passage of the housing, the first metering roller configured to be driven in rotation by the
33 first actuator for metering the commodity through the passage to the delivery system, the
34 second metering roller configured to be driven in rotation by the second actuator for
35 metering the commodity through the passage to the delivery system.

1 [0078] 13. The work vehicle of example 12, wherein the first metering roller and the
2 second metering roller are offset in a horizontal direction and in a vertical direction.

3 [0079] 14. The work vehicle of example 12, wherein the first metering roller, the second
4 metering roller, and the at least one tube are substantially parallel.

5 [0080] 15. The work vehicle of example 12, wherein the at least one tube includes a first
6 tube and a second tube; wherein the passage of the housing includes an inlet configured
7 to receive the commodity from the commodity container for metering by the first metering
8 roller and the second metering roller; wherein the passage includes a first outlet configured
9 to pass the commodity metered by the first metering roller to the first tube; and wherein the
10 passage includes a second outlet configured to pass the commodity metered by the second
11 metering roller to the second tube.

12 [0081] The terminology used herein is for the purpose of describing particular
13 embodiments only and is not intended to be limiting of the disclosure. As used herein, the
14 singular forms "a", "an" and "the" are intended to include the plural forms as well, unless
15 the context clearly indicates otherwise. It will be further understood that the terms
16 "comprises" and/or "comprising," when used in this specification, specify the presence of
17 stated features, integers, steps, operations, elements, and/or components, but do not
18 preclude the presence or addition of one or more other features, integers, steps,
19 operations, elements, components, and/or groups thereof.

20 [0082] The description of the present disclosure has been presented for purposes of
21 illustration and description, but is not intended to be exhaustive or limited to the disclosure
22 in the form disclosed. Many modifications and variations will be apparent to those of
23 ordinary skill in the art without departing from the scope and spirit of the disclosure.
24 Explicitly referenced embodiments herein were chosen and described in order to best
25 explain the principles of the disclosure and their practical application, and to enable others
26 of ordinary skill in the art to understand the disclosure and recognize many alternatives,
27 modifications, and variations on the described example(s). Accordingly, various
28 embodiments and implementations other than those explicitly described are within the
29 scope of the following claims.

30 [0083] Throughout this specification and the claims which follow, unless the context
31 requires otherwise, the word "comprise", and variations such as "comprises" and
32 "comprising", will be understood to imply the inclusion of a stated integer or step or group
33 of integers or steps but not the exclusion of any other integer or step or group of integers
34 or steps.

35 [0084] The reference in this specification to any prior publication (or information derived
36 from it), or to any matter which is known, is not, and should not be taken as an

1 acknowledgment or admission or any form of suggestion that that prior publication (or
2 information derived from it) or known matter forms part of the common general knowledge
3 in the field of endeavor to which this specification relates.

1 THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

2 What is claimed is:

3 1. A work vehicle with a commodity metering system comprising:
 4 a commodity container;
 5 an actuator system with a plurality of actuators;
 6 a delivery system with a plurality of tubes; and
 7 a metering system with a plurality of metering rollers that are configured to be
 8 individually actuated by respective ones of the plurality of actuators to meter out a
 9 commodity from the commodity container to respective ones of the plurality of tubes, the
 10 plurality of metering rollers arranged substantially parallel to each other, the plurality of
 11 metering rollers being staggered in a vertical direction and staggered in a horizontal
 12 direction.

13
 14 2. The work vehicle of claim 1, wherein the plurality of metering rollers is arranged
 15 in a first row and a second row, the first row being spaced apart at a vertical distance from
 16 the second row, the first row being offset at a horizontal distance with respect to the second
 17 row.

18
 19 3. The work vehicle of claim 1 or 2, wherein at least one of the plurality of tubes is
 20 operatively connected to a downstream manifold, the downstream manifold configured to
 21 direct the commodity between a plurality of row units for delivery to the ground.

22
 23 4. The work vehicle of any one of claims 1 to 3, wherein the plurality of tubes
 24 includes at least one group of tubes each configured to receive commodity metered out
 25 from a single one of the plurality of metering rollers.

26
 27 5. The work vehicle of any one of claims 1 to 4, wherein the plurality of tubes are
 28 arranged substantially parallel to each other, the plurality of tubes being staggered in the
 29 vertical direction and staggered in the horizontal direction.

30
 31 6. The work vehicle of claim 5, wherein the plurality of tubes are arranged
 32 substantially parallel to the plurality of metering rollers.

33
 34 7. The work vehicle of any one of claims 1 to 6, further comprising a frame that
 35 supports the metering system; and

1 further comprising a housing that houses a group of the plurality of metering rollers;
2 wherein the housing is removably attached to the frame.

3
4 8. The work vehicle of claim 7, wherein the housing is one of a plurality of housings
5 that house different groups of the plurality of metering rollers;

6 wherein the plurality of housings are arranged in a row that extends in the horizontal
7 direction; and

8 wherein the group includes a first roller and a second roller that are spaced apart at
9 a vertical distance; and

10 wherein the first roller and the second roller are spaced apart at a horizontal
11 distance.

12
13 9. The work vehicle of claim 8, wherein at least one of the plurality of housings
14 includes an interior, the first and second rollers being supported for rotation within the
15 interior;

16 further comprising a shut-off valve that is disposed within the interior, the shut-off
17 valve having a first position and a second position;

18 the shut-off valve, in the first position, configured to prevent the commodity from
19 moving from the commodity container to the first and second rollers; and

20 the shut-off valve, in the second position, configured to allow the commodity to
21 move from the commodity container to the first and second rollers.

22
23 10. The work vehicle of claim 9, wherein the first roller is configured to rotate about
24 a first axis of rotation to meter out the commodity from the commodity container;

25 wherein the second roller is configured to rotate about a second axis of rotation to
26 meter out the commodity from the commodity container;

27 wherein the shut-off valve is configured to rotate about a third axis of rotation when
28 moving between the first position and the second position; and

29 wherein the first, second, and third axes of rotation are substantially parallel.

30
31 11. The work vehicle of any one of claims 1 to 10, further comprising a control
32 system configured to generate control signals for the plurality of actuators to selectively
33 actuate individual ones of the plurality of metering rollers.

1 12. The work vehicle of claim 1, wherein the metering system further includes a
2 housing and a passage defined through the housing configured to receive a commodity
3 from the commodity container, wherein a first metering roller of the plurality of metering
4 rollers and a second metering roller of the plurality of metering rollers are at least partly
5 disposed within the passage of the housing, the first metering roller configured to be driven
6 in rotation by a first actuator of the plurality of actuators for metering the commodity through
7 the passage to the delivery system, the second metering roller of the plurality of metering
8 rollers configured to be driven in rotation by a second actuator of the plurality of actuators
9 for metering the commodity through the passage to the delivery system.
10

11 13. The work vehicle of claim 12, wherein the first metering roller of the plurality of
12 metering rollers and the second metering roller of the plurality of metering rollers are offset
13 in a horizontal direction and in a vertical direction.
14

15 14. The work vehicle of claim 12 or 13, wherein the first metering roller of the
16 plurality of metering rollers, the second metering roller of the plurality of metering rollers,
17 and at least one tube of the plurality of tubes are substantially parallel.
18

19
20
21 15. The work vehicle of any one of claims 12 to 14, wherein the at least one tube
22 of the plurality of tubes includes a first tube and a second tube;

23 wherein the passage of the housing includes an inlet configured to receive the
24 commodity from the commodity container for metering by the first metering roller of the
25 plurality of metering rollers and the second metering roller of the plurality of metering
26 rollers;

27 wherein the passage includes a first outlet configured to pass the commodity
28 metered by the first metering roller of the plurality of metering rollers to the first tube of the
29 plurality of tubes; and

30 wherein the passage includes a second outlet configured to pass the commodity
31 metered by the second metering roller of the plurality of metering rollers to the second tube
32 of the plurality of tubes.
33
34

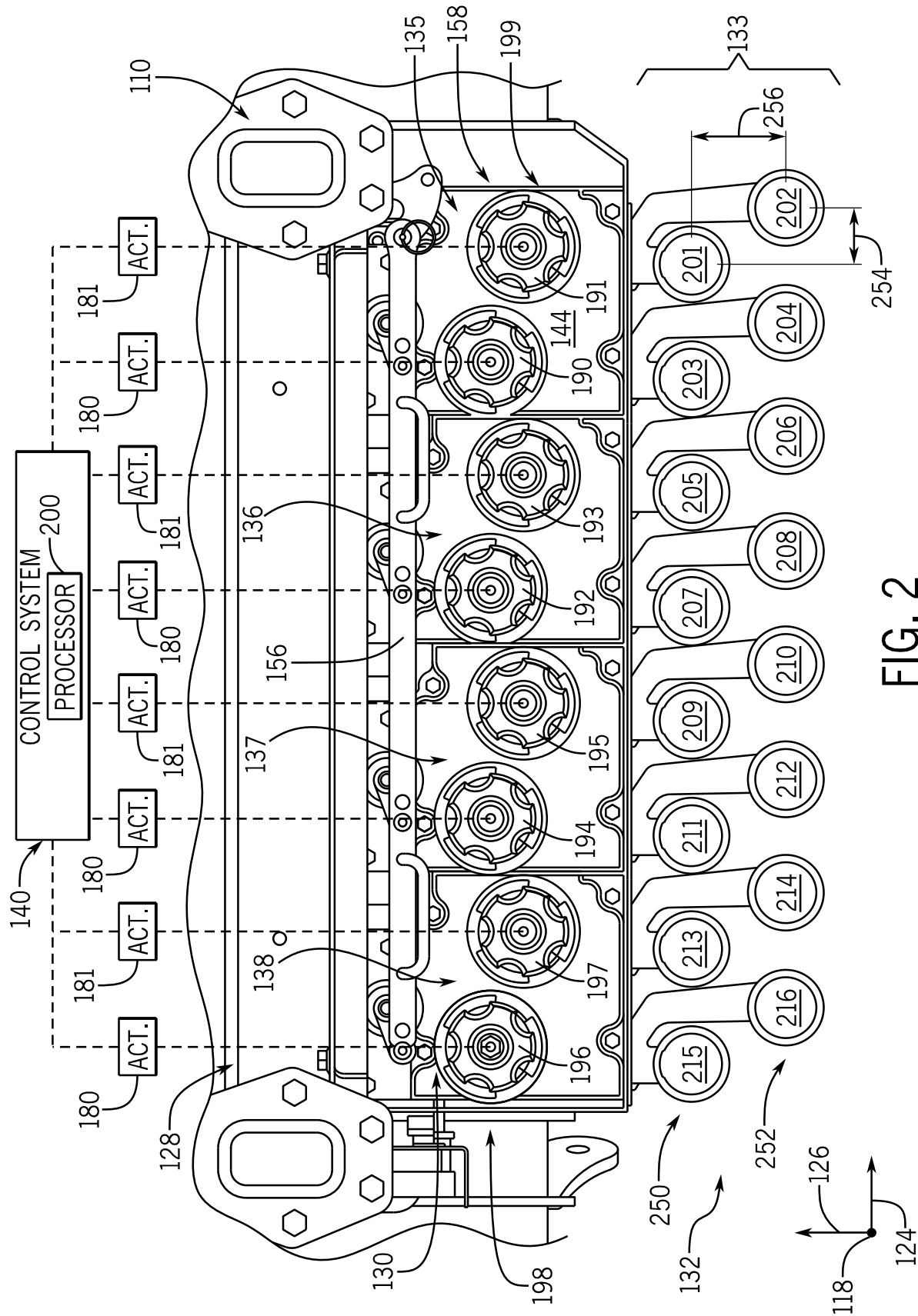


FIG. 2

3 / 4

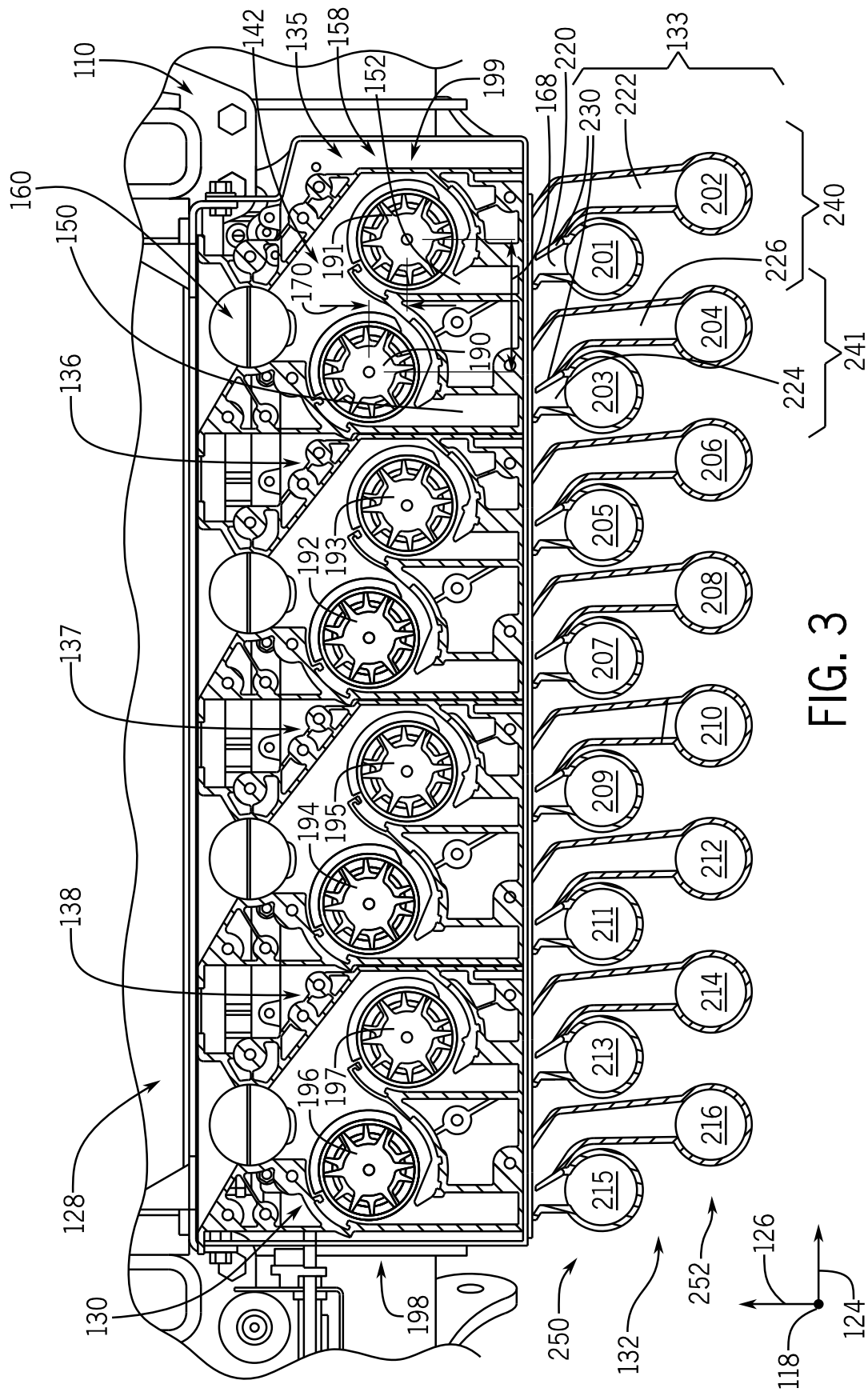


FIG. 3

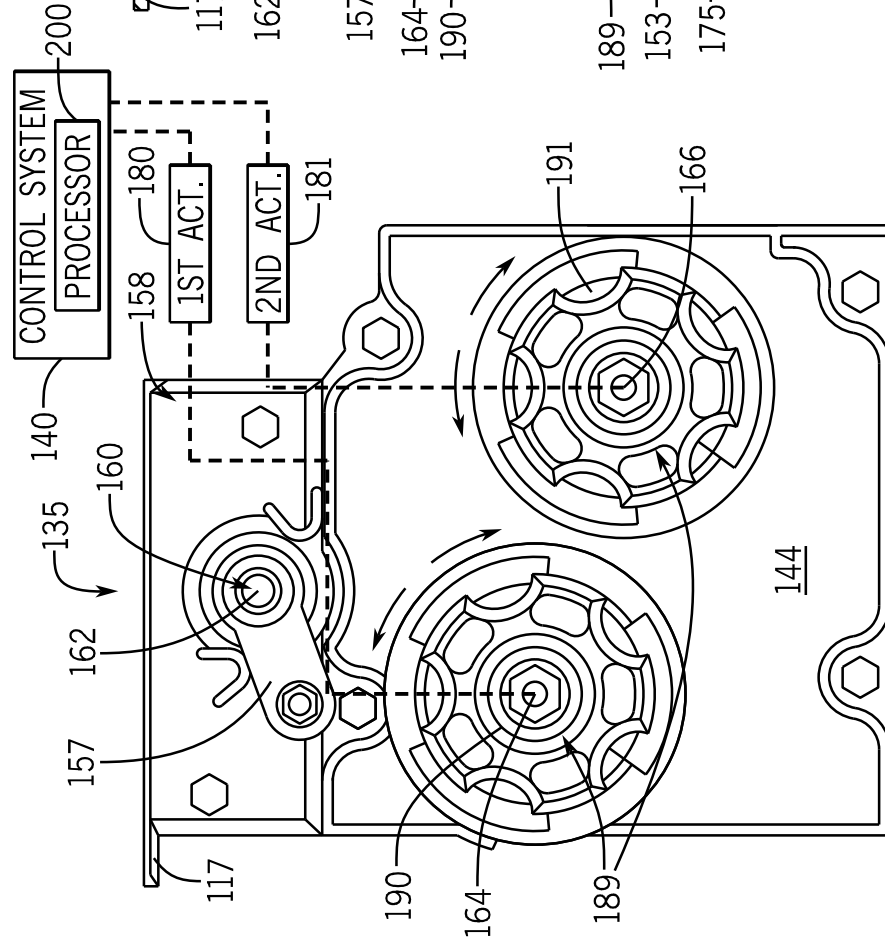


FIG. 4

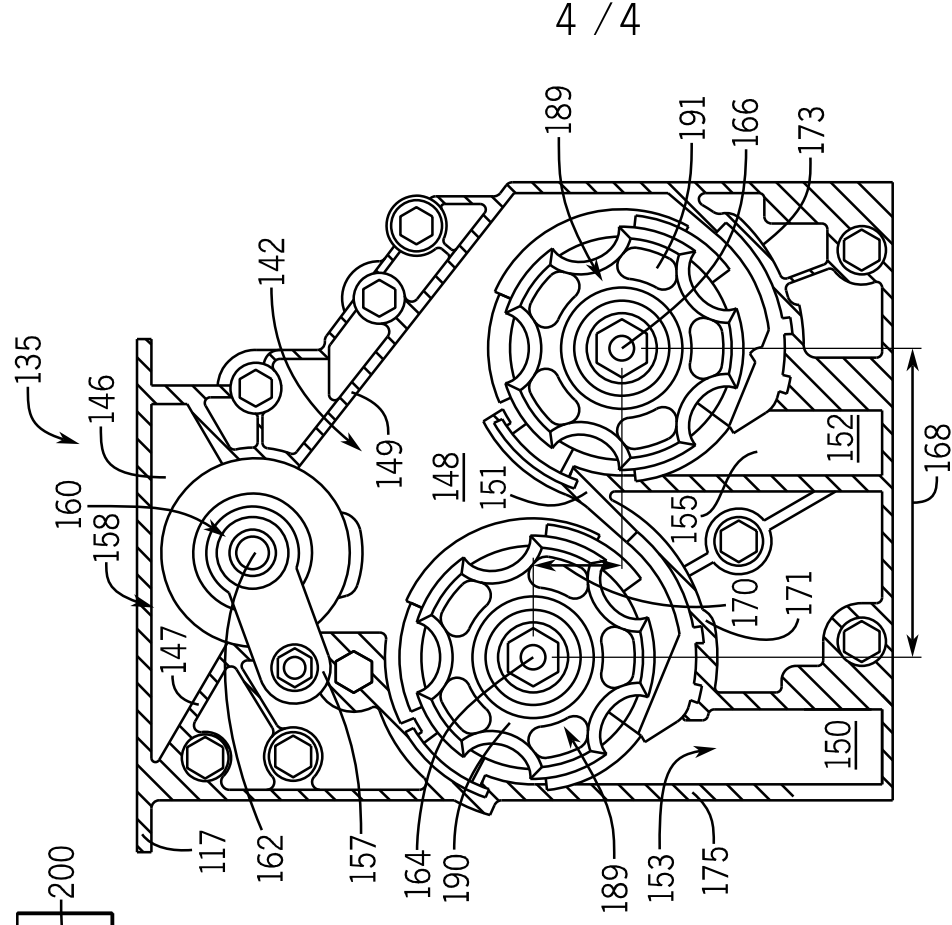


FIG. 5