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(54) **CROP INPUT APPLICATION APPARATUS, SYSTEMS AND METHODS**

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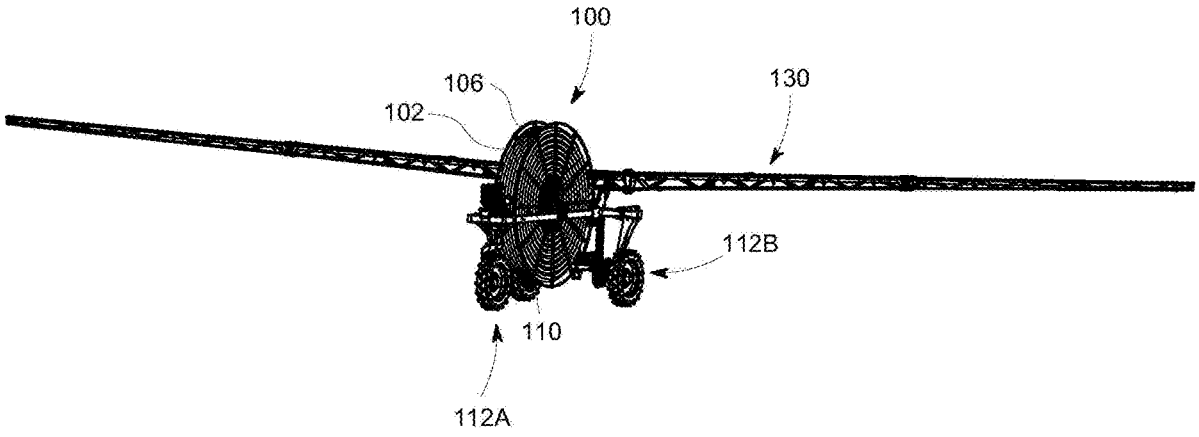
CPC ***A01G 25/16*** (2013.01); ***A01G 25/09*** (2013.01)

(57) **ABSTRACT**

An irrigation vehicle supports a reel and a flexible conduit positioned on the reel. A conduit control assembly controls dispensing and retraction of the flexible conduit from and to the reel. The conduit control assembly can include a conduit tension sensing assembly, a conduit angle sensing assembly and a frame supporting a gripping assembly.



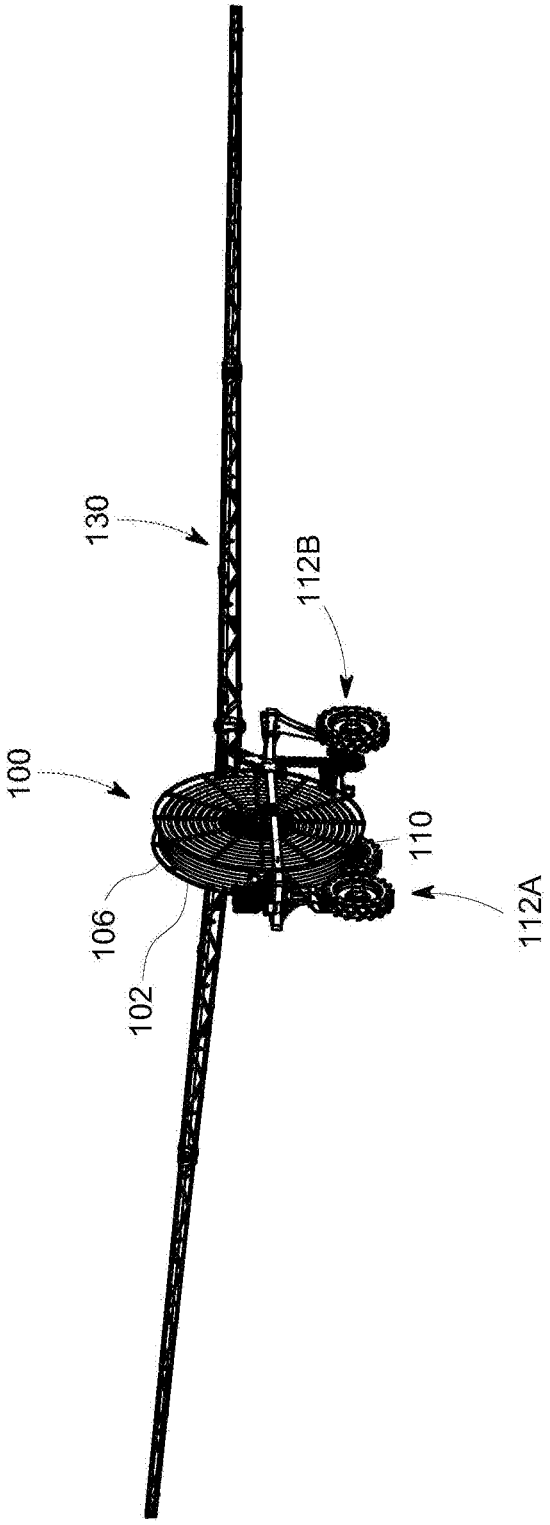


FIG. 1

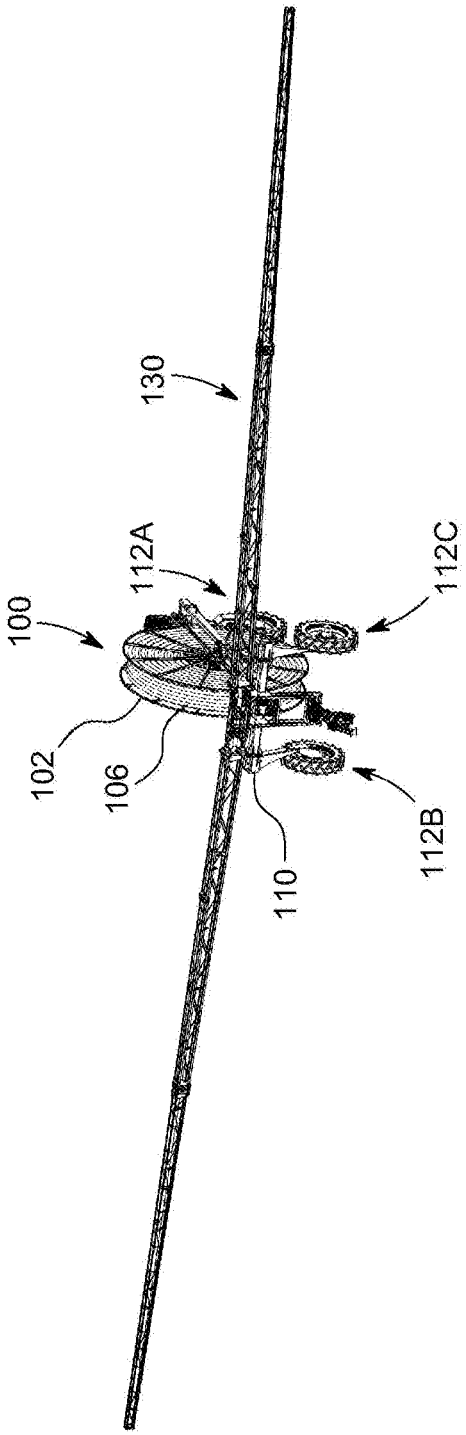


FIG. 2

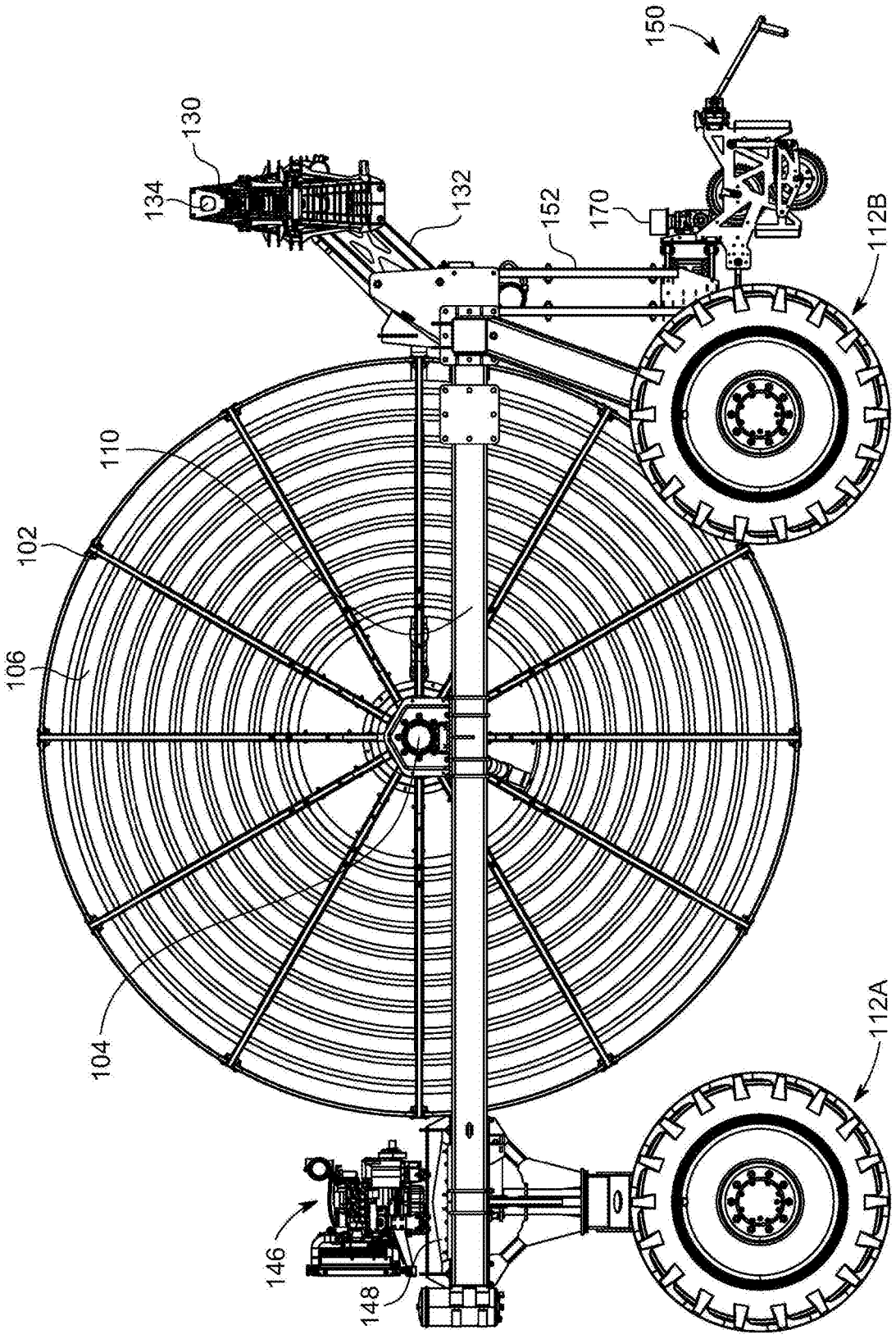


FIG. 3

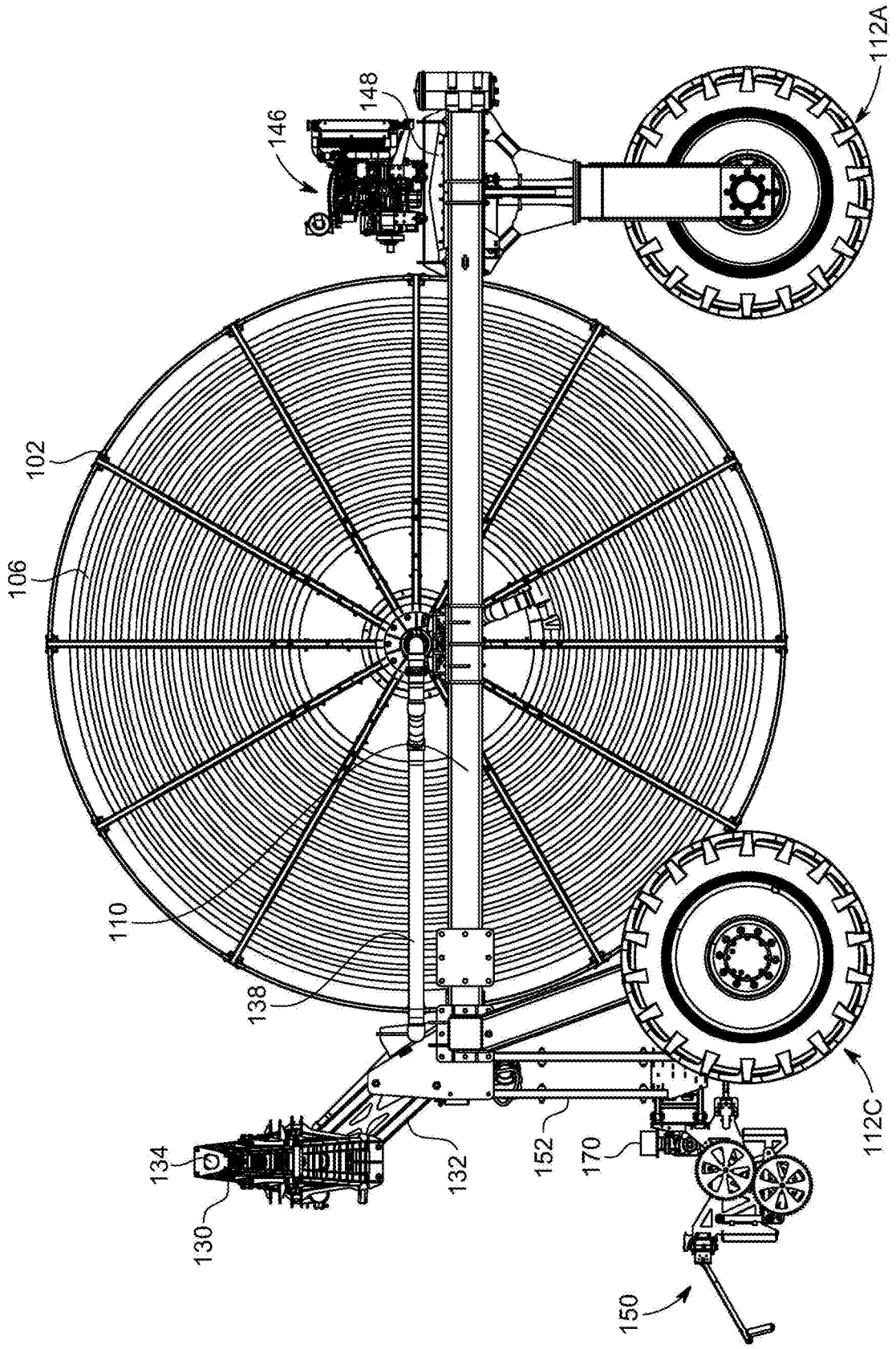


FIG. 4

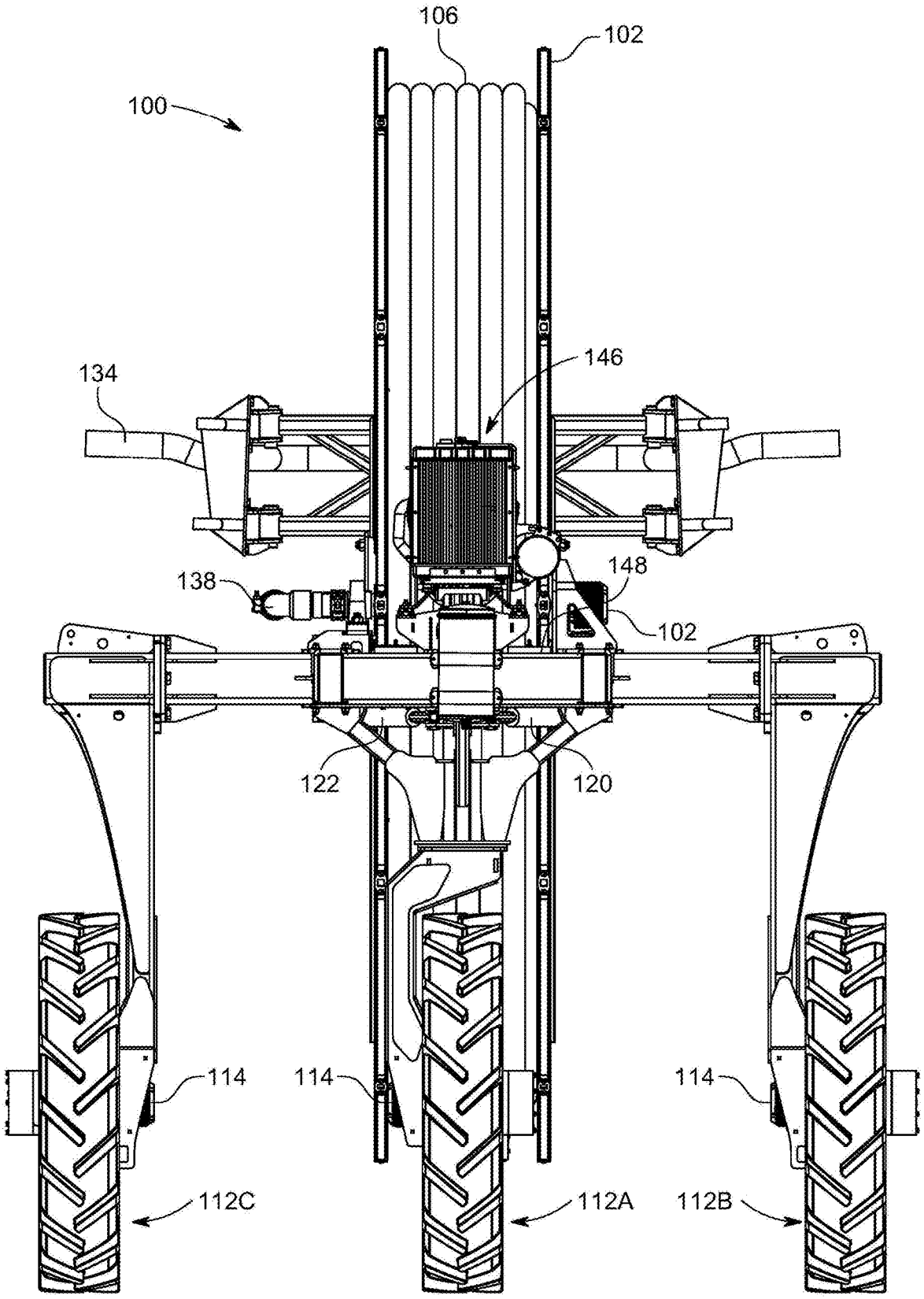

106
102
100
146
134
148
138
102
122
120
114
114
114
112C
112A
112B

FIG. 5

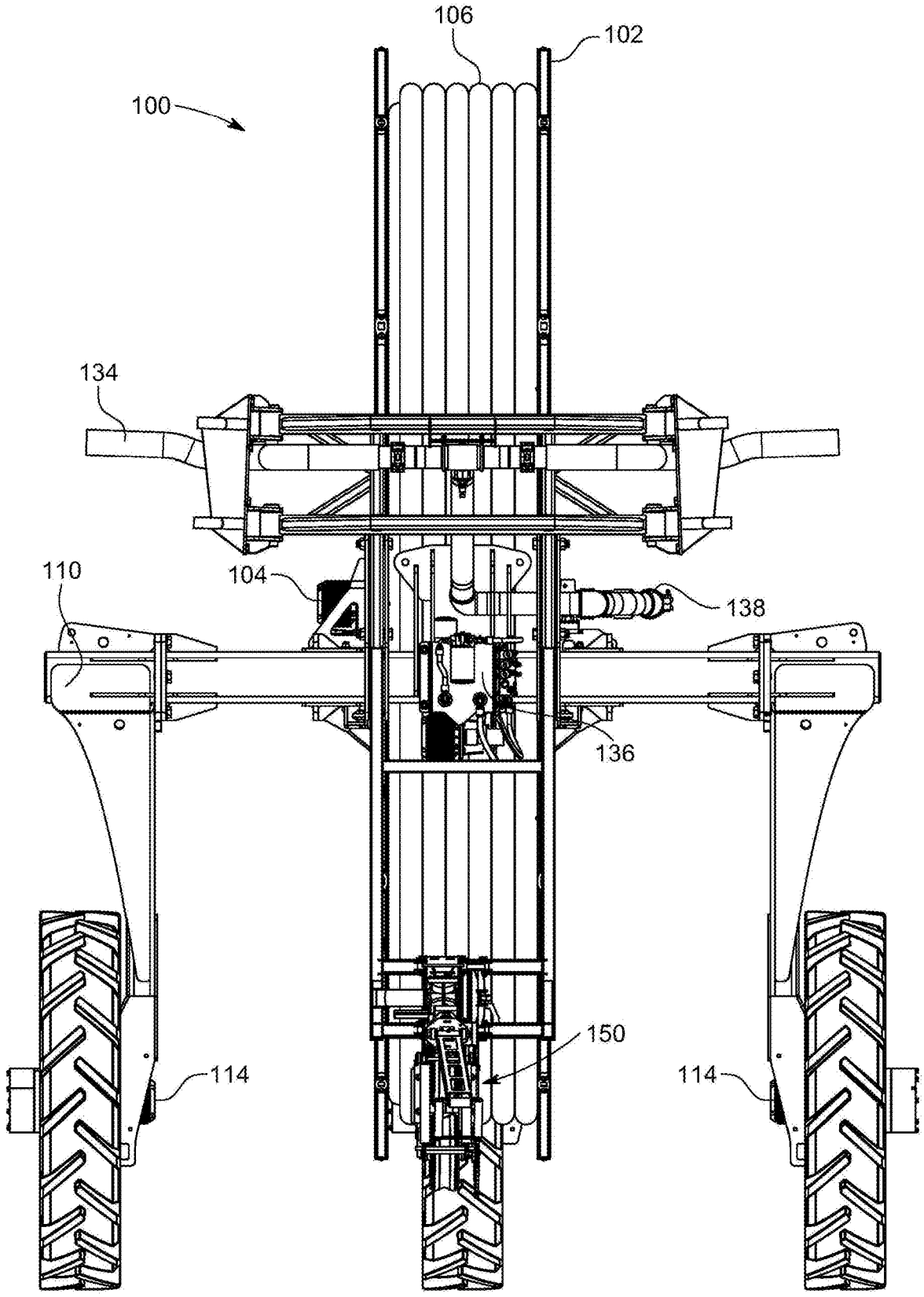


FIG. 6

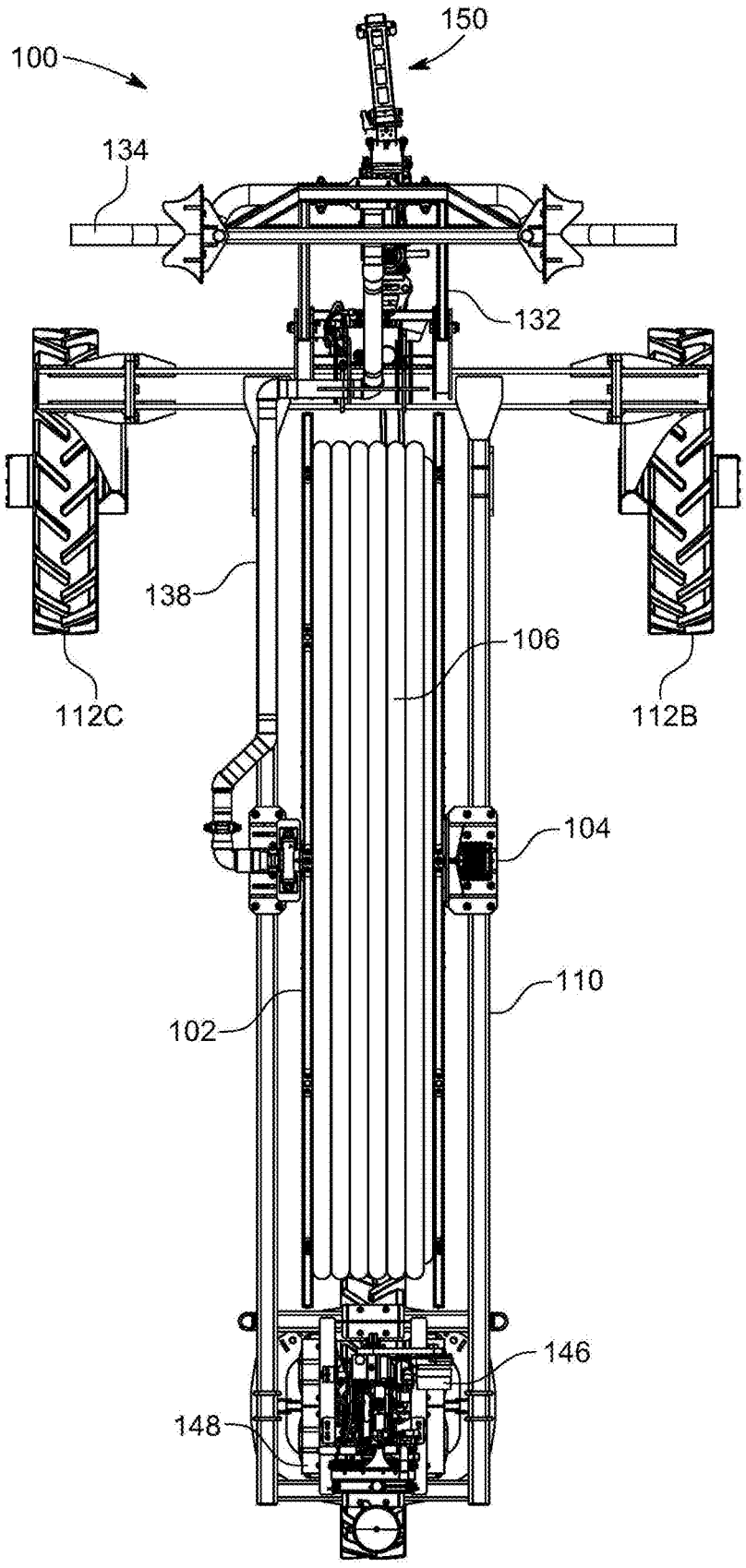


FIG. 7

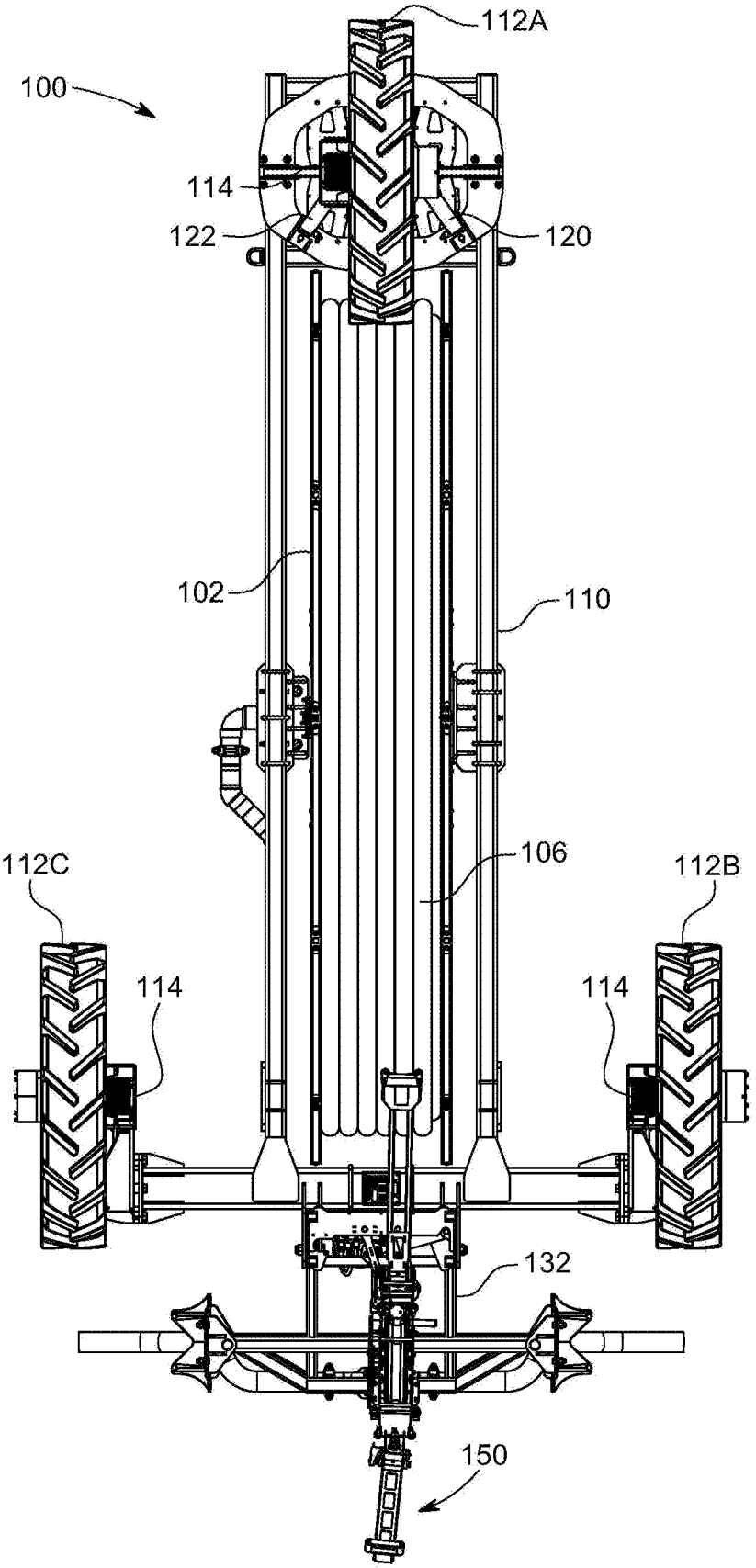


FIG. 8

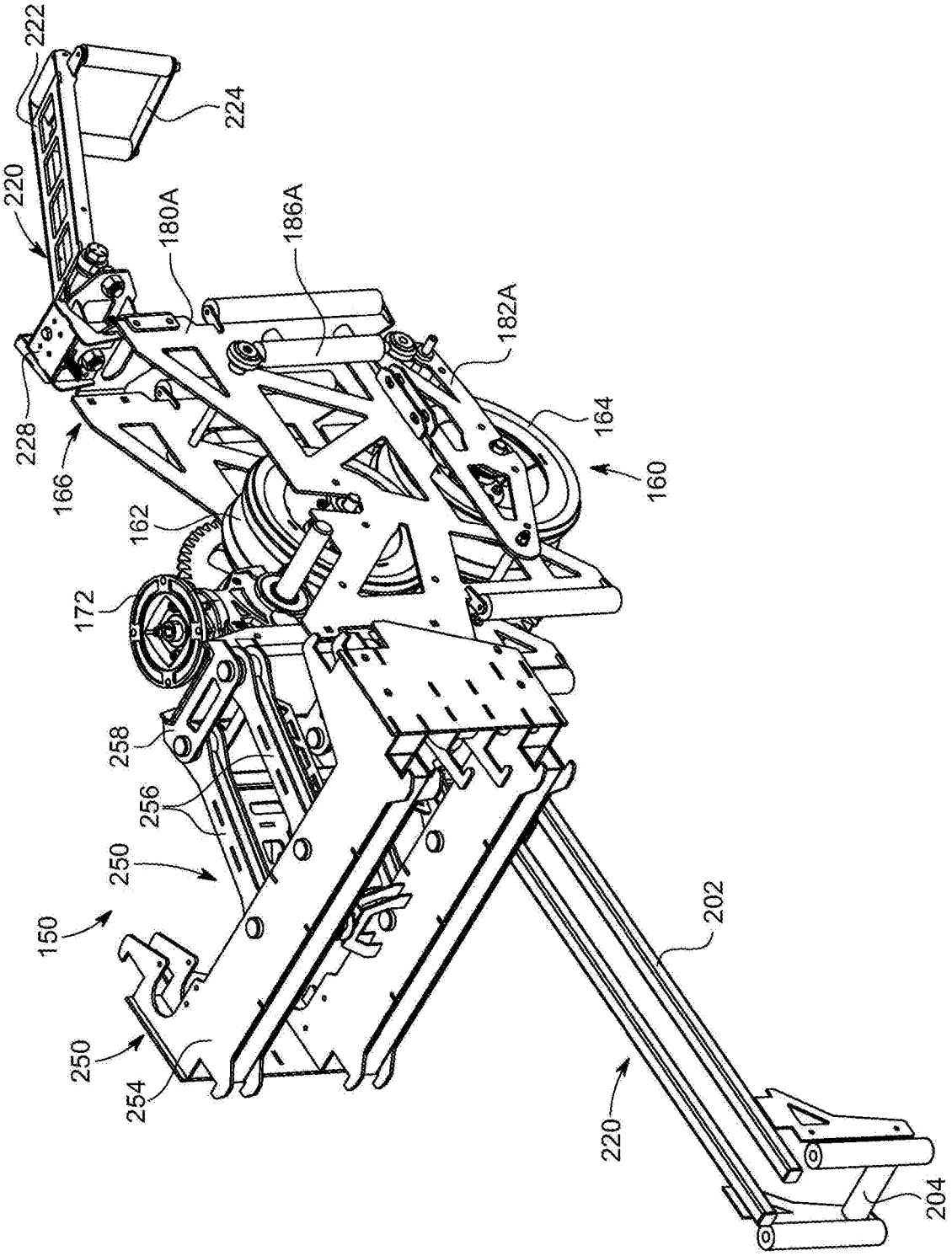

222
224
220
180A
186A
182A
164
160
228
166
162
172
258
256
250
150
250
254
202
220
204

FIG. 9

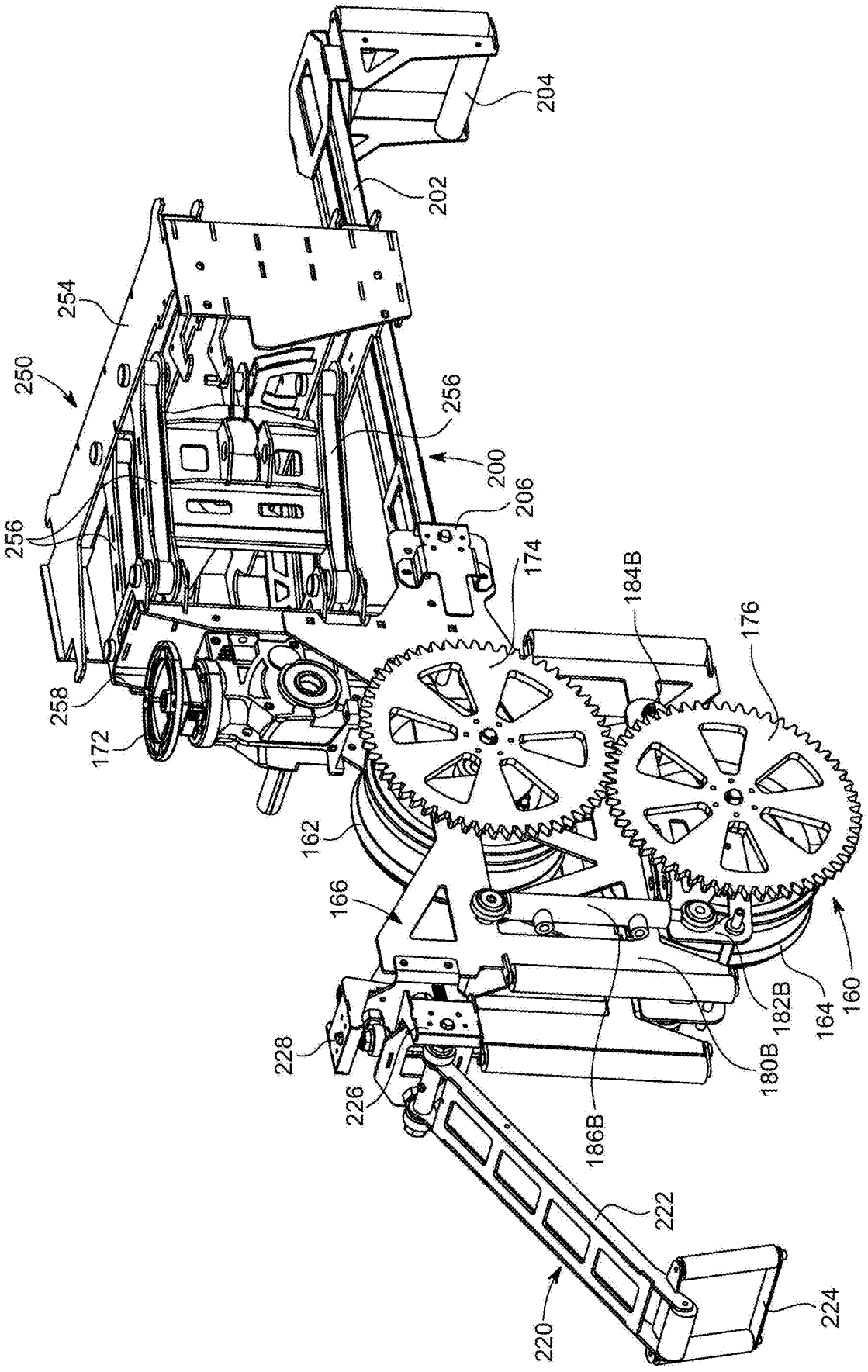

204
202
254
250
256
200
206
256
174
184B
176
258
172
162
166
160
164
182B
180B
228
226
186B
222
220
224

FIG. 10

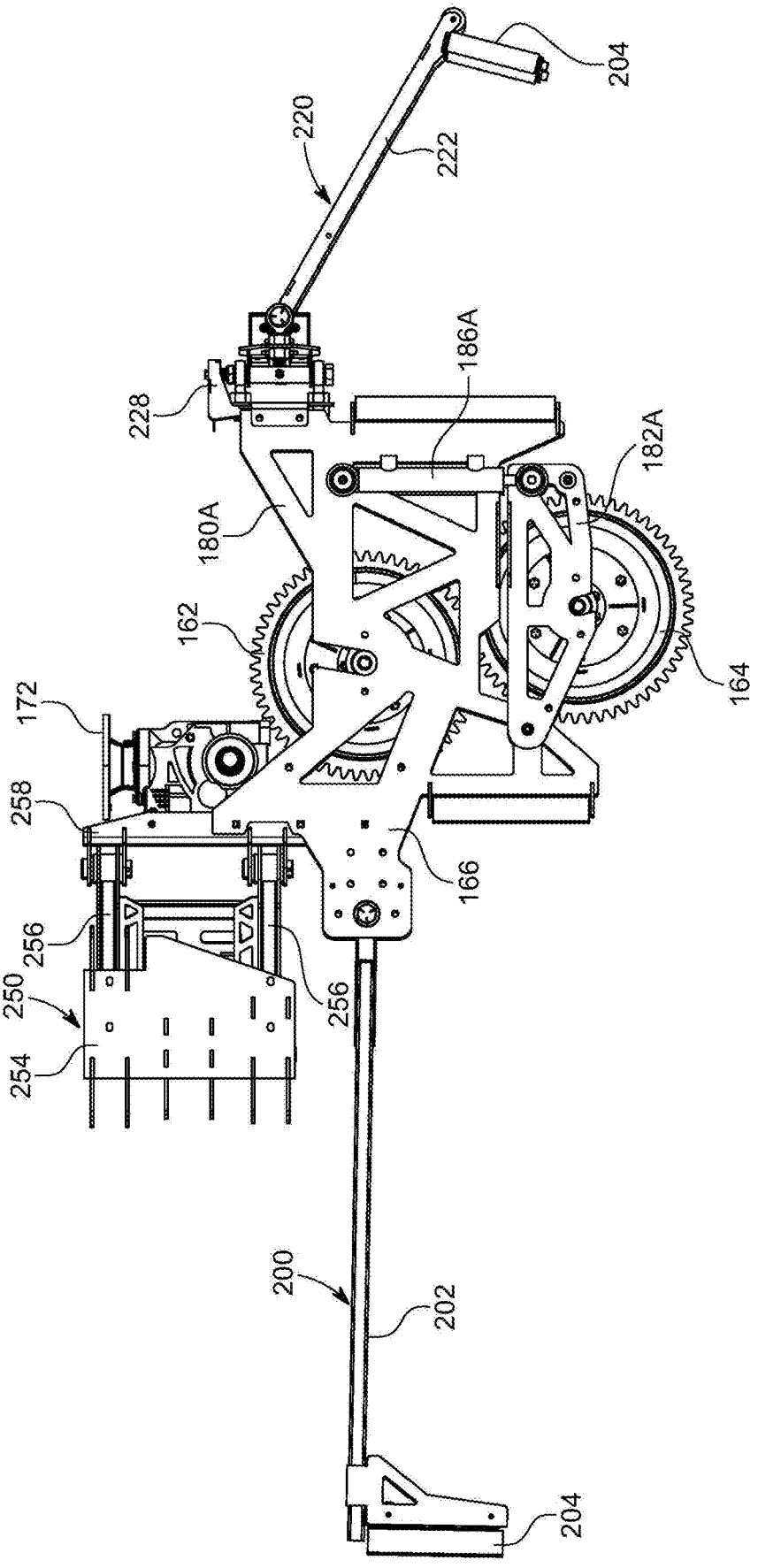

204
220
222
186A
228
182A
180A
162
164
172
258
166
256
250
256
254
200
202
204

FIG. 11

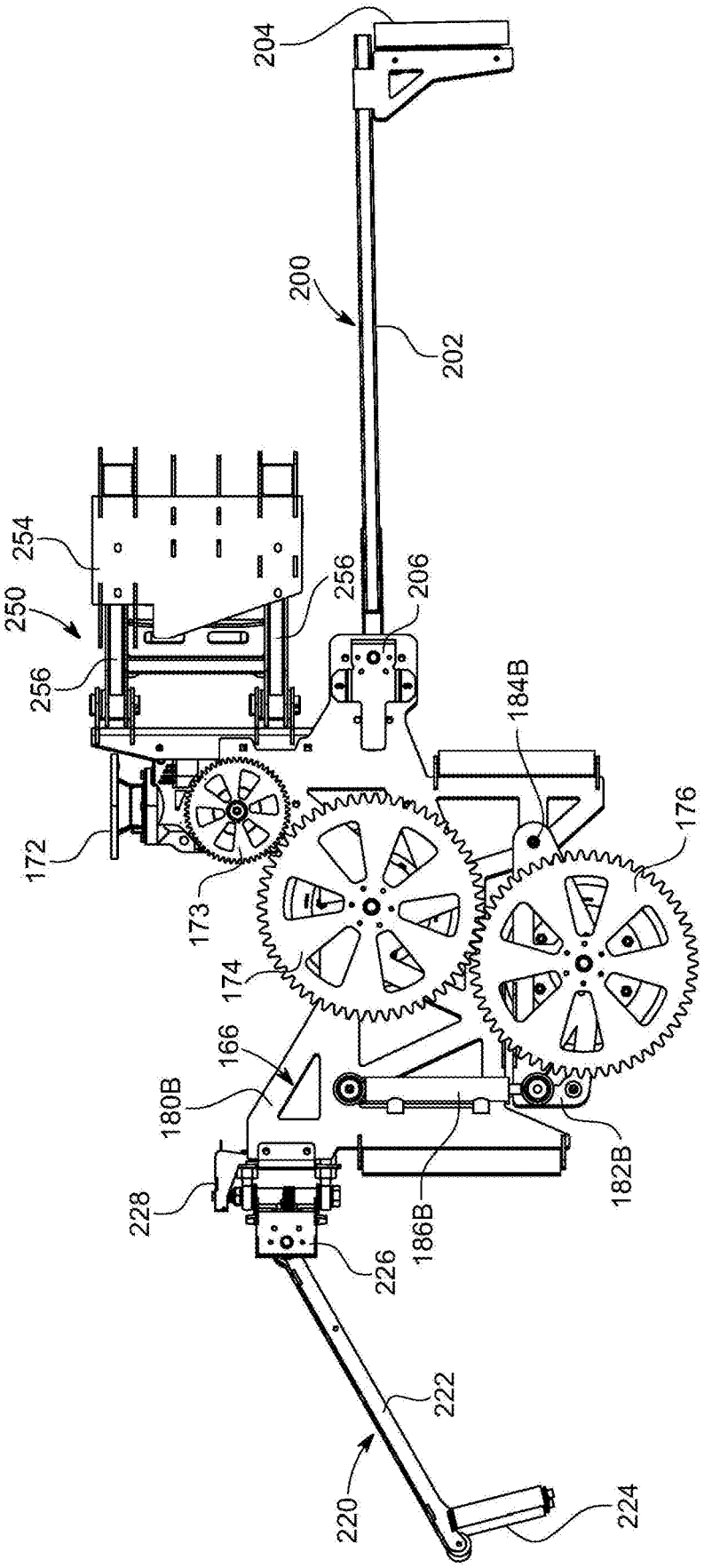

204
200
202
254
250
256
206
256
184B
172
176
173
174
166
180B
182B
228
186B
226
222
220
224

FIG. 12

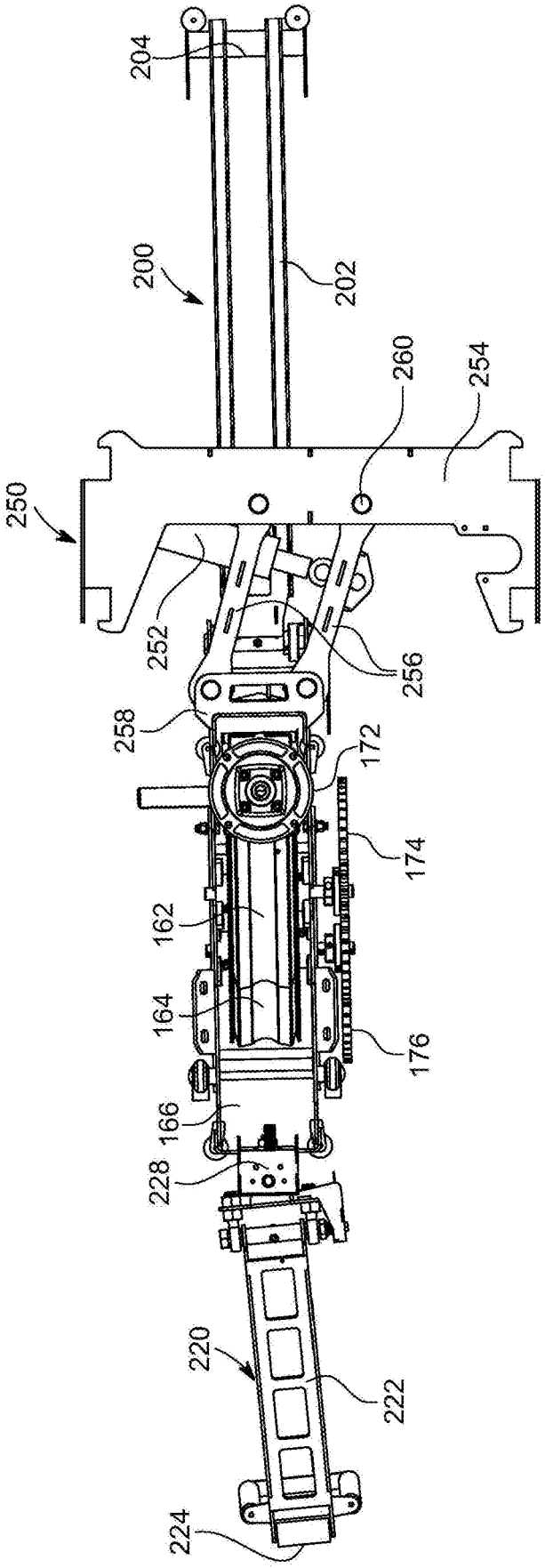

204
200
202
260
254
250
252
256
258
172
174
162
164
176
166
228
220
222
224

FIG. 13

CROP INPUT APPLICATION APPARATUS, SYSTEMS AND METHODS

BACKGROUND

[0001] This disclosure relates to application of crop input and use of vehicles for application of crop input. The vehicle supports a reel and flexible conduit that can be extended from or retracted onto said reel.

BRIEF DESCRIPTION OF DRAWINGS

[0002] FIG. **1** is a front perspective view of an application vehicle.

[0003] FIG. **2** is a rear perspective view of the application vehicle of FIG. **1**.

[0004] FIG. **3** is a right-side view of the application vehicle of FIG. **1**.

[0005] FIG. **4** is a left-side view of the application vehicle of FIG. **1**.

[0006] FIG. **5** is a front view of the application vehicle of FIG. **1**.

[0007] FIG. **6** is a rear view of the application vehicle of FIG. **1** with a boom removed.

[0008] FIG. **7** is a top view of the application vehicle of FIG. **1** with a boom removed.

[0009] FIG. **8** is a bottom view of the application vehicle of FIG. **1** with a boom removed.

[0010] FIG. **9** is a front perspective view of a conduit dispensing assembly.

[0011] FIG. **10** is a rear perspective view of the conduit dispensing assembly of FIG. **9**.

[0012] FIG. **11** is a right-side view of the conduit dispensing assembly of FIG. **9**.

[0013] FIG. **12** is a left-side view of the conduit dispensing assembly of FIG. **9**.

[0014] FIG. **13** is a top view of the conduit dispensing assembly of FIG. **9**.

DETAILED DESCRIPTION

[0015] It will be appreciated that different embodiments employing one or more features of crop input applicator vehicles are described herein. Features discussed with respect to one embodiment can be applied to other embodiments as desired. Referring now to the drawing figures wherein like reference numerals designate the same or corresponding components throughout the several figures, FIG. **1** illustrates one embodiment of a crop input applicator vehicle **100** including a reel **102** rotationally supported on a central shaft that is connected with a motor **104**. In one embodiment, the central shaft is connected with the motor **104** through a planetary gear. The reel **102** supports a flexible conduit **106**. The vehicle **100** includes a frame **110** supported on a plurality of wheel assemblies **112**, including a front wheel assembly **112**A and rear wheel assemblies **112**B and **112**C. Front wheel assembly **112**A is steerable with respect to the frame **110** to navigate the vehicle **100** through a field of crops (e.g., a row crop). Wheel assemblies **112**, in one embodiment, are powered by electric motors **114** that enable vehicle **100** to propel throughout the field. In some embodiments, an actuator assembly **118** is configured to steer the wheel assembly **112**, e.g., to pivot a wheel portion relative to the frame **110**. In the illustrated embodiment, actuator assembly **118** includes opposed hydraulic actuators **120** and **122**.

[0016] Extending from a rearward portion of the frame **110** is a boom **130** mounted on a linkage **132** supported by the frame **110**. According to various embodiments, the boom **120** can be of any number of different lengths and of any number of different configurations. For example, common boom **120** lengths include 40 feet, 60 feet, 80 feet, and 120 feet. Any other boom **120** length could be employed, as well, in accordance with different embodiments. In different embodiments, the boom **120** can be attached in front of frame **110** or behind the frame **110**.

[0017] The boom **120** supports a conduit **134** extending generally transversely across the vehicle **100** and further can support a plurality of applicators. In one embodiment, the applicators include drop assemblies fluidly coupled with the conduit **134**. A pump and valve assembly **136** (e.g., including an electric motor and valves) control the flow rate of fluid (e.g., crop input) to one or more selected applicators. A conduit **138** is positioned to carry fluid from conduit **106** to the conduit **134**.

[0018] A power unit **146** and master controller assembly **148** can be carried by frame **110** to provide power to one or more power-consuming devices (e.g., motors, pumps, processors) of vehicle **100**. In one embodiment, the power unit **146** includes a diesel generator and one or more batteries to store and/or deliver power to devices on the vehicle. In other embodiments, the power unit is another power source such as a battery pack or remote power source connected with vehicle **100**. Master controller **148** is connected to various components on vehicle **100** to provide control of the vehicle (e.g., application of liquid through drop assemblies, navigation of vehicle **100**).

[0019] Vehicle **100** further includes a conduit control assembly **150** that controls dispensing and retraction of flexible conduit **106** relative to the ground. In one embodiment, the conduit control assembly **150** is connected to frame **110** through a bracket **152**. In the illustrated embodiment, conduit control assembly **150** is positioned at a rear of vehicle **100**. In other embodiments, the conduit control assembly **150** can be positioned at a front or in an intermediate position of the vehicle **100**. During operation, motor **104** cooperates with conduit control assembly **150** to dispense and retract conduit **106** from and to the reel **102**. Conduit control assembly **150**, as discussed herein, can include one or more sensors to calculate a position of the conduit **106**. In one embodiment, these sensors include angle sensors such as PST-360G2 available from Amphenol Corporation of Wallingford, Connecticut. Angle sensors can utilize a Hall effect sensor to identify a position of a shaft relative to an opening.

[0020] Conduit control assembly **150** includes a gripping assembly **160** to frictionally engage conduit **106**. In the illustrated embodiment, gripping assembly **160** includes first and second gripping devices **162** and **164**. In an alternative embodiment, gripping assembly **160** includes a single gripping device that frictionally engages the conduit **106**. The gripping devices **162** and **164** herein are rollers, but can be other devices such as tires, tracks or other gripping devices. A frame **166** rotationally supports the gripping devices **162** and **164**. In one embodiment, one or more of the gripping devices **162** and **164** can be driven by a motor **170** or other actuator. In the illustrated embodiment, motor **170** is connected to a gearbox **172**, which in turn is connected through a spur gear **173** to a spur gear **174** connected to the frame **166** and rotationally connected with gripping device **162**.

Spur gear **174** is directly connected with spur gear **176**, which is rotationally connected with gripping device **164**. Gripping device **162** and gripping device **164** rotate in opposite directions upon operation of motor **170**. The gripping devices **162** and **164** can be turned at a speed such that the conduit **106** is dispensed off or returned onto the reel **102** at a speed equal and opposite to the ground speed of the vehicle **100**.

[0021] A distance between the gripping devices **162** and **164** can be a fixed distance or adjustable by an actuator or other mechanism (e.g., a spring) to maintain a gripping force by the gripping devices **162** and **164** onto the conduit **106**. In the illustrated embodiment, frame **166** includes upper plates **180**A and **180**B connected to either side of gripping device **162**. Additionally, frame **166** includes lower plates **182**A and **182**B connected to either side of the gripping device **164**. Lower plate **182**A is pivotally connected to upper plate **180**A about a connection **184**A. Additionally, a hydraulic cylinder **186**A connects the lower plate **182**A and upper plate **180**A. As lower plate **182**A pivots about connection **184**A, cylinder **186**A operates to maintain gripping pressure between griping devices **162** and **164**. Similarly, lower plate **182**B is pivotally connected to upper plate **180**B about a connection **184**B. Additionally, a hydraulic cylinder **186**B connects the lower plate **182**B and upper plate **180**B. As lower plate **182**B pivots about connection **184**B, cylinder **186**B operates to maintain gripping pressure between griping devices **162** and **164**. In a further embodiment, hydraulic cylinders **186**A and **186**B can be operated to master controller **148** to adjust the position of plates **182**A and **182**B relative to upper plates **180**A and **180**B, respectively, thereby adjusting a gripping pressure between gripping devices **162** and **164**.

[0022] A conduit tension sensing assembly **200** can be positioned between the frame **166** and the reel **102** to measure tension of the conduit **106** as the conduit **106** leaves or returns to the reel **102**. Conduit tension sensing assembly **200** includes an elongate member **202** connected with the frame **166** and a support member **204** to support the conduit **106**. A sensor **206** measures an angle of the elongate member **202** with respect to the frame **166** to calculate a tension of the conduit **106**.

[0023] Gripping devices **162** and **164**, in one embodiment, can be positioned to bias the conduit **106** higher or lower as the conduit **106** passes through frame **166**. In one embodiment, gripping device **162** is positioned more forward relative to gripping device **164**. This arrangement will bias any slack in the conduit **106** to be forced into the support member **204** to assist in obtaining a tension measurement. In one embodiment, output from sensor **206** is calculated with respect to a target set point. The target set point can be established based on a wrap layer (e.g., a position of the conduit along a width of the reel) of the conduit **106**. If sensor **206** is outside of a range of the target set point, reel speed can be adjusted.

[0024] A conduit angle sensing assembly **220** can be positioned between the frame **166** and ground to measure angles of the conduit **106** as the conduit **106** leaves and returns to the reel **102**. Conduit angle sensing assembly **220** includes an elongate member **222** and a support member **224**. Conduit **106** is positioned within the support member **224**. A vertical angle sensor **226** measures an angle of elongate member **222** about an axis parallel to the ground. Additionally, a horizontal angle sensor **228** measures an angle of elongate member **222** about an axis perpendicular to the ground.

[0025] Vertical conduit angle sensor **226** detects changes in the shape of the conduit as it leaves the frame **166**. If too much conduit is being dispensed relative to the ground speed of the vehicle, the conduit will tend to rise higher off the ground and lift the elongate member **222**. The speed of the gripping devices **162** and **164** can then be lowered to reduce the amount of conduit dispensed and allow the vertical angle sensor **226** to return to a selected target position. Likewise, if too little conduit is being dispensed relative to the ground speed of the vehicle, the conduit will drop towards the ground and pull the elongate member **222** down. The speed of the gripping devices **162** and **164** can then be increased to speed up the amount of conduit being dispensed such that the vertical angle sensor **226** returns to the selected target position.

[0026] During operation, a speed (i.e., displacement per unit of time) of the gripping devices **162** and **164** can be adjusted based on measurement from horizontal angle sensor **228** to account for errors that would result in an incorrect length of conduit leaving or returning to the reel **102**. In one embodiment, the speed of the conduit passing through the frame **166** is adjusted to keep the horizontal angle sensor **228** positioned straight relative to the frame **166**. In another embodiment, the speed of the conduit is adjusted to align the horizontal angle sensor **228** with a direction of travel of the vehicle **100** as it moves. In one example as the vehicle turns through a curve, too little conduit may be dispensed. The horizontal angle sensor **228** will be pulled towards the inside of the curve by the conduit. The speed of the gripping devices **162** and **164** can then be increased to dispense more conduit and thereby push the horizontal angle sensor **228** back to a selected target position. Likewise, if too much conduit is being dispensed, the conduit will push the horizontal angle sensor **228** away from the inside of the curve. The speed of the gripping devices **162** and **164** can then be reduced to dispense less conduit and allow the horizontal angle sensor to return to the selected target position.

[0027] The conduit control assembly **150** can further be mounted to a traverser **250** positioned to move the conduit **106** side to side (i.e., laterally) relative to the reel **102** as it passes through the frame **166**. As conduit **106** is retracted onto the reel **102**, the traverser **250** is moved by an actuator **252** (herein illustrated as a linear hydraulic cylinder) to position the conduit **106** next to the previous wrap created on the reel **102**. Traverser **250** includes a bracket **254** that is directly coupled with bracket **152**. Connected with the bracket **254** are linkage arms **256** coupled with the actuator **252**. Linkage arms **256** are further connected to a vertical bracket **258** that is directly coupled with frame **166**. Linkage arms **256** are connected to pivot with respect to the bracket **254** and the vertical bracket **258** such that actuator can pivot linkage arms **256**, which in turn positions frame **166**. This arrangement allows conduit **106** to be efficiently stored on the reel **102** in sequential wraps. A traverser sensor **260** may be used to monitor the position of the traverser. As conduit is removed from the reel **102**, the traverser **250** can be positioned to align with the wrap being unwound at that time, or be positioned in a center of the reel **102** and allow the conduit **106** to flex from where the conduit **106** was wrapped on the reel **102** to pass through the frame **166**.

[0028] Features of conduit control assembly **150** can be changed in various other embodiments. For example, a linear actuator can be used in place of gripping devices **162** and **164**. In this embodiment, two or more gripping arms can be mounted on the end of the linear actuator and positioned to selectively grip the conduit **106**. In order to dispense conduit **106**, the linear actuator retracts with the gripping arms spread apart. The gripping arms are then closed on the conduit **106** and the linear actuator pushed forward to dispense conduit **106** at a speed equal and opposite of the direction of travel of the vehicle. Sensors described herein may also be used to adjust the speed of the reel **102** or linear actuator to ensure the correct amount of conduit **106** is dispensed from or returned to the vehicle **100**.

[0029] In other embodiments, the conduit control assembly **150** can be mounted at the front of the vehicle **100** and dispense conduit from the reel **102** such that it tends to intersect the ground beneath the vehicle **100**. In this embodiment, conduit tension sensor **200**, or other forms of sensors such as an angle sensor, ultrasonic sensor, camera or other contact or non-contact sensor capable of measuring conduit tension may be positioned between the frame **166** and the reel **102** and the reel speed may be adjusted to maintain the conduit tension sensor **200** at a target tension.

[0030] In a further embodiment, conduit control assembly **150** can include a ground intersection sensor such as a contact arm with an angle sensor, a camera, ultrasonic, radar, or other contact or non-contact sensor positioned to measure a location where the conduit **106** first contacts or leaves the ground as the vehicle **100** dispenses or retracts conduit. The speed of the gripping devices **162** and **164** can be adjusted to maintain the consistent position where the conduit **106** first contacts or leaves the ground ensuring the correct amount of conduit is dispensed or retracted relative to the speed of the vehicle. One or more additional ground intersection sensors may be used along the remaining length of the vehicle **100** to confirm that the conduit **106** remains in the correct position on the ground.

[0031] In another embodiment a control arm extended from the conduit control assembly **150** and force is applied through the arm with a linear, rotary, or other actuator to push the conduit down on the ground so that a reliable first intersection position may be determined by an angle sensor positioned on the arm. Alternatively, or in addition, conduit guides may also be mounted along a length of the vehicle to limit the freedom of the conduit to move on the ground while the vehicle passes over it.

[0032] In another embodiment, two control arms can extended from the conduit control assembly **150**. A first control arm can apply force to the conduit **106** through an actuator to ensure a measurement by a sensor where the conduit **106** is in contact with the ground and the position of the ground relative to the vehicle. A second control arm can be mounted between the first control arm and the frame **166** to determine the path the conduit takes between the frame **166** and the first control arm by measuring its position with a sensor. The speed of gripping devices **162** and **164** can be adjusted so that the conduit **106** follows a desired path between the frame **166** and the ground ensuring that the amount of conduit dispensed or returned to the vehicle is correct.

[0033] Various embodiments of the invention have been described above for purposes of illustrating the details thereof and to enable one of ordinary skill in the art to make and use the invention. The details and features of the disclosed embodiment[s] are not intended to be limiting, as many variations and modifications will be readily apparent to those of skill in the art. Accordingly, the scope of the present disclosure is intended to be interpreted broadly and to include all variations and modifications coming within the scope and spirit of the appended claims and their legal equivalents.

1. A conduit control assembly in an irrigation vehicle having a reel supporting a flexible conduit such that the conduit can be extended from or retracted onto said reel, the conduit control assembly, comprising:

a frame supporting a gripping assembly;

a conduit tension sensing assembly coupled with the frame; and

a conduit angle sensing assembly coupled with the frame.

2. The conduit control assembly of claim **1**, wherein the conduit tension assembly includes an elongate member extending from the frame, a support member connected with the elongate member and a sensor, the sensor configured to calculate an angle of the elongate member about an axis with respect to the frame.

3. The conduit control assembly of claim **1**, wherein the conduit angle sensing assembly includes an elongate member extending from the frame, a support member connected with the elongate member and a sensor, the sensor configured to calculate an angle of the elongate member about an axis with respect to the frame.

4. The conduit control assembly of claim **3**, wherein the axis is horizontal.

5. The conduit control assembly of claim **3**, wherein the axis is vertical.

6. The conduit control assembly of claim **1**, wherein the conduit angle sensing assembly includes an elongate member extending from the frame, a support member connected with the elongate member, a first sensor and a second sensor, the first sensor configured to calculate a first angle of the elongate member about a first axis with respect to the frame and the second sensor configured to calculate a second angle of the elongate member about a second axis with respect to the frame, the second axis orthogonal to the first axis.

7. The conduit control assembly of claim **1**, further comprising a traverser, the traverser including an actuator configured to position the frame laterally with respect to the vehicle.

8. The conduit control assembly of claim **7**, wherein the traverser includes linkage arms pivotable with respect to a bracket.

9. The conduit control assembly of claim **1**, wherein the gripping assembly includes first and second gripping members supported by the frame.

10. The conduit control assembly of claim **1**, wherein the conduit tension assembly is positioned on a first side of the frame and the conduit angle sensing assembly is positioned on a second side of the frame, opposite the first side.

11. A crop input application vehicle, comprising:

a vehicle frame having a reel supporting a flexible conduit such that the conduit can be extended from or retracted onto said reel;

a conduit control assembly, comprising:

a support frame supporting a gripping assembly;

a conduit tension sensing assembly coupled with the support frame; and

a conduit angle sensing assembly coupled with the support frame.

12. The vehicle of claim **11**, wherein the conduit tension assembly includes an elongate member extending from the frame, a support member connected with the elongate member and a sensor, the sensor configured to calculate an angle of the elongate member about an axis with respect to the support frame.

13. The vehicle of claim **11**, wherein the conduit angle sensing assembly includes an elongate member extending from the support frame, a support member connected with the elongate member and a sensor, the sensor configured to calculate an angle of the elongate member about an axis with respect to the support frame.

14. The vehicle of claim **12**, wherein the axis is horizontal.

15. The vehicle of claim **12**, wherein the axis is vertical.

16. The vehicle of claim **11**, wherein the conduit angle sensing assembly includes an elongate member extending from the support frame, a support member connected with the elongate member, a first sensor and a second sensor, the first sensor configured to calculate a first angle of the elongate member about a first axis with respect to the support frame and the second sensor configured to calculate a second angle of the elongate member about a second axis with respect to the support frame, the second axis orthogonal to the first axis.

17. The vehicle of claim **11**, further comprising a traverser, the traverser including an actuator configured to position the support frame laterally with respect to the vehicle frame.

18. The vehicle of claim **16**, wherein the traverser includes linkage arms pivotable with respect to a bracket.

19. The vehicle of claim **11**, wherein the gripping assembly includes first and second gripping devices having the conduit positioned therebetween.

20. The vehicle of claim **11**, wherein the conduit tension assembly is positioned on a first side of the frame and the conduit angle sensing assembly is positioned on a second side of the frame, opposite the first side.

* * * * *