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(54) **CULTIVATOR**

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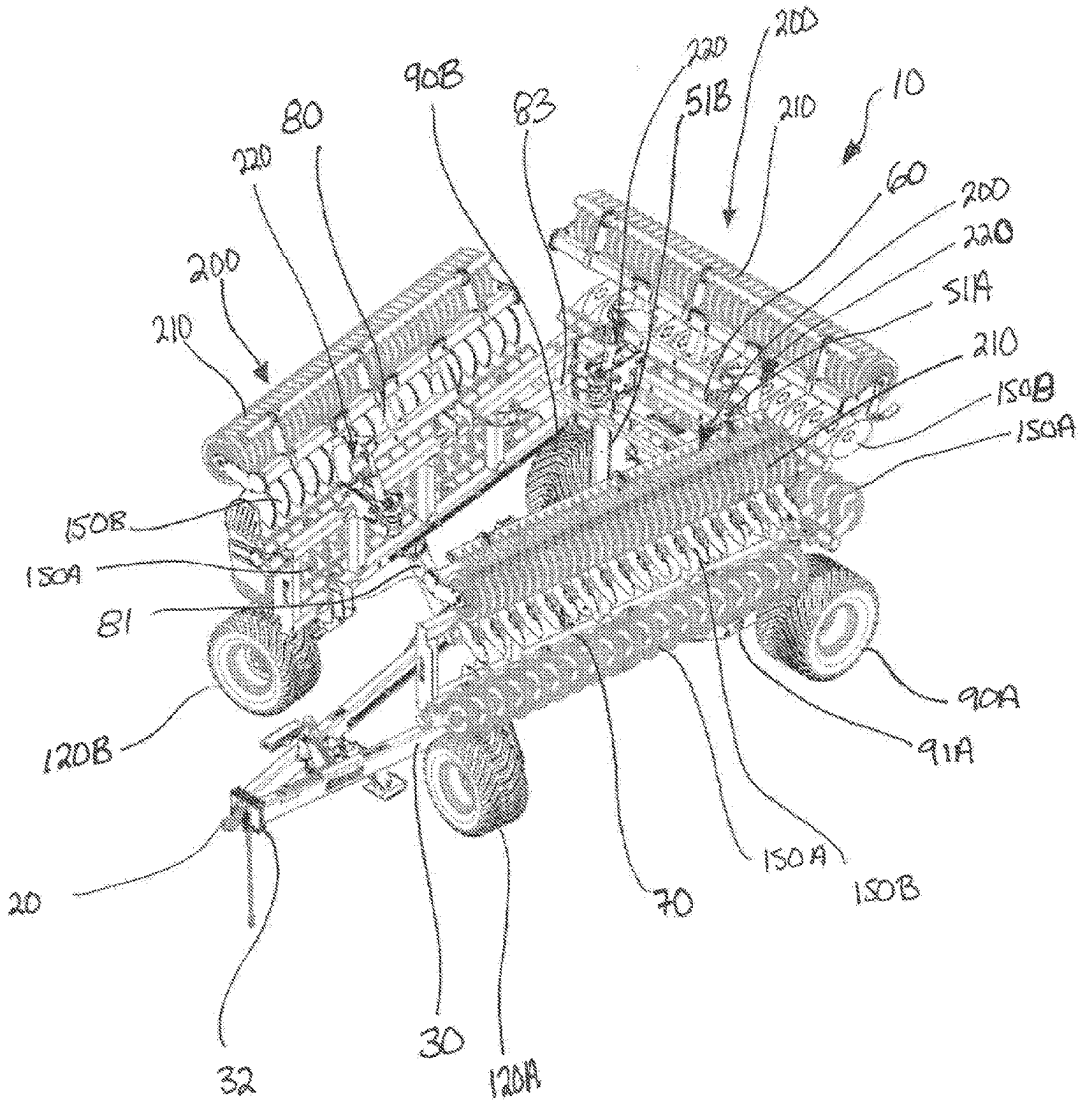
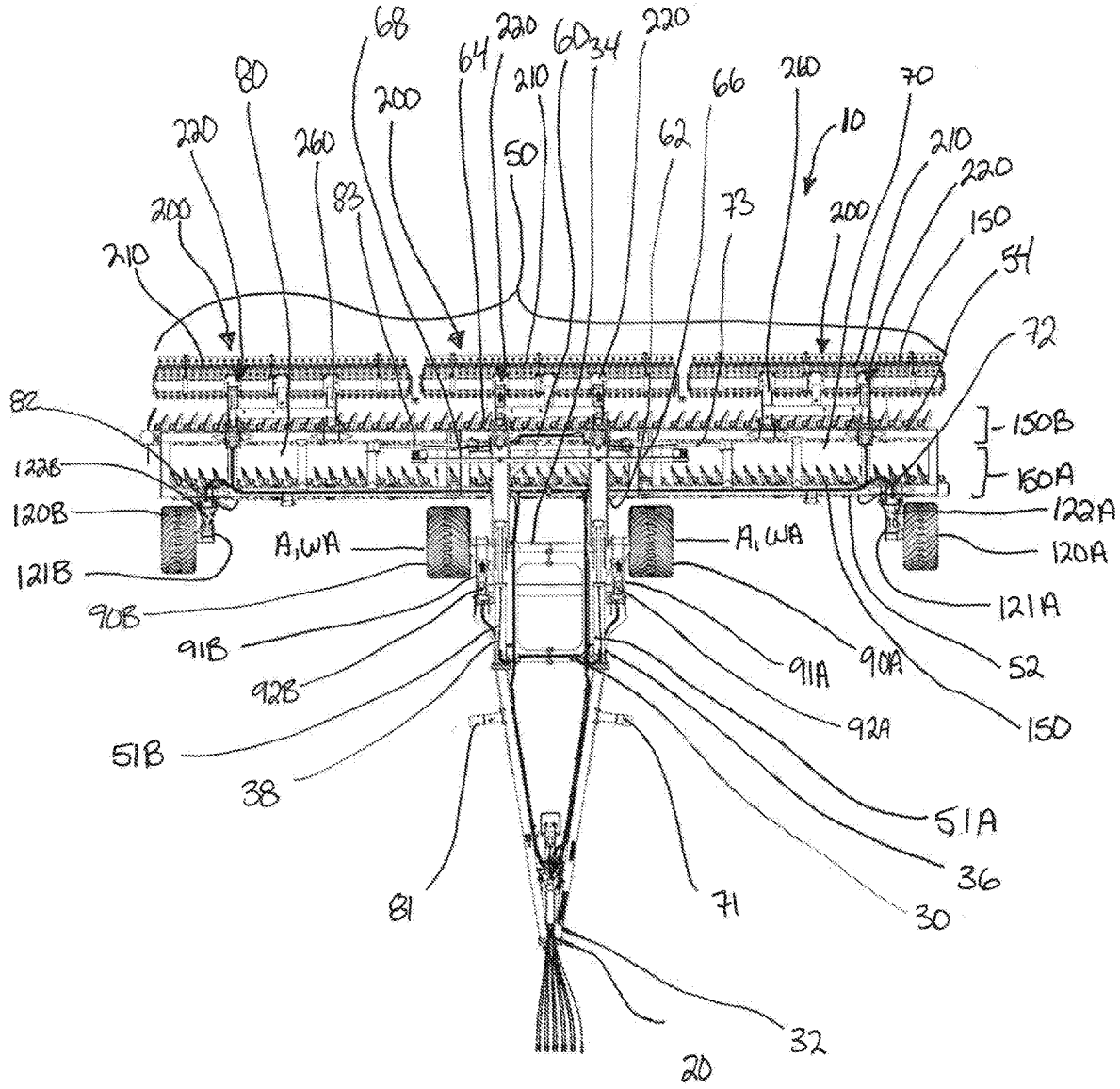
CPC ***A01B 73/065*** (2013.01); ***A01B 63/22*** (2013.01); ***A01B 63/32*** (2013.01)

(57) **ABSTRACT**

A cultivator is provided. The cultivator can have a main frame having a front end and a back end, a hitch assembly connected to the front end of the main frame, a tilling section attached to the back end of the main frame, a pair of main ground wheels, a first wing ground wheel and a second wing ground wheel, a plurality of ground engaging tools connected to and extending below the tilling section.

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64
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60
34
220
80
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66
260
70
220
200
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200
10
210
50
62
220
200
83
73
150
210
54
72
82
150B
122B
150A
120B
122A
A, WA
A, WA
121B
120A
90B
121A
91B
91A
90A
92B
52
92A
150
51B
51A
38
36
30
81
71
32
20

FIG. 1

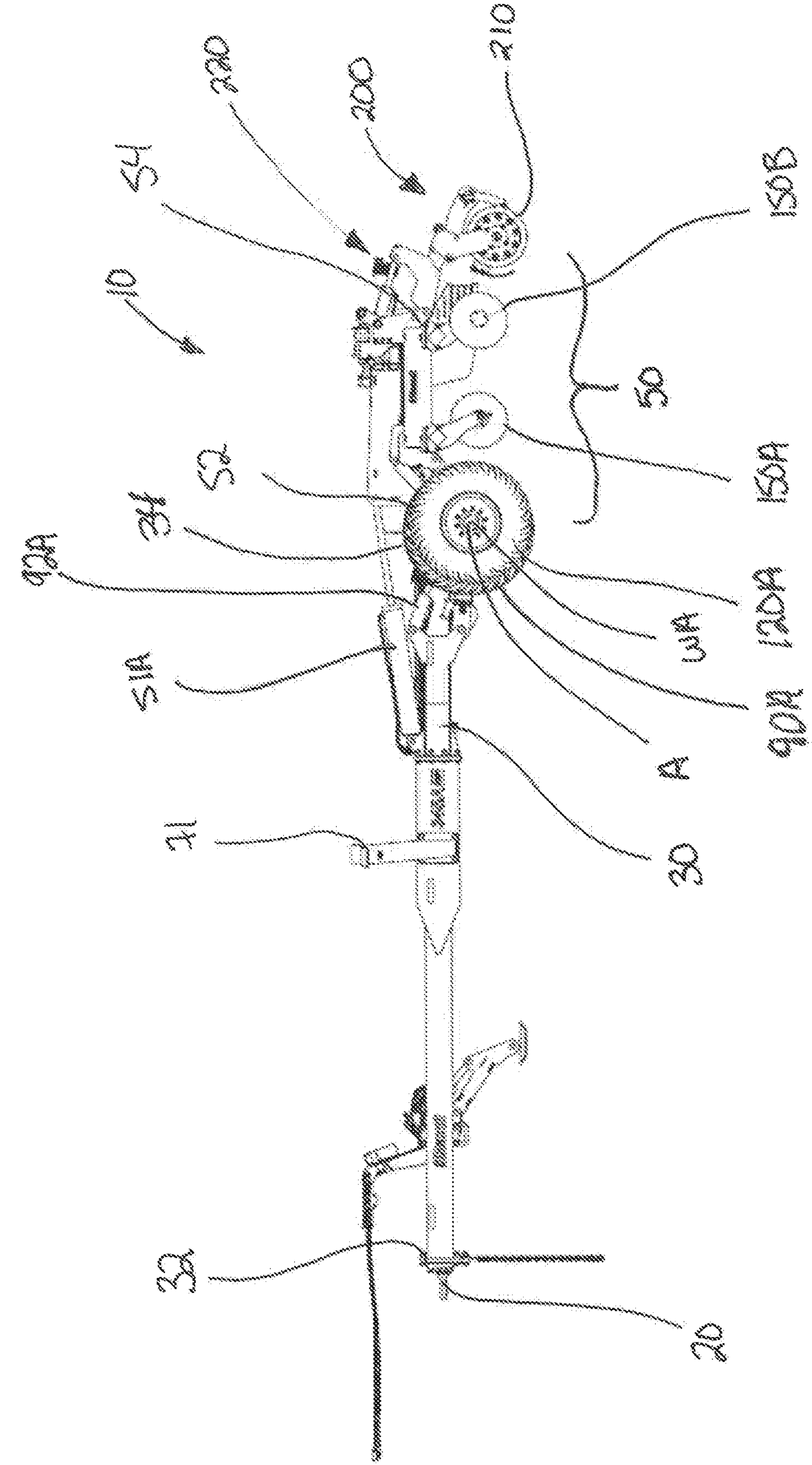
10
200
210
220
54
150B
50
150A
52
34
92A
51A
120A
WA
90R
A
30
21
32
20

FIG. 2

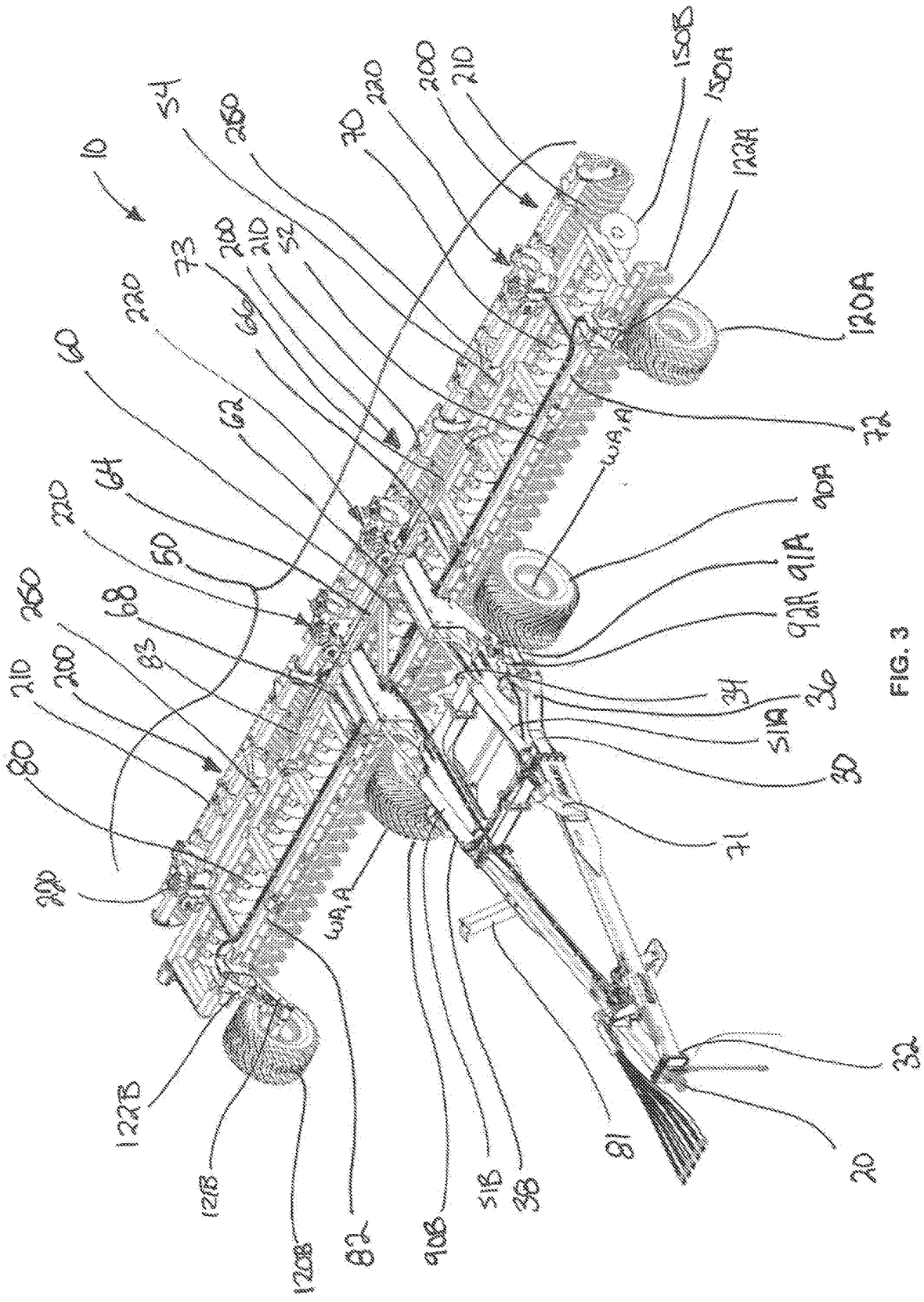
10
54
260
70
220
200
210
150B
150A
123A
120A
73
208
210
52
220
60
62
64
72
LUA,A
40A
91A
91A
34
36
51A
30
21
220
64
60
68
260
83
210
200
80
208
LUA,A
81
32
20
122B
121B
121A
82
90B
51B
38

FIG. 3

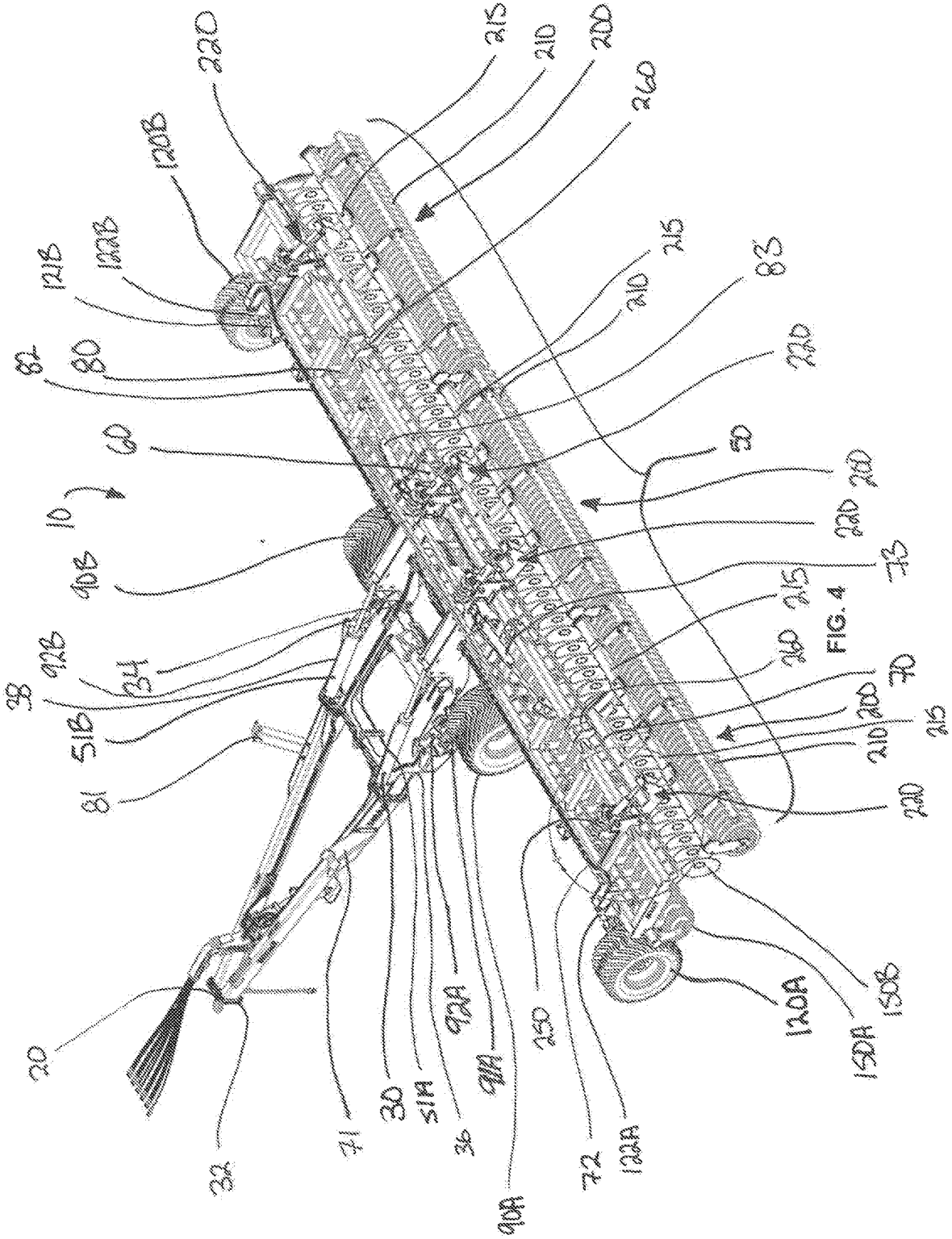
220
215
210
200
240
120B
122B
121B
82
80
60
10
405
92B
124
51B
81
20
32
41
30
51A
92A
90A
72
122A
150A
150B
120A
85
220
210
215
200
240
50
70
75
38

FIG. 4

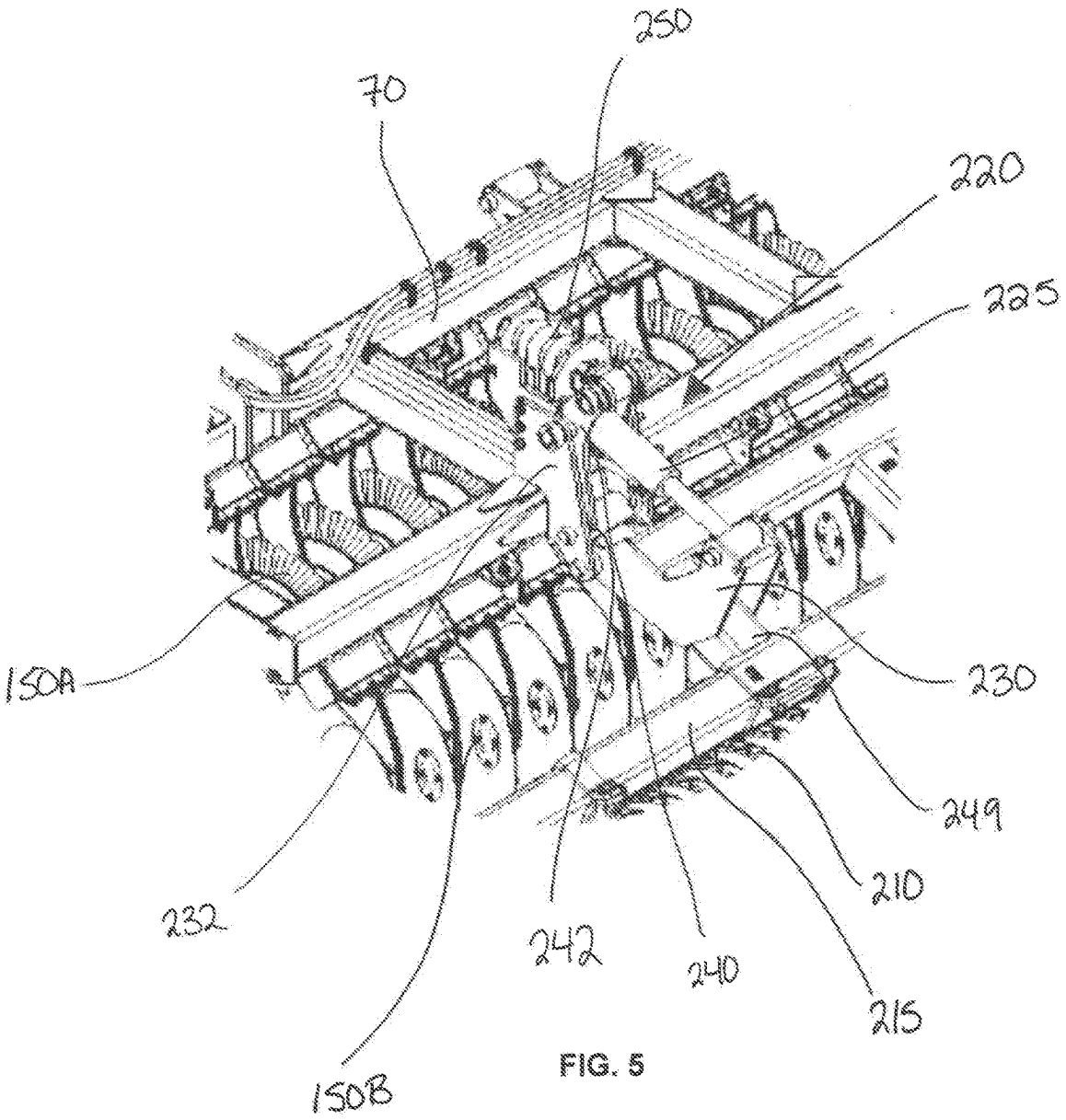

FIG. 5

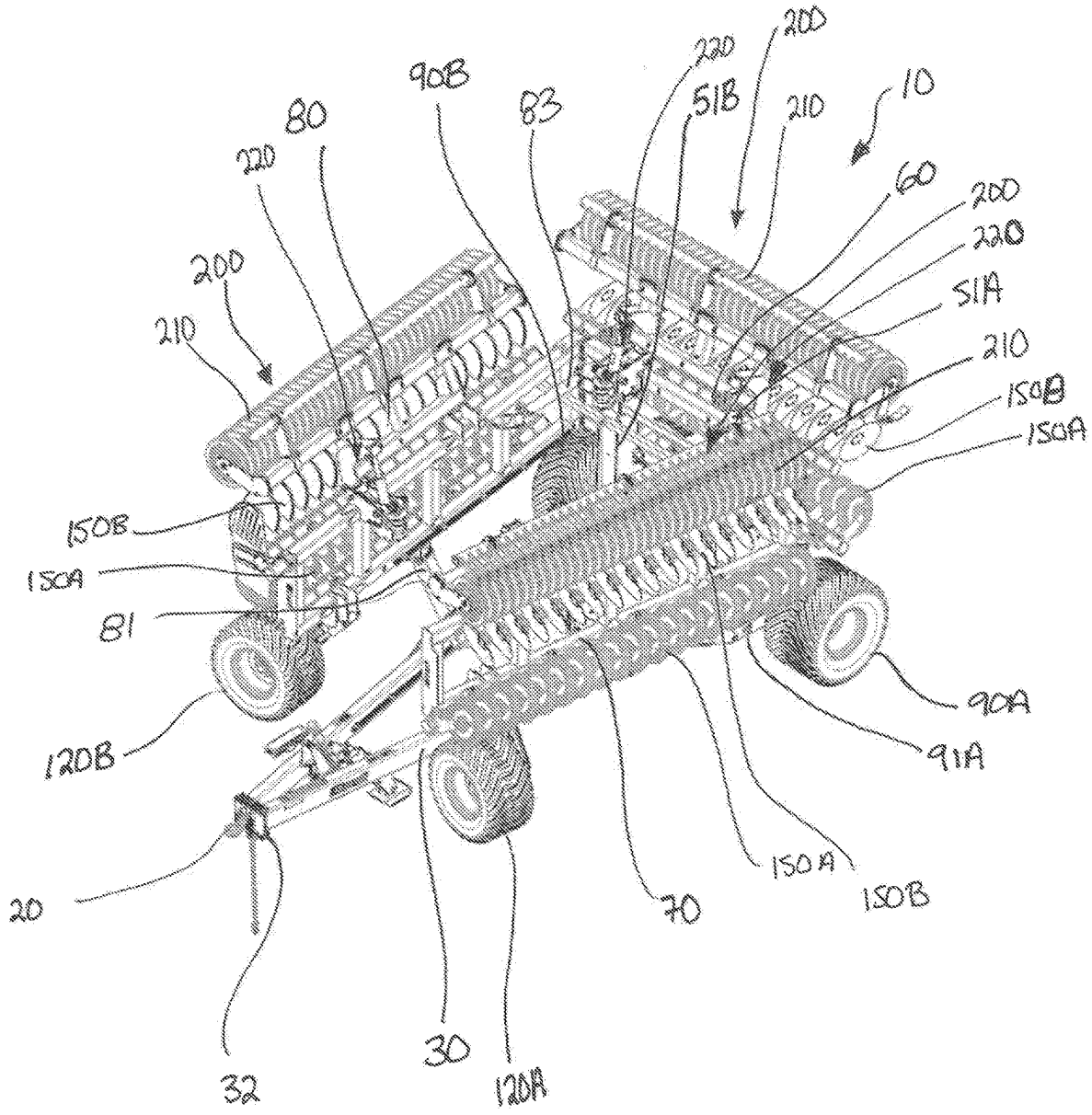
220
200
10
90B
83
80
51B
210
60
200
220
200
51A
210
210
150B
150A
150B
150A
81
120B
90A
91A
20
150A
150B
70
32
30
120A

FIG. 6

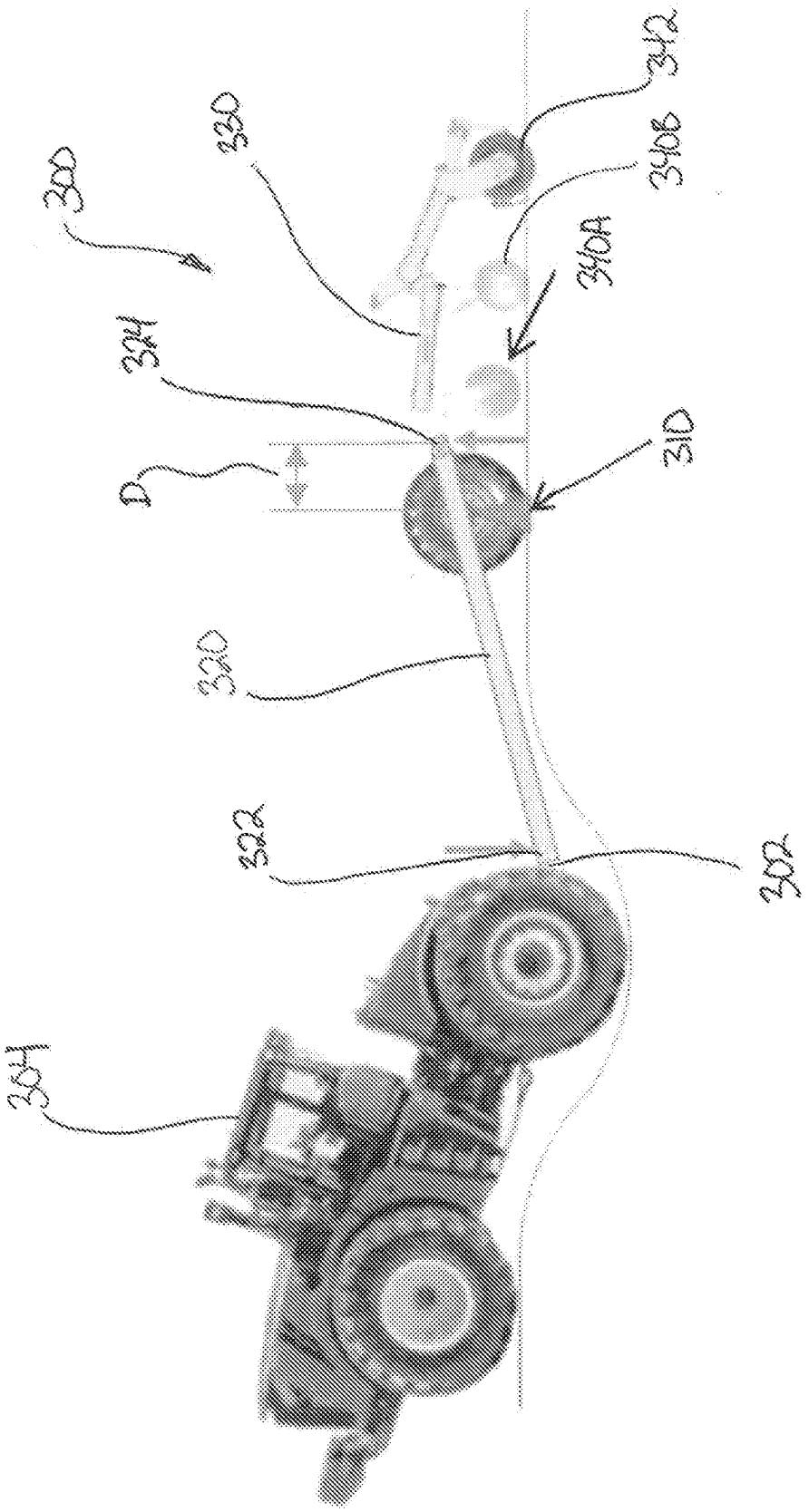

FIG. 7

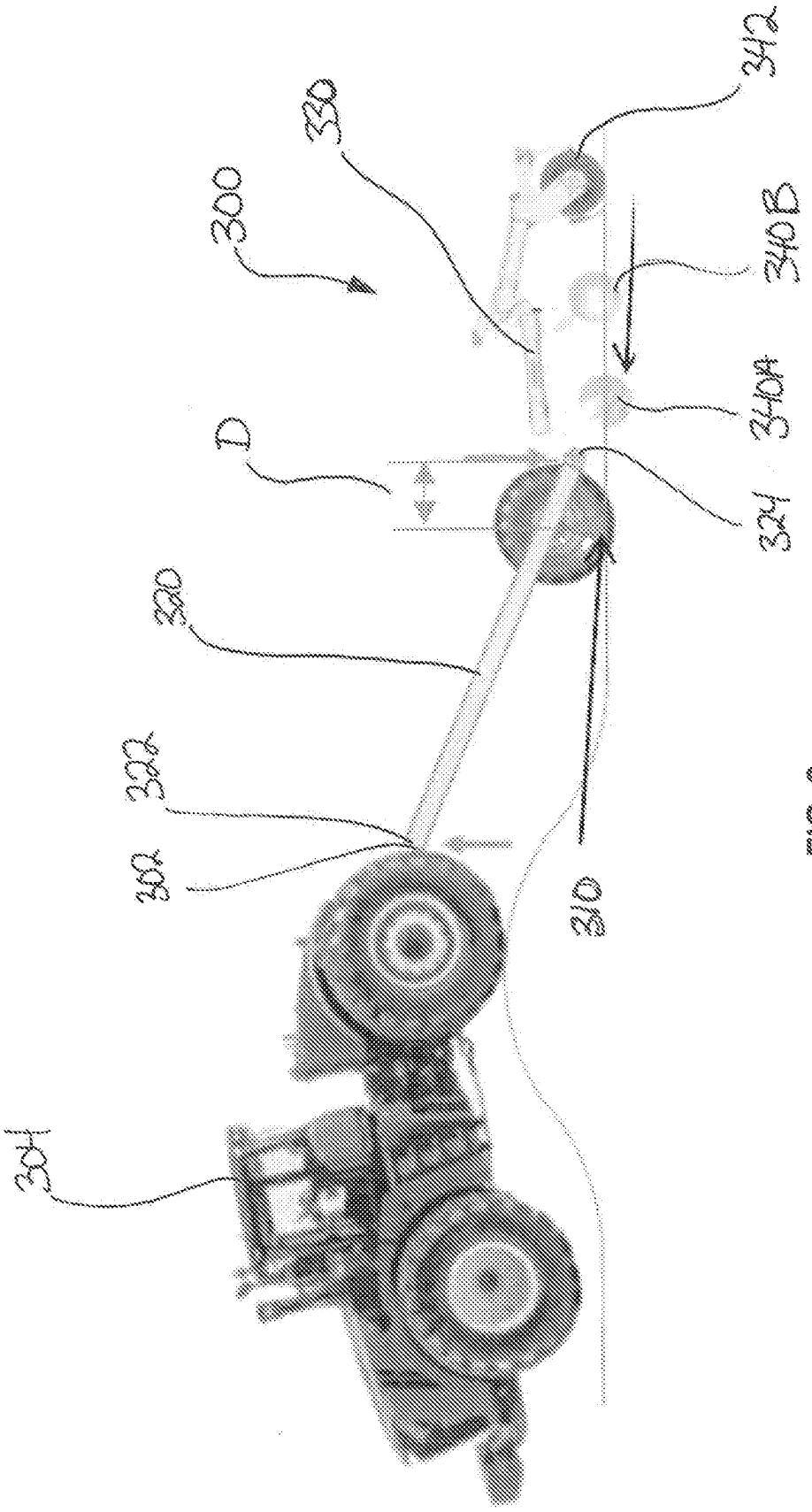

FIG. 8

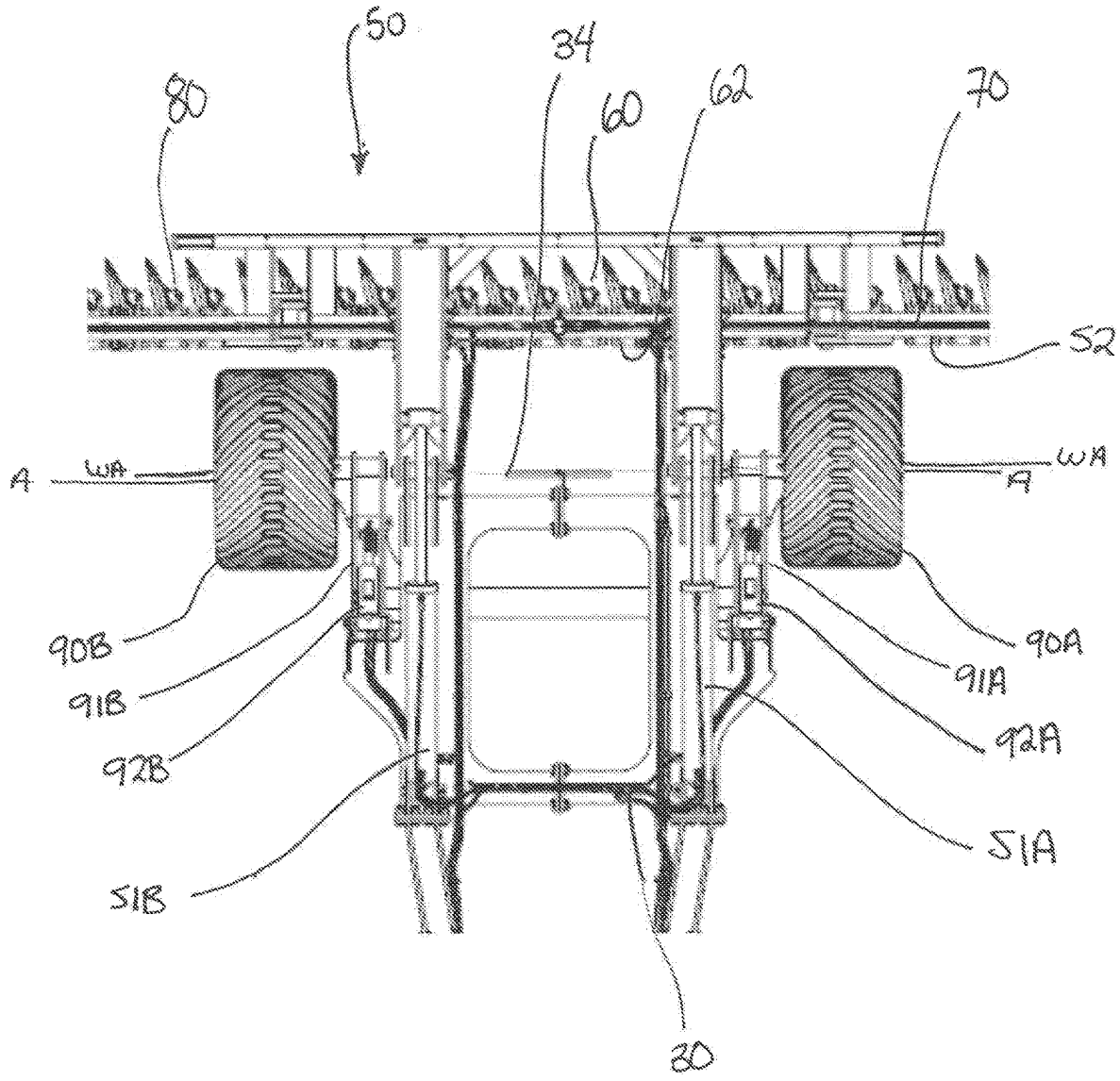

FIG. 9

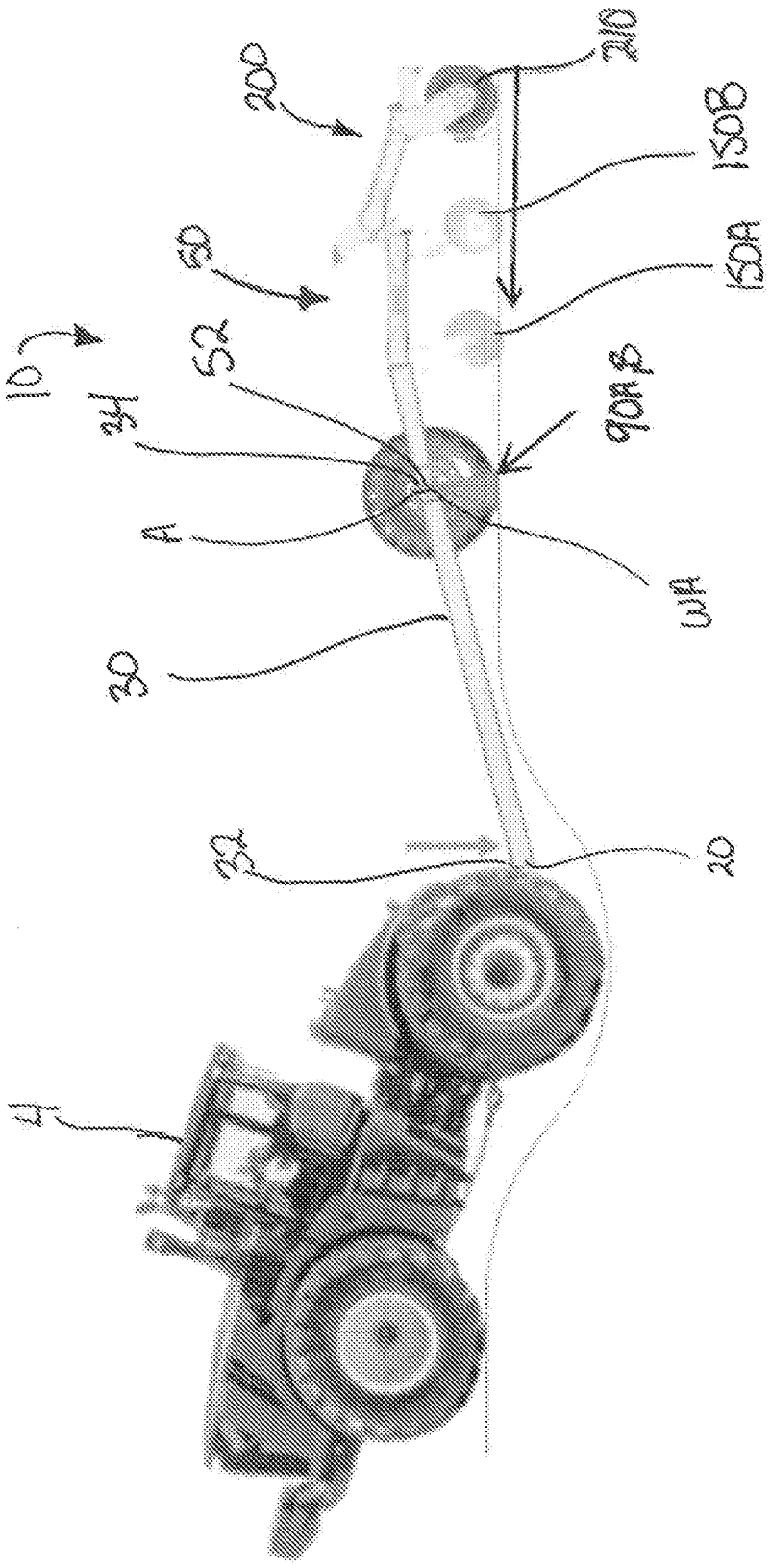

FIG. 10

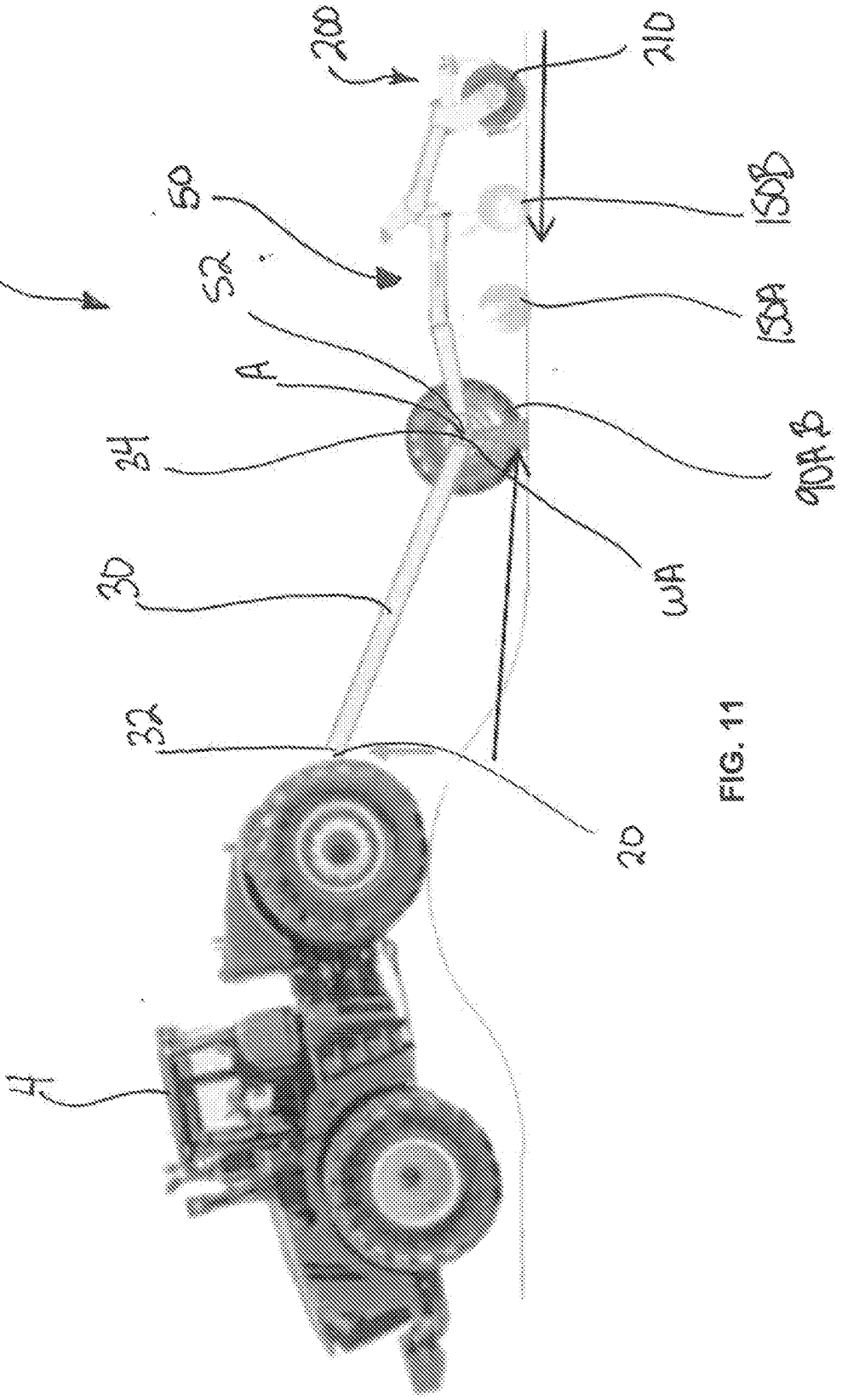

FIG. 11

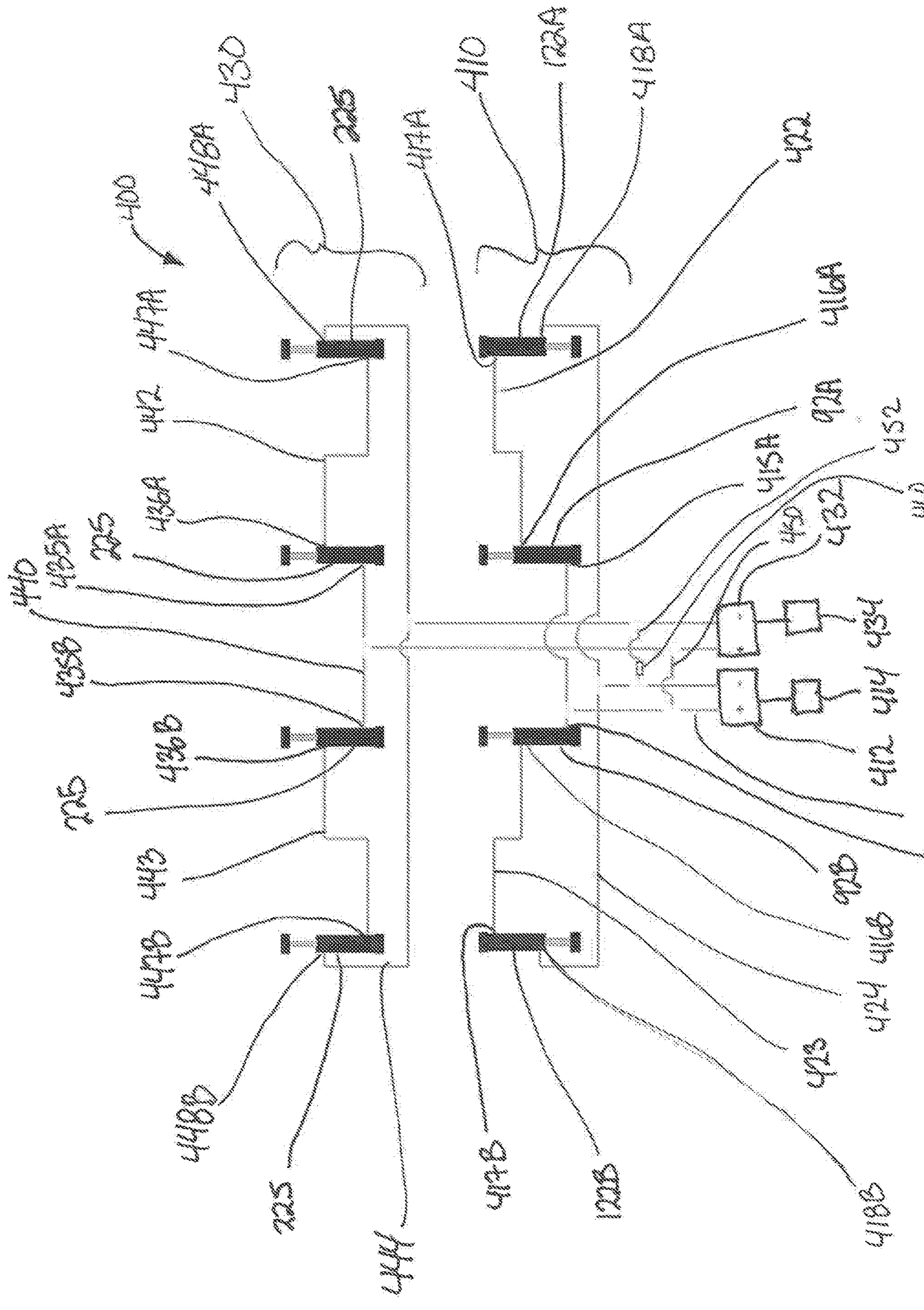

FIG. 12

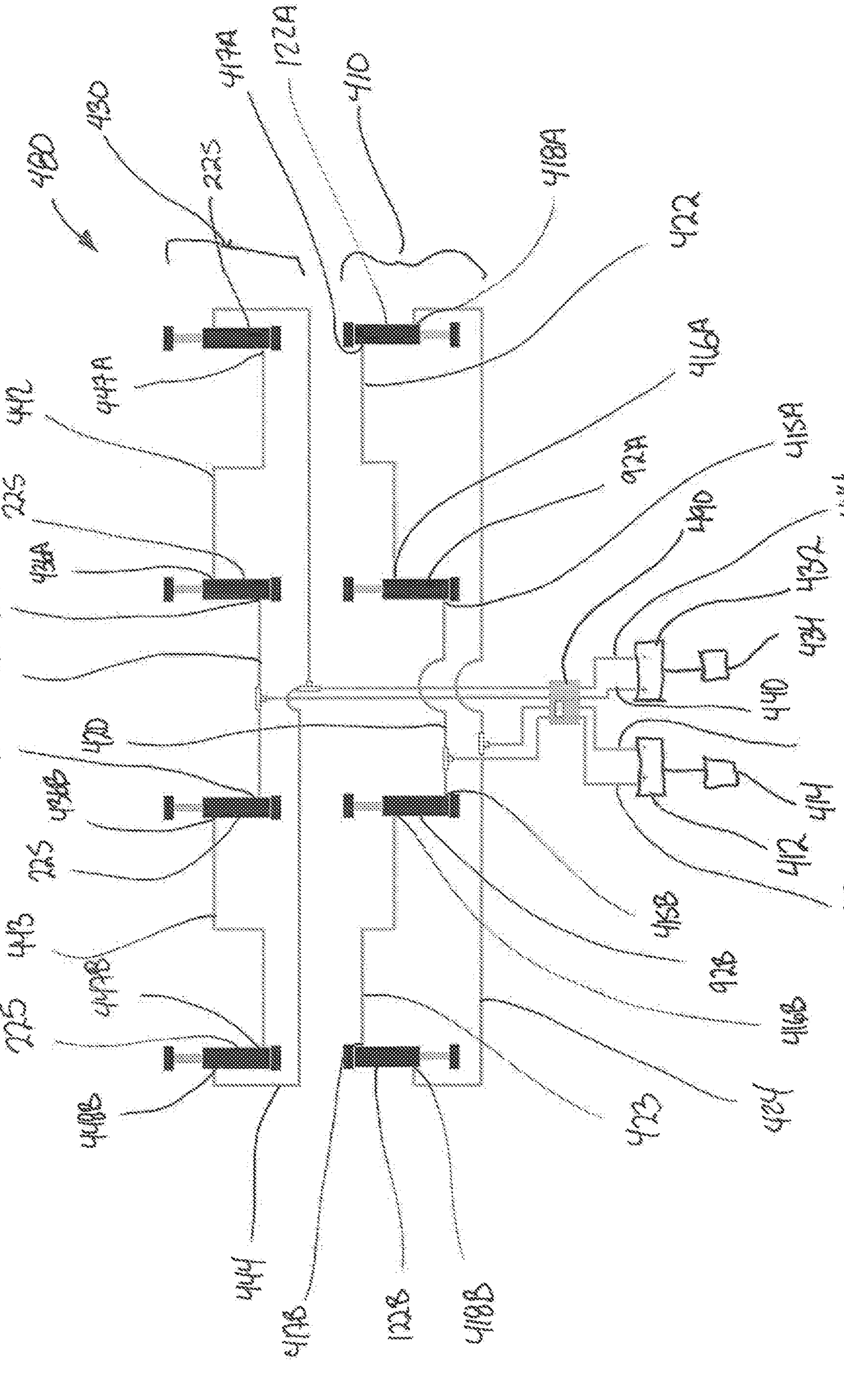

FIG. 12A

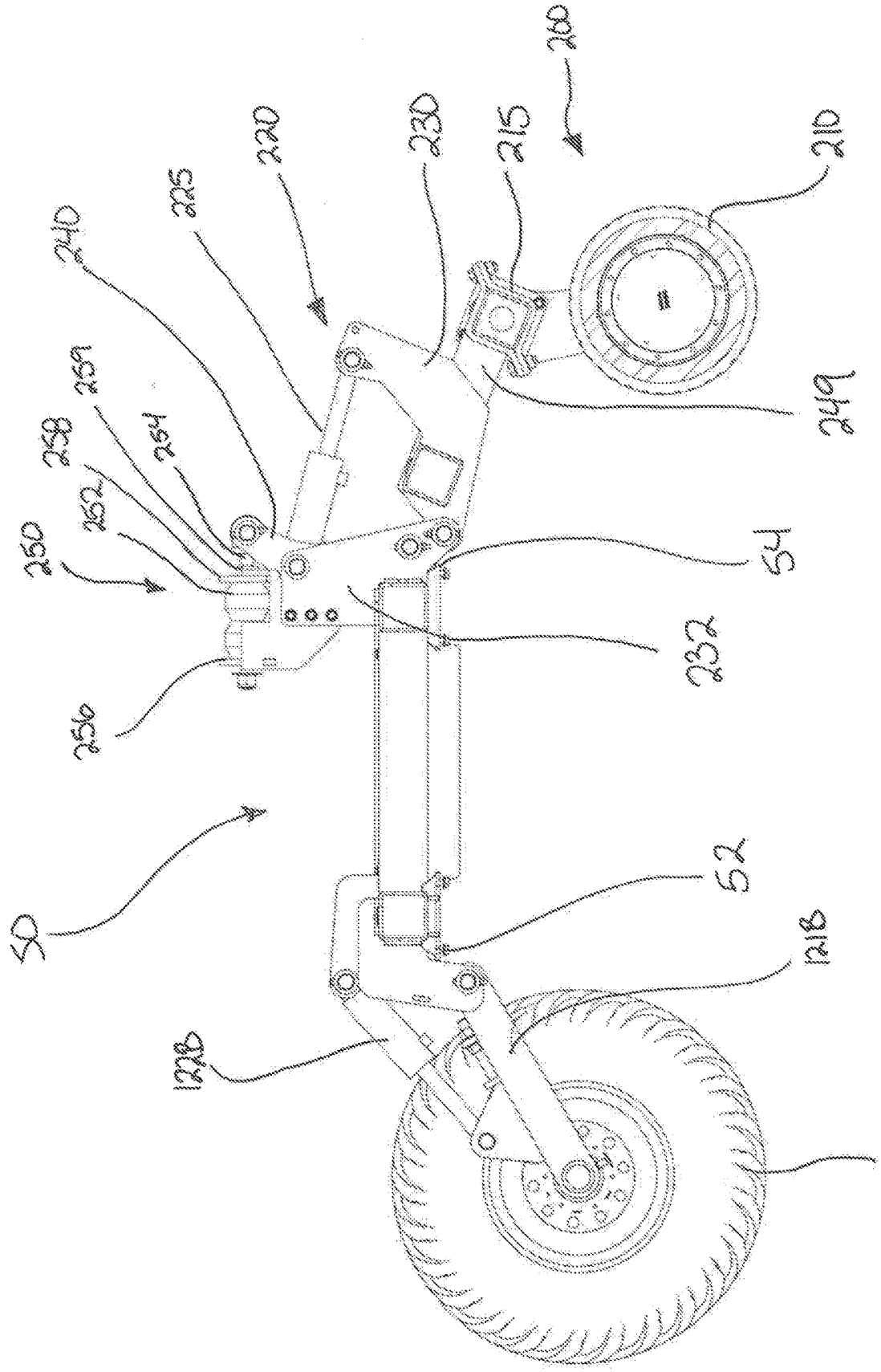
200
220
230
215
210
225
240
249
259
258
264
252
250
54
232
256
50
52
218
228
208

FIG. 13

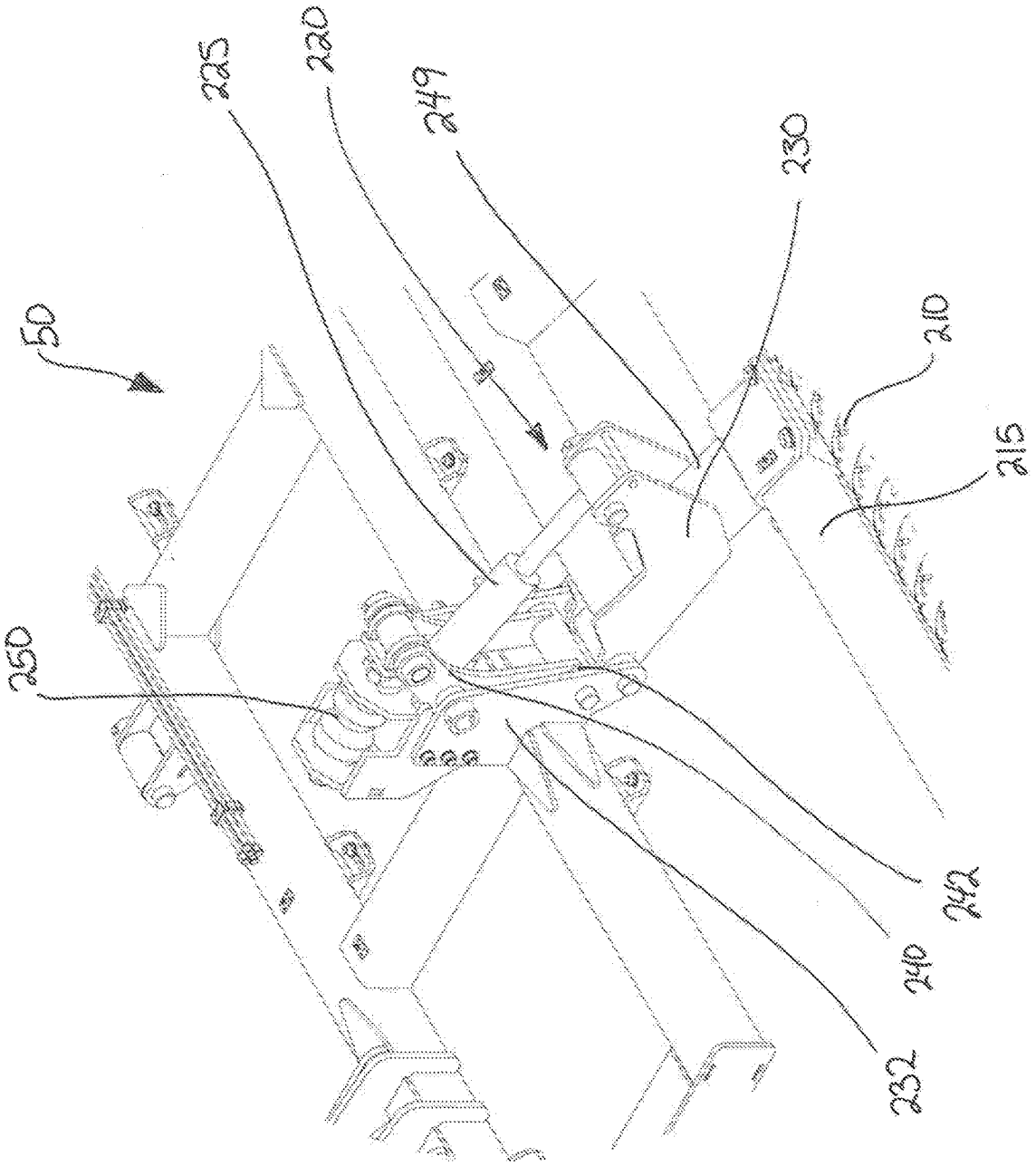

FIG. 14

CULTIVATOR

[0001] The present invention relates to a cultivator and, more particularly, a high-speed cultivator for cultivating or tilling a field.

CROSS-REFERENCE TO RELATED APPLICATIONS

[0002] This application is a divisional of U.S. application Ser. No. 17/940,146, filed Sep. 8, 2022, which claims priority to Canadian Patent Application No. 3152333, filed Mar. 14, 2022.

BACKGROUND

[0003] Cultivators are used in agriculture to till a field by mechanically agitating the soil. This can be done for a number of reasons including to prepare a good seedbed for crops to be planted in the field. With the increasing size of many agricultural operations and the increase in the area of the fields being seeded and harvested, modern cultivators have increased in size in order to cover more of a field with each pass and have been designed to operate at higher speeds to they can till a field faster. However, while the size and speed of operation of these more modern cultivators have allowed operators to till a field faster than more traditional cultivators, this increase in size and speed have created additional complications for these cultivators.

SUMMARY OF THE INVENTION

[0004] In a first aspect, a cultivator is having a main frame having a front end and a back end, a hitch assembly connected to the front end of the main frame, a tilling section pivotally attached to the back end of the main frame to pivot around a pivot axis, a pair of main ground wheels attached to the main frame, the main ground wheels defining a ground wheel axis passing through centers of the main ground wheels, a first wing ground wheel and a second wing ground wheel attached to a front end of the tilling section, and a plurality of ground engaging tools connected to and extending below the tilling section. The ground wheel axis is substantially aligned with the pivot axis in a horizontal direction.

[0005] In a further aspect, a cultivator is provided having a main frame having a front end and a back end, a hitch assembly connected to the front end of the main frame, a tilling section having a front end and a back end, the tilling section pivotally attached to the back end of the main frame to pivot around a pivot axis, a pair of main ground wheels vertically moveable relative to the front end of the tilling section, ground wheel actuators connected to the main ground wheels to vertically raise and lower the main grounds wheels relative to the front end of the tilling section, a first wing ground wheel and a second ground wheel vertically moveably relative to the front end of the tilling section, a first wing ground wheel actuator connected to the first wing ground wheel to move the first wing ground wheel vertically, a second wing ground wheel actuator connected to the second wing ground wheel to move the second wing ground wheel vertically, a plurality of ground engaging tools connected to and extending below the tilling section, a plurality of packer assemblies pivotally connected to the back end of the tilling section, each packer assembly having a packer roller, the packer roller vertically moveable relative to a back end of the tilling section, a packer actuator connected between the tilling section and each packer assembly to raise and lower the packer roller. A front hydraulic circuit operably connected to the main ground wheel actuators to extend and retract the main ground wheel actuators and a back hydraulic circuit operably connected to the packer actuators to extend and retract the packer actuators. The front hydraulic circuit and the back hydraulic circuit are operably connected in parallel. The plurality of ground engaging tools can include a first row of ground engaging tools and a second row of ground engaging tools. The first row of ground engaging tools positioned in front of and parallel to the second row of ground engaging tools.

[0006] In a further aspect, a cultivator is provided having a hitch assembly connectable to a tow vehicle, a tilling section having a front end and a back end, a plurality of ground engaging tools connected to and extending below the tilling section, a packer assemblies pivotally connected to the back end of the tilling section and having a packer roller, the packer roller vertically moveable relative to a back end of the tilling section; a packer actuator connected to the packer assembly to raise and lower the packer roller, and a suspension element operably connected between the packer actuator and the tilling section, the element having a compression element to absorb a compression load.

DESCRIPTION OF THE DRAWINGS

[0007] A preferred embodiment of the present invention is described below with reference to the accompanying drawings, in which:

[0008] FIG. **1** is a top view of a cultivator;

[0009] FIG. **2** is a side view of the cultivator shown in FIG. **1**;

[0010] FIG. **3** is a perspective view of the cultivator shown in FIG. **1**;

[0011] FIG. **4** is a rear perspective view of the cultivator shown in FIG. **1**;

[0012] FIG. **5** is a close up view of cultivator along line A of FIG. **4**;

[0013] FIG. **6** is a perspective view of the cultivator shown in FIG. **1** in a transport position;

[0014] FIG. **7** is schematic illustration of a cultivator with poor geometry affecting the depth the ground engaging tools penetrate a ground surface as a tow vehicle pulling the cultivator passes through a dip in a field;

[0015] FIG. **8** is a schematic illustration of the cultivator of FIG. **7** as the tow vehicle passes over a rise in a field;

[0016] FIG. **9** is a close up view of the cultivator of FIG. **1** showing the substantial alignment in the horizontal direction of the ground wheel axis and the pivoting axis;

[0017] FIG. **10** is schematic illustration of the cultivator shown in FIG. **1** as a tow vehicle pulling the cultivator through the field passes through a dip in a field;

[0018] FIG. **11** is a schematic illustration of the cultivator of FIG. **1** as a tow vehicle pulling the cultivator passes over a rise in a field;

[0019] FIG. **12** is a schematic illustration of a hydraulic circuit showing a hydraulic circuit for controlling the depth ground engaging tools of a cultivator engage soil;

[0020] FIG. **12**A is a schematic illustration of a hydraulic circuit showing a hydraulic circuit using a sequence valve for controlling the depth ground engaging tools of a cultivator engage soil;

[0021] FIG. **13** is a schematic illustration of a tilling section from the side showing a suspension element; and

[0022] FIG. **14** is a perspective view of a suspension element.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0023] FIGS. **1-4** illustrate a cultivator **10** for cultivating or tilling a field, typically used for growing agricultural crops. The cultivator **10** is pulled behind a tow vehicle (not shown), while the cultivator **10** is in a field position (as shown in FIG. **1-4**). Ground engaging tools **150** extend down from the cultivator **10** to penetrate into the soil of the field and till the soil in the field as the cultivator **10** is pulled through the field by the tow vehicle. The cultivator **10** can be transformed into a transport position, as shown in FIG. **6**, so that it can be towed from field to field, such as along a public roadway. The cultivator **10** can comprise: a hitch assembly **20**; a main frame **30**; a tilling section **50** having a rear frame **60**, a first wing frame **70**, and a second wing frame **80**; tilling section actuators **51**A, **51**B; a first wing actuator **73**; a second wing actuator **83**; a pair of main ground wheels **90**A, **90**B; ground wheel actuators **92**A, **92**B; a pair of wing ground wheels **120**A, **120**B; wing ground wheel actuators **122**A, **122**B; ground engaging tools **150**; packing assemblies **200**; bracket assemblies **220**; and packer actuators **225**.

[0024] The main frame **30** can have a front end **32** and a back end **34** with the hitch assembly **20** connected to the front end **32** of the main frame **30** for attachment to the tow vehicle (not shown). The main frame **30** can be pivotally attached to the tilling section **50**, comprising the rear frame **60**, the first wing frame **70**, and the second wing frame **80**, by the back end **34** of the main frame **30** being pivotally connected to the rear frame **60** so that the rear frame **60** can pivot upwards around a pivot axis A at the back end **34** of the main frame **30**.

[0025] The pair of main ground wheels **90**A, **90**B can be attached to the main frame **30** with a first main ground wheel **90**A attached to a first side **36** of the main frame **30** and a second main ground wheel **90**B attached to a second side **38** of the main frame **30**. The main ground wheels **90**A, **90**B are movably attached to the main frame **30** by swing arms **91**A, **91**B so that the main ground wheels **90**A, **90**B can be moved vertically, through an arc defined by the swing arms **91**A, **91**B, relative to the main frame **30** to raise and lower the main frame **30** relative to the main ground wheels **90**A, **90**B and thereby alter the height of the main frame **30** above the ground surface. The main ground wheels **90**A, **90**B can define a ground wheel axis WA passing through the center of the main ground wheels **90**A, **90**B and which the main ground wheels **90**A, **90**B rotate around.

[0026] The ground wheel actuators **92**A, **92**B, which can be double acting hydraulic cylinders, can be connected to the main ground wheels **90**A, **90**B to raise and lower the main ground wheels **90**A, **90**B. In one aspect, the ground wheel actuators **92**A, **92**B can extend between the main frame **30** and the swing arms **91**A, **91**B the main ground wheels **90**A, **90**B are connected to in order to move the main ground wheels **90**A, **90**B vertically, through an arc defined by the swing arms **91**A, **91**B, relative to the main frame **30**.

[0027] A pair of tilling section actuators **51**A, **51**B, such as double acting hydraulic cylinders, can be provided extending between the main frame **30** and the rear frame **60**. Retracting these tilling section actuators **51**A, **51**B will cause the rear frame **60** to pivot upwards relative to the main frame **30** and around pivot axis A at the back end **34** of the main frame **30**. Extending these tilling section actuators **51**A, **51**B will pivot the rear frame **60** downwards relative to the main frame **30** and around the pivot axis A at the back end **34** of the main frame **30**.

[0028] The rear frame **60**, the first wing frame **70**, and the second wing frame **80** together form the tilling section **50** having a front end **52** and a back end **54**.

[0029] The rear frame **60** will have a front end **62**, a back end **64**, a first side **66**, and a second side **68**. The front end **62** of the rear frame **60** can be pivotally connected to the back end **34** of the main frame **30** to pivot around the pivot axis A. The first side **66** of the rear frame **60** can be pivotally connected to the first wing frame **70** and the second side **68** of the rear frame **60** can be pivotally connected to the second wing frame **80**.

[0030] The first wing frame **70** can be pivotally connected to the first side **66** of the rear frame **60** so that the first wing frame **70** can pivot relative to the rear frame **30** around the first side **66** of the rear frame **60**. The first wing ground wheel **120**A can be attached at a front end **72** of the first wing frame **70** and movably attached to the front end **72** first wing frame **70** by a swing arm **121**A so that the first wing ground wheel **120**A can be moved vertically, through an arc defined by the swing arm **121**A, relative to the front end **72** of the first wing frame **70** to raise and lower the front end **72** of the first wing frame **70** and adjust the height of the front end **72** of the first wing frame **70** above ground surface.

[0031] The first wing ground wheel actuator **122**A, which can be a double acting hydraulic cylinder, can be used to vary the height between the first wing ground wheel **120**A and the front end **72** of the first wing frame **70**. The first wing ground wheel actuator **122**A can be connected between the first wing frame **70** and the swing arm **121**A the first wing ground wheel **120**A is connected to in order to move the first wing ground wheel **120**A vertically, through the arc defined by the swing arms **121**A, relative to the front end **72** of the first wing frame **70**.

[0032] An first wing actuator **73**, which can be a double acting hydraulic cylinder, can be connected between the rear frame **60** and the first side frame **70** so that the first wing actuator **73** can pivot the first wing frame **70** around the first side **66** of the rear frame **60** by retracting and extending the first wing actuator **73**.

[0033] The second wing frame **80** can be pivotally connected to the second side **68** of the rear frame **60** so that the second wing frame **80** can pivot relative to the rear frame **60** around the second side **68** of the rear frame **60**. The second wing ground wheel **120**B can be attached at a front end **82** of the second wing frame **80** and movably attached to the front end **82** of the second wing frame **80** by a swing arm **121**B so that the second wing ground wheel **120**B can be moved vertically, through an arc defined by the swing arm **121**B, relative to the front end **82** of the second wing frame **80** to raise and lower the front end **82** of the second wing frame **82** and adjust the height of the front end **82** of the second wing frame **80** above the ground surface.

[0034] The second wing ground wheel actuator **122**B, which can be a double acting hydraulic cylinder, can be used to vary the height between the second wing ground wheel **120**B and the front end **82** of the second side frame **80**. The second wing ground wheel actuator **122**B can be connected

between the second wing frame **80** and the swing arm **121**B the second wing ground wheel **120**B is connected to in order to move the second wing ground wheel **120**B vertically, through the arc defined by the swing arm **121**B, relative to the front end **82** of the second wing frame **80**.

[0035] Attached below the tilling section **50** and, specifically, the rear frame **60**, the first wing frame **70** and the second wing frame **80**, are the ground engaging tools **150** extending downwards beneath the tilling section **50** for penetrating the ground surface and engaging with the soil. The ground engaging tools **150** can positioned in a first row of ground engaging tools **150**A and a second row of ground engaging tools **150**B in the tilling section **50**. The first row of ground engaging tools **150**A can be positioned in front of, and parallel to, the second row of ground engaging tools **150**B.

[0036] Ground engaging tools **150** can be discs, coulter discs, harrow tines, ploughs, shanks, etc.

[0037] Packer assemblies **200** can be attached to the back end **54** of the tilling section **50** to pack and flatten the soil after it has been tilled up by the ground engaging tools **150** in the tilling section **50** with one packer assembly **200** attached behind the rear frame **60**, one packer assembly **200** attached behind the first wing frame **70** and one packer assembly **200** attached behind the second wing frame **80**.

[0038] Referring to FIG. **4**, each packing assembly **200** can have a packer roller **210** pivotally connected to a packer frame **215**, which packer frame **215** can be pivotally connected to the back end **54** of the tilling section **50** by one or more bracket assemblies **220**. The packer frame **215** connected to the first wing frame **70** and the packer frame **215** connected to the second wing frame **80** can also be pivotally connected by connection brackets **260** that freely pivot.

[0039] The bracket assemblies **220** allow the packer assemblies **200** to be selectively pivoted around the back end **54** of the tilling section **50**. Referring to FIG. **5**, the bracket assembly **220** can include: a packer actuator **225**, a packer bracket **230**; a frame bracket **232**; an intermediate link **240**; a suspension element **250**; and a roller linkage **249** for connection to packer frame **215**.

[0040] The roller linkage **249** can be connected to the packer frame **215** on one end and pivotally connected to the rear end **54** of the tilling section **50** at a second end. The packer bracket **230** can be connected, extending upwards, from the roller linkage **249**. The frame bracket **232** can be connected to one of the frames in the tilling section **50** and expending upwards. The intermediate link **240** can be pivotally connected to the frame bracket **232** at a first end **242** of the intermediate link **240** so that the intermediate link **240** can pivot around the first end **242** of the intermediate link **240** relative to the frame bracket **232**.

[0041] The packer actuator **225**, which can be a double acting hydraulic cylinder, can be connected between the packer bracket **230** and the intermediate link **240**, a first distance from the first end **242** of the intermediate link **240**.

[0042] The suspension element **250** can be connected between the frame bracket **232** and the intermediate link **240**, a second distance from the first end **242** of the intermediate link **240**.

[0043] The bracket assembly **220** can cause the packer assembly **200** to be selectively pivoted around the back end **54** of the tilling section **50** using the packer actuator **225** and thereby raise and lower the height of the packer roller **210** relative to the back end **54** of the tilling section **50**. By extending the packing actuator **225**, the packer bracket **230** and thereby the packer frame **215** and the packer roller **210**, can be pivoted downwards relative to the back end **54** of the tilling section **50**, thereby lowering the packer roller **210** and raising the back end **54** of the tilling section **50** relative to the ground surface. By retracting the packing actuator **225**, the packer bracket **230** and thereby the packer frame **215** and the packer roller **210**, can be pivoted upwards relative to the back end **54** of the tilling section **50**, thereby raising the packer roller **210** and lowering the back end **54** of the tilling section **50** relative to the ground surface.

[0044] The cultivator **10** can be transformed from the field position, as shown in FIGS. **1-4**, to the transport position, shown in FIG. **6** for transport from field to field. The tilling section actuators **51**A, **51**B can be retracted to pivot the tilling section **50** upwards and specifically the rear frame **60** around pivot axis A relative to the main frame **30**. This will lift the rear frame **60** as well as the first wing frame **70** and the second wing frame **80** that are attached to the sides **66**, **68** of the rear frame **60**, up off the ground surface. The main ground wheels **90**A, **90**B are attached to the main frame **30** so the main ground wheels **90**A, **90**B will remain in place as the tilling section **50** is pivoted upwards around the back end **34** of the main frame **30**. As the tilling section **50** is pivoted upwards to perpendicular relative to the main frame **30**, the weight of the tilling section **50** will move forward onto the main ground wheels **90**A, **90**B attached to the main frame **30**.

[0045] When the tilling section **50** is pivoted to substantially perpendicular relative to the main frame **30**, the first wing actuator **73** can be use to pivot the first wing frame **70** relative to the rear frame **30**, forwards towards the front end **32** of the main frame **30** and the second wing actuator **83** can be used to pivot the second wing frame **80** relative to the rear frame **30**, forwards towards the front end **32** of the main frame **30**. The first wing frame **70** can be rested on, and connected to, a first wing brace **71** and the second side wing frame **80** can be rested on, and connected to, a second wing brace **81** to secure the first and second wing frames **70**, **80** in the transport position shown in FIG. **6**.

[0046] When the cultivator **10** is being towed in the transport position, the weight that is carried on the main ground wheels **90**A, **90**B and the tow vehicle is much easier to predict because there is no fore and aft motion. However, while having its advantages for towing the cultivator **10** in the transport position, mounting of the main ground wheels **90**A, **90**B to the main frame **30** instead of the rear frame **60** (like the wing ground wheels **120**A, **120**B are mounted to the wing frames **70**, **80**), can cause problems when the cultivator **10** is in the field position and being pulled through a field to till the soil. The positioning of the main ground wheels **90**A, **90**B on the main frame **30** can affect the depth control of the soil engaging tools **150** on the tilling section **50** if the geometry of the main frame **30** and the main ground wheels **90**A, **90**B is not set up a specific way.

[0047] If the ground wheel axis WA is positioned a horizontal distance in front of the pivot axis A, the ground wheel axis WA can act as a fulcrum and amplify the movement of the main frame **30** affecting the depth the ground engaging tools **150** penetrate the ground surface.

[0048] Referring to FIGS. **7** and **8**, a prior art cultivator **300** with poor geometry is shown. For cultivator **300**, the ground wheels **310** are connected to a main frame **320** a distance D from a back end **324** of the main frame **320**. A

tilling section **330** is pivotally connected to the back end **324** of the main frame **320** and has a first row of ground engaging tools **340**A and a second row of ground engaging tools **340**B positioned behind the first row of ground engaging tools **340**A. A packer roller **342** is connected behind the tilling section **330**.

[0049] When a hitch assembly **302**, connecting the cultivator **300** to a tow vehicle **304**, is moved downwards, such as when the tow vehicle **304** passes through a dip in the field, as shown in FIG. **7**, the main frame **320** will move downwards at its front end **322** with the ground wheels **310** acting as fulcrum and the rear end **324** of the main frame **320** moving upwards relative to the ground surface. The front end of the tilling section **330**, that is pivotally attached to the rear end **324** of the main frame **320**, will also be moved upwards, with the packer roller **342** staying on top of the ground surface, which will in turn raise the first row of soil engaging tools **340**A upwards, reducing the depth this first row of soil engaging tools **340**A penetrate the ground surface or even moving the first row of ground engaging tools **340** up and out of the soil. The second row of ground engaging tools **340**B can also rise up, decreasing the depth of penetration of the second row of ground engaging tools **340**B in the soil, but not to the same extent as the first row of ground engaging tools **340**A.

[0050] When the hitch assembly **302** is moved upwards, such as when the tow vehicle **304** passes over a rise in the field, as shown in FIG. **8**, the main frame **320** will move upwards at its front end **322** with the ground wheels **310** acting as fulcrum and the rear end **324** of the main frame **320** moving downwards relative to the ground surface. The front end of the tilling section **330**, that is pivotally attached to the rear end **324** of the main frame **320**, will also be moved downwards, with the packing roller **342** staying to top of the ground surface. This will lower the first row of soil engaging tools **340**A downwards, increasing the depth this first row of soil engaging tools **340**A penetrate the ground surface. The second row of ground engaging tools **340**B can also be lowered, increasing the depth of penetration of the second row of ground engaging tools **340**B as well, but not to the same extent as the first row of ground engaging tools **340**A.

[0051] This geometry causing the ground wheels **310** on the main frame **320** to act as a fulcrum for the main frame **320** results in poor depth control of the ground engaging tools **340**A, **340**B as the tow vehicle **304** pulls the cultivator **300** through a field and through dips and rises in the field.

[0052] Referring again to FIG. **1**, the ground wheel axis WA can be positioned proximate a back end **34** of the main frame **30** and the ground wheel axis WA and the pivot axis A can be substantially aligned in the horizontal direction. The ground wheel axis WA may be positioned substantially at or behind the back end **34** of the main frame **30**. By placing the ground wheel axis WA proximate to the back end **34** of the main frame **30** and substantially aligning the ground wheel axis WA and the pivot axis A in the horizontal direction, the ground wheel axis WA does not act as a fulcrum for the main frame **30**. FIG. **9** shows a close up view of the main ground wheels **90**A, **90**B and the pivotal connection between the rear frame **60** of the tilling section **50** and the main frame **30** around pivot axis A, showing the ground wheel axis WA positioned at a back end **34** of the main frame **30** and the ground wheel axis WA and the pivot axis A to be substantially aligned in the horizonal direction. The ground wheel axis WA and the pivot axis A being substantially aligned in the horizonal direction means the main ground wheels **90**A, **90**B will set the height of the front end **62** of the rear frame **60** and therefore the height of the front end **52** of the tilling section **50** relative to the ground surface and since the height of the main ground wheels **90**A, **90**B can be set to a fixed height relative to the main frame **30**, the front end **52** of the tilling section **50** will also remain at a substantially fixed height relative to the ground surface, maintaining a more consistent depth of the first row of ground engaging tools **150**A and the second row of ground engaging tools **150**B.

[0053] The ground wheel axis WA and the pivot axis A may be at different vertical heights without affecting the height of the front end **52** of the tilling section **50**. The ground wheel axis WA and the pivot axis A may also not be perfectly aligned in the horizontal direction, but rather substantially aligned in the horizontal direction. Because the main ground wheels **90**A, **90**B are connected to the main frame by swing arms **91**A, **91**B, respectively, the main ground wheels **90**A, **90**B will move vertically through an arc defined by the swing arms **91**A, **91**B. This will cause the main ground wheels **90**A, **90**B to move horizontally slightly, relative to the pivot axis A, as the ground wheels **90**A, **90**B are moved vertically through an arc defined by the swing arms **91**A, **91**B. This means the ground wheel axis WA and the pivot axis A may not be perfectly aligned at all times and heights of the main ground wheels **90**A, **90**B, but can be positioned proximate and close to each other or "substantially aligned", rather than having a significant horizontal distance between them.

[0054] Referring to FIG. **10**, unlike the cultivator **300** where the ground wheels **310** act as a fulcrum for the main frame **320**, when a tow vehicle **4** pulling the cultivator **10** passes through a dip in the field, the hitch assembly **20** will move downwards and the main frame **30** will move downwards at its front end **32**. However, the main ground wheels **90**A, **90**B, defining the ground wheel axis WA at the back end **34** of the main frame **30** and substantially aligned with the pivot axis A, which pivotally connects the back end **34** of the main frame **30** to the front end **52** of the tilling section **50**, keep the front end **52** of the tilling section **50** at a substantially constant height relative to the ground surface, keeping the first row of ground engaging tools **150**A and the second row of ground engaging tools **150**B penetrating the ground surface at a substantially constant depth.

[0055] When the hitch assembly **20** of the cultivator **10**, is moved upwards, such as when the tow vehicle **4** passes over a rise in the field, as shown in FIG. **11**, the main frame **30** will move upwards at its front end **32**. The main ground wheels **90**A, **90**B, defining the ground wheel axis WA at the back end **34** of the main frame **30** and substantially aligned horizontally with the pivot axis A, which pivotally connects the back end **34** of the main frame **30** to the tilling section **50**, keeps the front end **52** of the tilling section **50** at a substantially constant height relative to the ground surface, keeping the first row of ground engaging tools **150**A and the second row of ground engaging tools **150**B penetrating the ground surface at a substantially constant depth.

[0056] Having the ground wheel axis WA proximate a back end **34** of the main frame **30** and substantially aligned in the horizontal direction with the pivot axis A, promotes consistent depth control with the ground engaging tools **150** in the tilling section **50** of the cultivator **10**.

[0057] The cultivator **10** requires precise land contouring to engage the soil and maintain a substantially constant depth of penetration by the soil engaging tools **150**. When the cultivator **10** is in the field position and being towed across a field to till the soil in the field, the tilling section actuators **51**A, **51**B can be put in a float position to allow the tilling section **50** to freely pivot relative to the main frame **30**, around the pivot axis A. This allows the tilling section **50** to follow the ground surface contours; maintaining a substantially constant depth of penetration of the soil engaging tools **150** as the cultivator **10** is pulled over undulations in the field.

[0058] The first wing actuator **73** and the second wing actuator **83** can be pressurized to provide a downward force on the first wing frame **70** and the second wing frame **80**, respectively, to compensate for the weight of the rear frame **60**, which tends to be heavier than the first wing frame **70** or the second wing frame **80**. By forcing the first wing frame **70** and the second wing frame **80** downwards, the weight the tilling section **50** places on the ground surface can be better equalized along the length of the tilling section **50**.

[0059] In addition, the angle of the tilling section **50**, and specifically the rear frame **60**, the first wing frame **70** and the second wing frame **80** can be altered by changing the height of the front end **52** of the tilling section **50** and the height of the rear end **54** of the tilling section **50**.

[0060] The ground wheel actuators **92**A, **92**B, which can vary the height of the main ground wheels **90**A, **90**B relative to the main frame **30**, will also vary the height of the front end **62** of the rear frame **60** that is pivotally connected to the main frame **30**. The first wing ground wheel actuator **122**A can vary the height of the first wing ground wheel **120**A relative to the front end **72** of the first side wing frame **70** and the second wing ground wheel actuator **122**B can vary the height of the second wing ground wheel **120**B relative to the front end **82** of the second wing frame **80**. Working in conjunction, the ground wheel actuators **92**, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B can raise or lower the front end **52** of the tilling section **50** relative to the ground surface.

[0061] The packer actuators **225** can pivot the packer assemblies **200** around the back end **54** of the tilling section **50**. This varies the height of the packer rollers **210** connected behind the tilling section **50** relative to the back end **54** of the tilling section **50** and therefore the height of the back end **54** of the tilling section **50** relative to the ground surface.

[0062] The ground wheel actuators **92**A, **92**B, the first wing wheel actuator **122**A, and the second wing wheel actuator **122**B can be used to raise and lower the front end **52** of the tilling section **50** and the packer actuators **225** can be used to raise and lower the back end **54** of the tilling section **50**. By using these actuators in conjunction, the height of the entire tilling section **50** relative to ground surface can be varied or the angle of the tilling section **50**, front to back, can be varied.

[0063] Using all of the actuators together to lower the tilling section **50** closer to the ground surface, will increase the depth the soil engaging tools **150** penetrate the ground surface. Using all of the actuators together to raise the tilling section **50** further above the ground surface will decrease the depth the soil engaging tools **150** penetrate the ground surface.

[0064] By angling the tilling section **50**, an operator can vary the depth of penetration of the first row of ground engaging tools **150**A relative to the second row of ground engaging tools **150**B. By angling the front end **52** of the tilling section **50** downwards and the back end **54** upwards, so that the front end **52** is lower than the back end **54**, the first row of ground engaging tools **150**A can penetrate the soil deeper than the second row of ground engaging tools **150**B or even lift the second row of ground engaging tools **150**B out of the soil completely. By angling the front end **52** of the tilling section **50** upwards and the back end **54** downwards, so that the front end **52** is higher than the back end **54**, the second row of ground engaging tools **150**B can penetrate the soil deeper than the first row of ground engaging tools **150**A or even lift the first row of ground engaging tools **150**A out of the soil completely.

[0065] For example, in drier conditions an operator may not want to fully cultivate or till the soil in order to conserve moisture, but some tillage may still be required to cut field residue. The operator may choose to tilt the tilling section **50** forwards so that the first row of ground engaging tools **150**A engage with the soil, but the second row of ground engaging tools **150**B do not. Alternatively, there may be a highly vegetative area of the field and the second row of engagement tools **150**B may need to be engaged to penetrate the soil deeper. This can happen many times in a day where an operator finds they have to adjust the depth of the soil engaging tools **150** or the angle of the tilling section **50** at different parts in a field they are tilling with the cultivator **10**.

[0066] FIG. **12** illustrates a hydraulic circuit **400** for controlling the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, the second wing ground wheel actuator **122**B and the packer actuators **225**. The hydraulic circuit **400** can have: a front hydraulic circuit **410**, connected to the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B for controlling these actuators; and a back hydraulic circuit **430**, connected to the packer actuators **225** for controlling these actuators.

[0067] The front hydraulic circuit **410** can be controlled by a first control valve **412** that is operatively connected to a first input **414** in a cab of a tow vehicle (not shown) that an operator can engage to retract and extend the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B, thereby altering the height of the front end **52** of the tilling section **50**.

[0068] The back hydraulic circuit **430** can be controlled by a second control valve **432** that is operatively connected to a second input **434** in a cab of the tow vehicle (not shown) that an operator can engage to retract and extend the packer actuators **225**, thereby altering the height of the back end **54** of the tilling section **50**.

[0069] The front hydraulic circuit **410** and the back hydraulic circuit **430** are fluidly connected allowing an operator to adjust the depth of the first row of ground engaging tools **150**A and the second row of ground engaging tools **150** with either the first input **414** or the second input **434** in the cab of the tow vehicle without requiring the operator to engage the two different inputs **414**, **434** separately. As the cultivator **10** is operating at high speed being towed through a field, multiple inputs to engage can require a lot of concentration by the operator, be stressful, and lead to greater amounts of operator fatigue.

[0070] A first front hydraulic flow line **420** can be connected from the first control valve **412** to first ports **415**A,

415B of the ground wheel actuators 92A, 92B, to extend the ground wheel actuators 92A, 92B. Second front hydraulic flow lines 422, 423 can be connected from second ports 416A, 416B of the ground wheel actuators 92A, 92B to first ports 417A, 417B on the wing ground wheel actuators 122A, 122B, respectively, to route hydraulic fluid from the extending ground wheel actuators 92A, 92B to the wing ground wheel actuators 122A, 122B to extend the wing ground wheel actuators 122A, 122B. A third front hydraulic flow line 424 can be routed from second ports 418A, 418B on the wing ground wheel actuators 122A, 122B, respectively, back to the second control valve 432.

[0071] By using the first input 414 to route the hydraulic fluid the other way through the front hydraulic cylinder 410, hydraulic fluid can be routed from the first control valve 412 through the third front hydraulic flow line 424, rather than the first front hydraulic flow line 420, and to the second ports 418A, 418B of the wing ground wheel actuators 122A, 122B, the wing ground wheel actuators 122A, 122B can be retracted and the retraction of the wing ground wheel actuators 122A, 122B can force hydraulic fluid out of the first ports 417A, 417B of the wing ground wheel actuators 122A, 122B through the second front flow lines 422, 423 to the second ports 416A, 416B of the ground wheel actuators 92A, 92B, to retract the ground wheel actuators 92A, 92B.

[0072] A first back hydraulic flow line 440 can be connected from the second control valve 432 to first ports 435A, 435B of a first pair of packer actuators 225, to extend the first pair of packer actuators 225. Second back hydraulic flow lines 442, 443 can be connected from second ports 436A, 436B of the first pair of packer actuators 225 to first ports 447A, 447B on a second pair of packer actuators 225, to route hydraulic fluid forced out of the extending first pair of packer actuators 225 to the second pair of packer actuators 225 to extend the second pair of packer actuators 225. A third back hydraulic flow line 444 can be routed from second ports 448A, 448B on the second pair of packer actuators 225, back to the first control valve 412.

[0073] By using the second input 434 to route the hydraulic fluid the other way through the back hydraulic cylinder 430, hydraulic fluid can be routed from the second control valve 432 through the third back hydraulic flow line 444, rather than the first back hydraulic flow line 440, and to the second ports 448A, 448B on the second pair of packer actuators 225. This will cause the second pair of packer actuators 225 to be retracted and the retraction of the second pair of packer actuators 225 can force hydraulic fluid out of the first ports 447A, 447B on the second pair of packer actuators 225 through the second back flow lines 442, 443 to the second ports 436A, 436B of the first pair of packer actuators 225, 92B, to retract the first pair of packer actuators 225.

[0074] A first cross-over line 450 can be connected between the first front hydraulic flow line 420 and the first back hydraulic flow line 440 and a second cross-over line 452 can be connected between the third front hydraulic flow line 424 and the third back hydraulic flow line 444 to connect the front hydraulic circuit 410 and the back hydraulic circuit 430 in parallel. A restrictor 460 is shown connected inline in the second cross-over line 452, but it could also be connected inline with the first cross-over line 450.

[0075] When an operator engages the first input 414 to cause hydraulic fluid to flow through the first front hydraulic flow line 420 to the ground wheel actuators 92A, 92B, the first wing wheel actuator 122A, and the second wing wheel actuator 122B to extend these actuators, raising the front end 52 of the tilling section 50 and decreasing the depth the first row of ground engaging tools 150A engage the soil, some of this hydraulic fluid flowing through the first front hydraulic flow line 420 will try and pass through the first cross-over line 450 to the first back hydraulic flow line 440 to the packer actuators 225. However, the pressure of the hydraulic fluid in the first back hydraulic flow line 440, the second back hydraulic flow lines 442, 443 and the third back hydraulic flow line 444, caused by the restrictor 460 restricting the flow of hydraulic fluid through the second cross-over line 452 will restrict the amount of hydraulic fluid flowing that flows from the first hydraulic circuit 410 causing the packer actuators 225 to extend, but to extend slower than the ground wheel actuators 92A, 92B, the first wing wheel actuator 122A, and the second wing wheel actuator 122B.

[0076] The restrictor 460 inline with the second cross-over line 452 can have a smaller orifice through which hydraulic fluid can flow thereby reducing the flow of hydraulic fluid through this restrictor 460 or restricting it. In this manner, restrictor 460 will cause one of the connected hydraulic circuits to have a decreased flow of hydraulic fluid passing through it. If hydraulic fluid is routed through the first hydraulic circuit 410, some of this flow of hydraulic flow will flow to the connected second hydraulic circuit 430, but the restrictor 460 will cause the flow of hydraulic fluid through the second hydraulic circuit 430 to be less than the flow of hydraulic fluid through the first hydraulic circuit 410. Alternatively, if hydraulic fluid is routed through the second hydraulic circuit 430, some of this flow of hydraulic flow will flow to the connected first hydraulic circuit 410, but the restrictor 460 will cause the flow of hydraulic fluid through the first hydraulic circuit 410 to be less than the flow of hydraulic fluid through the second hydraulic circuit 430.

[0077] In this manner, the ground wheel actuators 92A, 92B the first wing ground wheel actuator 122A, and the second wing ground wheel actuator 122B will extend; raising the front end 52 of the tilling section 50. The restrictor valve 460, the first cross-over line 450, and the second cross-over line 452 can allow hydraulic fluid to flow from the first hydraulic circuit 410 to the second hydraulic circuit 430, but at a reduced amount of flow from the flow of hydraulic flow flowing through the first hydraulic circuit 410. This will in turn allow hydraulic fluid flowing through the first front hydraulic flow lines 420 to flow through the first cross-over line 450, since the hydraulic fluid in the back hydraulic circuit 430 has somewhere to flow, to the back hydraulic circuit 430 to extend the packer actuators 225 and raise the back end 54 of the tilling section 50, but at a slower rate than the extension of the ground wheel actuators 92A, the first wing ground wheel actuator 122A, and the second wing ground wheel actuator 122B because of the reduced flow of hydraulic fluid in the back hydraulic circuit 430.

[0078] The tilling section 50 can also be lowered by using the first input 414. The first input 414 can be used to route hydraulic fluid from the first control valve 412, through the third front hydraulic flow line 424, to retract the wing ground wheel actuators 122A, 122B and the ground wheel actuators 92A, 92B; lowering the front end 52 of the tilling section 50. The restrictor valve 460, the first cross-over line 450, and the second cross-over line 452 can allow hydraulic fluid to flow from the first hydraulic circuit 410 to the second hydraulic circuit 430, but at a reduced amount of flow from

the flow of hydraulic flow flowing through the first hydraulic circuit **410**. Hydraulic fluid flowing into the third back hydraulic flow line **444** from the first hydraulic circuit **410** through the second cross-over line **452**, can flow to the packer actuators **225**, retracting these packer actuators **225**, but at a slower rate than the retraction of the ground wheel actuators **92**A, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B. Hydraulic fluid that flows out of the first pair of packer actuators **225** can flow through the first cross-over line **450**, to the first front hydraulic fluid flow line **420** and back to the first control valve **412**. Retracting the packer actuators **225** will lower the back end **54** of the tilling section **50**.

[0079] In this manner, the height of the front end **52** of the tilling section **50** can first be adjusted by using the first input **412** and first control valve **414** to extend or retract the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B in the first hydraulic circuit **410**, and hydraulic fluid can be routed from the front hydraulic circuit **410** to the back hydraulic circuit **430** to cause the packer actuators **224** to perform the same action as the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B and adjust the height of the rear end **54** of the tilling section **50**, but at a slower rate because of the restrictor **460**. An operator can stop using the first input **414** at any time when a desired angle of the tilling section **50** is achieved.

[0080] The second input **434** can also be used instead of the first input **414** to adjust the height of the tilling section **50**. However, when the second input **434** is used, the height of the back end **54** of the tilling section **50** is adjusted first, followed by the front end **52** of the tilling section **50**, which is opposite from what occurs when the first input **414** is used. The second input **434** can be used by an operator to route hydraulic fluid from the second control valve **432** through the back hydraulic circuit **430** causing the packer actuators **225** to extend or retract to adjust the height of the back end **54** of the tilling section **50**. The restrictor valve **460**, the first cross-over line **450**, and the second cross-over line **452** can allow hydraulic fluid to flow from the second hydraulic circuit **430** to the first hydraulic circuit **410**, but at a reduced amount of flow from the flow of hydraulic flow flowing through the second hydraulic circuit **430**. Hydraulic fluid flowing through the first cross-over line **450** and the second cross-over line **452**, from the back hydraulic circuit **430** to the front hydraulic circuit **410** can cause the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B to perform the same action as the packer actuators **225**, but at a slower rate, to adjust the height of the front end **52** of the tilling section **50**. An operator can stop using the second input **434** at any time when a desired angle of the tilling section **50** is achieved.

[0081] Referring to FIG. **12**A, in a further aspect, a hydraulic circuit **480** for controlling the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, the second wing ground wheel actuator **122**B and the packer actuators **225** having a sequence valve **490** is shown. The hydraulic circuit **480**, like the hydraulic circuit **400**, can have: a front hydraulic circuit **410**, connected to the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B for controlling these actuators; and a back hydraulic circuit **430**, connected to the packer actuators **225** for controlling these actuators.

[0082] The first front hydraulic flow line **420** can be connected from the first control valve **412** to first ports **415**A, **415**B of the ground wheel actuators **92**A, **92**B, to extend the ground wheel actuators **92**A, **92**B. The second front hydraulic flow lines **422**, **423** can be connected from second ports **416**A, **416**B of the ground wheel actuators **92**A, **92**B to first ports **417**A, **417**B on the wing ground wheel actuators **122**A, **122**B, respectively, to route hydraulic fluid from the extending ground wheel actuators **92**A, **92**B to the wing ground wheel actuators **122**A, **122**B to extend the wing ground wheel actuators **122**A, **122**B. The third front hydraulic flow line **424** can be routed from second ports **418**A, **418**B on the wing ground wheel actuators **122**A, **122**B, respectively, back to the first control valve **412**.

[0083] The first back hydraulic flow line **440** can be connected from the second control valve **432** to first ports **435**A, **435**B of a first pair of packer actuators **225**, to extend the first pair of packer actuators **225**. The second back hydraulic flow lines **442**, **443** can be connected from second ports **436**A, **436**B of the first pair of packer actuators **225** to first ports **447**A, **447**B on a second pair of packer actuators **225**, to route hydraulic fluid forced out of the extending first pair of packer actuators **225** to the second pair of packer actuators **225** to extend the second pair of packer actuators **225**. The third back hydraulic flow line **444** can be routed from second ports **418**A, **418**B on the second pair of packer actuators **225**, back to the first control valve **412**.

[0084] The sequence valve **490** is shown connected inline with the first front hydraulic flow line **420**, the third front hydraulic flow line **424**, the first back hydraulic flow line **440**, and the third back hydraulic flow line **444**. When a set pressure is reached, which will occur after a period of time has passed and the pressure has built up in a first of the hydraulic circuits, the sequence valve **490** will open and fluidly connect the front hydraulic circuit **410** and the back hydraulic circuit **430** together.

[0085] When an operator engages the first input **414** to cause hydraulic fluid to flow through the first front hydraulic flow line **420** to the ground wheel actuators **92**A, **92**B, the first wing wheel actuator **122**A, and the second wing wheel actuator **122**B to extend these actuators, raising the front end **52** of the tilling section **50** and decreasing the depth the first row of ground engaging tools **150**A engage the soil. Initially, the sequence valve **490** will keep the front hydraulic circuit **410** and the back hydraulic circuit **430** isolated from one another (with the exception that there may be a small orifice in the sequence valve **490** to flow some hydraulic fluid between the front hydraulic circuit **410** and the back hydraulic circuit **430** before the sequence valve **490** opens). After a period of time has passed, the sequencing valve **490** can open and allow the flow of hydraulic fluid, flowing through the front hydraulic circuit **410**, to flow to the back hydraulic circuit **430** and extend the packer actuators **225**.

[0086] In this manner, the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B will first extend; raising the front end **52** of the tilling section **50**. After a period of time, typically sufficient for the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B to fully extend, the sequencing valve **490** can fully open,

routing pressurized hydraulic fluid from the front hydraulic circuit **410** to the back hydraulic circuit **430** to extend the packer actuators **225** and raise the back end **54** of the tilling section **50**. If the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B are fully extended, most, if not all of the hydraulic flow, can flow through the back hydraulic circuit **430**, until the packer actuators **225** are also fully extended.

[0087] The tilling section **50** can also be lowered by using the first input **414**. The first input **414** can be used to route hydraulic fluid from the first control valve **412**, through the third front hydraulic flow line **424**, to retract the wing ground wheel actuators **122**A, **122**B and the ground wheel actuators **92**A, **92**B; lowering the front end **52** of the tilling section **50**. Initially, the sequencing valve **490** will prevent a substantial amount of hydraulic fluid from flowing from the front hydraulic circuit **410** to the back hydraulic circuit **430**. However, once a period of time has passed, the sequence valve **490** can open which will route hydraulic fluid from the from the front hydraulic circuit **410** to the back hydraulic circuit **430** and to the packer actuators **225**; retracting these packer actuators **225**. Retracting the packer actuators **225** will lower the back end **54** of the tilling section **50**.

[0088] In this manner, the height of the front end **52** of the tilling section **50** can first be adjusted by using the first input **414** and first control valve **412** to extend or retract the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B, then, when the sequence valve **490** is opened, hydraulic fluid can be routed from the front hydraulic circuit **410** to the back hydraulic circuit **430** to cause the packer actuators **225** to perform the same action as the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B and adjust the height of the rear end **54** of the tilling section **50**. An operator can stop using the first input **414** at any time when a desired angle of the tilling section **50** is achieved.

[0089] The second input **434** can also be used instead of the first input **414** to adjust the height of the tilling section **50**. However, when the second input **434** is used, the height of the back end **54** of the tilling section **50** is adjusted first, followed by the front end **52** of the tilling section **50**, which is opposite from what occurs when the first input **414** is used. The second input **434** can be used by an operator to route hydraulic fluid from the second control valve **432** through the back hydraulic circuit **430** causing the packer actuators **225** to extend or retract to adjust the height of the back end **54** of the tilling section **50**. Initially, the sequence valve **490** will prevent a significant flow of hydraulic fluid between the back hydraulic circuit **430** and the front hydraulic circuit **410** (with the exception that there may be a small orifice to allow a slight flow of hydraulic fluid through the sequence valve **490** before the sequence valve **490** opens). After a period of time, the sequence valve **490** can open, allowing hydraulic fluid to flow from the back hydraulic circuit **430** to the front hydraulic circuit **410** to cause the ground wheel actuators **92**A, **92**B, the first wing ground wheel actuator **122**A, and the second wing ground wheel actuator **122**B to perform the same action as the packer actuators **225**, and adjust the height of the front end **52** of the tilling section **50**. An operator can stop using the second input **434** at any time when a desired angle of the tilling section **50** is achieved.

[0090] Referring again to FIGS. **1-3**, the cultivator **10** requires precise contouring to engage the soil in a field and prepare a seed bed. To engage the soil, the cultivator **10** will typically be quite heavy, and especially the tilling section **50**, with the weight being used to ensure the ground engaging tools **150** penetrate into the soil and remain engaged in the soil as the cultivator **10** is pulled through the field and encounters different amounts of vegetation and soil conditions. However, as the cultivator **10** is pulled through a field, it can encounter an immovable objects, such as a stone(s) or rough terrain. The tilling section **50**, and specifically the rear frame **60**, the first wing frame **70**, or the second wing frame **80**, supporting the packing assemblies **200** and having the packer rollers **210** that hit the immovable object or rough terrain can receive a substantial shock load to it's structure. Incorporating a suspension between the packing assemblies **200** and the tilling section **50** can reduce this shock load, reducing or preventing damage being inflicted and lengthen the life of the cultivator **10**.

[0091] Referring again to FIGS. **4** and **5**, suspension elements **250** can be incorporated between the tilling section **50** and the packing assemblies **200** to absorb a shock load caused by a packer roller **210** on a packing assembly **200** hitting an immovable object or rough terrain. Referring to FIG. **13**, the suspension element **250** can include: a compression element **252**, such as a rubber compression element, that dampens a compression load; a rod **254** that holds the compression element **252**; a front plate **256** to secure a first side of the compression element **252**, a back plate **258** to secure a second side of the compression element **252**, and an adjustment nut **259** to position the front plate **256** against the first side of the compression element **252**.

[0092] Referring to FIG. **14**, the bracket assembly **220** can include: the packer actuator **225**, the packer bracket **230**; the frame bracket **232**; an intermediate link **240**; the roller linkage **249** and a suspension element **250**. Rather than the packer actuator **225** being connected directly between the tilling section **50** and the bracket assembly **220**, the suspension element **250** and the intermediate link **240** connect the packer actuator **225** to the tilling section **50** of the cultivator **10**. The suspension element **250** is connected between the frame bracket **232** on the tilling section **50** and the intermediate link **240** and the packer actuator **225** is connected between intermediate link **240** and the packer bracket **230** on the bracket assembly **220**.

[0093] The intermediate link **240** is pivotally connected to the frame bracket **232** at the first end **242** of the intermediate link **240** so that the intermediate link **240** can pivot around the first end **242** of the intermediate link **240** relative to the frame bracket **232**.

[0094] A first end of the packer actuator **225** can be connected to the intermediate link **240**, a first distance from the first end **242** of the intermediate link **240**, and a second end of the packer actuator **225** can be connected to the packer bracket **230**.

[0095] The suspension element **250** can be connected at a first end to the frame bracket **232** and at a second end to the intermediate link **240**, a second distance from the first end **242** of the intermediate link **240**. In one aspect, the first distance the first end of the packer actuator **225** is connected from the first end **242** of the intermediate link **240** can be less

than the second distance the second end of the suspension element **250** is connected from the first end **242** of the intermediate link **240**.

[0096] When the cultivator **10** is in the field position and being pulled through a field, the packer actuator **225** is pressurized to keep the packer roller **210** at a desired height relative to back end **54** of the tilling section **50**. This means the packer actuator **225** is pressurized to keep it from retracting and can act as a solid member. When the packer roller **210** hits an unmovable object or rough terrain that jars the packer roller **210**, the bracket assembly **220** will try to pivot upwards around the back end **54** of the tilling section **50** and the force of this shock will move through the packer bracket **230** and the packer actuator **225**, which will be pressurized to keep it from retracting, to the intermediate link **240**. This shock can pivot the intermediate link **240** around its first end **242**, which is pivotally connected to the frame bracket **232**. The suspension element **250** connected between the intermediate link **240** and the frame bracket **232** will be compressed by the intermediate link **24**. The shock force transmitted through the packer actuator **225** will be transmitted by the intermediate link **240** to the suspension element **250** where some or all of this force can be absorbed by the compression element **252** of the suspension element **250**, rather than being transmitted directly to the frame in the tilling section **50**.

[0097] The intermediate link **240** allows the suspension element **250** to be aligned so that the forces the suspension element **250** and the compression element **252** is subjected to from the packer actuator **225** and the pivoting of the bracket assembly **200** are substantially linear. In this manner, the suspension element **250**, and specifically the compression element **252**, will be subjected to a substantially linear (or compression) load.

[0098] The compression element **252** is provided on the rod **254** and the rod **254** is connected between the frame bracket **232** and the intermediate link **240**. The back plate **258** can be provided proximate or even as part of the frame bracket **232**. The compression element **252** is positioned on the rod **254** adjacent to the back plate **258**. The front plate **256** can be positioned against the other side of the compression element **252** and the adjustment nut **259** can be used to set the position of the front plate **256** against the compression element **252**. The adjustment nut **259** can be used to tune the suspension element **250** and adjust the linear load by pre-compressing the compression element **252** to maintain a desired level of the packer assembly **200**.

[0099] The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous changes and modifications will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all such suitable changes or modifications in structure or operation which may be resorted to are intended to fall within the scope of the claimed invention.

1. A cultivator comprising:

a hitch assembly connectable to a tow vehicle;

a tilling section having a front end and a back end;

a plurality of ground engaging tools connected to and extending below the tilling section;

a packer assembly pivotally connected to the back end of the tilling section and having a packer roller, the packer roller vertically moveable relative to a back end of the tilling section;

a packer actuator connected to the packer assembly to raise and lower the packer roller; and

a suspension element operably connected between the packer actuator and the tilling section, the suspension element having a compression element to absorb a compression load.

2. The cultivator of claim **1** further comprising:

a frame bracket connected to the tilling section and extending upwards, a first end of the suspension element connected to the frame bracket;

an intermediate link pivotally connected to the frame bracket, a second end of the suspension element connected to the intermediate link; and

a packer bracket connected to the packer assembly and extending upwards,

wherein the packer actuator is connected at a first end to the intermediate link and a second end of the packer actuator is connected to the packer bracket.

3. The cultivator of claim **2** wherein the first end of the packer actuator is connected a first distance from the first end of the intermediate link, and wherein the second end of the suspension element is connected a second distance from the first end of the intermediate link.

4. The cultivator of claim **3** wherein the first distance is less than the second distance.

5. The cultivator of claim **2** wherein the suspension element is oriented substantially horizontal.

6. The cultivator of claim **1** wherein the suspension element comprises a rubber compression element.

7. The cultivator of claim **6** wherein the suspension element further comprises: a rod holding the rubber compression element; a front plate to secure a first side of the compression element; and, a back plate to secure a second side of the compression element.

8. The cultivator of claim **7** wherein the suspension element further comprises an adjustment nut to position the front plate against the first side of the compression element.

9. A bracket assembly for pivoting a packer assembly around a back end of a tilling section of a cultivator, the bracket assembly comprising:

a packer bracket connected to the packer assembly and extending upwards;

a frame bracket connected to the tilling section and extending upwards;

an intermediate link pivotally connected to the frame bracket;

a packer actuator connected at a first end to the intermediate link and a second end of the packer actuator connected to the packer bracket;

a suspension element comprising a compression element to absorb a compression load, a first end of the suspension element connected to the frame bracket and a second end of the suspension element connected to the intermediate link.

10. The bracket assembly of claim **9** wherein the first end of the packer actuator is connected a first distance from the first end of the intermediate link, and wherein the second end of the suspension element is connected a second distance from the first end of the intermediate link.

11. The bracket assembly of claim **10** wherein the first distance is less than the second distance.

12. The bracket assembly of claim **9** wherein the suspension element comprises a rubber compression element.

13. The bracket assembly of claim **12** wherein the suspension element further comprises: a rod holding the rubber compression element; a front plate to secure a first side of the compression element; and, a back plate to secure a second side of the compression element.

14. The bracket assembly of claim **13** wherein the suspension element further comprises an adjustment nut to position the front plate against the first side of the compression element.

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