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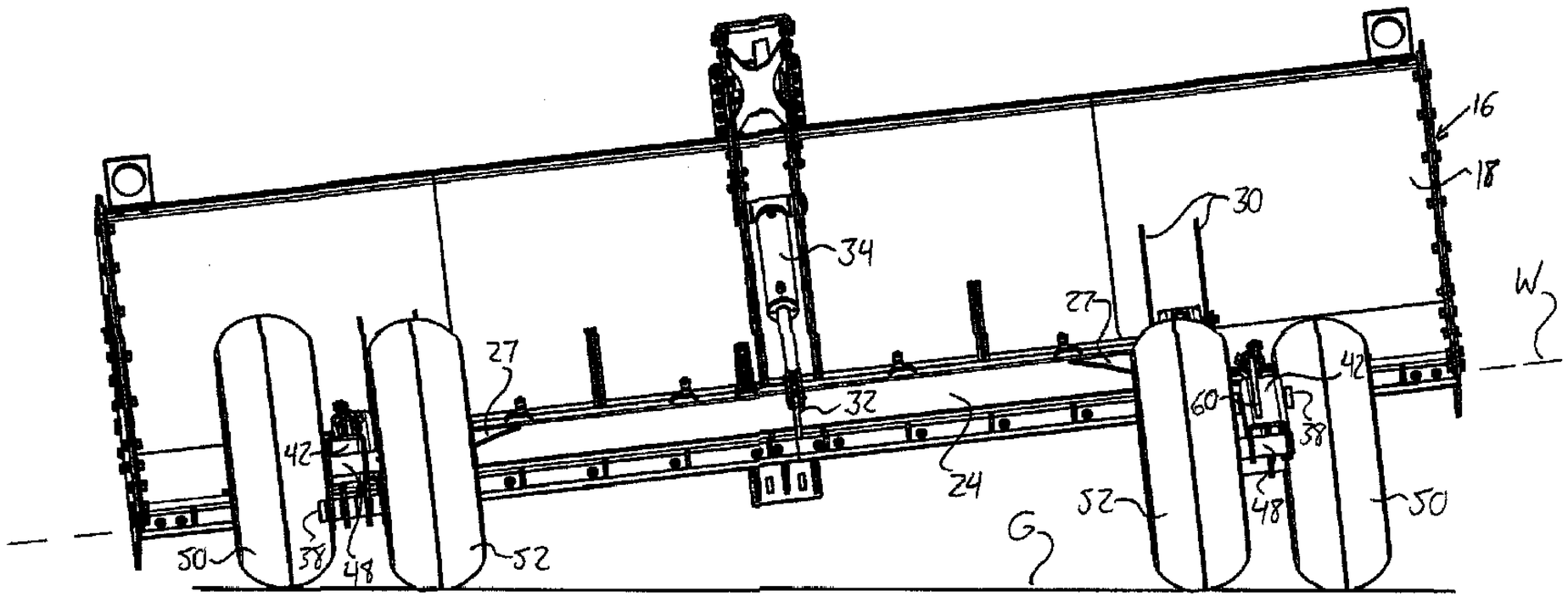
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(54) Titre : POUTRES OSCILLANTES SEPAREES SERVANT A MONTER ET BAISSER LES COTES RESPECTIFS D~UN VEHICULE OU D~UN CHASSIS D'ACCESSOIRE AFIN DE CONTROLER L'ANGLE D~INCLINAISON OU LA HAUTEUR DUDIT VEHICULE OU CHASSI

(54) Title: SPLIT WALKING BEAMS FOR RAISING AND LOWERING RESPECTIVE SIDES OF A VEHICLE OR IMPLEMENT FRAME TO CONTROL A TILT ANGLE OR HEIGHT THEREOF



(57) Abrégé/Abstract:
Vehicles or implements feature walking beam assemblies each having a front wheel and rear wheel carded adjacent opposite ends of the walking beam on opposite sides of a pivot point thereof. The conventional single beam is replaced by a split beam arrangement in which front and rear beams are pivotal relative to one another by an actuator, whereby changing the angle between the front and rear beams lifts or lowers the main pivot of the walking beam in order to adjust the height of the respective side of the vehicle frame. The split walking beam can be used to adjust the tilt angle of a scraper blade or other ground working arrangement in a land leveler or other earth working machine.

ABSTRACT

Vehicles or implements feature walking beam assemblies each having a front wheel and rear wheel carried adjacent opposite ends of the walking beam on opposite sides of a pivot point thereof. The conventional single beam is replaced by a split beam arrangement in which front and rear beams are pivotal relative to one another by an actuator, whereby changing the angle between the front and rear beams lifts or lowers the main pivot of the walking beam in order to adjust the height of the respective side of the vehicle frame. The split walking beam can be used to adjust the tilt angle of a scraper blade or other ground working arrangement in a land leveler or other earth working machine.

SPLIT WALKING BEAMS FOR RAISING AND LOWERING RESPECTIVE SIDES OF A VEHICLE OR IMPLEMENT FRAME TO CONTROL A TILT ANGLE OR HEIGHT THEREOF

FIELD OF THE INVENTION

The present invention relates generally to vehicles or implements employing walking beam assemblies each having a front wheel and rear wheel carried adjacent opposite ends of the walking beam on opposite sides of a pivot point thereof, and more particularly to a split walking beam assembly in which the conventional single-beam is replaced is replaced with a multi-piece beam assembly with front and rear beams that are pivotal relative to one another by an actuator, whereby changing the angle between the front and rear beams lifts or lowers the main pivot of the walking beam to adjust the height of the respective side of the vehicle frame.

BACKGROUND

It has previously been proposed in the prior art to provide a towed ground leveling or ground scraping implement in which a tilt angle of the scraper blade about a longitudinal fore-aft axis of the implement is adjustable by raising and lowering a side of the frame at an outboard location spaced laterally outward from a longitudinal mid-plane in which the fore-aft axis is located.

Such an implement is disclosed in U.S. Patent No. 4,055,222, in which a single wheel is provided at each side of a frame that is situated behind a scraper blade carried on a pull tongue of the towable implement. On one side of the frame, the axle of the respective wheel is attached to an inner one of a pair of telescopically nested tubes that stand upward from the frame, and an upright hydraulic cylinder has its respective ends coupled to the vehicle frame and the top end of the inner tube,

whereby extending the cylinder raises the inner tube in order to lift the respective wheel relative to the frame, thereby lowering the respective side of the frame to tilt the respective end of the blade downwardly toward the ground relative to the opposing end of the blade.

U.S. Patent 4,189,009 discloses another tilt-adjustable scraper with a single wheel on each side of the frame. In this reference, a single axle carrying the two wheels is pivotally coupled to a rear end of a frame disposed behind the scraper blade for relative pivoting between the axle and frame on a pivot axis residing in the central fore-aft longitudinal plane of the implement. A hydraulic cylinder has one end coupled to an upright bracket at the center of the axle, and the other end coupled to an outboard point on the frame, whereby extension and collapse of the cylinder tilts controls a tilt angle of the axle relative to the frame and blade in order to adjust the blade angle relative to the ground.

U.S. Patent 2,734,293 also discloses another example of a tilt-adjustable scraper with a single wheel at each end of an axle that is pivotally coupled to the frame for hydraulically actuated movement between the frame and axle about a tilt axis.

U.S. Patent Application Publication 2012/0311894 discloses another example of a tilt-adjustable scraper with a single wheel at each end of an axle or subframe that is pivotally coupled to the main frame for hydraulically actuated movement relative thereto in order to set the blade angle.

A potential drawback of the forgoing prior art is that, because the towed frame is carried only by a single wheel on each side of the frame, a rock or other ground protrusion in the path of either wheel will raise the frame and blade by the full height of the rock as the wheel rides overtop of same. It is known that the use of

walking beam axles can reduce the effective of such ground deviations, where front and rear wheels carried at respective ends of a beam pivotally coupled to the frame can 'walk' over such an obstacle, as the front wheel can ride at least partially over the obstruction before the rear wheel reaches the obstruction.

However, the prior art provides no teaching or suggestion of how to implement a walking beam in a setting in which the wheel position is also to be controlled relative to the frame for use in controlling a tilt angle of the blade.

The forgoing prior art implements each move at least one of the wheels relative to the frame of the implement in order change the tilt angle of the frame to which the blade is attached. In each of the above cases, the blade and frame are pivotally connected for relative movement about a transverse axis to raise and lower the blade relative to the frame, but the blade and frame remain in a matching orientation with one another relative to the tilt axis.

Another group of adjustable-tilt scrapers have fixed wheel axles that do not move relative to the frame, and instead employ a mechanism for tilting the blade relative to the frame. Examples of such scrapers are disclosed in U.S. Patents 2,284,550; 2,520,266; and 2,883,777.

In addition to the forgoing references concerning towed scraper implements, Applicant is also aware of U.S. Patent Application Publication 2012/0239258, teaches a self-propelled grader which employs a gyroscope together with blade slope and blade tilt sensors to monitor the blade position and automatically adjust same.

As these references adjustment the blade relative to the frame instead of adjusting the wheels relative to the frame, they also lack any teaching or suggestion of how to combine the advantages of a walking beam arrangement into a

blade-tilting arrangement relying on controlled movement between the frame and wheels.

Applicant has developed an adjustable height walking beam solution that can be employed on the frame of a scraper implement to address the identified shortcoming of the prior art, and that can also be employed to advantageous effect on other vehicle or implement types.

SUMMARY OF THE INVENTION

According to one aspect of the invention there is provided a vehicle or implement comprising:

a frame situated having opposing sides disposed on opposing sides of a longitudinal plane that runs in a longitudinal direction of the vehicle or implement;

a pair of wheel assemblies, each being attached to the frame adjacent a respective one of the opposing sides thereof so as to reside on and rollably carry a respective one of the opposing sides of the longitudinal plane, at least one of the wheel assemblies comprising:

a split walking beam assembly pivotally coupled to the frame for pivotal movement of the split walking beam assembly about a first walking beam pivot axis lying transversely to the longitudinal direction, the split walking beam assembly comprising:

a front beam having front and rear ends spaced apart in the longitudinal direction; and

a rear beam having forward and rearward ends spaced apart in the longitudinal direction, the front end of the front beam being situated forwardly of the forward end of the rear beam in the longitudinal direction, the rearward end of the rear beam being situated rearwardly of the rear end of the front

beam in the longitudinal direction, the front and rear beams being coupled together adjacent the rear and forward ends thereof, and the rear beam being pivotal relative to the front beam about a second walking beam pivot axis lying transversely of the longitudinal direction;

a front wheel rotatably coupled to the front beam adjacent the front end thereof;

a rear wheel rotatably coupled to the rear beam adjacent the rearward end thereof; and

a wheel assembly actuator coupled between the front and rear beams of the split walking beam assembly and operable to pivot the front and rear beams relative to one another to adjust an angle measured between the front and rear beams at an underside thereof, whereby an increase of the angle lowers the respective side of the frame and respective lateral end of the blade and a decrease of the angle raises the respective side of the frame and the respective lateral end of the blade.

In one embodiment, there is provided:

a tongue having fore and aft ends spaced apart in the longitudinal direction;

a hitch connector at the fore end of said tongue for coupling of the hitch connector to a hitch of a towing vehicle;

a ground working arrangement coupled to the tongue adjacent the rear end thereof with opposing lateral ends of the ground working arrangement disposed on opposing sides of the longitudinal plane of the vehicle or implement at outboard positions spaced laterally from said longitudinal plane;

wherein the frame is situated behind the ground working arrangement in

the longitudinal direction, whereby increasing the angle of each wheel assembly lowers the respective lateral end of the ground working arrangement and decreasing the angle raises the respective lateral end of the blade of the ground working arrangement.

Preferably there is provided:

a pivotal connection between the frame and the ground working arrangement that allows relative pivoting between the frame and the ground working arrangement about a pitch axis that lies in the transverse direction; and

a pitch actuator coupled between the frame and the blade and operable to tilt the ground working arrangement relative to the frame about the pitch axis.

Preferably the frame comprises a cross-member lying transversely to the longitudinal plane and a pair of rearward reaching frame members extending therefrom in the longitudinal direction adjacent opposing ends of the cross-member on the opposing sides of the longitudinal plane, each rearward reaching frame member having a respective one of the wheel assemblies connected thereto and split walking beam assembly being pivotally connected to the respective rearward reaching frame member.

Preferably the rearward reaching frame members are respectively connected to the cross-member at opposing ends thereof, and each extend forwardly past the cross-member to attach to the ground working arrangement.

In one embodiment, the ground working arrangement comprises a scraper blade lying transversely of the longitudinal plane with opposing ends of the blade defining the lateral ends of the ground working arrangement on the opposing sides of the longitudinal plane.

Preferably the wheel assemblies both comprise a respective walking

beam assembly, and the walking beam assemblies are arranged to be adjustable into different respective angles, thereby adjusting an angular position of the frame about a roll axis that extends in the longitudinal direction.

Preferably there is provided a control system operable to control movement of the wheel assembly actuators.

Preferably the control system is arranged to automatically extend one of the walking beam actuators while collapsing the other, thereby increasing the angle between the front and rear beams of one walking beam assembly while decreasing the angle between the front and rear beams of the other walking beam assembly so as to raise one side of the frame while lowering the other side of the frame.

Preferably, each walking beam actuator comprises a hydraulic cylinder with a respective extension port and respective retraction port;

the control system comprises a four-way, three-position, spring centered directional valve with a pressure port for coupling to the output of a hydraulic pump, a return port for coupling with a hydraulic fluid reservoir, and a pair of output ports connected to either the extension ports or the retraction ports of the walking beam actuators; and

a hydraulic connection line coupling together the other of the extension ports or the retraction ports of the walking beam actuators.

Preferably the directional valve is a double solenoid directional valve arranged to use electronic signals to control a position of the valve.

Preferably there is provided a monitoring system arranged to monitor an orientation of the frame about a longitudinal axis, and linked to the control system to automatically control the walking beam actuators and adjust the orientation of the frame.

Preferably the first walking beam pivot axis and second walking beam pivot axis of each wheel assembly are coincident with one another.

Preferably the first and second beams of each wheel assembly both pivot about the second walking beam pivot axis.

According to a second aspect of the invention, there is provided a method of providing tilt or height adjustment capabilities to a vehicle or implement that is at least partially supported by a pair of walking beam wheel assemblies are disposed on opposing sides of a longitudinal plane of the vehicle or implement and each feature front and rear wheels that are respectively mounted adjacent front and rear ends a single walking beam that is pivotally coupled to a frame of the vehicle or implement at a longitudinally intermediate location on the walking beam for pivoting of the walking beam about a walking beam pivot axis lying transversely to the central longitudinal plane, the method comprising:

replacing at least one walking beam assembly with a respective split walking beam assembly that is pivotally coupled to the frame for movement about the same walking beam pivot axis, and that comprises:

a front beam having front and rear ends spaced apart in a longitudinal direction in which the central longitudinal plane extends; and

a rear beam having forward and rearward ends spaced apart in the longitudinal direction, the front end of the front beam being situated forwardly of the forward end of the rear beam in the longitudinal direction, the rearward end of the rear beam being situated rearwardly of the rear end of the front beam in the longitudinal direction, the front and rear beams being coupled together adjacent the rear and forward ends thereof, and the rear beam being pivotal relative to the front beam about a second pivot axis lying transversely of the longitudinal direction;

a front wheel rotatably coupled to the front beam adjacent the front end thereof;

a rear wheel rotatably coupled to the rear beam adjacent the rearward end thereof; and

a wheel assembly actuator coupled between the front and rear beams of the split walking beam assembly and operable to pivot the front and rear beams relative to one another to adjust an angle measured between the front and rear beams at an underside thereof, whereby, with the front and rear wheels on a ground surface, an increase of the angle surface lowers the respective side of the frame and respective lateral end of the blade and a decrease of the angle raises the respective side of the frame and the respective lateral end of the blade.

The method may include replacing each walking beam assembly with a respective split walking beam assembly, and further comprising equipping the vehicle or implement with a control system operable to control movement of the wheel assembly actuators.

The control system may be arranged to extend one of the walking beam actuators while collapsing the other, thereby increasing the angle between the front and rear beams of one walking beam assembly while decreasing the angle between the front and rear beams of the other walking beam assembly so as to raise one side of the frame while lowering the other side of the frame.

In such instance, the walking beam actuator may comprise a hydraulic cylinder with a respective extension port and respective retraction port and the control system may comprise a four-way, three-position, spring centered directional valve, and the method may comprise coupling a pressure port of the directional valve to an output of a hydraulic pump, coupling a return port of the directional valve with a

hydraulic fluid reservoir, coupling output ports of the directional valve to either the extension ports or the retraction ports of the walking beam actuators, and coupling the walking beam actuators together at the other of the extension ports or the retractions ports.

The directional valve may be a double solenoid directional valve arranged to use electronic signals to control a position of the valve.

The method may include equipping the vehicle or implement with a tilt monitoring system arranged to monitor an angular position of the frame about a roll axis that extends in the longitudinal direction, and connecting the tilt monitoring system to the control system to automatically control the walking beam actuators and adjust the angular position.

Preferably the second pivot axis of each split walking beam assembly is coincident with the respective walking beam pivot axis.

Preferably the first and second beams of each split walking beam assembly both pivot about the second pivot axis.

According to a third aspect of the invention, there is provided a towable ground working implement comprising:

a tongue having fore and aft ends spaced apart in a longitudinal direction;

a hitch connector at the fore end of said tongue for coupling of the hitch connector to a hitch of a towing vehicle;

a scraper blade coupled to the tongue adjacent the rear end thereof and lying transversely to the longitudinal direction so as to place opposite lateral ends of the blade on opposing sides of a central longitudinal plane of the implement at outboard positions spaced laterally from said central longitudinal plane;

a frame situated behind the blade in the longitudinal direction with opposite sides of the frame disposed on the opposing sides of the longitudinal plane;

a pair of wheel assemblies, each being attached to the frame adjacent a respective one of the opposing sides thereof so as to reside on a respective one of the opposing sides of the longitudinal plane, at least one of the wheel assemblies comprising:

a split walking beam assembly pivotally coupled to the frame for pivotal movement of the split walking about a first walking beam pivot axis lying transversely to the longitudinal direction, the split walking beam assembly comprising:

a front beam having front and rear ends spaced apart in the longitudinal direction; and

a rear beam having forward and rearward ends spaced apart in the longitudinal direction, the front end of the front beam being situated forwardly of the forward end of the rear beam in the longitudinal direction, the rearward end of the rear beam being situated rearwardly of the rear end of the front beam in the longitudinal direction, the front and rear beams being coupled together adjacent the rear and forward ends thereof, and the beam being pivotal relative to the front beam about a second walking beam pivot axis lying transversely of the longitudinal direction;

a front wheel rotatably coupled to the front beam adjacent the front end thereof;

a rear wheel rotatably coupled to the rear beam adjacent the rearward end thereof; and

a wheel assembly actuator coupled between the front and rear beams of the split walking beam assembly and operable to pivot the front and rear

beams relative to one another to adjust an angle measured between the front and rear beams at an underside thereof, whereby, with the front and rear wheels on a ground surface, an increase of the angle lowers the respective side of the frame and respective lateral end of the blade and a decrease of the angle raises the respective side of the frame and the respective lateral end of the blade, thereby adjusting an angular tilt position of the blade about a roll axis that extends in the longitudinal direction.

BRIEF DESCRIPTION OF THE DRAWINGS

One embodiment of the invention will now be described in conjunction with the accompanying drawings in which:

Figure 1A is an overhead plan view of a land leveler of the present invention with a blade thereof residing in a level horizontal orientation parallel to the ground.

Figure 1B is left side elevational view of the land leveler of Figure 1A.

Figure 1C is a rear elevational view of the land leveler of Figure 1A.

Figure 2A is an overhead plan view of the land leveler of figure 1A with the blade residing in a tilted orientation in which the end of the blade on a left side of the machine is lowered into closer proximity to the ground than the opposing end of the blade on the right side of the machine.

Figure 2B is a right side elevational view of the land leveler of Figure 2A.

Figure 2C is a left side elevational view of the land leveler of Figure 2A.

Figure 2D is a rear elevational view of the land leveler of Figure 2A.

Figure 2E is a partial rear perspective view of the land leveler of Figure

2A from the right side thereof.

Figure 2F is a partial rear perspective view of the land leveler of Figure 2A from the left side thereof.

Figure 3A is a schematic overhead plan view illustrating a hydraulic control system for controlling the tilt angle of the land leveler of Figure 1A.

Figure 3B is side elevational view of select components of the hydraulic control system of Figure 3A.

Figure 3C is a schematic perspective view of the hydraulic control system components of Figure 3B.

Figure 3D is another schematic perspective view of the hydraulic control system components of Figure 3B.

Figure 4 is a closeup perspective view of a split walking beam tandem wheel assembly of the land leveler of Figure 1A with wheels thereof omitted for illustrative purposes.

Figure 5 is a perspective view of a conventional walking beam tandem wheel assembly for which the split walking beam tandem wheels assembly of Figure 4 may be substituted in order to provide a tilt or height adjustment functionality to a vehicle or implement previously lacking same.

Figures 6A through 6E are various views of a directional valve and manifold assembly of the hydraulic control system of Figure 3.

In the drawings like characters of reference indicate corresponding parts in the different figures.

DETAILED DESCRIPTION

Figures 1A through 2D illustrate a towed land leveler implement 10 of the present invention. The implement 10 features a pull tongue 12 equipped with a

hitch connector 14 at a fore end of the tongue for coupling to the hitch of a tow vehicle for pulling of the implement along the ground in forward working direction F. A box blade assembly 16 is rigidly attached to the tongue and features a rear blade 18 spanning transversely of the tongue 12 in a position therebeneath adjacent an aft end 18 thereof that lies opposite to the fore end at which the hitch connector 14 is mounted.

When the implement is in a level-blade configuration holding the box blade parallel to the underlying ground, the pull tongue 12 lies in a vertically oriented central longitudinal plane of the implement. The rear blade 18 spans from one side of the central longitudinal plane to the other in an orientation perpendicular thereto, thus placing each lateral end of the rear blade 18 at an outboard location horizontally outward from the tongue 12. At each end of the blade 18, a respective planar end wall 20 projects forwardly therefrom in a plane parallel to the tongue 12. Box blade structures of this type are known in conventional land leveler designs, and thus are not described herein in further detail. As is also well known in the art, the tongue 12 extends forwardly from the box blade assembly 16 to the hitch connector 14 at the fore end of the tongue, which therefore defines the forward or leading end of the overall machine by which it is pulled by a tractor or other suitable tow vehicle.

With reference to Figure 1A, a frame assembly 22 resides behind the blade 18 so as to trail the same during pulling of the implement by a tow vehicle. The frame 22 features a main cross-member 24 lying parallel to the blade 18 and perpendicularly transverse to the tongue 12. The cross-member 24 spans across the central longitudinal plane of the machine to place each of the cross-member 24 at an outboard location spaced laterally outward from the central longitudinal plane, just like the blade 18. The length of the cross-member between these two ends is parallel to,

but shorter than, the length of the blade 18, whereby each end of the cross-member 24 lies inboard of the respective end wall 20 of the box blade assembly 16. A respective longitudinal frame member 26 is attached to the main cross-beam at each end thereof, lies perpendicular to the cross-member 24, and extends both forwardly and rearwardly therefrom. As best seen in the plan views of Figures 1A and 2A, the relative positioning of the cross-member 24 and each longitudinal member 26 fixed thereto may be reinforced by a respective gusset plate 27.

The forward end of each longitudinal frame member 26 features a pivotal connection 28 to the blade 18, which enables pivoting of the frame assembly 22 relative to the box blade assembly 16 about a pivot axis that lies perpendicularly transverse to the tongue and parallel to the blade 18 and the main cross-member 24. The pivotal connections 28 of the two longitudinal frame members 26 to the blade 18 share this same pivot axis, which due to its orientation, may be considered to be a pitch axis P of the implement 10. As perhaps best shown in Figures 2E and 2F, each of these pivotal connections 28 may be formed by pinning of the respective longitudinal frame member 26 to a respective pair of rearwardly extending lugs 30 on the rear face of the blade 18. A central lug 32 is fixed on the main cross-beam 24 and projects rearwardly therefrom at a midpoint therealong, and one end of a hydraulic cylinder actuator 34 is pivotally coupled to the lug 32 by a pivot pin whose pivot axis is parallel to the pitch axis P. The opposing end of the hydraulic cylinder actuator 34 is likewise pivotally pinned to a pair of mounting brackets 36 on the rear of the blade 18, as perhaps best shown in Figure 2E. Extension and retraction of the actuator 34 thus pivots box blade assembly 16 and attached tongue 12 relative to the frame 12 about the pitch axis P, for example in order to lower the blade 18 down into engagement with the ground to perform a ground-working, earth-moving operation, or to raise the

blade out of contact with the ground for transport of the machine.

Each longitudinal frame member 26 defines a respective side of the frame 22 on a respective one of the two opposing sides of the central longitudinal plane of the machine. Near the rearward end of each longitudinal frame member 26 that lies distally of the cross-member 24, a pivot pin or stub shaft 38 passes transversely through the longitudinal frame member 26 in a direction parallel to the pitch axis P, and projects outwardly from the longitudinal frame member 26 through front and rear beams 40, 42 of a respective split walking beam assembly 44 in order to pivotally connect same to the frame 22. Like a conventional walking beam, this split walking beam assembly 44 rotatably supports a pair of wheel axles 46, 48 near its opposing ends, so that two wheels 50, 52 mounted on these axles are rotatably carried on the walking beam in tandem positions relative to one another. The wheel axles 46, 48 lie parallel to the pivot pin or stub shaft 38. However, in the present invention, instead of the front wheel 50 and rear wheel 52 being rotatably supported on the same rigid beam, the front wheel 50 is rotatably carried on the front beam 40 that spans a front half of the overall walking beam assembly 44, and the rear wheel 52 is rotatably carried on a rear beam 42 that spans a rear half of the overall walking beam assembly 44. In the fore-aft longitudinal direction of the implement, the front end of the front beam is spaced forwardly of the forward end of the rear beam in the long, the rearward end of the rear beam is spaced rearwardly of the rear end of the front beam, and the front and rear beam overlap one another at the forward end of the rear beam and rear end of the front beam.

In each split walking beam assembly 44, the front and rear beams 40, 42 lie side-by-side with one another a short distance to the outside of the respective longitudinal frame member 26, and each feature a respective upright lug 58, 60

projecting upward from the topside of the beam 40, 42. A respective hydraulic cylinder actuator 62 of each walking beam assembly 44 has its opposing ends pivotally coupled to the front and rear top lugs 58, 60 by pivot pins whose axes lie parallel to the pitch axis P of the machine.

The stub shaft or pivot pin 38 passing through the respective longitudinal frame member 26 also passes through both the front and rear beams 40, 42 of the respective walking beam assembly 44 at an area where the two beams 40, 42 overlap in the longitudinal direction of the machine. The stub shaft or pivot pin 38 thus defines a main walking beam pivot axis W on which the collective walking beam assembly is pivotal relative to the frame 22, and also defines a coincident second walking beam pivot axis about which the front and rear beams 40, 42 are pivotable relative to one another by extension and retraction of the walking beam actuator 62. This direct coupling together of the front and rear wheel carrying beams of the walking beam assembly by the same shaft or pin that couples the walking beam assembly to the frame 22 reduces the number of parts by avoiding an intermediary between the front and rear beams on which the front and rear wheels are mounted and sharing the same pivot point for both the relative pivoting between the front and rear beams and the pivoting of the overall walking beam assembly relative to the frame.

When the length of the walking beam actuator 62 is maintained, an angle α measured between the front and rear beams 40, 42 about the axis of the stub shaft or pivot pin 38 walking beam assembly 44 is likewise maintained, and the walking beam assembly acts as a conventional walking beam in which the positions of the two wheels 50, 52 are stationary relative to one another. On the other hand, each side of the frame 22 can be raised and lowered relative to the ground G by varying the angle α between the front and rear beams 40, 42 through extension and retraction of

the respective walking beam actuator 62. Particularly, if angle α is measured between the undersides of the two beams 40, 42, then extending the length of the actuator 62 pushes apart the front and rear lugs 58, 60 at the topsides of the beams 40, 42, thus forcing the undersides of the two beams toward one another and reducing the angle α. This pushes each of the two wheels 50, 52 downwardly against the ground G on an arcuate path about the stub shaft or pivot pin 38, thereby lifting the respective side of the frame 22 upwardly away from the ground G. Conversely, retracting the length of the actuator 62 draws the front and rear lugs 58, 60 toward one another, thus drawing the undersides of the two beams away from one another and increasing the angle α in order to lower the respective side of the frame 22 downwardly toward the ground G. By using the actuator 62 of each walking beam assembly to vary the positions of the two respective wheels 50, 52 relative to one another about the respective stub shaft or pivot pin 38, the height of each side of the frame can thus be varied, and the heights at the opposing sides of the frame can be set to different values in order to tilt the frame 22 and the connected box blade assembly 16 about a longitudinal roll axis R that lies perpendicular to the pivot axes W of the walking beam assemblies 44.

In the illustrated embodiment, the front beam 40 of each split walking beam assembly 44 resides adjacent the outer side of the respective longitudinal frame member 26, and the rear beam 42 resides opposite the longitudinal frame member 26 to the outside of the front beam 40. The rear wheel 52 is mounted to the inside of the rear beam 42, thus riding on the ground in a position trailing behind the longitudinal frame member 26 in the shadow of same. The front wheel 50 is mounted to the outside of the front beam 40, i.e. on the side thereof opposite the frame 22. The front wheel 50 resides nearer to the plane of the respective end wall 20 of the box blade

assembly 16 than the rear wheel, but still a short distance inboard from this plane. By placing the two wheels of each walking beam assembly on opposite sides thereof, the wheels are slightly spaced apart from one another in the tranverse direction of the machine. This way, a rock, bump or other surface disruption on the ground that is met by one wheel will not necessarily be hit by the other.

To demonstrate the functionality of the variable-angle split walking beams, comparison is made between Figures 1 and 2. Figure 1C shows the blade in a level orientation parallel to the ground G, i.e. in a horizontal orientation when all four wheels are resting on a planar, horizontal ground surface. As shown in Figure 1B, the value of angle α is the same for the two walking beam assemblies when the blade is level, specifically at a value of 180-degrees in the case of the illustrated scenario. In comparison, Figure 2D shows the box blade and frame in a tilted orientation with the left side thereof lowered into a position closer to the ground G than the right side. From the perspective views of this tilted blade orientation in Figures 2E and 2F, it can be seen that this orientation is achieved by using the actuators 62 of the walking beam assemblies to set the angle α of the left walking beam assembly to a greater value than that of the right walking beam assembly. From the initially level orientation of Figure 1, this tilted orientation was achieved by collapsing the actuator 62 of the left walking beam assembly in order to increase the angle α thereof, and extending the actuator of the right walking beam assembly in order to decrease the angle α thereof.

The illustrated embodiment is equipped with a control system 70 for monitoring and automatically controlling the tilt angle of the frame and blade about the roll axis R. This system 70 is schematically illustrated in Figure 3A. A four-way, three-position, double-solenoid, spring-centered directional valve 72 is used to control operation of the hydraulic cylinder actuators 62 of both walking beam assemblies so

as to automatically extend one of these actuators while collapsing the other during any adjustment of the blade tilt angle. Accordingly, tilting motion is achieved by simultaneous inverse operation of the two actuators 62 so to raise one side of the box blade 16 and frame 22 while lowering the other side thereof. A hydraulic manifold block 74 is cooperatively attached to the valve 72 for connection of the necessary hydraulic hoses to the valve. In the illustrated embodiment of the machine, the valve/manifold assembly 72, 74 is mounted atop the cross-beam 24 of the frame at a slightly off-centre position beside the mounting lug 32 of the pitch-angle blade 34 actuator, although other mounting positions can alternatively be employed.

Using the manifold block 74, a hydraulic supply hose 76 is coupled between a pressure inlet port of the valve 72 and a hydraulic pump 78 in order to provide fluid communication between same. The pump 78 may be part of the implement 10 or part of the tow vehicle. For example, conventional agricultural tractors have an onboard hydraulic system for powering hydraulically driven implements, in which case the existing pump of the tractor can be used to power the control system of the implement 10 by running the supply hose 76 along the tongue 12 from the directional control valve to the fore end of the tongee 12, where the supply hose has a suitable fitting for coupling to a power hose of the tractor that is fed by the tractor's hydraulic pump. Via the manifold block 74, a hydraulic return hose 80 is coupled between a tank return port of the valve 72 and a hydraulic fluid reservoir 82 in order to provide fluid communication between same. The valve 72 has two output ports, each connected to a respective one of the walking beam actuators 62, via the manifold block 74, by a respective hydraulic output hose. More specifically, via the manifold block 74, a first hydraulic output hose 84 is coupled between one output port of the valve 72 and the extension port 86 of one of the walking beam actuators 62 (i.e.

the port of the actuator on the side of its piston that drives extension of the actuator's piston rod when pressurized). A second hydraulic output hose 88 is likewise coupled between one output port of the valve 72 and the extension port 90 of the other one of the walking beam actuators 62. Finally, a hydraulic connection hose 92 completes the final hydraulic connection among the valve and walking beam actuators by connecting the retractions ports 93 of the two actuators 62 together (i.e. the port on the side of the piston that drives retraction of the piston rod further back into the cylinder when pressurized).

Through these connections, the two walking beam actuators 62 are connected together in series such that extension of one actuator automatically collapses or retracts the other. The valve 72 is a normally closed valve, in which the spool of the valve 72 is spring biased into a central closed position, blocking off the pressure port from both of the output ports. A respective solenoid 72a is attached to each end of the spool so that activation of either solenoid pulls the spool into a respective one of two open positions, each of which communicates the pressure port with a respective one of the two output ports and communicates the return port with the other one of the two output ports. In each open position, one of the walking beam actuators 62 is extended by pressurizing the extension side of the cylinder, which drives the internal piston toward the retraction port of that cylinder, thereby exhausting hydraulic fluid from the retraction side of that cylinder into the retraction side of the other hydraulic cylinder actuator, thereby pressurizing same. The second cylinder is thus retracted, with the hydraulic fluid on the extension side thereof being conveyed back to the manifold/valve for exhaust back to the reservoir tank 82. Accordingly, the two actuators 62 act inversely to one another, with one actuator being automatically retracted by the extension of the other.

An electronic tilt monitoring system 94 features a tilt sensor mounted somewhere on the box blade assembly 16 or frame 22 and operable to monitor the angular position of same about the roll axis R. Output signals from the tilt sensor are employed as an input for automatic control the directional valve 72 based at partially on these signals. The tilt monitoring system may be preconfigured or programmed with a target angular position that is to be maintained by this automated control, for example a tilt angle of 0-degrees, representing a level blade orientation. In preferred embodiments, the user can set or select a target angle, preferably on the fly from the operator cabin of the tow vehicle. Deviation from the target angular position in either direction activates the respective one of the solenoids 72a that extends the actuator 62 on the side of the frame that needs to be raised relative to the other in order to regain the target tilt angle of the blade, and holds this open condition of the valve until the target tilt angle is re-established, at which point the solenoid is deactivated, at which the spring-centered spool of the valve is returned to the closed position.

Directional control valves of the described type are well-known and commercially available. As an example, a model D1VW001CNCK4 directional control valve from Parker Hannifin Corporation of Elyria, Ohio may be employed. The illustrated embodiment is based on a prototype featuring a model AD03P012S parallel circuit valve manifold from Daman Products Company Inc. of Mishawaka, Indiana, which features two tank return ports T, two pressure ports P, a first output port A, and second output port B, but has been repurposed for the control system of the present invention from its original configuration by closing the T port on one face and the P port on the opposing face with threaded plugs 73, using the A port as the tank/return port for the reservoir tank 82, using the B port as the pressure port from the pump 78, using the remaining T port on one face of the manifold block as the output port to one

actuator 62 and using the remaining P port on the opposing face of the manifold block as the output port to the other actuator. Use of a specially produced manifold, or commercially available manifold of appropriate port and passage configuration, may of course be used in place of the repurposed Daman manifold.

U.S. Patent Application Publication 2012/0239258, the entirety of which is incorporated herein by reference, discloses and example of a tilt monitoring system that employs a blade tilt angle sensor in combination with a gyroscope and a blade tip angle sensor to provide optimal input to a hydraulic blade-tilt control system. The tilt measurement system of the incorporated reference may be employed as the blade tilt monitoring system 94 in the present invention, with the output therefrom controlling operation of the solenoids 72a of the directional control valve 72 so as to operate the walking beam actuators 62 of the present invention to lift and lower the frame and blade, instead of controlling the blade-tilt actuators 112, 114 of the prior art reference that act directly between a grader blade and primary frame of a grader vehicle. Other automated tilt monitoring systems and methods known in the art may alternatively be used as input to the hydraulic control system 70 of the present invention. For example, the tilt monitoring system 94 may use a single tilt sensor alone (i.e. without the accompanying gyroscope and tip-angle sensor from the incorporated reference) as the sole measurement source, although this may be prone to slower response time in control of the blade and reduced accuracy in the measurements, as outlined in the incorporated reference.

Although some embodiments of the present invention employ the above described automated control of the blade angle, other embodiments may be manually controlled by the operator of the tow vehicle, for example by conveying electrical control signals from a manual lever or other control mechanism in the operator cabin

of the tow vehicle to the directional control valve, for example via suitable wiring run along the pull tongue 12 of the implement, or by way of a wireless communication link. The solenoid-operated valve 72, and the monitoring system 94, may be powered from the electrical system of the tow vehicle, thus avoiding the need for a dedicated power supply onboard the implement itself, although such an option may be employed in other embodiments.

While the illustrated embodiment features two split walking beam assemblies 44, another embodiment may feature replacement of one of the split walking beam assemblies 44 with a conventional fixed-beam walking assembly, whereby the tilt angle of the blade is set by adjusting the one split walking beam assembly to set the height at one side of the frame, without changing the height of the other side of the frame. While the illustrated embodiment features a hydraulic control system that automatically operates the two actuators in inverse of one another, other embodiments are also contemplated. For example, split walking beam assemblies on opposing sides of a vehicle or implement (whether a land leveler, or other machine) may be beneficial even with other control configurations, for example in a control configuration where the two walking beam actuators are again operated simultaneously, but in the same direction, so as to control and overall height of the vehicle, or in a control configuration in which the two walking beam actuators are operable independently of one another, for example to set a desired height at one side of the frame, and a desired tilt angle of the frame. Split walking beam assemblies can thus be used for a variety of different vehicle or implement types, including self-conveying vehicles or implements (as opposed to the towed implement of the illustrated embodiment), earth-working implements other than levelers (for example implements of varying types of ground engagement arrangements, such as

gangs, groups or arrays of ground working members with discrete ground engagement points instead of a continuous blade running fully from one end of the ground working arrangement to the other), and vehicles or implements that lack an earth-working function, but nonetheless could benefit from height and/or tilt control in an adjustable angle split walking beam assembly.

With reference to Figures 4 and 5, a conventional rigid-beam walking axle assembly 100 of the type shown in Figure 5 can be substituted for a split walking beam assembly 44 of the present invention simply by replacing the existing stub shaft or pivot pin 102 of the existing walking beam 100 with a longer stub shaft or pivot pin 38 of sufficient length to pass through both beams of the new split walking beam assembly 44, which is thus mounted on this new stub shaft or pivot pin 38. Walking beams on opposing sides of the frame of the previously-conventional vehicle can thus be replaced in this manner. The hydraulic actuators 62 of the split walking beams then be connected to an existing hydraulic system of the vehicle or implement, if so equipped, or a hydraulic system can be added to the vehicle or implement if it previously lacked a suitable hydraulic power system for the split walking beams. Examples of vehicles in which an adjustable angle split walking beam axle may be useful include rock trucks, semis, mining equipment, military equipment such as troop transporters, or possibly even for idler wheels of track-equipped vehicles.

Since various modifications can be made in my invention as herein above described, and many apparently widely different embodiments of same made within the scope of the claims without departure from such scope, it is intended that all matter contained in the accompanying specification shall be interpreted as illustrative only and not in a limiting sense.

CLAIMS:

1. A vehicle or implement comprising:

a frame situated having opposing sides disposed on opposing sides of a longitudinal plane that runs in a longitudinal direction of the vehicle or implement;

a pair of wheel assemblies, each being attached to the frame adjacent a respective one of the opposing sides thereof so as to reside on and rollably carry a respective one of the opposing sides of the longitudinal plane, at least one of the wheel assemblies comprising:

a split walking beam assembly pivotally coupled to the frame for pivotal movement of the split walking beam assembly about a first walking beam pivot axis lying transversely to the longitudinal direction, the split walking beam assembly comprising:

a front beam having front and rear ends spaced apart in the longitudinal direction; and

a rear beam having forward and rearward ends spaced apart in the longitudinal direction, the front end of the front beam being situated forwardly of the forward end of the rear beam in the longitudinal direction, the rearward end of the rear beam being situated rearwardly of the rear end of the front beam in the longitudinal direction, the front and rear beams being coupled together adjacent the rear and forward ends thereof, and the rear beam being pivotal relative to the front beam about a second walking beam pivot axis lying transversely of the longitudinal direction;

a front wheel rotatably coupled to the front beam adjacent the front end thereof;

a rear wheel rotatably coupled to the rear beam adjacent the

rearward end thereof; and

a wheel assembly actuator coupled between the front and rear beams of the split walking beam assembly and operable to pivot the front and rear beams relative to one another to adjust an angle measured between the front and rear beams at an underside thereof, whereby an increase of the angle lowers the respective side of the frame and respective lateral end of the blade and a decrease of the angle raises the respective side of the frame and the respective lateral end of the blade.

2. The vehicle or implement of claim 1 comprising:

a tongue having fore and aft ends spaced apart in the longitudinal direction;

a hitch connector at the fore end of said tongue for coupling of the hitch connector to a hitch of a towing vehicle;

a ground working arrangement coupled to the tongue adjacent the rear end thereof with opposing lateral ends of the ground working arrangement disposed on opposing sides of the longitudinal plane of the vehicle or implement at outboard positions spaced laterally from said longitudinal plane;

wherein the frame is situated behind the ground working arrangement in the longitudinal direction, whereby increasing the angle of each wheel assembly lowers the respective lateral end of the ground working arrangement and decreasing the angle raises the respective lateral end of the blade of the ground working arrangement.

3. The vehicle or implement of claim 2 further comprising:

a pivotal connection between the frame and the ground working arrangement that allows relative pivoting between the frame and the ground working

arrangement about a pitch axis that lies in the transverse direction; and

a pitch actuator coupled between the frame and the blade and operable to tilt the ground working arrangement relative to the frame about the pitch axis.

4. The vehicle or implement of claim 2 or 3 wherein the frame comprises a cross-member lying transversely to the longitudinal plane and a pair of rearward reaching frame members extending therefrom in the longitudinal direction adjacent opposing ends of the cross-member on the opposing sides of the longitudinal plane, each rearward reaching frame member having a respective one of the wheel assemblies connected thereto and split walking beam assembly being pivotally connected to the respective rearward reaching frame member.

5. The vehicle or implement of claim 4 wherein the rearward reaching frame members are respectively connected to the cross-member at opposing ends thereof, and each extend forwardly past the cross-member to attach to the ground working arrangement.

6. The vehicle or implement of any one of claims 2 to 5 wherein the ground working arrangement comprises a scraper blade lying transversely of the longitudinal plane with opposing ends of the blade defining the lateral ends of the ground working arrangement on the opposing sides of the longitudinal plane.

7. The vehicle or implement of any one of claims 1 to 6 wherein the wheel assemblies both comprise a respective walking beam assembly, and the walking beam assemblies are arranged to be adjustable into different respective angles, thereby adjusting an angular position of the frame about a roll axis that extends in the longitudinal direction.

8. The vehicle or implement of claim 7 comprising a control system operable to control movement of the wheel assembly actuators.

9. The vehicle or implement of claim 8 wherein the control system is arranged to automatically extend one of the walking beam actuators while collapsing the other, thereby increasing the angle between the front and rear beams of one walking beam assembly while decreasing the angle between the front and rear beams of the other walking beam assembly so as to raise one side of the frame while lowering the other side of the frame.

10. The vehicle or implement of claim 9 wherein:

each walking beam actuator comprises a hydraulic cylinder with a respective extension port and respective retraction port;

the control system comprises a four-way, three-position, spring centered directional valve with a pressure port for coupling to the output of a hydraulic pump, a return port for coupling with a hydraulic fluid reservoir, and a pair of output ports connected to either the extension ports or the retraction ports of the walking beam actuators; and

a hydraulic connection line coupling together the other of the extension ports or the retraction ports of the walking beam actuators.

11. The vehicle or implement of claim 10 wherein the directional valve is a double solenoid directional valve arranged to use electronic signals to control a position of the valve.

12. The vehicle or implement of any one of claims 8 to 11 comprising a monitoring system arranged to monitor an orientation of the frame about a longitudinal axis, and linked to the control system to automatically control the walking beam actuators and adjust the orientation of the frame.

13. The vehicle or implement of any one of claims 1 to 12 wherein the first walking beam pivot axis and second walking beam pivot axis of each wheel

assembly are coincident with one another.

14. The vehicle or implement of any one of claims 1 to 13 wherein the first and second beams of each wheel assembly both pivot about the second walking beam pivot axis.

15. A method of providing tilt or height adjustment capabilities to a vehicle or implement that is at least partially supported by a pair of walking beam wheel assemblies are disposed on opposing sides of a longitudinal plane of the vehicle or implement and each feature front and rear wheels that are respectively mounted adjacent front and rear ends a single walking beam that is pivotally coupled to a frame of the vehicle or implement at a longitudinally intermediate location on the walking beam for pivoting of the walking beam about a walking beam pivot axis lying transversely to the central longitudinal plane, the method comprising:

replacing at least one walking beam assembly with a respective split walking beam assembly that is pivotally coupled to the frame for movement about the same walking beam pivot axis, and that comprises:

a front beam having front and rear ends spaced apart in a longitudinal direction in which the central longitudinal plane extends; and

a rear beam having forward and rearward ends spaced apart in the longitudinal direction, the front end of the front beam being situated forwardly of the forward end of the rear beam in the longitudinal direction, the rearward end of the rear beam being situated rearwardly of the rear end of the front beam in the longitudinal direction, the front and rear beams being coupled together adjacent the rear and forward ends thereof, and the rear beam being pivotal relative to the front beam about a second pivot axis lying transversely of the longitudinal direction;

a front wheel rotatably coupled to the front beam adjacent the

front end thereof;

a rear wheel rotatably coupled to the rear beam adjacent the rearward end thereof; and

a wheel assembly actuator coupled between the front and rear beams of the split walking beam assembly and operable to pivot the front and rear beams relative to one another to adjust an angle measured between the front and rear beams at an underside thereof, whereby, with the front and rear wheels on a ground surface, an increase of the angle surface lowers the respective side of the frame and respective lateral end of the blade and a decrease of the angle raises the respective side of the frame and the respective lateral end of the blade.

16. The method of claim 15 comprising replacing each walking beam assembly with a respective split walking beam assembly, and further comprising equipping the vehicle or implement with a control system operable to control movement of the wheel assembly actuators.

17. The method of claim 16 wherein the control system is arranged to extend one of the walking beam actuators while collapsing the other, thereby increasing the angle between the front and rear beams of one walking beam assembly while decreasing the angle between the front and rear beams of the other walking beam assembly so as to raise one side of the frame while lowering the other side of the frame.

18. The method of claim 17 wherein each walking beam actuator comprises a hydraulic cylinder with a respective extension port and respective retraction port and the control system comprises a four-way, three-position, spring centered directional valve, the method comprises coupling a pressure port of the directional valve to an output of a hydraulic pump, coupling a return port of the

directional valve with a hydraulic fluid reservoir, fluidly connecting output ports of the directional valve to either the extension ports or the retraction ports of the walking beam actuators, and fluidly connecting the walking beam actuators together at the other of the extension ports or the retractions ports.

19. The method of claim 18 wherein the directional valve is a double solenoid directional valve arranged to use electronic signals to control a position of the valve.

20. The method of any one of claims 16 to 19 comprising equipping the vehicle or implement with a tilt monitoring system arranged to monitor an angular position of the frame about a roll axis that extends in the longitudinal direction, and connecting the tilt monitoring system to the control system to automatically control the walking beam actuators and adjust the angular position.

21. The method of any one of claims 15 to 20 wherein the second pivot axis of each split walking beam assembly is coincident with the respective walking beam pivot axis.

22. The method of any one of claims 15 to 22 wherein the first and second beams of each split walking beam assembly both pivot about the second pivot axis.

23. A towable ground working implement comprising:

a tongue having fore and aft ends spaced apart in a longitudinal direction;

a hitch connector at the fore end of said tongue for coupling of the hitch connector to a hitch of a towing vehicle;

a scraper blade coupled to the tongue adjacent the rear end thereof and lying transversely to the longitudinal direction so as to place opposite lateral ends of

the blade on opposing sides of a central longitudinal plane of the implement at outboard positions spaced laterally from said central longitudinal plane;

a frame situated behind the blade in the longitudinal direction with opposite sides of the frame disposed on the opposing sides of the longitudinal plane;

a pair of wheel assemblies, each being attached to the frame adjacent a respective one of the opposing sides thereof so as to reside on a respective one of the opposing sides of the longitudinal plane, at least one of the wheel assemblies comprising:

a split walking beam assembly pivotally coupled to the frame for pivotal movement of the split walking about a first walking beam pivot axis lying transversely to the longitudinal direction, the split walking beam assembly comprising:

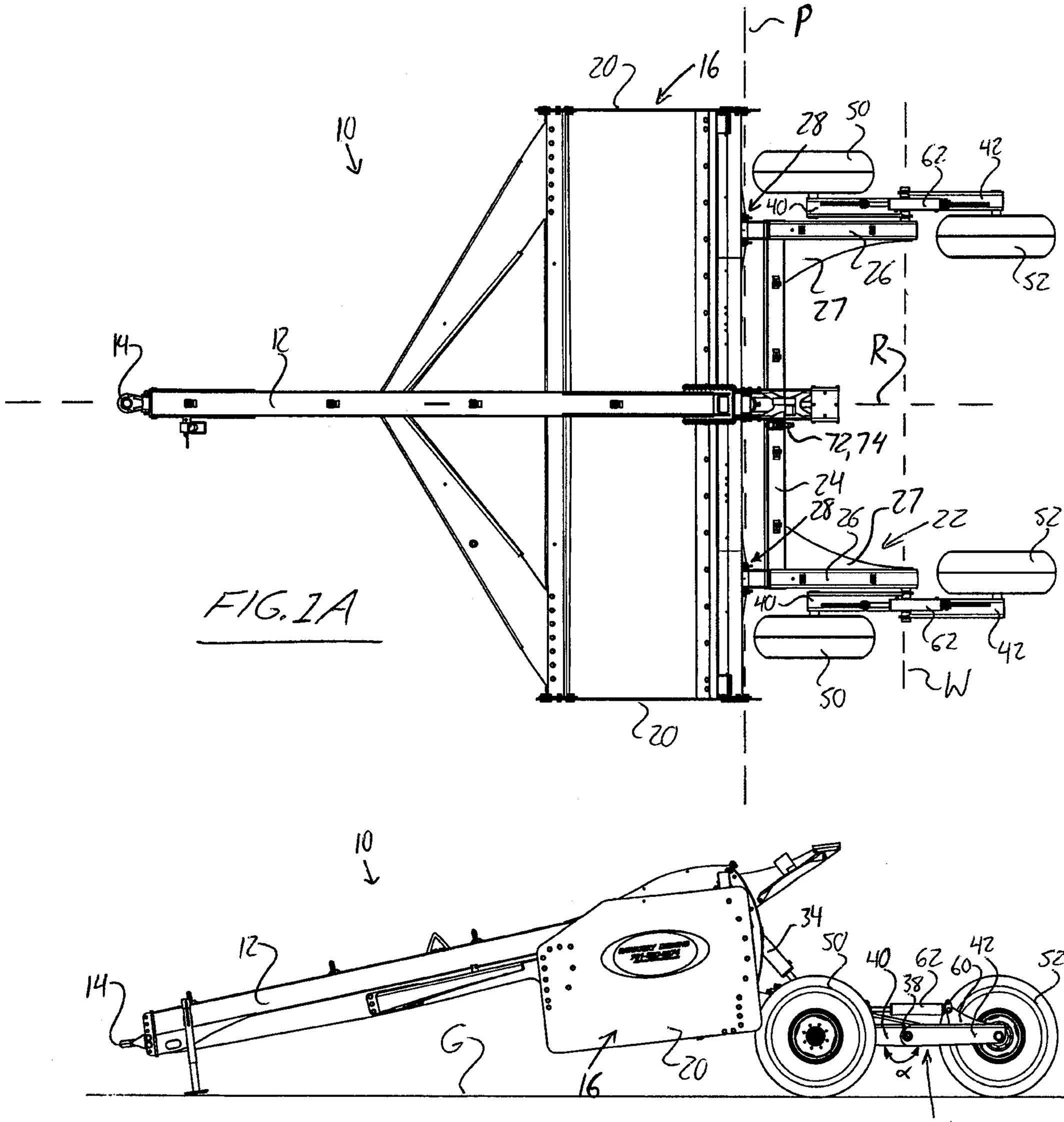
a front beam having front and rear ends spaced apart in the longitudinal direction; and

a rear beam having forward and rearward ends spaced apart in the longitudinal direction, the front end of the front beam being situated forwardly of the forward end of the rear beam in the longitudinal direction, the rearward end of the rear beam being situated rearwardly of the rear end of the front beam in the longitudinal direction, the front and rear beams being coupled together adjacent the rear and forward ends thereof, and the beam being pivotal relative to the front beam about a second walking beam pivot axis lying transversely of the longitudinal direction;

a front wheel rotatably coupled to the front beam adjacent the front end thereof;

a rear wheel rotatably coupled to the rear beam adjacent the rearward end thereof; and

a wheel assembly actuator coupled between the front and rear beams of the split walking beam assembly and operable to pivot the front and rear beams relative to one another to adjust an angle measured between the front and rear beams at an underside thereof, whereby, with the front and rear wheels on a ground surface, an increase of the angle lowers the respective side of the frame and respective lateral end of the blade and a decrease of the angle raises the respective side of the frame and the respective lateral end of the blade, thereby adjusting an angular tilt position of the blade about a roll axis that extends in the longitudinal direction.


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FIG. 1B

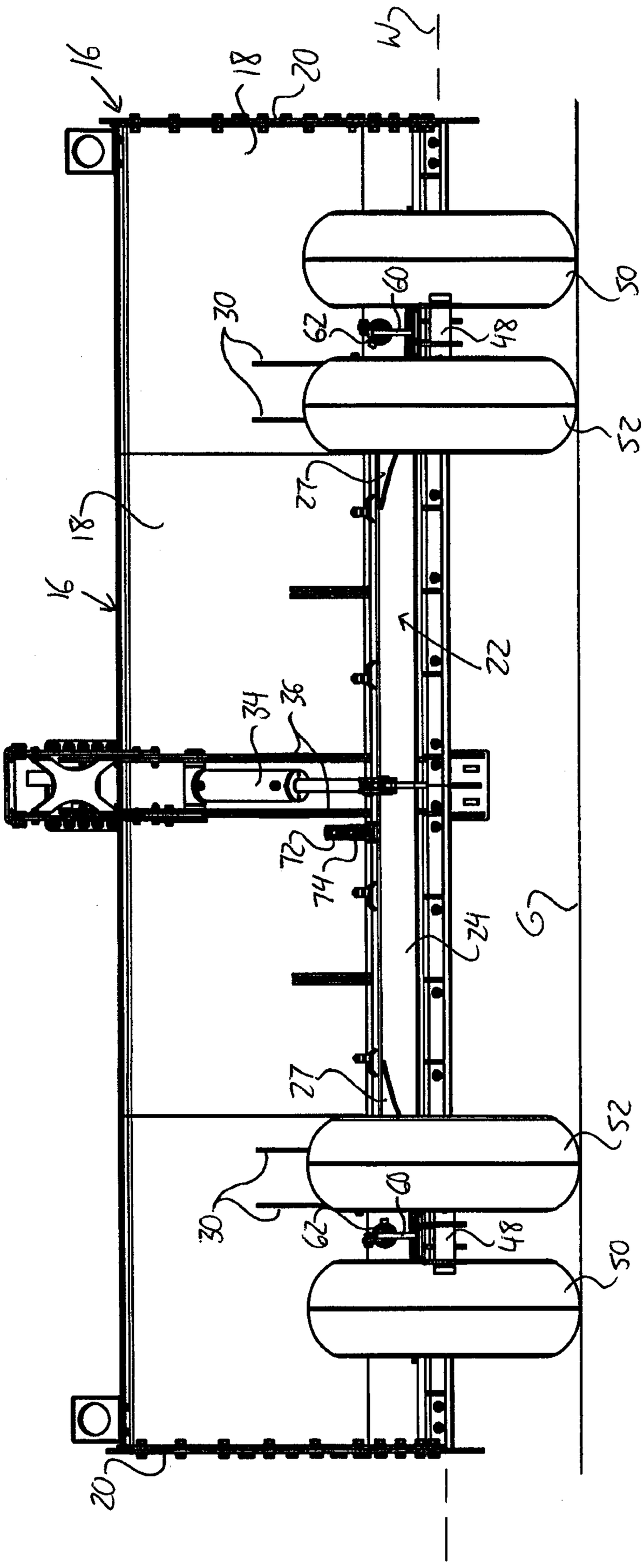

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FIG. 1C

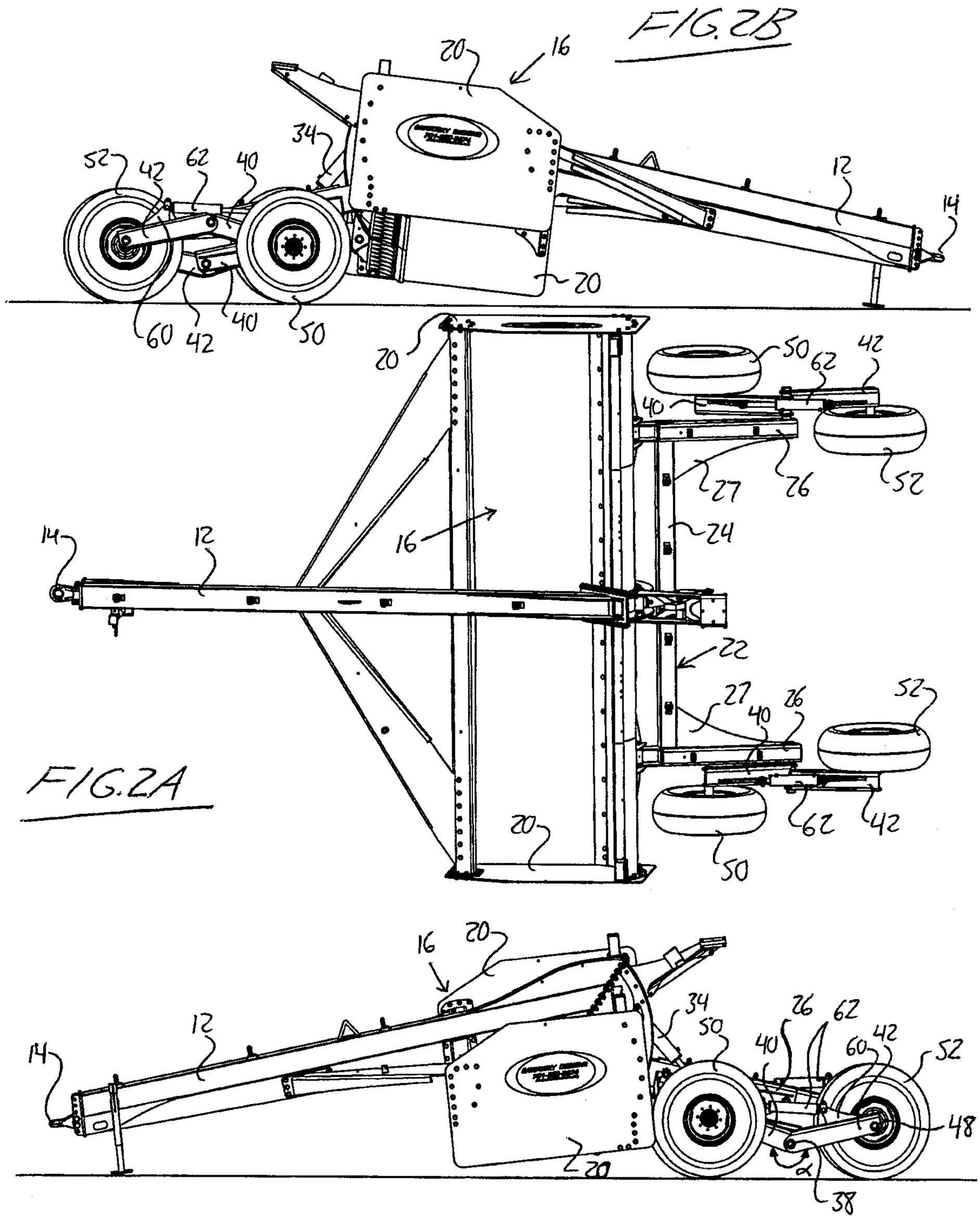

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FIG.2A

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FIG.2C

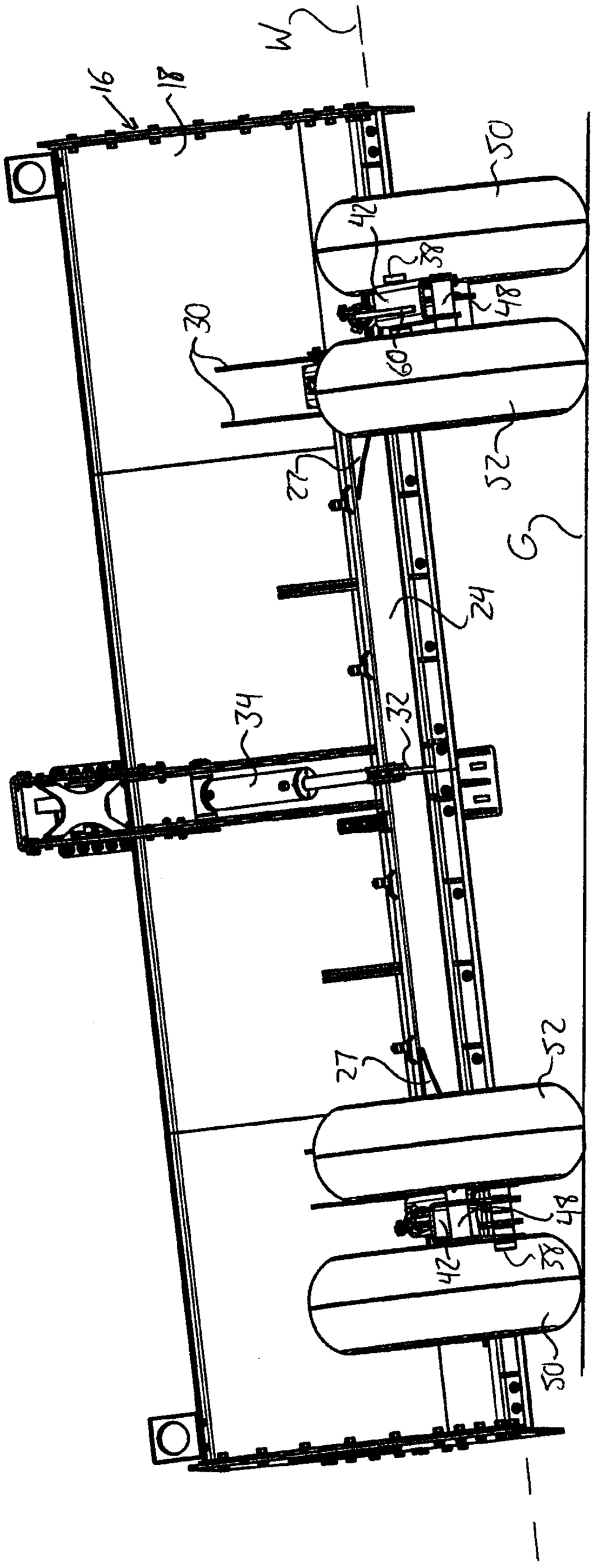


FIG. 2D

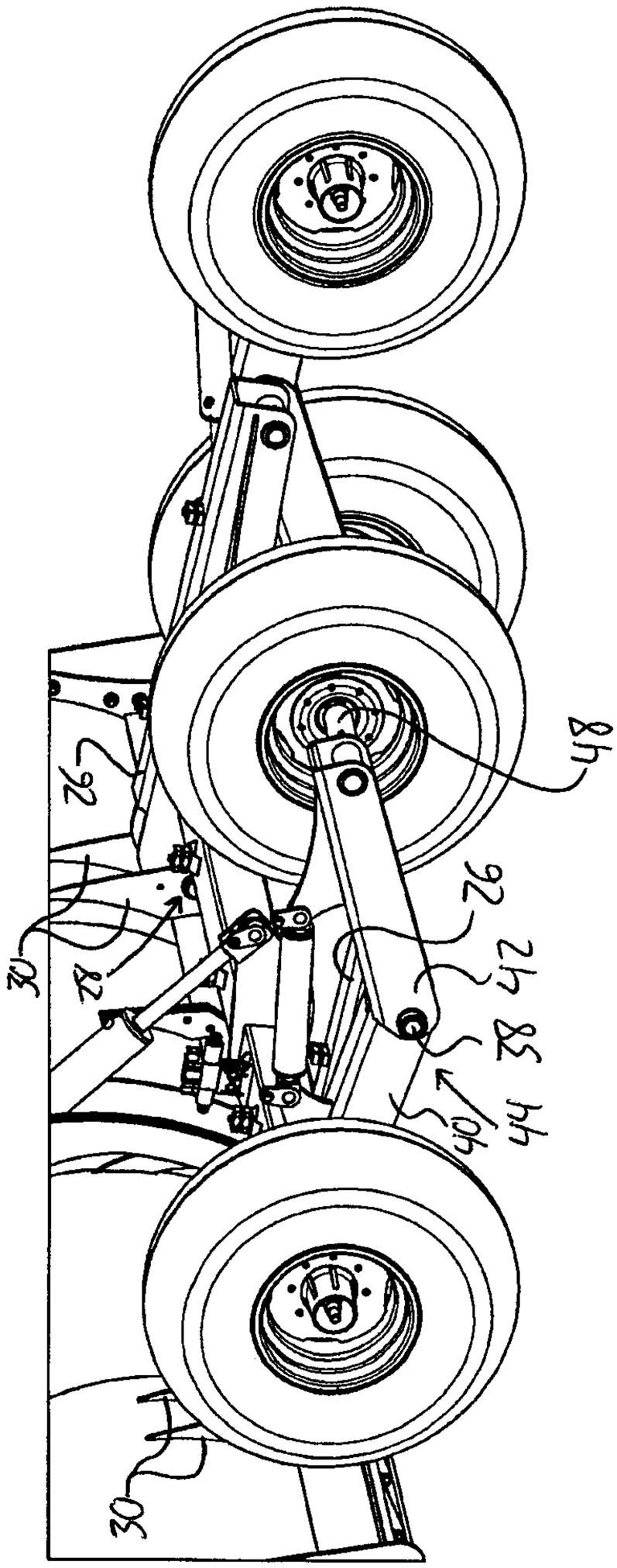

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FIG. 2E

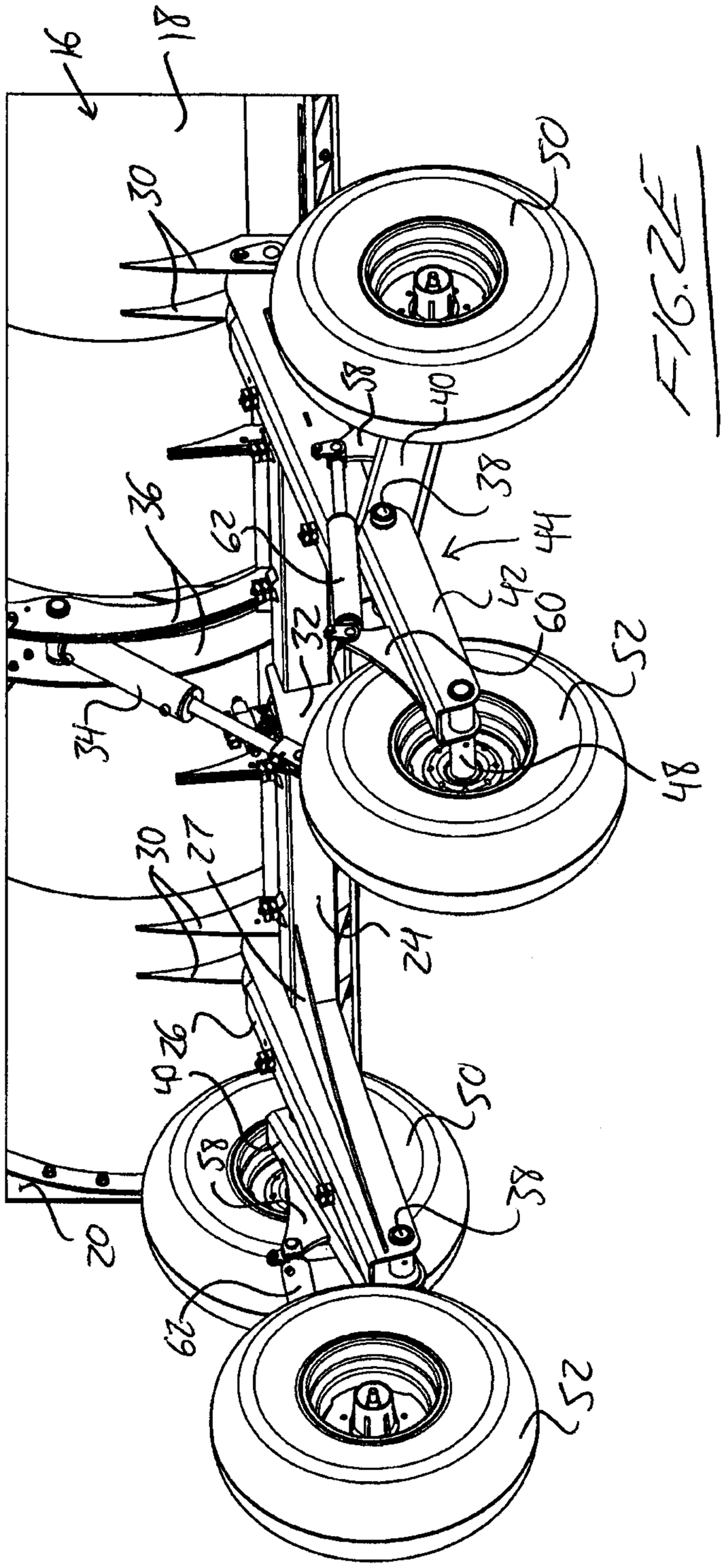

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FIG. 2F

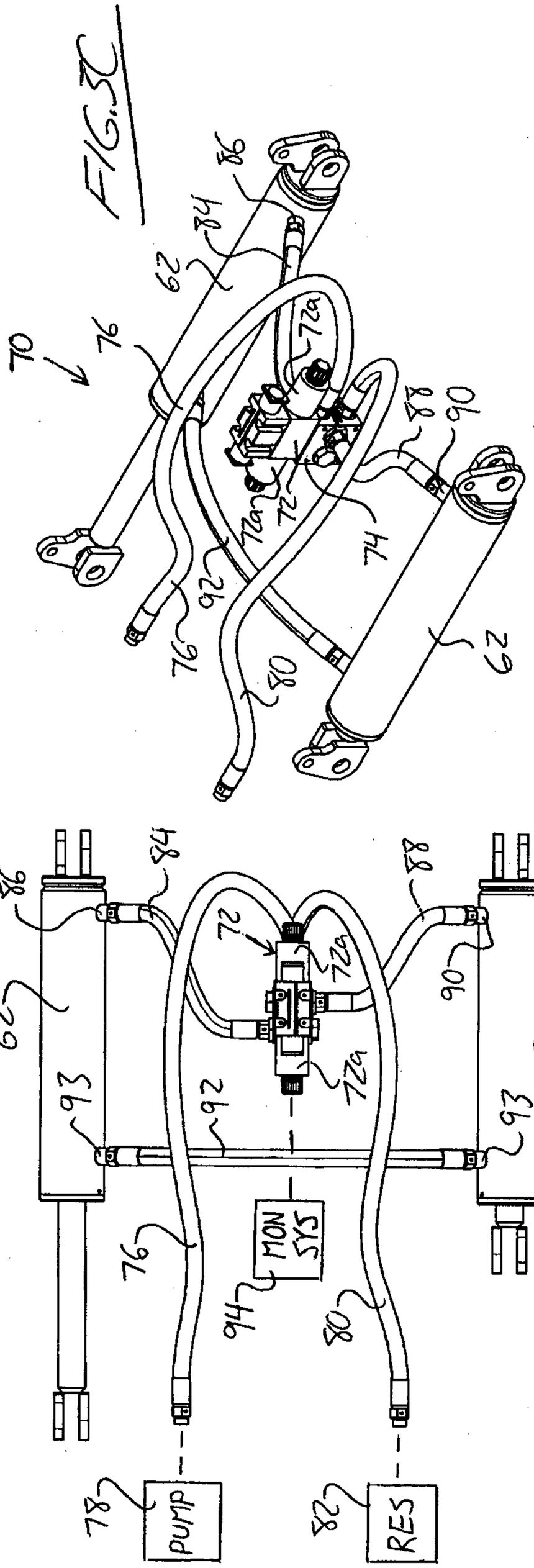


FIG. 3C

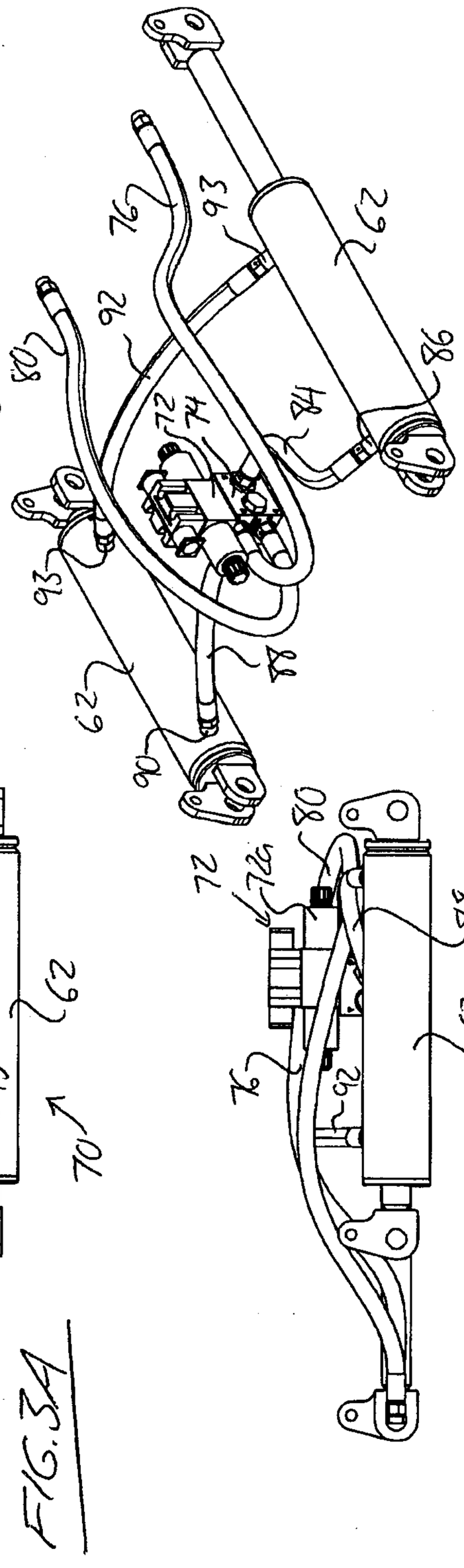


FIG. 3D

FIG. 3B

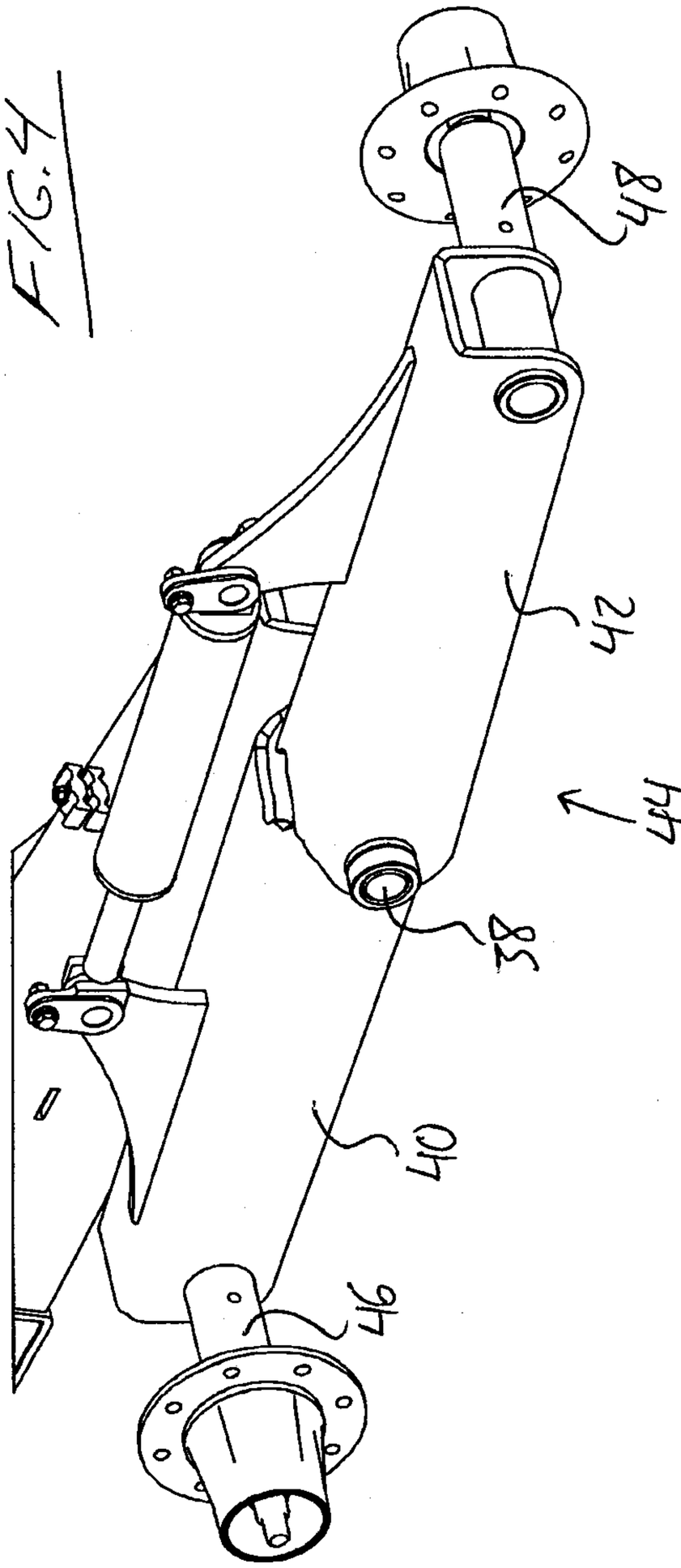


FIG. 4

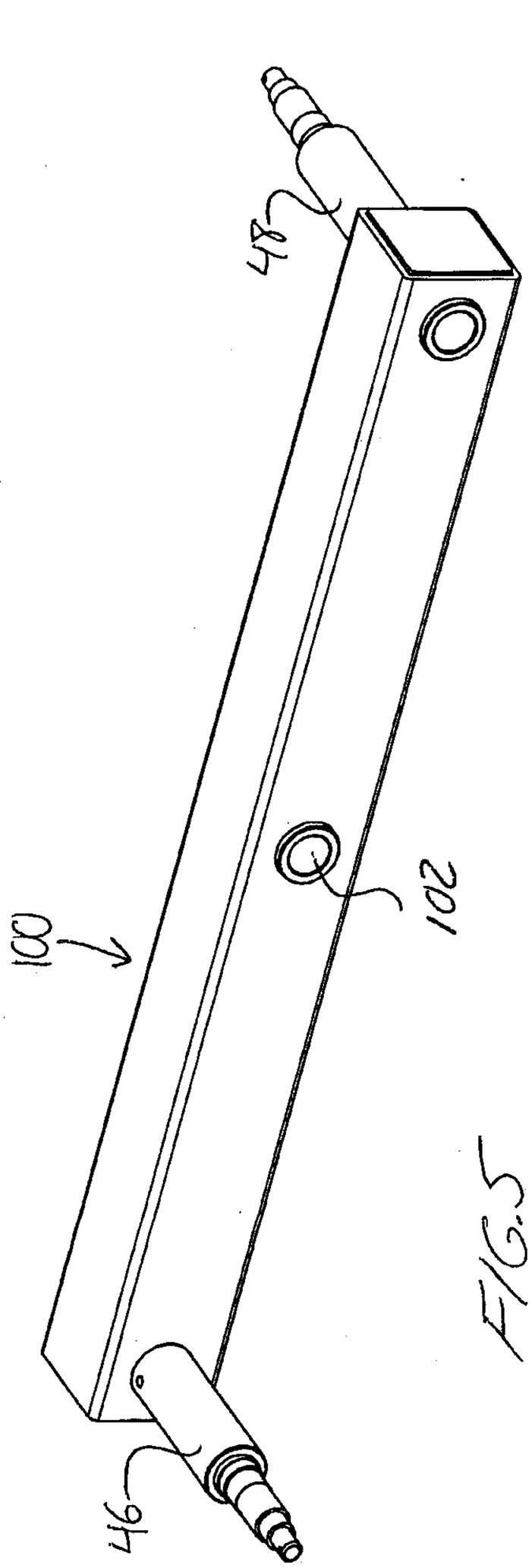


FIG. 5

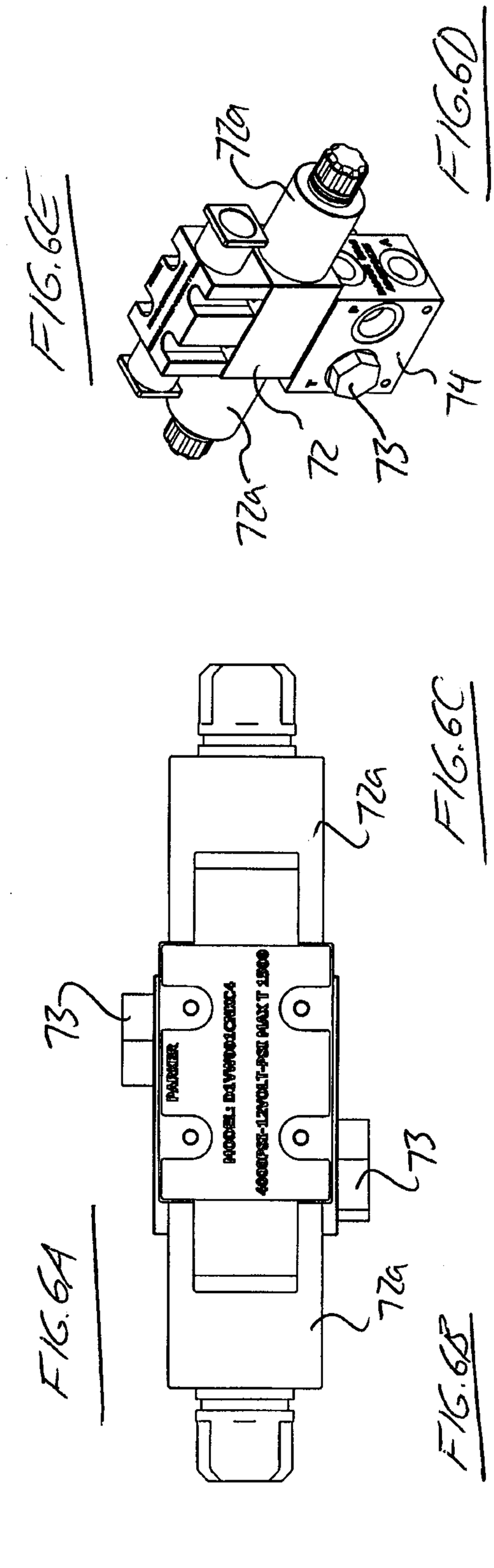


FIG. 6A

FIG. 6E

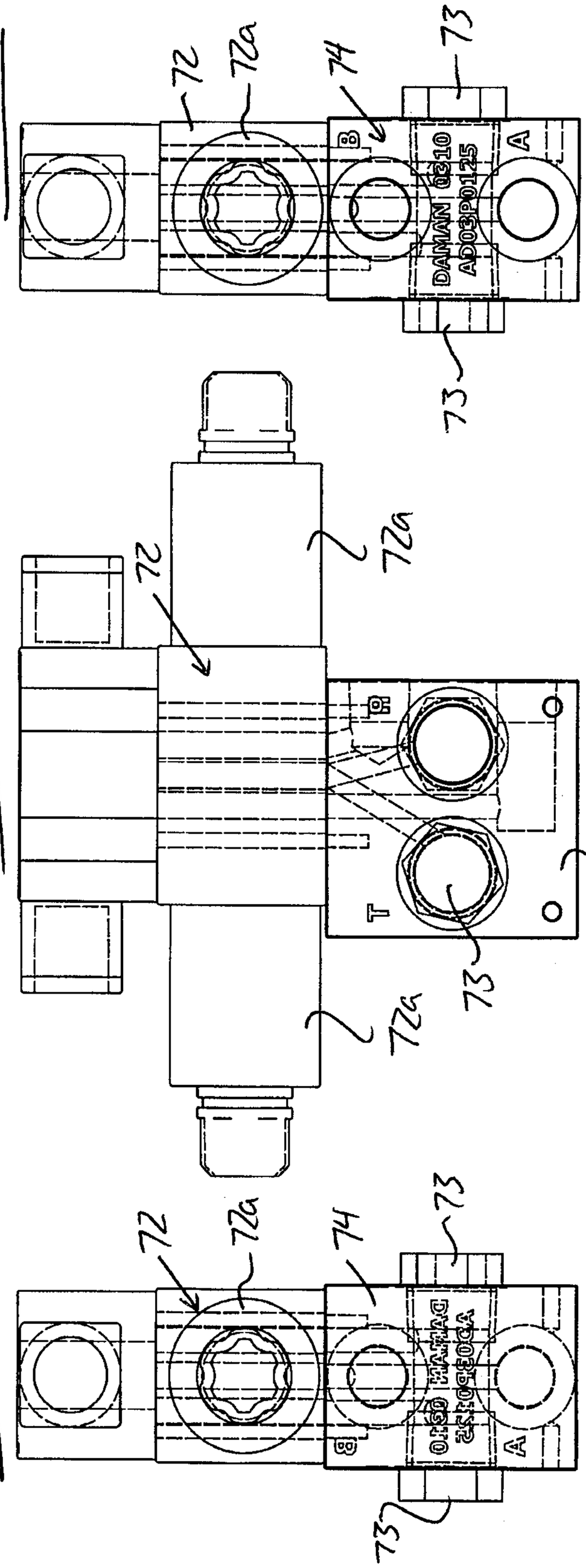
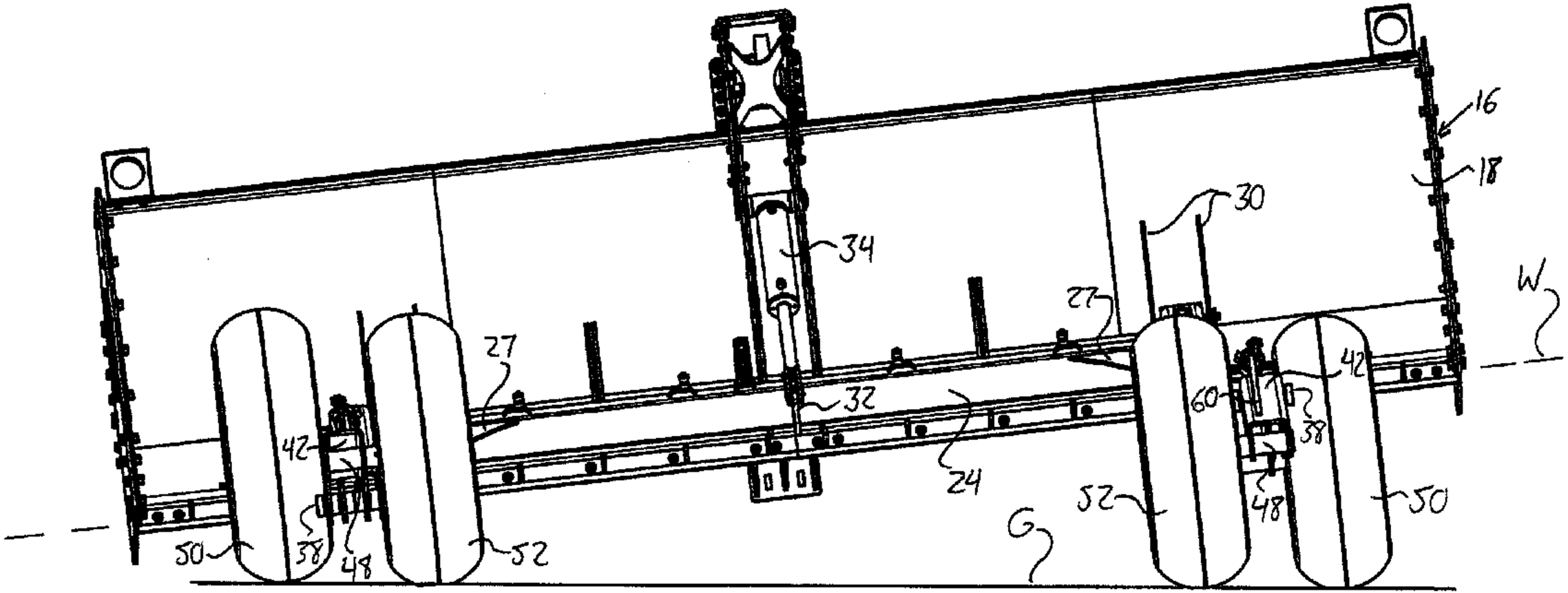


FIG. 6C

FIG. 6D

FIG. 6B


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