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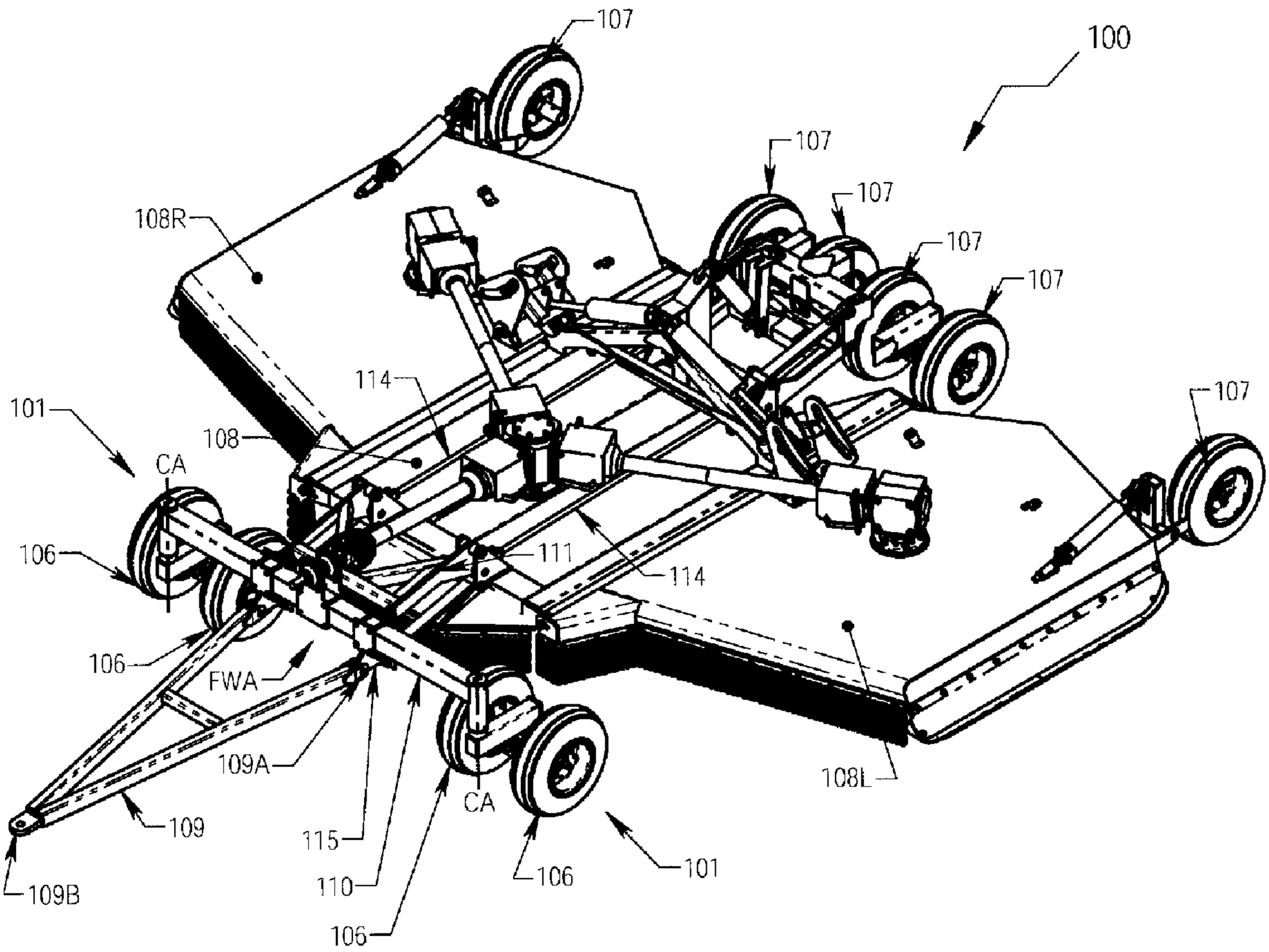
(54) Title: CASTERING WHEEL ASSEMBLY FOR ROTARY MOWERS



(57) Abrégé/Abstract:
A castering wheel assembly comprising of a vertical shaft for caster, a horizontal wheel-mount standard, an axle pivotally attached to the standard, two wheels; with one wheel at each end of the axle arranged such that when the wheel assembly is attached to a

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(57) Abrégé(suite)/Abstract(continued):
rotary mower apparatus, the apparatus will follow straight on a side slope. Two embodiments of a mower apparatus comprising a mower deck and two wings, with a plurality of rear wheels mounted behind the mower deck(s) and two castering wheel assemblies mounted ahead of the mower deck such that the mower deck(s) ride along the ground. A trailing or offset floating hitch member is pivotally attached at one end to the front wheel assembly of the center mower deck and pivotally attached at an opposite end to a tractor allowing the mower deck(s) to float with respect to the tractor to follow contours on the ground.

ABSTRACT

A castering wheel assembly comprising of a vertical shaft for caster, a horizontal wheel-mount standard, an axle pivotally attached to the standard, two wheels; with one wheel at each end of the axle arranged such that when the wheel assembly is attached to a rotary mower apparatus, the apparatus will follow straight on a side slope. Two embodiments of a mower apparatus comprising a mower deck and two wings, with a plurality of rear wheels mounted behind the mower deck(s) and two castering wheel assemblies mounted ahead of the mower deck such that the mower deck(s) ride along the ground. A trailing or offset floating hitch member is pivotally attached at one end to the front wheel assembly of the center mower deck and pivotally attached at an opposite end to a tractor allowing the mower deck(s) to float with respect to the tractor to follow contours on the ground.

CASTERING WHEEL ASSEMBLY FOR ROTARY MOWERS

This invention is in the field of rotary mowers and in particular a castering wheel assembly that allows the rotary mowers to follow a side slope as found in roadside ditches. This invention further allows the invention of a trailing floating hitch rotary mower apparatus and an offset floating hitch rotary mower apparatus to be used for roadside maintenance.

BACK GROUND

Rotary mowers are used for cutting vegetation of various types; crops and non-crop vegetation such as grass, weeds, and brush. Most commonly they are used to maintain roadside ditches and other public lands. These rotary mowers often include two or three mower decks mounted side by side. The decks are offset fore and aft to provide the required over lap from the rotating blade under one deck to that of the adjacent deck, and the outside decks or wings, fold upward to allow for transport. Wing rotary mowers are most often of the trailing type; wherein the mower is supported by the wheels behind the deck and by the hitch on the towing tractor. Such a wing rotary mower is disclosed in United States Patent 6,546,707 to Degelman et al.

Conventional trailing wing rotary mowers follow directly behind the tractor, and the mowers travel along or in the roadside ditch. In this situation, the mowers have to cope with a side sloped terrain as while as crossing intersecting road approaches. This often results in uneven cuts as while as gouging of the approach as the mower is pulled up and over. Wheels at the front of the wing-type rotary mower to allow the rotary mower to float where not added to the rotary mowers because of the difficulty the wheels had in castering on the side slope of the ditch. Conventional castering wheel systems are unable to follow on a side slope. The use of these conventional castering wheel systems resulted in extreme tire wear as while as the tires pulling off the wheel rims. Typical conventional castering wheel systems used on a mower are disclosed in United States Patent 5,129,218 to Youngberg et al. In US Patent 4,355,689 to Friggstad a typical dual caster is shown on a large winged trailing apparatus. Two wheels are used to distribute the weight from the apparatus on to each wheel to allow better floatation and they are mounted on an axle as close together as possible for stability in castering.

In a conventional dual castering wheel assembly a pivot could be added on the axle to better allow equal distribution of the weight on each tire and for use when on a slightly uneven terrain. If a pivot is added, it is usually a horizontal latitudinal walking axis with a limit that allows only a slight

forward and backward walking motion and the wheels are required to be slightly offset forward and aft to allow this movement.

When a ditch slope is at the typical 10 degree grade or when mowing in the roadside ditch, mowers pulled directly behind the tractor work safely, but can be extremely uncomfortable for the operator who sits at an angle in the tractor. When a tractor travels on ditch slopes with a steep grade or steeper grades present themselves, a potentially dangerous situation occurs, that sometimes results in tractor roll over and injury or death to the operator. Some small degree of offset can be provided for trailing mowers by moving the tractor drawbar to one side, an adjustment commonly found on tractors. For mounted rotary mowers, an offset is provided in the hitch of United States Patent 4,195,860 to Helams, and as well in the hitch of U.S. Pat. No.6,138,445 to Toth. In all cases the degree of offset is to small to allow the tractor to remain on the road while cutting the ditch. U.S. Pat. No. 5,957,475 to Pearen et al. provides an intermediate offset hitch apparatus that is hitched to the tractor on one side so as to tow behind the tractor. A rotary mower is hitched to the Pearen et al. apparatus at the rear of the opposite side. The apparatus essentially provides a hitching location and drivelines for the mower that is a clone of the tractor hitch it self, but offset sufficiently to allow the tractor to remain on the road while the mower cuts the slope of the ditch.

It would be desirable to have a castering wheel assembly for attachment to a rotary mower that would enable the rotary mower apparatus to follow on a side slope as found in roadside ditches.

It would be desirable to have a rotary mower apparatus that floated with respect to the tractor to allow the apparatus to follow the ground contours, to ensure an even cut when mowing roadside ditches as while as preventing gouging of the road approaches when going over them.

It would be desirable to have a rotary mower apparatus adapted for attachment to a tractor such that the mower apparatus follows a path offset from the path of the tractor allowing the tractor to remain on the road while the mower cuts the slope of the roadside ditch.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a castering wheel assembly that when attached to a rotary mower apparatus allows the apparatus to follow on a side slope to effectively cut roadside ditches.

It is a further object of the present invention to provide a rotary mower apparatus adapted for attachment to a tractor such that the rotary mower floats with respect to the tractor to allow the mower to follow the contours of the ground, ensuring an even cut.

It is a further object of the present invention to provide a rotary mower apparatus adapted for attachment to a tractor such that the mower apparatus follows a path offset from the path of the tractor and wherein the amount of offset can be varied, to provide operator safety and convenience when mowing roadside ditches

The present invention provides, in one aspect a castering wheel assembly for attachment to a rotary mower apparatus to allow travel along a side slope in an operating travel direction. The caster wheel assembly comprises of a vertical shaft for castering, a horizontal wheel mount standard, an axle pivotally attached to the wheel standard, and two wheels wherein each wheel is attached to the first and second end of the axle. The wheels pivot about a horizontal longitudinal axis and the wheels are arranged such that the distance between the centers of the wheels is greater then one-half the distance from the pivot point on the wheel axle to the running ground surface. This arrangement allows the castering wheel assembly to ride side slopes with a grade up to 45 degrees and still retain its ability to caster. This arrangement further allows the load center to remain between the wheel centers preventing the wheels from falling over and it allows the wheels to run perpendicular to the sloped surface preventing premature tire wear.

In a conventional dual caster wheel arrangement, the wheels are close together to allow maximum caster and any pivot that is added is limited, only allowing the wheels to clear small surface irregularities for terrain following ability. When these arrangements are used on extreme sloped surfaces they tend to ride on the up-side edge of the tires limiting their ability to caster properly on a side-slope grade typically found on a roadside ditch. On these arrangements the force of gravity tends to pull them downward and the up-slope edge of the tire tends to run behind the caster axis, all this causes the arrangement not to caster and the tires to scrub, preventing their reasonable use on side slopes as commonly found in roadside ditches.

In the arrangement of the present invention, two forces, gravity and a castering force act on the castering wheel assembly due to the weight of the apparatus. On level ground the weight of the apparatus is divided equally between the two wheels, and the castering force is divided equally between the two wheels, the force of gravity is straight down and does not affect the castering ability of the assembly. When on a side slope the castering wheel assembly follows such that there is an up-slope wheel and a down-slope wheel. Gravity tries to force the wheels down slope and the weight of the apparatus on the castering wheel assembly applies a castering force that rotates the

wheels up-slope, the down-slope wheel carries more of the weight of the apparatus then the up-slope wheel causing this down-slope wheel to have a greater upward castering force, this counteracts the downward force created by gravity in direct relationship to the grade of the slope; the steeper the slope, the more weight the down-slope wheel carries, the larger the up-ward castering force, the larger downward force of gravity to balance. This arrangement allows the wheels to follow perpendicular to the slope and the castering wheel assembly to retain its castering ability. The distance between the centers of the wheels determines the grade of the side slope that the castering wheel assemblies will follow straight on. Typical grades on ditch slopes on roadways are at least 10 degrees and some may be to a grade as steep as 45 degrees.

In the second aspect, the present invention provides a wing-type rotary mower apparatus adapted for attachment to a tractor for towing along the ground in an operating travel direction. The apparatus comprises a central mower deck and right and left wing mower decks pivotally attached to respective right and left sides of the central mower deck. A plurality of rear wheels is mounted behind the mower decks and at least one castering wheel assembly mounted to a front end of the central mower deck such that the mower decks ride along the ground on the wheels. A cutting blade element is rotatably mounted under each mower deck so as to rotate about right, left, and central substantially vertical blade axis. A floating hitch member is pivotally attached at the front wheel assembly of the central mower deck and is adapted for pivotal attachment at a tow end thereof to the tractor. The attachment at the ends of the floating hitch member allows the floating hitch member and the mower decks to float with respect to the tractor to follow the contours of the ground. A drive is adapted for connection to the tractor to rotate the cutting blade element. Thus front and rear wheels support the mower decks and the floating hitch member allows the deck to float to follow the ground contours.

In the third aspect, the present invention provides a single deck rotary mower apparatus or a wing-type rotary mower apparatus adapted for attachment to a tractor for towing along the ground in an operating travel direction. The apparatus comprises a single mower deck or a central mower deck and right and left wing mower decks pivotally attached to the respective right and left sides of the central mower deck. A plurality of rear wheels is mounted behind the mower deck(s) and a front wheel assembly is mounted to the front end of the central mower deck such that the mower deck(s) ride along the ground on wheels. A cutting blade element is mounted under each mower deck so as to rotate about right, left, and central substantially vertical blade axis. A floating hitch member is pivotally attached at the mower end thereof to the front wheel assembly so as to pivot about a substantially vertical axis and is adapted for pivotal attachment at a tow end thereof to the

tractor about a substantially vertical tow axis. The attachment at the ends of the floating hitch member further allow the floating hitch member and mower decks to float with respect to the tractor to follow the contours of the ground. A drive is adapted for connection to the tractor and is operative to transfer power from the tractor to rotate the cutting elements, and a mower angle control is operative to selectively pivot the floating hitch member about the vertical axis with respect to front wheel assembly of the central mower deck. Thus front and rear wheels support the mower deck, and the floating hitch member allows the decks to float to follow the contours of the ground. The mower deck(s) are guided into the desired offset path by selectively pivoting the floating hitch member about the vertical axis with respect to the front wheel assembly of the central mower deck. A driveline is conveniently provided by a series of gearboxes, universal joints, double universal joints and drive shafts having a rotational axis coincidental with the input of a gearbox having an output connected to rotate one or more cutting elements.

DESCRITION OF THE DRAWINGS

While the invention is claimed in the concluding portions hereof, preferred embodiments are provided in the accompany detailed description which may be best understood in conjunction with the accompanying diagrams where like parts in each of the several diagrams are labeled with like numbers, and where:

Fig. **1** is the front view of the caster wheel assembly embodiment of the invention.

Fig. **2** is the front isometric view of the caster wheel assembly embodiment of the invention.

Fig. **3** is the front view of the caster wheel assembly embodiment of the invention on a 30-degree side slope.

Fig. **4** is the front isometric view of the trailing floating hitch wing-type rotary mower apparatus embodiment of the invention.

Fig. **5** is the rear view perspective of the wing-type rotary mower apparatus embodiment of the invention with the floating hitch, wings, and drive components removed.

Fig. **6** is a front trimetric view of the offset floating hitch wing-type rotary mower apparatus embodiment of the invention with the floating hitch in a minimum offset position. Detail of the mower angle control with some hitch and drive components removed.

Fig. **7** is a top view of the offset floating hitch wing-type rotary mower apparatus embodiment of the invention with the floating hitch in the maximum offset position.

Fig. **8** is a side view of the offset floating hitch rotary mower apparatus embodiment of the invention. Detail of part of the driveline is shown.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

Figs. **1-3** illustrates the castering wheel assembly **1** of the invention for attachment to a rotary mower apparatus to allow travel on a side slope in an operating travel direction **T**. The castering wheel assembly **1** comprise of a vertical shaft **2** for castering about a caster axis **CA**, a horizontal wheel mount standard **3**, an axle **4** pivotally attached at **5** to the wheel standard **3**, and two wheels **6** wherein each wheel **6** is attached to the first and second end of the axle **4**. The wheels **6** pivot about a substantial horizontal longitudinal wheel-rocking axis **LWRA** and caster about the caster axis **CA**. The wheels **6** are arranged such that the distance **W** between the centers **WC** of the wheels **6** is greater then one-half the distance **H** from the pivot point **5** on the wheel axle **4** to the running ground surface **RGS**. This arrangement allows the castering wheel assembly **1** to follow on a side slopes with a grade of 14 degrees or greater in an operating travel direction **T**. This arrangement allows the load, from the weight of the apparatus, coincidently with the caster axis **CA** to stay between the centers **WC** of the wheels **6** preventing the wheels **6** from falling over and this arrangement further allows the wheels **6** to run perpendicular to the sloped surface as illustrated in Fig. **3** preventing premature tire wear and allowing proper caster on the side slope.

Two forces, gravity and a castering force act on the castering wheel assembly **1** due to the weight of the apparatus. On level ground the weight of the apparatus is divided equally between the two wheels **6,** the castering force is divided equally between the two wheels **6** and the force of gravity is straight down and does not affect the castering ability of the assembly. When on a side slope as illustrated in Fig. **3** the castering wheel assembly **1** follows such that there is an up-slope wheel **6a** and a down-slope wheel **6b**. Gravity tries to force the wheels **6** down slope and the weight of the apparatus on the wheels **6** tries to force the wheels to caster up-slope, the down-slope wheel **6b** carries more of the weight of the apparatus then the up-slope wheel **6a** causing this down-slope wheel **6b** to increase its upward castering force, this counteracts or balances the downward force created by gravity allowing the castering wheel assembly **1** to follow straight on a side slope. The distance **W** between the centers **WC** of the wheels **6** determines the grade of the side slope that

the castering wheel assembly **1** will follow straight on. Typically grades on ditch slopes are 10 degrees or greater.

Fig. **4** illustrates a trailing floating hitch wing type rotary mower apparatus **100** of the invention adapted for attachment to a tractor for towing along the ground in an operating travel direction **T**. The apparatus comprises a central mower deck **108**, and a right and left wing mower decks **108R**, **108L** pivotally attached to respective right and left sides of the central mower deck **108**.

Rear wheels **107** are mounted behind the mower decks **108**, **108R**, **108L** and a front wheel assembly **FWA** is attached to the front end of the central mower deck **108** such that the mower decks **108**, **108R**, **108L** ride along the ground on the wheels **107**, **106**. A cutting blade element, which is conventional and not shown, is rotatably mounted under each mower deck **108**, **108R**, and **108L** so as to rotate about a right, left, and central substantially vertical blade axis.

A floating hitch member **109** is pivotally attached at the mower end **109A** to lugs **115** on the cross member **110** of the front wheel assembly **FWA** attached to the central mower deck **108**. The floating hitch member **109** is adapted for pivotal attachment at the tow end **109B** thereof to the tractor.

A drive is adapted for connection to the tractor and operative to transfer power from the tractor to rotate the cutting blade element.

The front end of the central mower deck **108** is supported by the **FWA** which comprises of two castering wheel assemblies **101** attached at opposite ends to the cross member **110**. Front parallel linkages **111** are pivotally attached at rear ends thereof to opposite sides of the central mower deck **108** and at the front ends thereof to a cross member **110**. This cross member **110** does not pivot with respect to the central mower deck **108**.

Referring to Fig. **5**; to allow the central mower deck **108** to follow the ground and provide a satisfactory cut some of the technology from the castering wheel assembly **101** is used on the dual rear wheels system **132**. This system **132** comprises two sets of dual rear wheel **107** and each wheel **107** in the set is attached to an end of an axle **117**. The two axles **117** are pivotally attached to the walking beam standard **112** about a substantial horizontal longitudinal wheel-rocking axis **LWRA**. The distance **W** between the centers **WC** of the wheels **107** sets is the same as is used on the castering wheel assembly **101**. The ability to caster on a side slope is not necessary in this situation since the wheels **107** follow the center mower deck **108**. Instead the walking beam standard **112** is pivotally attached to the rear cross member **116** about a horizontal rear walking axis **HRWA**. The rear cross member **116** is attached to the rear of the central mower deck **108** by a pair of rear parallel linkages **113** that are connected to the front parallel linkages **111** by connecting rods **114**

such that the front and rear wheels **106**, **107** move up and down in concert, and the caster axes **CA** are maintained substantially vertical so that proper castering action occurs. A hydraulic actuator **118** is attached to the rear cross member **116** at one end and to the rear of the center mower deck **108** at the other end to effect this movement.

Figs. **6-8** illustrate an offset floating hitch wing-type rotary mower apparatus **200** adapted for attachment for towing along the ground in an operating travel direction **T**. The apparatus **200** comprises a central mower deck **208**, and a right and left wing mower decks **208R**, **208L** pivotally attached to respective right and left sides of the central mower deck **208**.

Rear wheels **207** are mounted behind the mower decks **208**, **208R**, **208L** and front wheel assembly **FWA** is mounted to the front end of the central mower deck **208** such that the mower decks **208**, **208R**, **208L** ride along the ground on the wheels **207**, **206.** A cutting blade element, which is conventional and not shown, is rotatably mounted under each mower deck **208**, **208R**, and **208L** so as to rotate about a right, left, and central substantially vertical blade axis.

A floating hitch member **219** is pivotally attached at the mower end **219A** via a vertical shaft **220** inserted in the hitch mount **221** attached to the cross member **210** so as to pivot about a substantially vertical hitch axis **VHA** located above and in front of the front wheel assembly **FWA** of the central mower deck **208**.

The floating hitch member **219** is adapted for pivotal attachment at the tow end **219B** thereof to the tractor about a substantially vertical tow axis **VTA**. A mower angle control comprising of a hydraulic cylinder **222**, and a bell-crank **231** fixedly attached to the vertical shaft **220** as illustrated in Fig. **6** detail. The hitch hydraulic cylinder **222** is operative to selectively pivot the floating hitch member **219** about the vertical hitch axis **VHA.**

The hydraulic cylinder **222** is oriented and configured to move the rotary mower **200** through a range of offset positions between that illustrated minimum offset position in Fig **6** and more offset position that is illustrated Fig. **7**. For a reasonable sized tractor, the greatest offset will be a position wherein the angle of the floating hitch member **219** is somewhat less than perpendicular to the operating travel direction **T**. The configuration can be changed to provide a desired range.

Refer to Fig. **7** the attachment at the hitch member ends **219A**, **219B** further allows the floating hitch member **219** and mower deck **208** to float with respect to the tractor to follow the contours of the ground. The hitch mower end **219A** is pivotally attached to the hitch standard **223** on the hitch mount **221** about a substantial horizontal hitch axis **HHA** oriented transversely to the floating hitch member **219**.

The axis **HHA** is provided by pins **224** on the hitch standard **223**. At the opposite tow end **219B** the floating hitch member **219** is attached to a tractor attachment adaptor that provides a substantially horizontal longitudinal tow axis **HLTA** oriented substantially parallel to the operating travel direction **T**, and a substantially horizontal transverse tow axis **HTTA** substantially perpendicular to the operating travel direction **T**. Pins **225** pass through holes in the ends of the conventional hitch arms of a tractor to provide the axis **HTTA**. Thus the offset rotary mower apparatus **200** can move with respect to the tractor to follow the ground.

A drive is adapted for connection to the tractor and operative to transfer power to the tractor to rotate the cutting blade element. A mechanical drive is incorporated in the embodiments of Fig. **6-8** Alternatively the drive could be hydraulic, requiring only connection of flexible hydraulic line from the tractor to hydraulic motors mounted on the central mower deck **208**.

In the embodiments of Fig. **6-8** the horizontal hitch axis **HHA** intersects the vertical hitch axis **VHA** at an intersection point **226** above the hitch standard **223** and the vertical shaft **220** as illustrated in Fig. **8** detail. Fig. **7** and **8** illustrates the driveline comprising a series of drive shafts **227**, universal joints **228**, and double universal joints **229**, arranged such that the intersection of the vertical hitch axis **VHA** and the horizontal hitch axis **HHA** is located substantially in the center of the double universal joint **229A**.

The double universal joints **229** and universal joints **228** allows connections of the drive shafts **227** where the alignment is at an angle and the location of the **HHA** at the center of the double universal joint **229A** allows proper operation of the drive when the hitch pivots about the horizontal hitch axis **HHA** with respect to the front wheel assembly **FWA** and the attached rotary mower decks **208**,**208R**, and **208L**.

The location of the vertical hitch axis **VHA** at the center of the double universal joint **229A** allows for proper operation of the drive when the hydraulic actuator **222** of the mower angle control is used to vary the offset of the rotary mower apparatus **200**.

The drive line comprising of drive shafts **227**, universal joints **228**, and double universal joints **229** is substantially aligned with the floating hitch member **219** and is adapted at the tow end **219B** thereof for pivotal connection via a primary shaft to a power output shaft of the tractor through another universal joint **228** and stacked gearboxes **230** which pivot with respect to each other about the vertical tow axis **VTA**.

The front end of the central mower deck **208** is supported by the front wheel assembly comprising of two castering wheel assemblies **201** attached at opposite ends to the cross member **210**. Front parallel linkages **211** are pivotally attached at rear ends thereof to opposite sides of the

central mower deck **208** and at the front ends thereof to a cross member **210**. This cross member **210** does not pivot with respect to the central mower deck **208**.

To allow the central mower deck **208** to follow the ground and provide a satisfactory cut, is the same as that described above in the embodiment of Fig. **5**.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

Claims:

1. A rotary mower apparatus adapted for attachment to a tractor for towing along the ground in an operating travel direction, the apparatus comprising;

a central mower deck and right and left wing mower decks pivotally attached to respective right and left sides of the central mower deck;

a plurality of rear wheels mounted behind the mower decks and at least two front wheels mounted to the front end of the central mower deck such that the mower decks ride along the ground on the wheels;

a cutting blade element rotatably mounted under each mower deck so as to rotate about right, left, and central substantially vertical blade axis;

a floating hitch member pivotally attached to the front wheel assembly of the central mower deck and adapted for pivotal attachment at a tow end thereof to the tractor allowing the floating hitch member and front wheel assembly and mower decks to float with respect to the tractor to follow contours of the ground;

a drive adapted for connection to the tractor and operative to transfer power from the tractor to rotate the cutting blade element;

wherein the central mower deck is supported at the front end thereof by a first and second front castering wheel assembly attached to the first and second ends of a substantially horizontal cross member, wherein the cross member is attached to the front end of the central mower deck by a front parallel linkage attached to each side of the front end of the central mower deck and wherein each castering wheel assembly comprises of a vertical shaft for caster; a horizontal wheel mount standard; an axle pivotally attached to the wheel standard; and two wheels; wherein each wheel is attached to the first and second end of the axle, and wherein the wheels are pivotable about a substantially horizontal longitudinal wheel-rocking axis oriented substantially parallel to the operating travel direction.

2. The apparatus of claim 1 wherein the load on the caster axis of the castering wheel assembly stays between the centers of the wheels when on a side slope.

3. The apparatus of claim 1 wherein the wheels of the castering wheel assembly run perpendicular to the running ground surface when on a side slope to allow proper caster.

4. The apparatus of claim 1 wherein each wheel of the castering wheel assembly is arranged such that the distance between the centers of the wheels is greater then one-half the distance between the pivot point on the axle and the running ground surface.

5. The apparatus of claim 1 wherein the central mower deck is supported at the rear end thereof by a dual wheel system comprising two sets of dual rear wheels wherein each wheel in a set is attached to first and second end of a substantially horizontal rear axle, wherein the two axles are pivotally attached to a walking beam standard wherein the wheels are pivotable about a substantial horizontal longitudinal wheel-rocking axis oriented substantially parallel with the operating travel direction, and wherein the walking beam standard is pivotally attached at the center to the rear cross member about a substantially horizontal rear walking axis oriented substantially parallel with the operating travel direction.

6. The apparatus of claim 5 wherein the rear cross member is connected to the central mower deck by a pair of rear parallel linkages that are connected to the front parallel linkages by connecting rods, and wherein an actuator operates to move the front and rear wheels up and down in concert, and the caster axes of the front wheels are maintained substantially vertical.

7. A rotary mower apparatus adapted for attachment to a tractor for towing along the ground in an operating travel direction, the apparatus comprising;

a central mower deck and right and left wing mower decks pivotally attached to respective right and left sides of the central mower deck;

a plurality of rear wheels mounted behind the mower decks and at least two front wheels mounted to the front end of the central mower deck such that the mower decks ride along the ground on the wheels;

a cutting blade element rotatably mounted under each mower deck so as to rotate about right, left, and central substantially vertical blade axis;

a floating hitch member pivotally attached to the front wheel assembly of the central mower deck, so as to pivot about a substantially vertical hitch axis, and adapted for pivotal attachment at a tow end thereof to the tractor about a substantially vertical tow axis and wherein the floating hitch member is pivotally attached to the front wheel assembly of the central mower deck, so as to pivot about a substantially horizontal hitch axis oriented transversely to the floating hitch member and adapted for attachment at the tow end to the tractor attachment adaptor that provides a substantially horizontal longitudinal tow axis oriented substantially parallel to the operating travel direction, and a substantially horizontal transverse tow axis oriented substantially perpendicular to the operating travel direction, the attachments further allowing the floating hitch member and mower decks to float with respect to the tractor to follow contours of the ground;

a drive adapted for connection to the tractor and operative to transfer power from the tractor to rotate the cutting blade element;

a mower angle control operative to selectively pivot the floating hitch member about a vertical hitch axis with respect to the front wheel assembly and mower decks.

wherein the central mower deck is supported at the front end thereof by a first and second front castering wheel assembly attached to the first and second ends of a substantially horizontal cross member, wherein the cross member is attached to the front end of the central mower deck by a front parallel linkage attached to each side of the front end of the central mower deck and wherein each front castering wheel assembly comprising a vertical shaft for castering; a horizontal wheel mount standard; an axle pivotally attached to the wheel standard; and two wheels; wherein each wheel is attached to the first and second end of the axle, and wherein the wheels are pivotable about a substantially horizontal longitudinal wheel-rocking axis oriented substantially parallel to the operating travel direction.

8. The apparatus of claim 7 wherein the central mower deck is supported at the rear end thereof by a dual wheel system comprising two sets of dual rear wheels wherein each wheel in a set is attached to first and second end of a substantially horizontal rear axle, wherein the two axles are pivotally attached to a walking beam standard wherein each wheel is pivotable about a substantial horizontal longitudinal wheel-rocking axis oriented substantially parallel with the operating travel direction, and wherein the walking beam standard is pivotally attached at the center to the rear cross member

about a substantially horizontal rear walking axis oriented substantially parallel with the operating travel direction.

9. The apparatus of claim **8** wherein the rear cross member is connected to the central mower deck by a pair of rear parallel linkages that are connected to the front parallel linkages by connecting rods, and wherein an actuator operates to move the front and rear wheels up and down in concert, and the caster axes of the front wheels are maintained substantially vertical.

10. The apparatus of claim **7** wherein each wheel of the castering wheel assembly is arranged such that the distance between the centers of the wheels is greater then one-half the distance between the pivot point on the axle and the running ground surface.

11. The apparatus of claim **7** wherein the wheels of the castering wheel assembly run perpendicular to the running ground surface when on a side slope to allow proper caster.

12. The apparatus of claim **7** wherein the load on the caster axis of the castering wheel assembly stays between the centers of the wheels when on a side slope.

13. The apparatus of claims **7** where in the rotary mower apparatus has a single deck.

14. A rotary mower apparatus adapted for attachment to a tractor for towing along the ground in an operating travel direction, the apparatus comprising;

a central mower deck and right and left wing mower decks pivotally attached to respective right and left sides of the central mower deck;

a plurality of rear wheels mounted behind the mower decks and at least two front wheels mounted to the front end of the central mower deck such that the mower decks ride along the ground on the wheels;

a cutting blade element rotatably mounted under each mower deck so as to rotate about right, left, and central substantially vertical blade axis;

a floating hitch member pivotally attached to the front wheel assembly of the central mower deck, so as to pivot about a substantially horizontal hitch axis oriented transversely to the floating hitch member and adapted for attachment at the tow end to the tractor attachment adaptor that provides a substantially horizontal longitudinal tow axis oriented substantially parallel to the operating travel

direction, and a substantially horizontal transverse tow axis oriented substantially perpendicular to the operating travel direction, the attachments further allowing the floating hitch member and mower decks to float with respect to the tractor to follow contours of the ground;

a drive adapted for connection to the tractor and operative to transfer power from the tractor to rotate the cutting blade element; wherein the drive comprises; gearboxes, drive shafts, universal joints, and double universal joints.

a mower angle control comprising a hydraulic actuator and a bell crank fixedly attached to the vertical shaft operative to selectively pivot the floating hitch member about a vertical hitch axis with respect to the front wheel assembly of the central mower deck.

wherein the horizontal hitch axis intersects the vertical hitch axis at a point above the hitch standard and the vertical shaft and this point is located substantially in the center of a double universal joint and wherein the location of the horizontal hitch axis at the center of the double universal joint allows proper operation of the drive when the hitch pivots about the horizontal hitch axis with respect to the attached front wheel assembly of the central mower deck.

15. The apparatus of claim **14** wherein the central mower deck is supported at the front end thereof by a first and second front castering wheel assembly attached to the first and second ends of a substantially horizontal cross member, wherein the cross member is attached to the front end of the central mower deck by a front parallel linkage attached to each side of the front end of the central mower deck and wherein each castering wheel assembly comprises of a vertical shaft for castering; a horizontal wheel mount standard; an axle pivotally attached to the wheel standard; and two wheels; wherein each wheel is attached to the first and second end of the axle, and wherein the wheels are pivotable about a substantially horizontal longitudinal wheel-rocking axis oriented parallel to the operating travel direction.

16. The apparatus of claim **15** wherein each wheel of the castering wheel assembly is arranged such that the distance between the centers of the wheels is greater then one-half the distance between the pivot point on the axle and the running ground surface.

17. The apparatus of claim **15** wherein the wheels of the castering wheel assembly run perpendicular to the running ground surface when on a side slope to allow proper caster.

18. The apparatus of claim **15** wherein the load on the caster axis of the castering wheel assembly stays between the centers of the wheels when on a side slope.

19. The apparatus of claim **14** wherein the central mower deck is supported at the rear end thereof by a dual wheel system comprising two sets of dual rear wheels wherein each wheel in a set is attached to first and second end of a substantially horizontal rear axle, wherein the two axles are pivotally attached to a walking beam standard wherein each wheel is pivotable about a substantial horizontal longitudinal wheel-rocking axis oriented substantially parallel with the operating travel direction, and wherein the walking beam standard is pivotally attached at the center to the rear cross member about a substantially horizontal rear walking axis oriented substantially parallel with the operating travel direction.

20. The apparatus of claim **19** wherein the rear cross member is connected to the central mower deck by a pair of rear parallel linkages that are connected to the front parallel linkages by connecting rods, and wherein an actuator operates to move the front and rear wheels up and down in concert, and the caster axes of the front wheels are maintained substantially vertical.

21. The apparatus of claim **14** wherein the drive is substantially aligned with the floating hitch member.

22. The apparatus of claim **14** wherein the rotary mower apparatus has a single deck.

23. A rotary mower apparatus adapted for attachment to a tractor for towing along the ground in an operating travel direction, the apparatus comprising;

a central mower deck and right and left wing mower decks pivotally attached to respective right and left sides of the central mower deck;

a plurality of rear wheels mounted behind the mower decks and at least two front wheels mounted to the front end of the central mower deck such that the mower decks ride along the ground on the wheels;

a cutting blade element rotatably mounted under each mower deck so as to rotate about right, left, and central substantially vertical blade axis;

a floating hitch member pivotally attached to the front wheel assembly of the central mower deck, so as to pivot about a substantially vertical hitch axis and adapted for pivotal attachment at a tow end thereof to the tractor about a substantially vertical tow axis, the attachments further allowing the floating hitch member and mower decks to float with respect to the tractor to follow contours of the ground wherein the tow end of the floating hitch is further adapted to the tractor about a substantially horizontal longitudinal tow axis oriented substantially parallel to the operating travel direction, and about a substantially horizontal transverse tow axis orientated substantially perpendicular to the operating travel direction;

a drive adapted for connection to the tractor and operative to transfer power from the tractor to rotate the cutting blade element, wherein the drive comprises; gearboxes, drive shafts, universal joints, and double universal joints.

a mower angle control comprising of a hydraulic actuator and a bell crank fixedly attached to the vertical shaft, operative to selectively pivot the floating hitch member about a vertical hitch axis with respect to the front wheel assembly of the central mower deck.

wherein the vertical hitch axis intersects the horizontal hitch axis at a point coincidental with the vertical shaft and located substantially in the center of the double universal joint, and wherein the location of the vertical hitch axis at the center of a double universal joint allows for proper operation of the drive when the mower angle control is used to vary the offset of the rotary mower apparatus.

24. The apparatus of claim **23** wherein the central mower deck is supported at the front end thereof by a first and second front castering wheel assembly attached to the first and second ends of a substantially horizontal cross member, wherein the cross member is attached to the front end of the central mower deck by a front parallel linkage attached to each side of the front end of the central mower deck and wherein each castering wheel assembly comprises of a vertical shaft for castering; a horizontal wheel mount standard; an axle pivotally attached to the wheel standard; and two wheels; wherein each wheel is attached to the first and second end of the axle, and wherein the wheels are pivotable about a substantially horizontal longitudinal wheel-rocking axis oriented parallel to the operating travel direction.

25. The apparatus of claim **24** wherein each wheel of the castering wheel assembly is arranged such that the distance between the centers of the wheels is greater then one-half the distance between the pivot point on the axle and the running ground surface.

26. The apparatus of claim **24** wherein the wheels of the castering wheel assembly run perpendicular to the running ground surface when on a side slope to allow proper caster.

27. The apparatus of claim **24** wherein the load on the caster axis of the castering wheel assembly stays between the centers of the wheels when on a side slope.

28. The apparatus of claim **23** wherein the central mower deck is supported at the rear end thereof by a dual wheel system comprising two sets of dual rear wheels wherein each wheel in a set is attached to first and second end of a substantially horizontal rear axle, wherein the two axles are pivotally attached to a walking beam standard wherein each wheel is pivotable about a substantial horizontal longitudinal wheel-rocking axis oriented substantially parallel with the operating travel direction, and wherein the walking beam standard is pivotally attached at the center to the rear cross member about a substantially horizontal rear walking axis oriented substantially parallel with the operating travel direction.

29. The apparatus of claim **28** wherein the rear cross member is connected to the central mower deck by a pair of rear parallel linkages that are connected to the front parallel linkages by connecting rods, and wherein an actuator operates to move the front and rear wheels up and down in concert, and the caster axes of the front wheels are maintained substantially vertical.

30. The apparatus of claim **23** wherein the drive is substantially aligned with the floating hitch member.

31. The apparatus of claims **23** where in the rotary mower apparatus has a single deck.

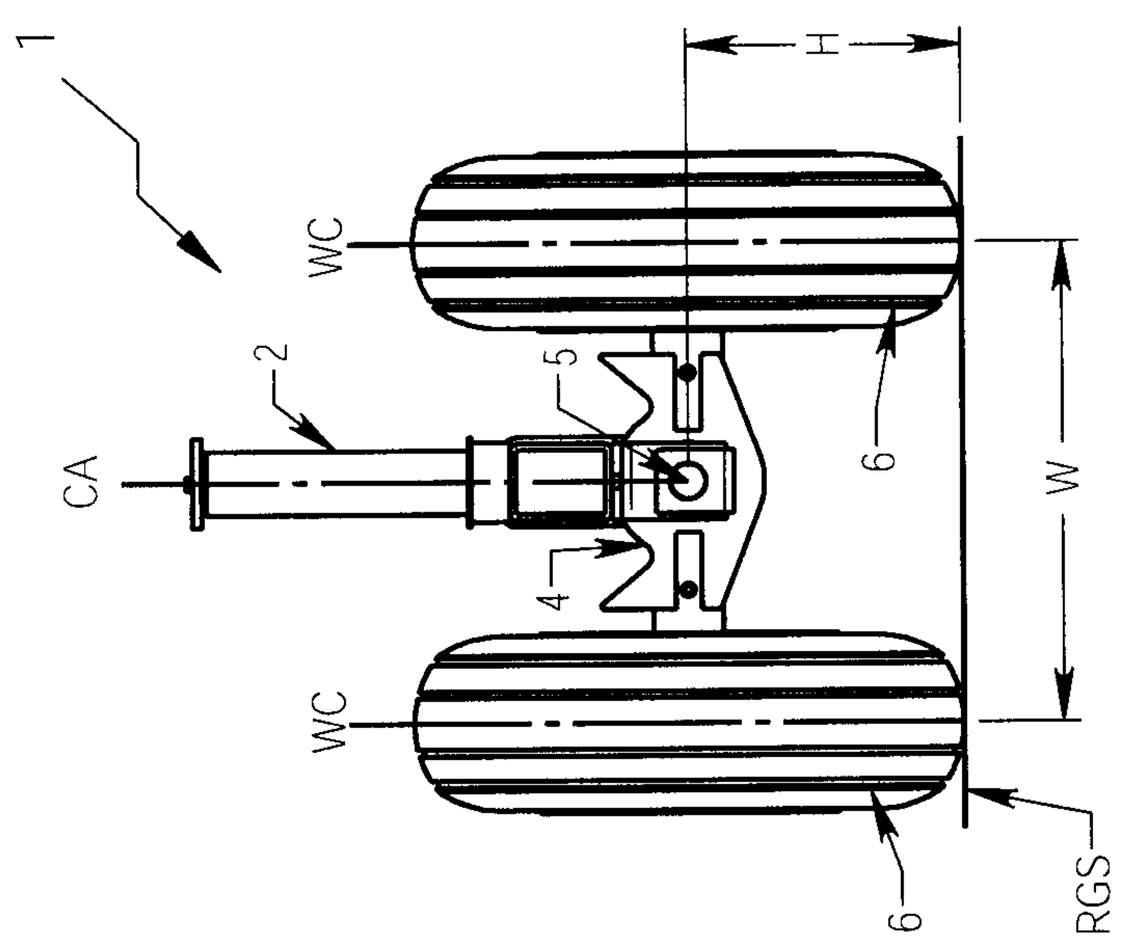

FIG. 1

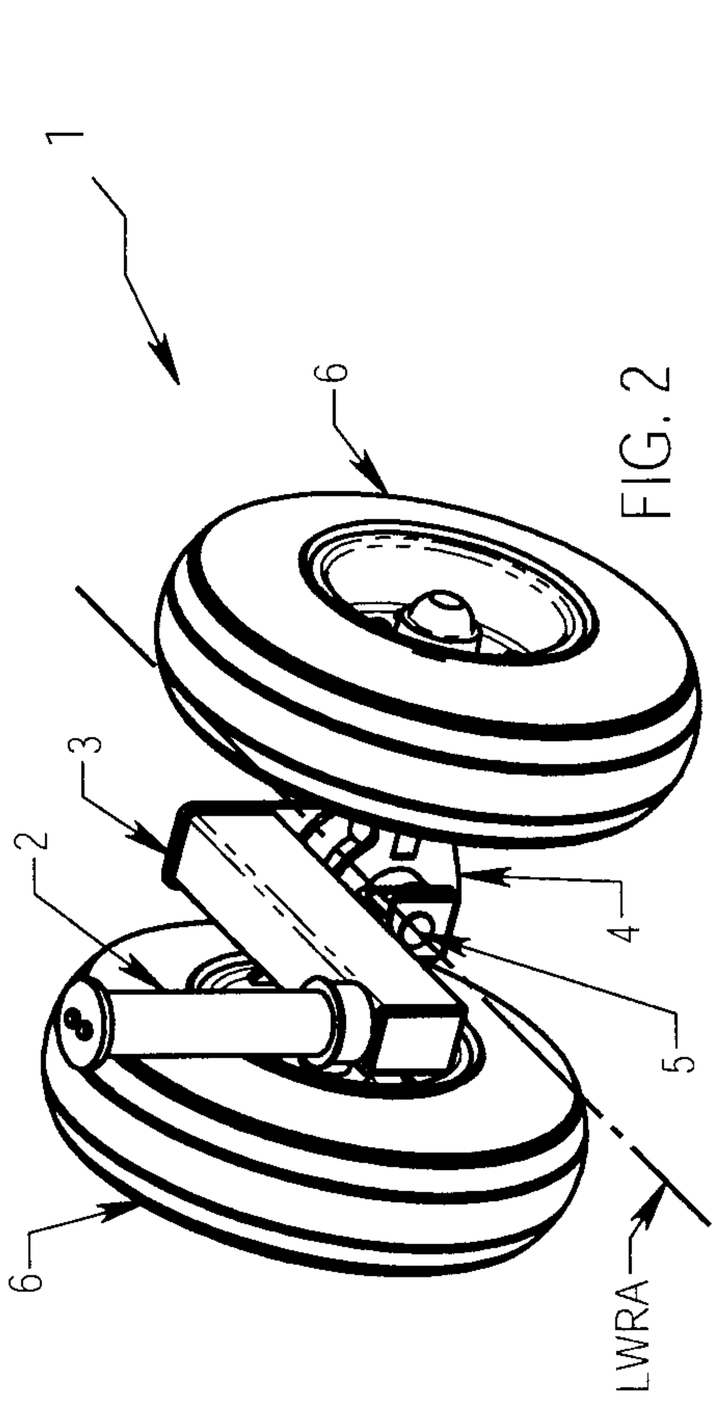

FIG. 2

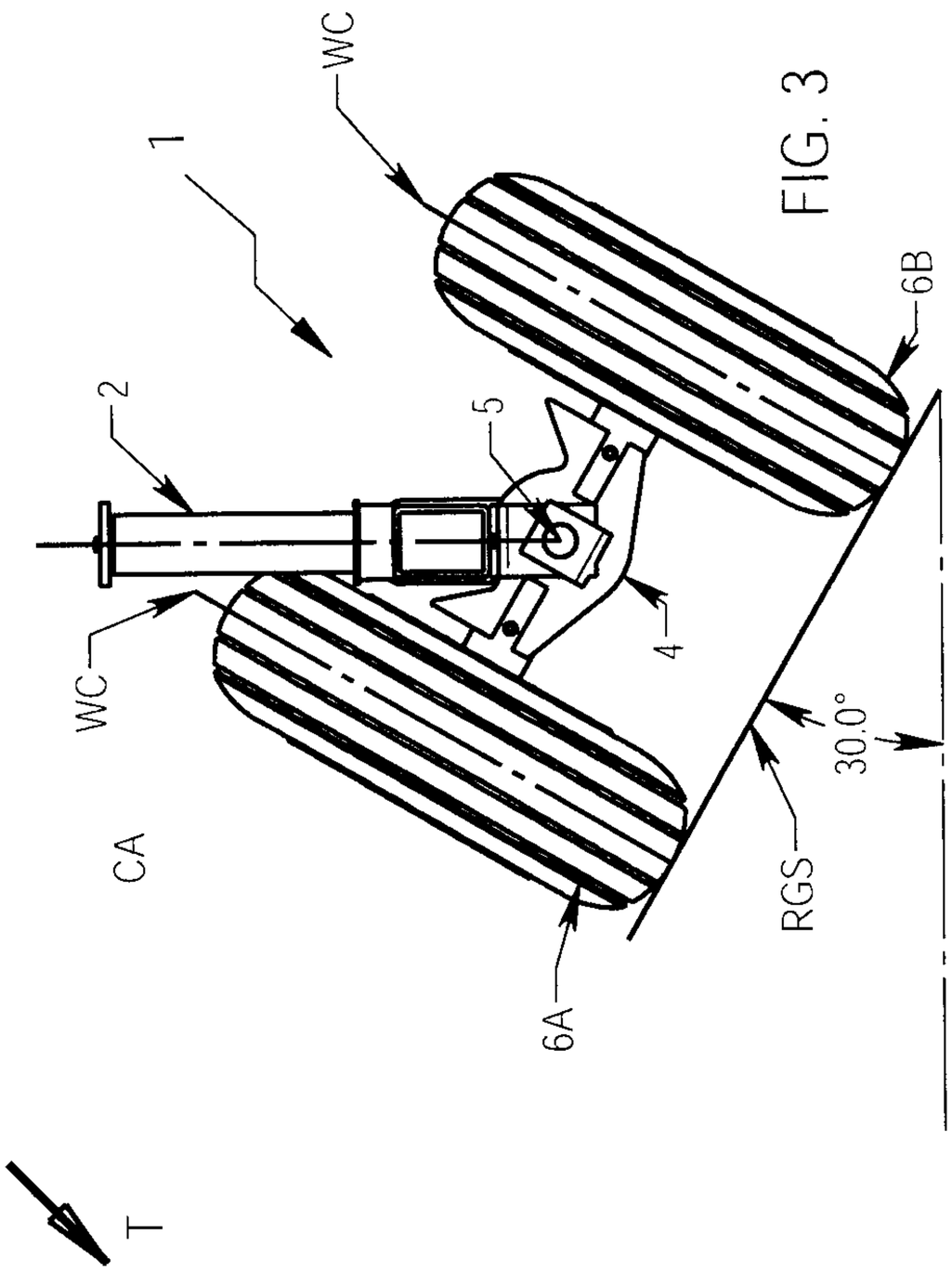

FIG. 3

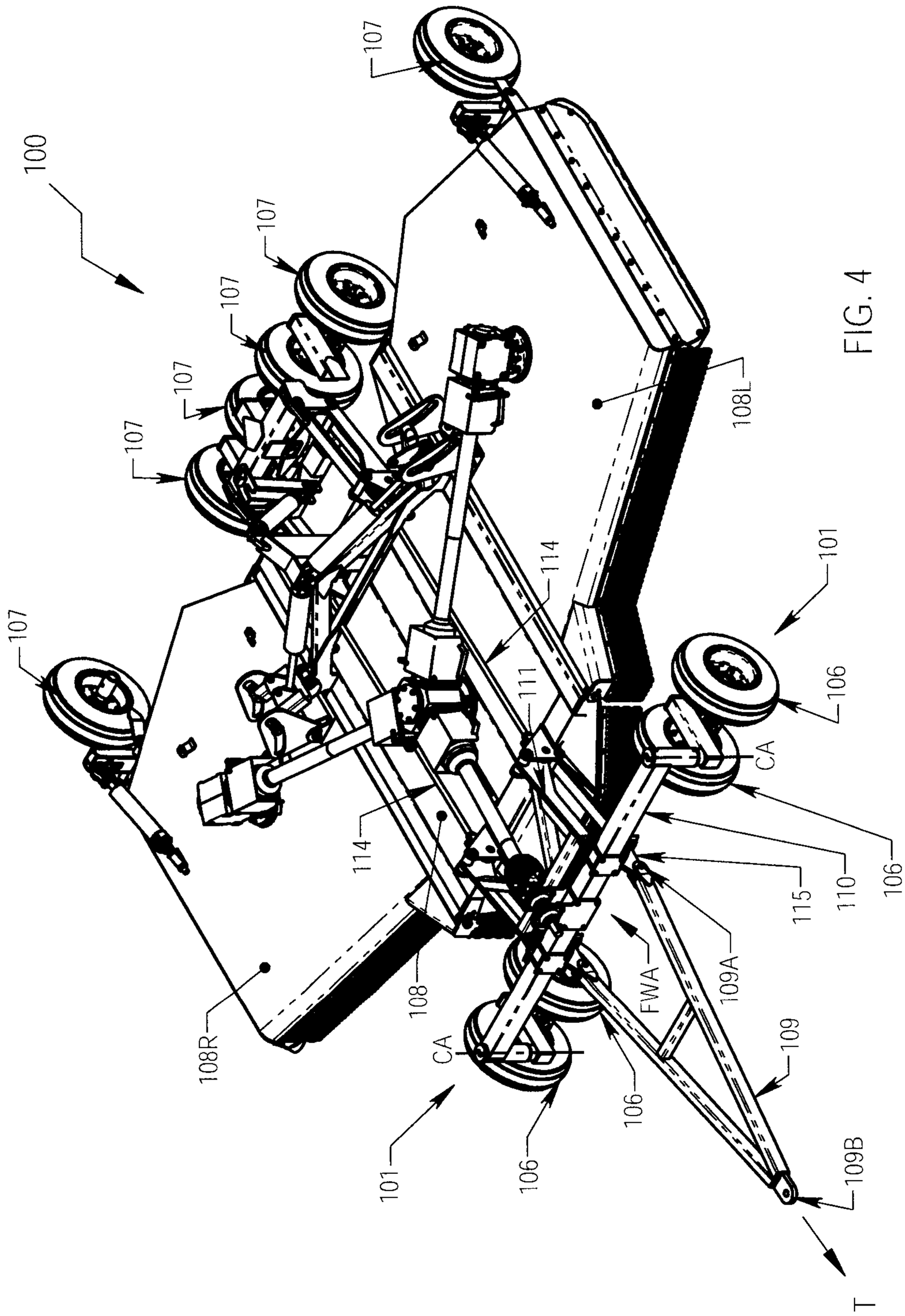
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FIG. 4

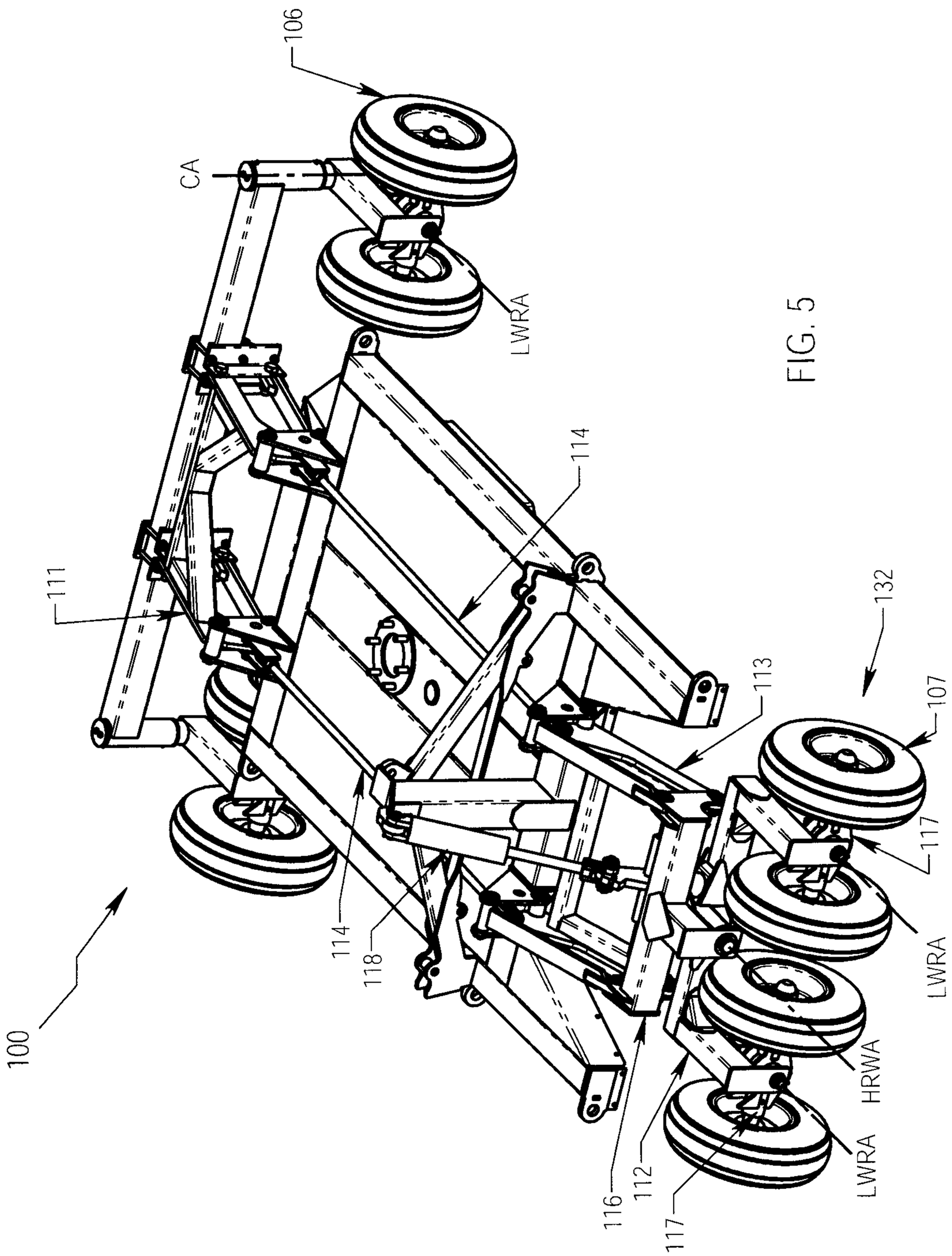
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FIG. 5

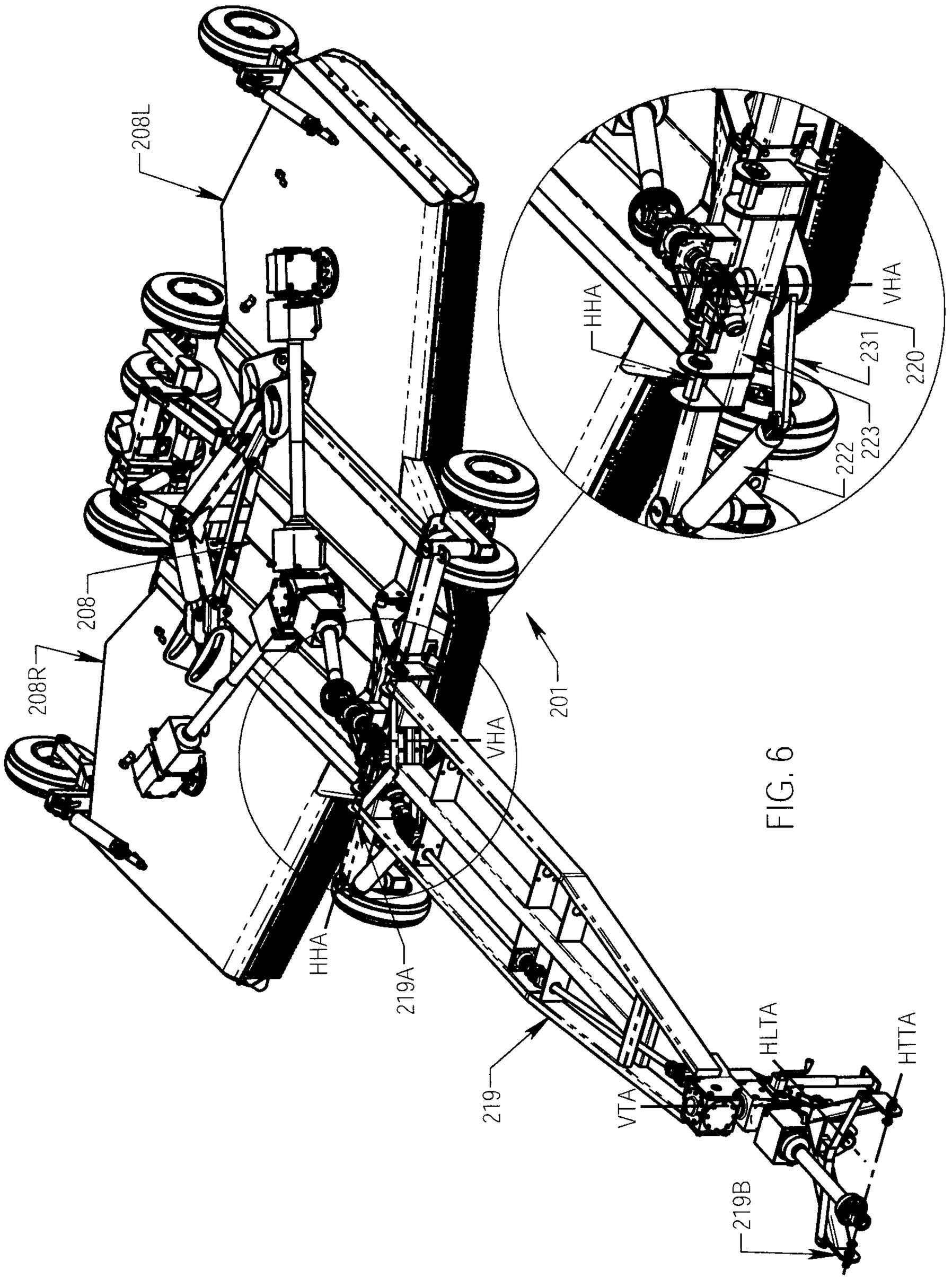
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FIG. 6

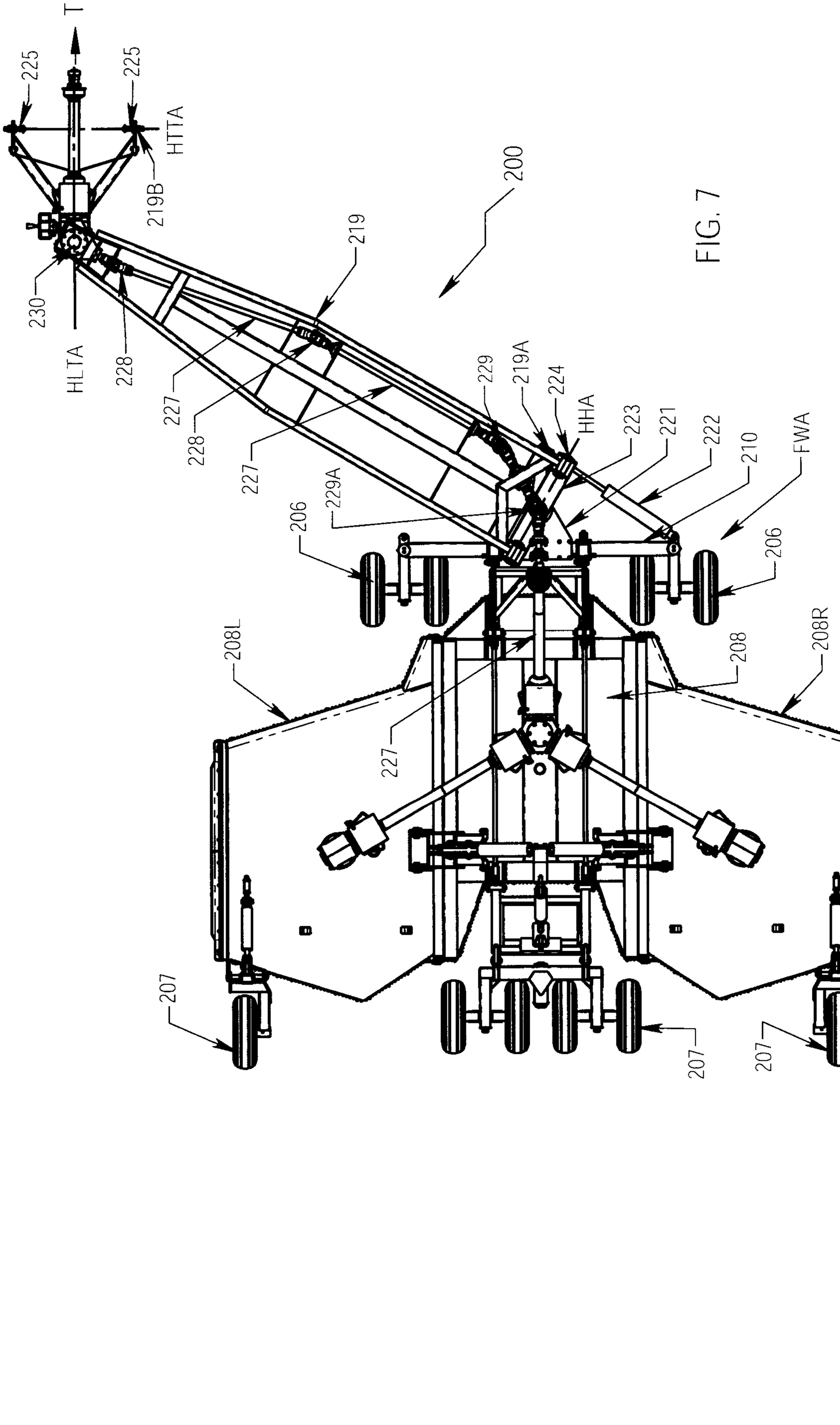
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FIG. 7

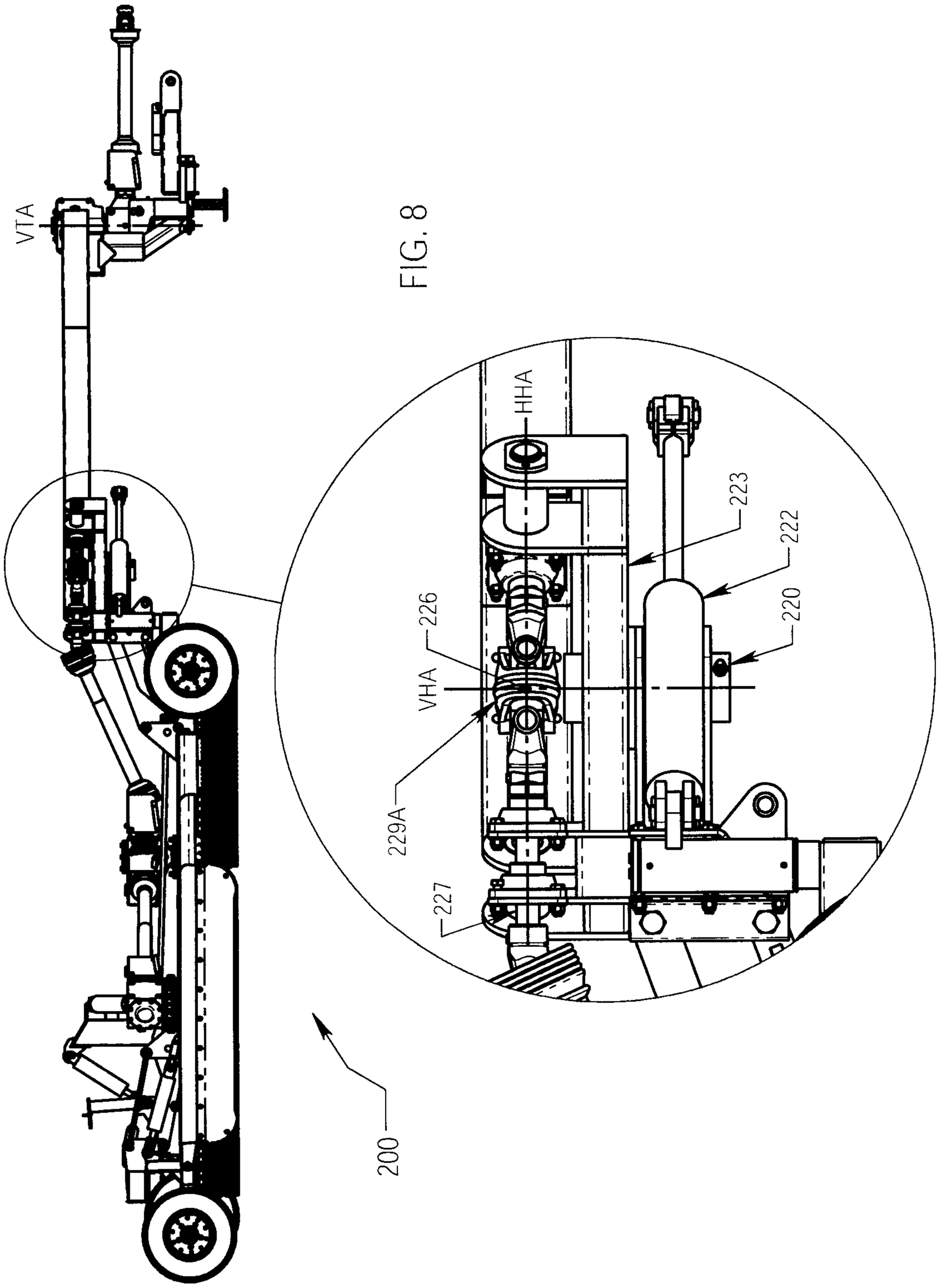
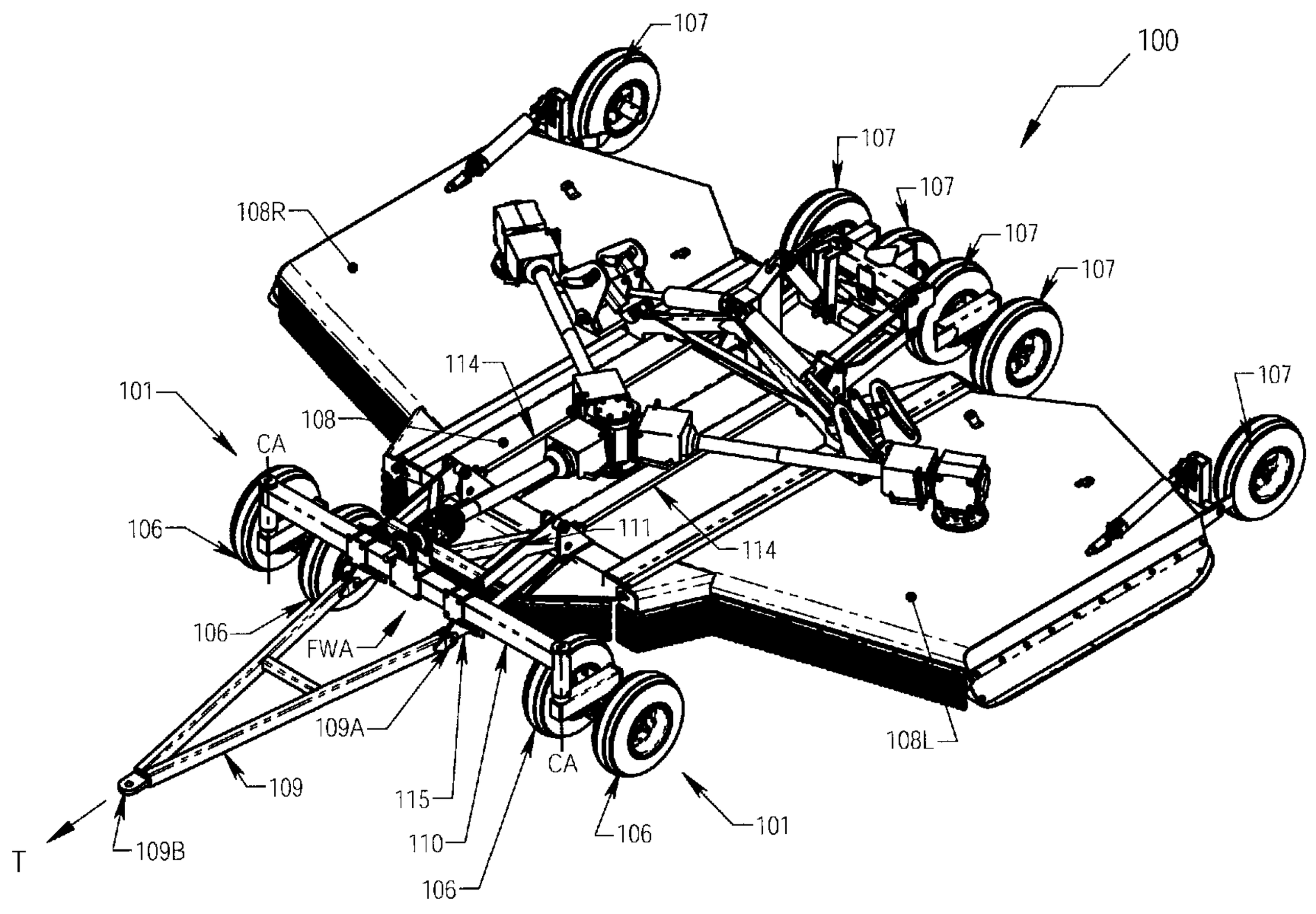


FIG. 8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