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(54) **SUSPENDED DRIVE AXLE AND AGRICULTURAL TRACTOR WITH SAME**

AUFGEHÄNGTE ANTRIEBSACHSE UND LANDWIRTSCHAFTLICHE ZUGMASCHINE MIT DIESER ACHSE

ARBRE D'ENTRAINEMENT SUSPENDU ET TRACTEUR AGRICOLE EQUIPE D'UN TEL ARBRE

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Description

Field of the Invention

[0001] The present invention relates to an agricultural tractor with a suspended drive axle and in particular to a tractor having an independent rear suspension. The present invention also relates to a universal joint for transmitting rotational power and to a suspension drive axle for a work vehicle.

Background of the Invention and Prior Art

[0002] An agricultural tractor is intended primarily for off-road usage and is designed primarily to supply power to agricultural implements. An agricultural tractor propels itself and provides a draft force in the direction of travel to enable an attached, soil engaging, implement to perform its intended function. Furthermore, an agricultural tractor may provide mechanical, hydraulic and/or electrical power to the implement. Agricultural tractors must be designed with sufficient normal force, down force, acting on the drive wheels to produce the needed draft force. Typically, in a two-wheel drive tractor, this results in a vehicle having rear drive wheels that are larger then the front wheels to accommodate the required normal force on the rear drive wheels. Agricultural tractors differ from cargo carrying vehicles, such as pickup trucks and semi-truck tractors, in that trucks do not need to produce a continuous draft load. A truck produces a draft load only during periods of acceleration and deceleration and relies on the weight of the cargo carried by the drive wheels to produce the draft load.

[0003] The productivity of an agricultural tractor can be increased by faster travel speeds in the field and on the road. A significant limiting factor to the travel speed of an agricultural tractor is the comfort of the operator when travelling over rough surfaces. A typical tractor has an integrated structure in which the rear axle and hitch are integrated into one unit and forms a part of the vehicle frame structure. In such a case, there is no suspension between the rear axle and the tractor frame. Tire deflection alone provides a cushioning between a rough surface and the tractor frame. Seat suspensions and cab suspensions have also been used with limited success to improve operator comfort.

[0004] The front axle, which may or not be driven, is typically a beam axle pivotally mounted to the tractor for limited rotation about a longitudinal axis. Suspended front axles have been developed for tractors such as that shown in U.S. Patent 5,879,016. There, a rigid beam axle having outboard planetary final drives is suspended from the tractor frame. Suspended front axles have provided improved comfort for operators.

[0005] However, due to the lack of a rear suspension, significant loads caused by an uneven terrain are still transmitted to the vehicle frame and to the vehicle operator. Tractor speed, particularly in the field, is limited by the jostling of the operator. Operator fatigue occurs sooner the more the operator is jostled in the cab. Thus there exists a need for a rear suspension in an agricultural tractor to reduce operator fatigue, thereby allowing the operator to productively work longer hours and/or to operate at a faster travel speed.

[0006] One attempt at providing a rear suspension is shown in U.S. Patent 5,538,264. There, a rear beam axle is suspended from the tractor frame. To include the suspension, the tractor design deviates from a conventional row crop tractor of comparable power in at least the following respects: 1) the rear axle is equipped with outboard final planetary drives instead of inboard final drives; 2) the tractor is equipped with four equal sized tires, all smaller than the large rear tires on a conventional row crop tractor of comparable power; and 3) the rear axle is moved substantially rearward relative to the tractor cab, as compared to a conventional row crop tractor.

[0007] The outboard final drives limit the adjustability of the tread width and prevent the tread width from being infinitely adjustable along the axle. Only discrete changes in the tread width are available through different wheel and rim configurations. Of the commercially available tractors embodying the invention of the U.S. Patent 5,538,264, only to lowest power tractors are available with a tread width as narrow as 152,4 cm (60 inches). The smaller tires have a lower load carrying capability, resulting in less traction. The rearward location of the rear axle relative to the cab interferes with visibility of the hitch by the operator. An additional disadvantage of this design is that the tractor hitch is carried by the suspended axle, and is thus part of the unsprung mass. The lack of a suspension for the hitch results in towed implements following the vertical motion of the tires and axle as opposed to the more steady movements of the tractor frame. A further disadvantage is that the beam axle does not enable an independent suspension.

[0008] As a result of all the differences between the tractor of the '264 patent and a conventional row crop tractor, the '264 tractor does not achieve the same level of performance of a comparable power row crop tractor. The tractor of the '264 patent does allow increased travel speeds, both in the field and on the road, but at a significant 'cost' in terms of performance in the field. The tractor of the '264 patent is designed more for use as a hauling vehicle and for road transport than for field work pulling a soil engaging implement. Accordingly, there still exists a need for a row crop tractor having a rear suspension while maintaining the performance and operational characteristics of a row crop tractor of comparable power with a rigid, non-suspended, rear drive axle.

[0009] A row crop agricultural tractor is designed to operate in the field with the tread width set for the wheels to travel between rows. Conventionally, this has meant a tractor with a tread width as narrow as 152,4 cm (60 inches), enabling the tractor to straddle two crop rows spaced 76,2 cm (30 inches) apart. The tread width is adjustable so that it can be customized for a particular

farm application with row spacings other than 76,2 cm (30 inches). Infinite adjustability can be provided by wheel hubs that clamp to an axle at any location along a length of the axle. This type of adjustment mechanism necessitates an inboard planetary final drive. Other adjustment mechanisms involve changing the wheel rim and disc configuration to change the tread width.

[0010] Small row crop tractors such as the JOHN DEERE 6010 Series tractors have power ratings ranging between 49 kW to 71 kW (65-95hp). Large row crop tractors such as the JOHN DEERE 8010 series tractors range in power from 123kW to 175kW (165 to 235hp). These tractors all have inboard final drives to enable an infinitely adjustable tread width. In the JOHN DEERE 8010 series tractors, the width of the rear differential case, between the inboard planetary final drives, is 665 mm (26.2 inches). A rear suspension must be packaged outboard of the final drive and inboard of the wheel mounting equipment at a 152,4 cm (60 inches) tread width to maintain the same row-crop capabilities in a suspended tractor of this size as in the non-suspended tractor.

[0011] EP 0 807 543 A2 discloses an axle of an agricultural tractor according the preamble of claim 1, and also the closest known prior art universal joint with respect to claim 30.

Objects of the Invention

[0012] It is an object of the present invention to provide an agricultural tractor with which the recited problems are overcome and the desires are met. In particular it is an object of the present invention to provide an agricultural tractor with a rear suspended drive axle which achieve the requirements of a crop row tractor with adjustable tread width. Furthermore it is an object of the present invention to provide an universal joint and a suspension system which couple the drive axle housing and the axle shafts of the vehicle movable to the vehicle frame structure.

Summary of the Invention

[0013] The objects are solved according to the invention by the teaching of one of the claims 1 and 30. Further advantageous arrangements and developments of the invention appear from the dependent claims.

[0014] In an advantageous embodiment of the present invention the tractor maintains the transmission, rear differential and inboard planetary final drive assembly of a comparable sized row crop tractor without a rear suspension. The tractor of the present invention provides left and right suspended axle housings each coupled to the final drive housing by a pair of suspension control arms and one or more spring assemblies. Left and right axle shafts are carried by the suspended axle housings and are coupled to the final drive outputs by a constant velocity joint, such as a double cardan joint. The constant velocity joint is configured with the end of the final drive output closely spaced from the inboard end of the axle shaft. The remainder of the joint, the two journal members and the connecting link, are larger in diameter and radially surround the shaft ends. This arrangement of the joints reduces the axially length of the universal joint to a minimum, to enable the suspension to be packaged in the narrow space available. A relatively large constant velocity joint is needed since it is downstream of the final drive, thus transmitting a large torque.

[0015] The fixed axle housing of a non-suspended axle, which extends outward from the final drive, is replaced by an inner suspension housing, fixed to the differential case. The upper and lower control arms extend from the inner suspension housing to the suspended axle housing. The axle shaft is supported by the axle housing and extends outwardly therefrom. Wheels are mounted to the left and right axle shafts in the same manner as in a non-suspended axle, providing infinite tread width adjustability. Dual tire capability is also maintained. One or more spring assemblies extending between the inner suspension housing and the axle housing allow the axle housing to resiliently move up and down relative to the tractor frame. By mounting the suspension to the differential case in place of the fixed axle housing of a non-suspended axle, a suspension axle is produced with only a few modifications to a non-suspended axle. As a result, a manufacturer can economically offer both suspended and non-suspended tractor models.

[0016] Preferably the tractor has an integrated structure in which the central housing of the drive axle forms a part of the vehicle frame structure. But it is also possible that the central housing is fixed to a separate tractor frame and the axle housings are movably coupled to the frame. The tractor hitch is mounted to the central housing of tractor frame.

Brief Description of the Drawings

[0017]

Figure 1 is a side view of a row crop tractor.

Figure 2 is a rear perspective view of a prior art non-suspended rear drive axle for the tractor of Fig. 1.

Figure 3 is a rear perspective view of the non-suspended rear drive axle shown in Fig. 2 with the left side axle housing removed to illustrate the inboard planetary final drive.

Figure 4 is a rear view of the left side suspension system of the present invention mounted to the differential case of the rear axle shown in Figs. 2 and 3.

Figure 5 is a front view of the left suspension system shown in Fig. 4.

Figure 6 is a cross sectional view through the connecting link as seen from substantially the line 6-6 of Fig. 5

Figure 7 is sectional view through the suspension upper control arm.

Figure 8 is sectional view through the suspension

lower control arm

Figure 9 is a fragmentary view of the ball joint attachment of the upper control arm to the outer suspension housing.

Figure 10 is a cross sectional view of the universal joint connecting the planetary final drive to the axle shaft.

Figure 11 is an exploded perspective view of the universal joint shown in Fig. 11.

Figure 12 is an elevational view of an alternative embodiment of the left suspension system including a rear wheel steering cylinder.

Figure 13 is an exploded perspective view of an exemplary tread width adjustment mechanism for a wheel.

Figure 14 is a simplified electro-hydraulic schematic.

Figure 15 is a side view of an articulated four-wheel drive tractor.

Description of the Preferred Embodiment

[0018] An agricultural row crop tractor 10 is shown in Fig. 1. The tractor 10 includes a frame 12, front tire and wheel assemblies 14, rear tire and wheel assemblies 16 and an operator station 18, including a cab. A hood 20 covers an engine 22.

[0019] With reference to Figs. 2 and 3, a non-suspended rear drive axle assembly 26 for the tractor 10 is shown. The rear drive axle assembly includes a differential case 28 mounted to a transmission housing 30 and located rearward thereof. The differential case 28 and transmission housing 30 are part of the powertrain and are rigidly secured to the tractor frame 12 and become a part of the frame 12. The differential case 28 is thus part of the tractor structure. A three-point hitch (not shown) is mounted to the upper portion 32 of the rear face of the differential case while a PTO housing (not shown) is mounted to the lower portion 34 of the rear face. The rearwardly extending shaft 36 drives the PTO.

[0020] Left and right axle housings 40, 42 support axle shafts 44, 46 extending to the left and right. The rear tires 16 are mounted to the axle shafts 44, 46. The left axle housing 40 is mounted to the differential case 28 through a plurality of bolts 48. The axle housing 40 is bolted to the ring gear 50 of the left inboard planetary final drive 52 (Fig. 3). The planetary final drive 52 includes a driven sun gear 54, a plurality of planet gears 56 and the stationary ring gear 50 that forms part of the differential case 28. A planet carrier 172, shown in Figs. 10 and 11, supports the planet gears 56. The carrier 172 is splined to the axle shaft 44 to drive the axle shaft 44 as the planet gears 56 travel around the ring gear 50. A right planetary final drive assembly includes the same components as the left planetary final drive assembly 52. Only the ring gear 58 of the right final drive is shown.

The Suspension

[0021] The suspension 60 of the present invention is illustrated in Fig. 4 where only the left side is shown. A substantially identical suspension 60 is provided on both the left and right sides of the tractor 10. The suspension assembly 60 includes an inner suspension housing 62 bolted to the final drive ring gear 50 in place of the axle housing 40 of the non-suspended axle shown in Fig. 2. Upper and lower control arms 64, 66 are mounted to the inner suspension housing 62 for pivotal motion about upper and lower axes 68, 70 (Figs. 7 and 8). At their outer ends, the control arms 64, 66 support an axle housing 72 through upper and lower ball joints 74, 76. The couplings of the upper and lower control arms 64, 66 to the inner suspension housing and to the axle housing are shown in greater detail with reference to Figures 7 and 8.

[0022] The differential case 28, the final drive ring gears 50, 58 and the left and right inner suspension housings 62 form a ridged body also referred to herein as a central housing. The central housing is attached to the tractor frame 12 and is part of the frame structure to which other vehicle components, such as the cab, are mounted.

[0023] An axle shaft 80 is rotatably carried by the axle housing 72 and extends laterally outwardly therefrom. The rear wheels and tires 16 of the tractor 10 are mounted to the axle shaft 80 as described below.

[0024] Vertical loads are transmitted between the inner suspension housing 62 and the axle housing 72 by front and rear hydraulic cylinders 82, 84. The cylinders 82, 84 are each coupled to the inner suspension housing 62 through a clevis 86 while the cylinder rods 88 are each coupled to the axle housing 72 by a clevis 90. The clevises 86, 90 can be integral with the inner suspension housing 62 and the axle housing 72 or separate items attached thereto.

[0025] Figure 4 shows the suspension 60 from the rear with the suspension components in a nominal, or centered, position relative to the tractor frame 12. Figure 5 shows the suspension 60 from the front with the rods 88 of the cylinders 82, 84 extended. This places the axle shaft 88 in a lowered position relative to the chassis as would occur when the left tire encountered a rut or depression in the ground surface. The axle shaft 80 is lower than the axis 170 of the planet carrier 172. The upper and lower control arms 64, 66 are downwardly inclined, as is the universal joint 150.

[0026] The axle housing 72 is coupled to the distal ends of the upper and lower control arms 64, 66 by upper and lower ball joints 74, 76, respectively, as described in more detail below. The ball joints allow the axle housing 72 to pivot about a generally upright axis passing through the ball joints 74, 76. To prevent this pivoting motion and keep the rear tires aligned with the tractor 10 fore and aft longitudinal axis, a fixed length connecting link 96 is coupled to the inner suspension housing 62 and the axle housing 72 on the front side of the suspension 60 (Figs. 5 and 6). The connecting link 96 prevents pivotal motion

of the axle housing 72 about the upright axis passing through the ball joints 74, 76.

[0027] The structure and attachment of the connecting link 96 is shown in Fig. 6. The link 96 is made of two halves 91, 92 that surround the front hydraulic cylinder 82. The halves are fastened to pivot balls 93 by shoulder bolts 94. The pivot balls 93 are fixed in sockets in mounting studs 95. The studs 95 are threaded into the inner suspension housing 62 and the axle housing 72. The ball and socket connections enable the connecting link 96 to pivot relative to the inner suspension housing 62 and the axle housing 72 as the axle housing 72 moves up and down.

[0028] The upper control arm 64 is shown in greater detail with reference to Fig. 7. The inner end of the control arm 64 is forked, forming a clevis that surrounds a mounting boss 98 of the inner suspension housing 62. A pivot pin 100 is press fit into the boss 98. A bearing set 102 in each fork of the clevis surrounds the pivot pin 100. Snap ring grooves 104 are formed in each fork of the clevis to receive a snap ring to retain the bearings 102. The pivot pin 100 defines the upper axis 68.

[0029] The upper and lower ball joints 74, 76 at the outer ends of the control arms 64, 66 are shown with reference to Figs. 7, 8, and 9. The ball joints 74, 76 include a spherical socket 132 in the control arms 64, 66 at the distal ends thereof. A ball stud 134 has a spherical ball portion 135 and oppositely extending studs 136, 137. The ball stud 134 is retained in the socket 132 by a treaded collar 138 in a known manner for a ball joint.

[0030] A pair of identical mounting blocks 140 (Fig. 9) attaches the ball studs 134 to the axle housing 72. The mounting blocks 140 each have a cross bore 142 that receives one stud of the ball stud 134. Each mounting block 140 has a slot 144 extending outward from the bore 142. Through bores transverse to the cross bore 142 receive bolts 146 that attach the mounting blocks 140 to the axle housing 72. The bolt 146 passing through the slot 144 clamps the mounting block 140 onto the stud to fix the ball stud 134 from rotation. The ball stud 134, together with the mounting blocks 140 and outer suspension housing, is allowed to pivot within the socket 132 at the end of the control arm 64, 66. An internal passage 148 in the ball stud 134 allows the ball joint to be lubricated. A grease fitting, not shown, is place in the passage 148 at the end of the stud 136.

[0031] The lower control arm 66 is shown in greater detail with reference to Fig. 8. The lower control arm 66 is generally Y shaped having front and rear legs 112, 114 separately attached to the inner suspension housing 62. The front leg 112 has a bore 115 therein which receives a doubled tapered roller bearing set 116 and seals 117. A mounting pin 118 extends through the bearing set 116 and is held in the bearings by a shoulder 119 at one end of the pin 118 and a nut 120 at the other end. A pair of bolts 121 fixes the pin 118 to the inner suspension housing 62.

[0032] The rear leg 114 is forked, forming a clevis 122 that surrounds a mounting boss 123 of the inner suspension housing 62. A pivot pin 124, a bushing 126 and a needle bearing set 127 are mounted in a bore 128 in the boss by a bolt 129. The end of the bolt 129 is threaded into one side of the clevis 122. The two pivot couplings of the lower control arm 66 to the inner suspension housing 62 define the lower axis 70. The outer distal end of the lower control arm 66 carries the ball joint assembly 76 which is substantially identical to the upper ball joint assembly 74 described above.

[0033] The mounting of the axle shaft 80 into the axle housing 72 is shown in greater detail with reference to Fig. 10. The axle housing 72 has an inwardly projecting center hub 160 that carries inner and outer tapered roller bearings 162, 164. The axle shaft 80 is rotatably supported in the axle housing 72 by the bearings 162, 164. Seals 166, 168 seal the bearings 162, 164. The seal 168 engages a ring 169 on the axle shaft 80.

[0034] The left and right sides of the suspension 60 are mechanically separate from one another whereby one side can move without mechanically causing the other side to move. As described below, in the preferred embodiment the hydraulic cylinders 82, 84 are cross-linked left to right such that movement on one side will have an effect on the opposite side. If desired, the left and right cylinders 82, 84 can be separated from one another.

The Universal Joint

[0035] Rotational power is transmitted from the planetary final drive 52 to the axle shaft 80 through a constant velocity universal joint 150. The joint 150 is located between the upper and lower control arms 64, 66 and between the front and rear hydraulic cylinders 82, 84. The constant velocity joint 150 is shown in detail in Figs. 10 and 11. The planet carrier 172 is coupled to a joint inner yoke 174 by a retaining disk 176 and bolt 178. The inner yoke 174 further has an external spline 180 that is fitted into the internal spline 182 of the planet carrier. The inner yoke 174 is supported in an outwardly projecting hub 184 of the inner suspension housing 62 by a double tapered roller bearing set 186. The inner yoke 174 projects radially outward at the end of the hub 184 of the inner suspension housing 62 and forms a reverse bend to extend axially inward, forming a collar 196 that surrounds the hub 184 of the inner suspension housing 62. The collar 196 extends axially inward beyond the outer edge of the bearing set 186.

[0036] The axle shaft 80 is splined to an outer yoke 190 and is also retained therein by a retaining disk 192 and bolt 194. The outer yoke 190 likewise projects radially outward and then forms a reverse bend to extend axially outward, forming a collar 198 surrounding the hub 160 of the axle housing 72. The collar 198 extends outward beyond the bearing 162. The inner and outer yokes 174, 190 are also referred to herein as drive and driven yokes 174, 190 respectively.

[0037] The constant velocity joint 150 is designed to locate the outer yoke 190 as close as possible to the inner yoke 174 to minimize the axial length of the constant velocity joint 150. Doing so provides room for the bearing support for the axle shaft 80 and enables the suspension assembly 60 to be packaged within the narrow space available. The bearing requirements for supporting the axle shaft 80 and still enable a minimum 152,4 cm (60 inches) tread width results in little axial distance between the bearing 162 of the axle shaft 80 and the bearing set 186 of the inner yoke 174. The yokes 174, 190, with collars that wrap around the hubs of the inner suspension housing 62 and the axle housing 72, allow the remaining components of the constant velocity joint 150 to be located radially outward from the drive and driven shafts. This is in contrast to a typical double cardan universal joint where the components are arranged axially in line with the drive and driven shafts. In a preferred embodiment, the outboard face 175 of the inner yoke 174 is space from the inner face 191 of the outer yoke 190 by less than 2.54 cm (1 inch).

[0038] The collar 196 of the inner yoke 174 has two radially outwardly projecting studs 200, spaced diametrically opposite one another. The studs 200 define a first joint pivot axis 202. Likewise, the collar 198 of the outer yoke has two radially outwardly projecting studs 204, spaced diametrically opposite one another and defining a third joint pivot axis 206. The studs 200 and 204 and the axes 202 and 206 are parallel to one another.

[0039] The joint 150 further includes axially inner and outer annular "cross" or ring members 210, 212. The ring members 210, 212 are used in place of the cross-shaped members in a typical cardan universal joint. The ring or cross members 210, 212 are also referred to herein generically as "journal" members 210, 212. The ring members 210, 212 are each formed of two half members 210a, 210b, and 212a, 212b. The half members 210a, 210b, 212a, 212b are bolted together on radial planes by a plurality of bolts 214, only one set of which is shown in Fig. 11. When assembled, the ring members 210, 212 form bores 220 that hold bearing cups 216. A pair of bearing cups 216 are placed on the studs 200 of the inner yoke 174 while a pair of bearing cups 218 are placed on the studs 204 of the outer yoke 190 to enable the ring members 210, 212 to pivot about the axes 202 and 206 respectively.

[0040] A two piece coupling yoke 222 has two halves 222a, 222b. The two halves 222a, 222b are joined together on an axial plane by a plurality of bolts 224. The coupling yoke 222 has four radially inwardly projecting studs, two axially inner studs 226 and two axially outer studs 228. The inner studs 226 define a second joint pivot axis 232 while the outer studs 228 define a fourth joint pivot axis 234. The inner studs 226 are captured in bores 238 formed by the inner ring member 210 while the outer studs 228 are captured in bores 240 in the outer ring member 212. Bearing cups 242, 244 are placed over the inner and outer studs 226, 228 respectively. Grease fittings 246 are provided for each of the bearing cups.

[0041] The joint 150 is a double cardan universal joint with the ring members 210, 212 connected by the coupling yoke 222. The suspension control arms 64, 66 control the movement of the axle housing 72 relative to the inner suspension housing 62 and keep the axis 81 of the axle shaft 80 generally parallel to the axis 170 of the inner yoke 174. This keeps the pivot angle at each of the ring members 210, 212 equal to one another so that a constant, or near constant, velocity output is achieved.

[0042] The universal joint 150 is made axially compact by forming the cross members as rings to move the ring members 210, 212 and coupling yoke 222 radially outward, to surround the drive and driven shafts. In this case, the bearing support for the axle shaft 80 is inside the U-joint, axially between the two ring members 210, 212. This enables the provision of a high torque capacity joint, while minimizing the axial length of the joint 150. High torque carrying capability is required since the joint 150 is located outboard, or downstream, of the planetary final drive 52. This arrangement of a U-joint relative to the drive and driven shaft bearings is made possible by the configuration of the yokes 174, 190, forming a collar 196, 198 that surrounds the hubs 160, 184 mounting the respective bearings.

[0043] It may also be possible to configure the universal joint 150 with the journal members 210, 212 and the coupling yoke 222 radially inward of the inner and outer yokes 174, 190. Such an arrangement would still have bearings located axially between the joint pivot axes.

[0044] The first and second joint pivot axes 202, 232 are in a common plane that is inboard of the outer edge of the bearing set 186. Likewise, the third and fourth joint pivot axes 206, 234 are in a common plane that is outboard of the inner edge of the bearing 162.

Rear Wheel Steering

[0045] An alternative embodiment of the invention is shown in Fig. 12. The connecting link 96 described above has been replaced with a hydraulic cylinder 250 having a cylinder rod 252. The cylinder 250 is located forward of suspension cylinder 82 which passed through the fixed length connecting link 96. The rod 252 can be extended or retracted to change the distance between the inner suspension housing 62 and axle housing 72 forward of the axle shaft 80. This allows the axle suspension housing 62 to rotate about the upright axis defined by the upper and lower ball joints 74, 76. This turns the rear wheels and tires 16, providing rear wheel steering to the tractor 10.

Tread Width Adjustment

[0046] The tread with adjustment mechanism for the wheels is described with reference to Fig. 13. The axle shaft 80 supports an adjustable wheel assembly that includes a wheel hub 254. The wheel hub 254 has a tapered

bore 256 large enough to accommodate the outside diameter of the shaft 80 and to provide an annular tapered bore in which upper and lower tapered flanged sleeves 260, 262 can be received in a wedging action within the tapered bore 256. The upper tapered flanged sleeve 260 has a radially extending, semi-circular flange 264 and a semi-conical, axially extending portion 266. The lowered tapered flange sleeve 262 is of the same configuration as the upper sleeve 260, having a radially extending, semi-circular flange 268 and a semi-conical, axially extending portion 270. Together, the semi-conical portions 266, 270 provide a frusto-conical mounting surface for the hub 254. The sleeves 260, 262 have semi-cylindrical inner surfaces which, when tightened into position, encompass and clamp to the axle shaft 80.

[0047] An annular collar 272 is slidably positioned on the axle shaft 80 between the wheel hub 254 and the sleeves 260, 262 to maintain the wheel in a proper attitude and prevent binding after the sleeves 260, 262 have been loosened from the tapered bore 256. The hub 254 is provided with a plurality of angularly spaced threaded bolt bores 274. Bolts 276 are received within the bolt bores 274. The semi-circular flanges 264, 268 of the sleeves 260, 262 are provided with a plurality of angularly spaced bolt holes 278. When the bolts 276 are treaded into the bores 274 in the hub 254, the semi-conical portions 266, 270 are drawn into the tapered bore 256 and are clamped to the axle shaft 80. Any variety of clamping arrangements can be used with the axle shaft 80 as are well known in adjusting the tread width of an agricultural tractor wheels and tires.

[0048] The axle shaft 80 is formed with a plurality of teeth creating a rack 280 on the surface of the shaft 80. This rack is used with a spur gear, not shown, to move the wheel hub 254 along the length of the axle shaft 80. The clamp mechanism shown in Fig. 13 enables the wheels to be infinitely adjustable along the axle shaft 80.

Suspension Hydraulics

[0049] A simplified schematic of the suspension hydraulic system is shown in Figure 14. An electronic controller 306 controls the extension of the cylinder rods 88. The controller 306 operates the solenoids of the left and right hydraulic valves 308, 310 to direct fluid from the pump 312 to the cylinders 82, 84 and back to the reservoir. The extension of the rods 88 is measured by left and right rotary potentiometers 314, 316. The potentiometers are located on the pivot pin 100 at the coupling of the upper control arm 64 to the inner suspension housing 62. The potentiometers 314, 316 measure the rotational position of the upper control arm 64, which is proportional to the rod extension. The valves 308, 310 are operated to extend or retract the rods 88 for level control of the vehicle based on the vehicle load. Pressure accumulators 318, 320 provide a hydro-pneumatic spring system to the suspension 60. Multiple accumulators with different volumes and pre-loads can also be used.

[0050] A switch 322 is located at the operator's station 18 for actuation by the operator while positioned at the operator's station 18. The switch 322 manually controls the suspension system 60 to raise or lower the tractor rear end, and thus the hitch, at a relatively slow rate. The switch 322 is only operational when the tractor 10 is stopped or moving at a slow speed, such as less than 2 or 3kph. The switch 322 is useful when connecting the tractor 10 to an implement, particularly to the tractor drawbar 324 (Fig. 1). After an implement is unhitched, the jack stand often settles into the ground, lowering the implement tongue height. The switch 322 is used to lower the drawbar 324 to a position beneath the implement tongue so that the implement need not be raised. After connecting the implement, the operator may raise the tractor rear end by the switch 322 or, if not, the suspension load leveling system will level the tractor 10 once the tractor 10 is in motion.

4-Wheel Drive Tractors

[0051] An articulated four-wheel drive tractor 290 is shown in Fig. 15. The tractor 290 includes a front portion 292 having a front drive axle 296 and a rear portion 294 having a rear drive axle 298. The front and rear portions 292, 294 are joined to one another by a coupling 300 to articulate about an upright axis 302 for steering. This type of 4-wheel drive tractor is well known. The tractor 290 is a 9000 series 4-wheel drive tractor available from John Deere.

[0052] The front and rear drive axles 296, 298 are similar to the axle shown in Fig. 2, having a central differential case 28, inboard planetary final drives 52 and left and right axle housings 72 projecting laterally outward to support axle shafts 44, 46. Both the front and rear drive axles 296, 298 can be equipped with the suspension 60 of the present invention. The laterally projecting axle housings are replaced with the inner suspension housings 62 of the present invention. The suspension system including the upper and lower control arms 64, 66 and the axle housings 72 are mounted to the inner suspension housings 62 as described above. The axle shafts 44, 46 are driven through the universal joint 150 described above. The provision of the suspension axles can improve operator comfort and provide for faster travel speeds. In addition, by allowing the drive wheels to move up and down relative to the tractor frame 12, the joint 300 can be simplified. The joint will no longer have to allow the front and rear portions 292, 294 of the tractor 10 to roll relative to one another.

[0053] The present invention has been described as having a differential case 28 to which the suspension components are attached with the suspension 60 including left and right inner suspension housings 62 rigidly coupled to the differential case 28. In a conventional row crop tractor the differential case 28 is part of the powertrain that includes the engine 22, transmission 30 and differential 28. These components may be mounted to a

frame structure 12 to which the front axle and operator's station 18 is then mounted or they may, themselves, form the vehicle frame structure 18. The control arms 64, 66 and hydraulic cylinders 82, 84 may be attached to the differential case 28, the inner suspension housings 62, the central housing or to the vehicle frame structure 12. The claim language that follows is thus to be broadly construed with this in mind.

[0054] While the invention has been described in the context of a wheeled tractor, it is possible to provide the suspended rear drive wheels on a track driven tractor. This could be either a friction or mechanical drive track.

[0055] The drive axle suspension 60 of the present invention provides a tractor 10 with a drive axle that is suspended. The suspended axle can be used as the rear axle in a row crop tractor that maintains the characteristics of a non-suspended row crop tractor. In addition, the suspended axle can be used as either the front or the rear axle of an articulated 4-wheel drive tractor.

[0056] The invention should not be limited to the above-described embodiment, but should be limited solely by the claims.

Claims

1. An agricultural tractor comprising:

an engine (22);
a transmission (30) driven by the engine (22);
a drive axle (26) driven by the transmission (30), the drive axle (26) including a central housing (28) having left and right drive output members, left and right axle housings (72) movably coupled to the central housing for vertical movement of the left and right axle housings (72) relative to the central housing (28), left and right axle shafts (44, 46) rotatably carried by the left and right axle housings (72) and left and right universal joints (150) drivingly coupling the left and right drive output members to the left and right axle shafts (44, 46) respectively; and
left and right wheel and tire assemblies (16) coupled to the left and right axle shafts (44, 46) respectively,

characterized in that
the universal joint (150) comprises:

a drive yoke (174) at an outboard end of the drive output member (172), the drive yoke defining (174) an outboard face (175);
a first journal member (210) coupled to the drive yoke (174) for pivotal motion about a first joint pivot axis (202) transverse to a longitudinal axis (170) of the drive output member (172), the first joint pivot axis (202) being inboard of the drive yoke outboard face (175);
a coupling yoke (222) joined to the first journal member (210) for pivotal motion about a second joint pivot axis (232) transverse to the longitudinal axis of the drive output member (172) and transverse to the first joint pivot axis (202);
a driven yoke (190) at an inboard end of the axle shaft (80), the driven yoke (190) defining an inboard face (191);
a second journal member (212) coupled to the second yoke (190) for pivotal motion about a third joint pivot axis (206) transverse to a longitudinal axis of the axle shaft (80), the third joint pivot axis (206) being outboard of the driven yoke inboard face (191); and
the second journal member (212) being joined to the coupling yoke (222) for pivotal motion about a fourth joint pivot axis (234) transverse to the longitudinal axis of the axle shaft (80) and transverse to the third joint pivot axis (206).

2. The agricultural tractor as defined by claim 1 wherein the central housing (28) includes left and right inboard final drives (52).

3. The agricultural tractor as defined by claim 2 further comprising left and right inboard final drives (52) in the central axle housing whereby the left and right drive output members rotate at the same speed as the left and right axle shafts (44, 46), respectively.

4. The agricultural tractor as defined by one of the preceding claims wherein the output members are planet carriers (172) of the inboard final drives (52).

5. The agricultural tractor as defined by one of the preceding claims further comprising means for infinitely adjusting the position of the wheel and tire assemblies (16) along the left and right axle shafts (44, 46).

6. The agricultural tractor as defined by one of the preceding claims wherein the left and right wheel and tire assemblies (16) are positioned at a 152,4 cm (60 inch) tread spacing.

7. The agricultural tractor as defined by one of the preceding claims wherein the engine (22) has a power rating of at least 75 kW (100 hp), preferably of at least 124 kW (165 hp).

8. The agricultural tractor as defined by one of the preceding claims wherein the central housing (28) is part of a agricultural tractor frame (12).

9. The agricultural tractor as defined by one of the preceding claims wherein the left and right axle housings (72) are each coupled to the central housing by left and right upper and lower control arms (64, 66) pivotally coupled to the central housing and the axle

housings (72) for movement of the axle housings (72) relative to the central housing and at least one spring member extending between the frame (12) and the axle housing (72) to resiliently transmit loads from the frame (12) to the axle housings (72).

10. The agricultural tractor as defined by claim 9 wherein the spring member is a hydraulic cylinder (82, 84) and extendable rod (88) coupled to the central housing and to the axle housing (72), the hydraulic cylinder (82, 84) being connected in a hydraulic circuit with at least one pressure accumulator (318, 320).

11. The agricultural tractor as defined by claim 9 or 10 further comprising a rotary potentiometer (314, 316) to measure the rotary position of one of the control arms (64, 66).

12. The agricultural tractor as defined by one of the claims 9 to 11 wherein the control arms (64, 66) are coupled to the axle housing (72) by upper and lower ball joints (74, 76) wherein the upper and lower ball joints (74, 76) define an upright axis about which the axle housing (72) can pivot to turn the wheel and tire assemblies (16) and further comprising a variable length member between the central housing and the axle housing (72) to control rotation of the axle housing (72) about the upright axis.

13. The agricultural tractor as defined by claim 12 wherein the variable length member is a hydraulic cylinder (250).

14. The agricultural tractor as defined by one of the preceding claims wherein the left and right axle housings (72) are mechanically separated from one another whereby one axle housing (72) can move without causing the other axle housing (72) to move through a mechanical coupling.

15. The agricultural tractor as defined by claim 1 wherein the outboard face (175) of the drive yoke (174) and the inboard face (191) of the driven yoke (190) are axially adjacent to one another, preferably spaced less than one inch from one another.

16. The agricultural tractor as defined by claim 1 or 15 wherein the first journal member (210) is an annular member surrounding a hub (184) of the central housing and/or the second journal member (212) is an annular member surrounding a hub (160) of the axle housing (72).

17. The agricultural tractor as defined by one of the claims 1, 15 or 16 further comprising inner bearings (186) carried by a hub (184) in the central housing and supporting the drive output member (172) therein, the inner bearings (186) extending axially outward beyond the first and second joint pivot axes (202, 232); and
outer bearings (162) carried by a hub (160) in the axle housing (72) and supporting the axle shaft (80) therein, the outer bearings (162) extending axially inward beyond the third and fourth joint pivot axes (206, 234).

18. The agricultural tractor as defined by one of the preceding claims wherein the universal joint comprises:

a drive yoke (174) at an outboard end of the drive output member (172);
a driven yoke (190) at an inboard end of the axle shaft (80);
inboard and outboard journal members (210, 212) pivotally coupled to the drive and driven yokes (174, 190) respectively;
a coupling yoke (222) pivotally coupled to both the inboard and outboard journal members (210, 212); and
the inboard and outboard journal members (210, 212) and the coupling yoke (222) being positioned radially outward of the drive yoke (174) and driven yoke (190).

19. The agricultural tractor as defined by claim 18 wherein the central housing has an axially extending bearing hub (184) supporting the drive output member (172), and the inboard journal member (210) radially surrounds the bearing hub (184) and/or the axle housing (72) has an axially extending bearing hub (160) supporting the axle shaft (80), and the outboard journal member (212) radially surrounds the bearing hub (160).

20. The agricultural tractor as defined by one of the preceding claims wherein the drive axle is a drive axle assembly (26) driven by the transmission (30), the axle assembly (26) including differential case (28) having left and right planetary final drives (52), the final drives having an output member (172), left and right inner suspension housings (62) fixed to the differential case(28), left and right upper and lower control arms (64, 66) pivotally coupled to the inner suspension housings (62) and extending outward to distal ends, left and right axle housings (72) pivotally coupled to the distal ends of the control arms (64, 66) for up and down movement of the axle housings (72) relative to the inner suspension housings (62), left and right axle shafts (44, 46) rotatably carried by the left and right axle housings (72), left and right universal joints (150) drivingly coupling the output members (172) of the left and right final drives (52) to the left and right axle shafts (44, 46) respectively, and left and right spring members extending between the left and right inner suspension housings (62)and the left and right axle housings (72) to resil-

iently transmit loads from the frame (12) to the axle housings; and
left and right wheel and tire assemblies (16) coupled to the left and right axle shafts (44, 46) respectively.

21. The agricultural tractor as defined by claim 20 wherein the differential case (28) and the left and right inner housings (62) are rigidly fixed to and part of the frame (12).

22. The agricultural tractor as defined by claim 20 or 21 wherein:

the control arms (64, 66) are coupled to the inner suspension housings (62) by pins (100, 118, 124) that define upper and lower pivot axes (68, 70); and
the axle housings (72) are coupled to the distal ends of the control arms (64, 66) by an upper ball joint (74) and a lower ball joint (76).

23. The agricultural tractor as defined by one of the claims 20 to 22 further comprising left and right connecting links (96) extending between the left and right inner suspension housings (62) and left and right axle housings (72) to prevent rotation of the left and right axle housings (72) about left and right upright axes defined by the left and right upper and lower ball joints (74, 76).

24. The agricultural tractor as defined by one of the claims 20 to 23 further comprising left and right variable length members extending between the left and right inner housings (62) and left and right axle housings (72) to control rotation of the left and right axle housings (72) about left and right upright axes defined by the left and right upper and lower ball joints (74, 76) to control turning of the left and right wheel and tire assemblies (14, 16) for steering of the tractor (10).

25. The agricultural tractor as defined by one of the claims 9 to 24 wherein the left and right spring members include hydraulic cylinders (82, 84) coupled in a hydraulic circuit to one or more pressure accumulators (318, 320).

26. The agricultural tractor as defined by one of the preceding claims comprising:

a front portion (292) having a front drive axle (296);
a rear portion (294) having a rear drive axle (298), the front and rear portions (292, 294) being joined to one another by an articulating joint (300) and both the front and rear drive axle assembly (296, 298) having left and right wheel and tire assemblies (14, 16);
at least one of the front and rear drive axles (296, 298) having a central housing having left and right drive output members (172), left and right axle housings (72) coupled to the central housing for vertical movement of the left and right axle housings (72) relative to the central housing, left and right axle shafts (44, 46) rotatably carried by the left and right axle housings (72) and left and right universal joints (150) drivingly coupling the left and right drive output members (172) to the left and right axle shaft (44, 46) respectively, the wheel and tire assemblies (14, 16) of the drive axle (296, 298) assembly being mounted to the left and right axle shafts (44,46).

27. The agricultural tractor as defined by one of the preceding claims comprising:

an operator's platform (18);
rear wheels (16);
a rear axle (26) carrying the rear wheels (16) and including a suspension system (60) coupling the rear wheels (16) to the frame (12) for vertical motion of the rear wheels (16) relative to the frame (12), the suspension system (60) including a hydro-pneumatic spring system including at least one hydraulic cylinder (82, 84) on each side of the tractor (10), the extension of the cylinder rod (88) determining the position of the rear wheels relative to the frame (12); and
a switch (322) at the operator's platform (18) for actuation by an operator to raise and lower the rear end of the tractor (10) by extending or retracting the cylinder rod (88) of the hydraulic cylinders (82, 84).

28. The agricultural tractor as defined by one of the preceding claims comprising a universal joint as defined by one of the claims 30 to 33.

29. The agricultural tractor as defined by one of the preceding claims comprising a suspended drive axle as defined by one of the claims 34 to 40.

30. A universal joint for transmitting rotary power:

a drive member (172) rotatably supported in a first housing (184) by a first bearing set (186) for rotation about a first longitudinal axis (170);
a driven member (80) rotatably supported in a second housing (160) by a second bearing set (162) for rotation about a second longitudinal axis (81);
a drive yoke (174) fixed to the drive member (172);
a first journal member (210) coupled to the drive yoke (174) for pivotal motion about a first joint pivot axis (202) transverse to a longitudinal axis

(170) of the drive member (172);
a coupling yoke (222) joined to the first journal member (210) for pivotal motion about a second joint pivot axis (232) transverse to the longitudinal axis of the drive member (172) and to the first joint pivot axis (202) and lying in the same plane as the first joint pivot (202) axis;
a driven yoke (190) fixed to the driven member (80);
a second journal member (212) coupled to the driven yoke (190) for pivotal motion about a third joint pivot axis (206) transverse to the second longitudinal axis (81); and
the second journal member (212) being joined to the coupling yoke (222) for pivotal motion about a fourth joint pivot (234) axis transverse to the second longitudinal axis (81) and to the third joint pivot axis (232) and lying in the same plane as the third joint pivot axis (232); and
at least a portion of the first and second bearing sets (162, 186) being located between the plane of the first and second joint pivot axes (202, 232) and the plane of the third and fourth joint pivot (206, 234) axes.

31. The universal joint as defined by claims 30 wherein the first and second journal members (210, 212) and the coupling yoke (222) radially surround the drive and driven yokes (174, 190).

32. The universal joint as defined by claims 30 or 31 wherein the first and second journal members (210, 212) are each two piece members with the two pieces (210a, 210b, 212a, 212b) of each journal member (210, 212) joined together along radially extending planes.

33. The universal joint as defined by one of the claims 30 to 32 wherein the coupling yoke (222) is a two piece member (222a, 222b) joined together along an axially extending plane.

34. A suspended drive axle for a work vehicle comprising:

a differential case (28) having left and right planetary final drives (52), the final drives (52) having each having an output member (172);
left and right inner suspension housings (62) fixed to the differential case (28);
left and right upper and lower control arms (64, 66) pivotally carried by the inner suspension housings (62) and extending outward to distal ends;
left and right axle housings (72) pivotally coupled to the distal ends of the control arms (64, 66) for up and down movement of the axle housings (72) relative to the inner suspension housings (62);
left and right axle shafts (44, 46) rotatably carried by the left and right axle housings (72);
left and right universal joints (150) according to one of the claims 30 to 33, the left and right universal joints (150) drivingly coupling the output members (172) of the left and right final drives to the left and right axle shafts (44, 46) respectively; and
left and right spring members extending between the left and right inner suspension housings (62) and the left and right axle housings (72) to resiliently transmit loads therebetween.

35. The drive axle as defined by claim 34 wherein:

the control arms (64, 66) are coupled to the inner suspension housings (62) by pins (100, 118, 124) that define upper and lower pivot axes; and
the axle housings (72) are coupled to the distal ends of the control arms (64, 66) by an upper and a lower ball joint (74, 76).

36. The drive axle as defined by claim 34 or 35 further comprising left and right connecting links (96) extending between the left and right inner suspension housings (62) and left and right axle housings (72) to prevent rotation of the left and right axle housings (72) about left and right upright axes defined by the left and right upper and lower ball joints (74, 76).

37. The drive axle as defined by one of the claims 34 to 36 further comprising left and right variable length members extending between the left and right inner suspension housings (62) and left and right axle housings (72) to control rotation of the left and right axle housings (72) about left and right upright axes defined by the left and right upper and lower ball joints (74, 76) to control turning of the left and right wheel and tire assemblies (14,16) for steering of the tractor (10).

38. The drive axle as defined by claim 37 wherein the variable length member is a hydraulic cylinder (250).

39. The drive axle as defined by one of the claims 34 to 38 wherein the left and right spring members include hydraulic cylinders (82, 84) coupled in a hydraulic circuit to one or more pressure accumulators (318, 320).

40. The drive axle as defined by one of the claims 34 to 39 wherein each universal joint (150) comprises:

a drive yoke (174) at an outboard end of the drive output member 172);
a driven yoke (190) at in inboard end of the axle shaft (80);

inboard and outboard journal members (210, 212) pivotally coupled to the drive and driven yokes (174, 190) respectively;
a coupling yoke (222) pivotally coupled to both the inboard and outboard journal (210, 212) members;
the inboard and outboard journal members (210, 212) and the coupling yoke (222) being positioned radially outward of the drive yoke (174) and driven yoke (190) wherein the drive yoke (174) and driven yoke (190) are axially adjacent one another.

Patentansprüche

1. Ein landwirtschaftlicher Traktor enthaltend:

einen Verbrennungsmotor (22),
ein durch den Verbrennungsmotor (22) angetriebenes Getriebe (30),
eine durch das Getriebe (30) angetriebene Antriebsachse (26), die Antriebsachse (26) enthält ein zentrales Gehäuse (28) mit linken und rechten Antriebsausgabebauteilen, linken und rechten Achsgehäusen (72), die zur vertikalen Bewegung der linken und rechten Achsgehäuse (72) relativ zum zentralen Gehäuse (28) beweglich mit dem zentralen Gehäuse gekoppelt sind, linke und rechte Achswellen (44, 46), die von den linken und rechten Achsgehäusen (72) drehbar aufgenommen werden, und linke und rechte Gelenkkupplungen (150), welche die linken und rechten Antriebsausgabebauteile antriebsartig mit der linken bzw. rechten Achswelle (44, 46) koppeln, und
linke und rechte Rad- und Reifenbaugruppen (16), die mit der linken bzw. rechten Achswelle (44, 46) gekoppelt sind,

dadurch gekennzeichnet, dass
die Gelenkkupplung (150) enthält:

eine antreibendes Joch (174) an einem außenseitigen Ende des Antriebsausgabebauteils (172), das antreibende Joch (174) definiert eine Außenfläche (175),
ein erstes Lagerzapfenelement (210), welches mit dem antreibenden Joch (174) zur Schwenkbewegung um eine erste Kupplungsdrehachse (202), die quer zu einer Längsachse (170) des Antriebsausgabebauteils (172) liegt, gekoppelt ist, die erste Kupplungsdrehachse (202) liegt innenseitig bezüglich der Antriebsjochaußenfläche (175),
ein Kopplungsjoch (222), welches zur Schwenkbewegung um eine zweite Kupplungsdrehachse (232), die quer zu der Längsachse des Antriebsausgabebauteils (172) und quer zu der ersten Kupplungsdrehachse (202) liegt, mit dem ersten Lagerzapfenelement (210) verbunden ist,
ein angetriebenes Joch (190) an einem innenseitigen Ende der Achswelle (80), das angetriebene Joch (190) definiert eine innen liegende Fläche (191),
ein zweites Lagerzapfenelement (212), welches mit dem zweiten Joch (190) zur Schwenkbewegung um eine dritte Kupplungsdrehachse (206), die quer zu einer Längsachse der Achswelle (80) liegt, gekoppelt ist, die dritte Kupplungsdrehachse (206) liegt außerhalb der Antriebsjochinnenfläche (191), und
das zweite Lagerzapfenelement (212) ist mit dem Kopplungsjoch (222) für eine Schwenkbewegung um eine vierte Kupplungsdrehachse (234), die quer zu der Längsachse der Achswelle (80) und quer zu der dritten Kupplungsdrehachse (206) liegt, verbunden.

2. Der landwirtschaftliche Traktor, wie durch Anspruch 1 definiert, wobei das zentrale Gehäuse (28) linke und rechte innen liegende Endantriebe (52) umfasst.

3. Der landwirtschaftliche Traktor, wie durch Anspruch 2 definiert, des Weiteren enthaltend linke und rechte innen liegende Endantriebe (52) in dem zentralen Achsgehäuse, wobei die linken und rechten Antriebsausgabebauteile mit derselben Drehzahl drehen wie die linke bzw. rechte Achswelle (44, 46).

4. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin die Ausgabebauteile Planetenträger (172) des innen liegenden Endantriebs (52) sind.

5. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, des Weiteren enthaltend Mittel zur stufenlosen Einstellung der Position der Rad- und Reifenbaugruppen (16) entlang der linken und rechten Achswellen (44, 46).

6. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin die linken und rechten Rad- und Reifenbaugruppen (16) innerhalb eines Spurweitenbereichs von 152,4 cm (60 inches) einstellbar sind.

7. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin der Verbrennungsmotor (22) eine Nennleistung von wenigstens 75 kW (100 hp), vorzugsweise von wenigstens 124 kW (165 hp) aufweist.

8. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin das zen-

trale Gehäuse (28) Teil eines landwirtschaftlichen Traktorrahmens (12) ist.

9. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin für eine Bewegung des Achsgehäuses (72) relativ zum zentralen Gehäuse jedes der linken und rechten Achsgehäuse (72) durch linke und
rechte obere und untere Lenker (64, 66), welche schwenkbar mit dem zentralen Gehäuse und den Achsgehäusen (72) verbunden sind, mit dem zentralen Gehäuse gekoppelt sind und wenigstens ein Federelement sich zwischen dem Rahmen (12) und dem Achsgehäuse (72) erstreckt, um Belastungen vom Rahmen (12) auf das Achsgehäuse (72) federnd zu übertragen.

10. Der landwirtschaftliche Traktor, wie durch Anspruch 9 definiert, worin das Federelement ein Hydraulikzylinder (82, 84) und eine ausfahrbare Stange (88) ist, welche an das zentrale Gehäuse und an das Achsgehäuse (72) gekoppelt sind, der Hydraulikzylinder (82, 84) ist an einen Hydraulikkreis mit wenigstens einem Druckspeicher (318, 320) angeschlossen.

11. Der landwirtschaftliche Traktor, wie durch Anspruch 9 oder 10 definiert, des Weiteren enthaltend ein Drehpotentiometer (314, 316), um die Drehposition eines der Lenker (64, 66) zu messen.

12. Der landwirtschaftliche Traktor, wie durch einen der Ansprüche 9 bis 11 definiert, worin die Lenker (64, 66) durch untere und obere Kugelgelenke (74, 76) an das Achsgehäuse (72) gekoppelt sind, worin die oberen und unteren Kugelgelenke (74, 76) eine aufrechte Achse definieren, um die sich das Achsgehäuse (72) verschwenken kann, um die Rad- und Reifenbaugruppen (16) zu verdrehen, und des Weiteren enthaltend ein zwischen dem zentralen Gehäuse und dem Achsgehäuse (72) liegendes Element variabler Länge, dass der Steuerung der Drehung des Achsgehäuses (72) um die aufrechte Achse dient.

13. Der landwirtschaftliche Traktor, wie durch Anspruch 12 definiert, worin das Element variabler Länge ein Hydraulikzylinder (250) ist.

14. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin die linken und rechten Achsgehäuse (72) voneinander mechanisch getrennt sind, wobei sich ein Achsgehäuse (72) bewegen kann, ohne dass andere Achsgehäuse (72) zu veranlassen, sich durch eine mechanische Kopplung zu bewegen.

15. Der landwirtschaftliche Traktor, wie durch Anspruch 1 definiert, worin die Außenfläche (175) des antreibendes Jochs (174) und die innen liegende Fläche (191) des angetriebenen Jochs (190) axial zueinander benachbart sind, vorzugsweise weniger als ein Inch zueinander beabstandet sind.

16. Der landwirtschaftliche Traktor, wie durch Anspruch 1 oder 15 definiert, worin das erste Lagerzapfenelement (210) ein ringförmiges Element ist, welches eine Nabe (184) des zentralen Gehäuses umschließt, und/oder das zweite Lagerzapfenelement (212) ein ringförmiges Element ist, welches eine Nabe (160) des Achsgehäuses (72) umschließt.

17. Der landwirtschaftliche Traktor, wie durch Anspruch 1, 15 oder 16 definiert, des Weiteren enthaltend innere Lager (186), die durch eine Nabe (184) in dem zentralen Gehäuse getragen werden und das Antriebsausgabebauteil (172) darin abstützen, die inneren Lager (186) erstrecken sich axial nach außen über die ersten und zweiten Kupplungsdrehachsen (202, 232) hinaus, und
äußere Lager (162), die durch eine Nabe (160) in dem Achsgehäuse (72) getragen werden und die Achswelle (80) darin abstützen, die äußeren Lager (162) erstrecken sich axial nach innen über die dritten und vierten Kupplungsdrehachsen (206, 234) hinaus.

18. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin die Gelenkkupplung enthält:

ein antreibendes Joch (174) an einem außen liegenden Ende des Antriebsausgabebauteils (172),
ein angetriebenes Joch (190) an einem innen liegenden Ende der Achswelle (80),
innen liegende und außen liegende Lagerzapfenelemente (210, 212), die schwenkbar an das antreibende bzw. angetriebene Joch (174, 190) gekoppelt sind,
ein Kopplungsjoch (222), das schwenkbar sowohl an das innen liegende als auch an das außen liegende Lagerzapfenelement (210, 212) gekoppelt ist, und
das innen liegende und das außen liegende Lagerzapfenelement (210, 212) und das Kopplungsjoch (222), welche radial außerhalb des antreibenden Jochs (174) und des angetriebenen Jochs (190) positioniert sind.

19. Der landwirtschaftliche Traktor, wie durch Anspruch 18 definiert, worin das zentrale Gehäuse eine sich axial erstreckende Lagernabe (184) aufweist, welche das Antriebsausgabebauteil (172) trägt, und das innen liegende Lagerzapfenelement (210) radial die Lagernabe (184) einschließt und/oder das Achsge-

häuse (72) eine sich axial erstreckende Lagernabe (160) aufweist, welche die Achswelle (80) trägt, und das außen liegende Lagerzapfenelement (212) radial die Lagernabe (160) einschließt.

20. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, worin die Antriebsachse eine durch das Getriebe (30) angetriebene Antriebsachsenbaugruppe (26) ist, die Achsbaugruppe (26) ein Differentialgehäuse (28) mit linken und rechten Planetenendantrieben (52) enthält, die Endantriebe ein Ausgabebauteil (172) haben, linke und rechte an dem Differentialgehäuse (28) befestigte innere Aufhängungsgehäuse (62), linke und rechte obere und untere Lenker (64, 66), welche schwenkbar mit den inneren Aufhängungsgehäusen (62) gekoppelt sind und sich nach außen zu Distalenden erstrecken, linke und rechte Achsgehäuse (72), welche schwenkbar an den Distalenden der Lenker (64, 66) zur Aufwärts- und Abwärtsbewegung der Achsgehäuse (72) relativ zu den inneren Aufhängungsgehäusen gekoppelt sind, linke und rechte Achswellen (44, 46), welche drehbar von den linken und rechten Achsgehäusen (72) getragen werden, linke und rechte Gelenkkupplungen (150), welche antriebsartig die Ausgabebauteile (172) der linken und rechten Endantriebe (52) mit den linken bzw. rechten Achswellen (44, 46) verbinden, und linke und rechte Federelemente, die sich zwischen den linken und rechten inneren Aufhängungsgehäusen (62) und den linken und rechten Achsgehäusen (72) erstrecken, um Belastungen vom Rahmen (12) auf das Achsgehäuse federnd zu übertragen, und
linke und rechte Rad- und Reifenbaugruppen (16), die an die linken bzw. rechten Achswellen (44, 46) gekoppelt sind.

21. Der landwirtschaftliche Traktor, wie durch Anspruch 20 definiert, worin das Differentialgehäuse (28) und die linken und rechten inneren Gehäuse (62) fest mit dem Rahmen (12) verbunden und Teil des Rahmens (12) sind.

22. Der landwirtschaftliche Traktor, wie durch Anspruch 20 oder 21 definiert, worin:

die Lenker (64, 66) durch Zapfen (100, 118, 124), welche obere und untere Schwenkachsen 68, 70) definieren, an die inneren Aufhängungsgehäuse (62) gekoppelt sind und
die Achsgehäuse (72) durch ein oberes Kugelgelenk (74) und ein unteres Kugelgelenk (76) an die Distalenden der Lenker (64, 66) gekoppelt sind.

23. Der landwirtschaftliche Traktor, wie durch einen der Ansprüche 20 bis 22 definiert, des Weiteren enthaltend linke und rechte Verbindungsglieder (96), welche sich zwischen den linken und rechten inneren Aufhängungsgehäusen (62) und den linken und rechten Achsgehäusen (72) erstrecken, um Drehungen des linken und rechten Achsgehäuses (72) um linke und rechte aufrechte Achsen, welche durch die linken und rechten oberen und unteren Kugelgelenke (74, 76) definiert werden, zu verhindern.

24. Der landwirtschaftliche Traktor, wie durch einen der Ansprüche 20 bis 23 definiert, des Weiteren enthaltend linke und rechte Elemente variabler Länge, welche sich zwischen den linken und rechten inneren Gehäusen (62) und den linken und rechten Achsgehäusen (72) erstrekken, um die Drehung des linken und rechten Achsgehäuses (72) um linke und rechte aufrechte Achsen, welche durch die linken und rechten oberen und unteren Kugelgelenke (74, 76) definiert werden, zu steuern, um zum Lenken des Traktors (10) die Verdrehung der linken und rechten Rad- und Reifenbaugruppe (14, 16) zu beeinflussen.

25. Der landwirtschaftliche Traktor, wie durch einen der Ansprüche 9 bis 24 definiert, worin die linken und rechten Federelemente Hydraulikzylinder (82, 84) enthalten, welche in einem Hydraulikkreis mit einem oder mehreren Druckspeichern (318, 320) gekoppelt sind.

26. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, enthaltend:

einen vorderen Bereich (292), welcher eine vordere Antriebsachse (296) aufweist,
einen hinteren Bereich (294), welcher eine hintere Antriebsachse (298) aufweist, die vorderen und hinteren Bereiche (292, 294) sind durch eine Gelenkverbindung (300) miteinander verbunden und sowohl die vordere als auch die hintere Antriebsachsbaugruppe (296, 298) haben linke und rechte Rad- und Reifenbaugruppen (14, 16),
wenigstens eine der vorderen und hinteren Antriebsachsen (296, 298) hat ein zentrales Gehäuse mit linken und rechten Antriebsausgabebauteilen (172), linke und rechte Achsgehäuse (72), welche mit dem zentralen Gehäuse für vertikale Bewegungen der linken und rechten Achsgehäuse (72) relativ zum zentralen Gehäuse gekoppelt sind, linke und rechte Achswellen (44, 46), welche drehbar von den linken und rechten Achsgehäusen (72) getragen werden, und linke und rechte Gelenkkupplungen (150), welche die linken und rechten Antriebsausgabebauteile (172) mit den linken bzw. rechten Achswellen (44, 46) verbinden, die Rad- und Reifenbaugruppen (14, 16) der Antriebsachsbaugruppen (296, 298) sind an den linken und rechten Achswellen (44, 46) befestigt.

27. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, enthaltend:

einen Führerstand (18),
Hinterräder (16),
eine Hinterachse (26), welche die Hinterräder (16) trägt und ein Federungssystem (60) enthält, welches zur vertikalen Bewegung der Hinterräder (16) relativ zu dem Rahmen (12) die Hinterräder (16) an den Rahmen (12) koppelt, das Federungssystem (60) beinhaltet ein hydraulisch-pneumatisches Federsystem, welches wenigstens einen Hydraulikzylinder (82, 84) auf jeder Seite des Traktors (10) enthält, das Ausfahren der Zylinderstange (88) legt die Position der Hinterräder relativ zum Rahmen (12) fest, und
einen durch eine Bedienungsperson betätigbaren Schalter (322) auf dem Führerstand (18), um durch Ausfahren oder Einfahren der Zylinderstange (88) des Hydraulikzylinders (82, 84) das hintere Ende des Traktors (10) anzuheben und abzusenken.

28. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, enthaltend eine Gelenkkupplung wie durch einen der Ansprüche 30 bis 33 definiert.

29. Der landwirtschaftliche Traktor, wie durch einen der vorstehenden Ansprüche definiert, enthaltend eine gefederte Antriebsachse wie durch einen der Ansprüche 34 bis 40 definiert.

30. Eine Gelenkkupplung zur Übertragung von Drehkräften:

ein Antriebsbauteil (172), welches durch einen ersten Lagersatz (186) zur Drehung um eine erste Längsachse (170) drehbar in einem ersten Gehäuse (184) gelagert ist,
ein angetriebenes Bauteil (80), welches durch einen zweiten Lagersatz (162) zur Drehung um eine zweite Längsachse (81) drehbar in einem zweiten Gehäuse (160) gelagert ist,
ein an dem Antriebsbauteil (172) befestigtes antreibendes Joch (174),
ein erstes Lagerzapfenelement (210), welches für eine Schwenkbewegung um eine erste Kupplungsdrehachse (202), die quer zu einer Längsachse (170) des Antriebsbauteils (172) verläuft, mit dem antreibenden Joch (174) gekoppelt ist,
ein Kopplungsjoch (222), welches für eine Schwenkbewegung um eine zweite Kupplungsdrehachse (232), die quer zu der Längsachse des Antriebsbauteils (172) und zu der ersten Kupplungsdrehachse (202) verläuft und in derselben Ebene wie die erste Kupplungsdrehachse (202) liegt, mit dem ersten Lagerzapfenelement (210) verbunden ist,
ein an dem angetriebenen Bauteil (80) befestigtes angetriebenes Joch (190),
ein zweites Lagerzapfenelement (212), welches für eine Schwenkbewegung um eine dritte Kupplungsdrehachse (206), die quer zu der zweiten Längsachse (81) verläuft, mit dem angetriebenen Joch (190) gekoppelt ist,
das zweite Lagerzapfenelement (212) ist für eine Schwenkbewegung um eine vierte Kupplungsdrehachse (234), die quer zu der zweiten Längsachse (81) und zu der dritten Kupplungsdrehachse (232) verläuft und in derselben Ebene wie die dritte Kupplungsdrehachse (232) liegt, mit dem Kopplungsjoch (222) verbunden, und
wenigstens ein Bereich des ersten und zweiten Lagersatzes (162, 186) ist zwischen der Ebene der ersten und der zweiten Kupplungsdrehachse (202, 232) und der Ebene der dritten und der vierten Kupplungsdrehachse (206, 234) lokalisiert.

31. Die Gelenkkupplung, wie durch Anspruch 30 definiert, worin das erste und zweite Lagerzapfenelement (210, 212) und das Kopplungsjoch (222) das antreibende Joch (174) und das angetriebene Joch (190) radial einschließen.

32. Die Gelenkkupplung, wie durch die Ansprüche 30 bis 32 definiert, worin sowohl das erste und als auch das zweite Lagerzapfenelement (210, 212) zweiteilige Bauteile sind, wobei die zwei Teile (210a, 210b, 212a, 212b) jedes Lagerzapfenelements (210, 212) entlang sich radial erstreckender Ebenen miteinander verbunden sind.

33. Die Gelenkkupplung, wie durch einen der Ansprüche 30 oder 31 definiert, worin das Kopplungsjoch (222) ein Bauteil aus zwei Teilen (222a, 222b) ist, die entlang einer sich axialen erstreckenden Ebene miteinander verbunden sind.

34. Eine gefederte Antriebsachse für ein Arbeitsfahrzeug enthaltend:

ein Differentialgehäuse (28) mit linken und rechten Planetenendantrieben (52), jeder Planetenendantrieb (52) hat ein Ausgabebauteil (172),
linke und rechte an dem Differentialgehäuse (28) befestigte innere Aufhängungsgehäuse (62),
linke und rechte obere und untere Lenker (64, 66), welche schwenkbar von den inneren Aufhängungsgehäusen (62) getragen werden und sich nach außen zu Distalenden erstrecken,
linke und rechte Achsgehäuse (72), welche

schwenkbar an den Distalenden der Lenker (64, 66) zur Aufwärts- und Abwärtsbewegung der Achsgehäuse (72) relativ zu den inneren Aufhängungsgehäusen gekoppelt sind,
linke und rechte Achswellen (44, 46), welche drehbar von den linken und rechten Achsgehäusen (72) getragen werden,
linke und rechte Gelenkkupplungen (150), gemäß eines der Ansprüche 30 bis 33, die linken und rechten Gelenkkupplungen (150) koppeln antriebsartig die Ausgabebauteile (172) der linken und rechten Endantriebe mit den linken bzw. rechten Achswellen (44, 46), und
linke und rechte Federelemente, die sich zwischen den linken und rechten inneren Aufhängungsgehäusen (62) und den linken und rechten Achsgehäusen (72) erstrecken, um zwischen ihnen Belastungen zu übertragen.

35. Die Antriebsachse, wie durch Anspruch 34 definiert, worin:

die Lenker (64, 66) durch Zapfen (100, 118, 124), welche obere und untere Schwenkachsen 68, 70) definieren, an die inneren Aufhängungsgehäuse (62) gekoppelt sind, und
die Achsgehäuse (72) durch ein oberes Kugelgelenk (74) und ein unteres Kugelgelenk (76) an die Distalenden der Lenker (64, 66) gekoppelt sind.

36. Die Antriebsachse, wie durch Anspruch 34 oder 35 definiert, des Weiteren enthaltend linke und rechte Verbindungsglieder (96), welche sich zwischen den linken und rechten inneren Aufhängungsgehäusen (62) und den linken und rechten Achsgehäusen (72) erstrecken, um Drehungen des linken und rechten Achsgehäuses (72) um linke und rechte aufrechte Achsen, welche durch die linken und rechten oberen und unteren Kugelgelenke (74, 76) definiert werden, zu verhindern.

37. Die Antriebsachse, wie durch einen der Ansprüche 34 bis 36 definiert, des Weiteren enthaltend linke und rechte Elemente variabler Länge, welche sich zwischen den linken und rechten inneren Aufhängungsgehäusen (62) und den linken und rechten Achsgehäusen (72) erstrecken, um die Drehung des linken und rechten Achsgehäuses (72) um linke und rechte aufrechte Achsen, welche durch die linken und rechten oberen und unteren Kugelgelenke (74, 76) definiert werden, zu steuern, um zum Lenken des Traktors (10) die Verdrehung der linken und rechten Rad- und Reifenbaugruppe (14, 16) zu beeinflussen.

38. Die Antriebsachse, wie durch Anspruch 37 definiert, worin das Element variabler Länge ein Hydraulikzylinder (250) ist.

39. Die Antriebsachse, wie durch einen der Ansprüche 34 bis 38 definiert, worin die linken und rechten Federelemente Hydraulikzylinder (82, 84) enthalten, welche in einem Hydraulikkreis mit einem oder mehreren Druckspeichern (318, 320) gekoppelt sind.

40. Die Antriebsachse, wie durch einen der Ansprüche 34 bis 39 definiert, worin jede Gelenkkupplung (150) enthält:

ein antreibendes Joch (174) an einem außen liegenden Ende des Antriebsausgabebauteils (172),
ein angetriebenes Joch (190) am innen liegenden Ende der Achswelle (80),
innen liegende und außen liegende Lagerzapfenelemente (210, 212), die schwenkbar an das antreibende bzw. angetriebene Joch (174, 190) gekoppelt sind,
ein Kopplungsjoch (222), das schwenkbar sowohl an das innen liegende als auch an das außen liegende Lagerzapfenelement (210, 212) gekoppelt ist, und
das innen liegende und das außen liegende Lagerzapfenelement (210, 212) und das Kopplungsjoch (222) sind radial außerhalb des antreibende Jochs (174) und des angetriebenen Jochs (190) positioniert, worin das antreibende Joch (174) und das angetriebene Joch (190) axial zueinander benachbart sind.

Revendications

1. Tracteur agricole comprenant :

un moteur (22) ;
une transmission (30) entraînée par le moteur (22) ;
un essieu d'entraînement (26) entraîné par la transmission (30), l'essieu d'entraînement (26) comprenant un boîtier central (28) ayant des éléments de sortie d'entraînement gauche et droit, des boîtiers d'essieu gauche et droit (72) couplés de manière mobile au boîtier central pour le mouvement vertical des boîtiers d'essieu gauche et droit (72) par rapport au boîtier central (28), les arbres d'essieu gauche et droit (44, 46) supportés de manière rotative par les boîtiers d'essieu gauche et droit (72) et des joints universels gauche et droit (150) couplant par entraînement les éléments de sortie d'entraînement gauche et droit aux arbres d'essieu gauche et droit (44, 46) respectivement ; et
des ensembles de roue et de pneumatique gauche et droit (16) couplés aux arbres d'essieu

gauche et droit (44, 46) respectivement,

caractérisé en ce que :

le joint universel (150) comprend :

une fourche d'entraînement (174) au niveau d'une extrémité externe de l'élément de sortie d'entraînement (172), la fourche d'entraînement définissant (174) une face externe (175) ;
un premier élément de tourillon (210) couplé à la fourche d'entraînement (174) pour le mouvement pivotant autour d'un premier axe de pivot de joint (202) transversal par rapport à un axe longitudinal (170) de l'élément de sortie d'entraînement (172), le premier axe du pivot de joint (202) étant à l'intérieur de la face externe (175) de la fourche d'entraînement ;
une fourche de couplage (222) assemblée au premier élément de tourillon (210) pour le mouvement pivotant autour d'un second axe de pivot de joint (232) transversal par rapport à l'axe longitudinal de l'élément de sortie d'entraînement (172) et transversal par rapport au premier axe de pivot de joint (202) ;
une fourche entraînée (190) au niveau d'une extrémité interne de l'arbre d'essieu (80), la fourche entraînée (190) définissant une face interne (191) ;
un second élément de tourillon (212) couplé à la seconde fourche (190) pour le mouvement pivotant autour d'un troisième axe de pivot de joint (206) transversal par rapport à un axe longitudinal de l'arbre d'essieu (80), le troisième axe de pivot de joint (206) étant à l'extérieur de la face interne (191) de la fourche entraînée ; et
le second élément de tourillon (212) étant assemblé à la fourche de couplage (222) pour le mouvement pivotant autour d'un quatrième axe de pivot de joint (234) transversal par rapport à l'axe longitudinal de l'arbre d'essieu (80) et transversal par rapport au troisième axe de pivot de joint (206).

2. Tracteur agricole selon la revendication 1, dans lequel le boîtier central (28) comprend des entraînements finaux internes gauche et droit (52).

3. Tracteur agricole selon la revendication 2, comprenant en outre des entraînements finaux internes gauche et droit (52) dans le boîtier d'essieu central moyennant quoi les éléments de sortie d'entraînement gauche et droit tournent à la même vitesse que les arbres d'essieu gauche et droit (44, 46), respectivement.

4. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel les éléments de sortie sont des supports planétaires (172) des entraînements finaux internes (52).

5. Tracteur agricole selon l'une quelconque des revendications précédentes, comprenant en outre des moyens pour régler de manière infinie la position des ensembles de roue et de pneumatique (16) le long des arbres d'essieu gauche et droit (44, 46).

6. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel les ensembles de roue et de pneumatique gauche et droit (16) sont positionnés selon un espacement de bande de roulement de 152,4 cm (60 pouces).

7. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel le moteur (22) a une puissance nominale d'au moins 75 kW (100 hp), de préférence d'au moins 124 kW (165 hp).

8. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel le boîtier central (28) fait partie d'un châssis (12) de tracteur agricole.

9. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel les boîtiers d'essieu gauche et droit (72) sont chacun couplés au boîtier central par des bras de commande inférieur et supérieur gauche et droit (64, 66) couplés de manière pivotante au boîtier central et aux boîtiers d'essieu (72) pour le mouvement des boîtiers d'essieu (72) par rapport au boîtier central et au moins un élément de ressort s'étendant entre le châssis (12) et le boîtier d'essieu (72) pour transmettre de manière élastique des charges du châssis (12) aux boîtiers d'essieu (72).

10. Tracteur agricole selon la revendication 9, dans lequel l'élément de ressort est un vérin hydraulique (82, 84) et une tige extensible (88) couplée au boîtier central et au boîtier d'essieu (72), le vérin hydraulique (82, 84) étant raccordé à un circuit hydraulique avec au moins un accumulateur de pression (318, 320).

11. Tracteur agricole selon la revendication 9 ou 10, comprenant en outre un potentiomètre rotatif (314, 316) pour mesurer la position de rotation de l'un des bras de commande (64, 66).

12. Tracteur agricole selon l'une des revendications 9 à 11, dans lequel les bras de commande (64, 66) sont couplés aux boîtiers d'essieu (72) par des joints à rotule supérieur et inférieur (74, 76), dans lequel les

joints à rotule supérieur et inférieur (74, 76) définissent un axe vertical autour duquel le boîtier d'essieu (72) peut pivoter pour faire tourner les ensembles de roue et de pneumatique (16) et comprenant en outre un élément à longueur variable entre le boîtier central et le boîtier d'essieu (72) pour contrôler la rotation du boîtier d'essieu (72) autour de l'axe vertical.

13. Tracteur agricole selon la revendication 12, dans lequel l'élément à longueur variable est un vérin hydraulique (250).

14. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel les boîtiers d'essieu gauche et droit (72) sont mécaniquement séparés l'un de l'autre moyennant quoi un boîtier d'essieu (72) peut se déplacer sans provoquer le mouvement de l'autre boîtier d'essieu (72) par le biais d'un couplage mécanique.

15. Tracteur agricole selon la revendication 1, dans lequel la face externe (175) de la fourche d'entraînement (174) et la face interne (191) de la fourche entraînée (190) sont axialement adjacentes l'une par rapport à l'autre, de préférence espacées à moins d'un pouce l'une de l'autre.

16. Tracteur agricole selon la revendication 1 ou 15, dans lequel le premier élément de tourillon (210) est un élément annulaire entourant un moyeu (184) du boîtier central et/ou le second élément de tourillon (212) est un élément annulaire entourant un moyeu (160) du boîtier d'essieu (72).

17. Tracteur agricole selon l'une quelconque des revendications 1, 15 ou 16, comprenant en outre des paliers internes (186) supportés par un moyeu (184) dans le boîtier central et supportant l'élément de sortie d'entraînement (172) à l'intérieur de celui-ci, les paliers internes (186) s'étendant de manière axiale vers l'extérieur au-delà des premier et second axes de pivot de joint (202, 232) ; et
les paliers externes (162) supportés par un moyeu (160) dans le boîtier d'essieu (72) et supportant l'arbre d'essieu (80) à l'intérieur de celui-ci, les paliers externes (162) s'étendant de manière axiale vers l'intérieur au-delà des premier et troisième axes de pivot de joint (206, 234).

18. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel le joint universel comprend :

une fourche d'entraînement (174) au niveau d'une extrémité externe de l'élément de sortie d'entraînement (172) ;
une fourche entraînée (190) au niveau d'une extrémité interne de l'arbre d'essieu (80) ;
des éléments de tourillon interne et externe (210, 212) couplés de manière pivotante aux fourches d'entraînement et entraînée (174, 190) respectivement ;
une fourche de couplage (222) couplée de manière pivotante à la fois aux éléments de tourillon interne et externe (210, 212) ; et
les éléments de tourillon interne et externe (210, 212) et la fourche de couplage (222) étant positionnés de manière radiale à l'extérieur de la fourche d'entraînement (174) et de la fourche entraînée (190).

19. Tracteur agricole selon la revendication 18, dans lequel le boîtier central a un moyeu de palier (184) s'étendant de manière axiale, supportant l'élément de sortie d'entraînement (172), l'élément de tourillon interne (210) entoure de manière radiale le moyeu de palier (184) et/ou le boîtier d'essieu (72) a un moyeu de palier (160) s'étendant de manière axiale supportant l'arbre d'essieu (80) et l'élément de tourillon externe (212) entoure radialement le moyeu de palier (160).

20. Tracteur agricole selon l'une quelconque des revendications précédentes, dans lequel l'essieu d'entraînement est un ensemble d'essieu d'entraînement (26) entraîné par la transmission (30), l'ensemble d'essieu (26) comprenant un carter différentiel (28) ayant des entraînements finaux planétaires gauche et droit (52), les entraînements finaux ayant un élément de sortie (172), les boîtiers de suspension internes gauche et droit (62) étant fixés au carter différentiel (28), les bras de commande inférieur et supérieur gauche et droit (64, 66) étant couplés de manière pivotante aux boîtiers de suspension internes (62) et s'étendant vers l'extérieur vers les extrémités distales, les boîtiers d'essieu gauche et droit (72) étant couplés de manière pivotante aux extrémités distales des bras de commande (64, 66) pour le mouvement de haut en bas des boîtiers d'essieu (72), par rapport aux boîtiers de suspension internes (62), les arbres d'essieu gauche et droit (44, 46) étant supportés de manière rotative par les boîtiers d'essieu gauche et droit (72), les joints universels gauche et droit (150) couplant par entraînement les éléments de sortie (172) des entraînements finaux gauche et droit (52) aux arbres d'essieu gauche et droit (44, 46) respectivement, et les éléments de ressort gauche et droit s'étendant entre les boîtiers de suspension internes gauche et droit (62) et les boîtiers d'essieu gauche et droit (72) pour transmettre des charges du châssis (12) aux boîtiers d'essieu ; et
les ensembles de roue et de pneumatique gauche et droit (16) étant couplés aux arbres d'essieu gauche et droit (44, 46) respectivement.

21. Tracteur agricole selon la revendication 20, dans lequel le carter différentiel (28) et les boîtiers internes gauche et droit (62) sont fixés de manière rigide à et font partie du châssis (12).

22. Tracteur agricole selon la revendication 20 ou 21, dans lequel :

les bras de commande (64, 66) sont couplés aux boîtiers de suspension internes (62) par des broches (100, 118, 124) qui définissent des axes de pivot supérieur et inférieur (68, 70) ; et
les boîtiers d'essieu (72) sont couplés aux extrémités distales des bras de commande (64, 66) par un joint à rotule supérieur (74) et un joint à rotule inférieur (76).

23. Tracteur agricole selon l'une des revendications 20 à 22, comprenant en outre des liaisons de raccordement gauche et droite (96) s'étendant entre les boîtiers de suspension internes gauche et droit (62) et les boîtiers d'essieu gauche et droit (72) pour empêcher la rotation des boîtiers d'essieu gauche et droit (72) autour des axes verticaux gauche et droit définis par les joints à rotule supérieur et inférieur gauche et droit (74, 76).

24. Tracteur agricole selon l'une quelconque des revendications 20 à 23, comprenant en outre des éléments à longueur variable gauche et droit s'étendant entre les boîtiers internes gauche et droit (62) et les boîtiers d'essieu gauche et droit (72) pour contrôler la rotation des boîtiers d'essieu gauche et droit (72) autour des axes verticaux gauche et droit définis par les joints à rotule supérieur et inférieur gauche et droit (74, 76) pour contrôler la rotation des ensembles de roue et de pneumatique gauche et droit (14, 16) pour diriger le tracteur (10).

25. Tracteur agricole selon l'une quelconque des revendications 9 à 24, dans lequel les éléments de ressort gauche et droit comprennent des vérins hydrauliques (82, 84) couplés dans un circuit hydraulique à un ou plusieurs accumulateurs de pression (318, 320).

26. Tracteur agricole selon l'une quelconque des revendications précédentes, comprenant :

une partie avant (292) ayant un essieu d'entraînement avant (296) ;
une partie arrière (294) ayant un essieu d'entraînement arrière (298), les parties avant et arrière (292, 294) étant assemblées l'une à l'autre par un joint d'articulation (300) et à la fois l'ensemble d'essieu d'entraînement avant et arrière (296, 298) ont des ensembles de roue et de pneumatique gauche et droit (14, 16) ;
au moins l'un des essieux d'entraînement avant et arrière (296, 298) a un boîtier central ayant des éléments de sortie d'entraînement gauche et droit (172), des boîtiers d'essieu gauche et droit (72) couplés au boîtier central pour le mouvement vertical des boîtiers d'essieu gauche et droit (72) par rapport au boîtier central, des arbres d'essieu gauche et droit (44, 46) supportés de manière rotative par les boîtiers d'essieu gauche et droit (72) et des joints universels gauche et droit (150) couplant par entraînement les éléments de sortie d'entraînement gauche et droit (172) à l'arbre d'essieu gauche et droit (44, 46) respectivement, les ensembles de roue et de pneumatique (14, 16) de l'ensemble d'essieu d'entraînement (296, 298) étant montés sur les arbres d'essieu gauche et droit (44, 46).

27. Tracteur agricole selon l'une des revendications précédentes, comprenant :

une plate-forme d'opérateur (18) ;
des roues arrière (16) ;
un essieu arrière (26) supportant les roues arrière (16) et comprenant un système de suspension (60) couplant les roues arrière (16) au châssis (12) pour le mouvement vertical des roues arrière (16) par rapport au châssis (12), le système de suspension (60) comprenant un système de ressort hydropneumatique comprenant au moins un vérin hydraulique (82, 84) de chaque côté du tracteur (10), l'extension de la tige de vérin (88) déterminant la position des roues arrière par rapport au châssis (12) ; et
un interrupteur (322) au niveau de la plate-forme d'opérateur (18) pour l'actionnement par un opérateur afin de lever et d'abaisser l'extrémité arrière du tracteur (10) en étendant ou en rétractant la tige de vérin (88) des vérins hydrauliques (82, 84).

28. Tracteur agricole selon l'une quelconque des revendications précédentes, comprenant un joint universel tel que défini par l'une de revendications 30 à 33.

29. Tracteur agricole selon l'une quelconque des revendications précédentes, comprenant un essieu d'entraînement suspendu tel que défini par l'une quelconque des revendications 34 à 40.

30. Joint universel pour transmettre la puissance de rotation :

un élément d'entraînement (172) supporté de manière rotative dans un premier boîtier (184) par un premier ensemble de palier (186) pour la rotation autour d'un premier axe longitudinal (170) ;

un élément entraîné (80) supporté de manière rotative dans le second boîtier (160) par un second ensemble de palier (162) pour la rotation autour d'un second axe longitudinal (81) ;
une fourche d'entraînement (174) fixée sur l'élément d'entraînement (172) ;
un premier élément de tourillon (210) couplé à la fourche d'entraînement (174) pour le mouvement pivotant autour d'un premier axe de pivot de joint (202) transversal par rapport à un axe longitudinal (170) de l'élément d'entraînement (172) ;
une fourche de couplage (222) assemblée au premier élément de tourillon (210) pour le mouvement pivotant autour d'un second axe de pivot de joint (232) transversal par rapport à l'axe longitudinal de l'élément d'entraînement (172) et par rapport au premier axe de pivot de joint (202) et se trouvant dans le même plan que le premier axe de pivot de joint (202) ;
une fourche entraînée (190) fixée sur l'élément entraîné (80) ;
un second élément de tourillon (212) couplé à la fourche entraînée (190) pour le mouvement pivotant autour d'un troisième axe de pivot de joint (206) transversal par rapport au second axe longitudinal (81) ; et
le second élément de tourillon (212) étant assemblé à la fourche de couplage (222) pour le mouvement pivotant autour d'un quatrième axe de pivot de joint (234) transversal au second axe longitudinal (81) et au troisième axe de pivot de joint (232) et se trouvant dans le même plan que le troisième axe de pivot de joint (232) ; et
au moins une partie des premier et second ensembles de palier (162, 186) étant située entre le plan des premier et second axes de pivot de joint (202, 232) et le plan des troisième et quatrième axes de pivot de joint (206, 234).

31. Joint universel selon la revendication 30, dans lequel les premier et second éléments de tourillon (210, 212) et la fourche de couplage (222) entourent de manière radiale les fourches d'entraînement et entraînée (174, 190).

32. Joint universel selon les revendications 30 ou 31, dans lequel les premier et second éléments de tourillon (210, 212) sont chacun des éléments à deux pièces avec les deux pièces (210a, 210b, 212a, 212b) de chaque élément de tourillon (210, 212) assemblées ensemble le long de plans s'étendant de manière radiale.

33. Joint universel selon l'une quelconque des revendications 30 à 32, dans lequel la fourche de couplage (222) est un élément à deux pièces (222a, 222b) assemblées ensemble le long d'un plan s'étendant de manière axiale.

34. Essieu d'entraînement suspendu pour un véhicule de travail comprenant :

un carter différentiel (28) ayant des entraînements finaux planétaires gauche et droit (52), les entraînements finaux (52) ayant chacun un élément de sortie (172) ;
des boîtiers de suspension internes gauche et droit (62) fixés sur le carter différentiel (28) ;
des bras de commande supérieur et inférieur gauche et droit (64, 66) supportés de manière pivotante par les boîtiers de suspension internes (62) et s'étendant vers l'extérieur vers les extrémités distales ;
les boîtiers d'essieu gauche et droit (72) couplés de manière pivotante aux extrémités distales des bras de commande (64, 66) pour le mouvement de haut en bas des boîtiers d'essieu (72) par rapport aux boîtiers de suspension internes (62) ;
des arbres d'essieu gauche et droit (44, 46) supportés de manière rotative par les boîtiers d'essieu gauche et droit (72) ;
des joints universels gauche et droit (150) selon l'une quelconque des revendications 30 à 33, les joints universels gauche et droit (150) couplant par entraînement les éléments de sortie (172) des entraînements finaux gauche et droit aux arbres d'essieu gauche et droit (44, 46) respectivement ; et
des éléments de ressort gauche et droit s'étendant entre les boîtiers de suspension internes gauche et droit (62) et les boîtiers d'essieu gauche et droit (72) pour transmettre de manière élastique des charges entre ceux-ci.

35. Essieu d'entraînement selon la revendication 34, dans lequel les bras de commande (64, 66) sont couplés aux boîtiers de suspension internes (62) par des broches (100, 118, 124) qui définissent des axes de pivot supérieur et inférieur ; et
les boîtiers d'essieu (72) sont couplés aux extrémités distales des bras de commande (64, 66) par un joint à rotule supérieur et inférieur (74, 76).

36. Essieu d'entraînement selon la revendication 34 ou 35, comprenant en outre des liaisons de raccordement gauche et droite (96) s'étendant entre les boîtiers de suspension internes gauche et droit (62) et les boîtiers d'essieu gauche et droit (72) pour empêcher la rotation des boîtiers d'essieu gauche et droit (72) autour des axes verticaux gauche et droit définis par les joints à rotule supérieur et inférieur gauche et droit (74, 76).

37. Essieu d'entraînement selon l'une quelconque des

revendications 34 à 36, comprenant en outre des éléments à longueur variable gauche et droit s'étendant entre les boîtiers de suspension internes gauche et droit (62) et les boîtiers d'essieu gauche et droit (72) pour contrôler la rotation des boîtiers d'essieu gauche et droit (72) autour des axes verticaux gauche et droit définis par les joints à rotule supérieur et inférieur gauche et droit (74, 76) pour contrôler la rotation des ensembles de roue et de pneumatique gauche et droit (14, 16) pour diriger le tracteur (10).

38. Essieu d'entraînement selon la revendication 37, dans lequel l'élément à longueur variable est un vérin hydraulique (250).

39. Essieu d'entraînement selon l'une quelconque des revendications 34 à 38, dans lequel les éléments de ressort gauche et droit comprennent des vérins hydrauliques (82, 84) couplés dans un circuit hydraulique à un ou plusieurs accumulateurs de pression (318, 320).

40. Essieu d'entraînement selon l'une quelconque des revendications 34 à 39, dans lequel chaque joint universel (150) comprend :

une fourche d'entraînement (174) au niveau d'une extrémité externe de l'élément de sortie d'entraînement (172) ;
une fourche entraînée (190) au niveau d'une extrémité interne de l'arbre d'essieu (80) ;
des éléments de tourillon interne et externe (210, 212) couplés de manière pivotante aux fourches d'entraînement et entraînée (174, 190) respectivement ;
une fourche de couplage (222) couplée de manière pivotante à la fois aux éléments de tourillon interne et externe (210, 212) ;
les éléments de tourillon interne et externe (210, 212) et la fourche de couplage (222) étant positionnés radialement vers l'extérieur de la fourche d'entraînement (174) et de la fourche entraînée (190), avec la fourche d'entraînement (174) et la fourche entraînée (190) adjacentes de manière axiale l'une par rapport à l'autre.

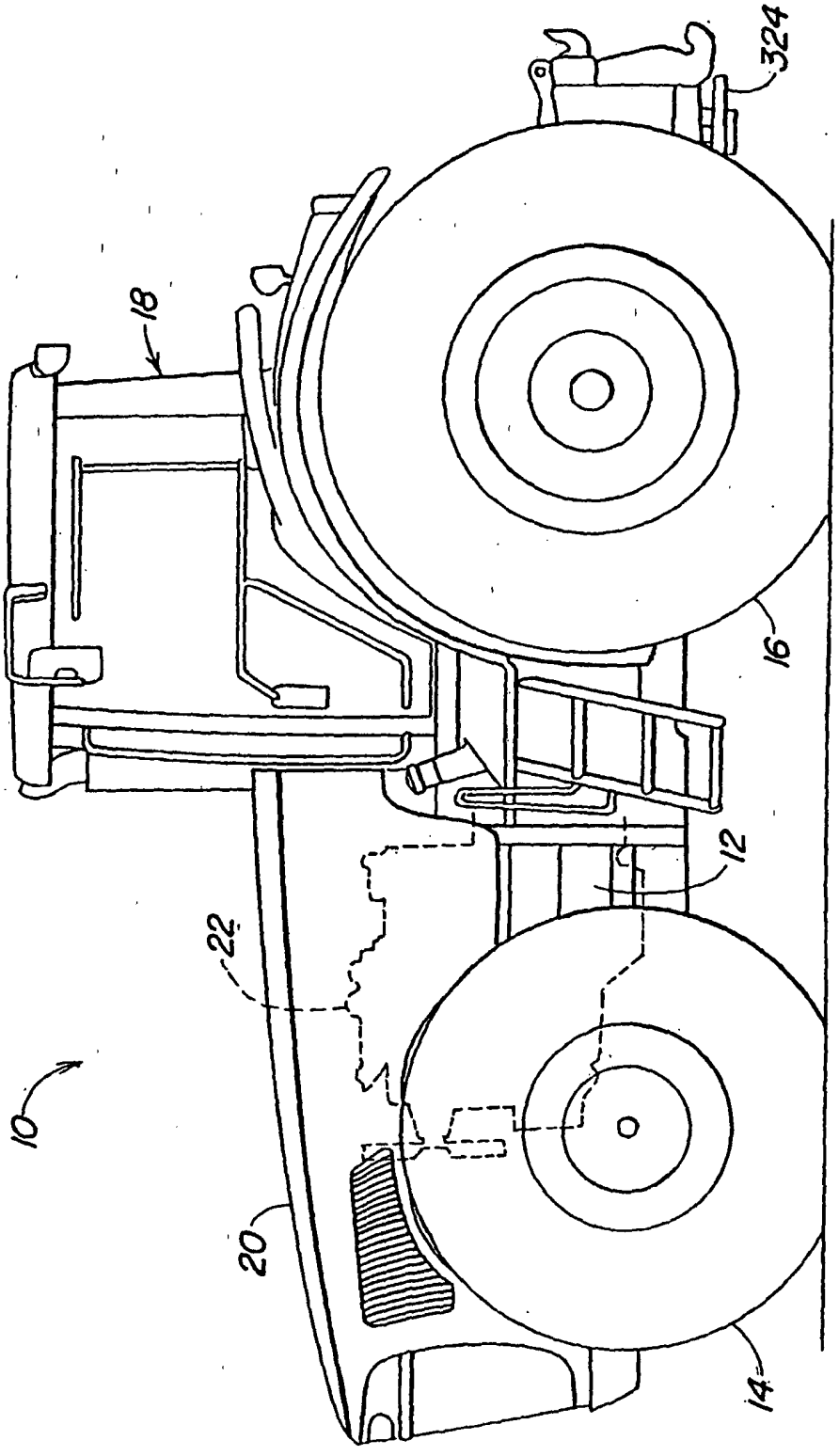

FIG. 1

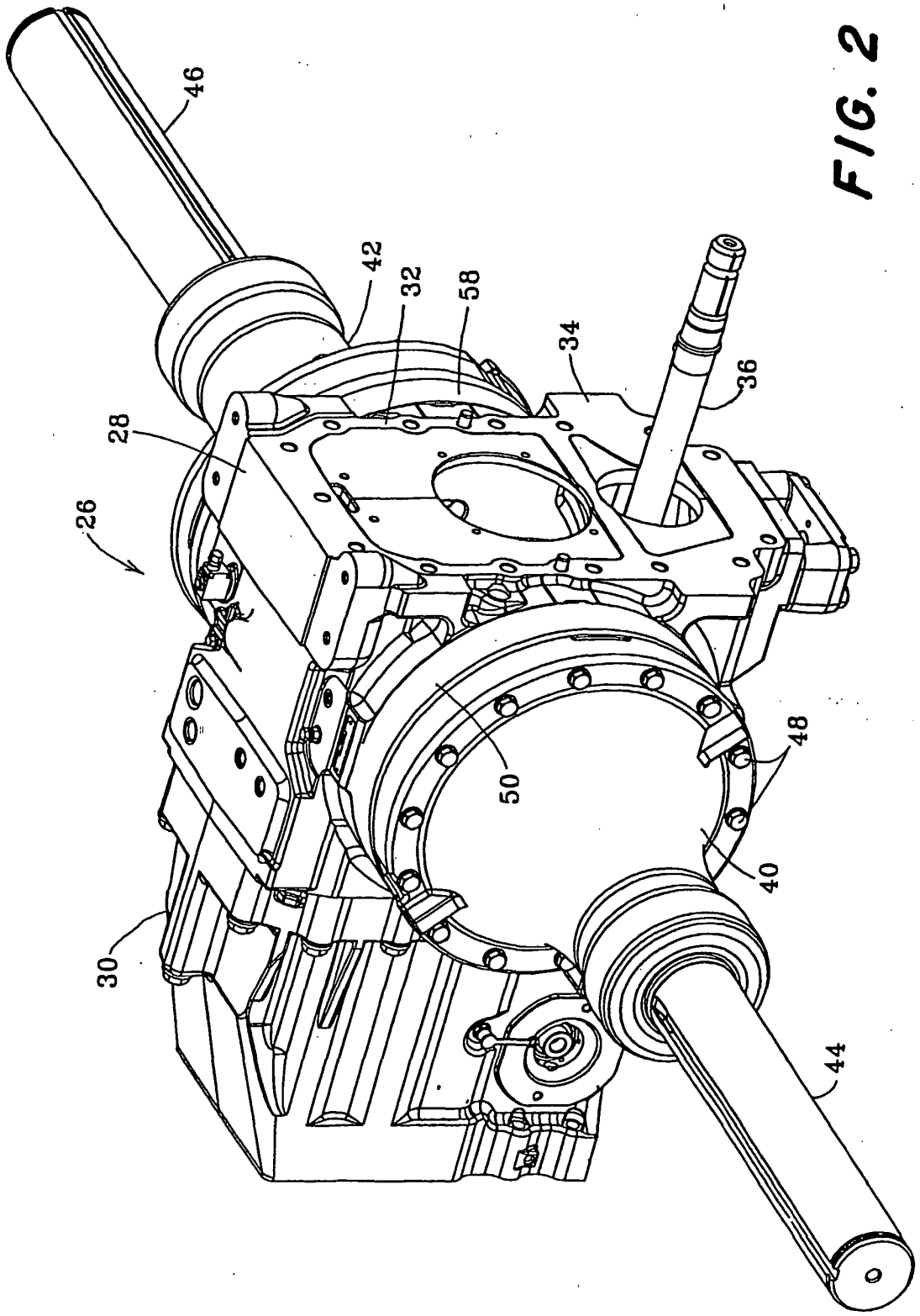

FIG. 2

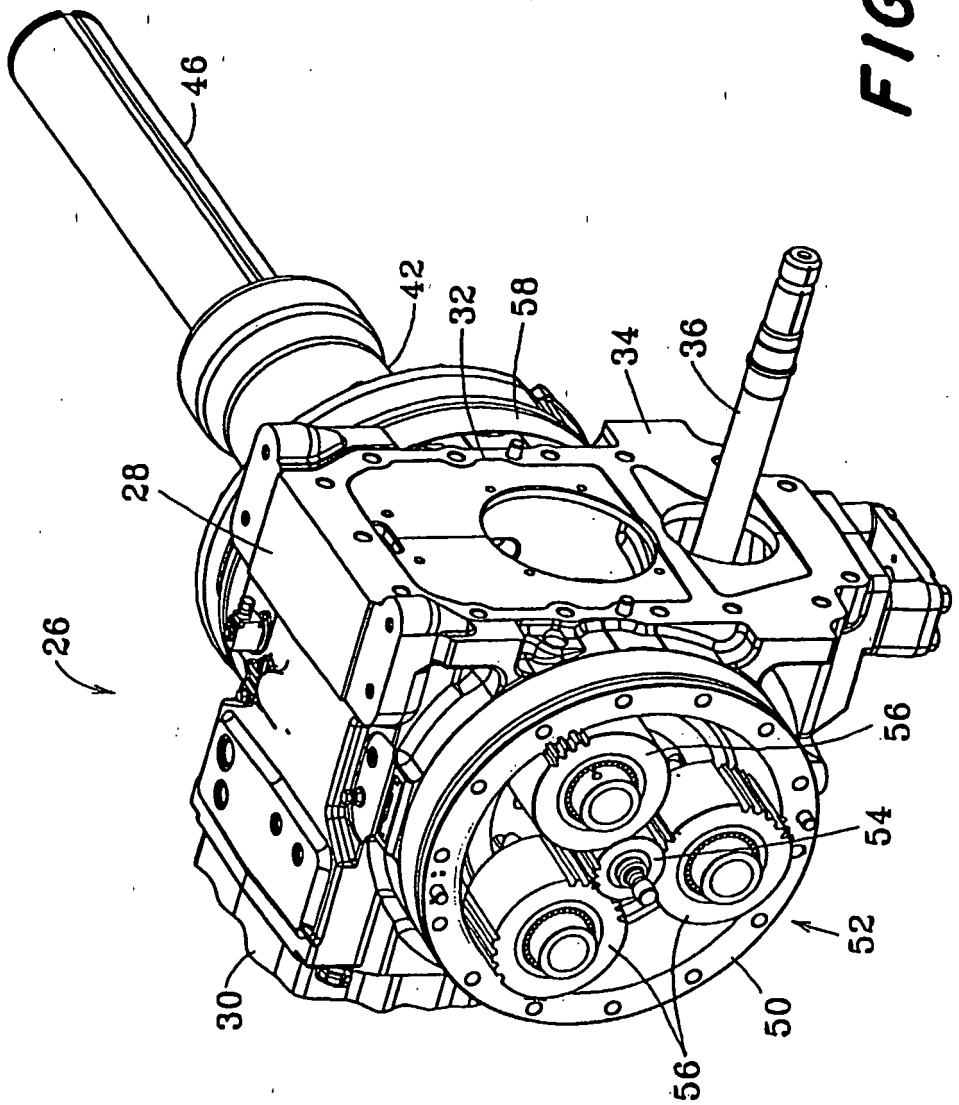

FIG. 3

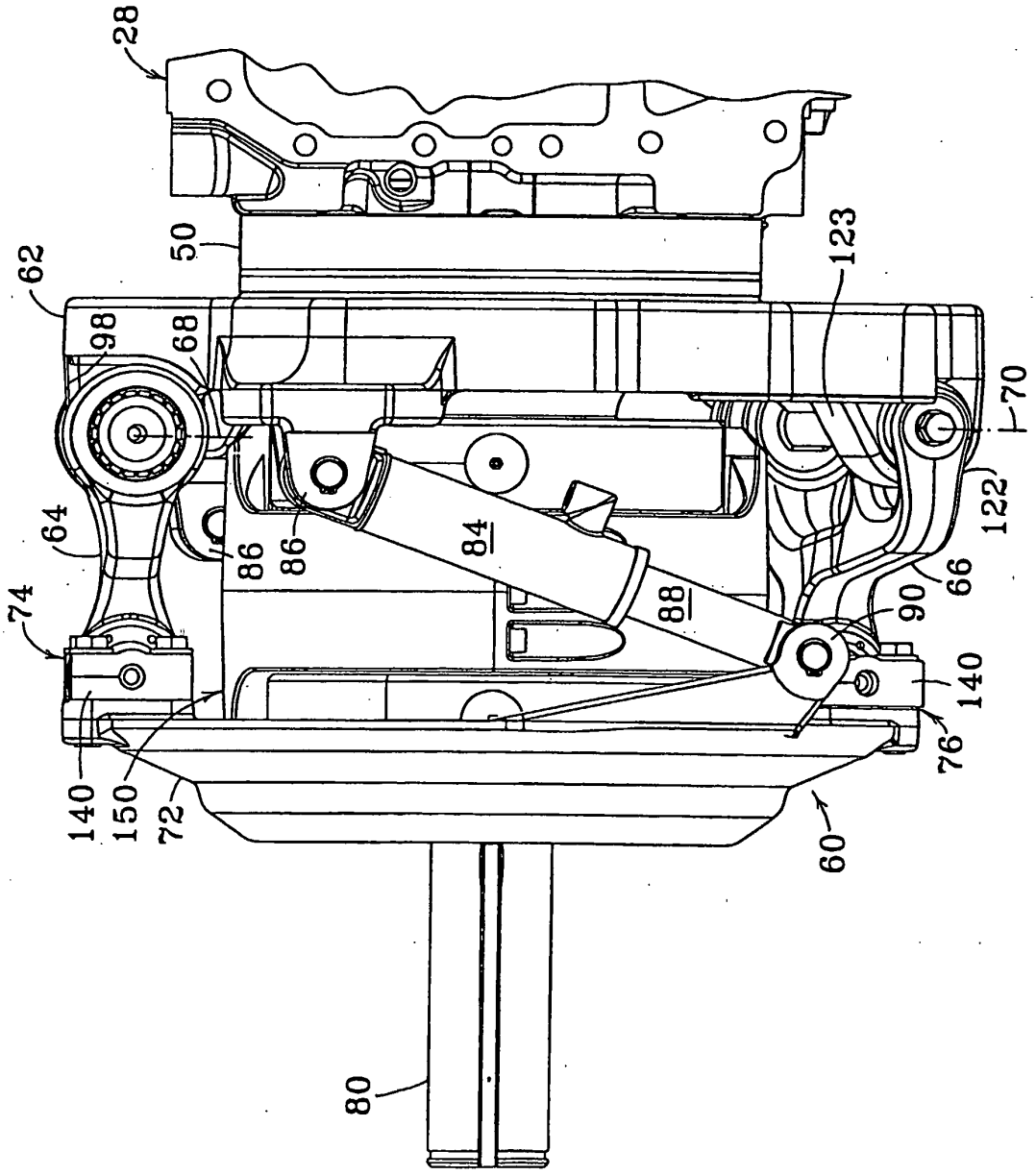
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FIG. 4

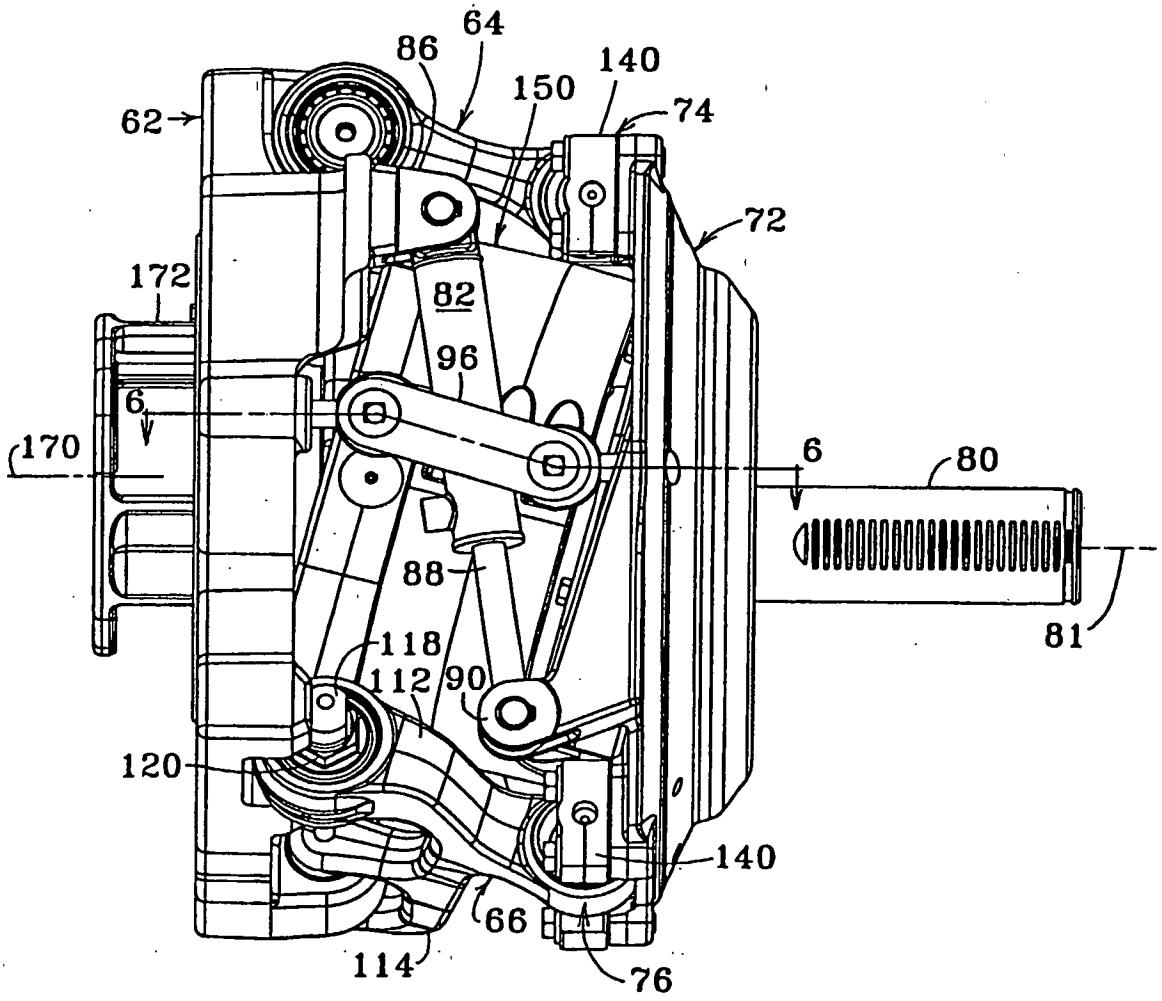
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FIG. 5

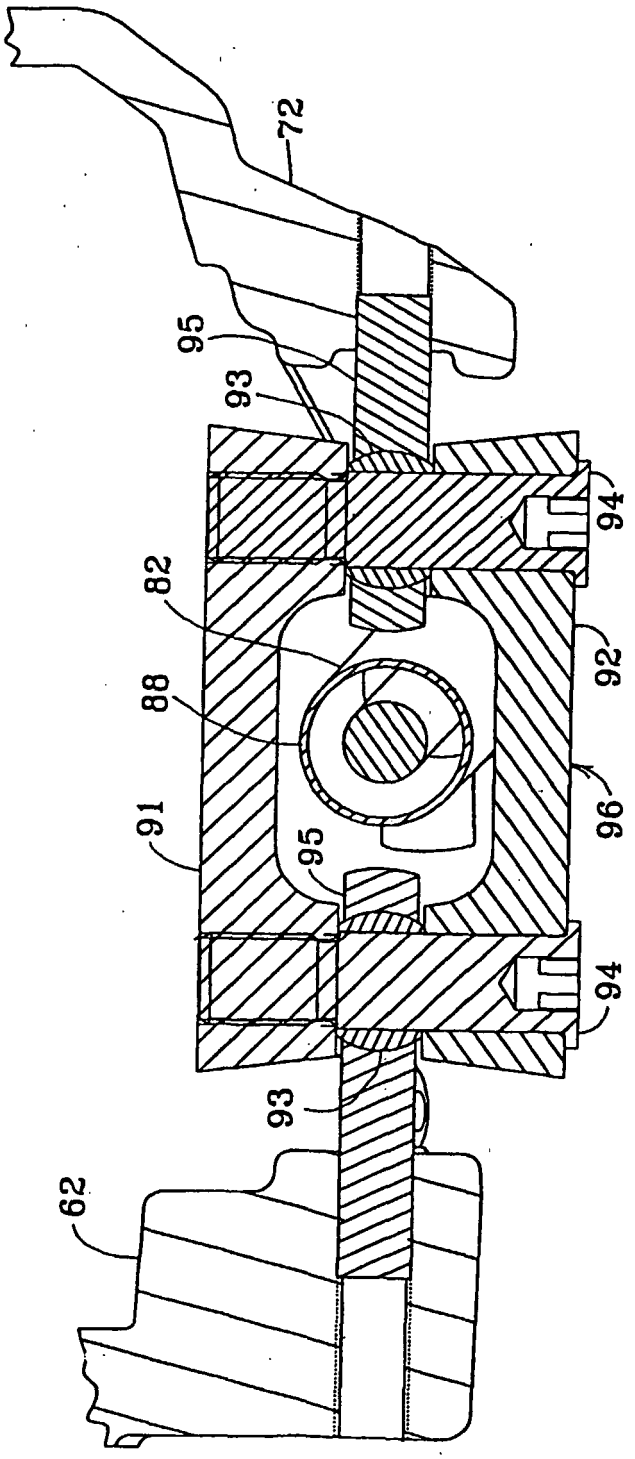
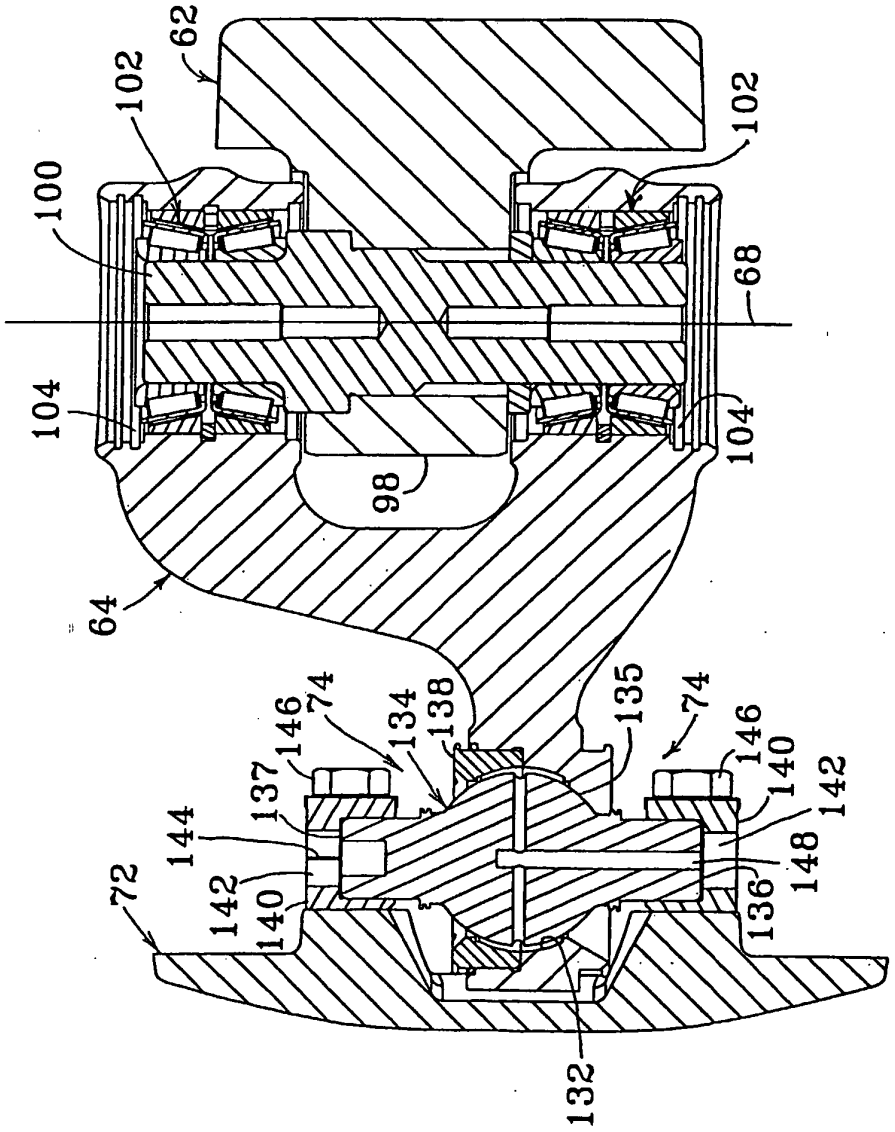


FIG. 6

FIG. 7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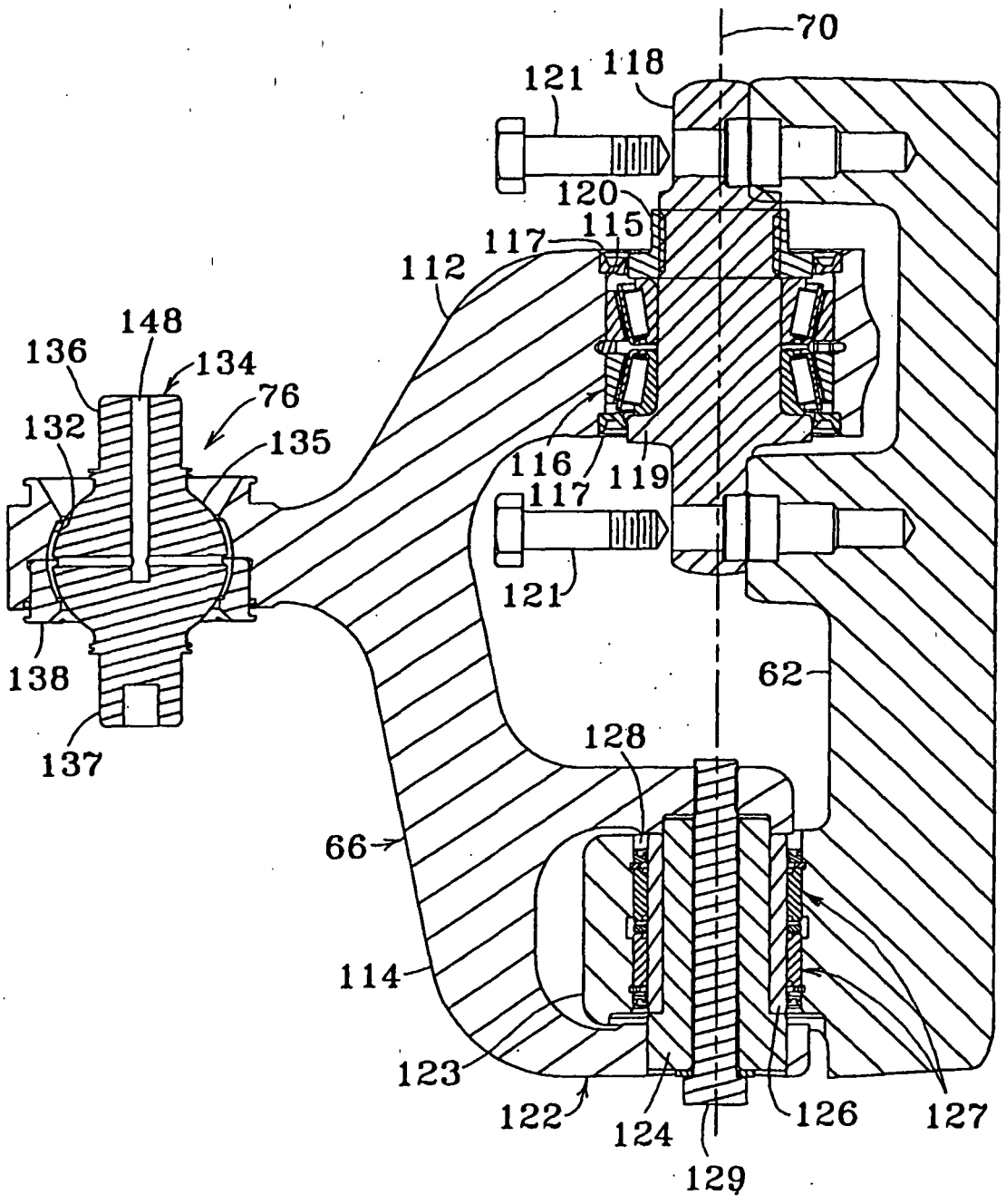
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FIG. 8

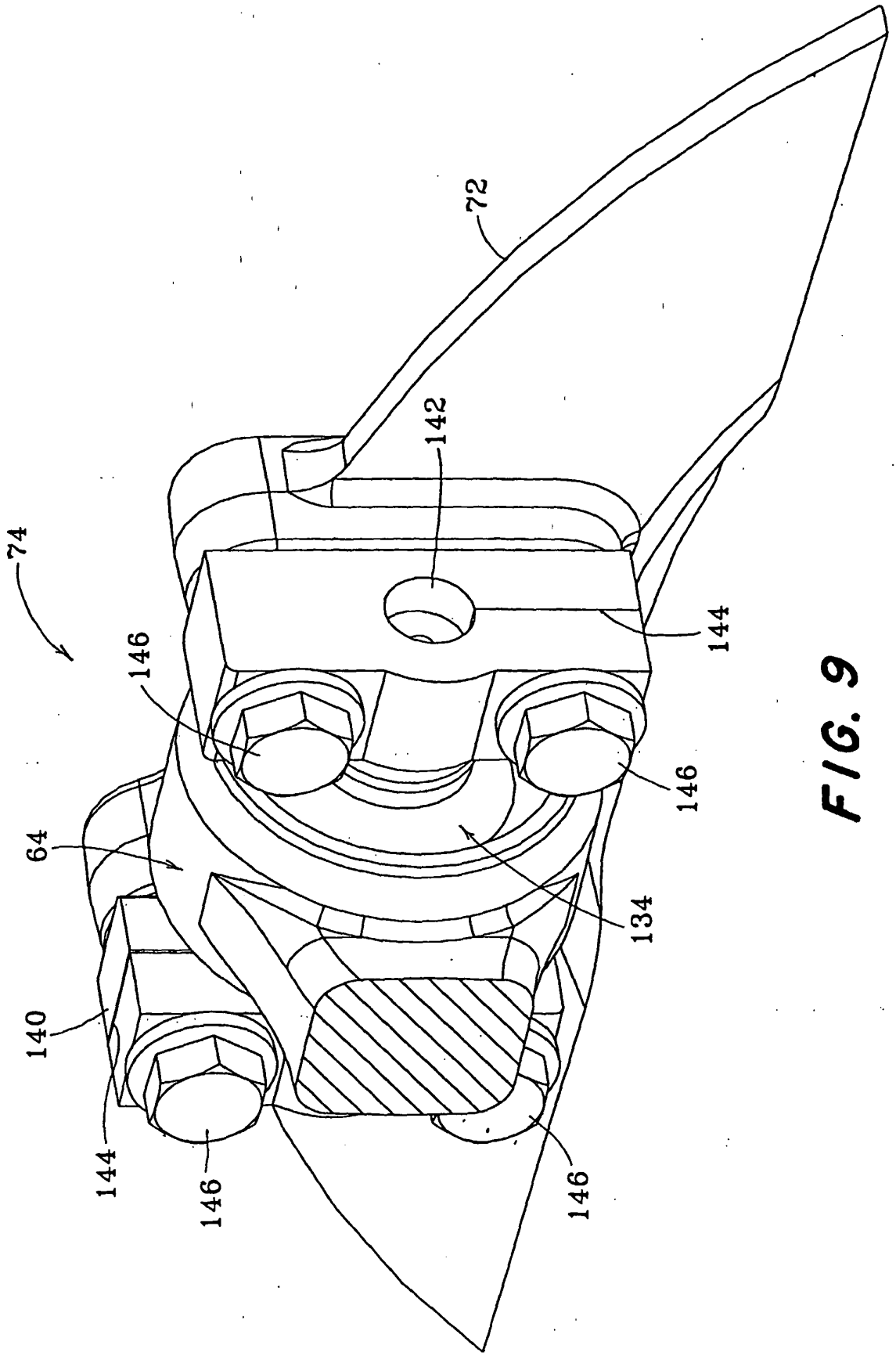

FIG. 9

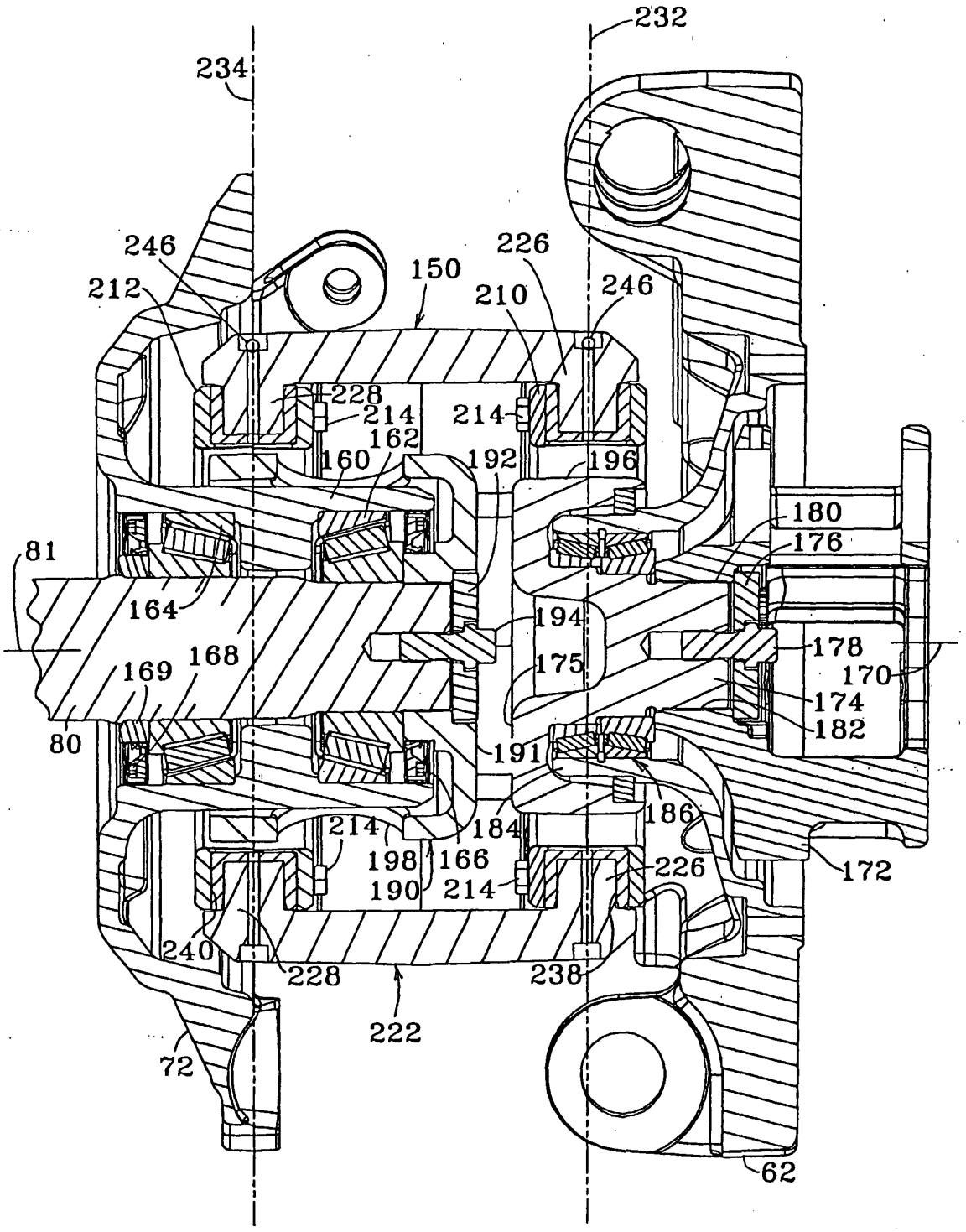
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FIG. 10

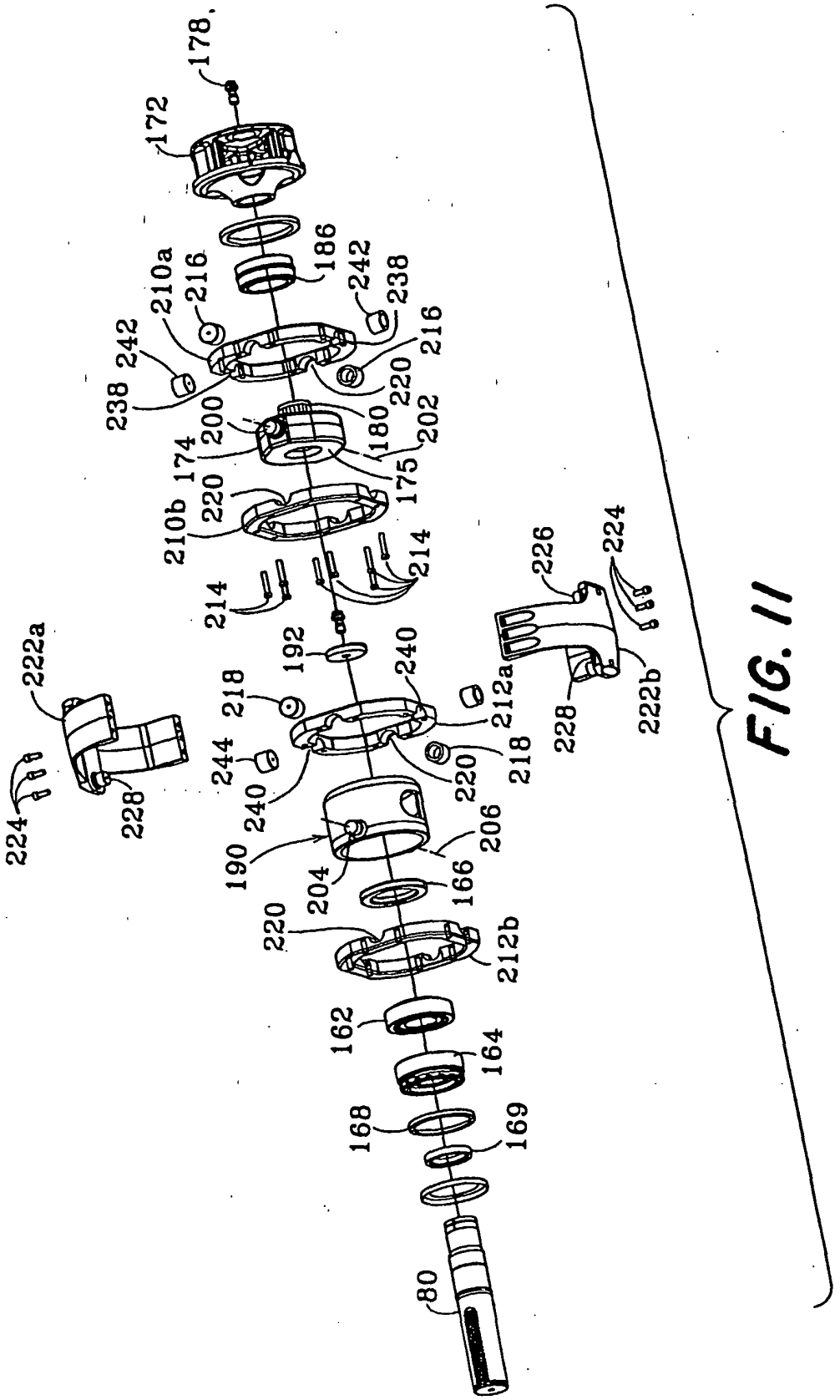
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FIG. 11

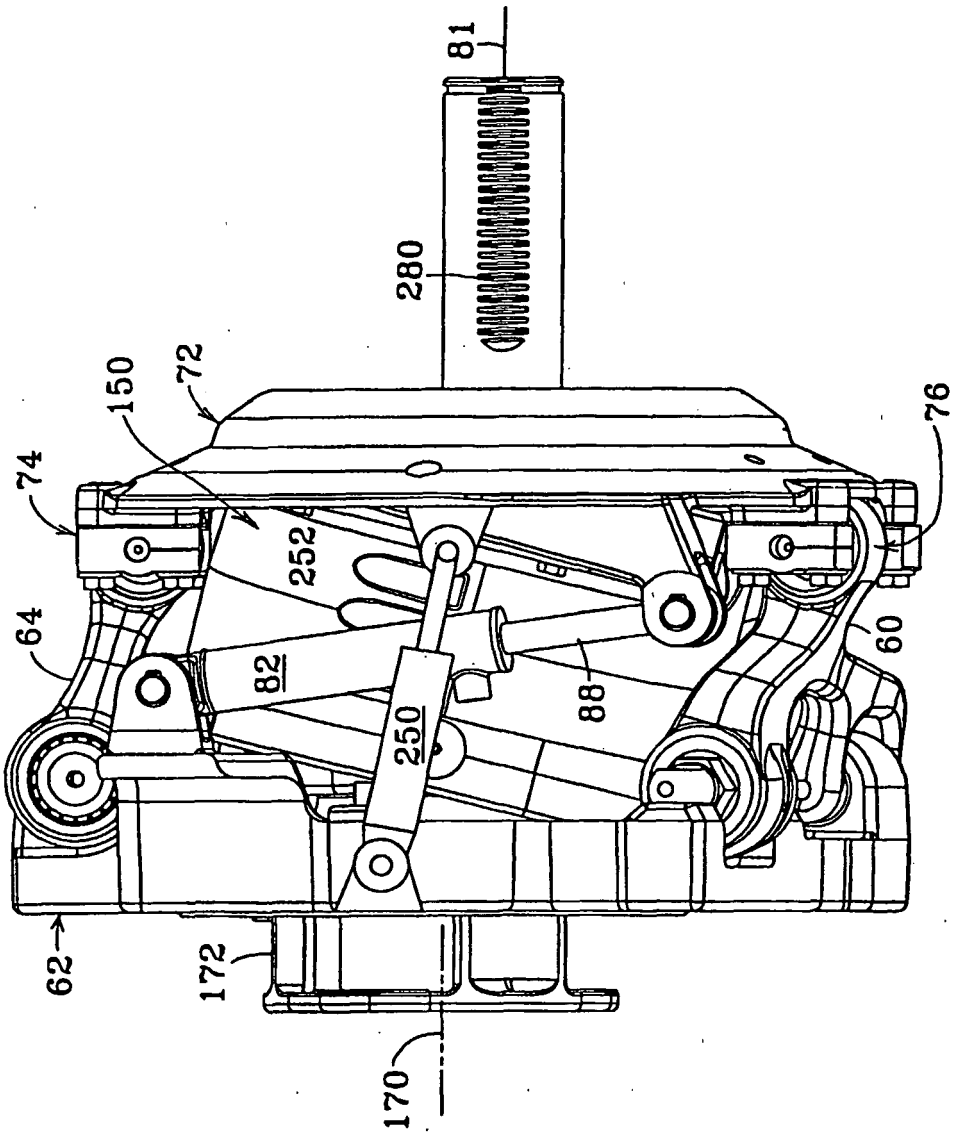

FIG. 12

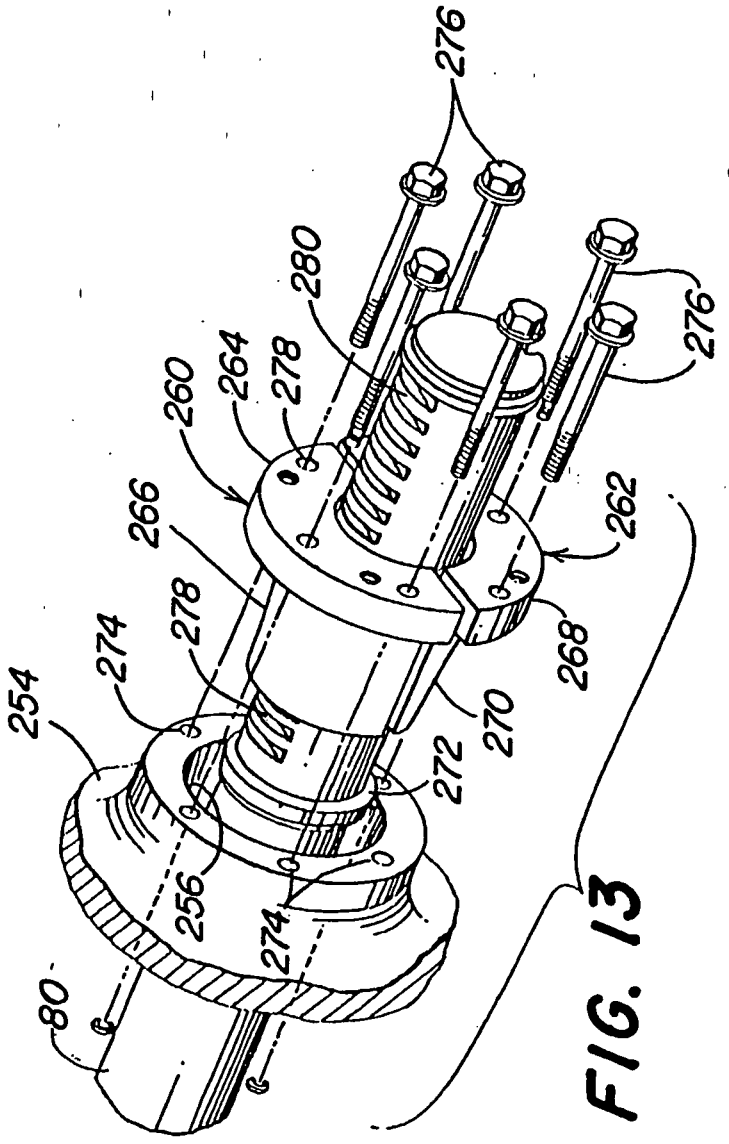
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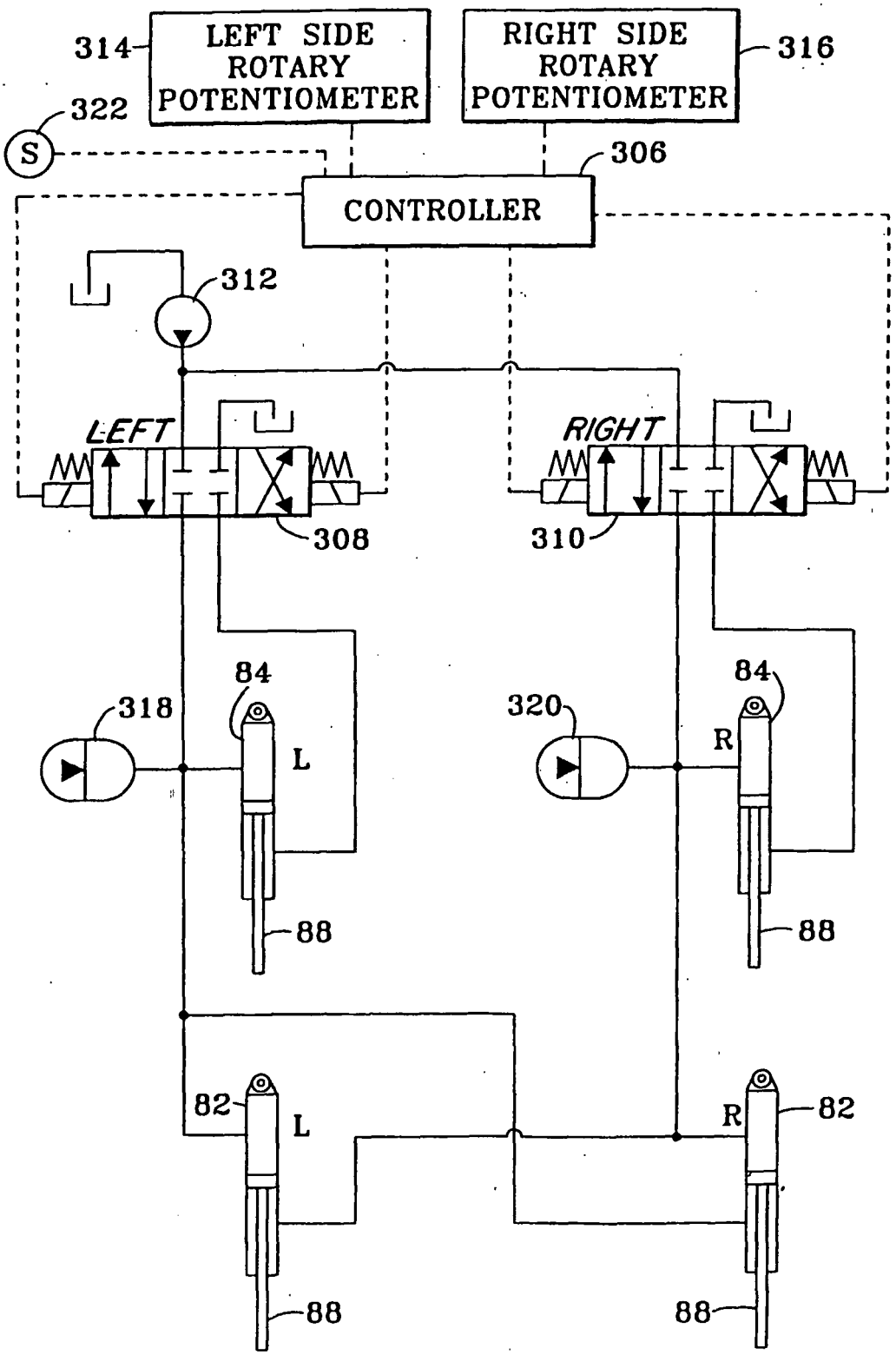
FIG. 13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LEFT SIDE ROTARY POTENTIOMETER
RIGHT SIDE ROTARY POTENTIOMETER
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CONTROLLER
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FIG. 14

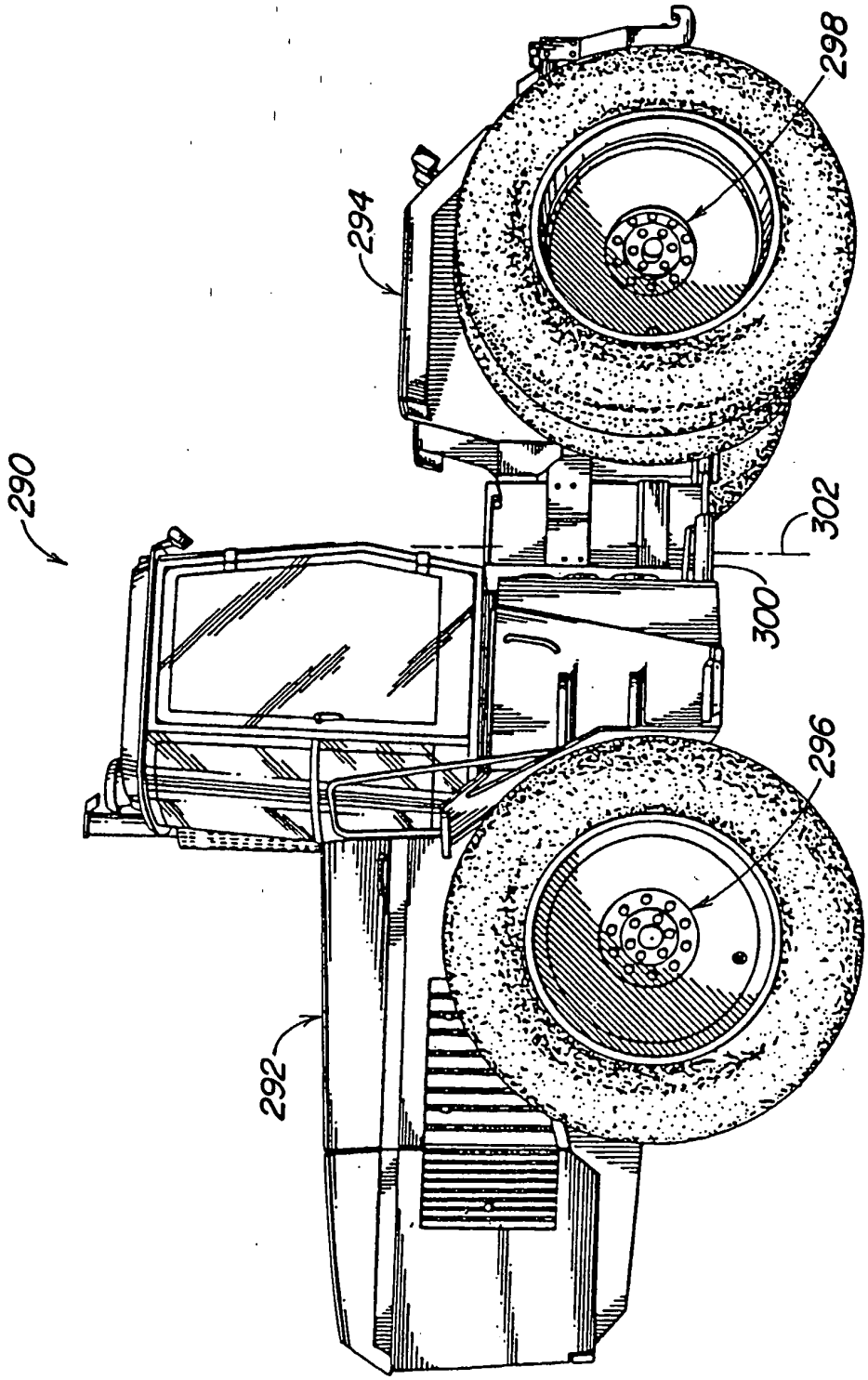

FIG. 15