



US011958535B2

(12) **United States Patent**  
**Gordon**

(10) **Patent No.: US 11,958,535 B2**  
(45) **Date of Patent: Apr. 16, 2024**

(54) **MODULAR FRONT DRIVETRAIN ASSEMBLY**

B60K 17/16; B60K 17/00; B60K 5/10;  
B60G 15/04; B60G 13/005; B60G 11/14;  
B60G 7/008; B60G 7/001

(71) Applicant: **Robby Gordon**, Charlotte, NC (US)

See application file for complete search history.

(72) Inventor: **Robby Gordon**, Charlotte, NC (US)

(56) **References Cited**

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 360 days.

U.S. PATENT DOCUMENTS

4,057,120 A \* 11/1977 Roethlisberger ..... B60G 7/02  
180/263  
2011/0086714 A1 \* 4/2011 Flores-Garay ..... F16D 3/221  
464/142

(21) Appl. No.: **17/019,829**

(Continued)

(22) Filed: **Sep. 14, 2020**

(65) **Prior Publication Data**

US 2021/0078639 A1 Mar. 18, 2021

FOREIGN PATENT DOCUMENTS

WO WO-2011119764 A1 \* 9/2011 ..... B60G 7/02  
WO WO-2017196776 A1 \* 11/2017 ..... B60G 11/27  
WO WO-2018096513 A1 \* 5/2018 ..... B60G 3/18

*Primary Examiner* — Jason D Shanske

*Assistant Examiner* — Matthew James O'Neill

**Related U.S. Application Data**

(60) Provisional application No. 62/900,481, filed on Sep. 14, 2019.

(74) *Attorney, Agent, or Firm* — Barry Choobin; Patent 360

(51) **Int. Cl.**

**B62D 21/18** (2006.01)

**B60G 7/00** (2006.01)

**B60G 11/14** (2006.01)

**B60G 13/00** (2006.01)

**B60G 15/04** (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ..... **B62D 21/183** (2013.01); **B60G 7/001**  
(2013.01); **B60G 7/008** (2013.01); **B60G 11/14**  
(2013.01); **B60G 13/005** (2013.01); **B60G**  
**15/04** (2013.01); **B60G 17/00** (2013.01); **B60K**  
**17/16** (2013.01); **B62D 3/00** (2013.01); **B62D**  
**7/20** (2013.01);

(Continued)

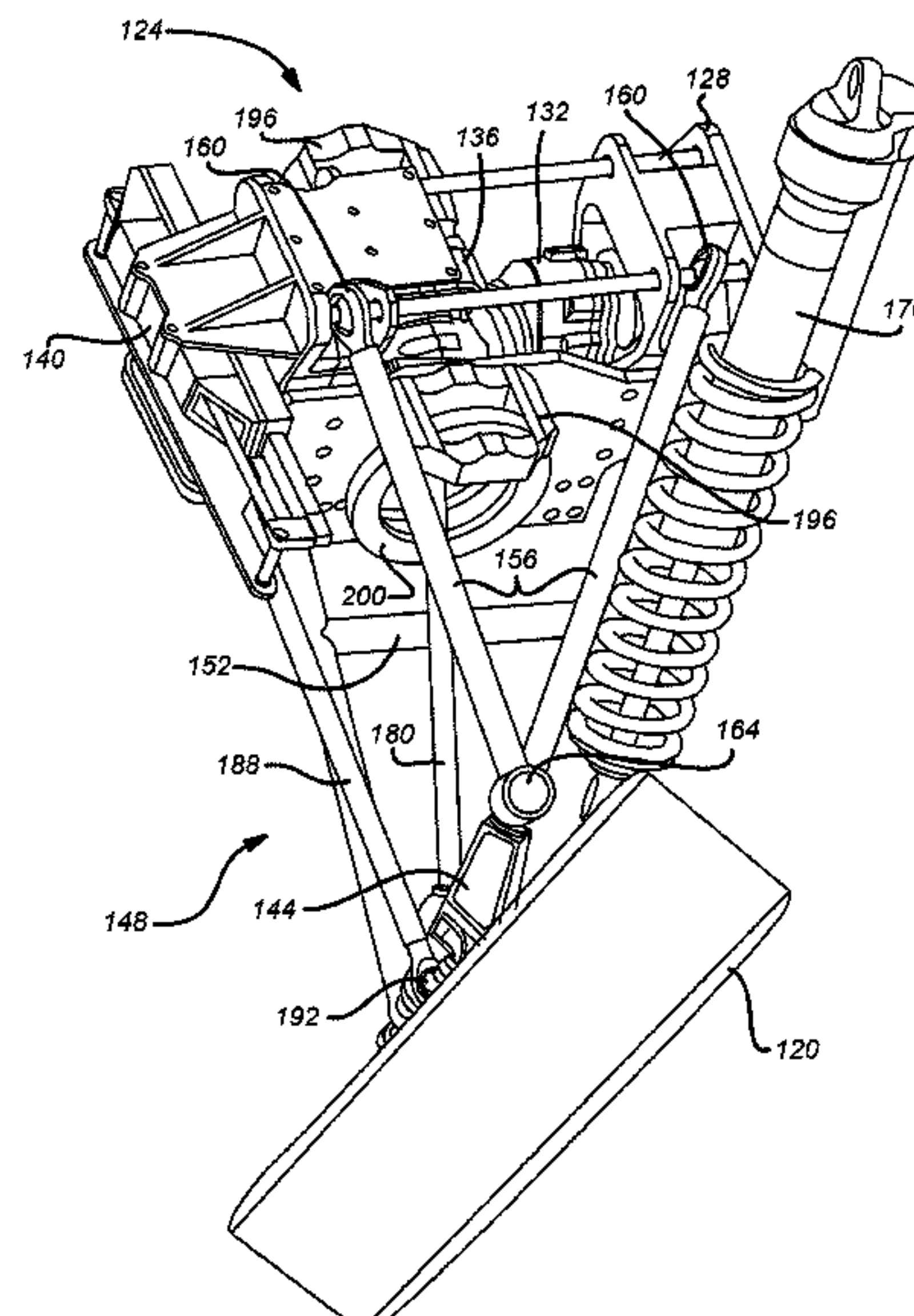
(58) **Field of Classification Search**

CPC ..... B62D 21/183; B62D 7/20; B62D 3/00;

**ABSTRACT**

An apparatus and methods are provided for a modular front drivetrain comprising a single assembly that may be installed onto and removed from a vehicle. The modular front drivetrain comprises a modular chassis supporting a transaxle, a front differential, and a steering gear for operating front wheels of the vehicle. The transaxle, the front differential and drive axles convey torque from an engine onboard the vehicle to the front wheels. A spindle assembly is coupled with each front wheel of the vehicle and pivotally joined with the modular chassis by way of a front suspension system. Steering rods coupled with the spindle assemblies horizontally rotate the front wheels according to operation of a steering wheel onboard the vehicle. The modular front drivetrain advantageously facilitates replacing an entire drivetrain and suspension assembly quickly and easily in the event of a part failure during racing applications.

**14 Claims, 3 Drawing Sheets**



- (51) **Int. Cl.**  
    *B60G 17/00* (2006.01)  
    *B60K 17/16* (2006.01)  
    *B62D 3/00* (2006.01)  
    *B62D 7/20* (2006.01)
- (52) **U.S. Cl.**  
    CPC ..... *B60G 2202/12* (2013.01); *B60G 2300/27*  
                    (2013.01); *B60G 2400/82* (2013.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2012/0029779	A1 *	2/2012	Dickinson	.....	F16H 48/32
					475/86
2019/0093745	A1 *	3/2019	Younggren	.....	B60K 6/48
2019/0145465	A1 *	5/2019	Olason	.....	F16D 3/223
					180/344
2022/0281275	A1 *	9/2022	Schlangen	.....	B60K 11/04

\* cited by examiner

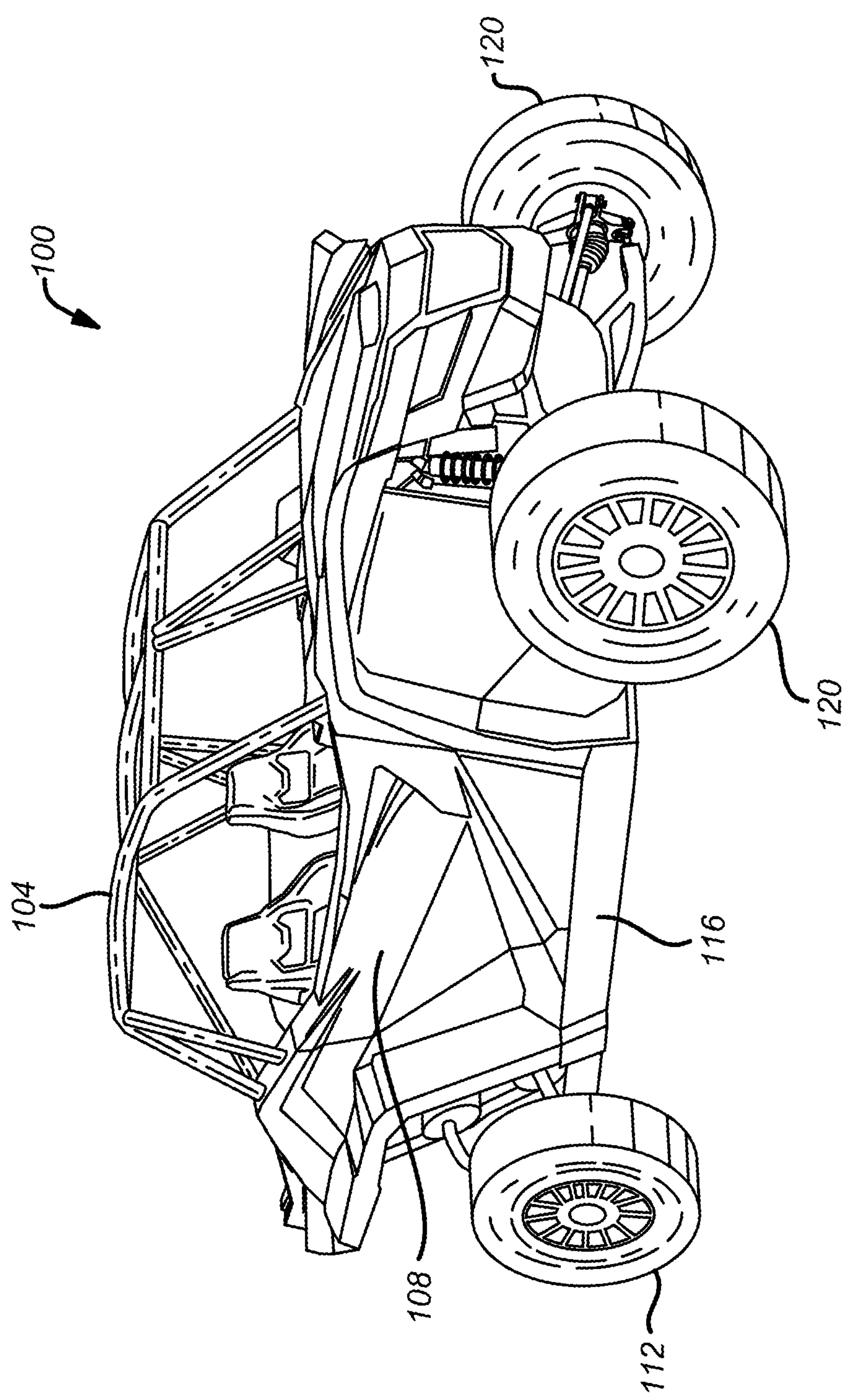


FIG. 1



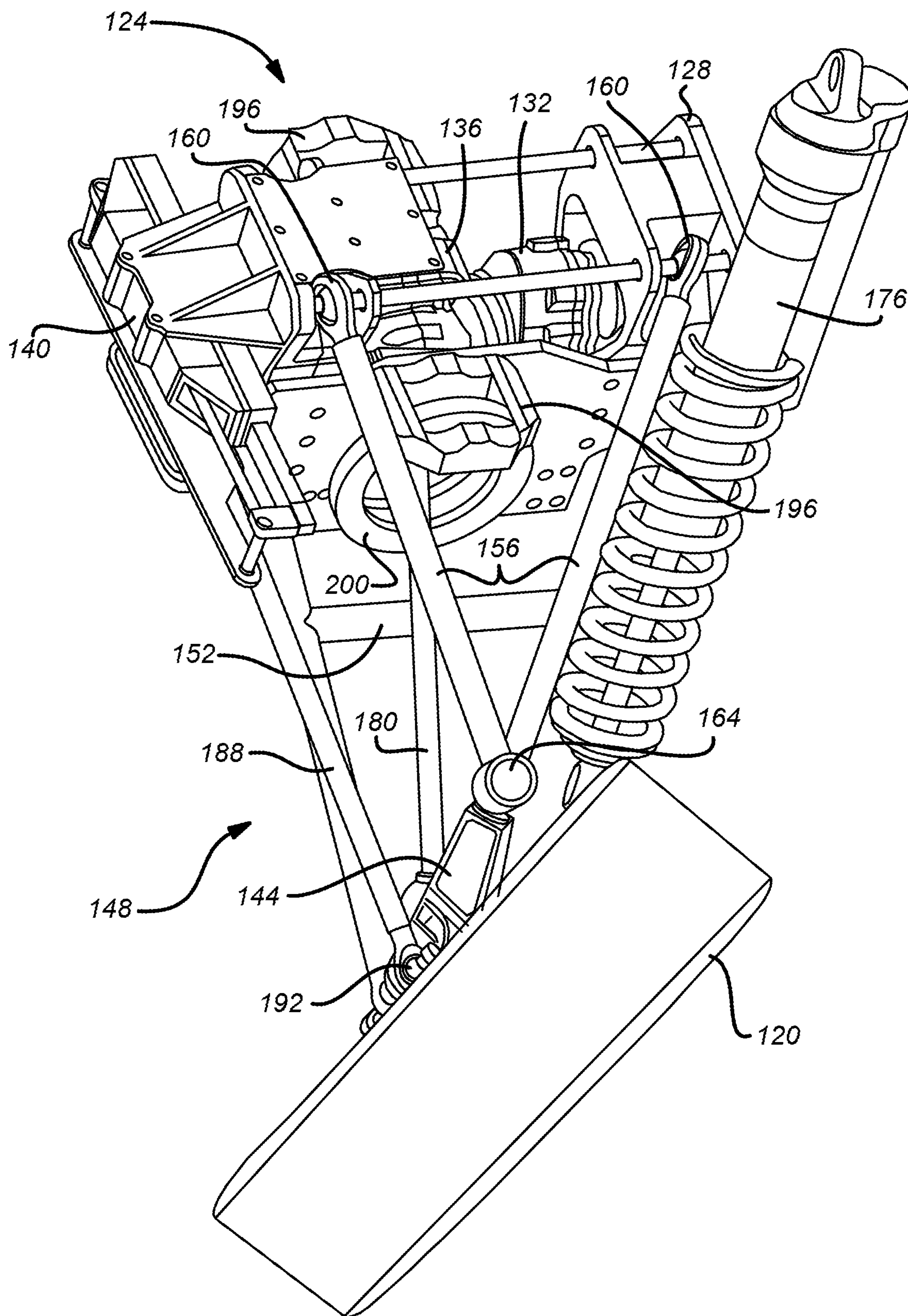
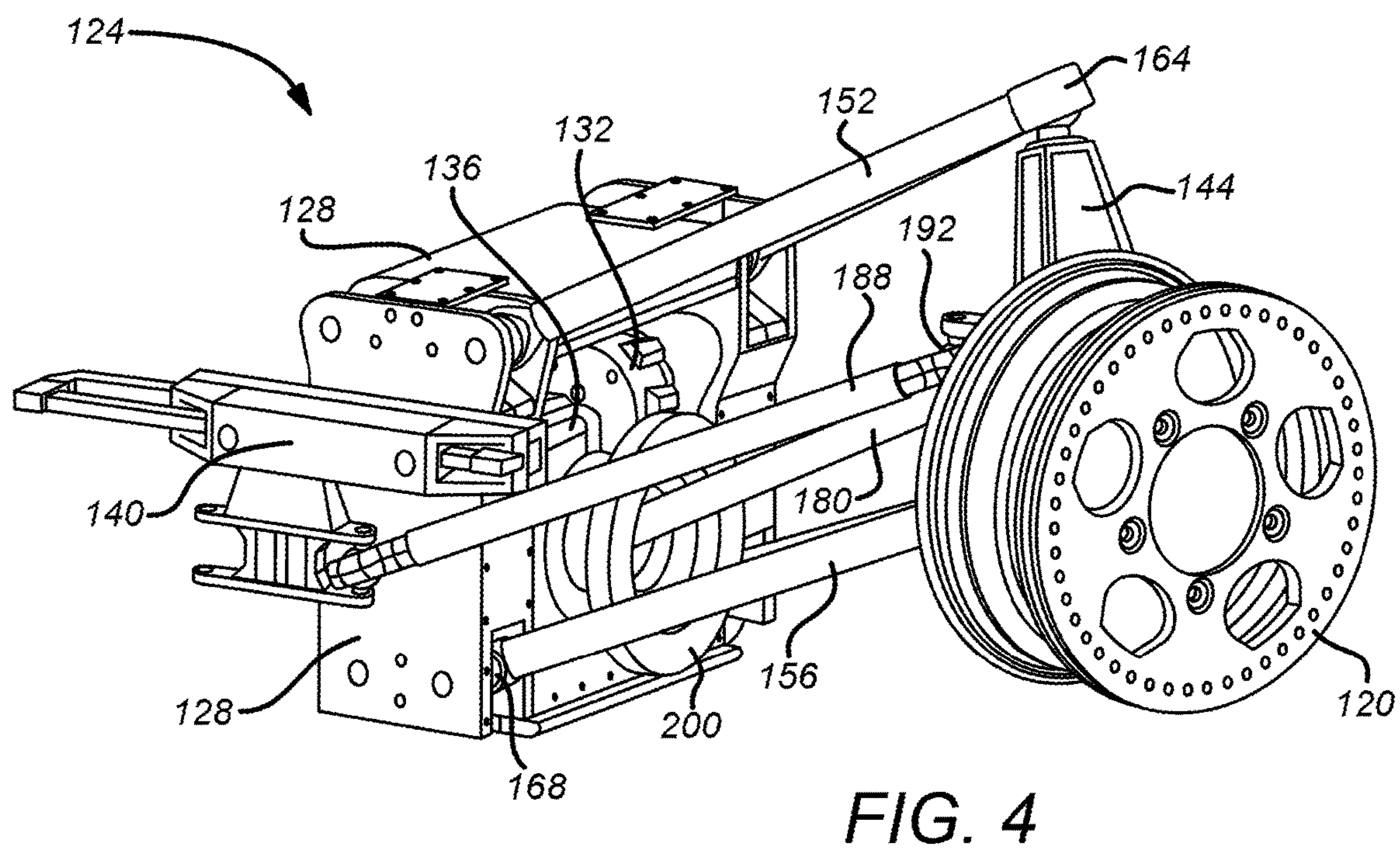
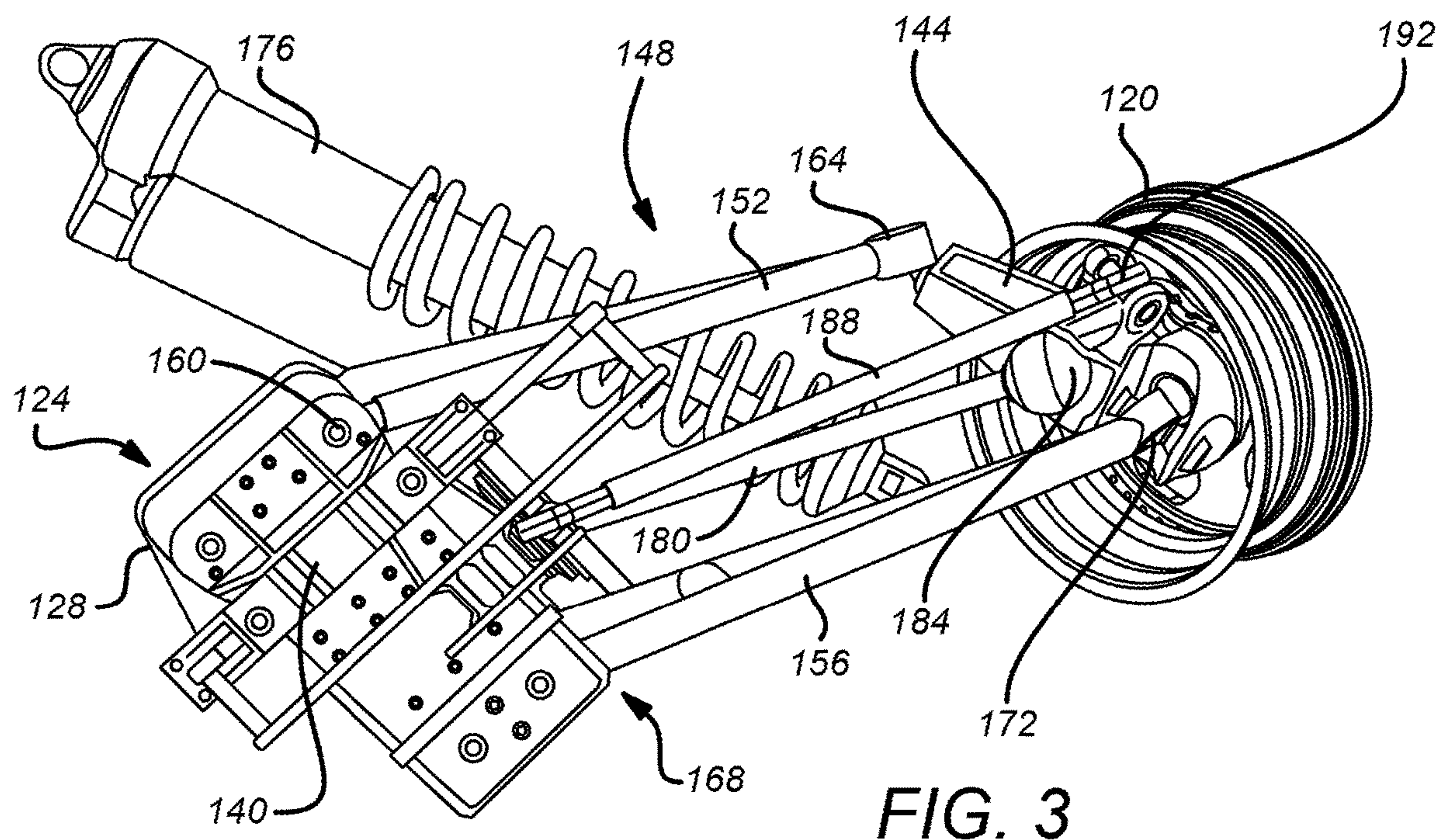


FIG. 2





1

## MODULAR FRONT DRIVETRAIN ASSEMBLY

### PRIORITY

This application claims the benefit of and priority to U.S. Provisional Application, entitled "Modular Front Drivetrain Assembly," filed on Sep. 14, 2019 and having application Ser. No. 62/900,481, the entirety of said application being incorporated herein by reference.

### FIELD

Embodiments of the present disclosure generally relate to the field of vehicle drivetrains. More specifically, embodiments of the disclosure relate to an apparatus and methods for a modular front drivetrain comprising a single assembly that may be installed onto and removed from a vehicle.

### BACKGROUND

A double wishbone suspension is a well-known independent suspension design using upper and lower wishbone-shaped arms to operably couple a front wheel of a vehicle. Typically, the upper and lower wishbones or suspension arms each has two mounting points to a chassis of the vehicle and one mounting joint at a spindle assembly or knuckle. A shock absorber and a coil spring may be mounted onto the wishbone to control vertical movement of the front wheel. The double wishbone suspension facilitates control of wheel motion throughout suspension travel, including controlling such parameters as camber angle, caster angle, toe pattern, roll center height, scrub radius, scuff, and the like.

Double wishbone suspensions may be used in a wide variety of vehicles, including heavy-duty vehicles, as well as many off-road vehicles, as shown in FIG. 1. FIG. 1 shows an off-road vehicle 100 that is of a Side by Side variety. The Side by Side is a four-wheel drive off-road vehicle that typically seats between two and six occupants and is sometimes referred to as a Utility Task Vehicle (UTV), a Recreational Off-Highway Vehicle (ROV), or a Multipurpose Off-Highway Utility Vehicle (MOHUV). In addition to the side-by-side seating arrangement, many UTVs have seat belts and roll-over protection, and some may have a cargo box at the rear of the vehicle. A majority of UTVs come factory equipped with hard tops, windshields, and cab enclosures.

The double-wishbone suspension often is referred to as "double A-arms," although the arms may be A-shaped, L-shaped, J-shaped, or even a single bar linkage. In some embodiments, the upper arm may be shorter than the lower arm so as to induce negative camber as the suspension jounces (rises). Preferably, during turning of the vehicle, body roll imparts positive camber gain to the lightly loaded inside wheel, while the heavily loaded outer wheel gains negative camber.

The spindle assembly, or knuckle, is coupled between the outboard ends of the upper and lower suspension arms. In some designs, the knuckle contains a kingpin that facilitates horizontal radial movement of the wheel, and rubber or trunnion bushings for vertical hinged movement of the wheel. In some relatively newer designs, a ball joint may be disposed at each outboard end to allow for vertical and radial movement of the wheel. A bearing hub, or a spindle to which wheel bearings may be mounted, may be coupled with the center of the knuckle.

2

Constant velocity (CV) joints allow pivoting of the suspension arms and the spindle assembly, while a drive shaft coupled to the CV joint delivers power from a transaxle to the wheels. Although CV joints are typically used in front wheel drive vehicles, off-road vehicles such as four-wheeled buggies comprise CV joints at all wheels. Constant velocity joints typically are protected by a rubber boot and filled with molybdenum disulfide grease.

Given that off-road vehicles routinely travel over very rough terrain, such as mountainous regions, there is a desire to improve the mechanical strength and performance of off-road drivetrain and suspension systems, while at the same reducing the mechanical complexity of such systems.

### SUMMARY

An apparatus and methods are provided for a modular front drivetrain comprising a single assembly that may be installed onto and removed from a vehicle. The modular front drivetrain comprises a modular chassis supporting a transaxle, a front differential, and a steering gear for operating front wheels of the vehicle. The transaxle and front differential are configured to convey torque from an engine onboard the vehicle to the front wheels. A spindle assembly is coupled with each front wheel of the vehicle and pivotally joined with the modular chassis by way of a front suspension system. A drive axle is engaged with the front differential and each spindle assembly for conveying torque to the front wheels. Steering rods coupled with the spindle assemblies are configured for horizontally rotating the front wheels according to operation of a steering wheel onboard the vehicle. The modular front drivetrain is configured to facilitate a practitioner replacing an entire drivetrain and suspension quickly and easily in the event of a part failure.

In an exemplary embodiment, a modular front drivetrain for operating front wheels of a vehicle comprises: a modular chassis supporting a drivetrain and a steering system operatively coupled with the front wheels; a spindle assembly coupled with each front wheel; and a front suspension system coupling each spindle assembly to the modular chassis.

In another exemplary embodiment, the modular front drivetrain comprises a single drivetrain and suspension assembly that is configured to be installed onto and removed from the vehicle. In another exemplary embodiment, the modular front drivetrain is configured to facilitate a practitioner replacing an entire drivetrain and suspension quickly and easily in the event of a part failure.

In another exemplary embodiment, the front suspension system includes an upper control arm and a lower control arm that are configured to couple the front wheel with the modular chassis. In another exemplary embodiment, the upper control arm comprises two inboard upper control arm joints that couple the upper control arm to the modular chassis and an outboard upper control arm joint that couples the upper control arm to the spindle assembly. In another exemplary embodiment, the lower control arm includes two inboard lower control arm joints that couple the lower control arm to the modular chassis and an outboard lower control arm joint that couples the lower control arm to the spindle assembly. In another exemplary embodiment, the upper control arm and the lower control arm are configured to facilitate vertical motion of the front wheel during travel over terrain and accommodate horizontal motion of the front wheel during steering of the front wheel by way of the steering gear. In another exemplary embodiment, a strut that is comprised of a shock absorber and a coil spring is mounted to the lower control arm by way of a lower pivot; and wherein a top of the strut is coupled to an upper pivot disposed on a chassis of the vehicle.



3

In another exemplary embodiment, the drivetrain includes a transaxle, a front differential and a drive axle coupled between each front wheel and the front differential. In another exemplary embodiment, the drive axle is configured to conduct torque from the transaxle to the front wheel and accommodate vertical pivoting motion of the front suspension system in response to road conditions. In another exemplary embodiment, the drive axle includes a constant velocity joint that is coupled with the spindle assembly and configured to allow uninterrupted torque transmission from the transaxle to the front wheel during vertical pivoting of the front suspension assembly due to road conditions.

In another exemplary embodiment, the steering system includes a steering rod coupled between each spindle assembly and a steering gear disposed on the modular chassis. In another exemplary embodiment, the steering gear is configured to cause the front wheels to articulate horizontally with respect to the modular chassis upon the steering gear being turned by way of a steering wheel of the vehicle. In another exemplary embodiment, the steering rod is coupled with each spindle assembly by way of a steering rod-end joint configured to allow vertical and horizontal rotational motion of the spindle assembly during operation of the vehicle. In another exemplary embodiment, the steering rod-end joint is coupled with each spindle assembly forward of a drive axle so as to provide a leading-edge steering system to the vehicle.

In an exemplary embodiment, a method for a modular front drivetrain for operating front wheels of a vehicle comprises: configuring a modular chassis for supporting a drivetrain to convey torque from an engine onboard the vehicle to the front wheels; coupling each front wheel to the modular chassis by way of a spindle assembly and a front suspension system; communicating torque from the drivetrain to the front wheel by way of a front differential and drive axles; coupling a braking system with the drive axles for slowing rotation of the front wheels; disposing a steering system on the modular chassis for directing horizontal motion of the front wheels; and installing the modular front drivetrain onto the vehicle.

In another exemplary embodiment, the method further comprises configuring the modular front drivetrain as a single drivetrain and suspension assembly to be installed onto and removed from the vehicle. In another exemplary embodiment, coupling includes configuring the front suspension system to allow vertical motion of the front wheels due to road conditions. In another exemplary embodiment, disposing includes coupling a steering rod between each spindle assembly and a steering gear disposed on the modular chassis. In another exemplary embodiment, coupling the steering rod includes coupling a steering rod-end joint with each spindle assembly forward of the drive axles to provide a leading-edge steering system to the vehicle. In another exemplary embodiment, communicating torque includes coupling each drive axle with the spindle assembly by way of a constant velocity joint configured to allow uninterrupted torque transmission from the transaxle to the front wheel during vertical pivoting of the front suspension assembly due to road conditions.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The drawings refer to embodiments of the present disclosure in which:

FIG. 1 illustrates an exemplary embodiment of an off-road vehicle that is particularly suitable for implementation of a modular front drivetrain in accordance with the present disclosure;

4

FIG. 2 illustrates an upper perspective view of a driver-side portion of an exemplary embodiment of a modular front drivetrain;

FIG. 3 illustrates a front view of the modular front drivetrain of FIG. 2; and

FIG. 4 illustrates an upper perspective view of a driver-side portion of an exemplary embodiment of a modular front drivetrain.

While the present disclosure is subject to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. The invention should be understood to not be limited to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the present disclosure.

#### DETAILED DESCRIPTION

In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. It will be apparent, however, to one of ordinary skill in the art that the invention disclosed herein may be practiced without these specific details. In other instances, specific numeric references such as “first joint,” may be made. However, the specific numeric reference should not be interpreted as a literal sequential order but rather interpreted that the “first joint” is different than a “second joint.” Thus, the specific details set forth are merely exemplary. The specific details may be varied from and still be contemplated to be within the spirit and scope of the present disclosure. The term “coupled” is defined as meaning connected either directly to the component or indirectly to the component through another component. Further, as used herein, the terms “about,” “approximately,” or “substantially” for any numerical values or ranges indicate a suitable dimensional tolerance that allows the part or collection of components to function for its intended purpose as described herein.

A double wishbone suspension generally comprises upper and lower suspension arms that operably couple a front wheel of a vehicle. The upper and lower suspension arms each typically include two mounting points to a chassis of the vehicle and one mounting joint at a spindle assembly. The spindle assembly is coupled between the outboard ends of the upper and lower suspension arms and is configured to allow vertical and horizontal radial movement of a wheel coupled with the spindle assembly. Constant velocity (CV) joints allow pivoting of the suspension arms and the spindle assembly, while a drive shaft coupled to the CV joint conveys power from a transaxle to the wheel. Given that off-road vehicles routinely travel over very rough terrain, such as mountainous regions, there is a desire to improve the mechanical strength and performance of off-road drivetrain and suspension systems, while at the same reducing the mechanical complexity of such systems. Embodiments of the disclosure provide to a modular front drivetrain comprising a single assembly that may be installed onto and removed from a vehicle.

FIG. 1 shows an off-road vehicle **100** that is particularly suitable for implementation of a modular front drivetrain in accordance with the present disclosure. As disclosed hereinabove, the off-road vehicle **100** generally is of a Utility Task Vehicle (UTV) variety that seats two occupants, includes a roll-over protection system **104**, and may have a cab enclosure **108**. Rear wheels **112** of the off-road vehicle **100** may be operably coupled with a chassis **116** by way of



## 5

a trailing arm suspension system. Front wheels **120** may be operably coupled with the chassis **116** by way of a front suspension system and a spindle assembly. It should be understood, however, that the modular front drivetrain disclosed herein is not to be limited to the off-road vehicle **100**, but rather the modular front drivetrain may be incorporated into a wide variety of vehicles, other than UTVs, without limitation.

FIG. **2** illustrates an upper perspective view of a driver-side portion of an exemplary embodiment of a modular front drivetrain **124** that may be implemented in the off-road vehicle **100**. The modular front drivetrain **124** includes a modular chassis **128** that supports a transaxle **132**, a front differential **136**, and a steering gear **140** that are operably coupled with a spindle assembly **144** and the front wheel **120** by way of a front suspension system **148**. Further, the modular chassis **128** provides mounting points for the front suspension **148**, in lieu of conventional mounting points that comprise portions of the chassis **116** of the vehicle. It is to be understood, therefore, that the modular front drivetrain **124** comprises a single drivetrain/suspension assembly that may be installed onto and removed from the vehicle **100**, unlike a conventional drivetrain and suspension that comprise multiple components that must be individually assembled onto the chassis **116** of the vehicle.

The front suspension system **148** includes an upper control arm (UCA) **152** and a lower control arm (LCA) **156** that couple the front wheel **120** with the modular chassis **128**. The UCA **152** comprises two inboard UCA joints **160** that couple the UCA **152** to the modular chassis **128** and an outboard UCA joint **164** that couples the UCA **152** to the spindle assembly **144**. As best shown in FIG. **3**, the LCA **156** includes two inboard LCA joints **168** that couple the LCA **156** to the modular chassis **128** and an outboard LCA joint **172** that couples the LCA **156** to the spindle assembly **144**. As will be recognized, the UCA and LCA **152**, **156** generally are of a double wishbone variety of suspension that facilitates vertical motion of the front wheel **120** during travel over terrain, as well as facilitating horizontal motion of the front wheel **120** during steering of the vehicle **100** by way of the steering gear **140**. The UCA and LCA **152**, **156** further facilitate controlling various parameters affecting the orientation of the front wheel **120** with respect to the off-road vehicle **100**, such as, by way of non-limiting example, camber angle, caster angle, toe pattern, roll center height, scrub radius, and scrub.

It should be understood that although the front suspension system **148** is disclosed specifically in connection with the driver-side of the off-road vehicle **100**, a passenger-side front suspension system is to be coupled with a passenger side of the modular chassis **128**. It should be further understood that the passenger-side front suspension system is substantially identical to the driver-side front suspension system **148**, with the exception that the passenger-side front suspension system is configured specifically to operate with the passenger-side of the modular chassis **128**. As will be appreciated, therefore, the passenger-side front suspension system and the driver-side front suspension system **148** may be configured as reflections of one another across a longitudinal midline of the off-road vehicle **100**.

As shown in FIGS. **2-3**, a strut **176** that is comprised of a shock absorber and a coil spring is mounted to the LCA **156** by way of a lower pivot (not shown). A top of the strut **176** is coupled to an upper pivot (not shown) that may be disposed on the chassis **116** of the vehicle **100**. The strut **176** is configured to dampen vertical motion of the front suspension system **148** due to movement of the front wheel **120**

## 6

as the vehicle **100** travels over terrain. The UCA **152** may be suitably configured, such as in the form of a J-arm, so as to facilitate coupling the strut **176** between the LCA **156** and the chassis **116** (see FIG. **1**) of the vehicle **100** in lieu of being coupled between the UCA **152** and the chassis **116**. Moreover, it is contemplated that in some embodiments, the strut **176** may be coupled between the LCA **156** and the modular chassis **128**, without limitation, and without deviating beyond the scope of the present disclosure.

As best shown in FIG. **2**, a drive axle **180** is coupled between the front wheel **120** and the front differential and transaxle **136**, **132**. The drive axle **180** is configured to conduct torque from the transaxle **132** to the front wheel **120** and accommodate vertical pivoting motion of the front suspension system **148** in response to road conditions, as is straightforward to see upon comparing FIG. **3** and FIG. **4**. As best shown in FIG. **3**, the drive axle **180** includes a constant velocity (CV) joint **184** that is coupled with the spindle assembly **144**. The CV joint **184** enables uninterrupted torque transmission from the transaxle **132** to the front wheel **120** during vertical pivoting of the front suspension assembly **148** due to road conditions.

In the embodiment illustrated in FIGS. **2-3**, a steering rod **188** couples the spindle assembly **144** with the steering gear **140** disposed on the modular chassis **128**. The steering rod **188** may be coupled with the spindle assembly **144** by way of a steering rod-end joint **192** that is similar to the inboard UCA joints **160**. It is contemplated, therefore, that the steering rod-end joint **192** may be of a Heim-joint variety or may be of a bushing variety, as desired. As will be appreciated, the steering rod-end joint **192** allows vertical and horizontal rotational motion of the spindle assembly **144** during operation of the vehicle **100**.

Moreover, the steering rod-end joint **192** is coupled with the spindle assembly **144** forward of the drive axle **180**, thereby providing a leading-edge steering system to the vehicle **100**. Experimentation has demonstrated that the leading-edge steering system shown in FIGS. **2-3** advantageously decreases leverage of the front wheel **120** on the steering rod-end joint **192** and the steering rod **188**, thereby substantially eliminating bump steer that may occur due to forces exerted on the front wheel **120** by rough terrain. Details pertaining to rod-end joints are disclosed in above-mentioned U.S. patent application Ser. No. 15/625,692, which is entitled "Rod-End Front Suspension." Further, details pertaining to leading-edge steering systems are disclosed in U.S. patent application Ser. No. 15/625,813, entitled "Leading-Edge Steering Assembly," filed on Jun. 16, 2017, the entirety of which is incorporated herein by reference.

Turning again to FIG. **2**, the modular front drivetrain **124** may further include a braking system configured to enable a practitioner to slow the rotation rate of the front wheel **120** during operation of the vehicle **100**. In the illustrated embodiment of FIGS. **2-3**, the brake system comprises a brake caliper **196** that is fastened onto the modular chassis **128**. A brake disc **200** is coupled to the drive axle **180** such that a periphery of the brake disc **200** passes within the brake caliper **196**. As will be recognized, when the practitioner depresses a brake pedal of the vehicle **100** the brake caliper **196** applies pressure to the brake disc **200**, thus slowing the rotation rate of the front wheel **120**. The brake caliper **196** may be cable operated or may be operated by way hydraulic lines. Although not shown in FIGS. **2-3**, the brake disc **200** may be coupled with a hub comprising the front differential **136**. In some embodiments, however, the brake disc **200** may be coupled with a constant velocity joint that is coupled



with the hub of the front differential 136. It is contemplated that the brake caliper 196 and the brake disc 200 may be incorporated into the modular front drivetrain 124 in a wide variety of configurations, without limitation, and without deviating beyond the scope of the present disclosure.

As disclosed hereinabove, the modular front drivetrain 124 comprises a modular chassis 128 that supports the transaxle 132, the front differential 136, the drive axle 180 and the front suspension system 148, such that engine torque applied to the transaxle 132 is conveyed to the front wheel 120. The modular chassis 128 also supports the steering gear 140 and the steering rod 188, such that turning the steering gear 140, by way of a steering wheel of the vehicle 100, causes the front wheel 120 to articulate horizontally with respect to the modular chassis 128. Further, the modular chassis 128 provides mounting points for the front suspension 148 that allow the front wheel 120 to move vertically from a low position (e.g., due to “maximal bounce”), shown in FIG. 3, to a high position (e.g., due to “maximal bump”), shown in FIG. 4. As such, the modular front drivetrain 124 is not limited to the specific configuration shown in FIGS. 2-3, but rather the configuration of the modular front drivetrain 124 may be varied in accordance with the configuration of each of the components comprising the modular front drivetrain 124, without limitation.

Moreover, the modular front drivetrain 124 generally may be varied in accordance with the specific type of vehicle 100 into which the modular front drivetrain 124 is to be implemented. It is contemplated that the modular front drivetrain 124 may be implemented in any of various off-road vehicles 100, such as, by way of non-limiting example, Utility Task Vehicles (UTVs), Recreational Off-Highway Vehicles (ROVs), or Multipurpose Off-Highway Utility Vehicles (MOHUVs), without limitation. As such, the modular front drivetrain 124 is particularly well-suited for off-road racing applications, such as desert racing, short course racing, hill climbing, rallying, and the like.

In addition to the off-road applications discussed above, it is contemplated that, in some embodiments, the modular front drivetrain 124 may be incorporated into racing vehicles that are not necessarily intended for off-road racing. For example, the modular front drivetrain 124 may be incorporated into racing vehicles that may be used for any of formula racing, sports car racing, stock car racing, drag racing, touring car racing, production car racing, as well as amateur open-wheel racing applications, such as karting, and the like. In such applications, the modular front drivetrain 124 advantageously enables an entire drivetrain and suspension assembly to be quickly and easily replaced in the event of a part failure, unlike in the case of conventional racing vehicles that may be sidelined during a race due to the failure of an individual part comprising the drivetrain or the suspension.

While the invention has been described in terms of particular variations and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the variations or figures described. In addition, where methods and steps described above indicate certain events occurring in certain order, those of ordinary skill in the art will recognize that the ordering of certain steps may be modified and that such modifications are in accordance with the variations of the invention. Additionally, certain of the steps may be performed concurrently in a parallel process when possible, as well as performed sequentially as described above. To the extent there are variations of the invention, which are within the spirit of the disclosure or equivalent to the inventions found in the claims, it is the

intent that this patent will cover those variations as well. Therefore, the present disclosure is to be understood as not limited by the specific embodiments described herein, but only by scope of the appended claims.

What is claimed is:

1. A modular front drivetrain for operating front wheels of a vehicle, the modular front drivetrain comprising:
  - a modular chassis comprising:
    - a front plate,
    - a top plate,
    - a bottom plate, and
    - a plurality of bars extending between the front plate and a rear plate, the modular chassis configured to mount a front differential and a transaxle, wherein a steering gear is mounted on the front plate;
  - a spindle assembly coupled with each front wheel; and
  - a front suspension system coupling each spindle assembly to the modular chassis,
 wherein the modular front drivetrain is configured to be removed from the vehicle in an intact state without removing at least the front suspension system from the modular chassis for servicing and is capable of being reinstalled.
2. The modular front drivetrain of claim 1, wherein the front suspension system comprises an upper control arm and a lower control arm that are coupled to the spindle assembly.
3. The modular front drivetrain of claim 2, wherein the upper control arm comprises two inboard upper control arm joints that couple the upper control arm to the modular chassis and an outboard upper control arm joint that couples the upper control arm to the spindle assembly.
4. The modular front drivetrain of claim 2, wherein the lower control arm includes two inboard lower control arm joints that couple the lower control arm to the modular chassis and an outboard lower control arm joint that couples the lower control arm to the spindle assembly.
5. The modular front drivetrain of claim 2, wherein the upper control arm and the lower control arm are configured to facilitate vertical motion of the front wheel during travel over terrain and accommodate horizontal motion of the front wheel during steering of the front wheel by way of the steering gear.
6. The modular front drivetrain of claim 2, wherein a strut that is comprised of a shock absorber and a coil spring is mounted to the lower control arm by way of a lower pivot; and wherein a top of the strut is coupled to an upper pivot disposed on a chassis of the vehicle.
7. The modular front drivetrain of claim 1, wherein a drive axle is configured to conduct torque from the transaxle to the front wheel and accommodate vertical pivoting motion of the front suspension system in response to road conditions.
8. The modular front drivetrain of claim 1, wherein the modular chassis is configured to support a drive axle that includes a constant velocity joint that is coupled with the spindle assembly and configured to allow uninterrupted torque transmission from the transaxle to the front wheel during vertical pivoting of the front suspension assembly due to road conditions.
9. The modular front drivetrain of claim 1, wherein a steering rod is coupled to the spindle assembly and the steering gear.
10. The modular front drivetrain of claim 9, wherein the steering gear is configured to cause the front wheels to articulate horizontally with respect to the modular chassis upon the steering gear being turned by way of a steering wheel of the vehicle.



**11.** The modular front drivetrain of claim **9**, wherein the steering rod is coupled with each spindle assembly by way of a steering rod-end joint configured to allow vertical and horizontal rotational motion of the spindle assembly during operation of the vehicle.

5

**12.** The modular front drivetrain of claim **11**, wherein the steering rod-end joint is coupled with each spindle assembly forward of a drive axle so as to provide a leading-edge steering system to the vehicle.

10

**13.** A method for a modular front drivetrain for operating front wheels of a vehicle, the method comprising: providing a modular front drivetrain comprising: a modular chassis comprising: a plurality of bars extending between a front plate and a rear plate, the modular chassis configured to mount a drivetrain, a transaxle, a steering gear, and a front differential, a spindle assembly coupled with each front wheel, and a front suspension system coupling each spindle assembly to the modular chassis; coupling the front suspension system to the spindle assembly mounted to a front wheel; mounting a steering rod extending from the steering gear to the spindle assembly, the steering gear mounted to a front plate of the modular chassis; removing the modular front drivetrain from the vehicle without removing at least the front suspension system from the modular chassis for servicing; and upon removing, reinstalling the modular front drivetrain to the vehicle.

15

20

25

**14.** The method of claim **13**, further comprising configuring the modular front drivetrain as a single drivetrain and suspension assembly to be installed onto and removed from the vehicle.

30

\* \* \* \* \*