



София,
Ж.к. Южен парк, бл.1р вх.Д, ап.1
invertortonchev@gmail.com
Георги Тончев

Наш знак: **СПИС-382** 28.04.2025
Ваш знак:

Искане за предварително проучване за новост на
изобретение с наименование
„Универсална автономна електро-гравитационна система за превантивно
механо-динамично противодействие на центробежната сила на ремаркета в завои“

Патентното ведомство Ви уведомява, че във връзка с Ваше искане № СПИС-382 от 17.04.2025г. е извършено проучване въз основа на:

- ☒ описанието, претенциите
- ☒ приложените фигури

Класове по МПК: B60T7/20; G06F7/00; B62D63/06; B60D1/01; B60D1/06
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Бази-данни: IPAS; Esp@cenet,

При проучването са намерени следните документи, посочени в приложения доклад:

Патентни документи:

US2024010036 (A1), US2023356707 (A1), US6424907

И. Стефанова
Главен експерт ДЕЗИПМПД



СТАНОВИЩЕ

ОТНОСНО: предварително проучване за новост на
изобретение с наименование

„Универсална автономна електро-гравитационна система за превантивно
механо-динамично противодействие на центробежната сила на ремаркета в завои“

вх. № СпИС-382/17.04.2025 г.

Проучването е направено въз основа на представените 31 патентни претенции
описание и приложенияте към него фигури.

Обект на настоящото проучване е универсална автономна електро-
гравитационна система за превантивно механо-динамично противодействие на
центробежната сила на ремаркета в завои.

Съгласно независима патентна претенция 1, универсалната автономна
електро-гравитационна система за превантивно механо-динамично противодействие
на центробежната сила на ремаркета в завои, включва: теглещо превозно средство,
притежаващо: задна броня (1), механизъм за теглич на ремарке (2) с топка за теглич на
ремарке (3); ремарке (4), теглич на ремарке (5), лапа на теглича (6), система от
датчици, безжично свързани с интелигентен управленски компютърен блок (7), като
има баластен акумулатор (8), пързаящ се, възвратно постъпателно, напречно на
надлъжната ос на ремаркетото на ролкови колелца (9), движещи се по двустранно
наклонящи се успоредни релси (10), едностранно кинематично свързани с наклонящ ги
електрически механизъм (11), чийто електрически захранващ входен кабел е свързан,
през първо изпълнително устройство (12), с първи извод от баластния акумулатор (8),
втори електрически извод от баластния акумулатор (8), през второ изпълнително
устройство (13), е свързан към електрически вход на кордов реверсивен електрически
мотор (14), първи броневи механичен захват (15) е кинематично свързан с първа корда
(16), която през първа обратна кордова ролка (17) е кинематично свързана към
първата страна на баластния акумулатор (8), втори броневи механичен захват (18) е
кинематично свързан с втора корда (19), която през втора обратна кордова ролка (20),
е кинематично свързана към втората страна на баластния акумулатор (8), първи 15
команден извод от интелигентния управленски компютърен блок (7) е кабелно свързан
с първото изпълнително устройство (12), втори команден извод от интелигентния
управленски компютърен блок (7) е кабелно свързан с второто изпълнително
устройство (13), при което първи безжичен сигнален вход на интелигентния
управленски компютърен блок (7) е свързан със сигнален извод от диференциален

дистанционен датчик (21), втори безжичен сигнален вход на интелигентния управленски компютърен блок (7) е свързан със сигнален извод от скоростен датчик (22), трети безжичен сигнален вход на интелигентния управленски компютърен блок (7) е свързан със сигнален извод от инерционен датчик (23), а зареждащ вход на баластния акумулатор (8), през зареждащ контролер (24), е кабелно свързан с общ извод от фотоволтаични панели (25,26), монтирани на покривите, съответно на ремаркетото (4) и на теглещо превозно средство, като към надлъжните ръбове на всеки фотоволтаик, успоредни, съответно на надлъжните оси на ремаркетото (4) и на теглещо превозно средство, са шарнирно свързани огледални рефлектори (27), а интелигентният управленски компютърен блок (7) е конфигуриран за програмиране със самообучаващ се изкуствен интелект и е интегриран с хардуерен блок за архивна памет.

Съгласно зависима претенция 2, баластният акумулатор (8) е монтиран в пързяляща се количка (28) на ролкови колелца (9) по наклонени релси (10).

Съгласно зависима претенция 3, баластният акумулатор (8) е със странични механични захвати (29), за които шарнирно са свързани краищата на съответните първа корда (16) и втора корда (19).

Съгласно зависима претенция 4, всяко ролково колелце (9) е с вътрешен страничен борд (30).

Съгласно зависима претенция 5, характеризираща се с това, че ремаркетото (4) е с повече от една ос (31).

Съгласно зависима претенция 6, осите (31) са със зависимо окачване към пода на (4).

Съгласно зависима претенция 7, осите (31) са с независимо окачване към пода на ремаркетото (4).

Съгласно зависима претенция 8, кабелните връзки (32) между зареждащия контролер (24) и баластния акумулатор (8) са гъвкави.

Съгласно зависима претенция 9, електрическият механизъм (11) и кордовият реверсивен електрически мотор (14), са безчеткови електросилови машини.

Съгласно зависима претенция 10, фотоволтаичните панели (25,26), монтирани на покривите, съответно на ремаркетото (4) и на теглещо превозно средство, са на антивибрационни тампони.

Съгласно зависима претенция 11, шарнирно свързаните огледални рефлектори (27) към фотоволтаичните панели (25,26) са с регулируеми наклони, спрямо плоскостите на шарнирно свързаните огледални рефлектори (27), които са сгъваеми.

Съгласно зависима претенция 12, шарнирно свързаните огледални рефлектори (27) към фотоволтаичните панели (25,26) са рециклируеми полимерни огледала.

Съгласно зависима претенция 13, наклонените релси (10) са подвижно монтирани върху теглича на ремаркетото (5).

Съгласно зависима претенция 14, първата корда (16) и втората корда (19) са от нееластичен гъвкав материал.

Съгласно зависима претенция 15, колелата на ремаркетото (4) са с широки протектори.

Съгласно зависима претенция 16, колелата на ремаркетото (4) са самонапомпващи се надуваеми.

Съгласно зависима претенция 17, колелата на ремаркетото (4) са от плътни еластомери.

Съгласно зависима претенция 18, механизмът за теглича на ремаркетото 18 (2) е подвижно монтиран към задната част на шасито на теглещо превозно средство.

Съгласно зависима претенция 19, задната броня (1) е монтирана към задната част на шасито на теглещото превозно средство, чрез хоризонтални амортизатори (34).

Съгласно зависима претенция 20, наклонящият електрически механизъм (11) включва кинематично необратим редуктор.

Съгласно зависима претенция 21, кордовият реверсивен електрически мотор (14) включва кинематично обратим редуктор.

Съгласно зависима претенция 22, на теглича на ремаркетото (4) е монтиран поне един шарнир (35), към който е фиксиран горният край на един еднораменен лост (36), на чийто срещуположен край лагерува едно колело (37) на хоризонтален вал.

Съгласно зависима претенция 23, между едно раменния лост (36) и теглича на ремаркетото (4) е монтиран поне един пневматичен амортизатор с вграден еластичен елемент (38).

Съгласно зависима претенция 24, между еднораменния лост (36) теглича на ремаркетото (4) е монтиран поне един торсионен гумен амортизатор (38).

Съгласно зависима претенция 25, размерите на колела (37, 39, 40, 41 и 42) са еднакви.

Съгласно зависима претенция 26, всеки шарнир (35) лагерува около един наклонен вал (43).

Съгласно зависима претенция 27, колелите на всички оси на ремаркетото (4) са равни помежду си.

Съгласно зависима претенция 28, колелата на предната ос на ремаркетото (4) е по-широка от останалите колела.

Съгласно зависима претенция 29, колелата на задната ос (39 и 42) на ремаркетото (4) са двигателни.

Съгласно зависима претенция 30, колелата на предната ос на ремаркетото (4) са завиващи.

Съгласно зависима претенция 31, колелата на всички оси на ремаркетото (4) са завиващи.

Обект на настоящото проучване е да се обезпечи универсална автономна електрогравитационна система за превантивно механо-динамично противодействие на центробежната сила на ремаркета в завои, която радикално да преодолее недостатъците на разгледаните системи и ефективно да стабилизира безопасното движение на ремаркетата, при което е задължително ремаркетото да може надеждно и ефективно да балансира в завои по чисто кинематичен начин, като ползва стандартния кормилен усилвател на теглещото превозно средство.

В патентен документ US2024010036 (A1) е разкрита системата за контрол на гравитацията на ремаркетото за превозно средство включваща: задвижващ механизъм за предно ляво активно окачване, свързан с предно ляво колело на превозното средство; преден десен задвижващ механизъм за активно окачване, свързан с предно дясно колело на превозното средство; активатор на задно ляво активно окачване, свързан със задно ляво колело на превозното средство; активатор на задно дясно активно окачване, свързан със задно дясно колело на превозното средство; модул за управление на задвижващия механизъм, който е конфигуриран: въз основа на силите

на теглича при теглича на ремаркетото на превозното средство в надлъжна, странична и вертикална посока, да определя целевите вертикални сили за активатора на предното ляво активно окачване, предното дясно активно окачване задвижващ механизъм, задвижващият механизъм на задното ляво активно окачване и съответно задвижващият механизъм на задното дясно активно окачване; и селективно да регулира на предния ляв и десен задвижващ механизъм на активното окачване, задния ляв и десен задвижващ механизъм на активното окачване въз основа съответно на целевите вертикални сили; модул за управление на задвижващия механизъм, конфигуриран да определя целевите вертикални сили на базата на минимизиране на разликите между силата на теглича и референтната сила на теглича; модул за еталонни сили на теглича, конфигуриран да задава референтните стойности на силата на теглича; модул за управление на задвижващия механизъм, конфигуриран да определя целевите вертикални сили допълнително въз основа на скоростта на отклонение на превозното средство и е конфигуриран да определя целевите вертикални сили на базата на минимизиране на разликата между скоростта на отклонение и референтната скорост на отклонение; модул за еталонна скорост на завъртане, конфигуриран да задава еталонната скорост на завъртане на базата на ъгъл на завиване на превозното средство и да задава еталонната скорост на завъртане допълнително въз основа на скоростта на превозното средство; преден ляв електрически мотор, конфигуриран да извежда въртящ момент към предното ляво колело на превозното средство; преден десен електрически мотор, конфигуриран да извежда въртящ момент към предното дясно колело на превозното средство; заден ляв електрически мотор, конфигуриран да извежда въртящ момент към задното ляво колело на превозното средство; заден десен електрически мотор, конфигуриран да извежда въртящ момент към задното дясно колело на превозното средство; и модул за управление на колело, конфигуриран да: въз основа на първата сила на захващане, втората сила на захващане и третата сила на захващане, определя целевите изходни стойности на въртящия момент съответно на предния ляв електрически мотор, предния десен електрически мотор, задния ляв електрически мотор и задния десен електродвигател; и селективно регулиране на предния ляв електродвигател, предния десен електромотор, задния ляв електромотор и задния десен електромотор въз основа съответно на целевия въртящ момент; модулът за управление на колелото е конфигуриран да определя целевите изходящи въртящи моменти допълнително въз основа на целевите вертикални сили; модулът за управление на задвижващия механизъм е конфигуриран да определя целевите вертикални сили допълнително въз основа на целевия изходен момент на въртящия момент.

В патентен документ US2023356707 (A1) са разкрити метод и система, като системата включва: превозно средство, което има електрическо задвижвано ремарке, теглено към него; контролер, програмиран да задвижва превозното средство с ремаркетото, теглено към него, който управлява задвижването на превозното средство и на ремаркетото. Контролерът е допълнително програмиран да управлява компонентите на силовото предаване на превозното средство и на ремаркетото, да получава данни за загуба на компоненти на задвижването на превозното средство и на ремаркетото; картата на ефективността, свързана с факторите на задвижването на превозното средство в данните за загубите на компонентите на задвижването на превозното средство и картата на ефективността, свързана с факторите на задвижването на ремаркетото, в данните за загубите на компонентите на задвижването на ремаркетото;

комбинираната карта на ефективността осигурява работа на задвижването на превозното средство и задвижването на ремаркетото да имат най-висока комбинирана ефективност за дадена комбинация от мощност и скорост на превозното средство, изисквана от водача; силовото предаване на превозното средство включва първа тягова батерия; задвижването на ремаркетото включва втора тягова батерия; задвижването на превозното средство допълнително включва двигател; контролерът е допълнително програмиран да предизвиква прехвърляне на електрическа енергия между първата тягова батерия и втората тягова батерия, за да поддържа работата на задвижването на превозното средство и задвижването на ремаркетото съгласно комбинираната карта на ефективност; контролерът е допълнително програмиран да реализира работата на задвижването на превозното средство и задвижването на ремаркетото чрез векторизиране на въртящия момент между задвижващите оси и източниците на задвижване на задвижването на превозното средство и задвижването на ремаркетото и да генерира комбинирана карта на ефективност при свързване на ремаркетото към превозното средство; ремаркетото е електрифицирано, тъй като задвижването на ремаркетото включва тягова батерия за осигуряване на мощност за задвижване на ремаркетото.

В едно от примерните изпълнения, за разлика от задвижването на превозното средство, задвижването на ремаркетото не включва двигател. Силовото предаване на ремаркетото допълнително включва електрически мотор, който е механично свързан към задвижваща ос, която е механично свързана с колелата на ремаркетото. Тяговата батерия за съхранява електрическа енергия, може да се използва от електрическия мотор за задвижване на ремаркетото. Тяговият акумулатор е електрически свързан към електрическия мотор чрез инвертор на силовото предаване на ремаркетото. Инвертора преобразува постоянен ток от тяговата батерия в променливотоково захранване, за да управлява електрически мотор за задвижване на ремарке.

В патентен документ US6424907 са разкрити системи за измерване на стабилността на превозното средство и по-специално метод и свързано устройство за откриване на промени в центъра на тежестта на масата на превозно средство.

Устройство за откриване на опасност от преобръщане на превозно средство, включва най-малко две оси и най-малко три колела; средство за отчитане на състояние на шофиране при маневра в завой; средство за определяне на вариации в центъра на тежестта на масата; средство за откриване на първи променливи на състоянието, които съответстват на съответното натоварване на колелата върху най-малко две колела; средство за сравняване на откритите променливи на първо състояние с референтни стойности, представителни за съответната маневра на завиване; средство за изчисляване на промяната в центъра на тежестта от разликите между откритите първи променливи на условието и референтните стойности и средство за определяне на втора променлива на условието, представителна за опасността от преобръщане, от изчисленото изменение на центъра на тежестта; средства за измерване на поне един ход на пружината на окачването на колелото, налягането на пружината на окачването на колелото, налягането на амортизатора на амортизатора, налягането на въздуха вътре в гумата, страничната деформация на гумата и използване на такова измерване като основа за първата променлива на условието, която съответства на натоварването на колелото; средство за измерване на поне едно от напречното ускорение, което действа

върху центъра на тежестта на превозното средство, ъгъла на накланяне на превозното средство, ъгъла на наклона на превозното средство, скоростта на превозното средство, ъгъла на завиване, скоростта на отклонение и използване на такова измерване като основа за втората променлива на условието, представителна за опасността от преобръщане; превключвател за крайна позиция, осигурен на амортизатор или върху пружинен елемент на окачването на колелото, точката на превключване на превключвателя за крайна позиция е свързана чрез времева корелация с втората променлива на условието, представителна за опасността от преобръщане.

Анализът на обекта на проучването и известните решения показва следното:

Новост

При извършен сравнителен анализ между обекта, предмет на настоящето проучване и намерените при проучването документи, се установи, че в нито един от намерените документи не е разкрита универсалната автономна електро-гравитационна система за превантивно механо-динамично противодействие на центробежната сила на ремаркета в завои, която да включва всички технически признаци на обекта на проучването.

Следователно, обектът на настоящето проучване, съгласно така формулираните претенции е нов по смисъла на чл. 8 от Закона за патентите и регистрацията на полезните модели (ЗПРПМ).

И. Стефанова
Главен експерт ДЕЗИПМПД



ДОКЛАД ОТ ПРОУЧВАНЕ ПРОУЧВАНЕ ВХ. № СпИС-382/17.04.2025 г.		
I. Уточнен класификационен индекс по МПК/КПК		
МПК: B60T7/20; G06F7/00; B62D63/06; B60D1/01; B60D1/06 КПК: B60T7/20; G06F7/00; B62D63/06; B60D1/01; B60D1/06; B60T8/248		
II. ОБЛАСТ НА ПРОУЧВАНЕ:		
Минимален обхват на проучване		
Вид класификация:	Класификационен индекс:	
МПК/КПК	МПК: B60T7/20; G06F7/00; B62D63/06; B60D1/01; B60D1/06 КПК: B60T7/20; G06F7/00; B62D63/06; B60D1/01; B60D1/06; B60T8/248	
Бази данни, в които е извършено проучването		
Esp@cenet; IPAS; Internet		
III. Релевантни документи		
Категория	Цитиране на документите с посочване на релевантните части	Релевантни претенции
A	US2024010036 (A1), [DRIV AUTOMOTIVE INC [САЩ] ±], публ. на 11.01.2024г.	1-31
A	US2023356707 (A1), [FORD GLOBAL TECH LLC [US] ±], публ. на 09.11.2023г.	1-31
A	US6424907, [CONTINENTAL TEVES AG & CO OHG [DE] ±], публ. на 23.07.2002г.	1-31
Категория на документа		
X – документът е от особено значение; претендираното изобретение няма новост или изобретателска стъпка, когато документът се разглежда самостоятелно Y – документът е от особено значение; претендираното изобретение няма изобретателска стъпка, когато документът се комбинира с един или повече други документи и тази комбинация е очевидна за специалист в областта A – документ, отразяващ нивото на техниката, който не е от особено значение D – документ, цитиран в описанието O – неписмено разкриване, използване, прилагане, докладване или демонстриране P - документ, публикуван преди датата на подаване в България, но след приоритетната дата E – по-рано подадена българска заявка, но публикувана на или след датата на подаване L – документ, който може да предизвика съмнение относно приоритета на претенциите или който е цитиран с цел установяване датата на публикация на друг документ или друга специална причина (както е посочено) & - документ от една патентна фамилия		
Дата: 28.04.2025	Име: И. Стефанова	
	И. Стефанова Главен експерт ДЕЗИПМПД	



US006424907B1

(12) **United States Patent**
Rieth et al.

(10) **Patent No.:** **US 6,424,907 B1**
(45) **Date of Patent:** **Jul. 23, 2002**

(54) **METHOD AND DEVICE FOR
DETERMINING AND DETECTING THE
OVERTURNING HAZARD OF A VEHICLE**

5,825,284 A * 10/1998 Dunwoody et al. 340/440
5,904,218 A * 5/1999 Watkins 180/209

FOREIGN PATENT DOCUMENTS

(75) Inventors: **Peter Rieth**, Eltville; **Alfred Eckert**,
Mainz; **Bernhard Schmittner**,
Aschaffenburg, all of (DE)

DE	32 22 149	11/1983
DE	42 01 146	7/1992
DE	43 21 571	1/1994
DE	43 42 732	6/1995
DE	44 16 991	11/1995
DE	196 19 381	11/1997
DE	196 23 595	12/1997
DE	197 46 889	5/1998
DE	197 51 935	5/1999
EP	0 758 601	2/1997

(73) Assignee: **Continental Teves AG & Co., OHG**,
Frankfurt (DE)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

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§ 371 (c)(1),
(2), (4) Date: **Mar. 23, 2001**

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PCT Pub. Date: **Jan. 27, 2000**

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Feb. 3, 1999 (DE) 199 04 216

(51) **Int. Cl.**⁷ **G06F 17/10**; G06G 7/48

(52) **U.S. Cl.** **701/124**; 701/29; 340/438;
340/440

(58) **Field of Search** 701/1, 70, 72,
701/79, 80, 124, 29; 180/170, 197; 340/431,
438, 440

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,927,173 A * 5/1990 Clifton 280/755

* cited by examiner

Primary Examiner—Gertrude Arthur

(74) *Attorney, Agent, or Firm*—Rader, Fishman & Grauer
PLLC

(57) **ABSTRACT**

A method and device is disclosed for determining and detecting the rollover hazard of a vehicle through a dynamic detection of variations in the center of gravity of the vehicle. During cornering of the vehicle, first condition variables, which correspond to the respective wheel load, are detected on at least two wheels. The detected first condition variables are compared to reference values representative of the respective cornering maneuver. A corresponding change in the center of gravity is calculated from the differences between the detected first condition variables and the reference values.

8 Claims, 4 Drawing Sheets

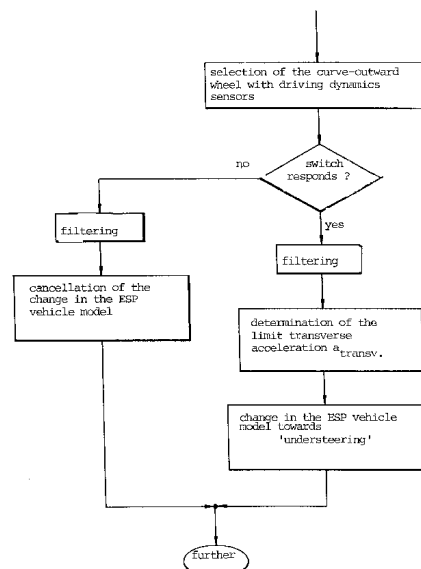
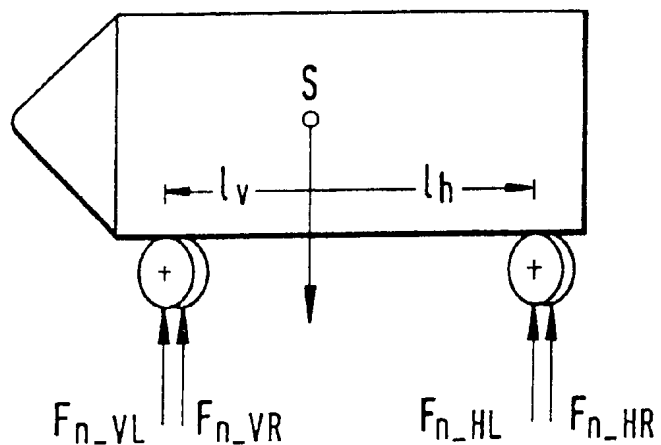


Fig. 1a

PRIOR ART

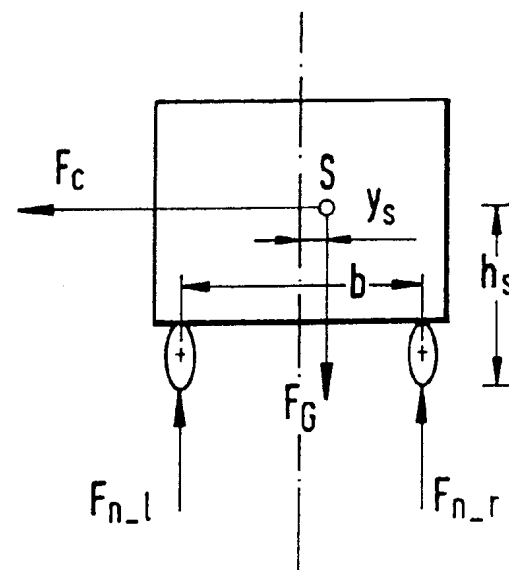


$$F_G = F_{n_VL} + F_{n_VR} + F_{n_HL} + F_{n_HR}$$

and in the static case for an axle

Fig. 1b

PRIOR ART



$$: F_{G_A}^{xle} * (b/2 + y_s) = F_n * b$$

Fig. 2

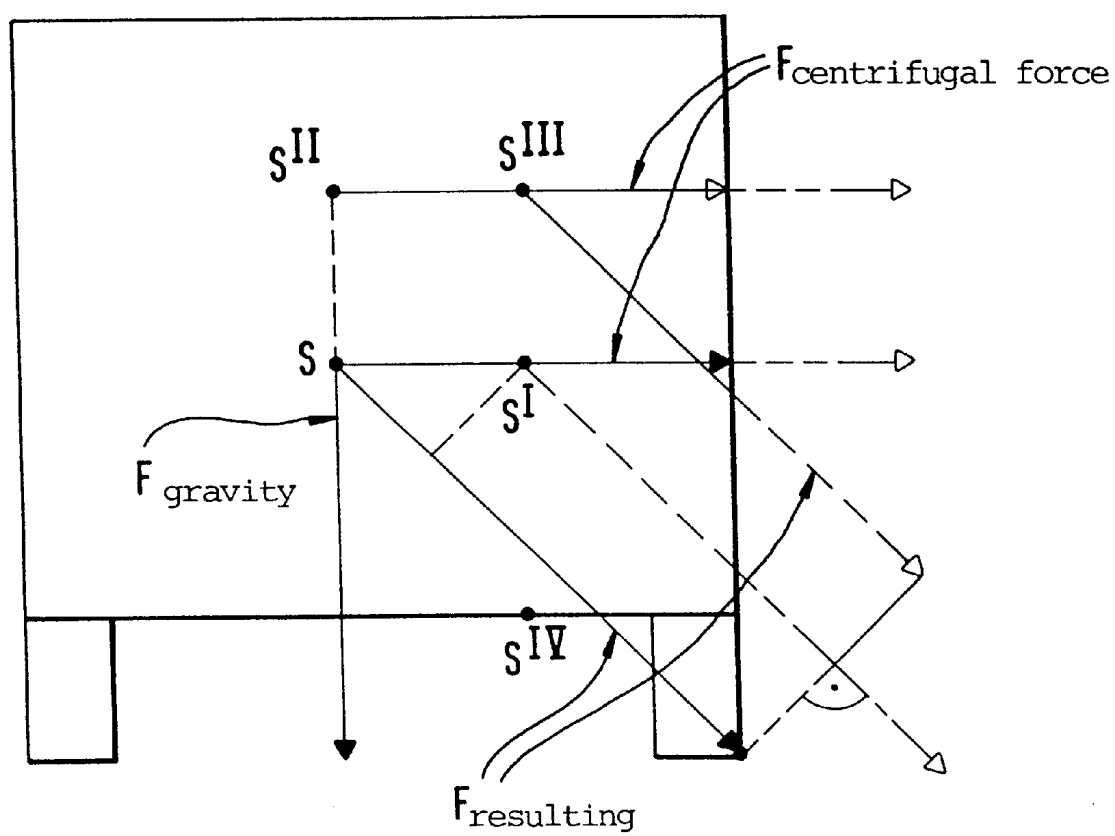


Fig. 3

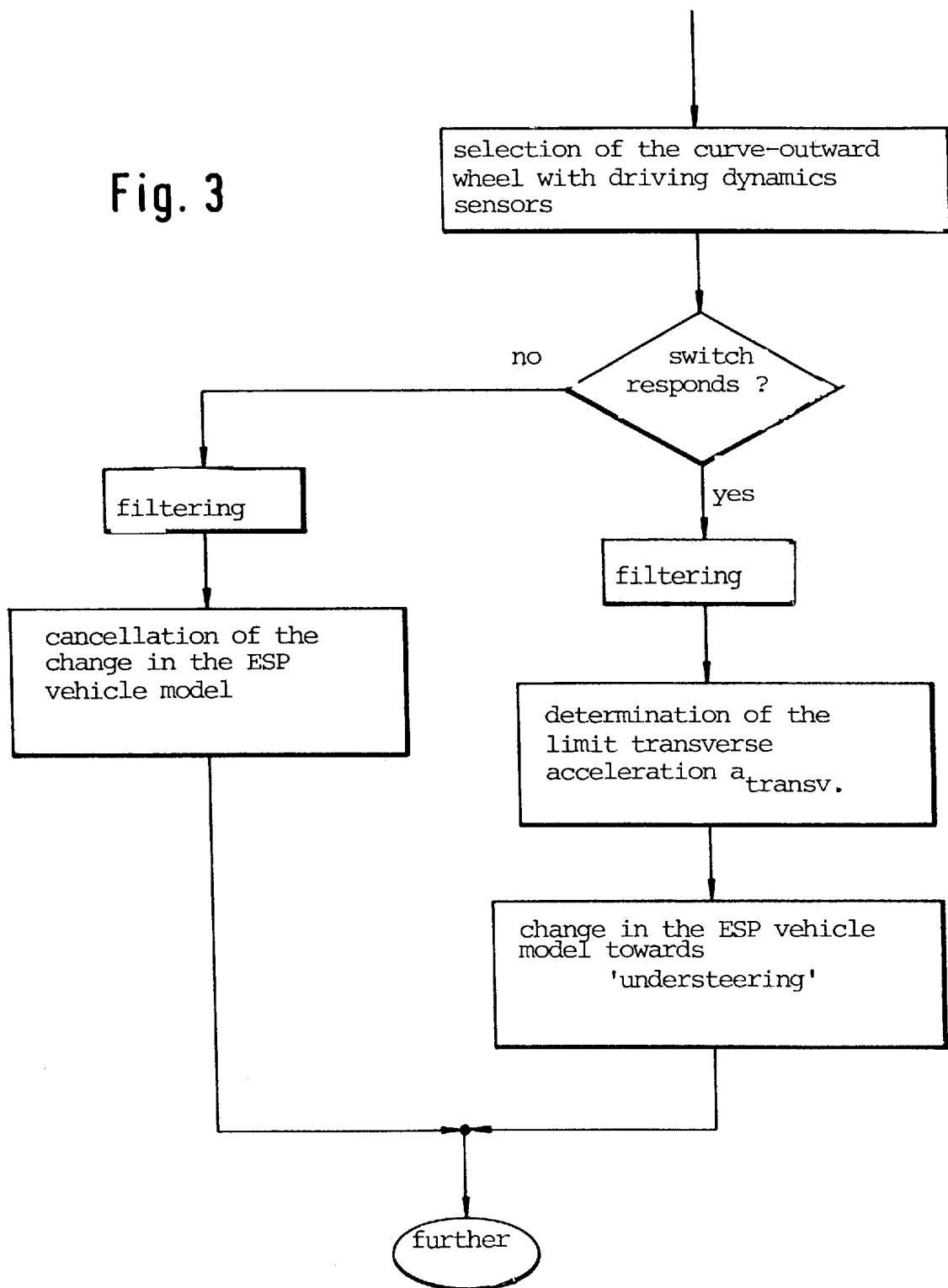


Fig. 4a

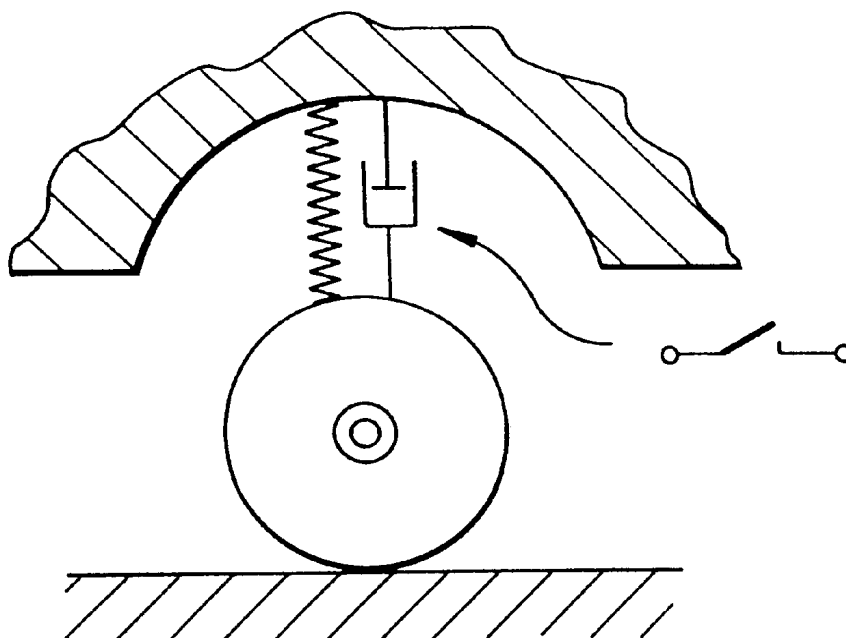
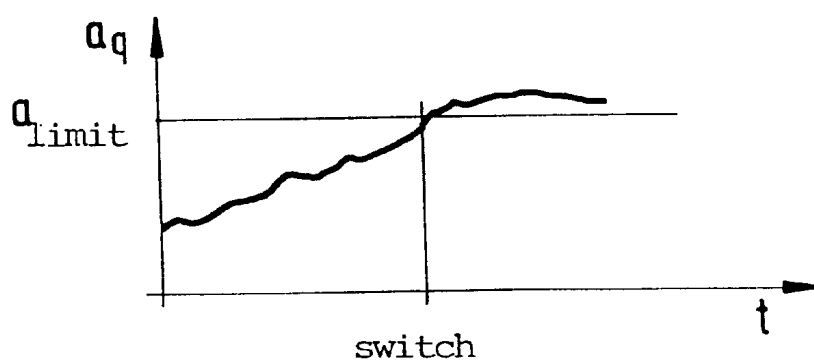


Fig. 4b



METHOD AND DEVICE FOR DETERMINING AND DETECTING THE OVERTURNING HAZARD OF A VEHICLE

CROSS-REFERENCES TO RELATED APPLICATIONS

The present application is a U.S. national phase application of International Application PCT/EP99/05079 (International Publication WO00103900), filed Jul. 16, 1999.

TECHNICAL FIELD

The present invention generally relates to systems for measuring vehicle stability, and more particularly relates to a method and a related device for detecting variations of the center of gravity of the mass of a vehicle.

BACKGROUND OF THE INVENTION

Various models for rollover accidents are described on pages 309 to 333, chapter 9, in "Fundamentals of Vehicle Dynamics", by T. D. Gillespie, Society of Automotive Engineers, Inc., Warrendale 1992. Starting with a quasi-stationary model for a rigid vehicle, via a quasi-stationary model for a sprung vehicle up to dynamic models in consideration of inherent roll frequencies, conditions for existing rollover hazards are indicated.

While it was known at the time the above-mentioned book was published that in trucks, truck trailer units, buses, small buses, and off-road vehicles having a high center of gravity and/or a small tread width, there is a rollover risk during cornering in the event of a major roll motion, it has been found only recently that lateral motions of passenger vehicles are also likely to build up until the vehicle rolls over. Such a risk of rollover is considerably increased by improper loading, e.g. extremely toward one side or on the vehicle roof, because the center of gravity of the mass of the vehicle is shifted upwards or to one side.

As is shown in FIGS. 1a and 1b, the analysis of the forces and moments is decisive in the static case for the stable equilibrium of a vehicle.

FIG. 1a shows the distribution of the vehicle weight force F_G to the wheel tread forces $F_{A_{xx}}$. The lateral offset y_s of the center of gravity S from the vehicle center is shown in FIG. 1b. The offset of moments with respect to a wheel shows the influence of the shift of the center of gravity in the static and dynamic case.

If, during driving operations, a disturbing force occurs, such as the centrifugal force during cornering or a wheel load variation due to a rough road section, the vehicle will move into the labile or unstable condition depending on the magnitude of the disturbing force.

With an Electronic Stability Program (ESP), for example, the system developed and sold by the applicant, a system is on hand which is apt to detect critical driving conditions by comparing the course of driving predefined by a driver with the actual track of the vehicle, and to prevent these conditions by a well-defined brake intervention. Wheel rotational speeds, the transverse acceleration, the steering angle, and the yaw rate are provided as data for this purpose. In case the driving condition defined by these data reaches a critical range, the proper steering behavior of the vehicle defined by the vehicle model of the ESP controller will be maintained by a wheel-selective brake intervention. Thus, this control action can only influence all two-dimensional processes and condition variables, that means processes which can be

described by transverse acceleration and rotation about the vertical vehicle axis (yaw).

Once the position of the center of gravity in a longitudinal and/or transverse direction of the vehicle changes, e.g., due to loading, the changed cornering limit speeds are automatically taken into account in the ESP system because the proper steering behavior determined in the vehicle model shall be maintained. When the center of gravity shifts, e.g. in a rearward direction, the augmented oversteering tendency during cornering is counteracted by reducing the allowed cornering speed, in the event that the basic setting is established as understeering.

A change in the height of the center of gravity will now cause a changed side-tilt behavior of the vehicle in longitudinal and transverse directions. When a transverse acceleration acts on the vehicle, according to FIG. 1b, the analysis of moments

$$F_c \times h_s + F_{n_{r,l}} \times b = F_G \times (b/2 + y_s) \quad (1)$$

applies, wherein F_c designates the centrifugal force due to the transverse acceleration a_{transv} , F_G is the center of gravity, m is the vehicle mass, $F_{n_{r,l}}$ designates the vertical wheel force (wheel load) for the right and the left wheel, h_s , y_s the height of the center of gravity, y_s the lateral distance of the center of gravity from the vehicle center, and b designates the tread width. From this follows directly the correlation for the transverse acceleration a_{transv} .

$$a_{transv} = 1/h_s \times [g(b/2 + y_s) - F_{n_{r,l}} \times b/m] \quad (2)$$

Rollover of the vehicle will thus be reached when a critical transverse acceleration is exceeded for which the following correlation applies:

$$a_{transv,critical} = (b/2 + y_s)/h_s \times g \quad (3)$$

Thus, the critical transverse acceleration depends directly on the center of gravity.

Besides, in prior art vehicle motion control systems, wherein the objective is to increase driving stability, especially during cornering, that means to avoid lateral rollover in particular, it is generally the transverse vehicle acceleration or the roll angle of the vehicle which is taken as a basis for critical condition variables that describe the rollover hazard.

Thus, DE-A 197 46 889 describes a system to increase the lateral stability during cornering which is equipped with a side-tilt detection device. This side-tilt detection device measures either the difference in height between the right and the left vehicle side, or the transverse acceleration of the vehicle in order to detect the roll angle between the vehicle horizontal and the roadway horizontal. When the side-tilt detection device detects a rollover hazard, a countersteering yaw torque will be produced by decelerating the curve-outward front wheel.

However, as described hereinabove, the allowed transverse acceleration and the allowed roll angle are greatly responsive to the position of the center of gravity of the vehicle, especially the height of the center of gravity. In the generic methods and devices known from the state of the art, the center of gravity of the vehicle, especially variations in the center of gravity, is not taken into consideration to a sufficient degree as far as a preventive rollover prediction is concerned.

BRIEF SUMMARY OF THE INVENTION

Please delete the abstract on page 13 and replace it with the abstract set forth immediately below in clean form.

Additionally, in accordance with 37 CFR 1.121(b)(iii), all paragraphs amended herein are set forth in a marked up version on the sheets attached to this amendment.

Therefore, an object of the present invention is to provide a method and a device which render it possible to counteract a rollover hazard as early as possible. The primary objective of the present invention is a prediction of an imminent rollover condition of a vehicle to permit a best possible prevention.

According to the present invention, this object is achieved in that first condition variables which correspond to the respective wheel load are detected on at least two wheels during cornering, in that the detected first condition variables are compared with reference values representative of the respective cornering maneuver, and in that a related variation of the center of gravity is calculated from the differences between the detected first condition variables and the reference values.

The present invention is based on the recognition that the most appropriate coefficient of influence in a best possible preventive detection of the rollover hazard of a vehicle is the position of the center of gravity of the vehicle. Thus, the current center of gravity as an output quantity is made the important basis of the method and the device disclosed in the present invention.

The coefficient of influence directly indicates the existence of a critical rollover condition. Either active control interventions, e.g. by means of ESP, or a passive warning to the driver will be considered as a countermeasure to prevent rollover.

In contrast to the state of the art, the preventive procedure disclosed by the present invention includes the advantage that the vehicle remains steerable during a correcting intervention required and the driving comfort is also preserved during an active control intervention. Another advantage of the present invention over the state of the art can be seen in that the possible intervention strategies in response to detection of a critical driving situation are almost optional, not least due to the detection which offers extreme prediction. Therefore, the present invention can be realized without special effort and cost as an extension or an improvement of an existing driving stability control system, for example, the Electronic Stability Program (ESP) of the applicant.

The spring travel that can be measured at the wheel suspension, the spring pressure, the damper pressure that can be measured at the shock absorber, the inside tire pressure, or the lateral deformation of the tire can be made the basis of a first condition variable that is correlated to the wheel load.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1a is a schematic side view of a four-wheel vehicle in a cornering maneuver.

FIG. 1b is a schematic rear view of a four-wheel vehicle also in a right-curve cornering maneuver.

FIG. 2 is a rear view of a vehicle in a left curve, corresponding to FIG. 1, to represent the physical condition variables related to driving for the description of a rollover condition.

FIG. 3 is a flow chart showing a preferred sequence of operation of the method according to the present invention and the corresponding device.

FIG. 4 is a schematic view of a preferred embodiment of the device of the present invention including a spring travel switch at one wheel and a characteristic curve that illustrates the point of time of switching of the spring travel switch.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The embodiment described hereinbelow relates to modifications in an Electronic Stability Control system (ESP). In contrast to the two-dimensional model used in the state of the art, the present invention is based on a three-dimensional vehicle model wherein beside the transverse acceleration and the yaw, also pitching and rolling of the vehicle can be taken into account, with the result that the rollover tendency is also considered a value of the critical condition variable. A principal adaption of the vehicle model in consideration of the current static center of gravity will considerably support the control success. But also a reaction only to the side-tilt behavior of the vehicle will achieve already a major improvement of stability control.

The information required for determining the center of gravity and the vehicle side-tilt may preferably be obtained from the spring travel variations. The center of gravity can be determined by a measurement of the static compression travel with respect to axles without level control device or by a measurement of the pressure in the level control device. With a known spring rigidity C of the chassis support spring, the wheel normal force F_{-xx} (FIG. 1a) can be determined from the known force $F_{n_xx_o}$ in the construction position with spring travel S_{-xx_o} as follows:

$$F_{n_xx} = F_{n_xx_o} + K \cdot \Delta S$$

wherein ΔS represents the measured spring travel variation with a direction-responsive sign (positive for compression travel, negative for rebound travel).

A level control device compensates a compression travel, thus, ΔS becomes 0. The system pressure variation Δp necessary for this compensation is proportional to the change in force, and consequently

$$F_{n_xx} = F_{n_xx_o} + K \cdot \Delta p$$

applies, wherein k is the proportionality factor.

The roll angle is determined by way of the different spring travels on the left and the right vehicle side, and the pitch angle is determined accordingly by way of the spring travels on the front and the rear end.

The height of the center of gravity can be calculated from the side-tilt angle and the associated acceleration. The center of gravity in a longitudinal and transverse direction (I_v , I_h , y_s) is known from the static analysis. The height of the center of gravity may hence be derived from the correlation described hereinabove, with the transverse acceleration known, according to

$$h_s = \frac{1}{a_{transv.}} \cdot [g \cdot (y_s + y_s) - F_{n_r} \cdot b/m]$$

or, with the longitudinal acceleration known, according to

$$h_s = \frac{1}{a_{along.}} \cdot \left[\frac{F_n - VA}{m} \cdot l_v - \frac{F_n - HA}{m} \cdot l_r \right]$$

A center of gravity shifted from the vehicle center can be determined by the roll angle which is different responsive to the direction, with a transverse acceleration existing. Thus, e.g. for a vehicle with a level control device at the rear axle, four sensors for determining the spring travel are required and, in the event of an axle control on each individual wheel, one or two sensors for determining the pressure in the level control device of the rear axle are required.

The flow chart shown in FIG. 3 illustrates an exemplary sequence of operation of a modified ESP control, wherein an

end position switch is used corresponding to the mentioned simplified embodiment of this invention. The end position switch responds when a predetermined spring travel threshold value in one or more of the vehicle wheels is exceeded, that means, when a predetermined wheel load is exceeded with respect to the prevailing forces. Because the mode of operation of the end position switch hence depends on the direction of cornering, it is first of all necessary to find out which wheel (the wheel on the front axle is preferred) or which wheels are disposed on the curve-outward side of the vehicle. This is because only the curve-outward wheels are able to respond in the mentioned manner corresponding to the vehicle tilt during cornering. The selection of the curve-outward wheels can be effected by means of sensors related to driving dynamics, e.g., a steering angle sensor and/or a yaw rate sensor, which are already provided in an ESP system. In general, other sensors may also be used which permit determining the direction of a cornering maneuver.

In the event that one or more of the end position switches arranged on the curve-outward side of the vehicle respond, the variation of the ESP vehicle model which has already been described in detail hereinabove will be performed. It is initially necessary, however, to check or filter the switch signals received to the end that those signals are "filtered out" which induced one or more end position switches to respond due to road conditions, e.g. due to bumps, although there was no cornering maneuver and, consequently, there was no rollover hazard.

In consideration of further quantities related to driving dynamics, for example, the steering angle and the vehicle speed, a corresponding change of the center of gravity of the vehicle is calculated, and from the change center of gravity a changed or corrected limit transverse acceleration is calculated by way of the mathematical correlations mentioned hereinabove. By way of the corrected limit transverse acceleration, the ESP vehicle model will then be changed in a manner such that the vehicle temporarily becomes "understeering" and is, hence, better adapted to the changed center-of-gravity conditions.

In the normal case, the end position switch will no longer respond after termination of the cornering maneuver. The correspondingly filtered signal cancels the temporary change of the ESP vehicle model and, thus, reestablishes the condition of the ESP prior to the cornering maneuver.

In the embodiment referred to above, the ESP vehicle model is modified only temporarily, i.e., during cornering maneuvers. It may, however, also be provided that on command of the mentioned signals of the end position switch, there is a reaction to changed center-of-gravity conditions that is followed by permanent variations of the ESP vehicle model. The above-mentioned statements will apply accordingly in this case.

Due to the knowledge about a changed center of gravity, the vehicle model prevailing in an Electronic Stability Program (ESP), for example, the program of the applicant, can be adapted to the changed center-of-gravity conditions. It is initially necessary in the adaptation of the ESP control, to predefine a critical condition variable, for example, a limit transverse acceleration a_{limit} , in consideration of the current quantity and position of the vehicle center of gravity. This limit acceleration, in the capacity of a parameter variation, can be taken into consideration within the vehicle model in the form of a variation= basic variation+ $k \times f(a_{transv.,limit})$ (4) in the ESP control, and $a_{transv.}$ designates the current value of the transverse vehicle acceleration and $a_{transv.,limit}$ designates the corresponding critical limit value. Besides, 'F' is a proportional factor and $f(x)$ is a function with a predeter-

mined top and bottom limit, wherein it applies for the bottom limit that the change must not become less than zero. The above-mentioned functional correlation can preferably be implemented as a P-controller or PI-controller, with the addend on the right side of the equation (4) being configured to either act proportionally as a P-controller, i.e., according to the relation

$$k \times [abs(a_{transv.}) - abs(a_{transv.,limit})], \quad (5)$$

or proportional-integrally as a PI-controller, i.e., according to the following equation:

$$k \times [abs(a_{transv.}) - abs(a_{transv.,limit})] + k \times \text{integral}[abs(a_{transv.}) - abs(a_{transv.,limit})], \quad (6)$$

A change to 'understeering' can be defined by way of lateral rigidities.

In the vehicle model of ESP (single-track model)

$$m \cdot v \cdot (\psi - \beta) F_{lateral\ force\ front} + F_{lateral\ force\ rear}$$

$$\Theta \psi = F_{sv} \cdot l_v - F_{sh} \cdot l_h$$

$$\text{with } F_{sv} = C_{sv} \cdot \left(\delta + \beta - \frac{lv \cdot \psi}{v} \right)$$

$$\text{with } F_{sh} = C_{sh} \cdot \left(\beta \frac{lh \cdot \psi}{v} \right)$$

the lateral tire rigidities C_{sv} , C_{sh} , front and rear, are comprised.

$C_{sv,sh}$ may now be understood as C_{sv} , C_s for the normal operation and C_{1sv} , C_{1sh} may be added as variable component.

$$C_{sv} = C_{0sv} + C_{1sv}$$

$$C_{sh} = C_{0sh} + C_{1sh}$$

These C_{1sv} , C_{1sh} may now be changed in dependence on the transverse acceleration, as described on page 10 (P, PI-controller), namely

$$C_{1sv} \text{ smaller}$$

$$C_{1sh} \text{ greater}$$

so that an ESP brake intervention on the curve-outward wheel stabilizes the vehicle.

When the curve limit acceleration or speed which is predetermined by the possibly changed center of gravity or center of gravity mass is exceeded, an intervention which prevents rollover, such as a brake intervention, may be carried out. Corresponding intervention strategies are e.g. disclosed in applications 198 21 593.2 and 198 16 430.0, to which reference is made herein in full extent. Thus, values may again drop below the critical condition variable, e.g. the transverse acceleration, by a defined understeering of the vehicle, especially by a corresponding re-tuning or readjustment of the vehicle model on which the ESP control actions are based, whereby rollover is prevented.

Only the roll behavior of the vehicle is taken into consideration in a simplified embodiment. When it is further assumed that the center of gravity is shifted only insignificantly from the longitudinal vehicle axis, one spring travel information per axle is sufficient. A critical situation may also be recognized by only one single spring travel when the height of the center of gravity remains virtually the same. In this arrangement, the vehicle model is conformed to the roll behavior, and the allowed transverse acceleration is reduced while the defined inherent steering behavior is maintained. This adaptation can be effected analogously, e.g., by means of information given by sensor signal(s), and digitally, e.g., by means of information given by switches. In view of the above, the most simple embodiment is a spring travel switch on one wheel which will be described hereinbelow by way of FIG. 4.

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One preferred embodiment of an end position switch relating to a simplified way of control is represented in FIG. 4a. This way of control can be realized advantageously as an ESP that is extended by an end position switch arranged at the shock absorber or at the spring of the wheel suspension. The following procedure is advisable corresponding to the time variation shown in FIG. 4b with respect to an end position switch configured as a spring travel switch. When the switch on at least one curve-outward wheel, which is preferably the outward front wheel, responds, the critical transverse acceleration $a_{transv.,limit}$ will be exceeded corresponding to the assumed course of characteristic curve, and a defined counteraction is initiated to prevent further buildup of the transverse acceleration or to reduce it.

Understeering of the vehicle is preferred, for example, by means of a corresponding 're-tuning' of the ESP vehicle model to become 'understeering', that means by a change in the travel trajectory, for example, by a way of control corresponding to equations (4) to (6).

The variation may be defined by way of the lateral rigidities of the tires, and 'understeering' means that the lateral rigidity at the front axle of the vehicle diminishes.

The intervention into the vehicle model causes braking and, thus, reduction of the cornering force at the curve-outward wheel. With respect to the physical correlation between cornering force and brake slip (longitudinal force), reference is made in the present context in full extent to German published patent application DE-A 196 32 943 'Method for operating an automotive vehicle with brake interventions that stabilize driving', by Daimler-Benz AG.

When the switch closes again, this variation will be cancelled with time, i.e., forgotten. This control action will be terminated herewith.

Monitoring of the switch is possible also by way of a plausibility analysis. It may be provided, for example, that during straight travel the switch is only allowed to close for a minimum duration of e.g. 200 msec before countermeasures to reduce the transverse acceleration are activated. Alternatively, it may be provided that the triggering of countermeasures, beside the switch position, is linked to further conditions, for example, a threshold value for the transverse acceleration, such as $>0.5-0.7$ g.

What is claimed is:

1. A method for detecting the rollover hazard of a vehicle that includes at least two axles and at least three wheels, wherein variations in the vehicle's center of gravity are determined in the operation of the vehicle during cornering, comprising the steps of:

- detecting first condition variables which respectively correspond to each respective wheel load during cornering on at least two wheels,
- comparing each detected first condition variable to reference values representative of the respective cornering maneuver,
- calculating a corresponding change in the center of gravity from the differences between the detected first condition variables and the reference values, and
- determining a correspondingly changed, critical second condition variable representative of the rollover hazard from the calculated center of gravity variation.

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2. The method as claimed in claim 1, further including the step of using at least one of a spring travel that can be measured at the wheel suspension, a spring pressure, a damper pressure that can be measured at a shock absorber, an inside tire pressure, and a lateral deformation of the vehicle tire as a basis for a first condition variable that corresponds to the wheel load.

3. The method as claimed in claim 1, further including the step of using at least one of a transverse acceleration which acts on the center of gravity of the vehicle, a roll angle of the vehicle, a pitch angle of the vehicle, a vehicle speed, a steering angle, and a yaw rate as a basis for the second condition variable representative of the rollover hazard.

4. A device for detecting the rollover hazard of a vehicle that includes at least two axles and at least three wheels, comprising:

- a means for sensing a driving condition in a cornering maneuver,
- a means for determining variations in the center of gravity of mass,
- a means to detect first condition variables which correspond to the respective wheel load on at least two wheels,
- a means to compare the detected first condition variables with reference values representative of the respective cornering maneuver,
- a means to calculate the change in the center of gravity from the differences between the detected first condition variables and the reference values, and
- a means to determine a second condition variable representative of the rollover hazard from the calculated center of gravity variation.

5. The device as claimed in claim 4, further including means for measuring at least one of the wheel suspension spring travel, the wheel suspension spring pressure, the shock absorber damper pressure, the pressure of the air inside of the tire, the lateral deformation of the tire, and using such measurement as a basis for the first condition variable that corresponds to the wheel load.

6. The device as claimed in claim 4, further including means for measuring at least one of the transverse acceleration which acts on the center of gravity of the vehicle, the roll angle of the vehicle, the pitch angle of the vehicle, the vehicle speed, the steering angle, the yaw rate, and using such measurement as a basis for the second condition variable representative of the rollover hazard.

7. The device as claimed in claim 4, further including an end position switch provided on a shock absorber or on a spring element of the wheel suspension, the switching point of the end position switch is linked by a time correlation to the second condition variable representative of the rollover hazard.

8. The device as claimed in claim 7, wherein the switching point of the end position switch is linked to further driving state conditions.

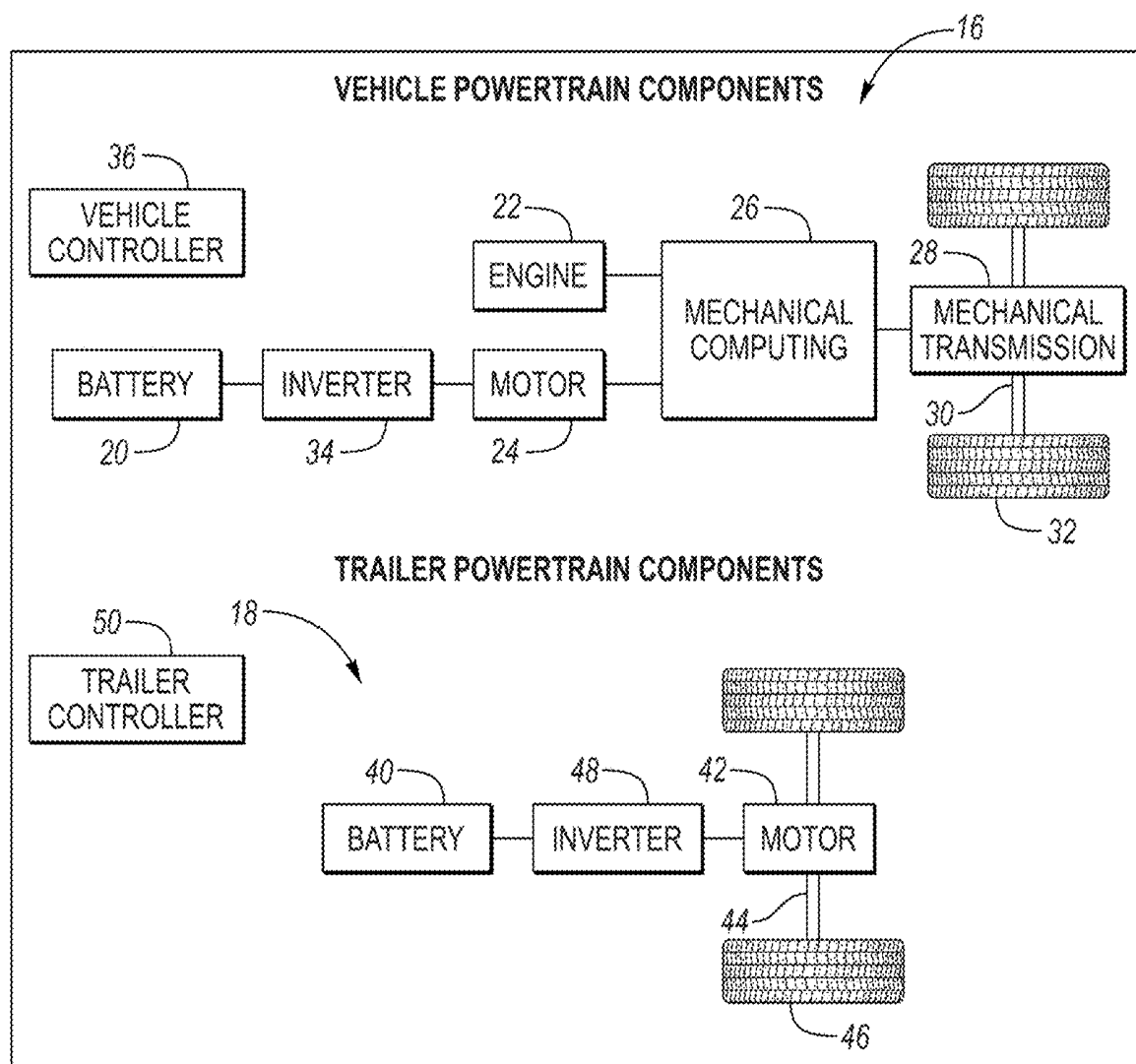
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(19) **United States**(12) **Patent Application Publication**
Weston et al.(10) **Pub. No.: US 2023/0356707 A1**(43) **Pub. Date: Nov. 9, 2023**(54) **ENERGY OPTIMIZATION FOR
INTEGRATED POWERTRAIN OF
COMBINED VEHICLE SYSTEM HAVING
VEHICLE AND ELECTRICALLY POWERED
TRAILER TOWED BY THE VEHICLE**(71) Applicant: **Ford Global Technologies, LLC,**
Dearborn, MI (US)(72) Inventors: **Keith Weston**, Canton, MI (US); **David
Guglielmo**, Northville, MI (US);
Andrew Denis Lewandowski, Sterling
Heights, MI (US); **Shehan
Haputhanthri**, Canton, MI (US);
Brendan F. Diamond, Grosse Pointe,
MI (US)(73) Assignee: **Ford Global Technologies, LLC,**
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2510/1025 (2013.01); **B60W 2510/102**
(2013.01)(57) **ABSTRACT**

A system includes a vehicle having an electrically powered trailer towed thereto. The vehicle has a vehicle powertrain, and the trailer has a trailer powertrain. A controller, in order to propel the vehicle with the trailer towed thereto, operates the vehicle powertrain and the trailer powertrain according to a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain.



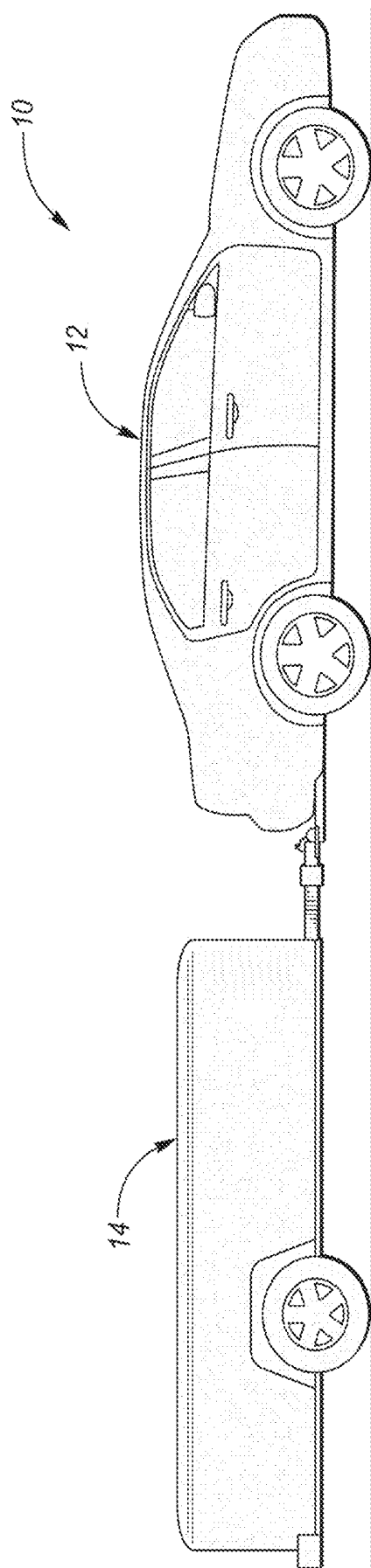


FIG. 1

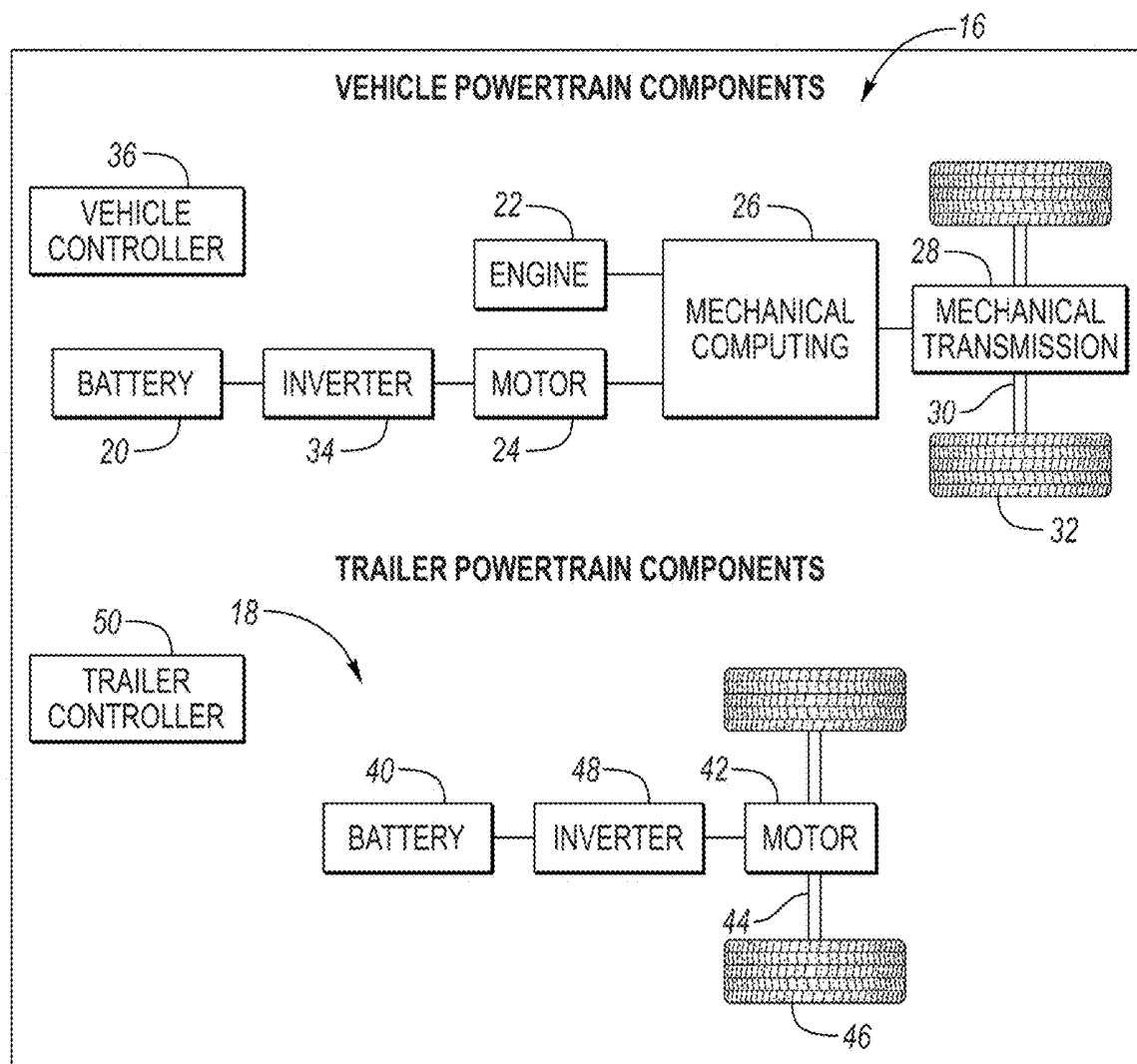


FIG. 2A

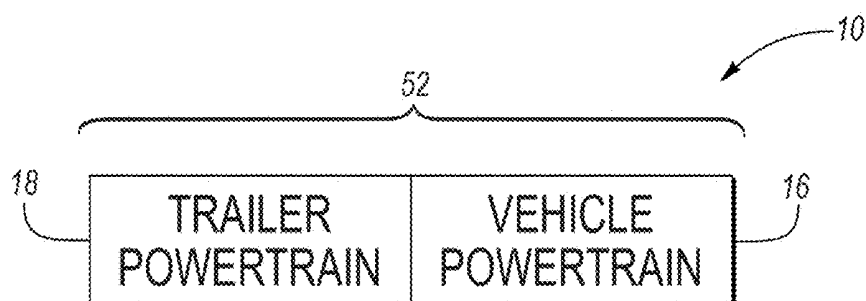


FIG. 2B

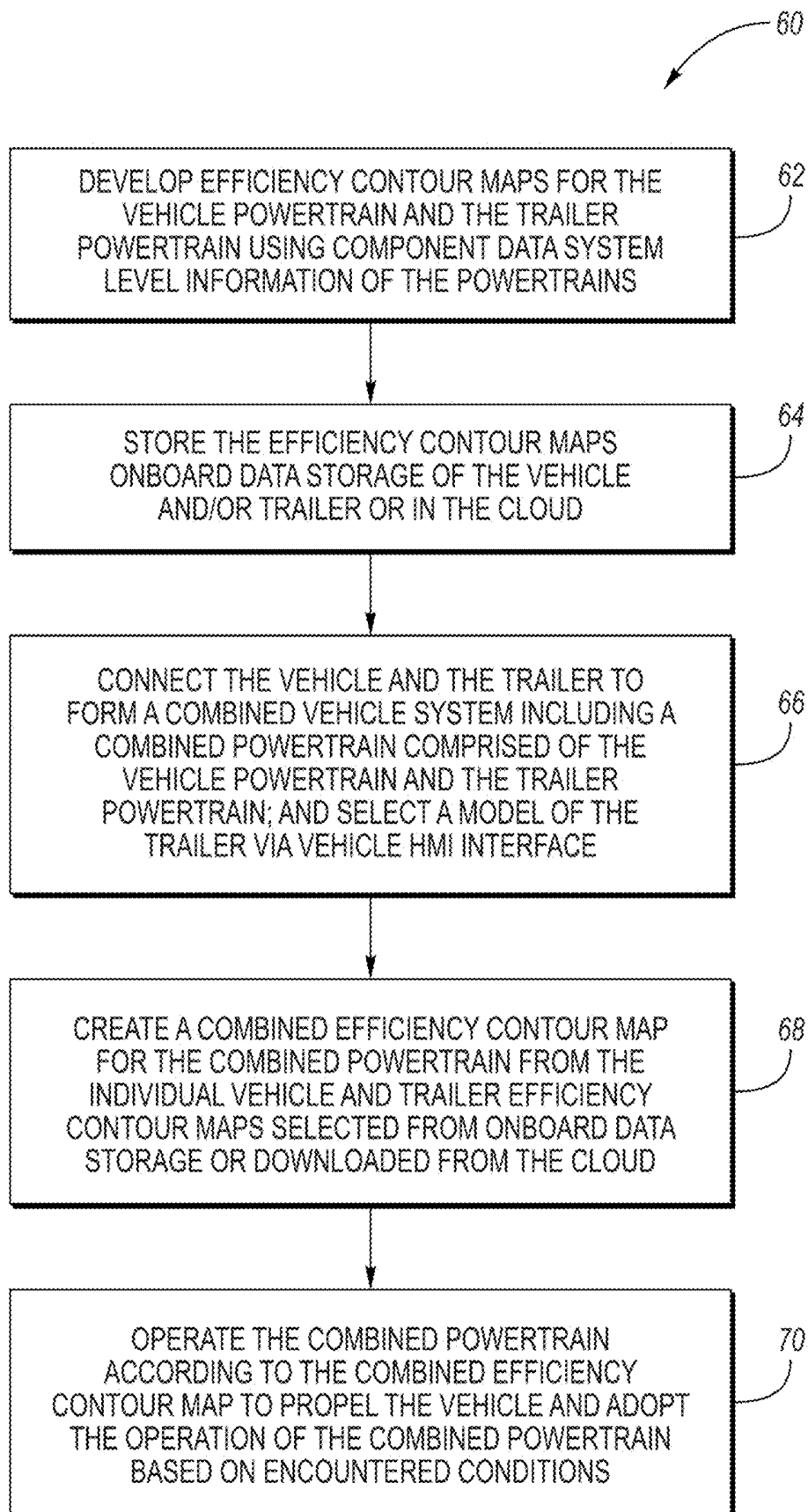


FIG. 3

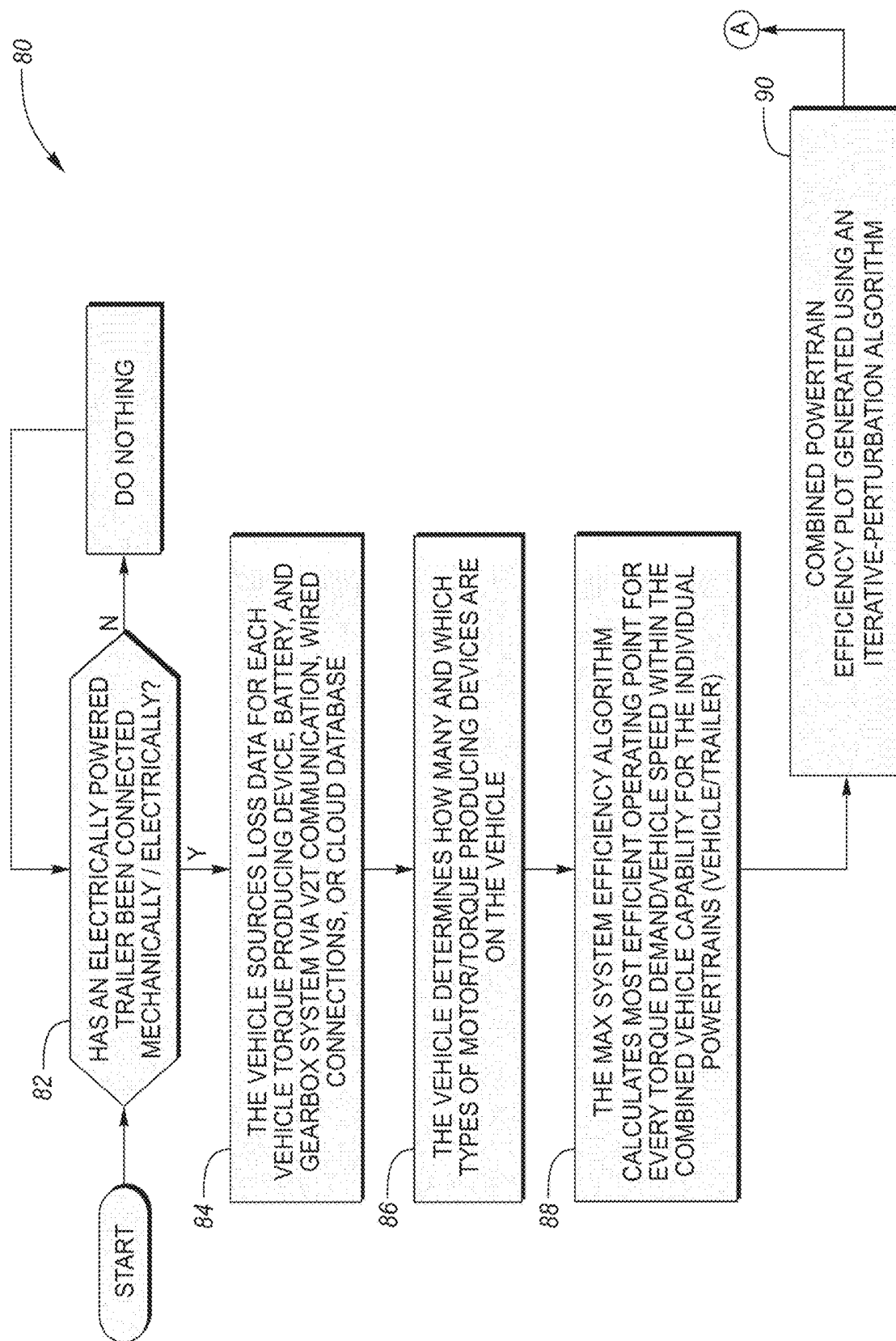


FIG. 4A

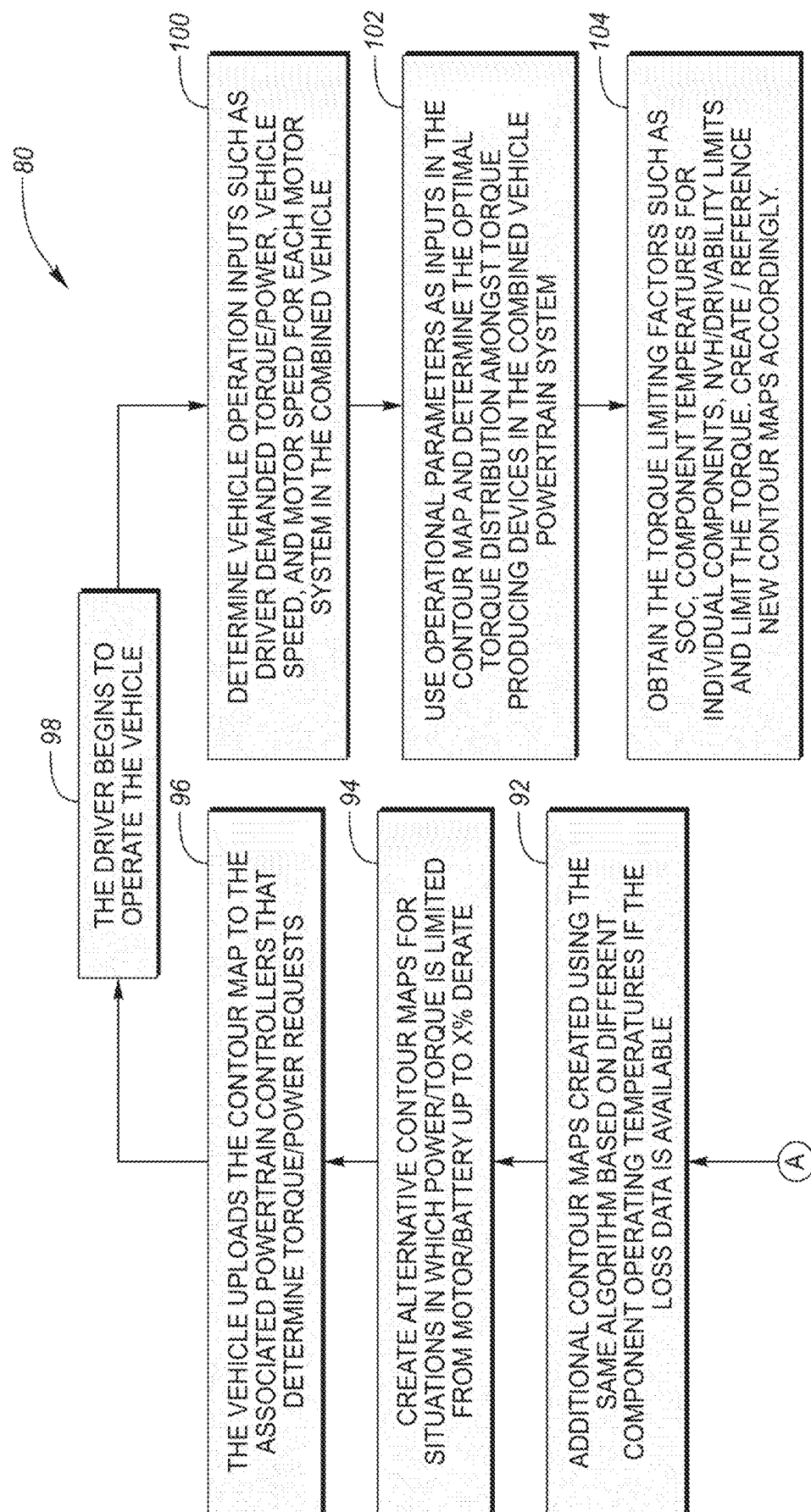


FIG. 4B

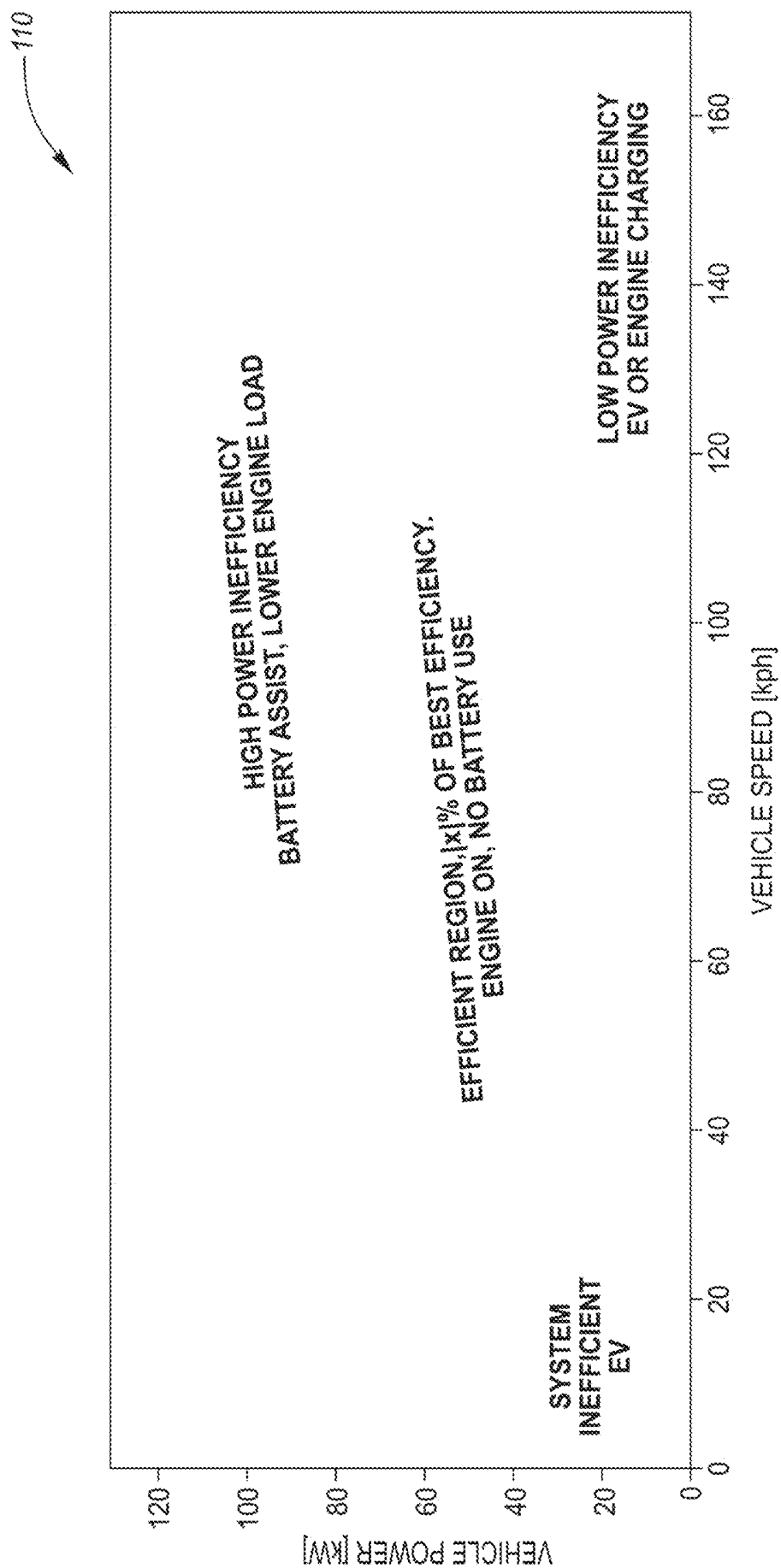


FIG. 5A

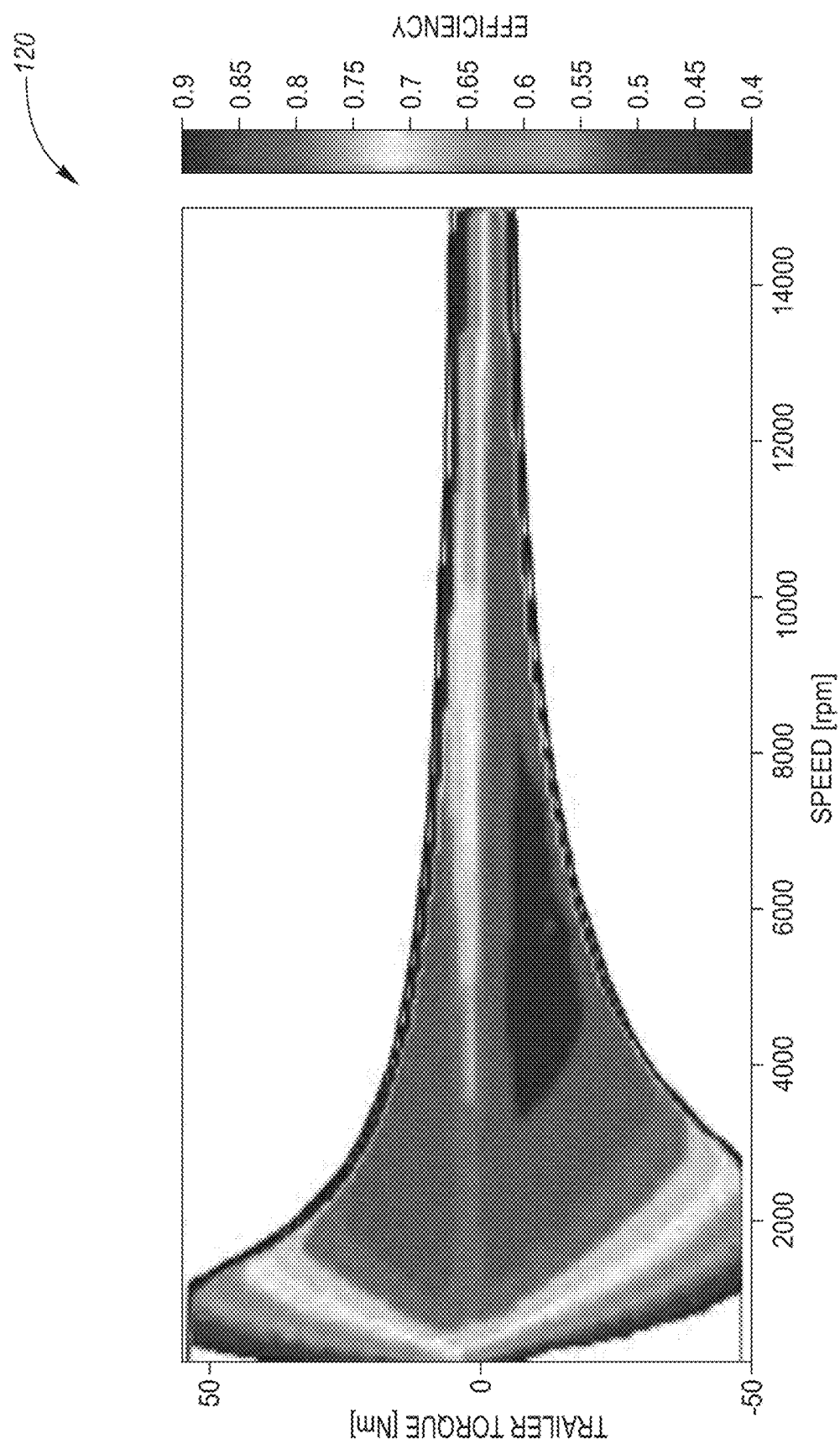
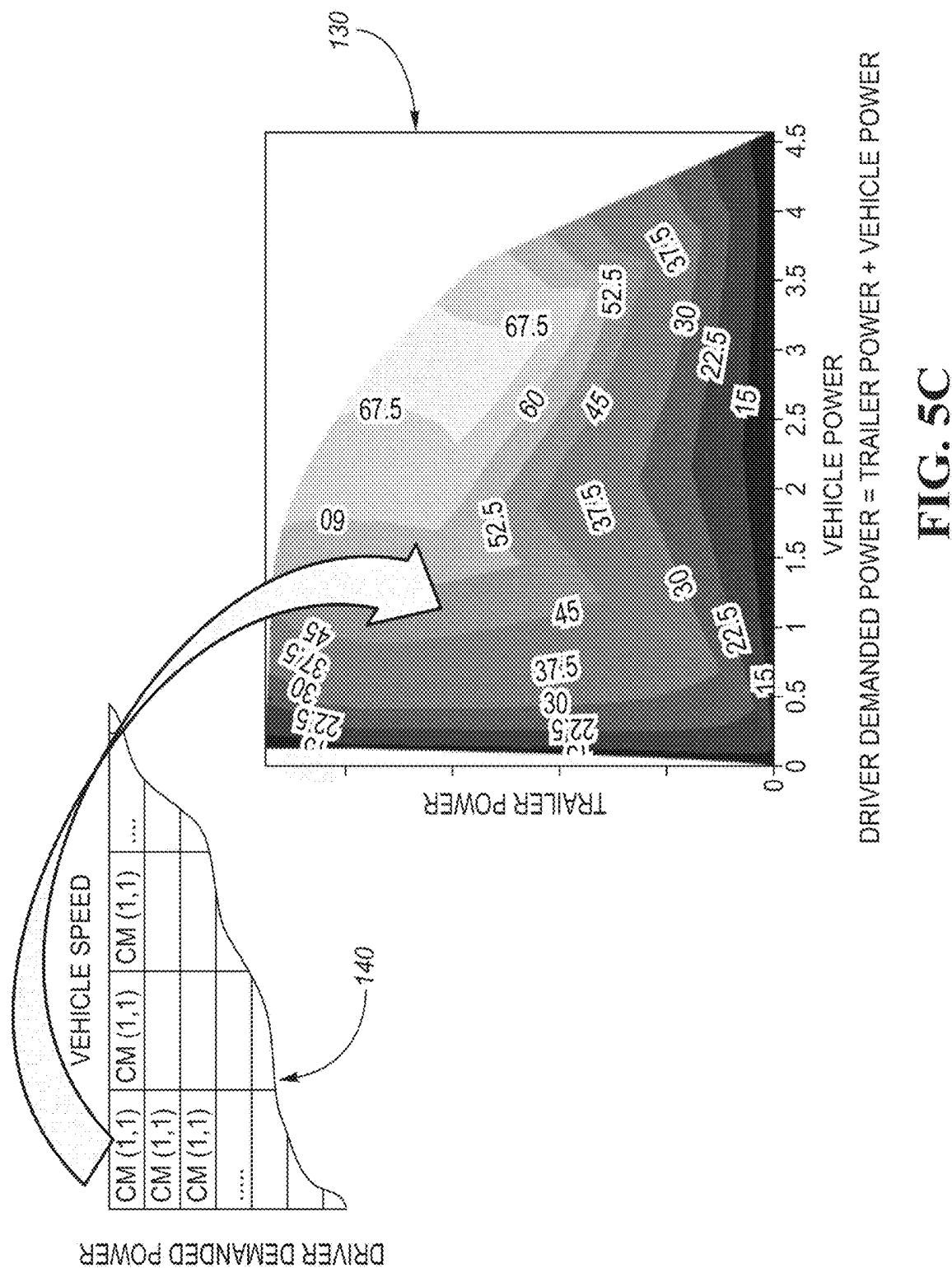


FIG. 5B



**ENERGY OPTIMIZATION FOR
INTEGRATED POWERTRAIN OF
COMBINED VEHICLE SYSTEM HAVING
VEHICLE AND ELECTRICALLY POWERED
TRAILER TOWED BY THE VEHICLE**

TECHNICAL FIELD

[0001] This disclosure relates to a combined vehicle system having a vehicle and an electrically powered trailer towed by the vehicle.

BACKGROUND

[0002] A combined vehicle system having a vehicle and an electrically powered trailer towed by the vehicle includes two powertrains. One of the powertrains belongs to the vehicle and the other one of the powertrains belongs to the trailer. An issue is how these two powertrains are to be operated due to the presence of one another.

SUMMARY

[0003] A system including a vehicle having an electrically powered trailer towed thereto is provided. The vehicle has a vehicle powertrain, and the trailer has a trailer powertrain. A controller is programmed to, in order to propel the vehicle with the trailer towed thereto, operate the vehicle powertrain and the trailer powertrain according to a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain.

[0004] The controller may be further programmed to control components of the vehicle powertrain and components of the trailer powertrain for efficiency or torque split based on operational status of the vehicle in realizing operation of the vehicle powertrain and the trailer powertrain according to the combined efficiency map.

[0005] The controller may be further programmed to obtain loss data of components of the vehicle powertrain and to obtain loss data of components of the trailer powertrain. In this case, the efficiency map associated with the vehicle powertrain may factor in the loss data of components of the vehicle powertrain and the efficiency map associated with the trailer powertrain may factor in loss data of components of the trailer powertrain. The loss data can be estimated from component models as well.

[0006] The combined efficiency map may provide for operation of the vehicle powertrain and the trailer powertrain to have a highest combined efficiency for a given driver demanded power and vehicle speed combination.

[0007] The combined efficiency map may provide for operation of the vehicle powertrain to be in a most efficient region of the efficiency map associated with the vehicle powertrain.

[0008] The vehicle powertrain may include a first traction battery, and the trailer powertrain may include a second traction battery. The vehicle powertrain may further include an engine. The controller may be further programmed to cause electrical power to be transferred between the first traction battery and the second traction battery in order to maintain operation of the vehicle powertrain and the trailer powertrain according to the combined efficiency map.

[0009] The controller may be further programmed to realize operation of the vehicle powertrain and the trailer

powertrain via torque vectoring between drive axles and propulsion sources on the vehicle powertrain and the trailer powertrain.

[0010] The controller may be further programmed to generate the combined efficiency map upon the trailer being connected to the vehicle.

[0011] The controller may be further programmed to share the efficiency map associated with the vehicle powertrain and/or the efficiency map associated with the trailer powertrain with a third party.

[0012] A control system for a combined vehicle system having a vehicle and an electrically powered trailer towed by the vehicle with the vehicle including a vehicle powertrain and the trailer including a trailer powertrain is also provided. The control system includes a controller programmed to, in order to propel the combined vehicle system, operate the vehicle powertrain and the trailer powertrain according to a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain.

[0013] A method is also provided. The method includes, upon an electrically powered trailer having a trailer powertrain being connected to a vehicle having a vehicle powertrain for the trailer to be towed by the vehicle, generating, by a controller of the vehicle, a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain. The method further includes operating, by the controller of the vehicle, in order to propel the vehicle with the trailer towed thereto, the vehicle powertrain and the trailer powertrain according to the combined efficiency map.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 illustrates a perspective view of a combined vehicle system having an electrified vehicle (EV) and an electrically powered trailer towed by the EV;

[0015] FIG. 2A illustrates a block diagram of a vehicle powertrain of the EV and a trailer powertrain of the trailer;

[0016] FIG. 2B illustrates a block diagram of an integrated powertrain of the combined vehicle system, the integrated powertrain being comprised of the vehicle powertrain and the trailer powertrain;

[0017] FIG. 3 illustrates a flowchart depicting operation of an energy management optimization strategy for the integrated powertrain of the combined vehicle system;

[0018] FIGS. 4A and 4B illustrate a more detailed flowchart depicting operation of the energy management optimization strategy;

[0019] FIG. 5A illustrates an exemplary efficiency contour map for the vehicle powertrain;

[0020] FIG. 5B illustrates an exemplary efficiency contour map for the trailer powertrain; and

[0021] FIG. 5C illustrates an exemplary combined efficiency contour map for the integrated powertrain, the combined efficiency contour map being a function of the efficiency contour map for the vehicle powertrain and the efficiency contour map for the trailer powertrain, and the combined efficiency contour map being generated from an exemplary three-dimensional efficiency contour table for the integrated powertrain.

DETAILED DESCRIPTION

[0022] Embodiments are disclosed herein. It is to be understood, however, that the disclosed embodiments are merely examples and other embodiments may take various and alternative forms. The figures are not necessarily to scale. Some features may be exaggerated or minimized to show details of particular components. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting, but merely as a representative basis for teaching one skilled in the art.

[0023] Referring now to FIGS. 1, 2A, and 2B, a combined vehicle system 10 will be described. FIG. 1 illustrates a perspective view of combined vehicle system 10. As shown in FIG. 1, combined vehicle system 10 includes an electrified vehicle (EV) 12 and an electrically powered trailer 14 towed by the EV. As shown in the block diagrams of FIGS. 2A and 2B, EV 12 includes a powertrain 16 and trailer 14 includes a powertrain 18. Thus, as shown in FIG. 2B, combined vehicle system 10 includes an integrated powertrain 52 (or “combined powertrain”) comprised of vehicle powertrain 16 and trailer powertrain 18.

[0024] Vehicle powertrain 16 includes a traction battery 20 for providing power to propel EV 12. In this example, vehicle powertrain 16 further includes an engine 22. As such, in this example, for instance, vehicle powertrain 16 is a “hybrid electric vehicle” (HEV) powertrain. In other embodiments, vehicle powertrain 16 does not include an engine. As such, in these other embodiments, for instance, vehicle powertrain 16 is a “battery-only electric vehicle” (BEV) powertrain.

[0025] Vehicle powertrain 16 further includes an electric motor 24 mechanically connected via a mechanical computing device 26 to a transmission 28. Transmission 28 is mechanically connected to a drive axle 30 that is mechanically connected to wheels 32 of EV 12. Engine 22 is also mechanically connected via mechanical computing device 26 to transmission 28. Electric motor 24 can provide propulsion capability for EV 12 while engine 22 is turned on or off.

[0026] Traction battery 20 stores electrical energy that can be used by electric motor 24 for propelling EV 12. Traction battery 20 typically provides a high-voltage (HV) direct current (DC) output. Traction battery 20 is electrically connected to electric motor 24 via an inverter 34 of vehicle powertrain 16. Inverter 34 provides the ability to transfer energy from traction battery 20 to electric motor 24. For example, traction battery 20 provides a DC voltage while electric motor 24 requires an alternating current (AC) input to function. Inverter 34 converts DC power from traction battery 20 into AC power to operate electric motor 24 for propelling EV 12.

[0027] Vehicle powertrain 16 further includes a controller (“vehicle controller”) 36. Vehicle controller 36 is operable to control and monitor the operation of the components of vehicle powertrain 16. Vehicle controller 36 includes electronics, software, or both, to perform control functions for operating vehicle powertrain 16. In embodiments, vehicle controller 36 is a combination vehicle system controller and powertrain control module (VSC/PCM). Although vehicle controller 36 is shown as a single device, vehicle controller 36 may include one or more controllers in the form of one or more hardware devices, or one or more software controllers with one or more hardware devices.

[0028] Trailer 14 is an electrified trailer in that trailer powertrain 18 includes a traction battery 40 for providing power to propel the trailer. In this example, unlike vehicle powertrain 16, trailer powertrain 18 does not include an engine. Trailer powertrain 18 further includes an electric motor 42. Electric motor 42 is mechanically connected to a drive axle 44 that is mechanically connected to wheels 46 of trailer 14. Traction battery 40 stores electrical energy that can be used by electric motor 42 for propelling trailer 14. Traction battery 40 is electrically connected to electric motor 42 via an inverter 48 of trailer powertrain 18. Inverter 48 converts DC power from traction battery 40 into AC power to operate electric motor 42 for propelling trailer 14.

[0029] Trailer powertrain 18 further includes a controller (“trailer controller”) 50. Trailer controller 50 is operable to control and monitor the operation of the components of trailer powertrain 18. Trailer controller 50 includes electronics, software, or both, to perform control functions for operating trailer powertrain 18. In embodiments, trailer controller 50 is a combination trailer system controller and powertrain control module (TSC/PCM). Although trailer controller 50 is shown as a single device, trailer controller 50 may include one or more controllers in the form of one or more hardware devices, or one or more software controllers with one or more hardware devices.

[0030] As indicated, trailer 14 is connected to EV 12 to form combined vehicle system 10. As EV 12 includes vehicle powertrain 16 and as trailer 14 includes trailer powertrain 18, combined vehicle system 10 includes integrated powertrain 52 comprised of vehicle powertrain 16 and trailer powertrain 18. This integration of trailer powertrain 18 with vehicle powertrain 16 into a combined powertrain can assist with increasing the range of EV 12 and enabling the EV to tow heavier loads.

[0031] Power and/or control hardware connection lines may extend between vehicle powertrain 16 and trailer powertrain 18 via the connection between EV 12 and trailer 14. As such, for instance, vehicle controller 36 and trailer controller 50 may communicate control signals with one another whereby the controllers may coordinate the operation of vehicle powertrain 16 and trailer powertrain 18, a controller of one of the powertrains may control the controller of the other powertrain whereby the one controller is effectively the sole controller for integrated powertrain 52, and the like; traction battery 20 and traction battery 40 may transfer power between one another such as for recharging; etc. Of course, such control communications may be done wirelessly.

[0032] For EV 12, regardless of the type of its powertrain architecture, there is a set of operational conditions of vehicle powertrain 16 for each torque demand, vehicle speed, vehicle mass, etc., in which the overall vehicle, after accounting for aerodynamics, weight, desired maneuver, etc., will have the highest system level energy efficiency.

[0033] In the exemplary example, vehicle powertrain 16 is a hybrid electric vehicle powertrain having electric motor 24 and engine 22 coupled with transmission 28 to propel EV 12. Due to the relatively sophisticated nature of how the components of vehicle powertrain 16 work together, an energy management strategy optimization and traction battery energy management calibration tool is used to define when and how much to charge and discharge traction battery 20, when and how much to use engine 22, etc. This tool takes

in inputs like fuel maps, electrical and mechanical losses, hardware configuration, gear ratio, vehicle road loads, state-of-charge (SOC) windows, drivability constraints, and the like to determine the optimal system efficiency of vehicle powertrain 16.

[0034] In further detail, HEV powertrains control the engine (e.g., engine on time including when to start and stop the engine, the engine power, etc.) and the traction battery (e.g., when the battery charges and discharges, the traction battery power, etc.) according to energy management calibration tables to change the operation conditions of the vehicle. Such energy management tables can be calibrated to operate the vehicle powertrains in desired regions to achieve an optimal system level fuel economy.

[0035] AWD (all-wheel drive) BEV powertrains have the ability to independently control torque distribution between the front and rear sets of wheels through independent motors on each axle. Due to various factors including electric motor efficiency and system losses varying based on speed and torque output, determining the optimal torque distribution for each axle with respect to a system energy management perspective is desired in order to optimize energy usage during vehicle operation. For an eAWD vehicle, optimal efficiency torque split can differ significantly from an equal proportion, especially in applications where the axle capacity varies. Operating in an efficiency split allows for a best possible energy efficiency. Switching to tables to define amount of torque to send to the different axles is employed to optimize vehicle overall performance.

[0036] Trailer powertrain 18 has the same type of architecture as an AWD BEV powertrain in that torque distribution to drive axle 44 is accomplished through electric motor 42 on the drive axle. Due to many factors including efficiency of electric motor 42 and system losses varying based on speed and torque output, determining the optimal torque distribution for drive axle 44 with respect to a system energy management perspective is desired to optimize energy usage during operation of trailer powertrain 18.

[0037] With a purpose of incorporating trailer 14 with EV 12 being to increase range and capability to the EV, an issue is how vehicle powertrain 16 and trailer powertrain 18 are to operate together. That is, an issue is how integrated powertrain 52, comprised of vehicle powertrain 16 and trailer powertrain 18, is to be operated.

[0038] Combined vehicle system 10 in accordance with this disclosure employs an energy management optimization strategy for integrated powertrain 52. The energy management optimization strategy factors in system level electrical and mechanical losses across various operation conditions for both vehicle powertrain 16 and trailer powertrain 18 to determine a most efficient (i.e., optimized) operation for integrated powertrain 52. This optimized operation for integrated powertrain 52 may be realized via energy management calibration for vehicle powertrain 16 (which is a HEV powertrain) and torque vectoring for trailer powertrain 18 (which is a BEV powertrain) (and for vehicle BEV powertrains) between each powered axle and propulsion source on EV 12 and trailer 14. A controller such as vehicle controller 36, in coordination with trailer controller 50, is configured to control vehicle powertrain 16 and trailer powertrain 18, and thereby control integrated powertrain 52, pursuant to the energy management optimization strategy.

[0039] Three general aspects are involved in developing and deploying the energy management optimization strat-

egy. The first aspect includes obtaining component level operation data (for efficiency) for each component in the architecture of integrated powertrain 52 and developing system level efficiency contour maps for vehicle powertrain 16 and trailer powertrain 18. The efficiency contour maps for vehicle powertrain 16 and trailer powertrain 18 are developed to map efficiencies across speed, torque, traction battery state-of-charge (SOC), and other relevant inputs. Much of this loss map and road load determination is typically completed during vehicle and trailer development.

[0040] The second aspect involves communicating information regarding system optimal efficiencies between vehicle controller 36 and trailer controller 50 upon trailer 14 being connected to EV 12. Using an in-vehicle or cloud-based optimization algorithm, such as used during vehicle development for HEV or BEV type vehicles, coupling between vehicle powertrain 16 and trailer powertrain 18 for optimal efficiency operation occurs to create a new combined system level efficiency contour map for integrated powertrain 52. Using this combined efficiency map for integrated powertrain 52, a new set of calibration tables may be created corresponding to the architecture of integrated powertrain 52. These calibrations are uploaded to vehicle controller 36. Vehicle controller 36 can thereby control vehicle powertrain 16 in a desired region of the combined efficiency map for integrated powertrain 52 and/or maintain optimal torque split between powered axles of EV 12 and trailer 14 based on the current operational status of EV 12.

[0041] The optimization algorithm initially focuses on optimizing for most commonly encountered conditions to minimize wait/down time after coupling of trailer 14 to EV 12. A base calibration providing a generic vehicle to trailer operation can be employed until a more refined optimized calibration can be finished. Once a calibration is created based on a vehicle and a trailer, the calibrations can be used for other users by identifying similar vehicle and trailer characteristics. Essentially pre-built energy optimized calibrations can be accessed via the cloud by users of different vehicles. These pre-built combined vehicle energy management optimized calibrations can be uploaded to vehicles via over-the-air updates.

[0042] The communicating of information regarding system optimal efficiencies between vehicle controller 36 and trailer controller 50 upon trailer 14 being connected to EV 12 may occur using wireless (e.g., Bluetooth, vehicle modem, etc.) or wired (e.g., controller area network (CAN)/local area network (LAN)) communications. Information indicative of EV 12 of the communicated information may include information such as powertrain architecture and capability (power split, BEV, etc.) of vehicle powertrain 16, loss maps associated with the vehicle powertrain, road loads (F terms), size/capacity of traction battery 20, existing optimal vehicle powertrain operation, and weight and towing capacity of the EV. Information indicative of trailer 14 of the communicated information may include information such as information of trailer powertrain 16 including number of motors, number of wheels, road loads, loss maps, size/capacity of traction battery 40, capability of the trailer powertrain, and weight of the trailer. The loss maps can be estimated from component models as well.

[0043] The energy management-based optimization occurs based on powertrain architecture and control strategy used on the vehicle. Main inputs from driving the vehicle include traction battery SOC, driver demanded wheel

torque, vehicle speed, combined vehicle weight, and relative powertrain capability. Optimization outputs can include for all powertrain types, torque split between vehicle and trailer and powered axles on trailer during regenerative braking and propulsion; for BEV powertrains, torque split between axles; for modular hybrid transmission (MHT) powertrains, when to shift, engine on time including when to start and stop the engine, traction battery charging, etc.; and for power-split powertrains, engine speed, traction battery charging, when to start and stop the engine, etc.

[0044] Further, calibration ranges can also be predetermined such that the calibration that is created for optimal energy management does not violate predetermined noise, vehicle, harshness (NVH)/drivability rules. Some of these rules could be embedded to algorithms/rules which create the calibration tables from the system efficiency maps.

[0045] The third aspect involves applying optimal torque vectoring calibration to EV 12 and trailer 14 during steady state and varying operating conditions. Adjustments from optimal operating conditions during driving of combined vehicle system 10 based on encountered operational conditions are made. For example, in the case of excessive thermal status of components such as traction battery 20 and/or electric motor 24 of vehicle powertrain 16 becoming very hot, an adjustment is to switch to more propulsion from trailer powertrain 18; in the case of excessive wheel torque being demanded, an adjustment is to apply full torque capability from both vehicle powertrain 16 and trailer powertrain 18; in the case of excessive slip being detected, an adjustment is to request equally distributed torque split, up to capacity, across all axles; and in the case of instability of trailer 14, an adjustment is requesting trailer powertrain 18 based instability arresting torque as needed.

[0046] Further, during the optimization, rules can be applied to account for drivability/NVH concerns such as leveraging existing drivability/efficiency optimized calibrations within EV 12 and trailer 14. For example, in AWD BEVs, generally, it is advantageous to command at least some torque on the secondary drive unit (SDU) (even though entirely primary drive unit (PDU) based torque is more efficient) for drivability, lash, efficiency, and other vehicle performance/drivability concerns.

[0047] Referring now to FIG. 3, with continual reference to FIGS. 1, 2A, and 2B, a flowchart 60 depicting operation of an energy management optimization strategy for integrated powertrain 52 of combined vehicle system 10 is shown. The operation begins with developing efficiency contour maps for vehicle powertrain 16 and trailer powertrain 18 using component data system level information of the vehicle and trailer powertrains, as indicated by process block 62. The efficiency contour maps are stored in onboard data storage of EV 12 and/or trailer 14 or in the cloud, as indicated by process block 64. Trailer 14 is then connected to EV 12 to form combined vehicle system 10 which includes integrated (combined) powertrain 52 comprised of vehicle powertrain 16 and trailer powertrain 18, as indicated by process block 66. A user of combined vehicle system 10 then selects the model or type of trailer 14 such as via a human-machine interface (HMI) of EV 12, as further indicated by process block 66. This selection is for identifying trailer 14 whereby the efficiency contour map for the particular model or type of trailer powertrain 18, as opposed to

the efficiency contour map for some other model or type of trailer powertrain, will be used for the energy management optimization strategy.

[0048] The operation further includes creating a combined efficiency contour map for integrated powertrain 52 from the individual efficiency contour maps for vehicle powertrain 16 and trailer powertrain 18, as indicated by process block 68. The individual efficiency contour maps for vehicle powertrain 16 and trailer powertrain 18 are selected from onboard data storage or downloaded from the cloud, as further indicated by process block 68. Integrated powertrain 52 is then operated according to the combined efficiency contour map to propel EV 12, with trailer 14 connected thereto, as indicated by process block 70. The operation of integrated powertrain 52 is handled by vehicle controller 36 alone or in conjunction with trailer controller 50 as described above. The operation of integrated powertrain 52 is adapted based on encountered conditions, as further indicated by process block 70.

[0049] Referring now to FIGS. 4A and 4B, with continual reference to FIGS. 1, 2A, 2B, and 3, a more detailed flowchart 80 depicting operation of the energy management optimization strategy is shown. For simplicity, it is assumed that vehicle controller 36 alone and without trailer controller 50 handles aspects of the operation.

[0050] The operation begins with vehicle controller 36 detecting whether an electrically powered trailer has been connected to EV 12, as indicated by decision block 82. The operation continues once an electrically powered trailer, such as trailer 14, is connected to EV 12. Upon continuation of the operation, vehicle controller 36 sources loss data for each torque producing device (e.g., electric motor 24), traction battery (e.g., traction battery 20), and gearbox system (e.g., transmission 28) of vehicle powertrain 16 and sources loss data for each torque producing device (e.g., electric motor 42) and traction battery (e.g., traction battery 40) of trailer powertrain 18, as indicated by process block 84. As described, the loss map creation occurs during development of the vehicle powertrain/vehicle and during development of the trailer powertrain/trailer. Optimal torque vectoring between each electric motor is predetermined based on wheel torque and vehicle (trailer) speed.

[0051] Vehicle controller 36 then determines how many and which types of motor/torque producing devices are on vehicle powertrain 16 (and on trailer powertrain 18), as indicated by process block 86.

[0052] A maximum system efficiency algorithm is then used to calculate a most efficient operating point for every torque demand/vehicle speed combination within the combined vehicle capability for the individual vehicle powertrain 16 and trailer powertrain 18, as indicated by process block 88. The algorithm iterates through each potential speed/torque combination/option to meet a desired torque/power request by changing the torque/power produced by each torque producing device on vehicle powertrain 16 and trailer powertrain 18 (trailer powertrain 18 produces "X" Nm, vehicle powertrain 16 produces "Y" Nm, loss is "Z" Nm, and repeat). Once the algorithm iterates through each operating point, the algorithm determines the torque split/operating conditions for each point with the lowest energy consumption/lowest loss. These are the ideal operating points for integrated powertrain 52 and are programmed into the contour map and combined vehicle calibration. In conjunction with process block 88, a combined powertrain

efficiency plot for integrated powertrain 52 is generated using an iterative-perturbation algorithm, as indicated by process block 90.

[0053] The operation of process blocks 88 and 90 will be described in further detail with reference to FIGS. 5A, 5B, and 5C. FIG. 5A illustrates an exemplary efficiency contour map 110 for vehicle powertrain 16; FIG. 5B illustrates an exemplary efficiency contour map 120 for trailer powertrain 18; and FIG. 5C illustrates an exemplary combined efficiency contour map 130 for integrated powertrain 52 that is generated from an exemplary three-dimensional (3D) efficiency contour table 140 for the integrated powertrain. As described, the operation of process blocks 88 and 90 entails creating a combined efficiency contour map (i.e., combined efficiency contour map 130) for integrated powertrain 52 from the individual efficiency contour maps (i.e., efficiency contour map 110 for vehicle powertrain 16 and efficiency contour map 120 for trailer powertrain 18). In this way, combined efficiency contour map 130 for integrated powertrain 52 is a function of (i) efficiency contour map 110 for vehicle powertrain 16 and (ii) efficiency contour map 120 for trailer powertrain 18.

[0054] More particularly, as noted, the maximum system efficiency algorithm determines the torque split/operating conditions for each point with the lowest energy consumption/lowest loss. These are the ideal operating points for integrated powertrain 52. The operating conditions are a function of driver demanded power and vehicle speed; and the driver demanded power is the demanded power of combined vehicle system 10 (i.e., the driver demanded power is the sum of (i) the power of vehicle powertrain 16 and (ii) the power of trailer powertrain 18). Initially, the maximum system efficiency algorithm uses efficiency contour map 110 for vehicle powertrain 16 and determines power to be drawn from vehicle powertrain 16 that is in the most efficient region of efficiency contour map 110. Next, the maximum system efficiency algorithm uses efficiency contour map 120 for trailer powertrain 18 and determines efficiency for the remaining power to be drawn from trailer powertrain 18 (vehicle speed is a constant). (The remaining power is the power from vehicle powertrain 16 subtracted from the driver demanded power.) The maximum system efficiency algorithm then runs an iterative algorithm, which is based on perturbation, to determine whether the combined efficiency could be increased with different torque splits. This information is stored as three-dimensional efficiency contour table 140, which converts into combined efficiency contour map 130 for integrated powertrain 52. Combined efficiency contour map 130 is a contour map for integrated powertrain 52 that is generated for each driver demanded power and vehicle speed combination of combined vehicle system 10.

[0055] Turning back to FIG. 4, the operation may further continue with creating additional contour maps using the same algorithm based on different powertrain component operating temperatures when the loss data is available, as indicated by process block 92. Alternative contour maps for situations in which power/torque is limited from motor/battery up to X % derate may be created, as indicated by process block 94.

[0056] The operation further includes EV 12 uploading combined efficiency contour map 130 for integrated powertrain 52 to the associated powertrain controllers that determine torque/power requests, as indicated by process

block 96. In this example, combined efficiency contour map 130 is uploaded to vehicle controller 36.

[0057] Operation of combined vehicle system 10 by a driver of EV 12 then begins, as indicated by process block 98. During operation of combined vehicle system 10, vehicle controller 36 determines vehicle operation inputs such as driver demanded torque/power, vehicle speed, motor speeds, and the like, as indicated by process block 100. In turn, vehicle controller 36 uses operational parameters as inputs in combined efficiency contour map 130 for integrated powertrain 52 and determines therefrom the optimal torque distribution amongst torque producing devices in the powertrains (i.e., vehicle powertrain 16 and trailer powertrain 18) comprising the integrated powertrain, as indicated by process block 102.

[0058] The operation may further include obtaining torque limiting factors such as SOC, component temperatures for individual components, and NVH/drivability limits, and limiting the torque, and accordingly creating or referencing new contour maps, as indicated by process block 104.

[0059] The description of the operation of flowchart 80 is exemplary. Other considerations that could be accounted for by creating new contour maps can include: NVH constraints; thermal derate of traction battery/engine/electric motors/inverter/gearbox/etc. on the vehicle and/or the trailer (separate contour maps can be created for either scenario based on detecting a thermal derate event); stability constraints during braking; and supply energy constraints and trip metrics.

[0060] Regarding supply energy constraints and trip metrics, based on the estimated length of the trip and the energy available for use on the vehicle/trailer, certain powertrains could be leveraged more to ensure both powertrains can provide propulsion assistant throughout the duration of the trip. When the vehicle powertrain is gas based and the trailer powertrain is electrified, the trailer might have a more limited energy supply than the vehicle and as a result the output torque should be rationed or regen braking should occur as frequently as possible to recharge the traction battery of the trailer. When the vehicle powertrain is of a hybrid variant, the engine can run to charge the traction batteries of the vehicle and the trailer and separate contour maps should be created. When both powertrains are electrified and the energy storage system on the trailer is separate from the vehicle, biasing the torque of the units may be needed. When both powertrains are electrified and a shared energy system is used (the situation that is assumed in flowchart 80), the true most efficient operating conditions can be realized throughout the trip due to the vehicle/trailer having the ability to pull energy from the same energy storage device or transfer energy between storage devices.

[0061] As described, this disclosure relates to an electrically powered vehicle and an electrically powered trailer towed by the vehicle. The trailer includes its own powertrain having a traction battery and an electric motor for propelling the trailer. A combined vehicle-trailer integrated powertrain energy management method is provided that factors in system level electrical and mechanical losses across all operation conditions to determine a most efficient powertrain operation for the combined vehicle powertrain system. The method uses torque vectoring between each powered axle and propulsion source on the vehicle and the trailer. The method maps efficiency contour maps for the vehicle and the trailer for various inputs such as speed,

torque, SOC, and others. The method develops a new combined efficiency contour map when the trailer is connected to the vehicle, updates the calibration tables for the various vehicle and trailer components, and controls the components for efficiency or torque split based on the operational status of the vehicle. The unique calibrations or contour maps for a vehicle and trailer pair may be shared with other vehicles such as via V2X.

[0062] As described, advantages of the integrated powertrain energy management optimization strategy include being implementable for various types of vehicle and trailer powertrain architectures, allowing for electrified vehicles to tow heavier trailer loads, reducing need for tow specific capable vehicles, increasing vehicle range, and leveraging existing vehicle and trailer data to optimize usage of the integrated vehicle/trailer powertrain.

[0063] The algorithms, methods, or processes disclosed herein can be deliverable to or implemented by a computer, controller, or processing device, which can include any dedicated electronic control unit or programmable electronic control unit. Similarly, the algorithms, methods, or processes can be stored as data and instructions executable by a computer or controller in many forms including, but not limited to, information permanently stored on non-writable storage media such as read only memory devices and information alterably stored on writable storage media such as compact discs, random access memory devices, or other magnetic and optical media. The algorithms, methods, or processes can also be implemented in software executable objects. Alternatively, the algorithms, methods, or processes can be embodied in whole or in part using suitable hardware components, such as application specific integrated circuits, field-programmable gate arrays, state machines, or other hardware components or devices, or a combination of firmware, hardware, and software components. The words processor and processors may be interchanged herein, as may the words controller and controllers.

[0064] While exemplary embodiments are described above, it is not intended that these embodiments describe all possible forms encompassed by the claims. The words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the disclosure. Additionally, the features of various implementing embodiments may be combined to form further embodiments.

What is claimed is:

1. A system comprising:

- a vehicle having an electrically powered trailer towed thereto, the vehicle having a vehicle powertrain and the trailer having a trailer powertrain; and
- a controller programmed to, in order to propel the vehicle with the trailer towed thereto, operate the vehicle powertrain and the trailer powertrain according to a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain.

2. The system of claim 1 wherein:

the controller is further programmed to control components of the vehicle powertrain and components of the trailer powertrain for efficiency or torque split based on operational status of the vehicle in realizing operation of the vehicle powertrain and the trailer powertrain according to the combined efficiency map.

3. The system of claim 1 wherein:

the controller is further programmed to obtain loss data of components of the vehicle powertrain and to obtain loss data of components of the trailer powertrain; and the efficiency map associated with the vehicle powertrain factors in the loss data of components of the vehicle powertrain and the efficiency map associated with the trailer powertrain factors in loss data of components of the trailer powertrain.

4. The system of claim 1 wherein:

the combined efficiency map provides for operation of the vehicle powertrain and the trailer powertrain to have a highest combined efficiency for a given driver demanded power and vehicle speed combination.

5. The system of claim 1 wherein:

the combined efficiency map provides for operation of the vehicle powertrain to be in a most efficient region of the efficiency map associated with the vehicle powertrain.

6. The system of claim 1 wherein:

the vehicle powertrain includes a first traction battery; and the trailer powertrain includes a second traction battery.

7. The system of claim 6 wherein:

the vehicle powertrain further includes an engine.

8. The system of claim 6 wherein:

the controller is further programmed to cause electrical power to be transferred between the first traction battery and the second traction battery in order to maintain operation of the vehicle powertrain and the trailer powertrain according to the combined efficiency map.

9. The system of claim 1 wherein:

the controller is further programmed to realize operation of the vehicle powertrain and the trailer powertrain via torque vectoring between drive axles and propulsion sources on the vehicle powertrain and the trailer powertrain.

10. The system of claim 1 wherein:

the controller is further programmed to generate the combined efficiency map upon the trailer being connected to the vehicle.

11. The system of claim 1 wherein:

the controller is further programmed to share the efficiency map associated with the vehicle powertrain and/or the efficiency map associated with the trailer powertrain with a third party.

12. A control system for a combined vehicle system having a vehicle and an electrically powered trailer towed by the vehicle, the vehicle having a vehicle powertrain and the trailer having a trailer powertrain, the control system comprising:

a controller programmed to, in order to propel the combined vehicle system, operate the vehicle powertrain and the trailer powertrain according to a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain.

13. The control system of claim 12 wherein:

the controller is further programmed to obtain loss data of components of the vehicle powertrain and to obtain loss data of components of the trailer powertrain; and the efficiency map associated with the vehicle powertrain factors in the loss data of components of the vehicle powertrain and the efficiency map associated with the trailer powertrain factors in loss data of components of the trailer powertrain.

14. The control system of claim 12 wherein:
the combined efficiency map provides for operation of the vehicle powertrain to be in a most efficient region of the efficiency map associated with the vehicle powertrain.
15. The control system of claim 12 wherein:
the controller is further programmed to cause electrical power to be transferred between a traction battery of the vehicle powertrain and a traction battery of the trailer powertrain in order to maintain operation of the vehicle powertrain and the trailer powertrain according to the combined efficiency map.
16. The control system of claim 12 wherein:
the controller is further programmed to realize operation of the vehicle powertrain and the trailer powertrain via torque vectoring between drive axles and propulsion sources on the vehicle powertrain and the trailer powertrain.
17. A method comprising:
upon an electrically powered trailer having a trailer powertrain being connected to a vehicle having a vehicle powertrain for the trailer to be towed by the vehicle,

- generating, by a controller of the vehicle, a combined efficiency map based on (i) an efficiency map associated with the vehicle powertrain and (ii) an efficiency map associated with the trailer powertrain; and
operating, by the controller of the vehicle, in order to propel the vehicle with the trailer towed thereto, the vehicle powertrain and the trailer powertrain according to the combined efficiency map.
18. The method of claim 17 further comprising:
controlling, by the controller of the vehicle, components of the vehicle powertrain and components of the trailer powertrain for efficiency or torque split based on operational status of the vehicle in realizing operation of the vehicle powertrain and the trailer powertrain according to the combined efficiency map.
19. The method of claim 17 wherein:
the vehicle powertrain includes a first traction battery; and
the trailer powertrain includes a second traction battery.
20. The method of claim 19 wherein:
the vehicle powertrain further includes an engine.

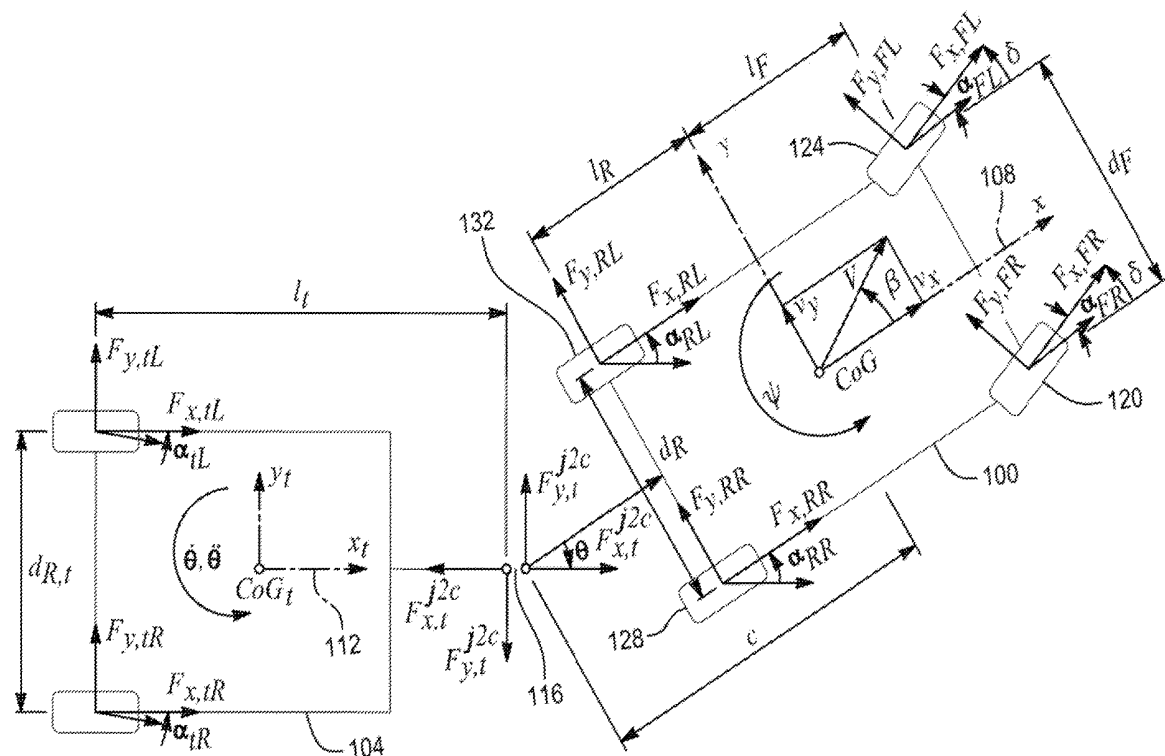
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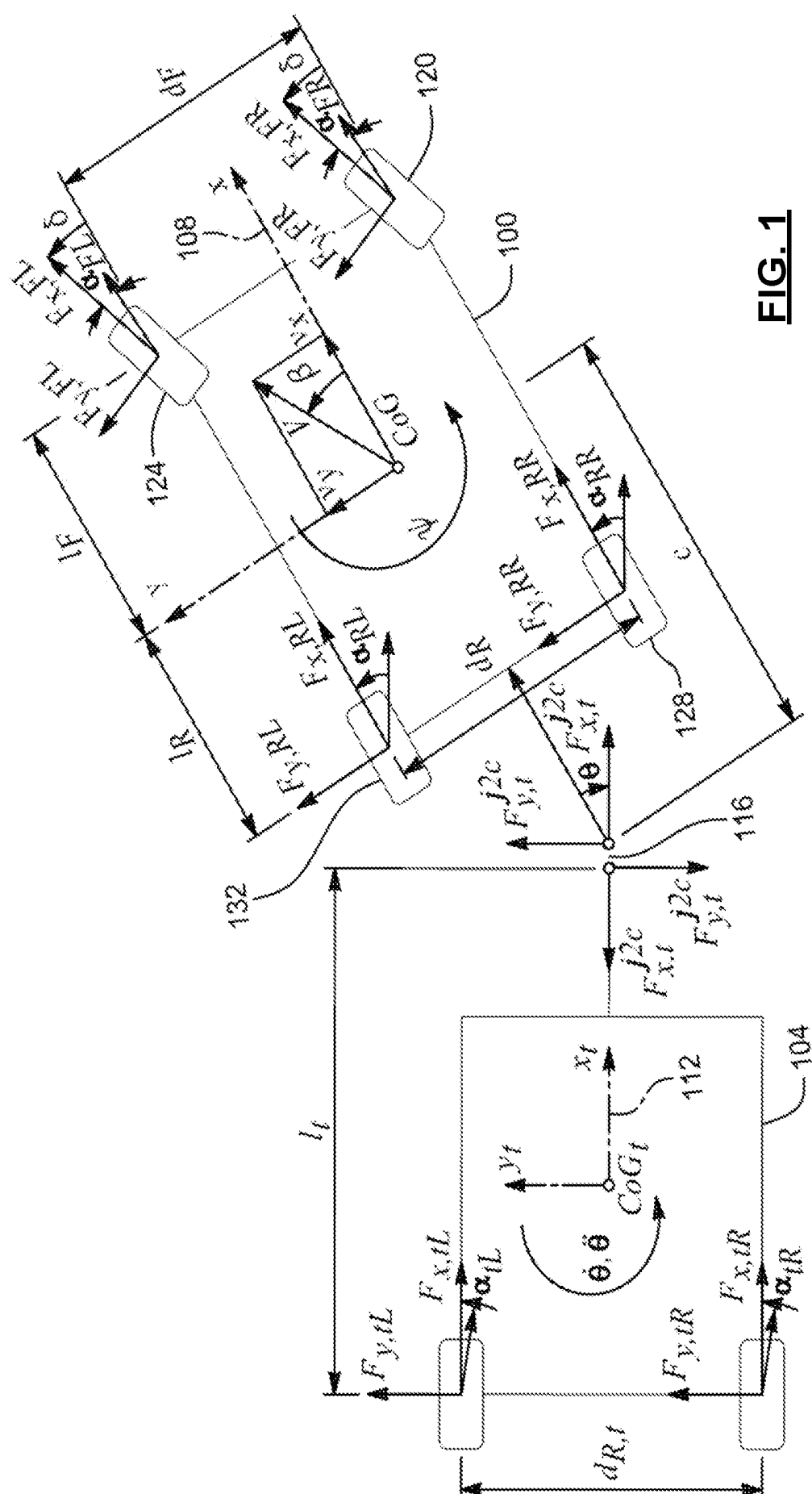


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(19) **United States**(12) **Patent Application Publication**
DHAENS et al.(10) **Pub. No.: US 2024/0010036 A1**(43) **Pub. Date: Jan. 11, 2024**(54) **VEHICLE CONTROL SYSTEMS AND
METHODS BASED ON TRAILER HITCH
JOINT FORCES**(52) **U.S. CL.**
CPC **B60D 1/30** (2013.01); **B60D 1/62** (2013.01)(71) Applicant: **DRiV Automotive Inc.**, Southfield, MI
(US)(72) Inventors: **Miguel DHAENS**, Lommel (BE);
Victor MAZZILLI, Guildford (GB);
Gabriele RINI, Guildford (GB);
Patrick GRUBER, Guildford (GB);
Aldo SORNIOTTI, Guildford (GB);
Sebastiaan VAN AALST, Hasselt (BE)(21) Appl. No.: **17/861,825**(22) Filed: **Jul. 11, 2022****Publication Classification**(51) **Int. Cl.**
B60D 1/30 (2006.01)
B60D 1/62 (2006.01)(57) **ABSTRACT**

A trailer sway control system for a vehicle includes: a front left active suspension actuator; a front right active suspension actuator; a rear left active suspension actuator; a rear right active suspension actuator; and an actuator control module configured to: based on (a) a first hitch force at a trailer hitch in a longitudinal direction, (b) a second hitch force at the trailer hitch in a lateral direction, and (c) a third hitch force at the trailer hitch in a vertical direction, determine target vertical forces for the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator, respectively; and selectively adjust the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator based on the target vertical forces, respectively.





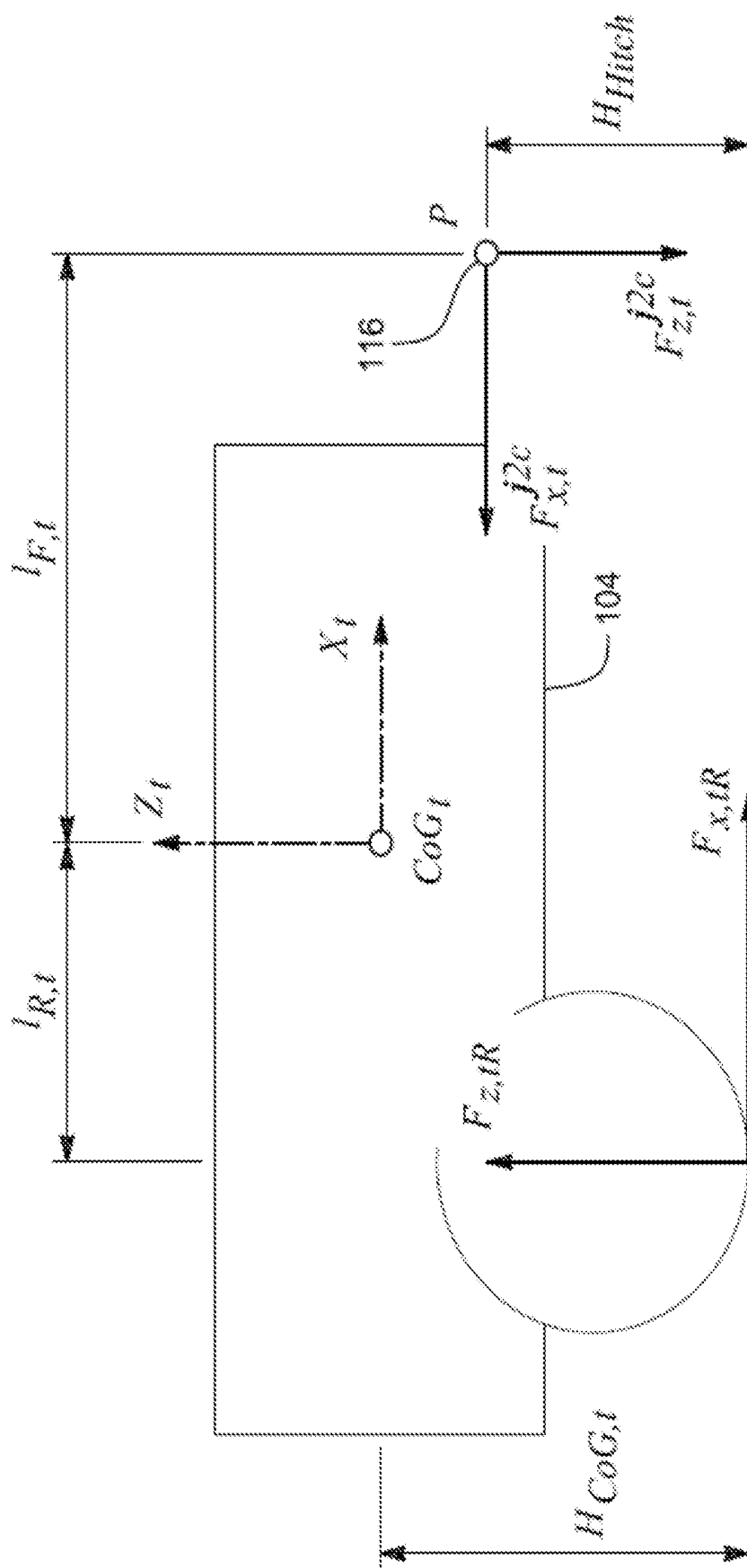


FIG. 2

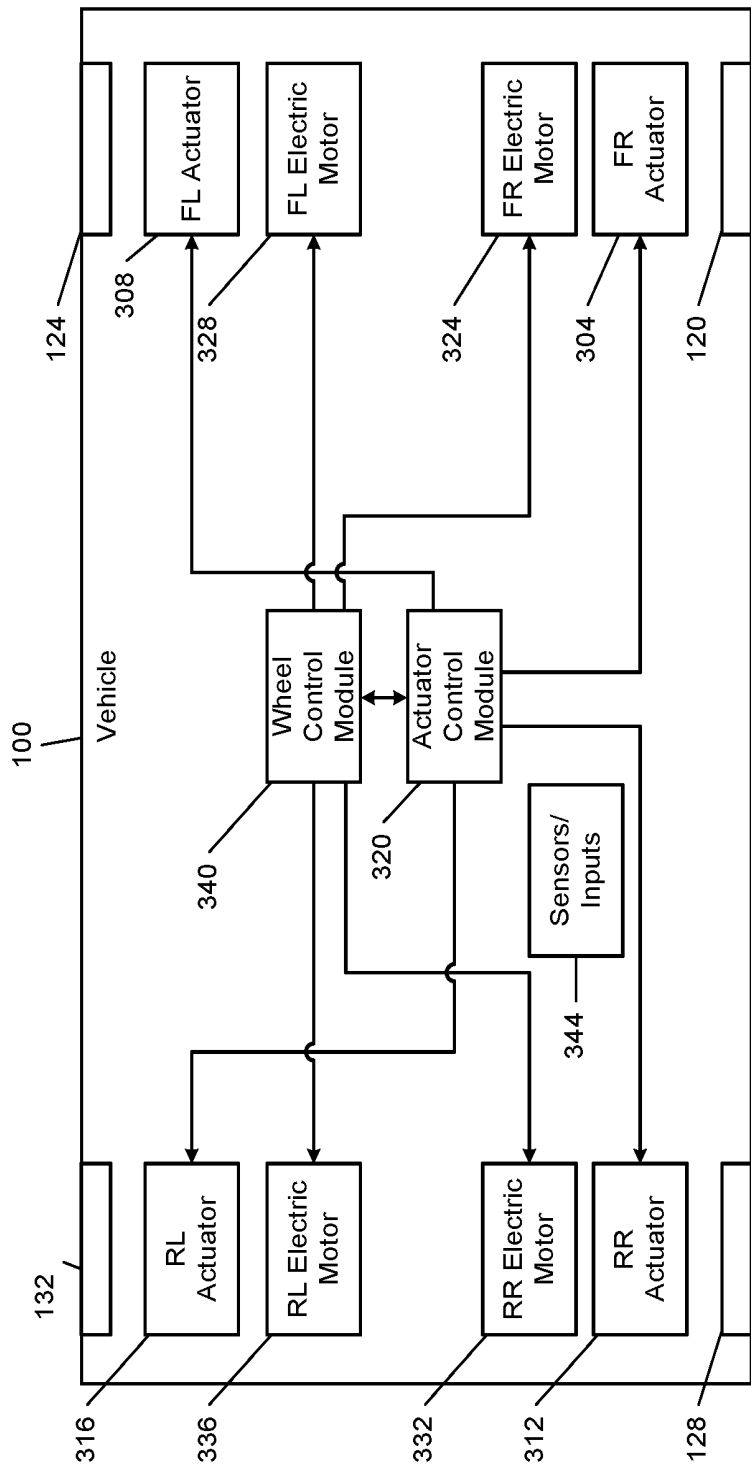


FIG. 3

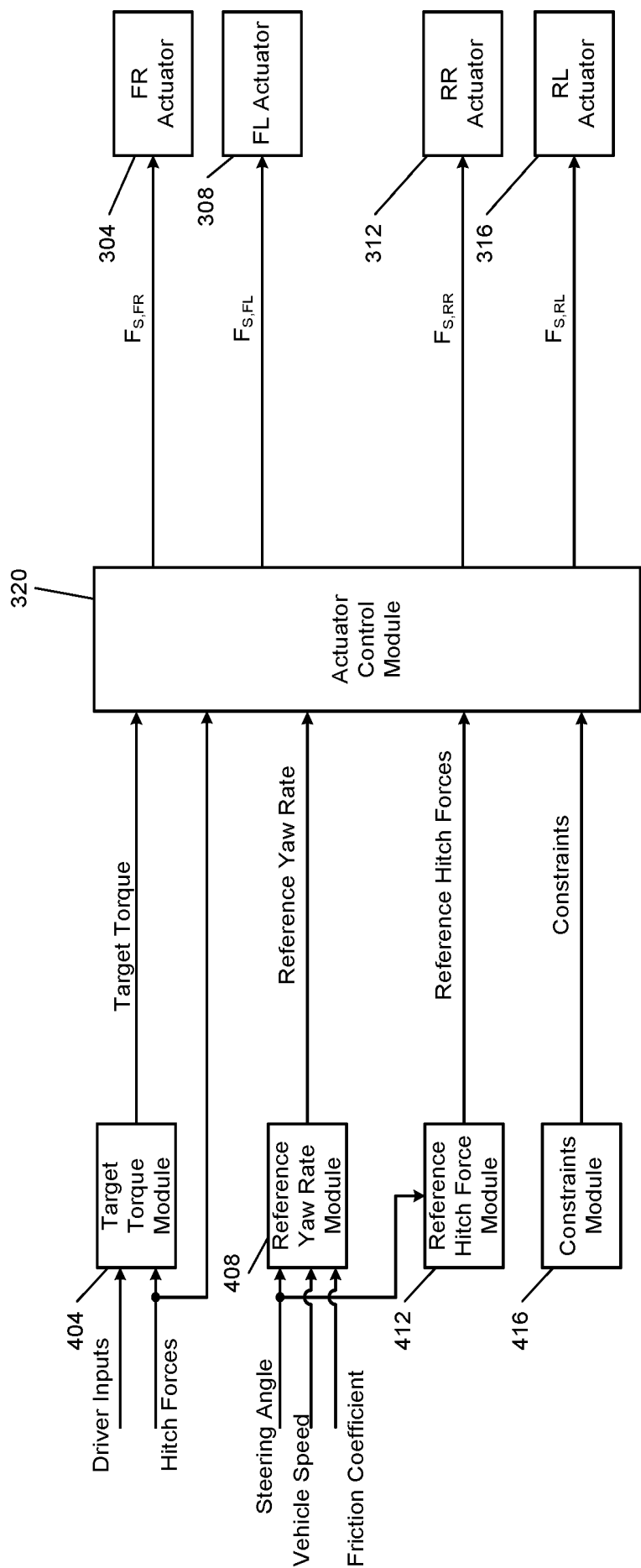


FIG. 4

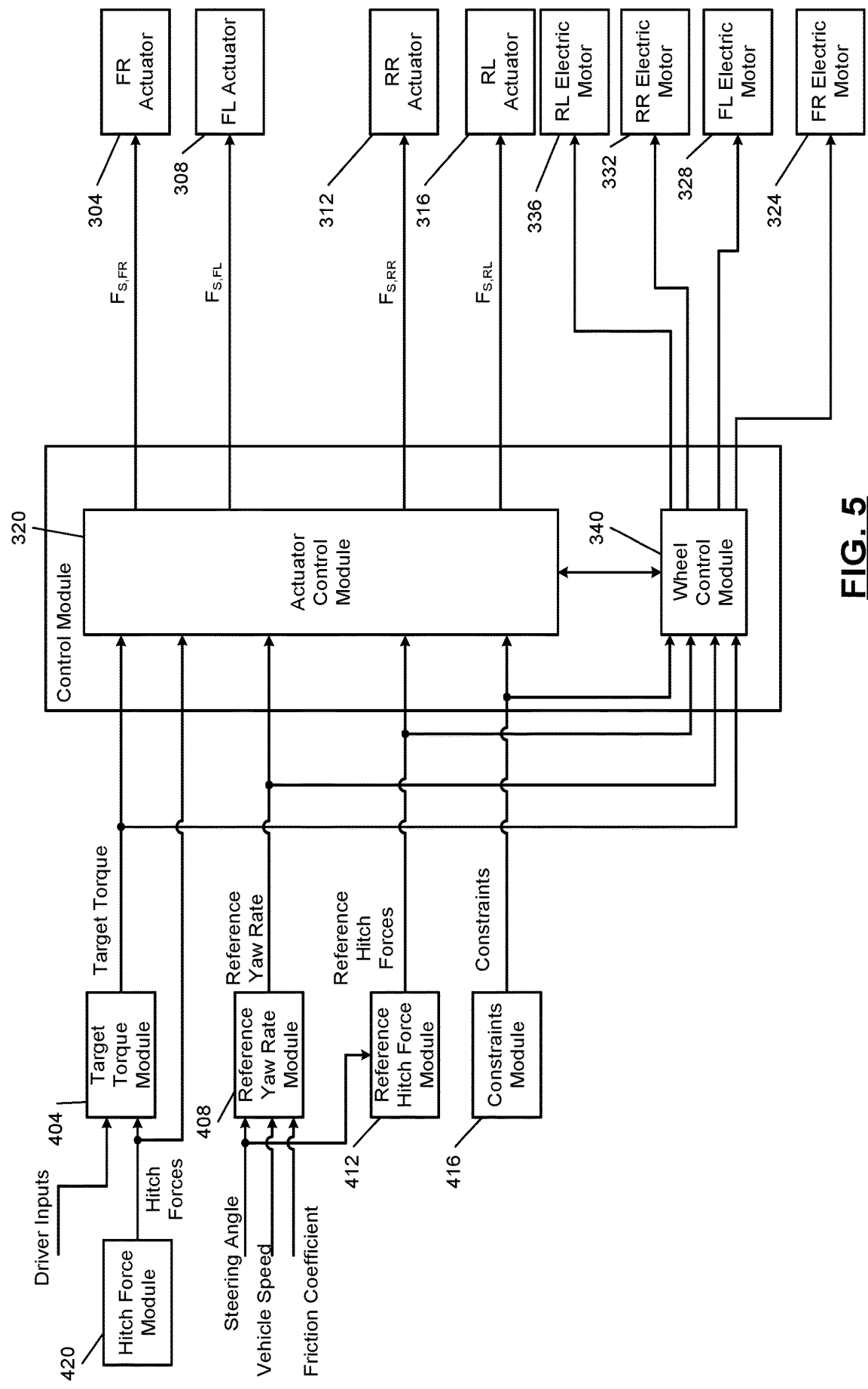


FIG. 5

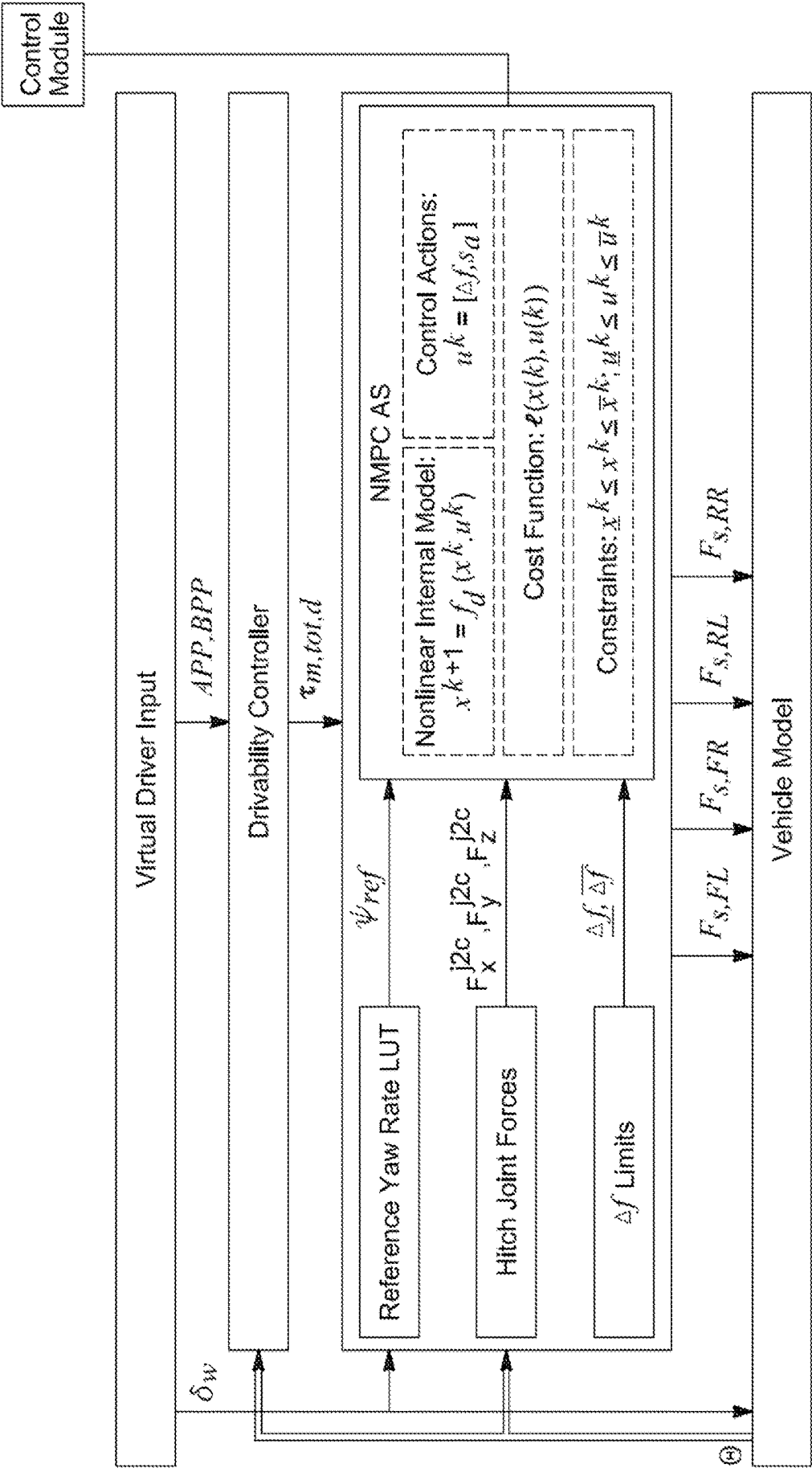


FIG. 6

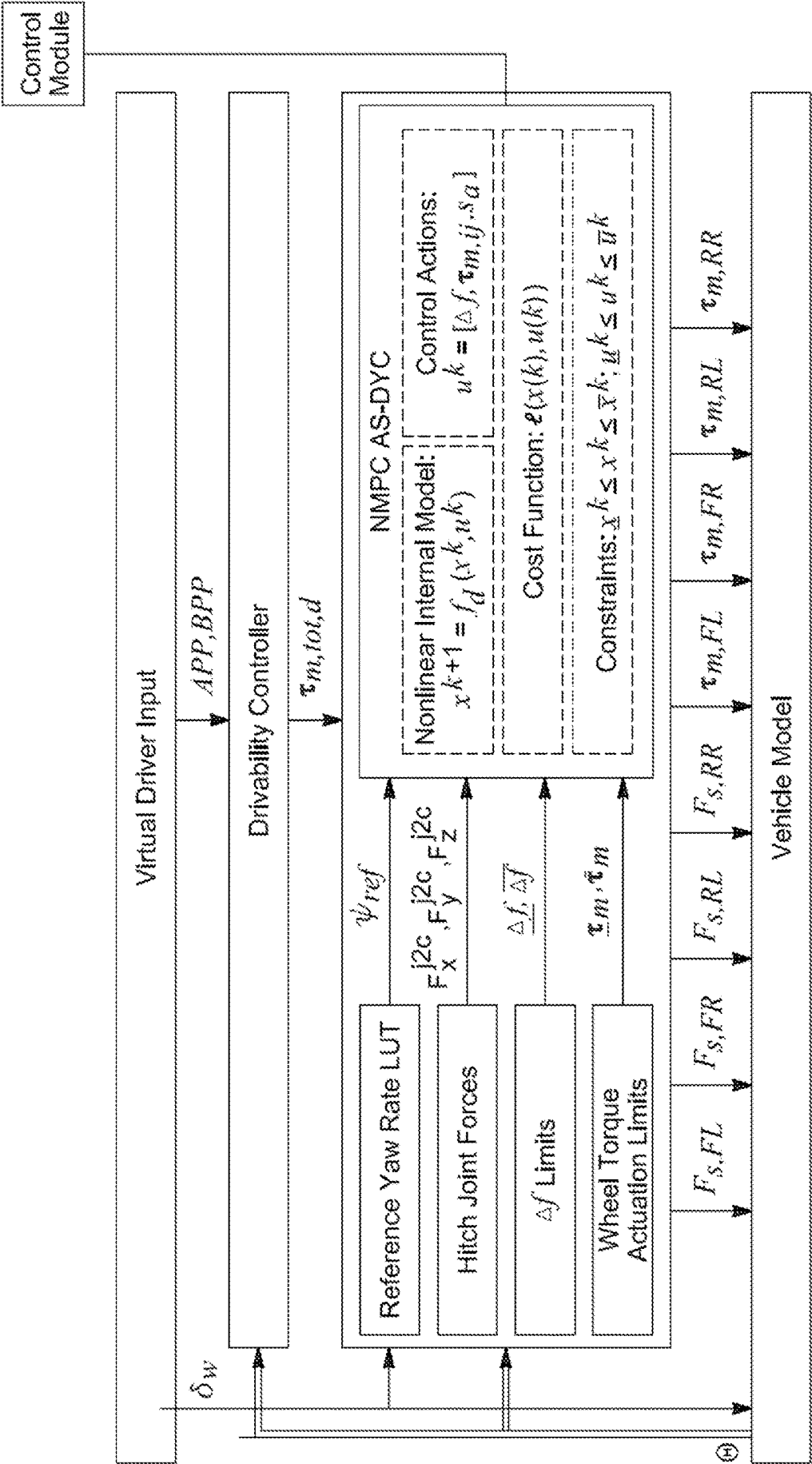


FIG. 7

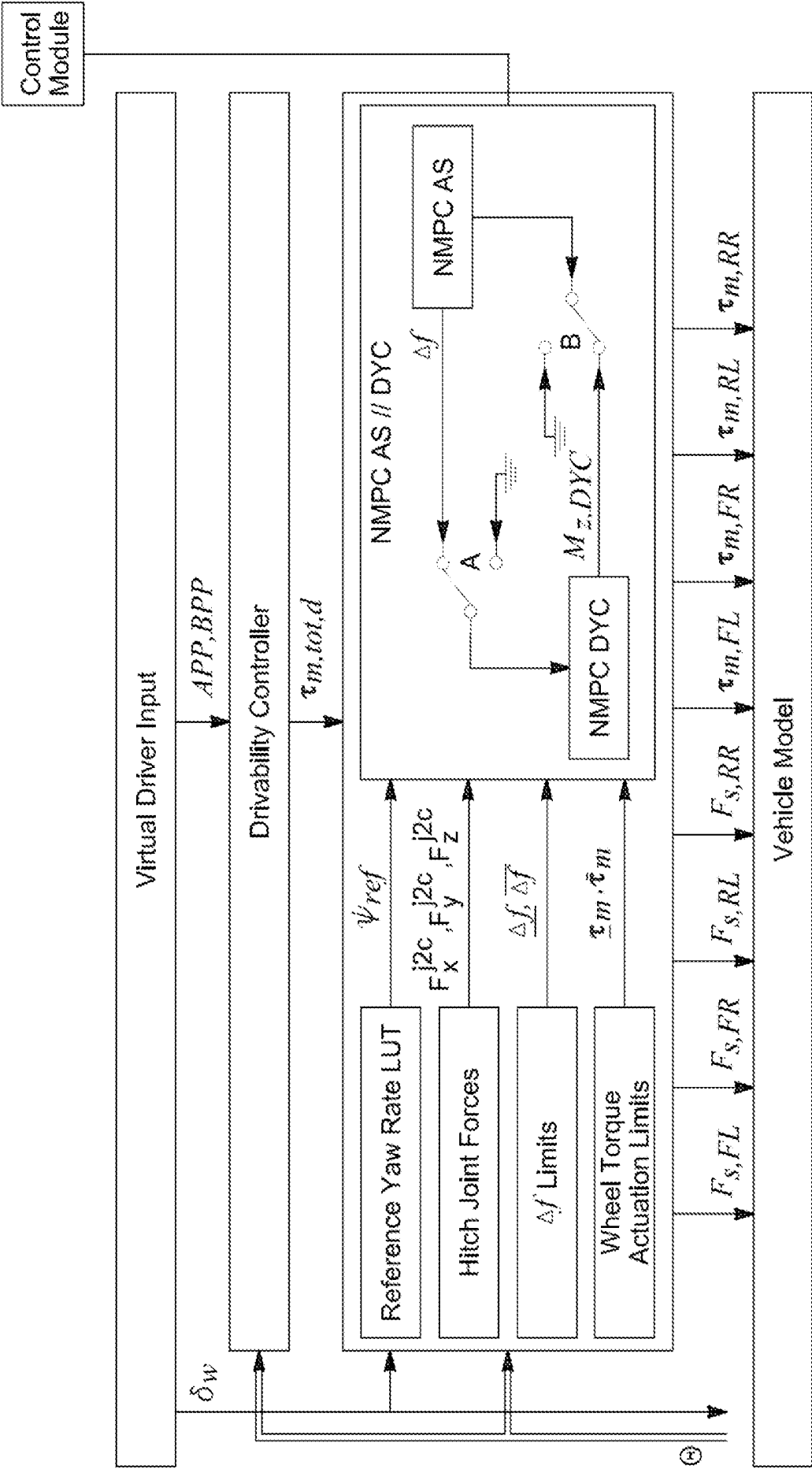


FIG. 8

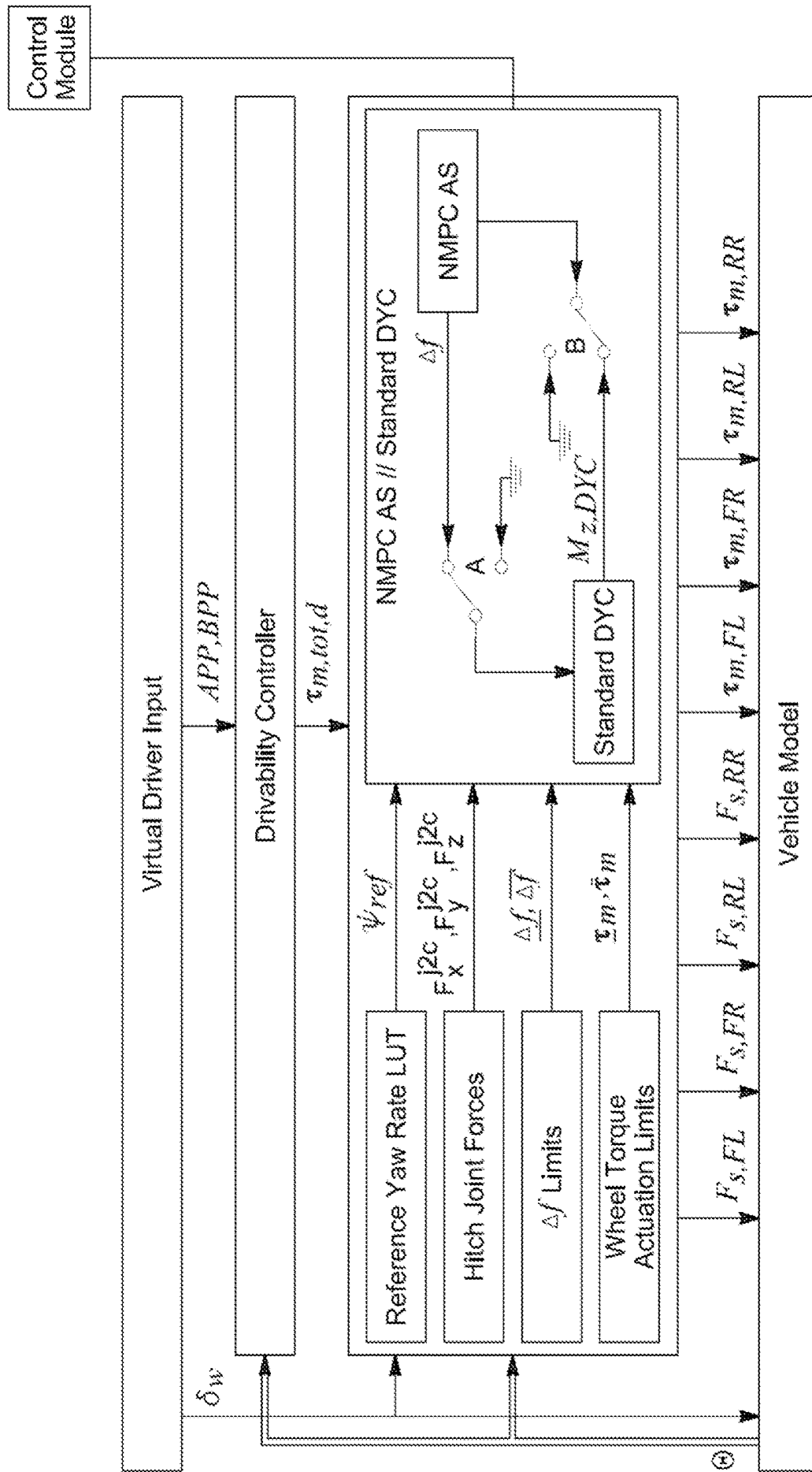
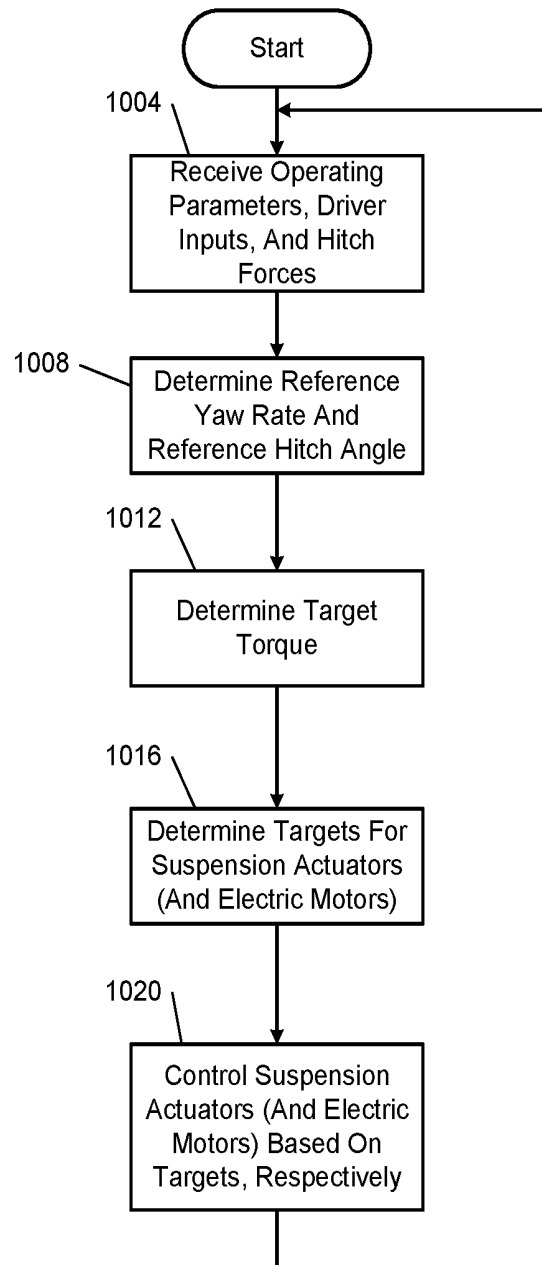


FIG. 9

**FIG. 10**

VEHICLE CONTROL SYSTEMS AND METHODS BASED ON TRAILER HITCH JOINT FORCES

FIELD

[0001] The present disclosure relates to control systems and methods of vehicles and more particularly to vehicle control based on forces at a hitch where a trailer is hitched to the vehicle.

BACKGROUND

[0002] The background description provided here is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

[0003] Various different types of vehicles are available. For example, coupes, sedans, convertibles, trucks, station wagons, and utility vehicles are available. There are multiple different types of utility vehicles, such as sport utility vehicles (SUVs), crossover utility vehicles, etc.

[0004] Some types of vehicles are designed to tow trailers. For example, trucks and utility vehicles may be used to tow trailers. Various different types of trailers are available. Examples of trailers include cargo trailers, trailers for vehicles (e.g., land based vehicles, watercraft, etc.), travel trailers, and other types of trailers.

SUMMARY

[0005] In a feature, a trailer sway control system for a vehicle includes: a front left active suspension actuator associated with a front left wheel of the vehicle; a front right active suspension actuator associated with a front right wheel of the vehicle; a rear left active suspension actuator associated with a rear left wheel of the vehicle; a rear right active suspension actuator associated with a rear right wheel of the vehicle; and an actuator control module configured to: based on (a) a first hitch force at a trailer hitch of the vehicle in a longitudinal direction, (b) a second hitch force at the trailer hitch of the vehicle in a lateral direction, and (c) a third hitch force at the trailer hitch of the vehicle in a vertical direction, determine target vertical forces for the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator, respectively; and selectively adjust the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator based on the target vertical forces, respectively.

[0006] In further features, the actuator control module is configured to determine the target vertical forces based on minimizing (a) a first difference between the first hitch force and a first reference hitch force, (b) a second difference between the second hitch force and a second reference hitch force, and (c) a third difference between the third hitch force and a third reference hitch force.

[0007] In further features, a reference hitch forces module is configured to set the first reference hitch force, the second reference hitch force, and the third reference hitch force based on a steering angle of the vehicle.

[0008] In further features, the actuator control module is configured to determine the target vertical forces further based on a yaw rate of the vehicle.

[0009] In further features, the actuator control module is configured to determine the target vertical forces based on minimizing a difference between the yaw rate and a reference yaw rate.

[0010] In further features, a reference yaw rate module is configured to set the reference yaw rate based on a steering angle of the vehicle.

[0011] In further features, the reference yaw rate module is configured to set the reference yaw rate further based on a vehicle speed.

[0012] In further features: a front left electric motor is configured to output torque to the front left wheel of the vehicle; a front right electric motor is configured to output torque to the front right wheel of the vehicle; a rear left electric motor is configured to output torque to the rear left wheel of the vehicle; a rear right electric motor is configured to output torque to the rear right wheel of the vehicle; and a wheel control module is configured to: based on the first hitch force, the second hitch force, and the third hitch force, determine target torque outputs of the front left electric motor, the front right electric motor, the rear left electric motor, and the rear right electric motor, respectively; and selectively adjust the front left electric motor, the front right electric motor, the rear left electric motor, and the rear right electric motor based on the target torque outputs, respectively.

[0013] In further features, the wheel control module is configured to determine the target torque outputs further based on the target vertical forces.

[0014] In further features, the actuator control module is configured to determine the target vertical forces further based on the target torque outputs.

[0015] In further features: a front electric motor is configured to output torque to front wheels of the vehicle; a rear electric motor is configured to output torque to rear wheels of the vehicle; and a wheel control module is configured to: based on the hitch angle, determine target torque outputs of the front and rear electric motors, respectively; and selectively adjust the front and rear electric motors based on the target torque outputs, respectively.

[0016] In further features: an electric motor is configured to output torque two or more wheels of the vehicle; and a wheel control module is configured to: based on the hitch angle, determine a target torque of the electric motor; and selectively adjust the electric motor based on the target torque.

[0017] In a feature, a trailer sway control method for a vehicle includes: based on (a) a first hitch force at a trailer hitch of the vehicle in a longitudinal direction, (b) a second hitch force at the trailer hitch of the vehicle in a lateral direction, and (c) a third hitch force at the trailer hitch of the vehicle in a vertical direction, determining target vertical forces for a front left active suspension actuator, a front right active suspension actuator, a rear left active suspension actuator, and a rear right active suspension actuator, respectively, the front right active suspension actuator associated with a front right wheel of the vehicle, the front left active suspension actuator associated with a front left wheel of the vehicle, the rear left active suspension actuator associated with a rear left wheel of the vehicle, and the rear right active suspension actuator associated with a rear right wheel of the

vehicle; and selectively adjusting the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator based on the target vertical forces, respectively.

[0018] In further features, determining the target vertical forces includes determining the target vertical forces based on minimizing (a) a first difference between the first hitch force and a first reference hitch force, (b) a second difference between the second hitch force and a second reference hitch force, and (c) a third difference between the third hitch force and a third reference hitch force.

[0019] In further features, the method further includes setting the first reference hitch force, the second reference hitch force, and the third reference hitch force based on a steering angle of the vehicle.

[0020] In further features, determining the target vertical forces includes determining the target vertical forces further based on a yaw rate of the vehicle.

[0021] In further features, determining the target vertical forces includes determining the target vertical forces based on minimizing a difference between the yaw rate and a reference yaw rate.

[0022] In further features, the method further includes setting the reference yaw rate based on a steering angle of the vehicle.

[0023] In further features, setting the reference yaw rate includes setting the reference yaw rate further based on a vehicle speed.

[0024] In further features, the method further includes: based on the hitch angle, determining a target torque of an electric motor configured to output torque two or more wheels of the vehicle; and selectively adjust the electric motor based on the target torque.

[0025] Further areas of applicability of the present disclosure will become apparent from the detailed description, the claims and the drawings. The detailed description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0027] FIG. 1 is top view of a model including a vehicle and a trailer;

[0028] FIG. 2 is a side view of an example model of the trailer including various parameters;

[0029] FIG. 3 is a functional block diagram of example components of the vehicle;

[0030] FIGS. 4-9 are functional block diagrams of example implementations of a trailer sway control system; and

[0031] FIG. 10 is a flowchart depicting an example method of controlling one or more vehicle actuators based on hitch forces of the trailer.

[0032] In the drawings, reference numbers may be reused to identify similar and/or identical elements.

DETAILED DESCRIPTION

[0033] Vehicles may be used to tow trailers. A vehicle may include one or more trailer sway mitigation modules that

selectively adjust one or more operating parameters of the vehicle to decrease sway of a trailer when swaying occurs.

[0034] The present application involves control of at least one of suspension actuators of the vehicle and wheel torques of the vehicle based on a one or more hitch forces at the hitch where the trailer is hitched to the vehicle. The hitch forces include a force in a longitudinal direction of the trailer, a lateral direction of the trailer, and a vertical direction. The control enhances cornering stability of a vehicle towing a trailer and minimizes sway of the trailer.

[0035] FIG. 1 is top view of a model including a vehicle 100 and a trailer 104. CoG represents the center of gravity of a body. Longitudinal axes of the vehicle 100 and the trailer 104 are illustrated by 108 and 112, respectively. The trailer 104 is hitched to the vehicle 100 at trailer hitch 116. A hitch angle θ represents the angle between the longitudinal axes of the vehicle 100 and the trailer 104 (between 108 and 112). A hitch force in a longitudinal direction of the trailer 104 is expressed as $F_{x,t}$. A hitch force in a lateral direction of the trailer 104 is expressed as $F_{y,t}$.

[0036] The vehicle 100 includes front right and left wheels 120 and 124, respectively. The vehicle 100 also includes rear right and left wheels 128 and 132, respectively. The front wheels 120 and 124 are turnable left and right to enable vehicle turning. In various vehicles, the rear wheels 128 and 132 may also be turnable left and right or may be fixed parallel to the longitudinal axis 108 of the vehicle 100. The trailer 104 includes two or more wheels, such as illustrated. Parameters of the trailer 104 are denoted with a subscript t. FIG. 2 is a side view of an example model of the trailer 104 including various parameters. A hitch force in a vertical direction of the trailer 104 is expressed as $F_{z,t}$.

[0037] FIG. 3 is a functional block diagram of example components of the vehicle 100. As discussed above, the vehicle 100 includes the front right and left wheels 120 and 124 and the rear right and left wheels 128 and 132. The vehicle 100 may include additional wheels, such as in the example of dual rear wheel vehicles.

[0038] A front right (FR) suspension actuator 304 is an active suspension actuator and damps vertical motion near a FR corner of the vehicle 100, such as at the front right wheel 120. A front left (FL) suspension actuator 308 is an active suspension actuator and damps vertical motion near a FL corner of the vehicle 100, such as at the front left wheel 124. A rear right (RR) suspension actuator 312 is an active suspension actuator and damps vertical motion near a RR corner of the vehicle 100, such as at the rear right wheel 128. A rear left (RL) suspension actuator 316 is an active suspension actuator and damps vertical motion near a RL corner of the vehicle 100, such as at the rear left wheel 132. An actuator control module 320 controls damping forces ($F_{s,FR}$, $F_{s,FL}$, $F_{s,RR}$, $F_{s,RL}$) of the suspension actuators 304, 308, 312, and 316, respectively, based on at least one of the hitch forces ($F_{x,t}$, $F_{y,t}$, $F_{z,t}$), as discussed further below. The actuator control module 320 may control, for example, a pressure of a hydraulic fluid within one or more portions of a suspension actuator, control electric power (e.g., voltage, current) applied to a suspension actuator, or control the damping force of the suspension actuator in another suitable manner.

[0039] The vehicle 100 includes one or more torque producing devices that output torque to two or more of the wheels 120-132. For example, the vehicle 100 may include a FR electric motor 324 that outputs torque to the FR wheel

120 and a FL electric motor 328 that outputs torque to the FL wheel 124. The vehicle 100 may also include a RR electric motor 332 that outputs torque to the RR wheel 128 and a RL electric motor 336 that outputs torque to the RL wheel 132. Other motor configurations are also possible, such as one electric motor that outputs torque to the front wheels 120 and 124 and/or one electric motor that outputs torque to the rear wheels 128 and 132. Electric motors can also apply negative torque to slow/brake the vehicle 100. The vehicle 100 also includes friction brakes at each wheel that can be applied to slow that wheel. A wheel control module 340 controls the torque at each wheel. For example, the wheel control module 340 may control the torque at a wheel via controlling an electric motor and/or controlling application of the friction brake at that wheel. Additionally or alternatively to the actuator control module 320 controlling the damping forces based on the hitch force(s), the wheel control module 340 may control the torques ($\tau_{m,FR}$, $\tau_{m,FL}$, $\tau_{m,RR}$, $\tau_{m,RL}$) at the wheels, respectively, based on the hitch force(s).

[0040] The vehicle 100 includes various sensors and other input devices collectively illustrated by 344. Examples of sensors include but are not limited to an accelerator pedal position (APP) sensor, a brake pedal position (BPP) sensor, and other types of sensors. Examples of other types of input devices include, for example, cameras, radar sensors, ultrasonic sensors, and other types of sensors. As an example of a camera, a rear backup camera may be included. Images from the rear backup camera may be used to determine the hitch angle of the trailer 104. In various implementations, the hitch angle may be determined, measured, or estimated in another suitable manner.

[0041] FIG. 4 is a functional block diagram of an example implementation of a trailer sway control system. A target torque module 404 determines a target torque ($\tau_{m,tot,d}$) based on one or more driver inputs and the hitch forces of the trailer 104. The target torque module 404 may determine the target wheel torque, for example, using one or more equations and/or lookup tables that relate the driver inputs and the hitch forces to target torques. The driver inputs may include, for example, the APP measured using the APP sensor and the BPP measured using the BPP sensor.

[0042] A reference yaw rate module 408 determines a reference (target) yaw rate of the vehicle based on one or more inputs, such as steering angle δ , vehicle speed V , and tire-road coefficient of friction μ . The reference yaw rate module 408 may determine the reference yaw rate using one or more equations and/or lookup tables that relate steering angles, vehicle speeds, and coefficients to reference yaw rates. The steering angle may be determined, for example, based on measurements from a steering wheel angle (SWA) sensor, such as using one or more lookup tables or equations that relate SWAs to steering angles. The vehicle speed may be measured or estimated using one or more sensors. For example, the vehicle speed may be set based on one or more wheel speeds measured using one or more wheel speed sensors, respectively. The tire-road coefficient of friction may be determined, for example, based on wheel slip. The reference yaw rate module 408 may filter the reference yaw rate before use, such as using a first order transfer function or another suitable filter. In various implementations, the vehicle speed and tire-road coefficient of friction may not be used, and the reference yaw rate module 408 may determine

the reference yaw rate based on the steering angle. Further example detail is provided below.

[0043] A reference hitch forces module 412 determines reference (target) hitch forces. The reference hitch forces module 412 may determine the reference hitch forces based on the steering angle and one or more other parameters. The reference hitch forces module 412 may determine the reference hitch forces using one or more equations and/or lookup tables that relate the steering angle and the other parameter(s) to reference hitch forces. Further example detail is provided below.

[0044] A constraints module 416 determines one or more constraints (or limits). The constraints may be fixed predetermined values or may be variable. In the example of variables, the constraints module 416 may set one or more of the constraints based on one or more operating parameters of the vehicle 100 and/or the trailer 104.

[0045] The actuator control module 320 determines the damping forces for the suspension actuators 304-316, respectively, based on the target torque, (present) hitch forces, the reference yaw rate, the reference hitch forces, and the constraints. The actuator control module 320 may determine the damping forces further based on a present yaw rate of the vehicle 100. The present yaw rate of the vehicle 100 may be, for example, measured using a yaw rate sensor (of the sensors 344). The actuator control module 320 may determine the damping forces using one or more equations and/or lookup tables that relate target torques, reference yaw rates, yaw rates, reference hitch forces, hitch forces, and constraints to damping forces. The actuator control module 320 may determine the damping forces to minimize the difference (error) between the yaw rate and the reference yaw rate and to minimize the difference (error) between the hitch forces and the reference hitch forces. In other words, the actuator control module 320 may determine the damping forces to adjust the yaw rate toward or to the reference yaw rate and adjust the hitch forces toward or to the reference hitch forces.

[0046] The actuator control module 320 controls the suspension actuators 304-316 to achieve the damping forces, respectively. The actuator control module 320 may control, for example, hydraulic pressure and/or power applied to the suspension actuators 304-416.

[0047] In various implementations, the actuator control module 320 may initiate controlling the damping forces based on the hitch forces when the yaw rate is different than the target yaw rate by at least a predetermined amount. In various implementations, the actuator control module 320 may continuously control the damping forces based on the hitch forces, even when the yaw rate is within the predetermined amount of the target yaw rate.

[0048] In various implementations, the actuator control module 320 may set the damping forces using model predictive control (MPC), such as a nonlinear model predictive control (NMPC).

[0049] FIG. 5 is a functional block diagram of an example control system. As illustrated in FIG. 5, the wheel control module 340 may determine the torques ($\tau_{m,FR}$, $\tau_{m,FL}$, $\tau_{m,RR}$, $\tau_{m,RL}$) at the wheels, respectively, based on the target torque, (present) hitch forces, the reference yaw rate, the reference hitch forces, and the constraints. The wheel control module 340 may determine the torques further based on the present yaw rate of the vehicle 100. The wheel control module 340 may determine the torques using one or more equations

and/or lookup tables that relate target torques, reference yaw rates, yaw rates, reference hitch forces, hitch forces, and constraints to wheel torques. The wheel control module **340** may determine the torques to minimize the difference (error) between the yaw rate and the reference yaw rate and to minimize the difference (error) between the hitch forces and the reference hitch forces. In other words, the wheel control module **340** may determine the torques to adjust the yaw rate toward or to the reference yaw rate and adjust the hitch forces toward or to the reference hitch forces.

[0050] The wheel control module **340** controls the motors **324-336** to achieve the torques, respectively. The wheel control module **340** may for example control the power applied to the electric motors **324-336** based on the torques, respectively. The wheel control module **340** may additionally control application of the friction brakes of the wheels based on the torques, respectively. While the example of one motor per wheel is provided, the present application is also applicable to one electric motor for the front axle and one electric motor for the rear axle and to only one electric motor for the front or rear axle. In various implementations, an internal combustion engine may be included, and the wheel control module **340** may additionally or alternatively control torque output of the internal combustion engine based on the torques. In various implementations, the wheel control module **340** may additionally or alternatively control one or more differentials based on the torques.

[0051] In various implementations, the wheel control module **340** may initiate controlling the torques based on the hitch forces when the yaw rate is different than the target yaw rate by at least a predetermined amount. In various implementations, the wheel control module **340** may continuously control the torques based on the hitch forces, even when the yaw rate is within the predetermined amount of the target yaw rate.

[0052] In various implementations, the actuator control module **320** and the wheel control module **340** may share parameters. For example, the actuator control module **320** may set the damping forces at the wheels based on the torques, respectively, at the wheels. As another example, the wheel control module **340** may set the torques at the wheels based on the damping forces, respectively, at the wheels.

[0053] In various implementations, the wheel control module **340** may set the torques using MPC control, such as NMPC control. An example implementation of NMPC control of the wheel torques is discussed further below. An example implementation of NMPC control of the damping forces and the wheel torques is also discussed further below. In various implementations, the wheel control module **340** and the actuator control module **320** may be implemented together within a control module, such as illustrated in FIG. 5.

[0054] The driver inputs may be assumed to be constant along the NMPC prediction horizon. The driver inputs may include the steering angle θ_{sw} , the accelerator pedal position APP, and the brake pedal position or force BPP. Other inputs that may be fixed along the prediction horizon are: i) the towing vehicle **100** longitudinal and lateral accelerations, a , and y that may be used to determine the load transfers (e.g., by the actuator control module); ii) a baseline front-to-total anti-roll moment distribution for; control parameters, e.g., constraints, weights, flags, etc.; iv) the trailer **104** longitudinal and lateral accelerations (which may be estimated) $\alpha_{x,t}$ and $\alpha_{y,t}$. Control of the vehicle yaw rate and hitch force

dynamics adopts the reference variables that define the steady-state cornering condition of the vehicle, for the given driver inputs.

[0055] The steady-state reference yaw rate of the vehicle-trailer system $\dot{\psi}_{ref}$ is configured to match a steady-state cornering response of the passive rigid vehicle. $\dot{\psi}_{ref}$ may be stored as nonlinear map (e.g., lookup table), and the reference yaw rate may be determined as function of steering angle δ , vehicle speed V , and tire-road friction coefficient μ . The output of the map (lookup table) may be filtered by the reference yaw rate module **408**, such as using a first order transfer function. The dynamic instability of the vehicle-trailer system may be detected by the control module when the actual yaw rate differs from the reference yaw rate by at least a predetermined amount. The map may be based on, for example, a nonlinear quasi-static or dynamic vehicle models and minimize additional key performance criteria such as tire slip power losses or total power losses. In various implementations, the reference yaw rate may be determined by the reference yaw rate module **408** based only on the steering angle.

[0056] The reference yaw rate may target the control of the vehicle cornering behavior, but may also account for the trailer presence. In various implementations example, the reference yaw rate module **408** may apply a band pass filter that outputs signals within a predetermined frequency band that are indicative of actual trailer sway. The predetermined frequency band may be, for example, 0.5 Hertz (Hz) to 1.5 Hz or another suitable frequency band. In various implementations, the control module may blend the yaw rate and hitch forces reference contributions when the trailer dynamics when one or more differences between ones of the hitch forces and respective reference hitch forces is/are greater than a predetermined value. The hitch forces may be measured using a sensor or estimated. In various implementations, the hitch forces may be determined by a hitch forces module **420** based on one or more measured operating parameters of the vehicle **100** and parameters of the trailer **104**, for example, using one or more lookup tables and/or equations.

[0057] Vehicle roll stability may be preserved by the control module during steering maneuvers by controlling the actuators **304-316** and/or the motors **316-336** to adjust a roll angle toward or to a target roll angle of the sprung masses. The target roll angle may be a predetermined value, such as 1 degree for a lateral acceleration of 5 m/s² or another suitable value. In various implementations, the control module may control the actuators **304-316** and/or the motors **316-336** to adjust a rollover prevention index RI which depends on roll dynamics and lateral acceleration to less than a predetermined value, such as 0.8 or another suitable value.

[0058] Despite being an additional reference state for the vehicle-semitrailer stability, roll angle may not be considered among the target variables in various implementations. Details of various parameters are illustrated in FIGS. 1 and 2.

[0059] FIGS. 6-9 include functional block diagrams of example implementations of the system of FIG. 4. FIG. 6 includes an example active suspension (AS) configuration. FIGS. 7-9 include example AS plus dynamic yaw control (DYC) configurations. The control inputs for the AS configuration (FIG. 6) are a front-to-total anti-roll moment distribution variation, Δf , of the active suspension system,

with respect to a predetermined nominal value. In the example of FIG. 7, in addition to the inputs of FIG. 6, the four torques on each wheel are used as control inputs. The control inputs in this example are Δf , $\tau_{m,FL}$, $\tau_{m,FR}$, $\tau_{m,RL}$, and $\tau_{m,RR}$. In the example of FIG. 8, the standalone AS and DYC for the articulated vehicle run in parallel sharing or not sharing the output control actions with each other. The control inputs for this example are Δf , $\tau_{m,FL}$, $\tau_{m,FR}$, $\tau_{m,RL}$, and $\tau_{m,RR}$. In the example of FIG. 9, the standalone AS for articulated vehicle and the standalone DYC for the isolated vehicle run in parallel sharing or not sharing the output control actions with each other. The control inputs for this example are Δf , $\tau_{m,FL}$, $\tau_{m,FR}$, $\tau_{m,RL}$, and $\tau_{m,RR}$.

[0060] In the formulations herein, the subscript i, with i=F,R indicates the axle, whereas the subscript j, with j=L,R, indicates the vehicle side. The notation ‘(·)’ indicates a time derivative, while ‘(·)’ indicates a second order time derivative. The subscript ‘t’ indicates forces applied to the vehicle according to the directions of the trailer reference frame. Other variables are the sideslip angle at the CoG, β ; the vehicle speed, V; and the hitch angle θ , namely the angle between the longitudinal axes of the trailer and the towing vehicle.

[0061] The proposed controller internal model, namely the model used by NMPC model of the control module for predicting the system response along the prediction horizon may be based on the following assumptions: motion is planar, and thus the road bank and inclination angles are negligible; heave, roll and pitch dynamics are disregarded; powertrain and braking torque on each corner is known in a first approximation; lateral and longitudinal displacements of the center of gravity caused by the roll and pitch motions are neglected;

[0062] The vehicle model used to determine the target forces for the suspension actuators may have 7 degrees of freedom, such as described by equations (1)-(4). FIGS. 1 and 2 illustrate states and parameters in accordance with their positive sign conventions.

[0063] Longitudinal force balance may be described by the equation:

$$m[\dot{v}_x - \dot{\psi}v_y] = \sum_{j=L,R} [F_{x,Fj} \cos(\delta) - F_{y,Fj} \sin(\delta)] + \sum_{j=L,R} F_{x,Rj} - F_{drag} \quad (1)$$

[0064] Lateral force balance may be described by the equation:

$$m[\dot{v}_y + \dot{\psi}v_x] = \sum_{j=L,R} [F_{x,Fj} \sin(\delta) + F_{y,Fj} \cos(\delta)] + \sum_{j=L,R} F_{y,Rj} + F_y^{j2c} \quad (2)$$

[0065] Yaw moment balance may be described by the equation:

$$J_z \ddot{\psi} = l_F [F_{x,FL} \sin(\delta) + F_{y,FL} \cos(\delta) + F_{x,FR} \sin(\delta) + F_{y,FR} \cos(\delta)] - l_R [F_{x,RL} + F_{y,RR}] - \frac{l_F}{2} [F_{x,RL} + F_{x,RR}] - \frac{l_F}{2} [F_{x,FL} \cos(\delta) -$$

-continued

$$F_{x,FR} \cos(\delta)] + \frac{l_F}{2} [F_{y,FL} \sin(\delta) - F_{y,FR} \sin(\delta)] + cF_y^{j2c} + \sum_{\substack{j=L,R \\ i=F,R}} M_{z,ij}$$

[0066] Moment balance for a wheel ij may be described by the equation

$$J_{w,i} \ddot{\theta} = \tau_{m,ij} - \tau_{b,ij} - R_{i,ij} F_{x,ij} - M_{y,ij} \quad (4)$$

[0067] In equations (1)-(4), m is the towing vehicle mass, v_x is the component of the velocity vector at the center of gravity along the longitudinal axis of the vehicle reference system, v_y is the component of the velocity vector at the center of gravity along the lateral axis of the vehicle reference system; $\dot{\psi}$ is the vehicle yaw rate, $F_{x,ij}$ is the longitudinal force of the ij-th tire/wheel, $F_{y,ij}$ is the lateral force of the ij-th wheel, F_x^{j2c} , F_y^{j2c} , F_z^{j2c} are the hitch joint force components along the longitudinal, lateral and vertical axes of the reference system of the vehicle, respectively, δ is an (e.g., average) steering angle of the front wheels. F_{drag} is an aerodynamic drag force, J_z is the yaw mass moment of inertia of the car, $M_{z,ij}$ is a self-alignment moment of the ij-th wheel, l_F and l_R are the front and rear wheelbases of the vehicle, t_F and t_R are the front and rear track widths, c is the distance of the hitch joint to the CoG of the car. $J_{w,i}^{eq}$ is the equivalent mass moment of inertia of the front wheels, which may be approximated as equal to the polar inertia, $\tau_{m,ij}$ are the wheel motor/powertrain torques, and $\tau_{b,ij}$ are the wheel braking torques. In this example, the Magic Formula (e.g., version 2002 or another nonlinear tire model) may be used to determine the rolling radius, laden radius, rolling resistance, longitudinal force, lateral force, and self-aligning moment of the tires, namely $R_{e,ij}$, $R_{l,ij}$, $M_{y,ij}$, $F_{x,ij}$, $F_{y,ij}$ and $M_{z,ij}$, as functions of the tire slip angle α_{ij} , longitudinal slip ratio $\sigma_{x,i,j}$, vertical load $F_{z,ij}$ which is expressed as a function of F_x^{j2c} , F_y^{j2c} , F_z^{j2c} , F_z^{j2c} , the longitudinal load transfer and the lateral load transfer, including the anti-roll moment contribution due to the active suspension actuation. Alternative formulations can be used in the example of a semi-active suspension system. The vertical loads may be expressed as:

$$\begin{aligned} F_{z,Fj} &= \frac{1}{2} F_z^{stat} + \frac{1}{2} \Delta F_{z,F}^x + k_1 \Delta F_{z,F}^y \\ F_{z,Rj} &= \frac{1}{2} F_z^{stat} + \frac{1}{2} \Delta F_{z,R}^x + k_1 \Delta F_{z,R}^y \\ F_{z,F}^{stat} &= \frac{mg l_R}{l} + F_z^{j2c,stat} \frac{c - l_R}{l} \\ F_{z,R}^{stat} &= \frac{mg l_F}{l} - F_z^{j2c,stat} \frac{c + l_F}{l} \\ \Delta F_{z,F}^x &= -ma_x \frac{H_{CoG}}{l} + F_x^{j2c} \frac{H_{Hitch}}{l} + \Delta F_{z,t}^x \frac{c - l_R}{l} \\ \Delta F_{z,R}^x &= ma_x \frac{H_{CoG}}{l} - F_x^{j2c} \frac{H_{Hitch}}{l} - \Delta F_{z,t}^x \frac{c + l_F}{l} \\ \Delta F_{z,F}^y &= ma_x \frac{H_{CoG}}{l} - F_x^{j2c} \frac{H_{Hitch}}{l} - \Delta F_{z,t}^y \frac{c + l_F}{l} \\ \Delta F_{z,R}^y &= -ma_x \frac{H_{CoG}}{l} + F_x^{j2c} \frac{H_{Hitch}}{l} + \Delta F_{z,t}^y \frac{c - l_R}{l} \\ \Delta F_{z,f}^y &= \left[ma_y \frac{l_R}{l} + F_y^{j2c} \frac{c - l_R}{l} \right] \frac{H_{RC}}{d_F} + \frac{M_{AR,F}^{tot}}{d_F} \\ \Delta F_{z,R}^y &= \left[ma_y \frac{l_F}{l} - F_y^{j2c} \frac{c + l_F}{l} \right] \frac{H_{RC}}{d_R} + \frac{M_{AR,R}^{tot}}{d_R} \end{aligned} \quad (5)$$

where H_{CoG} is the height of the CoG, H_{RC} is the roll axis height at the longitudinal coordinate of the CoG, $F_z^{j2c,stat}$ is a static contribution of the vertical component of the hitch joint force, and ΔF_z^x is the longitudinal load transfer contribution of the vertical component of the hitch joint force due to the trailer longitudinal acceleration. In this example, the total active suspension anti-roll moment on the front and rear axles, $M_{AR,F}^{tot}$ and $M_{AR,R}^{tot}$, may be determined using the equations:

$$\begin{aligned} M_{AR,F}^{tot} &= M_{AR,F}^{passive} + M_{AR,F}^{AS} \\ M_{AR,R}^{tot} &= M_{AR,R}^{passive} + M_{AR,R}^{AS} \end{aligned} \quad (6)$$

where the passive vehicle anti-roll moment on the i -th axle, $M_{AR,i}^{passive}$, and the active suspension anti-roll moments $M_{AR,F}$ include the hitch joint force components contributions, and may be determined using the equations:

$$\begin{aligned} M_{AR,F}^{passive} &= \frac{K_{\phi,F}}{K_{\phi,F} + K_{\phi,R}} \left([1 - K_{comp}] m_{a_y} [H_{CoG} - H_{RC}] - F_y^{j2c} [H_{Hitch} - H_{RC}] \right) \\ M_{AR,R}^{passive} &= \frac{K_{\phi,R}}{K_{\phi,F} + K_{\phi,R}} \left([1 - K_{comp}] m_{a_y} [H_{CoG} - H_{RC}] - F_y^{j2c} [H_{Hitch} - H_{RC}] \right) \\ M_{AR,F}^{AS} &= K_{comp} f m_{a_y} [H_{CoG} - H_{RC}] \\ M_{AR,R}^{AS} &= K_{comp} [1 - f] m_{a_y} [H_{CoG} - H_{RC}] \end{aligned}$$

where $K_{\phi,i}$ is the roll stiffness of the considered axle, K_{comp} is a factor expressing the level of roll angle compensation of the active suspension actuation, and $f = f_{AR,0} + \Delta f$ is the controllable front-to-total anti-roll moment distribution. The total active suspension anti-roll moment may have different formulations, depending on the control implementation.

[0068] Suspension stiffness and damping characteristic may be known predetermined values. The total passive anti-roll moment may depend on the roll dynamics of the rigid vehicle and may be determined by the control module using the equations:

$$\begin{aligned} M_{AR,\phi,i}^{passive} &= K_{\phi,i} \dot{\phi} \\ M_{AR,\phi,i}^{passive} &= K_{\phi,i} \phi \end{aligned} \quad (8)$$

where ϕ is the roll angle, $\dot{\phi}$ is the roll rate, $K_{\phi,i}$ is a roll damping coefficient, $M_{AR,\phi,i}^{passive}$ is the anti-roll moment due to the passive suspension roll stiffness, and $M_{AR,\phi,i}^{passive}$ is the anti-roll moment due to passive suspension roll damping properties.

[0069] This example may involve extension of the internal model to the equations of motion by an additional degree of freedom, namely a roll dynamics contribution:

$$\begin{aligned} I_x \ddot{\phi} &= m_{a_y} [H_{CoG} - H_{RC}] \cos(\phi) + m_g [H_{CoG} - H_{RC}] \sin(\phi) - \\ &M_{AR,\phi,F}^{passive} - M_{AR,\phi,R}^{passive} - M_{AR,\phi,F}^{passive} - M_{AR,\phi,R}^{passive} - M_{AR,F}^{AS} - M_{AR,R}^{AS} + \\ &\frac{m_t g l_{tF}}{l_t} [H_{Hitch} - H_{RC}] \sin(\phi) + F_y^{j2c} [H_{Hitch} - H_{RC}] \cos(\phi) \end{aligned} \quad (9)$$

where m_t is the mass of the trailer, l_{tF} is the hitch joint to trailer CoG distance, $\alpha_{y,t}$ and $\alpha_{x,t}$ are the acceleration components of the trailer, and F_y^{j2c} depends on the trailer acceleration components, trailer parameters, and trailer hitch

angle. The roll dynamics may be disregarded, so sensing devices on the trailer may not be included, such as to measure θ , $\alpha_{y,t}$ and $\alpha_{x,t}$.

[0070] The longitudinal and lateral slips $\sigma_{x,i,j}$ and α_{ij} may be determined by the control module using the equations:

$$\alpha_{ij} = \tan^{-1} \left(\frac{v_y \pm \dot{\psi} l_i}{v_x \mp \frac{d_i}{2} \dot{\psi}} \right) - k_2 \delta \quad \begin{cases} k_2 = 1 & \text{if } i = F \\ k_2 = 0 & \text{if } i = R \end{cases} \quad (10)$$

$$\sigma_{x,ij} = \frac{\omega_{ij} R_{e,ij} - v_{x,ij}}{v_{x,ij}} \quad (11)$$

where $v_{x,ij}$ is the longitudinal component of the peripheral wheel speed.

[0071] The prediction model could have different formulations. For example, the prediction model may not involve wheel dynamics.

[0072] In various implementations, the hitch force module 420 may determine hitch joint force components (or hitch forces) based on the following assumptions: the yaw and pitch acceleration of the trailer 104 are disregarded; and the longitudinal and lateral accelerations of the trailer $\alpha_{x,t}$ and $\alpha_{y,t}$ are approximated by the hitch force module 420 based on the acceleration components of the vehicle 100.

[0073] FIGS. 1 and 2 show the orientation of the hitch joint force components together with the sign conventions for the trailer variables. The longitudinal component $F_{x,t}^{j2c}$ is determined by the hitch force module 420 based on the longitudinal forces balance, such as using the equation:

$$F_{x,t}^{j2c} = -m_t \alpha_{x,t} \approx -m_t \alpha_x \quad (12)$$

where m_t is the mass of the trailer 104. Considering the example of FIG. 1, the rotation balance with respect to the CoG of the trailer axle may be used by the hitch force module 420 to determine the latitudinal force, such as using the equation:

$$F_{y,t}^{j2c} = -\frac{m_t a_{y,t} l_{tR}}{l_t} \approx -\frac{m_t a_y l_{tR}}{l_t} \quad (13)$$

where l_{tR} is the trailer CoG to the trailer axle distance, and l_t is the hitch joint to trailer axle distance. $F_{x,t}^{j2c}$ and $F_{y,t}^{j2c}$ may be transposed by the hitch force module 420 into the towing vehicle coordinate system and defined as:

$$F_x^{j2c} = -m_t a_x \cos(\theta_{kin}) - \frac{m_t a_y l_{tR}}{l_t} \sin(\theta_{kin}) \quad (14)$$

$$F_y^{j2c} = m_t a_x \sin(\theta_{kin}) - \frac{m_t a_y l_{tR}}{l_t} \cos(\theta_{kin}) \quad (15)$$

where θ_{kin} is the kinematic hitch angle, the hitch angle in absence of slip angles. An example equation describing the evolution of the kinematic hitch angle for a given vehicle speed is:

$$\theta_{kin} = \tan^{-1} \left(\frac{\tan(\delta) [l^2 l_t + [c - l_R] \sqrt{\tan(\delta)^2 l^2 [c - l_R]^2 - \tan(\delta)^2 l^2 l_t^2 + l^4}]}{l [-\tan(\delta)^2 l_t [c - l_R] + \sqrt{\tan(\delta)^2 l^2 [c - l_R]^2 - \tan(\delta)^2 l^2 l_t^2 + l^4}]} \right) \quad (16)$$

[0074] Alternative formulations for computing hitch angle may be based on its value in quasi-steady-state cornering conditions, such as mapped in look-up tables as functions of steering angle, vehicle speed, and tire-road friction coefficient. Alternatively, a state observer including the trailer dynamics may be used to determine the hitch angle.

[0075] Considering the example in FIG. 2, the rotation balance with respect to the CoG of the trailer axle can be used to determine the vertical hitch force by the hitch force module 420, such as using the equation:

$$F_{z,t}^{j2c} = F_{z,t}^{j2c,stat} + \Delta F_{z,t}^x = -\frac{m_t g l_{R,t}}{l_t} + \frac{m_t a_{x,t} [H_{CoG,t} - H_{Hitch}]}{l_t} \cong -\frac{m_t g l_{R,t}}{l_t} + \frac{m_t a_x [H_{CoG,t} - H_{Hitch}]}{l_t} \quad (17)$$

$F_{z,t}^{j2c}$ assumes the same value when transposed to the towing car coordinate system.

[0076] The NMPC model may be expressed by the following continuous formulation

$$\dot{x}(t) = f(x(t), u(t)) \quad (18)$$

where the state vector for the articulated vehicle model and the state vector for the rigid vehicle model x is:

$$x = [v_x, v_y, \dot{\psi}, \omega_{FL}, \omega_{FR}, \omega_{RL}, \omega_{RR}] \quad (19)$$

and the control vector u of the control module is:

$$u = [\Delta f, \tau_{m,FL}, \tau_{m,FR}, \tau_{m,RL}, \tau_{m,RR}] \quad (20)$$

[0077] In example of the roll dynamics being included in the NMPC model formulation, the following state vector may be considered:

$$x_\phi = [v_x, v_y, \dot{\psi}, \omega_{FL}, \omega_{FR}, \omega_{RL}, \omega_{RR}] \quad (21)$$

[0078] The NMPC control law may minimize a cost function J , subject to equality and inequality constraints. The nonlinear optimal control problem may be defined in discrete time as:

$$\min_u J(x(0), u(\cdot) := \ell_N(x(N)) + \sum_{k=0}^{N-1} \ell(x(k), u(k)) \quad (22)$$

s.t.

$$x(0) = x_{in}$$

$$x(k+1) = f_a(x(k), u(k))$$

$$\underline{x} \leq x(k) \leq \bar{x}$$

$$\underline{x} \leq x(N) \leq \bar{x}$$

$$\underline{u} \leq u(k) \leq \bar{u}$$

$$u(\cdot) \in [0, N-1]$$

where $\ell_N(x(N))$ is a terminal cost, N is the number of steps of the prediction horizon H_p (e.g., equal to the control

horizon H_c , i.e. $H_p = H_c = N T_s$ with T_s being the sampling time, but could be a different value), k indicates the discretization step, $\underline{x}$ and $\bar{x}$ are the lower and upper limits for x , $\underline{u}$ and $\bar{u}$ are the lower and upper limits for u , $x(k+1) = f_a(x(k), u(k))$ is a discretized model defined in equation (18). The stage cost functions may be defined as a least-squares functions and are given by equation (23) for configurations with the articulated and the isolated vehicle model, respectively.

$$\ell(x(k), u(k)) = W_{Q,\Delta\psi} \Delta\dot{\psi}^2 + W_{Q,\Delta\varphi} \Delta\varphi^2 + \quad (24)$$

$$W_{Q,\Delta\tau_{m,tot}} \Delta\tau_{m,tot}^2 + W_{R,\tau_{m,ij}} \sum \tau_{m,ij}^2 + W_{R,\Delta f} \Delta f^2 + W_{R,s_{\alpha_R}} s_{\alpha_R}^2$$

where $W_{Q,\dot{\psi}}$, $W_{Q,\Delta\varphi}$, $W_{Q,\Delta\tau_{m,tot}}$ and $W_{Q,\theta}$ are the cost function weights, respectively, tracking of the rigid vehicle reference yaw rate of the rigid vehicle roll angle, of the torque demand (target) or of the articulation hitch angle,

$$W_{R,s_{\alpha_R}}$$

is a weighting coefficient referred to as a rear tire slip angle slack variable, $W_{R,\tau_{m,ij}}$ and $W_{R,\Delta f}$ are the cost function weights referred to as available actuators. The contributions in equation (23) are based on:

$$\Delta\dot{\psi} = \dot{\psi}_{ref} - \dot{\psi}, \text{ the yaw rate tracking error;}$$

$$\Delta\varphi = \varphi_{ref} - \varphi,$$

[0079] $\Delta\varphi = \varphi_{ref} - \varphi$, roll angle tracking error and rollover index (RI) minimization, respectively.

Alternatively, rollover prevention may be accounted for by adding a soft constraint on the rollover index through a slack variable, $RI \leq RI^{max}(1 + s_{RI})$, where $s_{RI} \geq 0$ is the slack variable. In the following application, the contribution of tracking the roll angle error may be disregarded.

[0080] $\Delta\tau_{m,tot}$ is a torque demand tracking error at the vehicle level between the driver demands and a reference total torque. Slack variables may be used to set the soft constraints.

[0081] The following state and control action bounds have been implemented in equation 22 as constraints (lower and upper limits):

[0082] Wheel torque constraints, i.e. $\underline{\tau}_m \leq \tau_{m,ij} \leq \bar{\tau}_m$, where $\underline{\tau}_m$ and $\bar{\tau}_m$ are the predetermined minimum and maximum values of the wheel torques, used to generate the direct yaw moment control action, in addition to the total traction or braking torques;

[0083] The front-to-total anti-roll moment distribution deviation constraint, $\underline{\Delta f} \leq \Delta f \leq \bar{\Delta f}$, where $\underline{\Delta f}$ and $\bar{\Delta f}$ are predetermined minimum and maximum anti-roll front-to-total moment distribution deviations from a nominal value;

[0084] Rear tire slip angle constraint to account for vehicle lateral stability, $|\alpha_R| \leq \alpha_R^{max}(1 + s_{\alpha_R})$, where $s_{\alpha_R} \geq 0$ is the slack variable; and α_R^{max} is the maximum admissible tire slip angle, for example, $\alpha_R^{max} = 3$ degrees or another suitable value.

[0085] Further constraints are possible, such as to prevent the activation of a stability controller. Constraints on the front slip angle of the vehicle, on the vehicle sideslip angle,

and on the tire slip ratios of the vehicle may additionally or alternatively be implemented.

[0086] FIG. 6 shows the schematics of a standalone AS implementation. Here, the driver inputs are APP, BPP and δ_{in} . Θ represents the vehicle operational parameters measured by sensors and received via a network bus of the vehicle. The driver inputs are converted into the reference yaw rate and torque demand, which together with the reference hitch forces and the actuator physical constraints, are conveyed to the control module as constant inputs in the prediction horizon. In various implementations, NMPC (nonlinear model predictive control) may be used by the control module. The NMPC includes a nonlinear optimal control problem, where the inputs undergo a nonlinear internal model to define the optimal control actions along the prediction horizon. The control actions are defined by minimizing the constrained objective function. The final outputs are the forces of the actuators 304-316 on each corner of the vehicle.

[0087] FIG. 7 is an example of an NMPC AS-DYC implementation, where DYC is a torque-vectoring actuation strategy involving control of the electric motors 324-336. Here, physical constraints of the motors are an additional input with respect to the standalone AS implementation of FIG. 6. Moreover, the final outputs of the nonlinear optimal control problem of the example of FIG. 7 are the vertical forces for the actuators 304-316 and the wheel torques for the electric motors 324-336.

[0088] Parallel or independent control of the actuators 304-316 and the wheel torques for the electric motors 324-336 may be performed. For example, an NMPC AS//DYC implementation with and without communication between the actuator and wheel control modules is illustrated in FIG. 8. In this example, a standalone AS NMPC implementation (e.g., FIG. 6) with an articulated vehicle internal model runs in parallel to a NMPC DYC implementation with an internal model formulation resembling NMPC AS, namely with the hitch angle dynamics to account for the trailer, represented by equations 19-21 and 23. The two subsystems (actuator and motor controls) run independently either sharing the information of their respective control actions which are taken into account as additional inputs by the other (with communication) or without sharing the information of their respective control actions with each other.

[0089] FIG. 9 includes an example NMPC AS//Standard DYC implementation with and without communication between the actuator and motor controls, where a standalone AS NMPC implementation (e.g., FIG. 6) with an articulated vehicle internal model in parallel to a standard NMPC DYC implementation with a rigid vehicle internal model, calibrated for an isolated vehicle. Here, the same communication options may be enabled or disabled. In FIGS. 8 and 9, where the switches A and B enable or disable the communication between the two controls running in parallel.

[0090] The NMPC can be implemented on a software environment for automatic control and dynamic optimization. The following may be used: Gauss Newton Hessian approximation, multiple shooting discretization, a qpOASES solver, a number of optimization steps may be set equal to 2, a discretization time of the internal models may be set to 5 ms (this may ensures their numerical stability without significantly affecting the computational time), for the integrator types and orders 2nd order Implicit Runge Kutta

(IRK-GL2) for the controls based on the articulated vehicle and 4th order Implicit Runge Kutta (IRK-GL4) for DYC based on the rigid vehicle model, sampling time for each articulated vehicle model may be 35 ms (milliseconds), while the sampling time for DYC implementation may be 15 ms. Example implementation settings are summarized in the following table with measured variables coming from the vehicle.

TABLE I

Example of Implemented Control Module Settings			
Actuation	Integrator	t_d (ms)	t_{sa} (ms)
AS	IRK-GL4	5	15
AS-DYC	IRK-GL4	5	15
AS//DYC	IRK-GL4	5	15
AS//Standard DYC	IRK-GL4	5	15

[0091] Testing proved that these parametrizations are a good compromise between performance and computational efficiency. The present application involves use of active suspension system on the towing vehicle to limit the trailer sway with, for example, a nonlinear model predictive control (NMPC) on an articulated vehicle model that includes the trailer parameters and dynamics. Additionally, the present application involves use of the active suspension and direct yaw control on the towing vehicle to preserve the articulated vehicle stability and to limit the trailer sway with nonlinear model predictive control coordination based on an articulated vehicle model which includes the trailer parameters and dynamics. Additionally, the present application involves use of active suspension and direct yaw moment control coordination with two parallel NMPC configuration based on an articulated vehicle model (or isolated vehicle model for the case of the Standard DYC) as an alternative in preserving the articulated vehicle stability and to limit the trailer sway.

[0092] The control described herein stabilizes the vehicle-trailer system as opposed to the passive vehicle. The active suspension control NMPC AS effectively tracks the towing vehicle reference yaw rate and tracks and limits the hitch force errors (differences between the hitch forces and reference hitch forces, respectively) and the trailer roll angle. AS plus DYC implementation can further improve the yaw and hitch damping capability relative to only AS control. Moreover, the trailer roll angle is further limited.

[0093] FIG. 10 is a flowchart depicting an example method of controlling one or more vehicle actuators based on hitch forces. Control begins with 1004 where the driver inputs, the hitch forces, and other vehicle operating parameters are received.

[0094] At 1008, the reference yaw rate module 408 determines the reference yaw rate based on the steering angle, the vehicle speed, and the tire-road coefficient of friction. The reference hitch forces module 412 also determines the reference hitch forces at 1012. At 1012, the target torque module 404 determines the target torque based on the driver inputs and the hitch forces.

[0095] At 1016, the actuator control module 320 determines target forces for the suspension actuators 304-316, respectively, based on the hitch forces, the reference hitch forces, the target torque, the reference yaw rate, and the yaw rate, such as using NMPC control. The actuator control module 320 may set the target forces, for example, to

minimize the difference (error) between the hitch forces and the reference hitch forces and to minimize the difference (error) between the yaw rate and the reference yaw rate.

[0096] Also at 1016, the wheel control module 340 may determine target torques for the motors 324-336, respectively, based on the hitch forces, the reference hitch forces, the target torque, the reference yaw rate, and the yaw rate, such as using NMPC control. The wheel control module 340 may set the target torques, for example, to minimize the difference (error) between the hitch forces and the reference hitch forces and to minimize the difference (error) between the yaw rate and the reference yaw rate. In various implementations, the wheel control module 340 may determine the target torques based on the target forces and/or determine the target forces based on the target torques.

[0097] At 1020, the actuator control module 320 controls the suspension actuators 304-316 to achieve the target (vertical) forces, respectively. The actuator control module 320 may, for example, apply power or hydraulic fluid to the suspension actuators 304-326 based on the target forces, respectively. The wheel control module 340 may also apply power to the electric motors 328-336 to achieve the target torques, respectively. Control returns to 1004 for a next control loop.

[0098] The foregoing description is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. The broad teachings of the disclosure can be implemented in a variety of forms. Therefore, while this disclosure includes particular examples, the true scope of the disclosure should not be so limited since other modifications will become apparent upon a study of the drawings, the specification, and the following claims. It should be understood that one or more steps within a method may be executed in different order (or concurrently) without altering the principles of the present disclosure. Further, although each of the embodiments is described above as having certain features, any one or more of those features described with respect to any embodiment of the disclosure can be implemented in and/or combined with features of any of the other embodiments, even if that combination is not explicitly described. In other words, the described embodiments are not mutually exclusive, and permutations of one or more embodiments with one another remain within the scope of this disclosure.

[0099] Spatial and functional relationships between elements (for example, between modules, circuit elements, semiconductor layers, etc.) are described using various terms, including “connected,” “engaged,” “coupled,” “adjacent,” “next to,” “on top of,” “above,” “below,” and “disposed.” Unless explicitly described as being “direct,” when a relationship between first and second elements is described in the above disclosure, that relationship can be a direct relationship where no other intervening elements are present between the first and second elements, but can also be an indirect relationship where one or more intervening elements are present (either spatially or functionally) between the first and second elements. As used herein, the phrase at least one of A, B, and C should be construed to mean a logical (A OR B OR C), using a non-exclusive logical OR, and should not be construed to mean “at least one of A, at least one of B, and at least one of C.”

[0100] In the figures, the direction of an arrow, as indicated by the arrowhead, generally demonstrates the flow of information (such as data or instructions) that is of interest

to the illustration. For example, when element A and element B exchange a variety of information but information transmitted from element A to element B is relevant to the illustration, the arrow may point from element A to element B. This unidirectional arrow does not imply that no other information is transmitted from element B to element A. Further, for information sent from element A to element B, element B may send requests for, or receipt acknowledgements of, the information to element A.

[0101] In this application, including the definitions below, the term “module” or the term “controller” may be replaced with the term “circuit.” The term “module” may refer to, be part of, or include: an Application Specific Integrated Circuit (ASIC); a digital, analog, or mixed analog/digital discrete circuit; a digital, analog, or mixed analog/digital integrated circuit; a combinational logic circuit; a field programmable gate array (FPGA); a processor circuit (shared, dedicated, or group) that executes code; a memory circuit (shared, dedicated, or group) that stores code executed by the processor circuit; other suitable hardware components that provide the described functionality; or a combination of some or all of the above, such as in a system-on-chip.

[0102] The module may include one or more interface circuits. In some examples, the interface circuits may include wired or wireless interfaces that are connected to a local area network (LAN), the Internet, a wide area network (WAN), or combinations thereof. The functionality of any given module of the present disclosure may be distributed among multiple modules that are connected via interface circuits. For example, multiple modules may allow load balancing. In a further example, a server (also known as remote, or cloud) module may accomplish some functionality on behalf of a client module.

[0103] The term code, as used above, may include software, firmware, and/or microcode, and may refer to programs, routines, functions, classes, data structures, and/or objects. The term shared processor circuit encompasses a single processor circuit that executes some or all code from multiple modules. The term group processor circuit encompasses a processor circuit that, in combination with additional processor circuits, executes some or all code from one or more modules. References to multiple processor circuits encompass multiple processor circuits on discrete dies, multiple processor circuits on a single die, multiple cores of a single processor circuit, multiple threads of a single processor circuit, or a combination of the above. The term shared memory circuit encompasses a single memory circuit that stores some or all code from multiple modules. The term group memory circuit encompasses a memory circuit that, in combination with additional memories, stores some or all code from one or more modules.

[0104] The term memory circuit is a subset of the term computer-readable medium. The term computer-readable medium, as used herein, does not encompass transitory electrical or electromagnetic signals propagating through a medium (such as on a carrier wave); the term computer-readable medium may therefore be considered tangible and non-transitory. Non-limiting examples of a non-transitory, tangible computer-readable medium are nonvolatile memory circuits (such as a flash memory circuit, an erasable programmable read-only memory circuit, or a mask read-only memory circuit), volatile memory circuits (such as a static random access memory circuit or a dynamic random access memory circuit), magnetic storage media (such as an

analog or digital magnetic tape or a hard disk drive), and optical storage media (such as a CD, a DVD, or a Blu-ray Disc).

[0105] The apparatuses and methods described in this application may be partially or fully implemented by a special purpose computer created by configuring a general purpose computer to execute one or more particular functions embodied in computer programs. The functional blocks, flowchart components, and other elements described above serve as software specifications, which can be translated into the computer programs by the routine work of a skilled technician or programmer.

[0106] The computer programs include processor-executable instructions that are stored on at least one non-transitory, tangible computer-readable medium. The computer programs may also include or rely on stored data. The computer programs may encompass a basic input/output system (BIOS) that interacts with hardware of the special purpose computer, device drivers that interact with particular devices of the special purpose computer, one or more operating systems, user applications, background services, background applications, etc.

[0107] The computer programs may include: (i) descriptive text to be parsed, such as HTML (hypertext markup language), XML (extensible markup language), or JSON (JavaScript Object Notation) (ii) assembly code, (iii) object code generated from source code by a compiler, (iv) source code for execution by an interpreter, (v) source code for compilation and execution by a just-in-time compiler, etc. As examples only, source code may be written using syntax from languages including C, C++, C #, Objective-C, Swift, Haskell, Go, SQL, R, Lisp, Java®, Fortran, Perl, Pascal, Curl, OCaml, Javascript®, HTML5 (Hypertext Markup Language 5th revision), Ada, ASP (Active Server Pages), PHP (PHP: Hypertext Preprocessor), Scala, Eiffel, Smalltalk, Erlang, Ruby, Flash®, Visual Basic®, Lua, MATLAB, SIMULINK, and Python®.

What is claimed is:

1. A trailer sway control system for a vehicle, comprising:
 - a front left active suspension actuator associated with a front left wheel of the vehicle;
 - a front right active suspension actuator associated with a front right wheel of the vehicle;
 - a rear left active suspension actuator associated with a rear left wheel of the vehicle;
 - a rear right active suspension actuator associated with a rear right wheel of the vehicle; and
 - an actuator control module configured to:
 - based on (a) a first hitch force at a trailer hitch of the vehicle in a longitudinal direction, (b) a second hitch force at the trailer hitch of the vehicle in a lateral direction, and (c) a third hitch force at the trailer hitch of the vehicle in a vertical direction, determine target vertical forces for the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator, respectively; and
 - selectively adjust the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator based on the target vertical forces, respectively.

2. The trailer sway control system of claim 1 wherein the actuator control module is configured to determine the target vertical forces based on minimizing (a) a first difference between the first hitch force and a first reference hitch force, (b) a second difference between the second hitch force and a second reference hitch force, and (c) a third difference between the third hitch force and a third reference hitch force.

3. The trailer sway control system of claim 2 further comprising a reference hitch forces module configured to set the first reference hitch force, the second reference hitch force, and the third reference hitch force based on a steering angle of the vehicle.

4. The trailer sway control system of claim 1 wherein the actuator control module is configured to determine the target vertical forces further based on a yaw rate of the vehicle.

5. The trailer sway control system of claim 4 wherein the actuator control module is configured to determine the target vertical forces based on minimizing a difference between the yaw rate and a reference yaw rate.

6. The trailer sway control system of claim 5 further comprising a reference yaw rate module configured to set the reference yaw rate based on a steering angle of the vehicle.

7. The trailer sway control system of claim 6 wherein the reference yaw rate module is configured to set the reference yaw rate further based on a vehicle speed.

8. The trailer sway control system of claim 1 further comprising:

- a front left electric motor configured to output torque to the front left wheel of the vehicle;
- a front right electric motor configured to output torque to the front right wheel of the vehicle;
- a rear left electric motor configured to output torque to the rear left wheel of the vehicle;
- a rear right electric motor configured to output torque to the rear right wheel of the vehicle; and
- a wheel control module configured to:

- based on the first hitch force, the second hitch force, and the third hitch force, determine target torque outputs of the front left electric motor, the front right electric motor, the rear left electric motor, and the rear right electric motor, respectively; and
- selectively adjust the front left electric motor, the front right electric motor, the rear left electric motor, and the rear right electric motor based on the target torque outputs, respectively.

9. The trailer sway control system of claim 8 wherein the wheel control module is configured to determine the target torque outputs further based on the target vertical forces.

10. The trailer sway control system of claim 8 wherein the actuator control module is configured to determine the target vertical forces further based on the target torque outputs.

11. The trailer sway control system of claim 1 further comprising:

- a front electric motor configured to output torque to front wheels of the vehicle;
- a rear electric motor configured to output torque to front wheels of the vehicle; and
- a wheel control module configured to:
 - based on the hitch angle, determine target torque outputs of the front and rear electric motors, respectively; and

selectively adjust the front and rear electric motors based on the target torque outputs, respectively.

12. The trailer sway control system of claim **1** further comprising:

an electric motor configured to output torque two or more wheels of the vehicle; and

a wheel control module configured to:

based on the hitch angle, determine a target torque of the electric motor; and

selectively adjust the electric motor based on the target torque.

13. A trailer sway control method for a vehicle, comprising:

based on (a) a first hitch force at a trailer hitch of the vehicle in a longitudinal direction, (b) a second hitch force at the trailer hitch of the vehicle in a lateral direction, and (c) a third hitch force at the trailer hitch of the vehicle in a vertical direction, determining target vertical forces for a front left active suspension actuator, a front right active suspension actuator, a rear left active suspension actuator, and a rear right active suspension actuator, respectively,

the front right active suspension actuator associated with a front right wheel of the vehicle, the front left active suspension actuator associated with a front left wheel of the vehicle, the rear left active suspension actuator associated with a rear left wheel of the vehicle, and the rear right active suspension actuator associated with a rear right wheel of the vehicle; and

selectively adjusting the front left active suspension actuator, the front right active suspension actuator, the rear left active suspension actuator, and the rear right active suspension actuator based on the target vertical forces, respectively.

14. The trailer sway control method of claim **13** wherein determining the target vertical forces includes determining the target vertical forces based on minimizing (a) a first difference between the first hitch force and a first reference hitch force, (b) a second difference between the second hitch force and a second reference hitch force, and (c) a third difference between the third hitch force and a third reference hitch force.

15. The trailer sway control method of claim **14** further comprising setting the first reference hitch force, the second reference hitch force, and the third reference hitch force based on a steering angle of the vehicle.

16. The trailer sway control method of claim **13** wherein determining the target vertical forces includes determining the target vertical forces further based on a yaw rate of the vehicle.

17. The trailer sway control method of claim **16** wherein determining the target vertical forces includes determining the target vertical forces based on minimizing a difference between the yaw rate and a reference yaw rate.

18. The trailer sway control method of claim **17** further comprising setting the reference yaw rate based on a steering angle of the vehicle.

19. The trailer sway control method of claim **18** wherein setting the reference yaw rate includes setting the reference yaw rate further based on a vehicle speed.

20. The trailer sway control method of claim **13** further comprising:

based on the hitch angle, determining a target torque of an electric motor configured to output torque two or more wheels of the vehicle; and

selectively adjust the electric motor based on the target torque.

* * * * *



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(12) **United States Patent**
Wagner

(10) **Patent No.:** **US 12,280,746 B1**
(45) **Date of Patent:** **Apr. 22, 2025**

- (54) **MINIMAL LIFT BIKE CARRIER** 5,899,655 A * 5/1999 Miller B60P 3/122 414/537
- (71) Applicant: **SPECIALTY REC LLC**, Bloomington, MN (US) 9,039,263 B2 5/2015 Hofmann
9,321,388 B2 4/2016 Barnett
10,315,584 B2 * 6/2019 Kuhlbach B60L 50/20
11,383,652 B1 * 7/2022 Huang B60R 9/10
- (72) Inventor: **Reed B. Wagner**, Bloomington, MN (US) 2003/0062707 A1 4/2003 Koch
2004/0191037 A1 9/2004 Potts
2007/0001431 A1 1/2007 Fiorini
2008/0067209 A1 * 3/2008 Gunn B60R 9/10 224/504
- (73) Assignee: **SPECIALTY REC LLC**, Bloomington, MN (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 64 days. 2008/0085176 A1 4/2008 Statkus
2016/0068111 A1 3/2016 Walker
2019/0023190 A1 * 1/2019 Breen B60R 9/10

FOREIGN PATENT DOCUMENTS

- (21) Appl. No.: **18/082,299** WO WO 2018/057756 A1 3/2018
- (22) Filed: **Dec. 15, 2022** * cited by examiner
- Related U.S. Application Data**
- (60) Provisional application No. 63/290,896, filed on Dec. 17, 2021. *Primary Examiner* — Scott T McNurlen
(74) *Attorney, Agent, or Firm* — Muetting Raasch Group

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B60R 9/06 (2006.01)
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- (58) **Field of Classification Search**
CPC B60R 9/10; Y10S 224/924
USPC 224/924
See application file for complete search history.

(56) **References Cited**

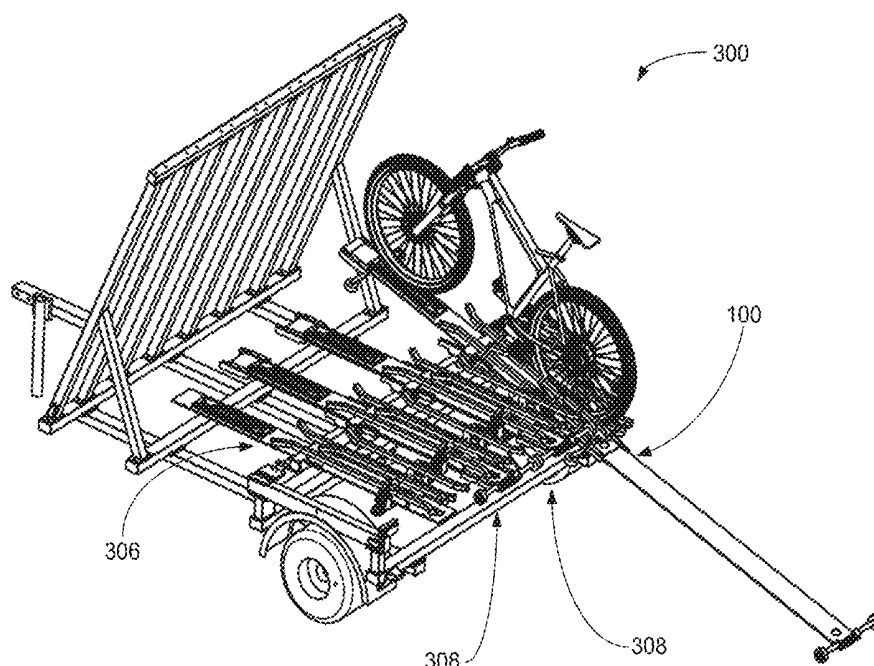
U.S. PATENT DOCUMENTS

- 3,843,001 A * 10/1974 Willis B60R 9/10 224/924
4,524,893 A * 6/1985 Cole B60R 9/10 211/5

(57) **ABSTRACT**

A carrier for supporting and transporting a recreational vehicle (e.g., bicycle, tricycle, quadracycle, or trailer) with minimal or no lifting. The carrier includes a support configured to receive and contact tires of the vehicle. The carrier also includes a ramp configured to move relative to the support and slides within one or more slots of the support. The carrier pivots relative to a pivot mount assembly such that the vehicle can be easily moved from a ground surface to the carrier and then pivoted to a generally horizontal position. The ramp acting as a lock for pivoting the carrier by restricting pivoting when slid within the one or more slots of the support and allowing pivoting when the ramp is extended from the support.

12 Claims, 26 Drawing Sheets



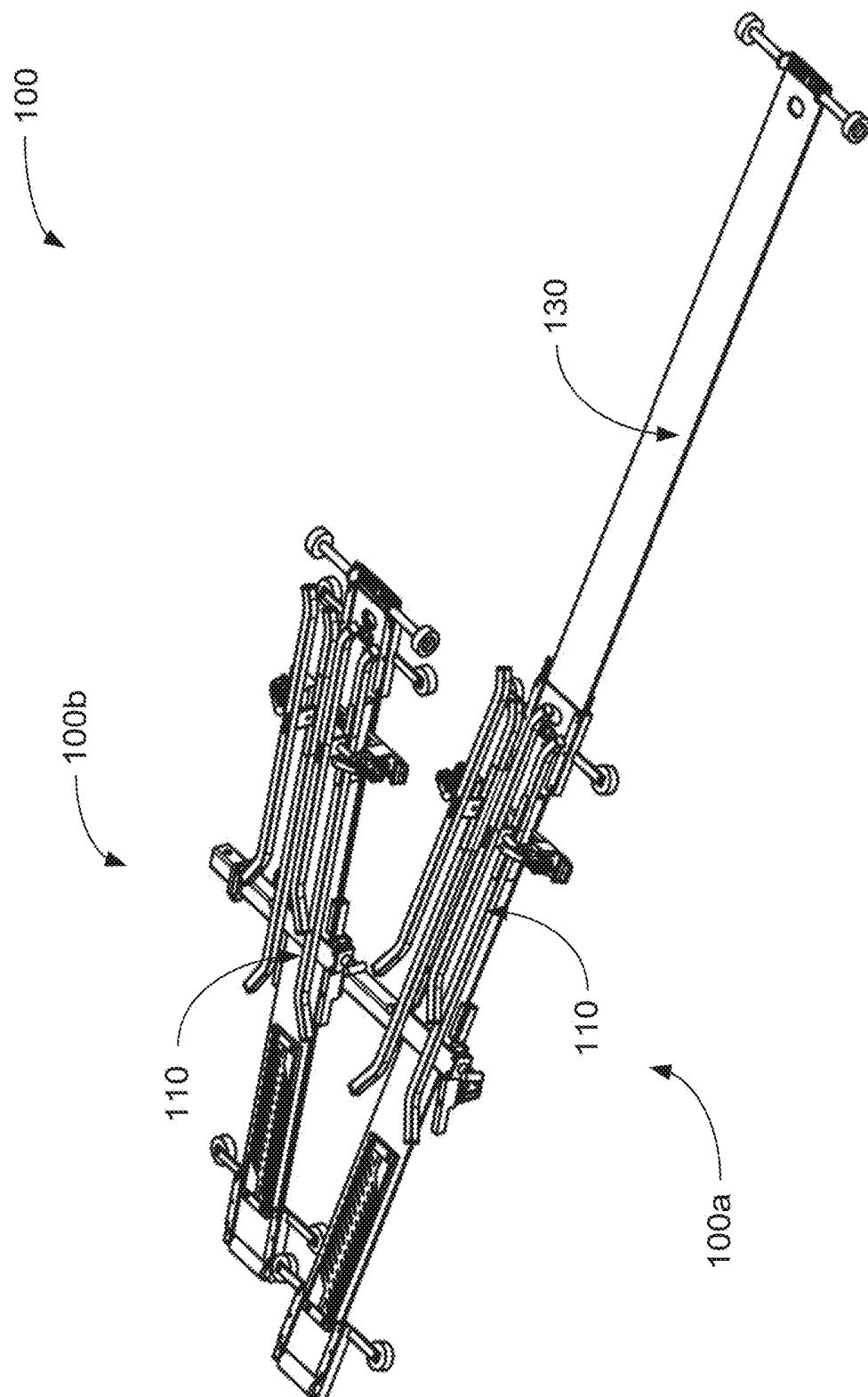
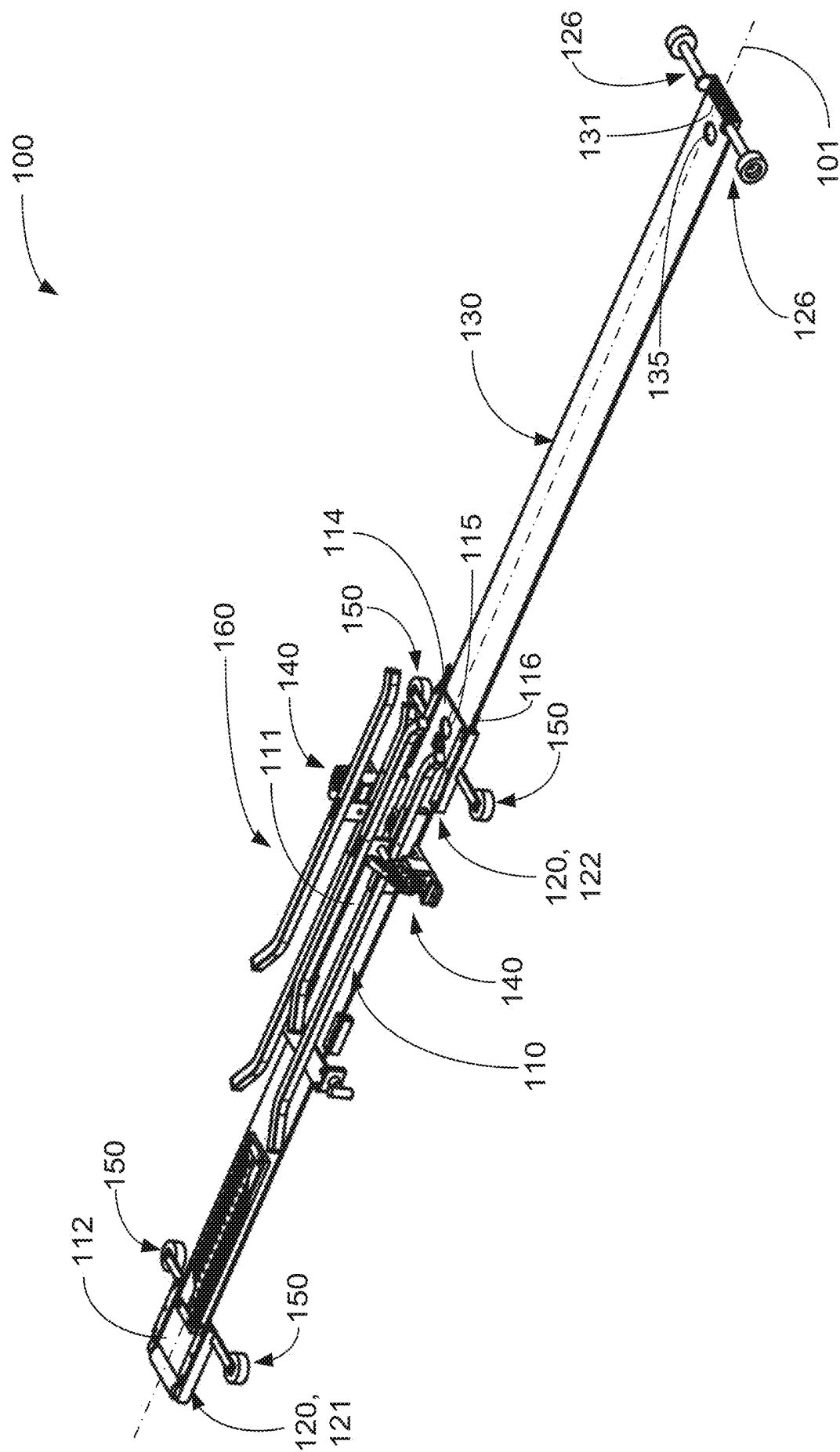


FIG. 1



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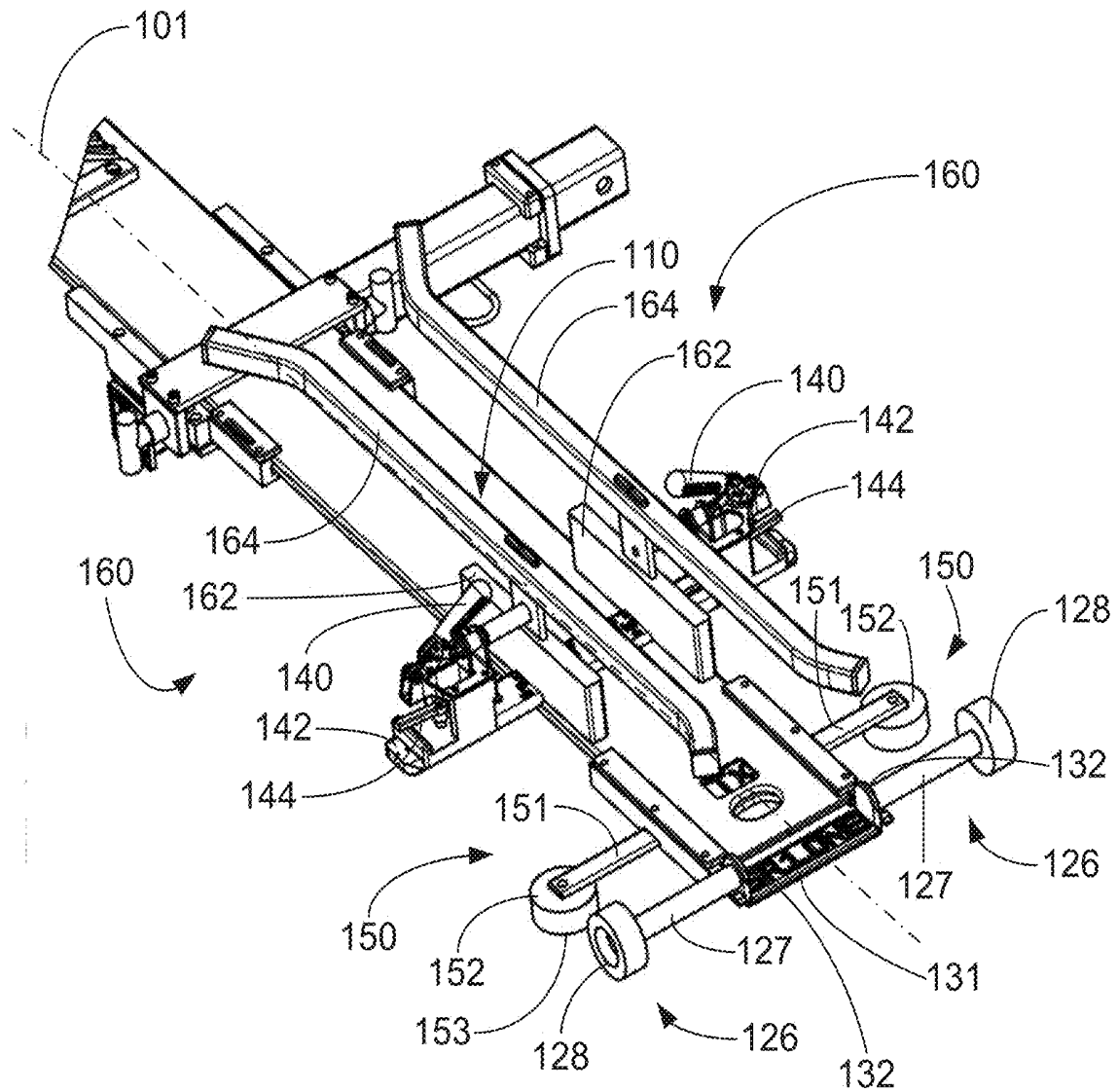


FIG. 3

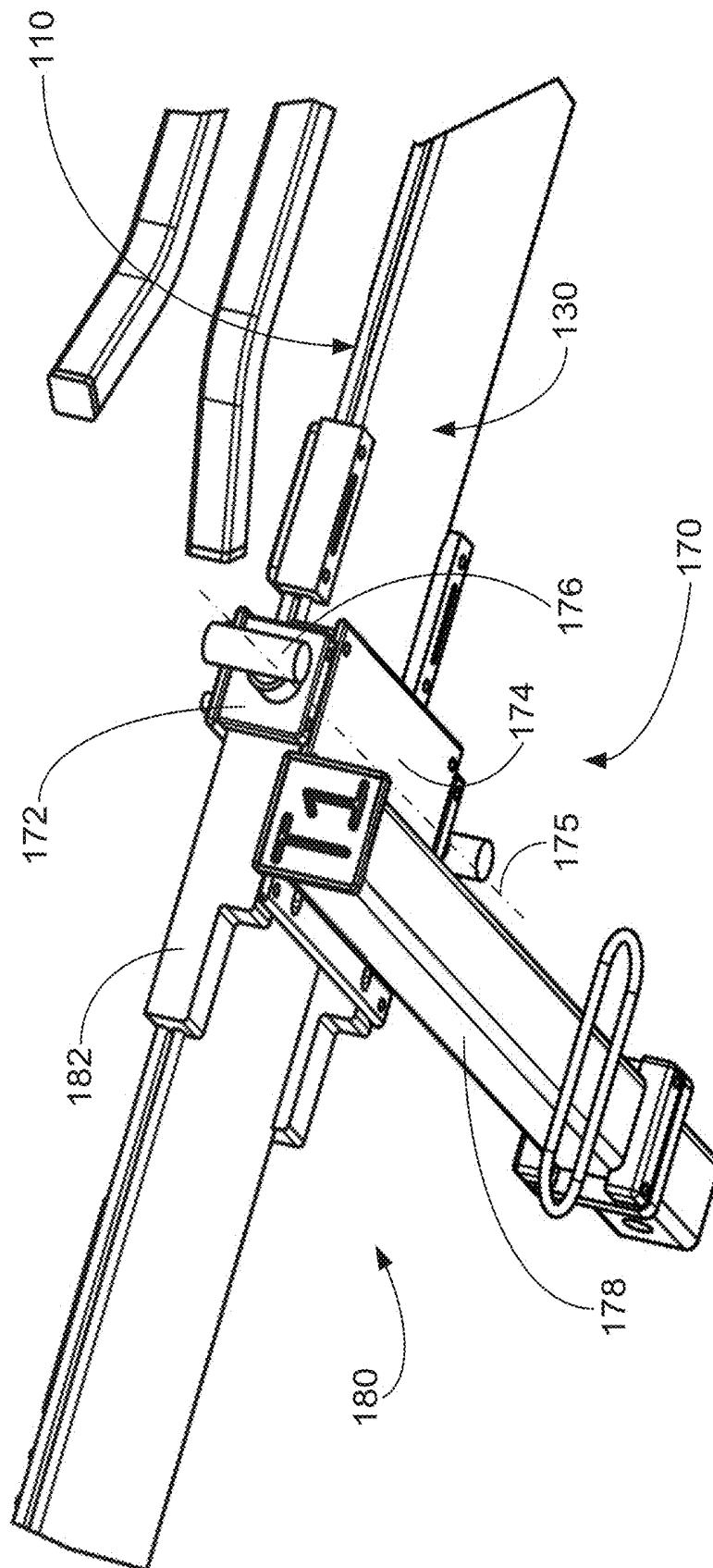


FIG. 4

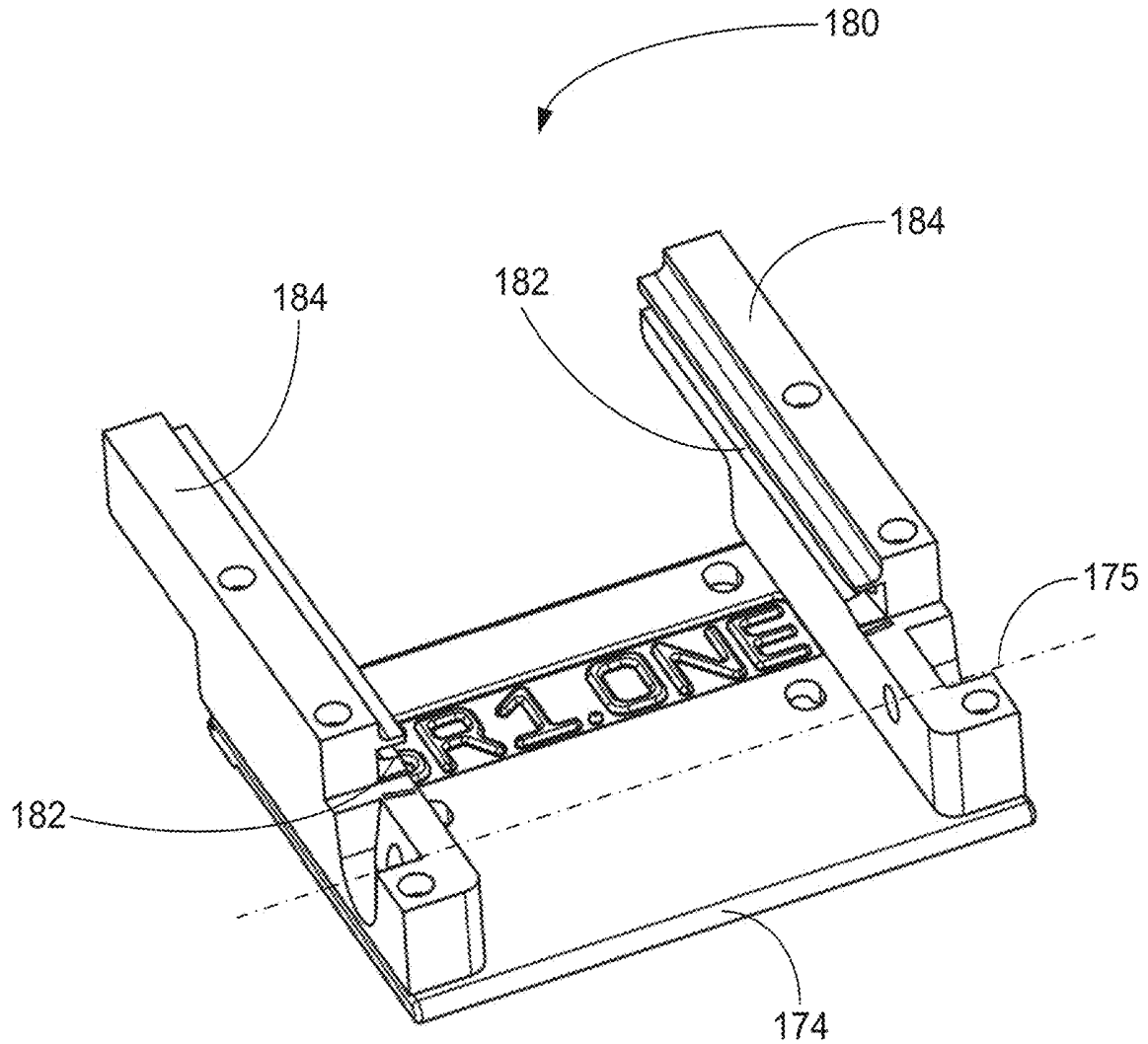


FIG. 5

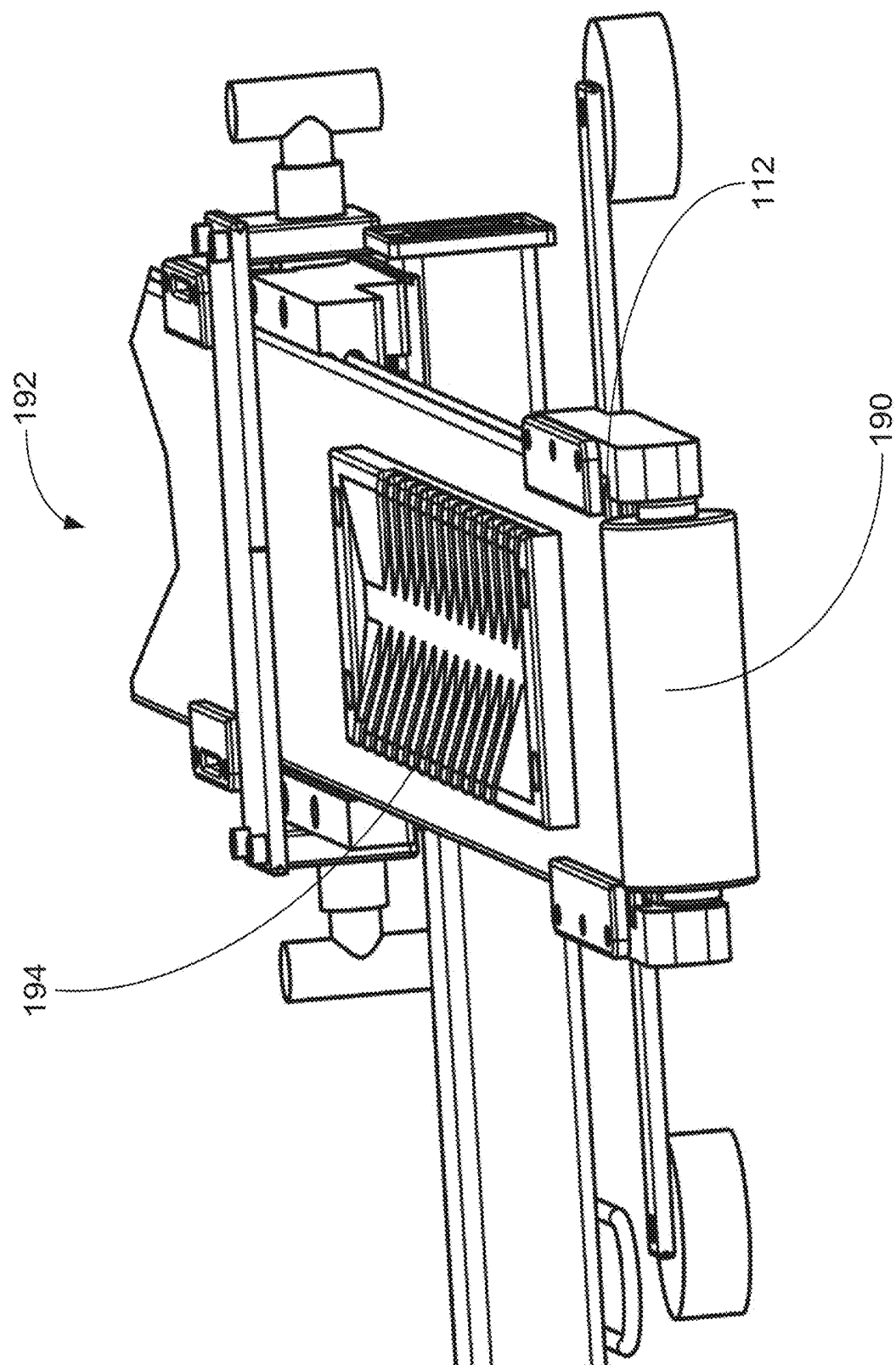


FIG. 6

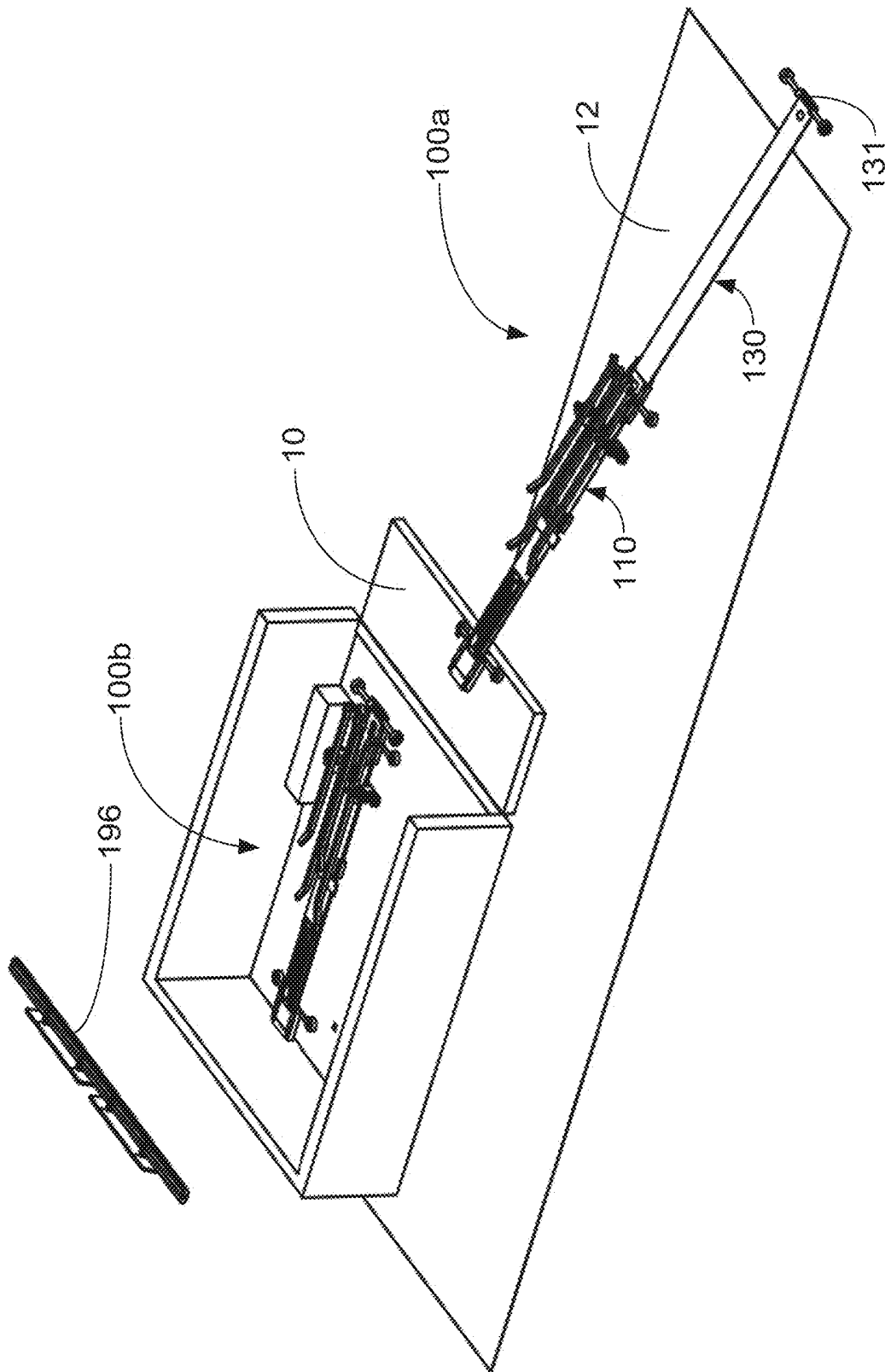


FIG. 7

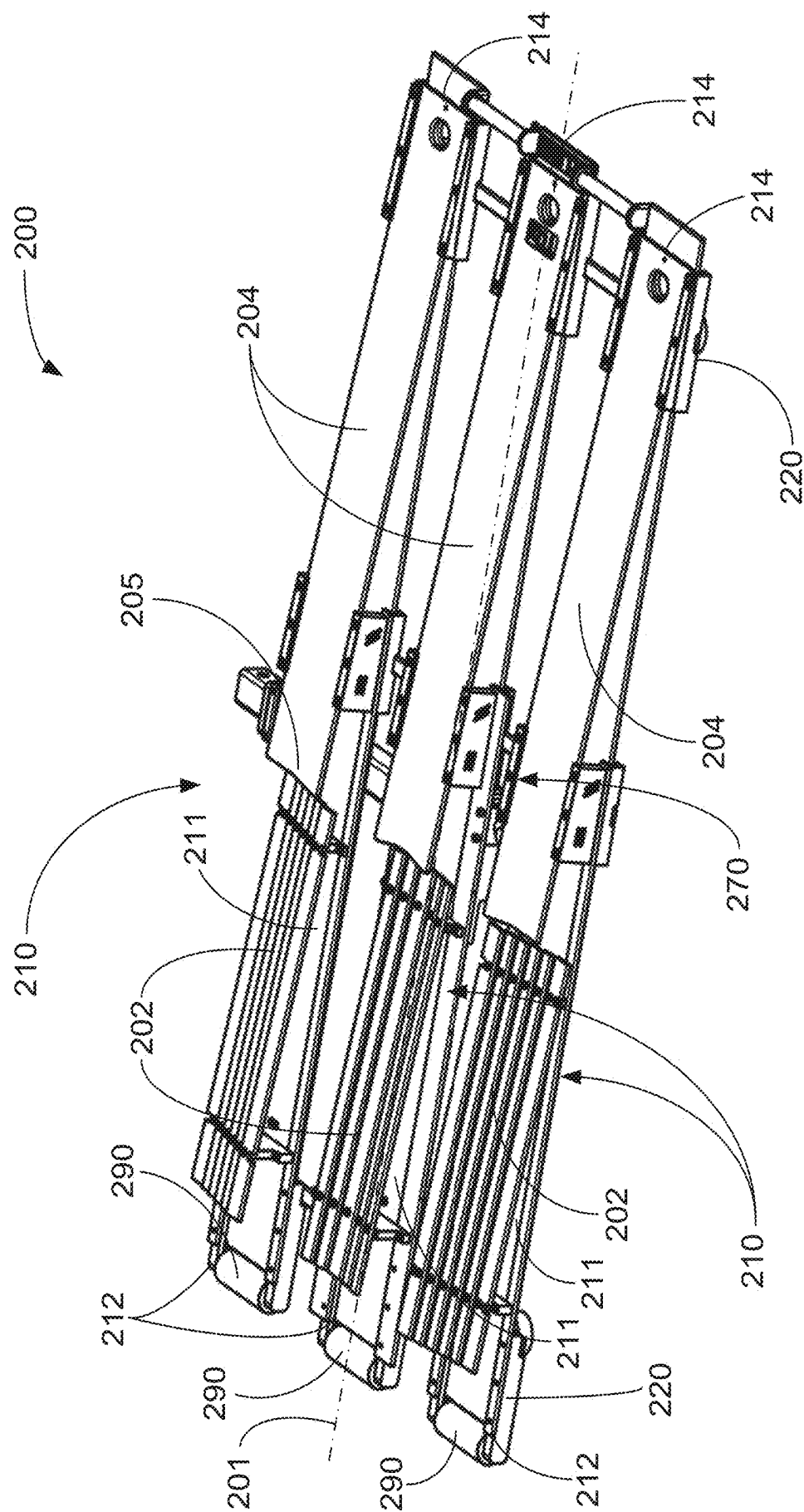


FIG. 8

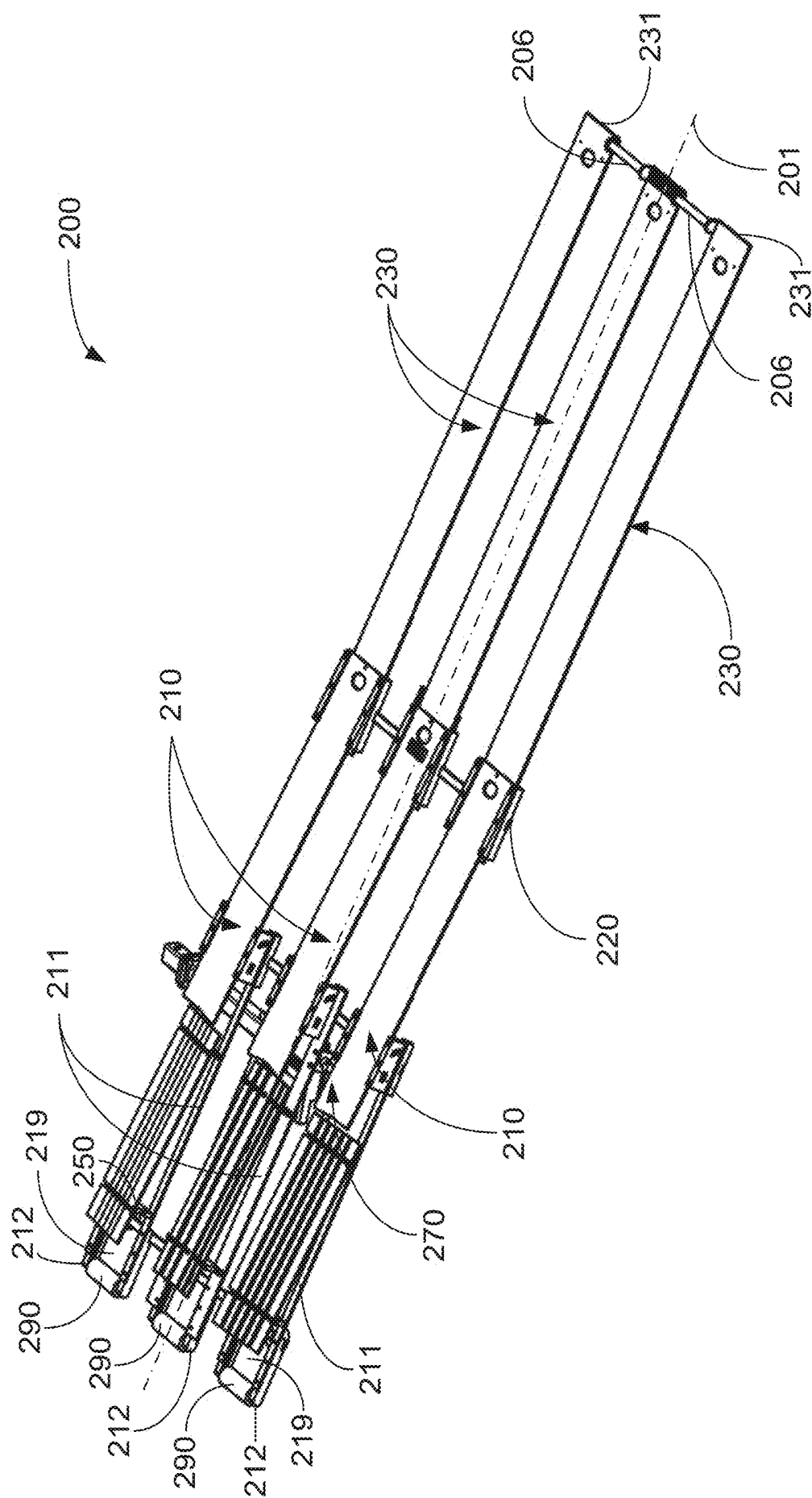


FIG. 9

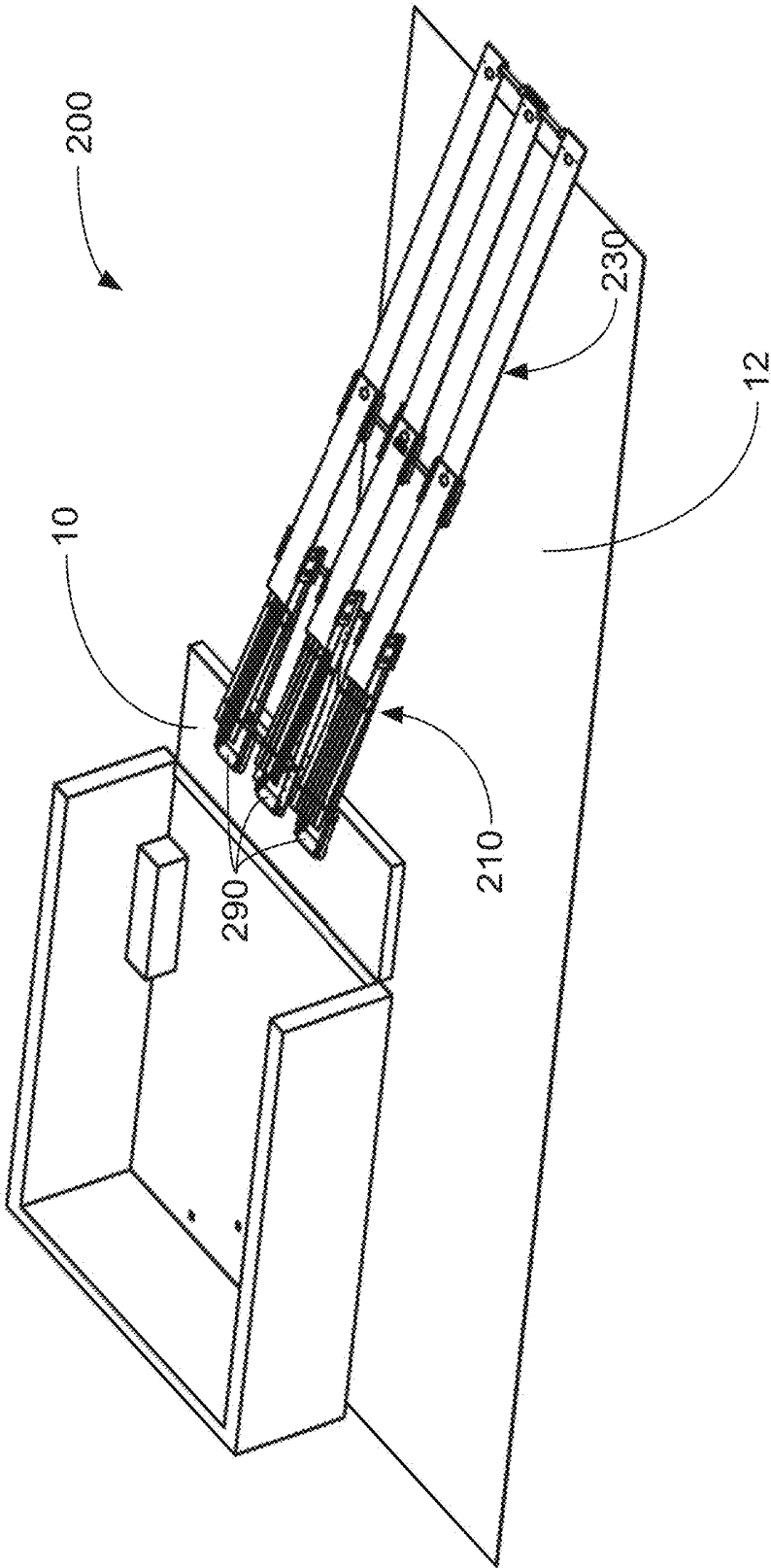


FIG. 10

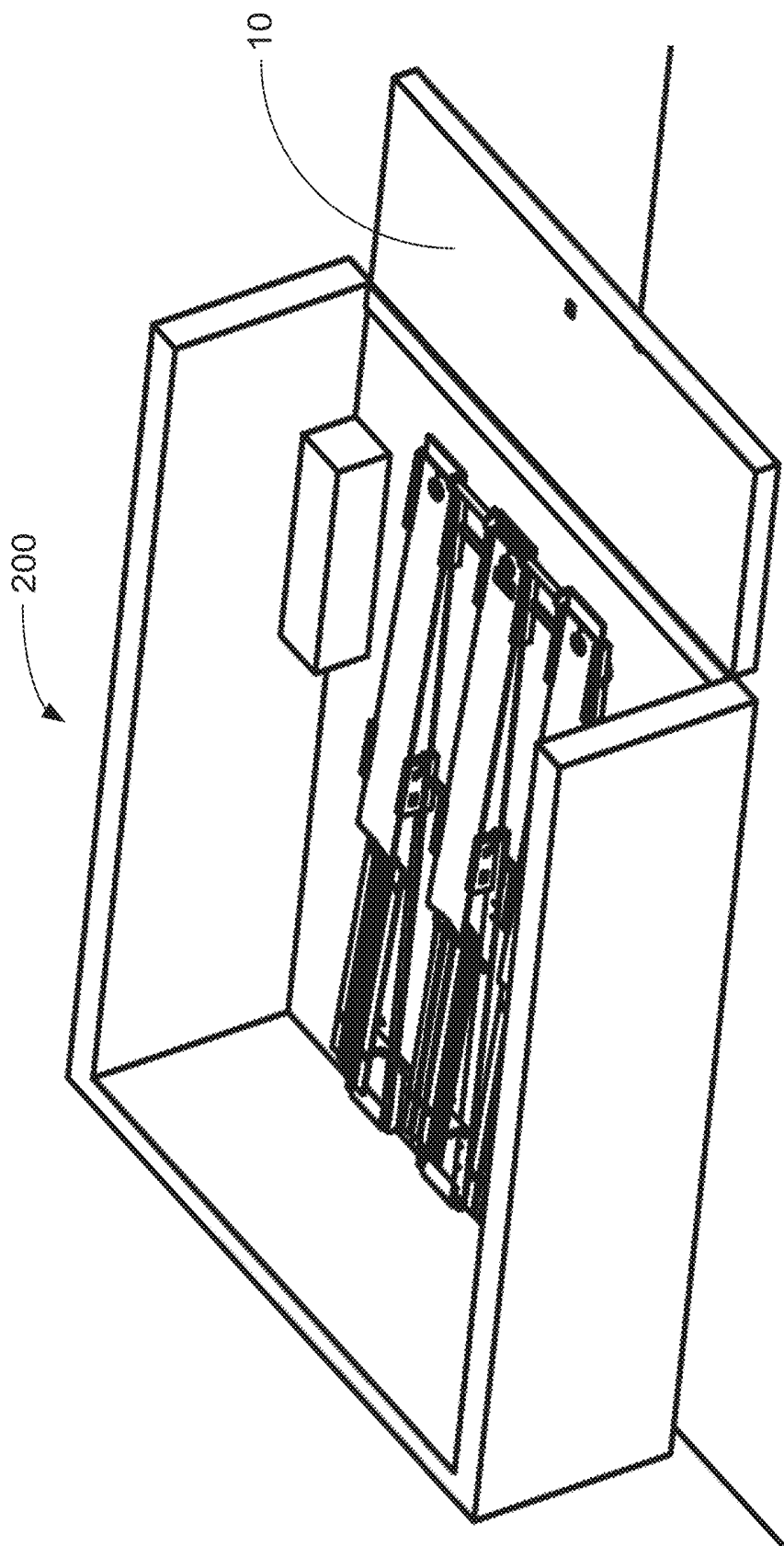


FIG. 11

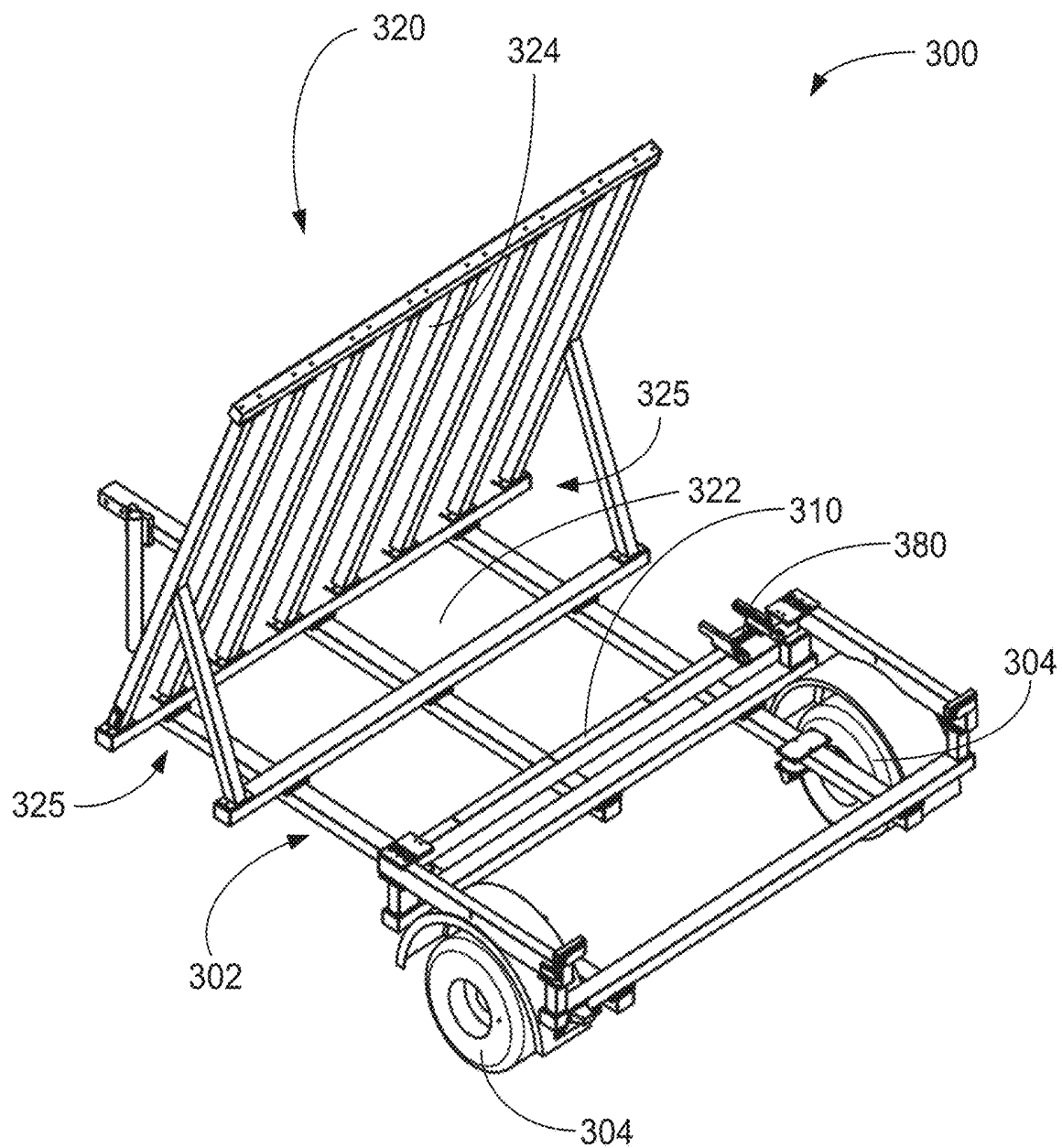


FIG. 12

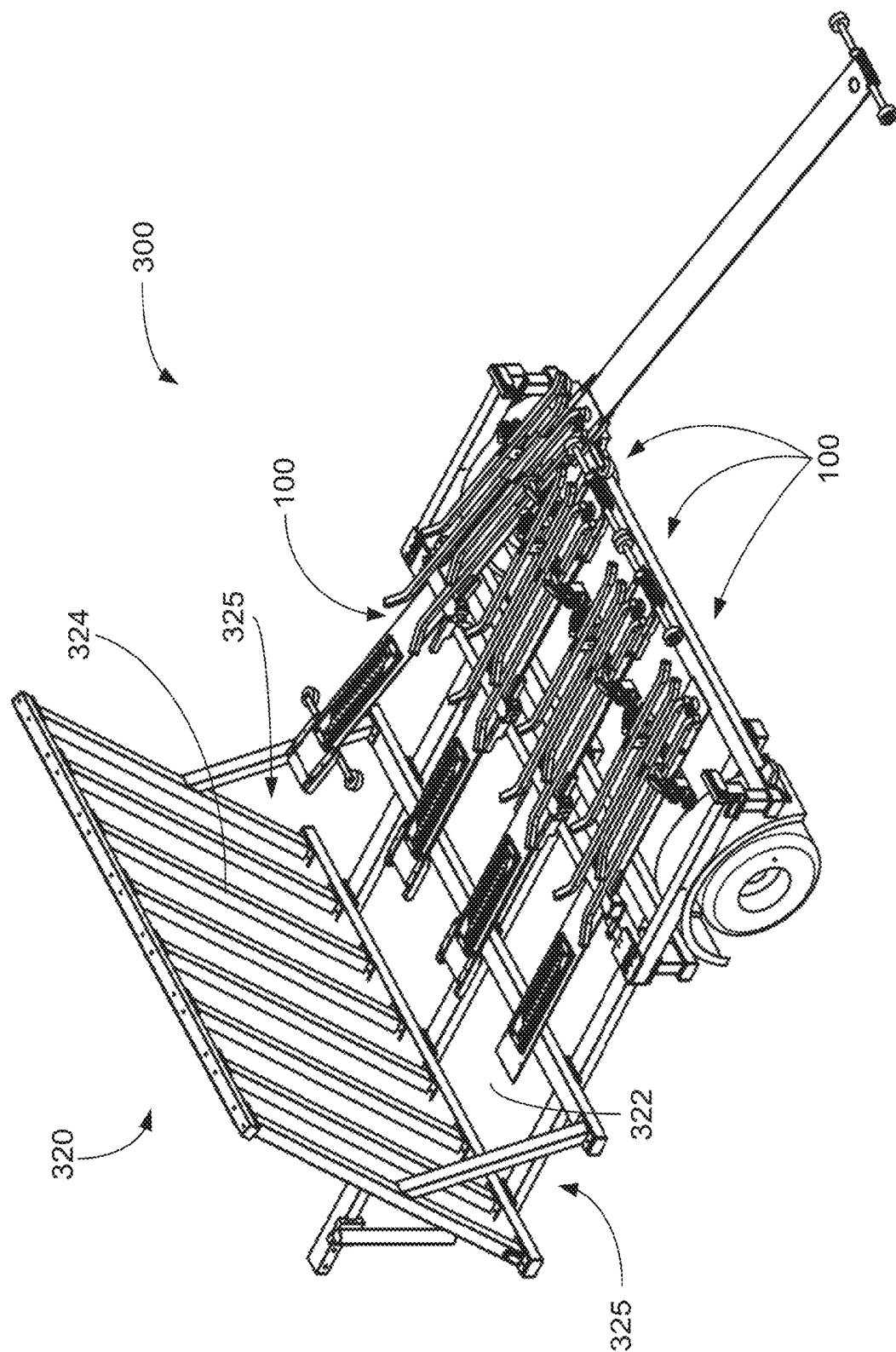


FIG. 13A

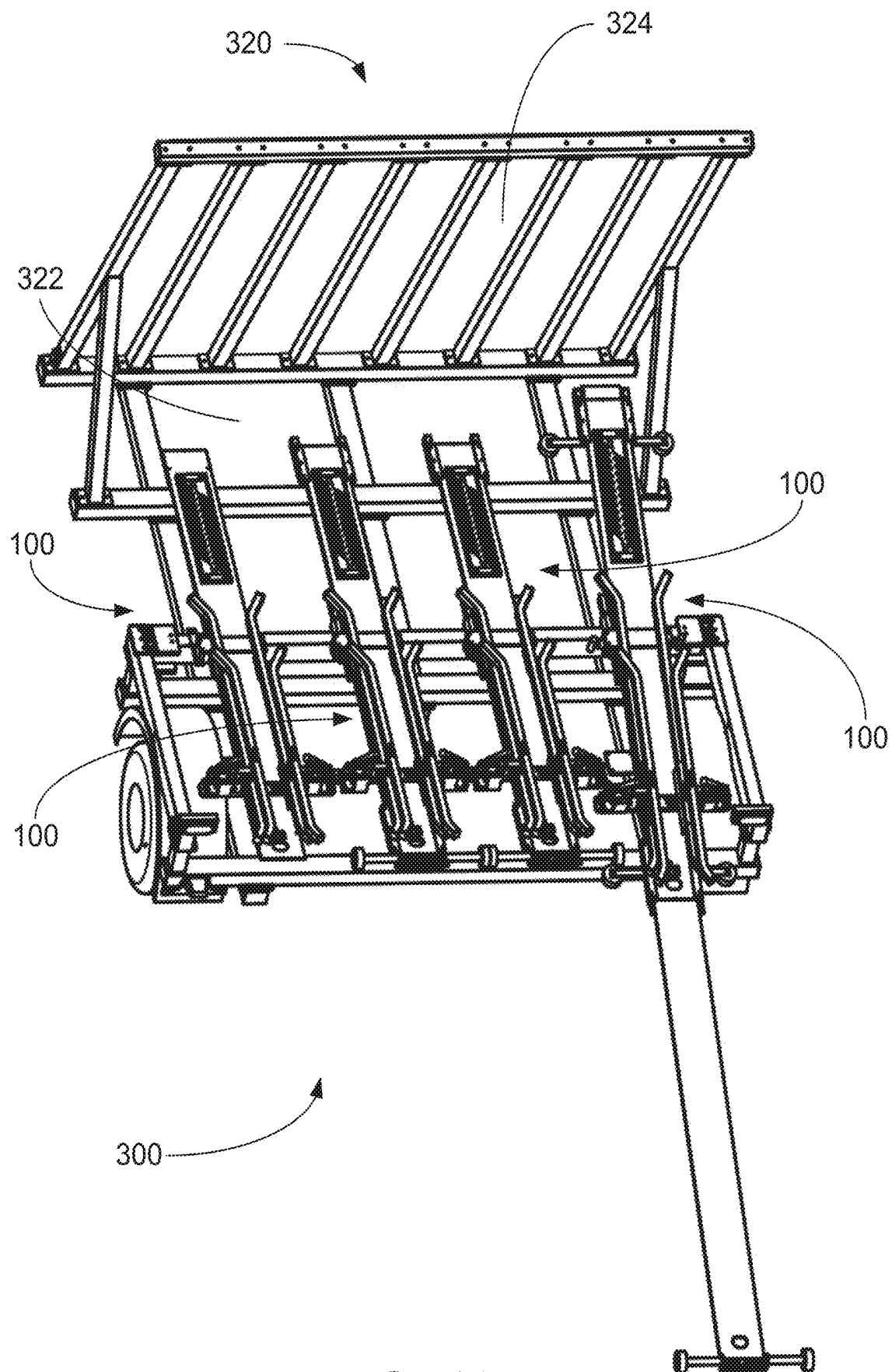


FIG. 13B

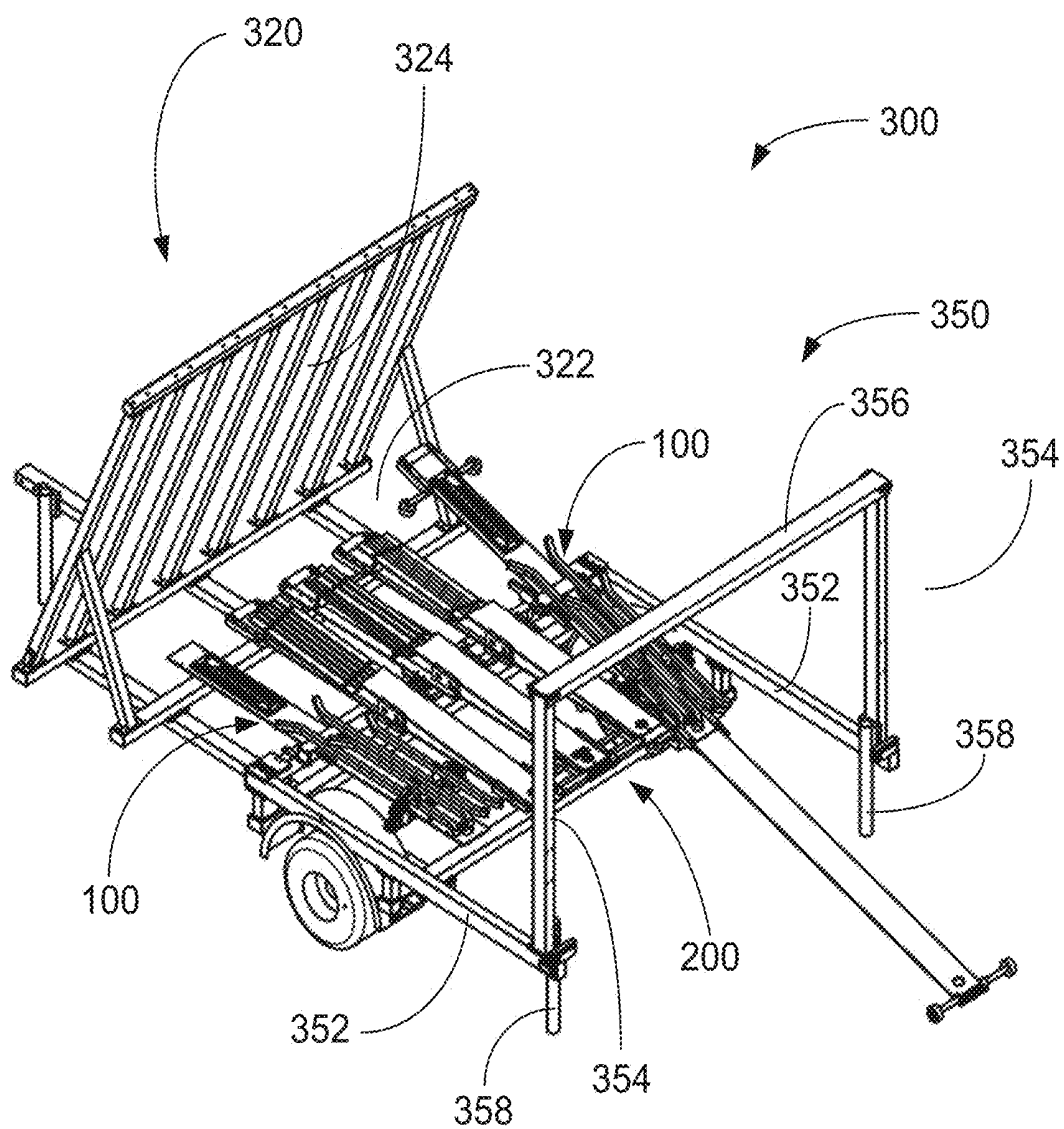


FIG. 14

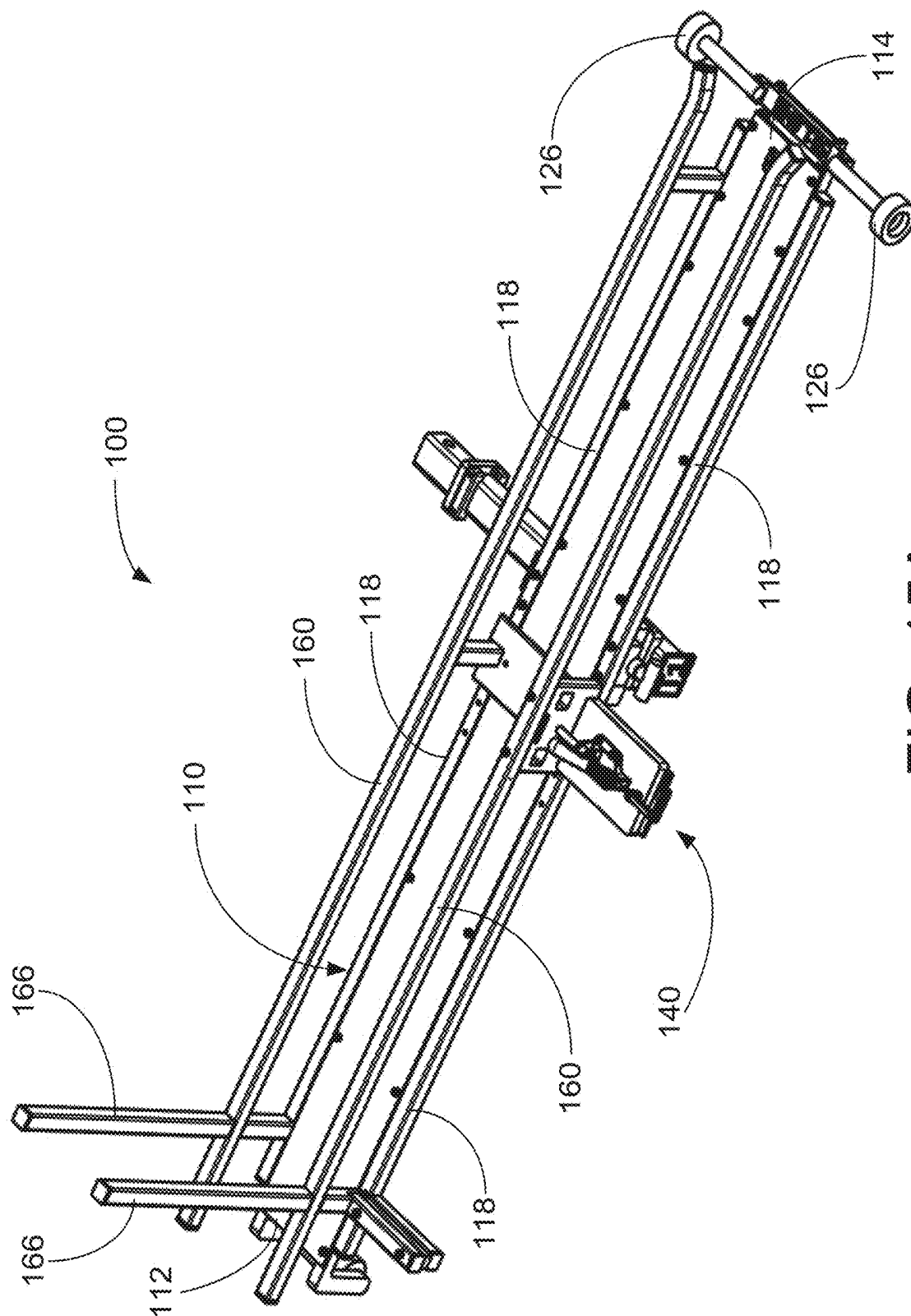


FIG. 15A

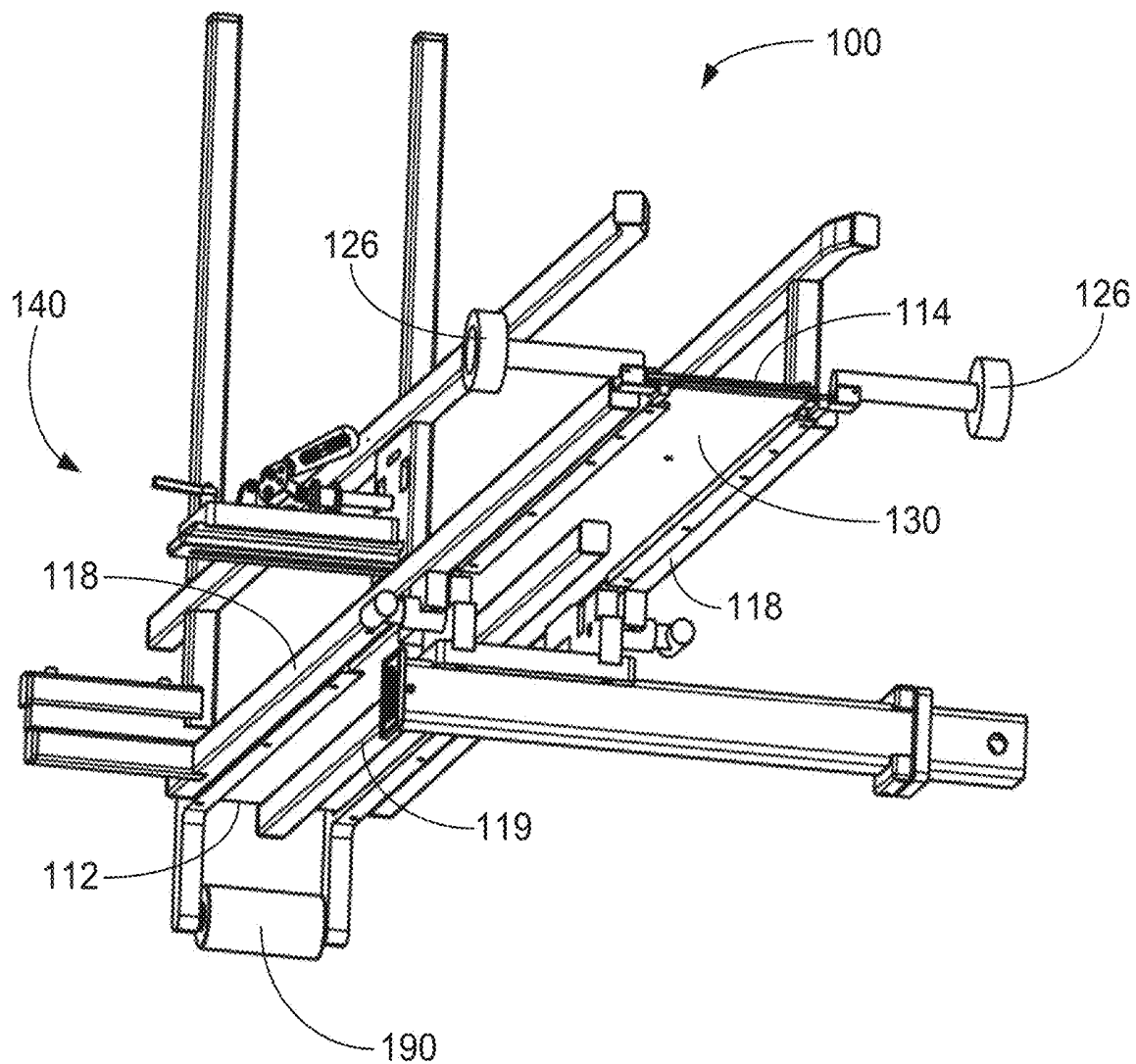


FIG. 15B

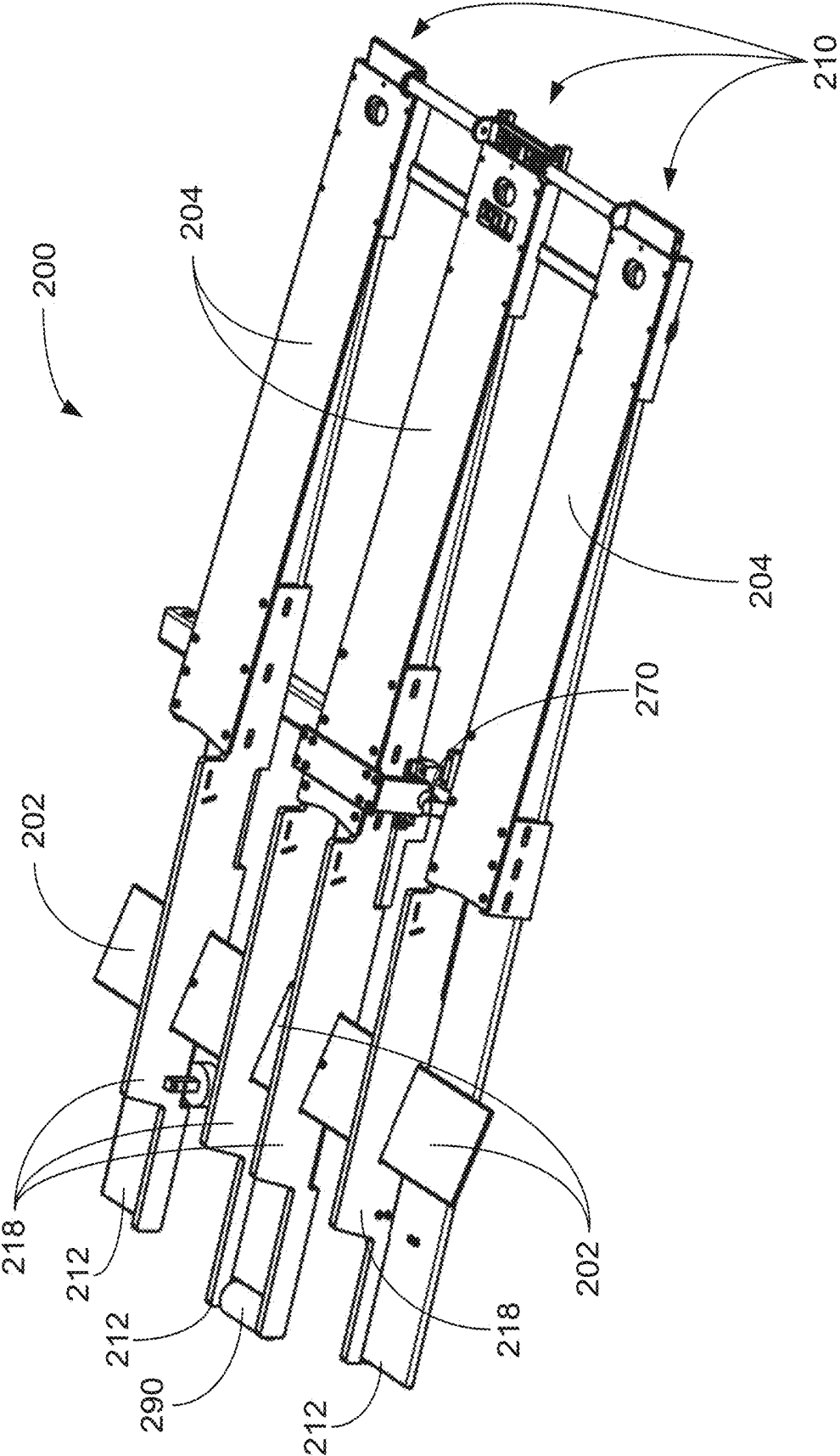


FIG. 16A

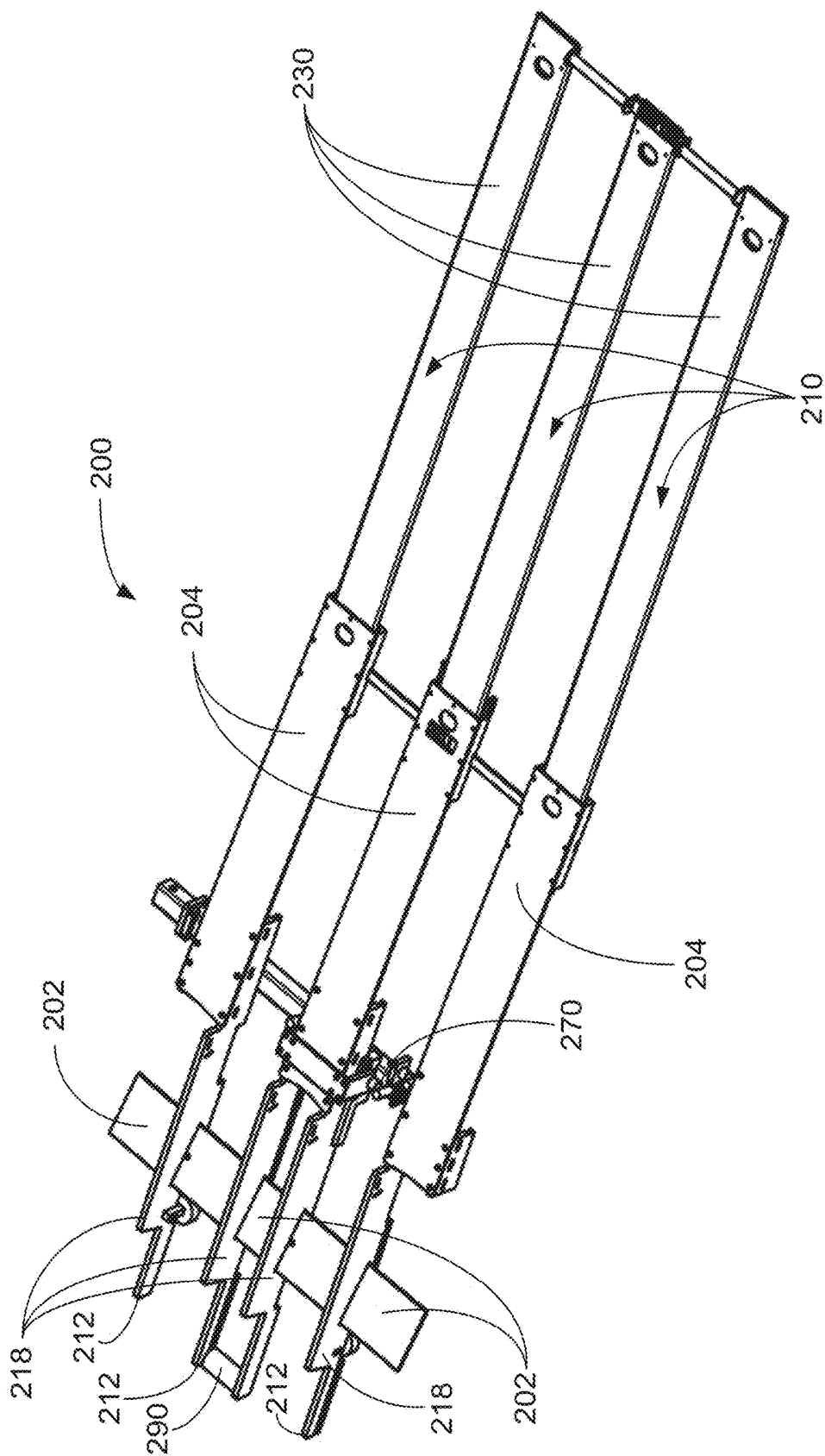


FIG. 16B

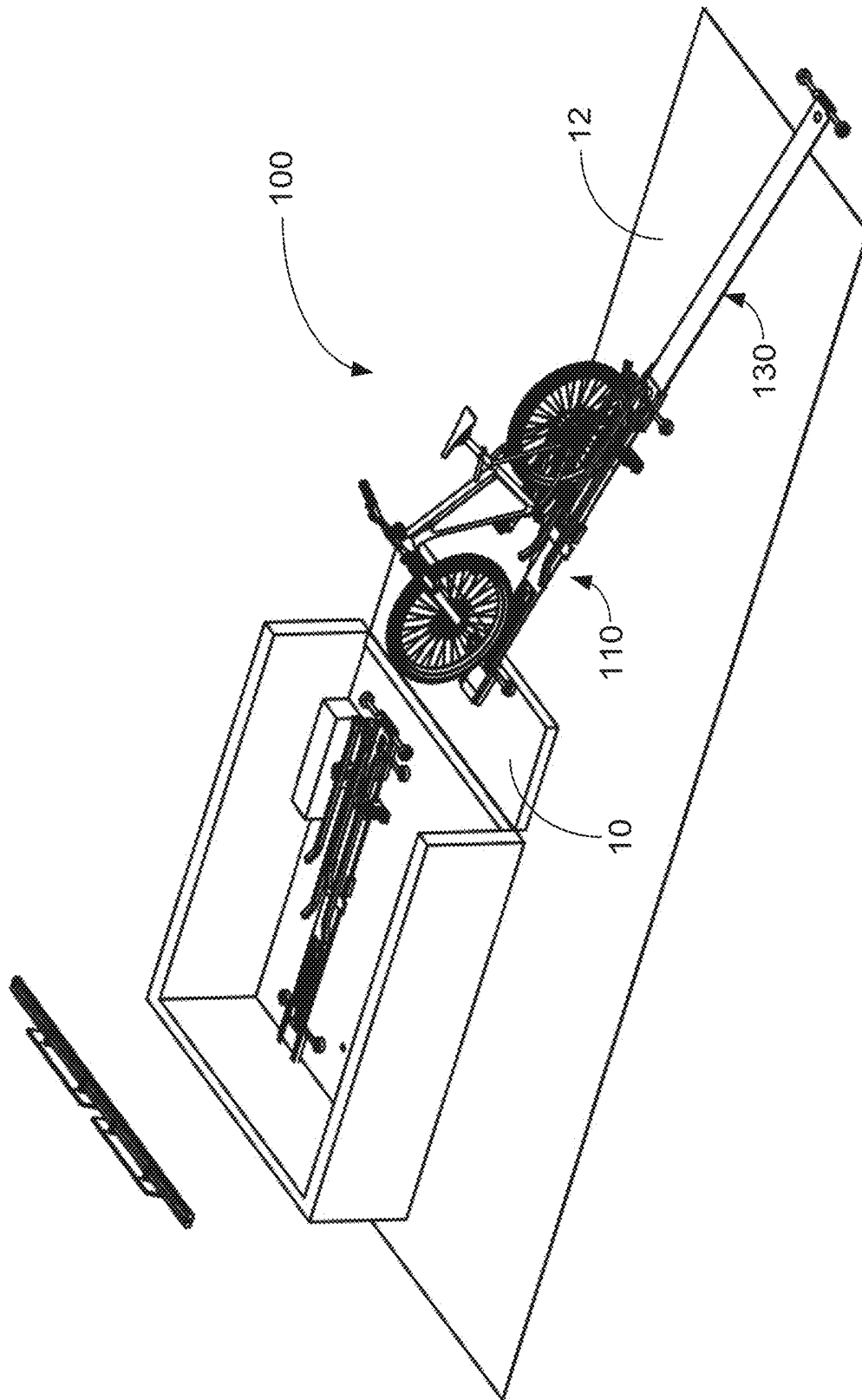


FIG. 17

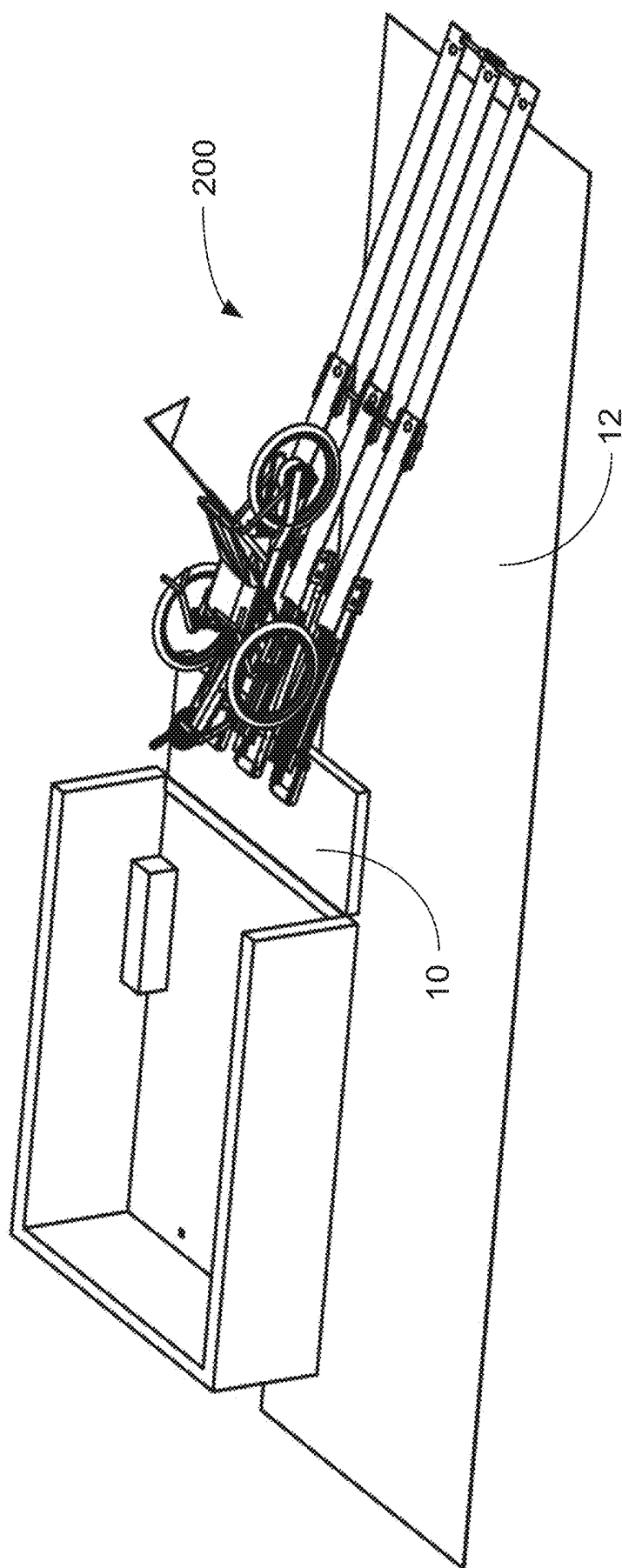


FIG. 18

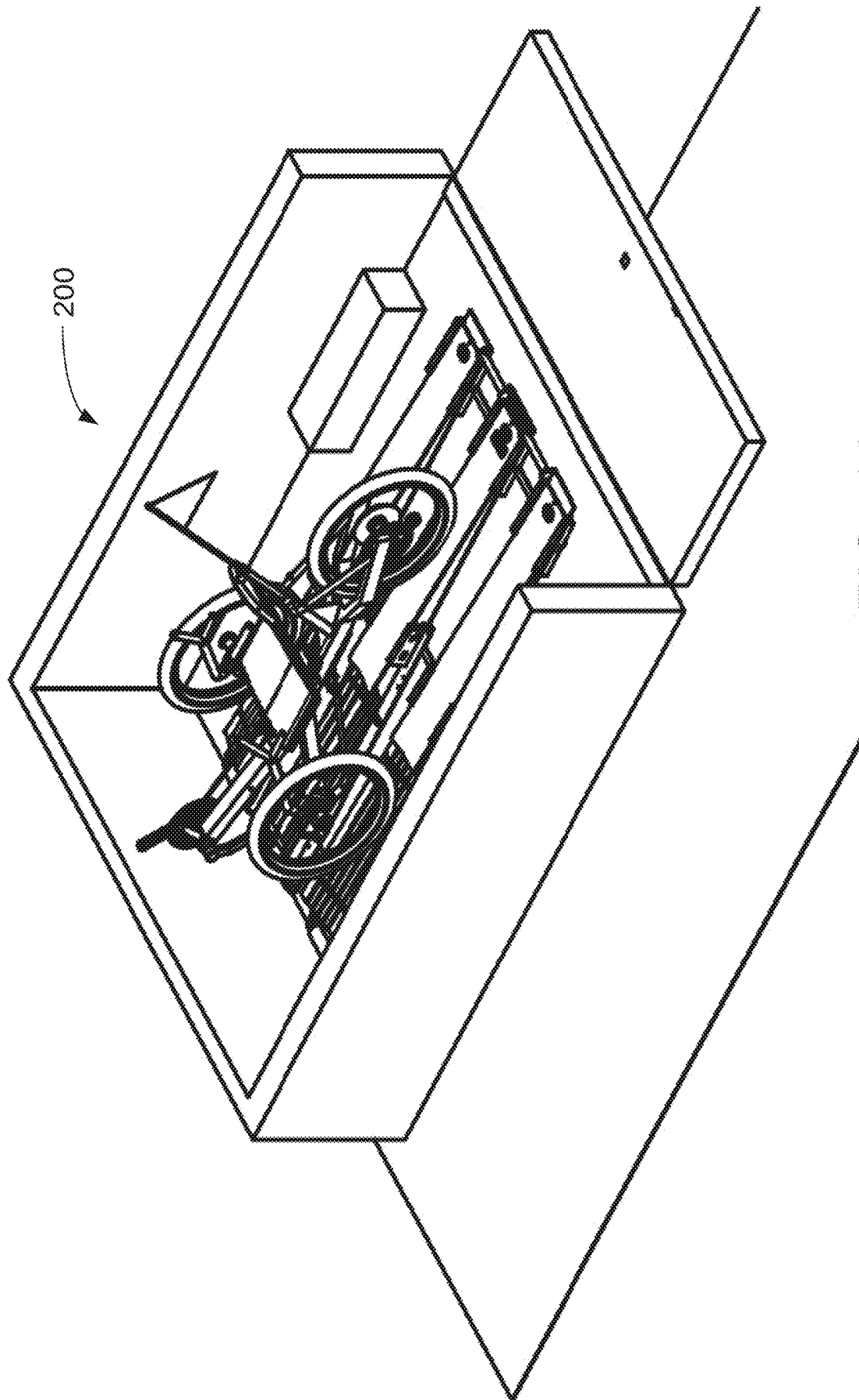


FIG. 19

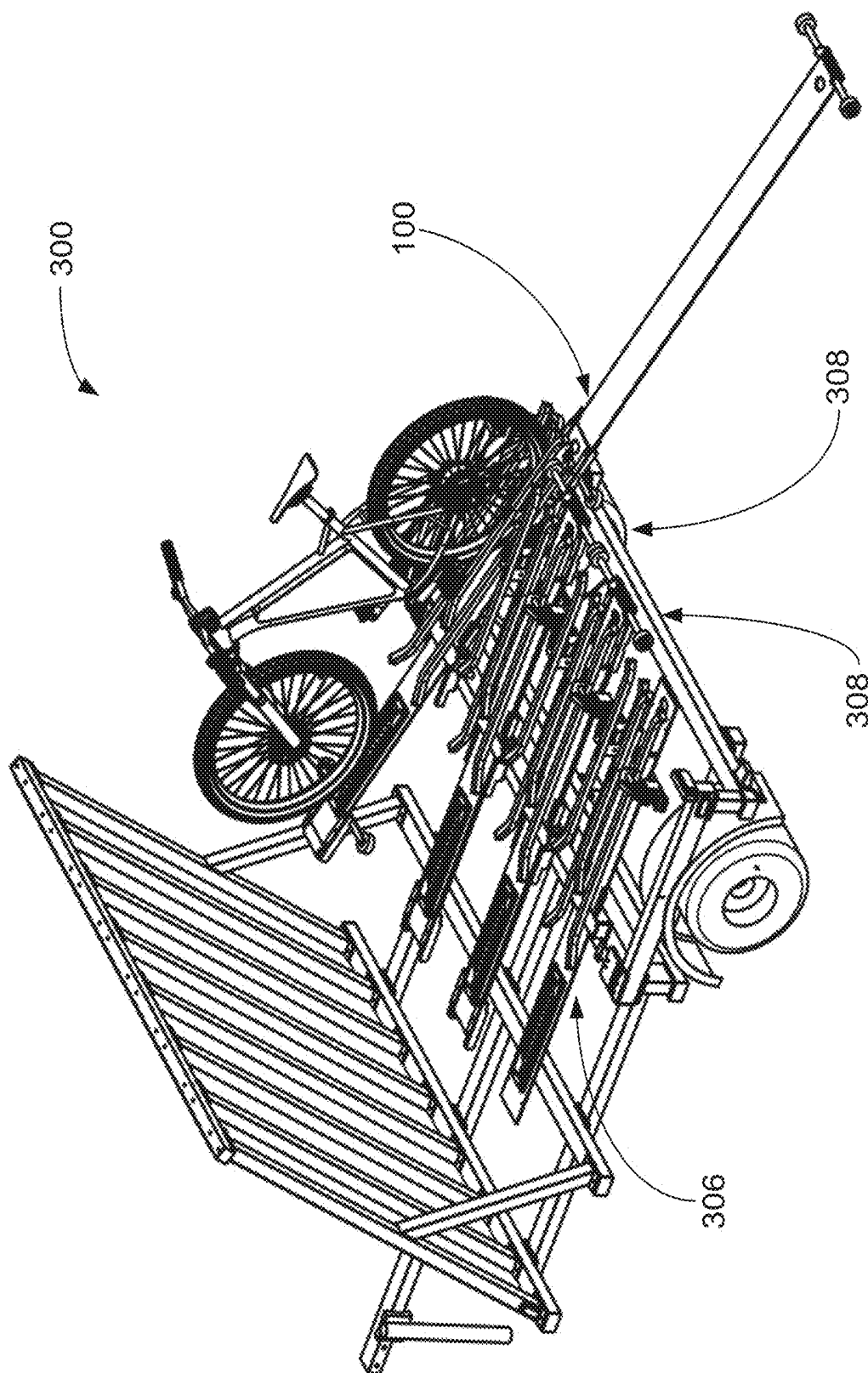


FIG. 20

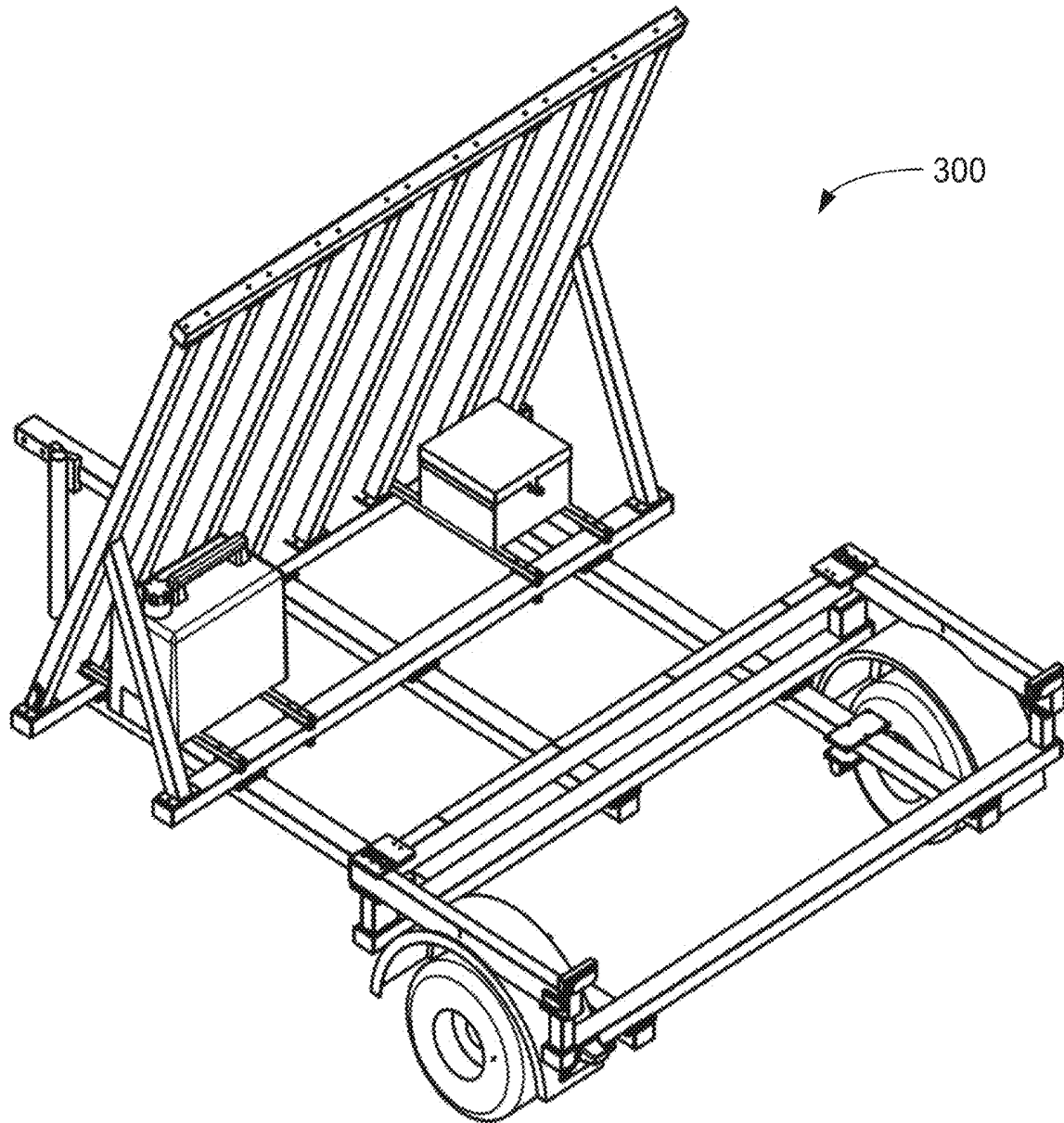
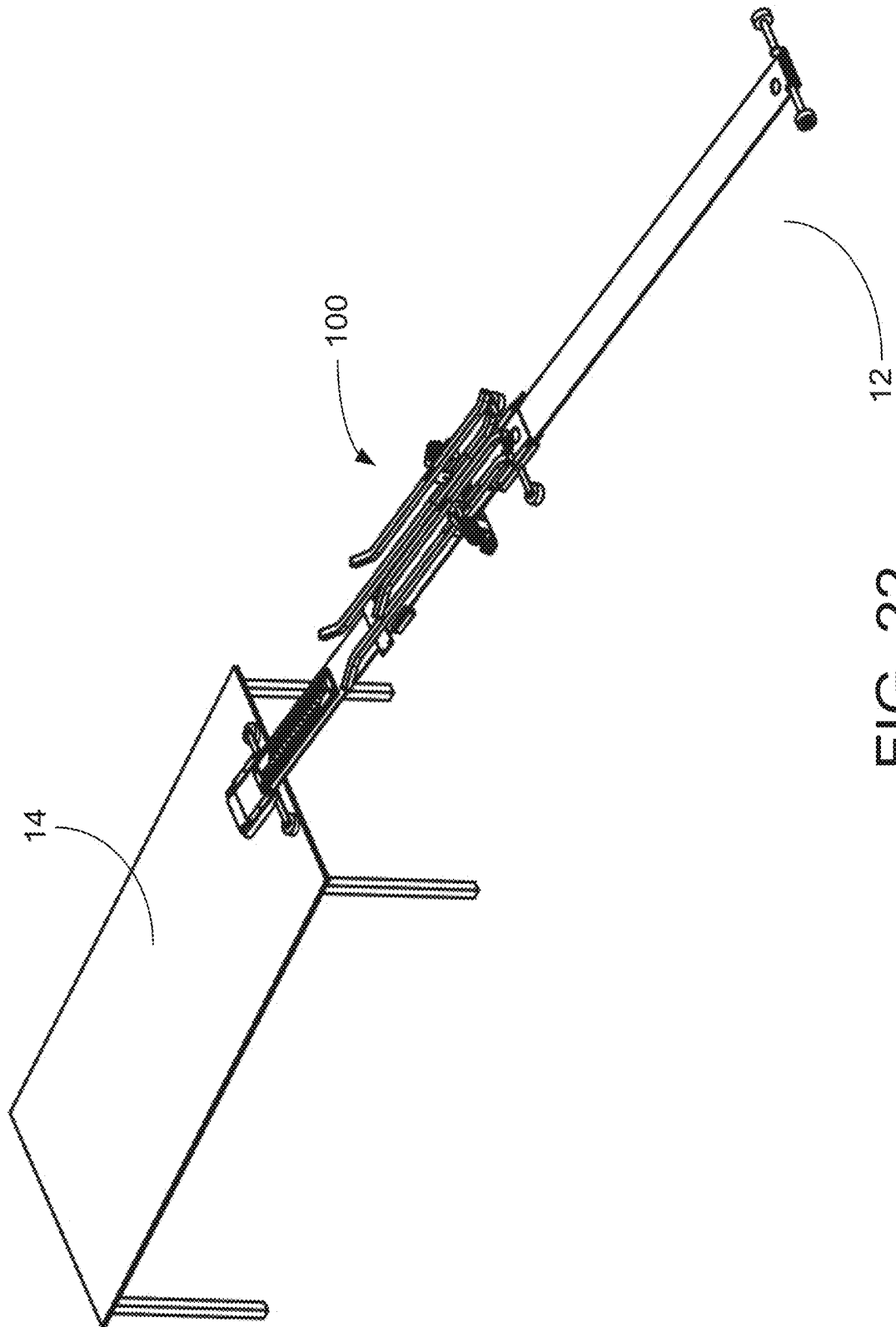


FIG. 21



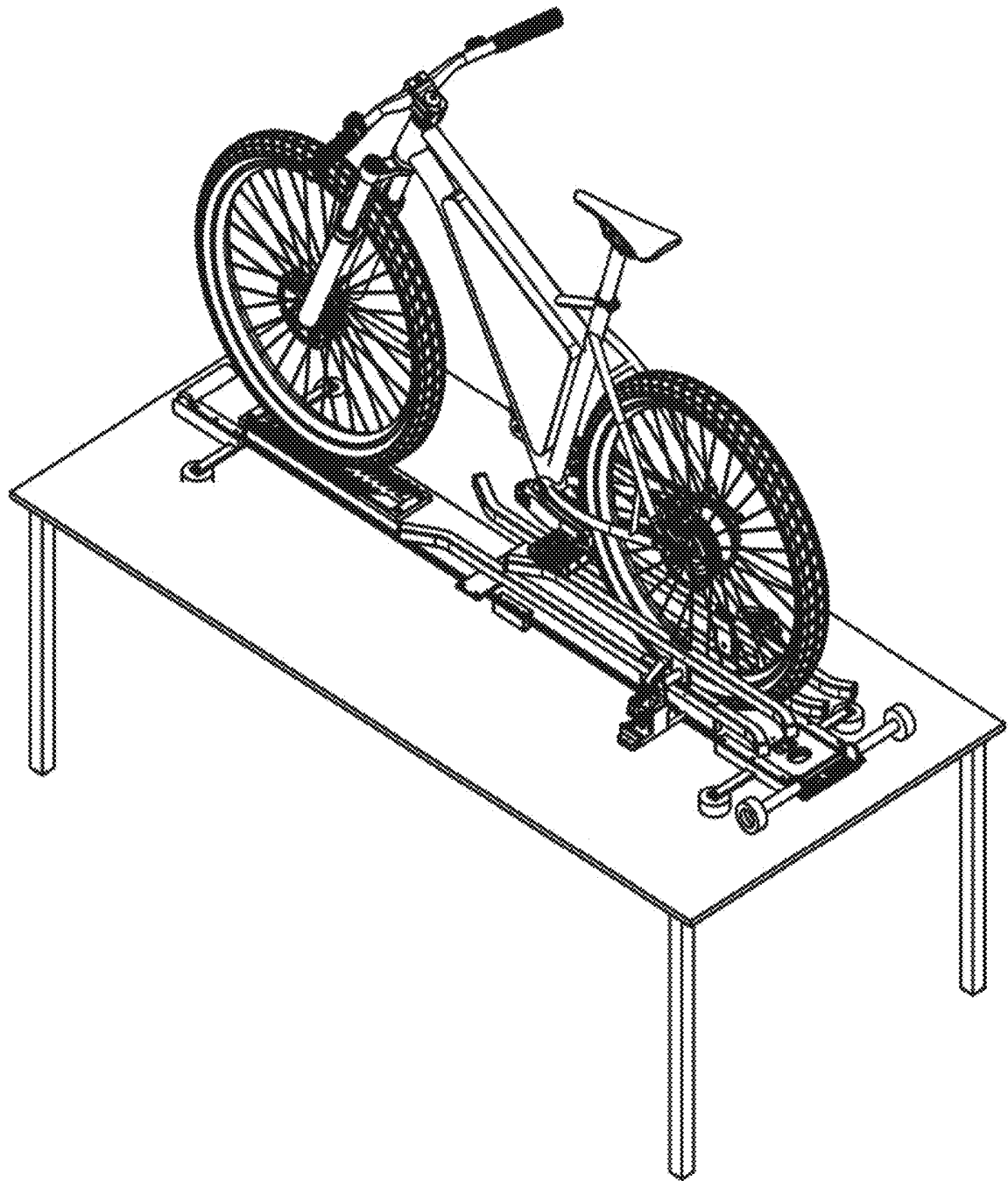


FIG. 23

MINIMAL LIFT BIKE CARRIER

The present application claims priority to and/or the benefit of U.S. Provisional Patent Application No. 63/290,896, filed Dec. 17, 2021, which is incorporated herein by reference in its entirety.

Embodiments of the present disclosure are directed to carriers designed for heavy and/or awkward bikes, trikes, quadricycles, and trailers (e.g., transporting people behind recreational vehicles) including electric types, and a transport trailer for transporting the carriers.

BACKGROUND

Bike carriers are typically designed to carry bicycles by having a user pick up and position the bicycle on the carrier. For example, the bicycle may be lifted to place the frame on extending hooks (e.g., such that the bicycle may be hanging from the hooks) or the wheels on a surface. Often bicycles are lightweight and simple which makes them easy to move, carry, and manipulate. Also, the lightweight characteristics of the bicycle may make the riding aspect more efficient.

On the other hand, some bikes are larger and heavier, and trikes, quadricycles, etc. are heavier and a more awkward form to lift. And particularly, electric bicycles (e.g., bicycles, trikes, quadricycles, etc.) include one or more electrical components that assist with the pedaling effort and are not found in conventional pedal bicycles. For example, the one or more electrical components may include a power source (e.g., a battery), an electric motor, wiring, switches, fuses, displays, controllers, etc. These electrical components often present additional considerations when supporting and transporting the electric bicycle. For example, these electrical components may increase the overall weight of the electric bicycle and may alter the general structure of a conventional bicycle.

For these heavier and more difficult to handle forms, it may be desirable for the user to be able to position the bicycle on a carrier in a way that minimizes lifting and carrying. Further, other limitations of the user may make it desirable to include a more accessible carrier. As such, the present disclosure describes a carrier for supporting and transporting these heavier and more difficult to lift forms with minimal lifting.

SUMMARY

Embodiments of the present disclosure may provide a carrier for supporting and transporting a bicycle. The carrier may include a support extending between a first end region and a second end region along a longitudinal axis. The support may define a top surface adapted to receive and contact tires of the bicycle. The support may include one or more slots extending along the longitudinal axis. The carrier may also include a ramp adapted to move relative to the support along the longitudinal axis. The ramp may slide within the one or more slots of the support. Further, the carrier may include a roller located proximate the first end region and adapted to rotate about an axis perpendicular to the longitudinal axis. The carrier may also include one or more ground engaging members located proximate an end of the ramp and extending beyond either side of the ramp. The one or more ground engaging members may be adapted to contact a ground surface.

Another embodiment of the present disclosure may provide a carrier for supporting and transporting a bicycle. The carrier may include a support extending between a first end

region and a second end region along a longitudinal axis. The support may define a top surface adapted to receive and contact tires of the bicycle. The carrier may also include a pivot mount assembly pivotably coupled to the support and may include a retention housing. The retention housing may define one or more slots extending along the longitudinal axis. The support may pivot about a pivot axis at an angle to the longitudinal axis. Further, the carrier may include a ramp adapted to move relative to the support along the longitudinal axis. The ramp may be adapted to slide within the one or more slots of the retention housing. The support may be restricted from pivoting about the pivot axis when the ramp is within the one or more slots and the support may be pivotable about the pivot axis when the ramp is not within the one or more slots.

Yet another embodiment of the present disclosure may provide a carrier for supporting and transporting a recreational vehicle (e.g., a tricycle, a quadricycle, a passenger trailer, etc.). The carrier may include at least two supports positioned apart from one another and extending parallel to one another. Each support may extend between a first end region and a second end region along a longitudinal axis. Each support may include a front portion and a rear portion extending at an angle to the front portion such that a front end of the rear portion is spaced a gap distance from a top surface of the front portion. Each support may be adapted to receive and contact tires of the recreational vehicle. Each support may include one or more slots extending along the longitudinal axis. The carrier may also include at least two ramps corresponding to each of the at least two supports and adapted to move relative to the corresponding support along the longitudinal axis. Each of the at least two ramps may slide within the one or more slots of the corresponding support.

Another embodiment of the present disclosure may provide a carrier for use with a transport trailer for supporting and transporting a bicycle. The carrier may include a support extending between a first end region and a second end region along a longitudinal axis. The support may define a top surface adapted to receive and contact tires of the bicycle. The support may be adapted to pivot relative to the trailer about a pivot axis. The carrier may also include a ramp adapted to move relative to the support along the longitudinal axis. The ramp may be adapted to slide within one or more slots of a retention housing coupled to the trailer. The support may be restricted from pivoting about the pivot axis when the ramp is within the one or more slots and the support may be pivotable about the pivot axis when the ramp is not within the one or more slots.

The above summary is not intended to describe each embodiment or every implementation. Rather, a more complete understanding of illustrative embodiments will become apparent and appreciated by reference to the following Detailed Description of Exemplary Embodiments and claims in view of the accompanying figures of the drawing.

BRIEF DESCRIPTION OF THE VIEWS OF THE DRAWING

Exemplary embodiments will be further described with reference to the figures of the drawing, wherein:

FIG. 1 is a perspective view of two carriers on a hitch shank for supporting and transporting a bicycle, including one in a storage position and one in an extended position, in accordance with embodiments of the present disclosure;

FIG. 2 is an exploded view of a carrier of FIG. 1;

FIG. 3 is an expanded view of a portion of a carrier of FIG. 1;

FIG. 4 is an expanded view of another portion of a carrier of FIG. 1;

FIG. 5 is an isolated view of a retention housing of a carrier of FIG. 1;

FIG. 6 is an expanded view of yet another portion of a carrier of FIG. 1;

FIG. 7 is a perspective view of two carriers positioned relative to an elevated bed in accordance with embodiments of the present disclosure;

FIG. 8 is a perspective view of a carrier for supporting and transporting a tricycle, quad, or trailer in accordance with embodiments of the present disclosure;

FIG. 9 is a perspective view of the carrier of FIG. 8 in an expanded and pivoted position;

FIG. 10 is a perspective view of the carrier of FIG. 9 positioned relative to an elevated bed;

FIG. 11 is a perspective view of the carrier of FIG. 10 in a storage position;

FIG. 12 is a perspective view of a transport trailer including components of a carrier in accordance with embodiments of the present disclosure;

FIG. 13A is a perspective view of the transport trailer of FIG. 12 having multiple carriers;

FIG. 13B is a top perspective view of the transport trailer of FIG. 13A having different carriers;

FIG. 14 is a perspective view of another transport trailer in accordance with embodiments of the present disclosure;

FIG. 15A is top perspective view of another embodiment of the carrier of FIG. 1;

FIG. 15B is a bottom perspective view of the carrier of FIG. 15A;

FIG. 16A is perspective view of another embodiment of the carrier of FIG. 8;

FIG. 16B is a perspective view of the carrier of FIG. 16A in an expanded position;

FIG. 17 is a perspective view of another embodiment of the two carriers of FIG. 7 including a bicycle positioned on the extended carrier;

FIG. 18 is a perspective view of another embodiment of the carrier of FIG. 10 including a tricycle positioned thereon;

FIG. 19 is a perspective view of another embodiment of the carrier of FIG. 11 including a tricycle positioned thereon;

FIG. 20 is a perspective view of another embodiment of the transport trailer of FIG. 13A including a bicycle on a carrier supported by the transport trailer;

FIG. 21 is a perspective view of yet another embodiment of the transport trailer of FIG. 12;

FIG. 22 is a perspective view of a carrier in an extended position and positioned relative to a table in accordance with embodiments of the present disclosure; and

FIG. 23 is a perspective view of the carrier of FIG. 22 in a stowed position on the table and including a bicycle positioned thereon.

The figures are rendered primarily for clarity and, as a result, are not necessarily drawn to scale. Moreover, various structure/components may be shown diagrammatically or removed from some or all of the views to better illustrate aspects of the depicted embodiments, or where inclusion of such structure/components is not necessary to an understanding of the various exemplary embodiments described herein. The lack of illustration/description of such structure/components in a particular figure is, however, not to be interpreted as limiting the scope of the various embodiments in any way.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

In the following detailed description of illustrative embodiments, reference is made to the accompanying figures of the drawing which form a part hereof. It is to be understood that other embodiments, which may not be described and/or illustrated herein, are certainly contemplated.

All headings provided herein are for the convenience of the reader and should not be used to limit the meaning of any text that follows the heading, unless so specified. Moreover, unless otherwise indicated, all numbers expressing quantities, and all terms expressing direction/orientation (e.g., vertical, horizontal, parallel, perpendicular, etc.) in the specification and claims are to be understood as being modified in all instances by the term "about." Furthermore, the terms "having," "including," "comprises" and variations thereof do not have a limiting meaning where these terms appear in this description and claims, and the terms "a," "an," "the," "at least one," and "one or more" are used interchangeably herein. The term "and/or" (if used) means one or all of the listed elements or a combination of any two or more of the listed elements. "I.e." is used as an abbreviation for the Latin phrase *id est*, and means "that is." "E.g.," is used as an abbreviation for Latin phrase *exempli gratia*, and means "for example."

Still further, relative terms such as "left," "right," "front," "fore," "forward," "rear," "aft," "rearward," "top," "bottom," "side," "upper," "lower," "above," "below," "horizontal," "vertical," and the like may be used herein and, if so, are from the perspective of one sitting on a bicycle, tricycle, or quadracycle positioned on the carrier 100. These terms are used only to simplify the description, however, and not to limit the interpretation of any embodiment described.

Also, as it pertains to the description of the present disclosure, electric bicycle may include any electrically assisted or powered vehicle having wheels on a frame such as for example, a bicycle having two wheels in a single track, a tricycle having three wheels, a quadracycle having four wheels, etc. In other words, any electrically assisted or powered vehicle contemplated herein may be described as a recreational vehicle, an electric bicycle or, more generically, a bicycle. It is further noted, that while the present disclosure pertains to a carrier used with an electric bicycle, any conventional bicycle may similarly be used with the described carrier. Additionally, the present disclosure includes description of a passenger/cargo trailer supported and transported by the carrier described herein. Such carrier may include any suitable passenger/cargo trailer used in conjunction with a bicycle.

Embodiments described and illustrated herein are directed to a carrier for supporting and transporting a bicycle (e.g., an electric bicycle, a conventional bicycle, etc.), a tricycle, a quadracycle, a passenger/cargo trailer, etc. The carrier may be extendable such that the carrier may extend into a ramp for loading a bicycle and retract into a shorter length for storage. As such, the bicycle may roll onto the ramp into a loading position for transporting. Further, in one or more embodiments, the carrier may be adapted to pivot about an axis such that the carrier may be pivoted between a loading position (e.g., with the ramp extended) oriented at an angle to a ground surface and a storage position (e.g., with the ramp retracted) oriented horizontally. In other embodiments, the carrier may be adapted to be slid into and out of an elevated surface (e.g., a truck bed, trailer deck, workstation, etc.) to, for example, form a ramp onto the elevated surface

and to support the bicycle when on the elevated surface. As such, the ramp extension may contact the ground surface creating a ramp for the bicycle to load onto the carrier. Also, in some embodiments, the carrier, or components thereof, may be included on a transport or lightweight trailer (e.g., one that is towed by a vehicle).

Additionally, the carrier may include one or more components that may lock the carrier into position. For example, the carrier may be locked to position the carrier in the storage position and prevent the carrier from pivoting. Specifically, the ramp extension may be adapted to act as the lock depending on whether the ramp is extended or retracted. As such, when the ramp extension is extended, the carrier may be allowed to pivot into a position for a bicycle to be loaded on the carrier (e.g., without needing to lift the bicycle). And after the carrier is pivoted back to a generally horizontal position, the carrier may be locked (e.g., by retracting the ramp extension) from pivoting.

The carrier may also include a roller located at an end of the carrier to assist in rolling the carrier into a desired position. For example, when the carrier is positioned on an elevated surface (e.g., a truck bed, trailer deck, workstation, etc.), the roller may assist in moving the carrier along the elevated surface. Specifically, the carrier may be lifted by the end opposite the roller and moved along a surface using the roller (e.g., to position the carrier between a horizontal position and a position extending between the elevated surface and the ground surface). Further, the carrier may include ground engaging members positioned on one or both ends of the carrier that elevate the carrier above the surface the ground engaging members are contacting (e.g., disengaging the roller from contacting the surface). These ground engaging members provide additional stability and traction for the carrier.

In one or more embodiments, the carrier may be configured to receive multiple tires (e.g., positioned on different tracks/paths) from a single recreational vehicle (e.g., a tricycle, a quadracycle, a passenger/cargo trailer, etc.). For example, the carrier may include two or more portions to support the multiple tires of the vehicle. Each of the two or more portions may include two sections spaced apart from one another by a gap such that the tires drop onto one of the sections and are restricted from moving backwards by the other of the sections (e.g., without lifting the tire over the gap). Additionally, each of the two or more portions may include a ramp that extends from and retracts into the corresponding portion such that the ramp may contact the ground and the vehicle can be loaded onto the carrier.

With reference to the figures of the drawing, wherein like reference numerals designate like parts and assemblies throughout the several views, FIG. 1 illustrates two carriers 100 for supporting and transporting a bicycle. Each carrier 100 may include a support 110 extending along a longitudinal axis 101 (e.g., as shown in FIG. 2) and a ramp 130 adapted to move relative to the support 110 along the longitudinal axis 101. The support 110 is adapted to support a bicycle on a top surface 111 (e.g., as shown in FIG. 2) thereof and the ramp 130 is adapted to slide relative to the support 110 to lengthen the carrier 100 and assist in loading the bicycle onto the support 110. For example, the ramp 130 is configurable between an extended position and a storage position. The ramp 130 is extended from the support 110 when in the extended position and the ramp 130 is stowed to coincide with the support 110 when in the storage position.

Specifically, as shown in FIG. 1, a first carrier 100a is configured into the extended position and a second carrier

100b is configured into the storage position. It is noted that either carrier 100 can move between the extended position and the storage position, but FIG. 1 depicts a carrier 100 in each of the positions. The carrier 100 may be pivoted when in the extended position to contact the ramp 130 with a ground surface to provide a continuous path for the bicycle to be loaded onto the carrier 100. In other words, the user may push the bicycle onto the support 110 (e.g., via the ramp 130) along an angled surface formed by the carrier 100 to load the bicycle onto the support 110 without having to lift the bicycle. Thereafter, the user may pivot the carrier 100 into a horizontal orientation and retract the ramp 130 for storing and/or transporting. As such, the process of loading the bicycle onto the carrier 100 may be easier than lifting the bicycle to an elevated support.

In one or more embodiments, the carrier 100 may be locked into position when in the extended position and/or the storage position. For example, when the ramp 130 is retracted into the support 110, the ramp 130 may engage a lock that prevents the carrier 100 from pivoting. Further, in one or more embodiments, the ramp 130 may be locked into position when in the extended position (e.g., using latches) to prevent inadvertent retraction of the ramp 130. As such, the support 110 and ramp 130 may include specific features (e.g., as discussed further herein) that interact to restrict movement of the carrier 100 (e.g., pivoting or extending) when in the storage position and/or the extended position.

FIG. 2 illustrates a single carrier 100 having some of the features of the carrier 100 spaced away from their normal position for better visualization. The carrier 100 may include a support 110 extending between a first end region 112 and a second end region 114 along a longitudinal axis 101. The support 110 may define a top surface 111 adapted to receive and contact tires of the bicycle. In other words, the support 110 may extend along a straight line such that a bicycle tire may travel along the top surface 111 of the support 110 from the second end region 114 towards the first end region 112.

Further, the length of the support 110 may be sufficient to position the multiple tires of the bicycle (e.g., two in-line tires of an electric bicycle) on the top surface 111 of the support 110 (e.g., with any needed extra surface of the support in front of the front tire and rearward of the rear tire). For example, the support 110 may define a length of about 65 inches to about 72 inches measured between the first end region 112 and the second end region 114 along the longitudinal axis 101. The length of the support 110 may also align with the amount of space provided within the bed of a pickup truck (e.g., when the carrier 100 is loaded into the bed) or such that the carrier 100 does not stick out beyond the sides of a vehicle (e.g., when the support 110 is positioned on the vehicle transverse to the direction of motion of the vehicle) such as, e.g., when the carrier 100 is attached to a hitch. Additionally, the support 110 may define a width of about 6 inches to about 12 inches measured perpendicular to the longitudinal axis 101 (e.g., to accommodate any width of bicycle tire).

The support 110 (and components that make up the support) may include (e.g., be formed of) any suitable materials. For example, the support 110 may include metal, plastic, rubber, anodizing, powder coating, natural or synthetic strap, case hardening, weld filler, etc.

In one or more embodiments, the carrier 100 may also include a strap (or multiple straps) adapted to extend through or over a tire of the bicycle positioned on the top surface 111 of the support 110. Specifically, the strap may assist in securing the bicycle tire to the support 110 after the bicycle tire is positioned on the support 110 (e.g., by applying a

downward force on the tire). The strap may include a chain, a cable, mesh, rubber, nylon, etc. and may be routed through a slot located proximate a pivot mount assembly. In one or more embodiments, the strap may be adapted to extend through or over a front tire of the bicycle proximate the first end region 112 of the support 110. Further, for example, the strap may extend from one side of the support 110, through the bicycle tire (e.g., through the spokes of the tire) or over the bicycle tire, and to the other side of the support 110. In one or more embodiments, the strap may be adjustable (e.g., at one of the sides of the support 110) to easily attach and detach, and to fit a variety of different sized tires. Additionally, in one or more embodiments, the strap may be used to pass over or through the frame of the bicycle to help hold onto the bicycle. In some embodiments, other suitable components may be used to secure the tires to the support 110 including, for example, clamps, etc. Specifically, in one or more embodiments, the carrier 100 may include clamps 140 on either side of the support 110 as shown in FIG. 3 and described further herein.

The carrier 100 may also include a ramp 130 adapted to move relative to the support 110 along the longitudinal axis 101. For example, the ramp 130 may move relative to the support 110 to extend the length of the carrier 100 such that the carrier 100 may create an incline access for a bicycle to be loaded on the carrier 100. In other words, the ramp 130 may be configurable into an extended position (e.g., as shown in FIG. 2) to assist in loading a bicycle on the carrier 100. Additionally, the ramp 130 may be stowed to coincide with the support 110 to minimize the overall length of the carrier 100 when the ramp 130 is not in use. In other words, the ramp 130 may also be configurable into a storage position (e.g., as shown in FIG. 1), e.g., after the bicycle is loaded on the carrier 100 and/or the carrier 100 is in transport.

The ramp 130 may be spaced apart from the support 110 by any suitable distance (e.g., gap distance). For example, the one or more slots 120 (e.g., described further herein) may be defined by the support 110 to guide the ramp 130 at a set distance from the support 110. In other words, the support 110 and the ramp 130 may each extend along a planar surface and the planar surfaces may be generally parallel to one another and spaced a distance apart. Specifically, the ramp 130 may be spaced apart from the support 110 by about 0.1 inches to about 0.5 inches (e.g., about 0.275 inches). In one or more embodiments, the ramp 130 may be positioned closer to the support 110 to minimize the bump therebetween when the bicycle transitions between the ramp 130 and the support 110.

The ramp 130 may define any suitable length to extend the overall length of the carrier 100. Further, the length of the ramp 130, and thereby the carrier 100, may change the angle at which the carrier 100 extends (e.g., making loading and unloading easier) and may provide differing mechanical advantages for pivoting the carrier 100 with a bicycle loaded thereon. In one or more embodiments, the ramp 130 may define a length that is less than or equal to the length of the support 110, e.g., such that that ramp 130 may be stowed to coincide with the support 110. For example, the ramp 130 may define a length that is substantially the same as the length of the support 110. In other embodiments, the length of the ramp 130 may be greater than the length of the support 110 such that the ramp 130 protrudes from an end of the support 110 when in the storage position. Specifically, the ramp 130 may define a length of about 70 inches to about 75 inches measured along the longitudinal axis. Further, the carrier 100 may define an overall length of about 130 inches

to about 135 inches when the ramp 130 is in the extended position (e.g., a fully extended position). It is noted that the ramp 130 may be extended from the support 110 by an amount that is less than fully extended (e.g., partially extended) as suitable for a specific application (e.g., if the ramp 130 is extended down to an elevated surface such as a curb or platform).

The ramp 130 (and components that make up the ramp 130) may include (e.g., be formed of) any suitable materials. For example, the ramp 130 may include metal (e.g., aluminum), plastic, rubber, anodizing, powder coating, natural or synthetic strap, case hardening, etc. In one or more embodiments, the ramp 130 (and/or, e.g., other components of the carrier 100) may include one or more support or stiffener rods/tubes extending through (e.g., within) and/or adjacent to (e.g., along the surface) the material of the ramp 130 to, e.g., provide more rigidity. For example, the one or more support or stiffener rods/tubes may be welded to the ramp 130 and/or the support 110. For example, as shown in FIGS. 15A and 15B, the support 110 may include stiffener rods 118 on either side of the support and the ramp 130 may include a stiffener rod 119 along the bottom of the ramp 130. Additionally, the ramp 130 may define any suitable thickness such as, e.g., about 0.25 inches, about 0.5 inches, about 0.75 inches, about 1 inch, etc.

The support 110 may define one or more slots 120 extending along the longitudinal axis 101. In one or more embodiments, the one or more slots 120 may be defined in structures or housing coupled to the sides of the support 110. The ramp 130 may be adapted to slide within the one or more slots 120 of the support 110 to maintain positioning when the ramp 130 moves relative to the support 110. In other words, the ramp 130 may be described as movably coupled to the support 110 because the ramp 130 may move relative to the support 110 without disengaging from the support 110. For example, the side edges of the ramp 130 may slide into opposing slots 120 on an under side of the support 110 to guide the ramp 130 to move relative to the support 110. The one or more slots 120 may be positioned proximate one or both of the first end region 112 of the support 110 and the second end region 114 of the support 110. For example, in one or more embodiments, the one or more slots 120 may include a first set of slots 121 located proximate the first end region 112 of the support 110 and a second set of slots 122 located proximate the second end region 114 of the support 110. In such embodiments having slots at both the first and second end regions 112, 114 of the support 110, the ramp 130 may be evenly supported within the slots 120 of the support 110. In one embodiment, the slots 120 may extend within the support 110 along the entire length of the support 110 (or a majority thereof) between the first and second end regions 112, 114.

In one or more embodiments, the support 110 may also include a stopper adapted to restrict movement of the ramp 130 relative to the support 110 such that the ramp 130 may be prevented from extending beyond the support 110 (e.g., such that the ramp 130 disconnects from the support 110). In other words, the stopper may limit the length of the ramp 130 that can extend from the support 110. The stopper may be located proximate the second end region 114 of the support 110. The stopper may include any suitable components to restrict movement of the ramp 130 relative to the support 110 once the ramp 130 reaches a specific position relative to the support 110. For example, in one or more embodiments, the support 110 may include a protrusion (e.g., a bolt head) that interacts with a protrusion (e.g., a bolt head) located on the ramp 130 to act as a mechanical stop.

In other embodiments, the stopper may be located on the ramp 130 and interact with a feature at the second end region 114 of the support 110.

Similarly, in one or more embodiments, the carrier 100 may include a latch 116 adapted to fix the position of the ramp 130 relative to the support 110 (e.g., as shown in FIG. 2). In other words, while the stopper described herein may prevent the ramp 130 from becoming disconnected from the support 110, the latch 116 may lock the position of the ramp 130 relative to the support 110. As such, the ramp 130 may be prevented from inadvertently extending or retracting relative to the support 110 due to the latch 116. The latch 116 may be positioned at the second end region 114 of the support 110 and interact with the ramp 130 to restrict movement thereof. Further, the latch 116 may fix the position of the ramp 130 relative to the support 110 in various different positions including, e.g., at the farthest extended position of the ramp 130, at the farthest retracted position (e.g., the storage position), or somewhere in between. The amount that the ramp 130 extends from the support 110 may alter the angle that is created by the carrier 100 when pivoted to the ground (e.g., also depending on the height of one end or the middle of the carrier 100 off the ground).

The carrier 100 may also include one or more ground engaging members 126 located proximate an end 131 of the ramp 130 (e.g., extending beyond either side of the ramp 130). For example, the ground engaging members 126 may contact the ground surface when the ramp 130 is in the extended position (e.g., to provide a softer contact with the ground surface). As such, the ramp 130 may more easily traverse the ground and protect the surfaces of the ramp 130 (e.g., from scraping along the ground surface). Additionally, the ground engaging members 126 may maintain the end 131 of the ramp 130 above the ground surface such that it is easier for the user to grasp the end 131 of the ramp 130 to lift and pivot the carrier 100. While the ground engaging members 126 illustrated in FIGS. 2 and 3 extend beyond either side of the ramp 130, the ground engaging members 126 may be positioned relative to the ramp 130 at any suitable position including, e.g., below or underneath the ramp 130, extending beyond the end of the ramp 130, adjacent to the sides of the ramp 130, etc.

The ground engaging members 126 may include any suitable components to space the ramp 130 from the ground surface. For example, the ground engaging members 126 may include wheels, pads, blocks, suction cups, etc. As shown in FIG. 3, each of the ground engaging members 126 include a spindle 127 extending outward from the side of the ramp 130 and a wheel 128 (e.g., a circular rubber bumper) that is adapted to have an anti-skid effect along the ground surface. For example, the wheel 128 may assist in preventing the ramp 130 from sliding when the bicycle is rolled onto the ramp 130. Further, the ramp 130 includes tabs 132 extending upward from each side of the end 131 of the ramp 130 and coupled to the spindles 127. In one or more embodiments, the tabs 132 may act as a guide for the bicycle tire entering the ramp 130 to load onto the carrier 100.

In one or more embodiments, the carrier 100 may include bumper feet 150 located at one or both ends of the support 110. The bumper feet 150 may be adapted to raise the support 110 and ramp 130 above a horizontal surface when placed parallel to the horizontal surface. Therefore, when the support 110 is lifted only on the bumper feet 150, the ramp 130 may move relative to the support 110 (e.g., extending away from and to coincide with) without any hinderance from the horizontal surface (e.g., to move freely). In other words, the bumper feet 150 may be used to provide stability

to the carrier 100 by supporting the support 110 only on the bumper feet 150. For example, in some embodiments, the carrier 100 may include various wheels and/or rollers to assist in moving the carrier 100, but the bumper feet 150 space the wheels and rollers above the ground surface when in a resting position (e.g., a storage position) such that the carrier 100 may not slide along the wheels and rollers. Specifically, as described further herein, the carrier 100 may be rolled from an angled position between an elevated surface and the ground surface (e.g., when in the extended position) to the storage position on the elevated surface. The user may be assisted by wheels or rollers to position the carrier 100 onto the elevated surface but, thereafter, the carrier 100 may be rested on the elevated surface and supported by the bumper feet 150 (e.g., and raising the wheels or rollers above the elevated surface). Further, as the ramp 130 is then retracted or stowed to coincide with the support 110, the support 110 may not move along the elevated surface because the support 110 is supported by the bumper feet 150.

As shown in FIG. 2, the carrier 100 includes a pair of bumper feet 150 proximate the first end region 112 of the support 110 and the second end region 114 of the support 110. Specifically, each of the bumper feet 150 may include an arm 151 (as shown in FIG. 3) coupled to the support 110 and extending to a side of the support 110. Further, each of the bumper feet 150 may include a foot 152 coupled to an end of the arm 151 and having a flat surface 153 facing a downward direction (e.g., to contact the surface upon which the carrier 100 is positioned). The bumper feet 150 are sized such that the support 110 may be elevated from a surface upon which the carrier 100 is positioned by about 0.5 inches. Further, the bumper feet 150 may be sized such that the roller 190 (as will be discussed further herein) may be spaced away from the surface by about 0.375 inches (e.g., to prevent the carrier 100 from rolling at an undesired time). Further, the distance from the roller 190 to the surface may be such that the carrier need not be lifted excessively high to engage the roller 190 with the surface. Further, in one or more embodiments, the bumper feet 150 (e.g., the foot or feet 152) may be positioned below or underneath the support 110.

The carrier 100 may also include side rails 160 positioned away from the top surface 111 of the support 110 and extending generally along the longitudinal axis 101. The side rails 160 may be adapted to guide tires of the bicycle onto the support 110 and maintain the tires on the support 110. For example, the side rails 160 may be positioned on each side of the support 110 such that the tires pass between the side rails 160 when loading onto the support 110. Further, the rear tire of the bicycle may be positioned between the side rails when the bicycle is loaded on the carrier 100 (e.g., creating a slot for the tire to be clamped into and vertically supported). Further yet, as will be described further herein, the side rails 160 may be coupled to clamps 140 such that the clamp 140 may move the side rails 160 to contact and hold the rear tire into place.

In one or more embodiments, the side rails 160 may include more than one side rail on either side of the support 110. For example, as shown in FIG. 2, the side rails 160 may include a pair of side rails on each side of the support. Specifically, the side rails 160 may include a lower side rail 162 that is positioned closer to the top surface 111 of the support 110 (e.g., but still spaced apart therefrom) and an upper side rail 164 that is spaced apart from the lower side rail 162. In FIG. 2, the side rails 160 both extend along the longitudinal axis. In FIG. 3, the lower side rail 162 defines

a plate (e.g., located at the clamp **140**). Having multiple side rails **160** at different elevations may assist in containing the tires of the bicycle and provides more points of contact upon which the side rails **160** may compress on the tire (e.g., when moved by the clamps **140** as described herein). Also, the two level side rails **160** may help to keep the bicycle in an upright position. In one or more embodiments, the side rails **160** may extend generally along the longitudinal axis **101** but may widen or taper at the ends of the side rails **160** to guide a tire of the bicycle through or between the side rails **160**.

As shown in FIG. 3, the carrier **100** may include clamps **140** (e.g., a pair of clamps) on either side of the support **110**. Specifically, the clamps **140** may be located proximate the second end region **114** of the support **110** and adapted to contact a rear tire of the bicycle. The clamps **140** may be adapted to be moved inward and outward (e.g., through a set clamping motion) relative to the sides of the support **110** to contact the rear tire of the bicycle when the bicycle is loaded on the carrier **100** (e.g., to physically restrict motion of the rear tire). In other words, the pair of clamps **140** may be positioned on either side of the support **110** such that a gap is defined between the pair of clamps **140**. As the clamps **140** are engaged (e.g., by engaging one or both of the clamps to move a set distance inward), the gap therebetween may decrease and a tire of the bicycle may be restricted by contact from the clamps **140** on both sides of the tire. As the clamps **140** are disengaged (e.g., by disengaging one or both of the clamps **140** to move a set distance outward), the gap therebetween may increase and the tire of the bicycle may be free to move between the clamps **140**. In other words, when the gap distance is less than the width of the tire, the clamps **140** may apply pressure to the tire to restrict it from moving and when the gap distance is greater than the width of the tire, the clamps **140** do not impede motion of the tire. In one or more embodiments (e.g., as described further herein in connection with FIGS. 15A and 15B), the carrier **100** may only include a single clamp **140** on one side of the support **110** and positioned between the first and second end regions **112**, **114** (e.g., between the front and rear wheels when the bicycle is positioned on the carrier **100**). A single clamp **140** may move relative to a rail positioned on the other side of the support **110** to apply pressure therebetween.

As noted herein, in one or more embodiments, each clamp **140** may be coupled to the side rails **160** (e.g., one or both of the lower and upper side rails **162**, **164**). Therefore, the side rails **160** may move inward and outward with the clamp **140** to contact the rear tire of the bicycle (e.g., when the clamps **140** are engaged or disengaged). By having the side rails **160** attached to the clamps **140**, the rear tire may be contacted by the side rails **160** at multiple locations and may provide more reliable compression on the rear tire (e.g., due to multiple contact points).

Also, the clamps **140** may be adjustable in a variety of different ways. For example, the clamps **140** may be adjusted to move along the longitudinal axis **101** to position the clamps **140** at a desired location along the length of the bicycle. Further, for example, the clamps **140** may be adjusted inward and/or outward (e.g., separate from the clamping motion associated with engaging and disengaging) to set the clamps **140** at an initial position. After the clamps **140** are set into place, the clamps **140** can be engaged or disengaged to move a set distance to clamp or release the tire. Specifically, each of the clamps **140** may be adapted to slide along a plate **142** (e.g., as shown in FIG. 3) in a direction transverse to the longitudinal axis **101**. Further, each of the clamps **140** may include a locking lever **144** to fix the clamp **140** to the plate **142**, thereby setting the

transverse position of the clamp **140** relative to the support **110** (and, e.g., the distance between the clamps **140**). In one or more embodiments, the plate **142** may include a scale (e.g., an engraving) to assist in pre-positioning the clamps **140** relative to one another (e.g., the scale may be configured to include increments of known tire widths). Further, in one or more embodiments, the plate **142** may extend above the support **110** to reduce the potential for interference with the ramp **130** that is positioned below the support **110**. In embodiments in which the side rails **160** are connected to the clamps **140**, the side rails **160** may also move along the longitudinal axis **101** and/or transverse to the longitudinal axis **101**.

In one or more embodiments, the support **110** may define a first opening **115** located proximate the second end region **114**. Similarly, the ramp **130** may also define a second opening **135** located proximate an end **131** of the ramp **130** that is adapted to correspond with the first opening **115**. When the ramp **130** is in the storage position (e.g., when the ramp **130** is stowed relative to the support **110**), the first and second openings **115**, **135** may align at least partially such that there is an opening that passes through both of the support **110** and the ramp **130**. When the first and second openings **115**, **135** are at least partially aligned, a locking device (e.g., a rope, a cable, a chain, etc. having a lock attached thereto) may extend through both of the openings **115**, **135** to lock the ramp **130** in position relative to the support **110**. This locking device may act as a security system to prevent the ramp **130** from being extended by someone other than the intended user. Further, the locking device may prevent the carrier **100** from being separated from the vehicle, trailer, etc. As shown in FIGS. 2 and 3, the first and second openings **115**, **135** define an oval shape, but may define any suitable shape (e.g., square, circle, rectangle, etc.).

Also, in one or more embodiments, the second opening **135** of the ramp **130** may also act as a handle (e.g., proximate the end **131** of the ramp **130**) to, e.g., provide the user with a handle to assist in moving the ramp **130** relative to the support **110**. For example, the user may use the second opening **135** of the ramp **130** to grasp the ramp **130** and extend/retract the ramp **130** relative to the support **110**. Further, the wheels **128** or the end **131** of the ramp **130** may be used as a handle to manipulate the ramp **130**.

FIG. 4 illustrates a pivot mount assembly **170** of the carrier **100** that pivots relative (e.g., pivotally coupled) to the support **110** such that the support **110** may pivot into a desired position. In other words, the support **110** may pivot to move between a loading position (e.g., when the carrier **100** is positioned at an angle to the ground surface) and a storage position (e.g., when the carrier **100** is positioned in a generally horizontal position). The pivot mount assembly **170** may include (e.g., be formed of) any suitable materials such as, e.g., plastic, metal, etc. In such embodiments in which the pivot mount assembly **170** includes plastic, metal on metal interactions may be avoided and may assist in positioning the ramp **130** closer to the support **110**. Further, the pivot mount assembly **170** may include a support plate **172** fixedly coupled to the support **110** and a mount plate **174** pivotably coupled to the support plate **172**. For example, each of the support plate **172** and the mount plate **174** may include features (e.g., knuckles) that intertwine with one another and include a pull pin **176** (e.g., a spring pin) extending through each of the knuckles. Therefore, the mount plate **174** may pivot relative to the support plate **172** about a pivot axis **175** defined by the pull pin **176** of the pivot mount assembly **170**. In one or more embodiments, the

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pull pin 176 may be removable from the mount plate 174 and the support plate 172 (e.g., to easily disassemble components, as described herein). In one or more embodiments, the pull pin 176 may be a fixed pin that is not adapted to be removed.

The pivot axis 175 may be positioned relative to the support 110 perpendicular to the longitudinal axis 101 between the first and second end regions 112, 114. Specifically, in some embodiments, the pivot axis 175 may be positioned just forward of the center of gravity of a bicycle supported on the support 110. As such, the bicycle may not automatically pivot the support 110 to a horizontal position when the bicycle is fully loaded on the support 110, but would only pivot due to the user manually pivoting the support 110. Therefore, due to the position of the pivot axis 175 relative to the center of gravity of the bicycle, the bicycle can be fully loaded on an angled carrier 100 and then the carrier 100 can be pivoted to a generally horizontal position. Although, in other embodiments, the pivot axis 175 may be positioned at or behind the center of gravity of a bicycle supported on the support 110.

When the pull pin 176 is positioned in the knuckles of the mount plate 174 and the support plate 172, the support 110 may pivot about the pivot axis 175, which is at an angle (e.g., perpendicular) to the longitudinal axis 101. When the pull pin 176 is removed from the knuckles of the mount plate 174 and the support plate 172, the support 110 and ramp 130 may be removed from the mount plate 174 for storage purposes (e.g., when the mount plate 174 is attached to a car hitch or trailer as described herein). In other words, the support 110 and ramp 130 may be easily stored without detaching other components that are attached to a vehicle or trailer. It is noted that while the pull pin 176 may be removable to easily attach and detach the support 110 and ramp 130 to and from the pivot components, in one or more embodiments, the pull pin 176 may be fixed (e.g., not removable).

The mount plate 174 may be fixedly coupled to any structure upon which the carrier 100 may be mounted or positioned. For example, the pivot mount assembly 170 may further include a mounting member 178 (e.g., a shank) fixedly coupled to the mount plate 174 and adapted to be inserted into a hitch receiver of a vehicle. As such, the carrier 100 may be inserted into and removed from the hitch receiver of the vehicle as desired. The hitch receiver may be on the front or back of a vehicle such as, e.g., a passenger vehicle, a public transportation vehicle (e.g., mass transit, a bus, train, etc.), a taxi, a self-driving vehicle, a trailer, a camper, a recreational vehicle, etc. The mounting member 178 may include an anti-rattle collar (e.g., two-piece) that may butt-up against the hitch receiver through a rubber anti-rattle rubber gasket that may fit between the collar and the hitch receiver tube. The mounting member 178 may also include a welded on loop to route a security chain or cable through (e.g., this weldment may be case hardened to help restrict cutting off). In one or more embodiments, the mounting member 178 may include an end stop so that if the fastener (e.g., U-bolt) mounting the pivot mount assembly 170 to the mounting member 178 were to unintentionally loosen, the pivot mount assembly 170 may not slide off the mounting member 178.

Further, the carrier 100 may pivot while attached to the vehicle so that the user may load the bicycle onto the carrier 100 (e.g., when the carrier 100 is extended through the ramp 130 and contacting the ground surface) for support and transportation (e.g., when the carrier 100 is in the storage position and the bicycle may be restricted thereon). Also, in one or more embodiments, the mount plate 174 may be

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fixedly coupled to a transport trailer (e.g., the retention housing 380 as shown in FIG. 12) such that the carrier 100 may pivot relative to the transport trailer and load a bicycle onto the carrier 100 to be transported by the transport trailer.

Additionally, the pivot mount assembly 170 may also include a retention housing 180 that defines one or more slots 182 extending along the longitudinal axis 101 (e.g., as shown in FIG. 5). The retention housing 180 may be fixedly coupled to the mount plate 174, as shown in FIG. 4, so that the support 110 and ramp 130 may be able to pivot relative to the retention housing 180. However, the retention housing 180 may also act as a lock for the pivoting motion of the support 110 and ramp 130. For example, the ramp 130 may be adapted to slide within the one or more slots 182 of the retention housing 180. Specifically, the one or more slots 182 of the retention housing 180 may be similar to the one or more slots 120 of the support 110 as described herein. The one or more slots 182 of the retention housing 180 may open inwardly and the retention housing 180 may extend on either side of the ramp 130 (e.g., the slots 182 may be positioned on either side of the ramp 130).

When the ramp 130 is positioned within the one or more slots 182 of the retention housing 180 (e.g., in the storage position), the support 110 may be restricted from pivoting relative to the retention housing 180 (e.g., about the pivot axis 175) because the ramp 130 is constrained by the one or more slots 182. In other words, because the ramp 130 pivots with the support 110, if the ramp 130 is prevented from pivoting due to being positioned in the one or more slots 182 of the retention housing 180, the support 110 (and the carrier 100) cannot pivot. When the ramp 130 is not positioned within the one or more slots 182 of the retention housing 180 (e.g., in the extended position), the support 110 is able to pivot relative to the retention housing 180 (e.g., about the pivot axis 175) to a position in which the ramp 130 contacts the ground surface to load a bicycle. In other words, because the ramp 130 is not restricted by being within the one or more slots 182 of the retention housing 180, the support 110 is free to pivot. Therefore, in one or more embodiments, the ramp 130 may act as a lock to the pivoting of the carrier 100, whether it is in the storage position (e.g., locked) or the extended position (e.g., unlocked). As a result, the pivot lock/unlock may be controlled by movement of the ramp 130, which is easily accessible to the user at the rear of the carrier 100 and does not interfere with a bicycle positioned on the carrier 100.

Further, as shown in FIG. 5, the retention housing 180 may define a top surface edges 184 on both sides (e.g., along the housing that defines the one or more slots 182) that are adapted to restrict the support 110 from pivoting in a direction through the retention housing 180. For example, because the support 110 pivots about the pivot axis 175, the support 110 can freely pivot in one direction, but may be restricted from pivoting in the other direction. Further, the top surface edges 184 of the retention housing 180 may act as a guide for retracting the ramp 130 into the one or more slots 182 of the retention housing 180 because the ramp 130 may be aligned with the one or more slots 182 when the support 110 is in contact therewith. The retention housing 180 may include (e.g., be formed of) any suitable material including, e.g., plastic, metal, etc.

As discussed herein, in one or more embodiments, the carrier 100 may include a roller 190 (e.g., as shown in FIG. 6). The roller 190 may be located proximate the first end region 112, under the support 110 and may be adapted to rotate about an axis perpendicular to the longitudinal axis 101. The roller 190 may be used to move and transport the

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carrier **100** across a surface. For example, the carrier **100** may be lifted at an angle such that only the roller **190** is in contact with the surface and the carrier **100** can be moved or transported using the roller **190**. In one or more embodiments, the roller **190** may extend at least partially beyond the first end region **112** of the support **110**.

Further, in one or more embodiments, the support **110** may also include a front tire portion **192** located proximate the first end region **112**. The front tire portion **192** may be adapted to contact a front tire of the bicycle loaded on the support **110**. The front tire portion **192** may define a plurality of channels **194** (e.g., front wheel slots) to assist in retaining the front tire of the bicycle on the top surface **111** of the support **110** (e.g., by providing traction and grip) when the bicycle is positioned on the carrier **100**. In one or more embodiments, the plurality of channels **194** may extend at an angle to the longitudinal axis **101**. For example, the plurality of channels **194** may extend at an angle of about 45 degrees to the longitudinal axis **101**.

As shown in FIG. 6, the plurality of channels **194** may be concave or V-shaped (e.g., so that the middle is lower than the sides) so that the front wheel may be easier to hold in place. Specifically, in one or more embodiments, the concave or V-shaped portion (e.g., inclined towards the center and the ends of the channels **194** more pronounced) form a surface on which the front wheel may be easier to turn and sit up on the ends of the channels **194** for increased leverage for holding the front wheel in place when the bicycle is strapped down. More specifically, the front fork rake angle may help with the wheel turn retention so the bicycle may not need to be highly forcibly strapped down.

Also, in one or more embodiments, the plurality of channels **194** may help to rotate the front tire into an angled position that helps retain the bicycle on the support **110**. Further, by turning the front tire of the bicycle, the overall width of multiple nested bicycles may decrease and the length of the stored bicycle may be reduced.

FIG. 7 illustrates two carriers **100** in different positions relative to an elevated surface **10**. For example, a first carrier **100a** is configured in the extended position and located between the elevated surface **10** and a ground surface **12**, and a second carrier **100b** is configured in the storage position and located on the elevated surface **10**. The first carrier **100a** configured in the extended position (e.g., having the ramp **130** extended from the support **110** to create a longer carrier) is ready for a bicycle to be loaded onto the support **110** of the first carrier **100a**. The second carrier **100b** configured in the storage position (e.g., having the ramp **130** retracted to coincide with the support **110**) represents a location when the carrier **100** is loaded onto the elevated surface **10**. As such, the carrier **100** provides a dual function of a ramp **130** (e.g., due to the retractable component of the ramp **130**) up to an elevated surface **10** and a structure for storing a bicycle (e.g., as compared to two separate components—a ramp to an elevated surface and a bike holder). As shown in FIG. 7, the elevated surface **10** is represented by a truck bed, but any elevated surface **10** is contemplated herein (e.g., including a trailer, a workbench, etc.).

The process of moving the carrier **100** from the extended position (e.g., as shown with the first carrier **100a**) to the storage position (e.g., as shown with the second carrier **100b**) may include loading the bicycle onto the carrier **100**, securing the bicycle to the carrier **100** (e.g., using the straps and/or clamps **140**), lifting the end of the ramp **130** until the roller **190** contacts the elevated surface **10**, rolling the carrier **100** onto the elevated surface **10**, lowering the carrier **100** until supported by the elevated surface **10** (e.g., using the

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bumper feet **150**), and retracting the ramp **130** into the support **110** (e.g., as shown with the second carrier **100b**). The process of moving the carrier **100** from the storage position (e.g., as shown with the second carrier **100b**) to the extended position (e.g., as shown with the first carrier **100a**) may include pulling the ramp **130** from the support **110** to the extended position, lifting the carrier **100** (e.g., via the end **131** of the ramp **130**) until the roller **190** contacts the elevated surface **10**, rolling the carrier **100** until the first end region **112** of the support **110** is near an edge of the elevated surface **10**, lowering the end **131** of the ramp **130** until the end **131** of the ramp **130** is proximate the ground surface **12** (e.g., as shown with the first carrier **100a**). These processes may be fully completed by the user while standing on the ground surface **12** (e.g., without climbing onto the elevated surface **10**) because the carrier **100** is moved relative to the elevated surface **10** with the bicycle loaded thereon.

Also illustrated in FIG. 7 is a bike facing fairing **196** positioned forward and elevated relative to the second carrier **100b**. For example, as shown in FIG. 7, the bike facing fairing **196** may be mounted to a truck rack cross bar. The bike facing fairing **196** may be adapted to break the wind or weather (e.g., flowing over the cab of the truck) to protect the electronics and mechanisms often located on handlebars of electronic bicycles.

FIGS. 8-11 illustrate another embodiment of a carrier **200** for supporting and transporting a multiple track recreational vehicle (e.g., a tricycle, a quadracycle, a trailer, etc.). It is noted that the carrier **200** illustrated in FIGS. 8-11 shares many features that are described in connection with the carrier **100** illustrated in FIGS. 1-7.

The carrier **200** may include at least two supports **210** positioned apart from one another and extending parallel to one another. As shown in FIG. 8, the carrier **200** may include three supports **210** to carry tires (e.g., three tires) positioned along three separate tracks (e.g., each tire arranged on its own track). In some embodiments, there may be only two separate tracks (e.g., two or more tires arranged on two separate tracks) positioned on two of the three supports **210** (e.g., the two outside supports, the left and middle supports, or the right and middle supports). In other embodiments, the carrier **200** may only include two supports, four supports, five supports, etc. to carry any number of tires arranged along any number of tracks. In one or more embodiments, the supports **210** of the carrier **200** may be separable from each other.

Also, in one or more embodiments, the supports **210** may be adjusted relative to one another (e.g., closer to one another or farther away from one another) to specifically fit any tire spacing. In other words, the user may adjust the carrier **200** to the appropriate support width for a given recreational vehicle.

Each of the supports **210** may extend between a first end region **212** and a second end region **214** along a longitudinal axis **201** (e.g., parallel to the longitudinal axis **201**). Each of the supports **210** may be adapted to receive and contact tires of the multiple track recreational vehicle (e.g., tricycle, quadracycle, trailer, etc.). For example, in some embodiments, the supports **210** may interact with a single tire or multiple tires (e.g., front and back tires along a single track).

Further, each of the supports **210** may include a front portion **202** and a rear portion **204** extending at an angle to horizontal such that a front end **205** of the rear portion **204** is spaced a gap distance from the front portion **202**. As such, a front tire traveling along the support **210** from the rear portion **204** to the front portion **202** may drop down the gap when transitioning from the rear portion **204** to the front

portion **202**. The angled rear portion **204** and gap between rear portion **204** and the front portion **202** may help secure the front tire on the front portion **202**. For example, the front tire may easily drop down from the rear portion **204** to the front portion **202** when loading the front tire on the support **210**, but when removing the front tire from the support **210**, the front tire may have to overcome the gap (e.g., by lifting or applying increased force) to move the front tire backwards for unloading. Further, in one or more embodiments (e.g., as shown in FIGS. **8** and **9**), the front portion **202** may include a ramp angled upwards (e.g., towards the first end region **112**) and supported on the top surface **211**. The ramp may help support the front wheel of the bicycle by forcing the wheel back towards the front end **205** of the rear portion **204**. Further, in one or more embodiments, the ramp on the front portion **202** may define channels that extend parallel to the longitudinal axis to assist in maintaining the front wheel in place.

In one or more embodiments, the carrier **200** may include stepped inclining centering bars located proximate the front portion **202** of the support **210**. The stepped inclining centering bars may assist in restricting the recreational vehicle from moving side to side when the vehicle is strapped down. Also, the stepped inclining centering bars may be inclined to form a slope such that the vehicle may be prevented from moving forward (e.g., similar to the incline of the rear portion **204**).

Similar to the other carrier **100** (e.g., described in connection with FIGS. **1-7**), each support **210** of the carrier **200** may include one or more slots **220** extending along the longitudinal axis **201**. Also, the carrier **200** may include at least two ramps **230** corresponding to each of the at least two supports **210** and adapted to move relative to the corresponding support **210** along the longitudinal axis **201**. Specifically, each of the at least two ramps **230** may slide within the one or more slots **220** of the corresponding support **210**.

The at least two ramps **230** may be configurable between an extended position (e.g., as shown in FIG. **9**) and a storage position (e.g., as shown in FIG. **8**). For example, the ramps **230** are extended from the supports **210** so that a recreational vehicle (e.g., tricycle, quadracycle, trailer, etc.) may be loaded on the carrier **200** and the ramps **230** are stowed to coincide with the supports **210** when in the storage position to store and/or transport the recreational vehicle.

Further, the length of the at least two supports **210** may be sufficient to position the tires of the recreational vehicle on the top surface **211** of the support **210** (e.g., with any needed extra surface of the support **210** in front of the front tire and rearward of the rear tire). For example, the at least two supports **210** may define a length of about 72 inches measured between the first end region **212** and the second end region **214** along the longitudinal axis **201**. The length of the at least two supports **210** may also align with the amount of space provided within the bed of a pickup truck (e.g., when the carrier **200** is loaded into the bed) or such that the carrier **200** does not stick out beyond the sides of a vehicle (e.g., when the at least two supports **210** are positioned on the vehicle transverse to the direction of motion of the vehicle) such as, e.g., when the carrier **200** is attached to a hitch. Additionally, each of the supports **210** may define a width of about 6 inches to about 12 inches measured perpendicular to the longitudinal axis **201** (e.g., to accommodate any width of bicycle tire) and the overall width of a carrier **200** including three supports **210** may be about 32 inches. It is noted that portions of the recreational vehicle may be wider than the carrier **200** and those portions may overhang the carrier **200**.

The at least two ramps **230** may define any suitable length to extend the overall length of the carrier **200**. Further, the length may change the angle at which the carrier **200** extends (e.g., making loading and unloading easier) and may provide differing mechanical advantages for pivoting the carrier **200** with a recreational vehicle loaded thereon. In one or more embodiments, the at least two ramps **230** may define a length that is less than or equal to the length of the at least two supports **210**, e.g., such that that ramp **230** may be stowed to coincide with the support **210**. For example, the at least two ramps **230** may define a length that is substantially the same as the length of the at least two supports **210**. In other embodiments, the length of the at least two ramps **230** may be greater than the length of the at least two supports **210** such that the at least two ramps **230** protrude from an end of the at least two supports **210** when in the storage position. Specifically, the at least two ramps **230** may define a length of about 65 inches to about 72 inches measured along the longitudinal axis. Further, the carrier **200** may define an overall length of about 132 inches to about 135 inches when the at least two ramps **230** are in the extended position.

As shown in FIGS. **8** and **9**, the carrier **200** may include a cross bar **206** coupled to an end **231** of each of the at least two ramps **230** to maintain spacing between the at least two ramps **230** and synchronize movement of each of the at least two ramps **230**. In other words, the ramps **230** move together when extended and retracted such that, e.g., when one ramp is moved, the other ramp(s) move the same. Further, the cross bar **206** maintains the spacing between the ramps **230** such that the tires of the recreational vehicle can move along the ramps **230** and maintain contact with the ramps **230**. It is noted that the cross bar **206** may also be used as a handle to extend and retract the ramps **230**.

Further, in one or more embodiments, the carrier **200** may include rollers **290** located proximate the first end region **212** of each of the at least two supports **210**. The roller **290** may be adapted to rotate about an axis perpendicular to the longitudinal axis **201** to roll the carrier **200** along a surface for transportation or positioning (e.g., similar to as described in connection with carrier **100**). Additionally, in one or more embodiments, the front portion **202** of each of the at least two supports **210** may define an opening **219** proximate the first end region **212**. The openings **219** may help reduce the overall weight of the carrier **200**.

Similar to the carrier **100** described in FIGS. **1-7**, the carrier **200** may include a feature that allows the carrier **200** to pivot about a pivot axis in such embodiments when the carrier **200** is positioned on a hitch mount or bar (e.g., for use with a pull-behind trailer). For example, the carrier **200** may include a pivot mount assembly **270** pivotably coupled to one support of the at least two supports. Also, the pivot mount assembly **270** may include a retention housing and an axis. The retention housing may define one or more slots extending along the longitudinal axis **201**. The support **210** may pivot about an axis transverse to the longitudinal axis **201**. The ramp **230** corresponding to the one support **210** may be adapted to slide within the one or more slots of the retention housing. The one support **210** may be restricted from pivoting about the axis when the ramp **230** is within the one or more slots and the one support **210** may be pivotable about the axis when the ramp **230** is not within the one or more slots.

In one or more embodiments, the carrier **200** may include more than one pivot mount assembly (e.g., one corresponding to each of the at least two supports) such that each support **210** may include a pivot point. It is noted that only one of the pivot mount assemblies may lock and unlock the

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carrier from pivoting (e.g., so that the carrier may not include multiple locks on the same carrier). Although, in some embodiments, the carrier may include multiple pivot mount assemblies that lock and unlock the carrier from pivoting.

Also, similar to the carrier 100 illustrated in FIGS. 1-7, the carrier 200 may be positioned relative to an elevated surface 10. For example, as shown in FIG. 10, the carrier 200 may be positioned between an elevated surface 10 (e.g., a truck bed, a trailer deck, a workstation, etc.) and a ground surface 12 when the carrier 200 is in an extended position (e.g., having the ramps 230 extended from the supports 210) such that a vehicle can be loaded onto the elevated surface via the carrier 200. As shown in FIG. 11, the carrier 200 may be positioned on the elevated surface 10 in a storage position (e.g., having the ramps 230 retracted to coincide with the supports 210). Further, the rollers 290 of the carrier 200 may assist in rolling the carrier 200 along the elevated surface 10 to transition between the storage position and the extended position. Further yet, similar to the carrier 100, the carrier 200 may include bumper feet 250 to support the carrier 200 on the elevated surface 10.

In one or more embodiments, the carrier 200 may include one or more straps to secure the recreational vehicle thereon. For example, the carrier 200 may include dual straps originating from about the center of the carrier 200. The first strap may be wrapped around the center of the recreational vehicle in a vertical plane, and together with the front stepped profiles, may prevent the recreational vehicle from moving side to side. Further, in combination with the rear inclined floors and the increasing heights of the front step profiles, the recreational vehicle may be prevented from moving forward. The second strap may extend from the center of the carrier 200 and angled back around the rear of the recreational vehicle to hold the vehicle forward against the inclines so the vehicle cannot move backwards.

FIG. 12 illustrates a transport trailer 300 that may be hauled behind a passenger vehicle and may include a carrier (e.g., the carrier 100 of FIGS. 1-7 and/or the carrier 200 of FIGS. 8-11) coupled thereto. For example, the trailer 300 may include a frame 302 that is attached to the passenger vehicle using a hitch mount/coupler and also supported above a ground surface by wheels 304. Further, the trailer 300 may have at least one crossmember 310 extending transversely and adapted to support the carrier 100, 200 (and/or, for example, a conventional bicycle carrier). In other words, the trailer 300 may act as a bike rack on wheels (e.g., by detaching the trailer 300 from the towing vehicle and positioned somewhere to be used as a bike rack) due to the carrier 100, 200 positioned on the trailer 300. For example, in one or more embodiments, the trailer 300 may be attached to a hitch ball attached to a wall (e.g., a wall in a garage) or on a post to be used as a bike rack when not connected to a towing vehicle. In one or more embodiments, the carrier 100 and/or carrier 200 may be not include a ramp or pivotability and may be used similar to a conventional bicycle carrier (e.g., the bicycle is lifted into place onto the carrier). These non-pivotable and no ramp carriers may be used in any configurations as described herein (e.g., in a truck bed, on a trailer 300, on an elevated surface, etc.).

Specifically, as shown in FIG. 12, a retention housing 380 of a pivot mount assembly (e.g., as described herein) may be fixedly coupled to the crossmember 310 of the trailer 300 (e.g., using any suitable fastener such as a U-bolt). Further, the remaining components of the carrier 100, 200 may be pivotably coupled to the retention housing 380. Therefore, the carrier 100, 200 may be pivotable relative to the reten-

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tion housing 380 (e.g., and the crossmember 310 of the trailer 300) and also pivotably lockable relative to the retention housing 380 (e.g., by extending or retracting the ramp as described herein). The carrier 100, 200 may be adapted to pivot such that an end of the ramp is touching the ground surface such that the vehicle can be loaded onto the carrier 100, 200, and the carrier 100, 200 may be pivoted to a generally horizontal position for transporting the vehicle.

As such, the trailer 300 may be adapted to receive and transport one or more recreational vehicles (e.g., bicycles, tricycles, quadracycles, trailers, etc.) using one or more carriers 100, 200. For example, any combination of carriers 100 and carriers 200 may be supported by the trailer 300 to transport the various types of recreational vehicles. Specifically, as shown in FIGS. 13A and 13B, the trailer 300 includes four carriers 100 to support and transport a vehicle having a single lane track (e.g., a bicycle). It is noted that the plurality of channels angled at 45 degrees proximate the first end region of the carriers may help to position the carriers closer to one another on the trailer (e.g., narrowing the overall width and reducing the length) due to, e.g., a nesting effect (e.g., of the handlebars). Although, in one or more embodiments, adjacent carriers may be offset along the longitudinal axis such that the bicycles carried thereon may be nested (e.g., by offsetting the handlebars of adjacent bicycles). In FIGS. 13A and 13B, one of the four carriers 100 is configured in the extended position (e.g., the ramp extended and pivoted such that an end of the ramp contacts the ground surface) and the other three carriers 100 are configured in the storage position. As shown in FIG. 14, the trailer includes two carriers 100 to support and transport a vehicle having a single lane track (e.g., a bicycle) and one carrier 200 to support and transport a vehicle having a multiple lane track (e.g., a tricycle, a quadracycle, a trailer).

Further, as shown in FIGS. 12-14, the trailer 300 may include a front fairing 320 and a floor area 322 located under the front fairing 320. The floor area 322 may include a solid floor or remain generally open (e.g., such that a solid floor surface may be optionally added later). A cover 324 may be positioned over the front fairing 320 to block wind, rain or anything kicked up by a vehicle when transporting the trailer 300. This may be particularly beneficial when carrying electronic bicycles due to the more expensive electronic components (e.g., by protecting them from potential harm when transporting). Further, the front slope and diagonal sides of the front fairing 320 may help to accelerate water, debris, etc. upward and outward such that the water, debris, etc. may be projected beyond the cargo and carriers 100, 200 of the trailer 300. In one or more embodiments, the cover 324 may include openings 325 near the floor area 322 and on the sides to provide access for loading and unloading cargo onto the floor area 322. In one or more embodiments, the cover 324 may be transparent or translucent such that a user may be able to see through the cover 324 (e.g., for better rearward visibility while driving and towing the trailer 300). The floor area 322 may be sized to fit a variety of different types of cargo including, e.g., batteries, chargers, generators, solar panels, tents or cabanas (e.g., to be used to further cover the trailer), backpacks, etc. In some embodiments, the floor area 322 may not be included or could be optionally installed at the need of the user. Further, optional specific purpose mounts may be provided for a more cost-effective method for securing and carrying specific devices such as, e.g., a generator and an enclosure for battery chargers for charging a battery enroute to destinations. For example, FIG. 21 illustrates a trailer 300 including various accessories that

may be used with the trailer 300. For example, a generator and a charger/battery box may be included in the front accessory mounting area.

The trailer 300 may define a height (measured from the ground surface) of less than or equal to seven feet (e.g., the typical garage door opening height). Also, the trailer 300 may not include a platform or surface (e.g., in addition to the frame) such that the carriers 100, 200 may pivot in place to contact the ground surface (e.g., instead of a platform or surface) for loading and unloading. Therefore, a user accessing the trailer 300 may stand on the ground surface due to the lower height of the carriers 100, 200. Further, the trailer 300 may have a reduced weight due to the lack of a platform or surface (e.g., to offset the potential increased weight of the electronic bicycles).

Additionally, as shown in FIG. 14, the trailer 300 may include a lift frame 350 located near the back of the trailer 300. For example, the trailer 300 may include two rear extending members 352 (e.g., one on each side) projected from the back of the trailer 300 to provide clearance for the lift frame 350 (e.g., to provide room under the lift frame 350 that is away from the carriers 100, 200). The lift frame 350 may be movably coupled to the rear extending members 352 at vertical members 354 and have a top beam 356 spanning between the vertical members 354. The top beam 356 may provide a sturdy structure from which devices and transport vehicles (e.g., cot, wheelchair, etc.) may be supported and lifted for increased accessibility for the user. For example, the lift frame 350 (e.g., the top beam 356, specifically) may help in assisting transfer of a disabled person from a wheelchair to recreational vehicles like an electronic tricycle, an electronic quadracycle, a beach wheelchair, etc. (e.g., providing a lift point or trolley for use with a portable patient lifter). Further, the trailer 300 may include trailer tongue jacks 358 for raising the lift frame 350 from a travel position and a use position. Also, the trailer tongue jacks 358 may help support the lifted weight and level the lift frame 350.

FIGS. 15A and 15B illustrate another embodiment of the carrier 100 described herein. For example, the side rails 160 (e.g., on either side of the support 110) may extend for a substantial portion of the support 110 (e.g., extending between the first and second end regions 112, 114). Specifically, the side rails 160 may be spaced apart from the support 110 by about 2 inches to about 6 inches (e.g., about 4.25 inches). In one or more embodiments (e.g., as shown in FIG. 15A), one of the side rails 160 may be fixed relative to the support 110 while the other side rail 160 may move relative thereto. For example, one of the side rails 160 may be movable inward and outward using the clamp 140. In other words, the gap between the side rails 160 may be altered by only moving one of the side rails 160 through the clamp 140.

Further, as shown in FIG. 15A, the carrier 100 may include vertical supports 166 proximate the first end region 112 of the support 110 on either side of the support 110. The vertical supports 166 may assist with stabilizing and supporting the bicycle in an upright position (e.g., by maintaining the front wheel in a straight configuration). Additionally, the carrier 100 may also include a roller 190 proximate the first end region 112 and offset below the support 110 (e.g., as shown in FIG. 15B). For example, the roller 190 may assist with rolling the carrier 100 into a storage location (e.g., a garage, etc.) without dragging or carrying the carrier 100. Further, the carrier 100 may rest on the roller 190 and the ground engaging member 126 (e.g., on a ground surface) to position the carrier 100 in a horizontal orientation to, e.g., operate as a bike rack.

FIGS. 16A and 16B illustrate another embodiment of the carrier 200 described herein, e.g., to support a multiple track recreational vehicle (e.g., a tricycle, a quadracycle, a trailer, etc.) with at least two supports 210 positioned apart from one another and extending parallel to one another. As shown in FIGS. 16A and 16B, the rear portion 204 of the support 210 is similar to as described herein and the front portion 202 may include a crossbar extending across the at least two supports 210. Further the crossbar of the front portion 202 may be angled relative to horizontal to help support the front wheel of the bicycle (e.g., between the front and rear portions 202, 204). Additionally, the carrier 200 may include sidewalls 218 extending for a length of the carrier proximate the front portion 202. The sidewalls 218 may be positioned on one or both sides of each support 210 to, e.g., assist in maintaining a lateral position of the front wheel(s) of the bicycle. As shown in FIGS. 16A and 16B, the middle support 210 includes sidewalls on both sides proximate the front portion 202 and the outer supports 210 include sidewalls only on the inner side proximate the front portion 202.

Furthermore, the carrier 200 illustrated in FIGS. 16A and 16B only includes a roller 290 located at the front end region 212 of the middle support 210. Also, the pivot mount assembly 270 is only positioned on the middle support 210 and pivoting of the middle support 210 is transferred to the outer supports 210.

FIG. 17 illustrates the carrier 100 extended and positioned between an elevated surface 10 (e.g., a truck bed) and a ground surface 12 with a bicycle in the loading process. For example, the rear wheel of the bicycle is clamped in to stabilize the bicycle relative to the carrier 100. Further, the front wheel of the bicycle is not yet rotated to 45 degrees and the bicycle is not yet strapped down. The next steps of loading the bicycle may include lifting the carrier 100 to a generally horizontal position, rolling the carrier 100 into the truck bed, and storing the ramp 130 to coincide with the support 110.

FIG. 18 illustrates the carrier 200 of FIG. 8 in the extended position between an elevated surface 10 and a ground surface 12 including a tricycle positioned on the carrier 200. FIG. 19 illustrates the carrier 200 loaded into the truck bed, in a stowed position, having the tricycle positioned on the carrier 200.

FIG. 20 illustrates the trailer 300 including a bicycle coupled to the carrier 100 before turning the front wheel 45 degrees, strapping down the bicycle, pivoting the carrier 100 to a generally horizontal position, and retracting the ramp 130. Additionally, carrier 306 positioned on the left side of the trailer 300 represents a simplified carrier that does not include a ramp, rollers, pivot mount, or bumper feet. The carrier 306 may be a more conventional bike carrier in which the bicycle may be lifted into position on the carrier 306 and secured to the carrier 308 using the features described herein. Also, carrier 308 is positioned in the middle two positions of the trailer 300 and includes an extension ramp and pivot mount, but does not include rolling features and the pivot mount includes a fixed pin (e.g., instead of a spring pin). In other words, the carrier 308 may be simplified and more permanently mounted to the trailer 300.

FIG. 22 illustrates a carrier 100 in an extended position between a service table 14 and the ground surface 12. The carrier 100 may be used to secure a bicycle (e.g., hold upright in a secure position) and move the bicycle from the ground surface 12 to the service table 14 so that the bicycle can be serviced at a more practical height (e.g., as shown in FIG. 23).

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Illustrative embodiments are described and reference has been made to possible variations of the same. These and other variations, combinations, and modifications will be apparent to those skilled in the art, and it should be understood that the claims are not limited to the illustrative embodiments set forth herein.

What is claimed is:

1. A carrier for supporting and transporting a bicycle, the carrier comprising:

a support extending between a first end region and a second end region along a longitudinal axis, the support defining a top surface configured to receive and contact tires of the bicycle;

a pivot mount assembly pivotably coupled to the support and comprising a retention housing, wherein the retention housing defines one or more slots extending along the longitudinal axis, wherein the support pivots about a pivot axis extending transverse to the longitudinal axis; and

a ramp configured to move relative to the support along the longitudinal axis, wherein the ramp is configured to slide within the one or more slots of the retention housing, wherein the support is restricted from pivoting about the pivot axis when the ramp is within the one or more slots and the support is pivotable about the pivot axis when the ramp is not within the one or more slots.

2. The carrier of claim 1, wherein the pivot mount assembly further comprises a mounting member configured to be inserted into a hitch receiver.

3. The carrier of claim 1, wherein the retention housing extends on either side of the ramp and the one or more slots comprises a slot on either side of the ramp.

4. The carrier of claim 1, wherein the pivot axis is positioned relative to the support along the longitudinal axis between the first and second end regions at a position forward of a center of gravity of the carrier with the ramp extended and the bicycle supported on the support.

5. The carrier of claim 1, wherein the ramp is configurable between an extended position and a storage position, wherein the ramp is extended from the support when in the extended position and the ramp is stowed to coincide with the support when in the storage position.

6. The carrier of claim 1, further comprising at least one clamp located on one side of the support and configured to contact the bicycle.

7. The carrier of claim 6, wherein the at least one clamp is configured to move inward and outward between an engaged position and a disengaged position with the bicycle.

8. The carrier of claim 1, further comprising side rails positioned away from the top surface of the support and extending along the longitudinal axis, wherein the side rails

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are configured to guide tires of the bicycle and located such that a rear tire of the bicycle is positioned between the side rails when the bicycle is loaded on the carrier.

9. A carrier for supporting and transporting a recreational vehicle, the carrier comprising:

at least two supports positioned apart from one another and extending substantially parallel to one another, each support extending between a first end region and a second end region along a longitudinal axis, each support comprising a front portion and a rear portion extending at an angle to horizontal such that a front end of the rear portion is spaced a gap distance from the front portion, wherein each support is configured to receive and contact tires of the recreational vehicle, wherein each support comprises one or more slots extending along the longitudinal axis;

at least two ramps corresponding to each of the at least two supports and configured to move relative to the corresponding support along the longitudinal axis, wherein each of the at least two ramps slides within the one or more slots of the corresponding support; and

a pivot mount assembly pivotably coupled to one support of the at least two supports and comprising a retention housing and an axis, wherein the retention housing defines one or more slots extending along the longitudinal axis, wherein the support pivots about the axis transverse to the longitudinal axis, wherein the ramp corresponding to the one support is configured to slide within the one or more slots of the retention housing, wherein the one support is restricted from pivoting about the axis when the ramp is within the one or more slots and the one support is pivotable about the axis when the ramp is not within the one or more slots.

10. The carrier of claim 9, further comprising one or more rollers located proximate the first end region of each of the at least two supports, wherein the one or more rollers are configured to rotate about an axis perpendicular to the longitudinal axis.

11. The carrier of claim 10, further comprising bumper feet located proximate the first end region of the at least two supports, wherein the bumper feet are configured to contact a surface, wherein the one or more rollers is spaced apart from the surface when bumper feet are contacting the surface.

12. The carrier of claim 9, wherein the at least two ramps are configurable between an extended position and a storage position, wherein the at least two ramps are extended from the at least two supports when in the extended position and the at least two ramps are stowed to coincide with the at least two supports when in the storage position.

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(71) Anmelder: **AUER Hydraulics GmbH**
42699 Solingen (DE)

(72) Erfinder: **Auer, Michael**
42699 Solingen (DE)

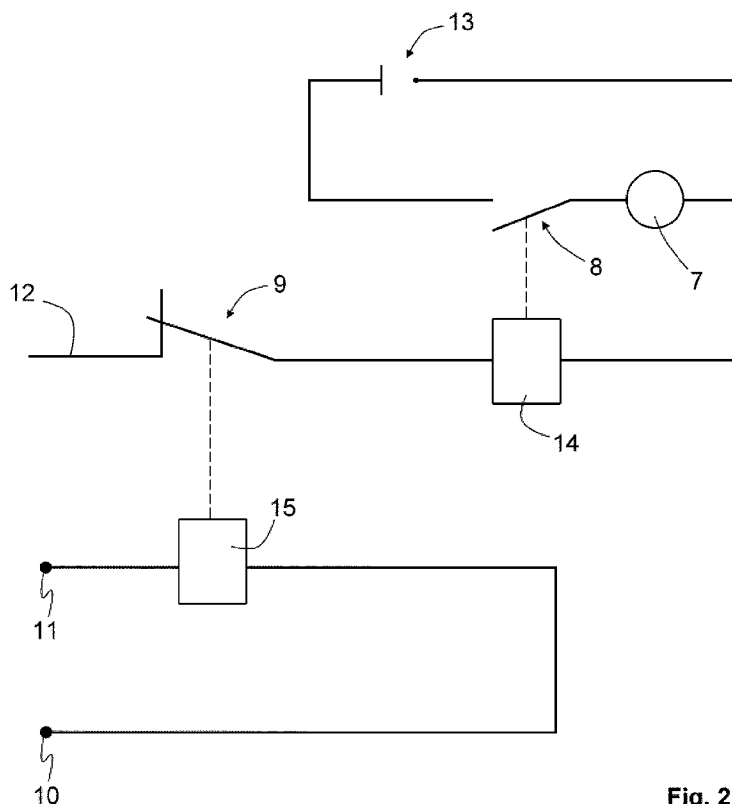
(74) Vertreter: **Patentanwälte Vomberg & Schar**
Schulstraße 8
42653 Solingen (DE)

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(54) PKW-KIPPANHÄNGER

(57) Die Erfindung betrifft einen PKW-Kippanhänger, der über einen Kabelanschluss mit dem Spannungsbordnetz eines PKW verbindbar ist, mit einem Anhängerrahmen und einer schwenkbar angeordneten Ladebrücke, die mittels eines Hydraulikaggregates heb- und senkbar ist, das eine Pumpe und einen Hydraulikzylinder aufweist, die von einem Elektromotor antreibbar sind, der

über eine drahtlose Fernsteuerung steuer- und/oder regelbar ist. Um ein versehentliches Auslösen des Hydraulikaggregates sicher zu vermeiden, wird zwischen dem Elektromotor (7) und dem Spannungsbordnetz (10, 11) des PKW ein Schalter angeordnet, der die Spannungszufuhr des Elektromotors (7) unterbricht, sobald und solange die Zündung des PKW aktiviert ist.

**Fig. 2****EP 4 122 761 A1**

Beschreibung

[0001] Die Erfindung betrifft einen PKW-Kippanhänger, der über einen Kabelanschluss mit dem Spannungsbordnetz eines PKW verbindbar ist, mit einem Anhängerrahmen und einer schwenkbar angeordneten Ladebrücke, die mittels eines Hydraulikaggregates heb- und senkbar ist, das eine Pumpe und einen Hydraulikzylinder aufweist, die von einem Elektromotor antreibbar sind, der über eine drahtlose Fernsteuerung steuer- und/oder regelbar ist.

[0002] Kippanhänger, die temporär an einen mit einer Anhängerkupplung ausgestatteten PKW gehängt werden können, eignen sich zum Transport schwerer Lasten wie z.B. Bau-, Abriss- und Gartenabfall, Sand, Steinen und sonstigen Schüttgütern. Die Kippanhänger können als Rückwärtskipper oder auch als Dreiseitenkipper ausgebildet sein. Das Hydraulikaggregat besitzt einen Hydraulikzylinder, wenigstens ein elektrisch ansteuerbares Kippventil zur Steuerung des Hubbetriebes und des Senkbetriebes des Hydraulikzylinders sowie ein Hydraulikreservoir, aus dem mittels der bereits erwähnten Pumpe das Hydrauliköl gefördert werden kann. Die Hydraulikaggregate können große Kräfte erzeugen. Der Elektromotor, der zum Antrieb der Hydraulikpumpe verwendet wird, erhält seine Spannung aus einer Anhängerbatterie.

[0003] Gesteuert oder geregelt wird der Elektromotor vorzugsweise über eine drahtlose Fernsteuerung, welche nicht nur eine bequeme Bedienung ermöglicht, sondern auch den Vorteil hat, dass die Ladebrücke auch aus der Entfernung gehoben und gesenkt werden kann. Eine drahtlose Fernsteuerung kann aus einer Funkfernsteuerung oder einer Anwendungssoftware (APP) mittels Bluetooth-Verbindungen realisiert werden. Die betreffenden Bediengeräte besitzen Tasten oder Bedienfelder für das Heben der Ladebrücke, das Senken der Ladebrücke, ggf. einen Notausschalter und einen Regler, mit dem die Hub- und Senkgeschwindigkeit eingestellt werden kann.

[0004] Die betreffenden Handgeräte werden im PKW mitgeführt. Dies kann dazu führen, dass sich der Fahrer oder Beifahrer versehentlich auf das Handgerät setzt und ungewollt einen Hubimpuls auslöst. Solche Hubauslösungen können auch von mitfahrenden Personen (z.B. Kindern) verursacht werden. Das ungewollte Hochklappen einer Ladebrücke stellt jedenfalls eine hohe Gefahrenquelle dar, die vermieden werden soll.

[0005] Es sind Kippanhänger bekannt, deren Ladebrücken fixiert werden können. Zwar vermeidet eine solche Fixierung das ungewollte Aufklappen der Ladebrücke, aber nicht aufgrund der hohen durch die Hydraulik erzeugten Kräfte drohende Verformungen der Brücke bzw. des Hilfsrahmens, die zur Beseitigung der Schäden aufwendigere Reparaturen notwendig machen.

[0006] Es ist daher Aufgabe der vorliegenden Erfindung, einen PKW-Kippanhänger zu schaffen, bei dem ein versehentliches Auslösen des Hydraulikaggregates

sicher vermieden werden kann.

[0007] Diese Aufgabe wird bei dem PKW-Kippanhänger nach Anspruch 1 dadurch gelöst, dass zwischen dem Elektromotor und dem Spannungsbordnetz des PKW ein Schalter angeordnet ist, der die Spannungszufuhr des Elektromotors unterbricht, sobald und solange die Zündung des PKW aktiviert ist.

[0008] Diese Zwangsabschaltung des Elektromotors durch Unterbrechung der Spannung ist relativ einfach und sicher, da ohne den Elektromotor die Hydraulikpumpe nicht arbeiten kann. Es sind auch keine zusätzlichen Arbeiten wie etwa eine Verriegelung mittels Bolzen oder sonstige Abschaltungen erforderlich, die aus Fahrlässigkeit oder Unachtsamkeit vergessen werden können. Ungewollte Betätigungen der Bedienschalter oder Bedienfelder bleiben jedenfalls wirkungslos, so lange die Zündung des PKW aktiviert ist.

[0009] Dies gilt auch für PKW mit einer Start-Stopp-Automatik, da das elektrische System auch bei abgeschaltetem Motor weiter arbeitet.

[0010] Vorzugsweise besteht der Schalter aus einem Relais. Diese Bauteile sind kostengünstig und arbeiten zuverlässig.

[0011] Weitere Details werden im folgenden anhand der Figuren beschrieben. Es zeigen:

Fig. 1 eine schematische Darstellung eines PKW-Kippanhängers und

Fig. 2 eine Schaltskizze.

[0012] Der PKW-Kippanhänger nach Fig. 1 besitzt einen Anhängerrahmen 1, dessen vorderer Teil als Zugdeichsel 2 ausgebildet ist. Das Fahrgestell besteht im vorliegenden Fall aus zwei Achsen 3, kann jedoch auch ein- oder dreiachsig ausgeführt sein.

[0013] An dem Anhängerrahmen 1 angelenkt ist eine schwenkbar angeordnete Ladebrücke 4, die im vorliegenden Fall als Rückwärtskipper ausgebildet ist. Wesentliche Teile des Hydraulikaggregates sind der (Teleskop-)Hydraulikzylinder 5 sowie die Pumpe 6, die von einem Elektromotor betrieben wird, und womit das Hydrauliköl aus einem Hydraulikreservoir in die Hubzylinder gepumpt werden kann. Der Elektromotor bezieht seine Spannung aus einer am Kippanhänger angeordneten Batterie. Die Anhängerbatterie hat den Vorteil, dass die Ladebrücke des Kippanhängers auch unabhängig von dem PKW, also nach dem Entkuppeln, betrieben werden kann.

[0014] Wie aus der schematischen Zeichnung in Fig. 2 ersichtlich, ist der Elektromotor 7 in einem Stromkreis integriert, der über einen Schalter 8 geöffnet oder geschlossen werden kann. Dies geschieht über ein Relais 14, das Funkfernsignale 12 von einem Handgerät erhält. Zusätzlich ist ein weiteres Relais 15 vorgeschaltet, das als Öffner derart ausgebildet ist, dass bei aktivierter PKW-Zündung die Spannungszufuhr des Elektromotors unterbrochen wird. Dies geschieht über die Pole 10 und 11 zum Kraftfahrzeug, die auch zur elektrischen Versor-

gung der Leuchtanzeigen (Bremslicht, Blinker, Rücklicht) am Anhänger verwendet werden. Bei aktivierter Zündung oder im Falle einer Start-Stopp-Automatik bei laufendem Motor ist die Stromversorgung des Elektromotors abgeschaltet, so dass eine Fehlbedienung während der Fahrt ausgeschlossen werden kann. 5

Bezugszeichenliste

[0015]		10
1	Anhängerrahmen	
2	Zugdeichsel	
3	Achse	
4	Ladebrücke	15
5	Hydraulikzylinder	
6	Pumpe	
7	Elektromotor	
8	Schalter	
9	Schalter	20
10	Pol	
11	Pol	
12	Signal FB	
13	Batterie	
14, 15	Relais	25

Patentansprüche

1. PKW-Kippanhänger, der über einen Kabelanschluss mit dem Spannungsbordnetz eines PKW verbindbar ist, mit einem Anhängerrahmen (1) und einer schwenkbar angeordneten Ladebrücke (4), die mittels eines Hydraulikaggregates heb- und senkbar ist, das eine Pumpe (6) und einen Hydraulikzylinder (5) aufweist, die von einem Elektromotor (7) antreibbar sind, der über eine drahtlose Fernsteuerung (12) steuer- und/oder regelbar ist, **dadurch gekennzeichnet, dass** zwischen dem Elektromotor (7) und dem Spannungsbordnetz (10, 11) des PKW ein Schalter angeordnet ist, der die Spannungszufuhr des Elektromotors (7) unterbricht, sobald und solange die Zündung des PKW aktiviert ist. 30 35 40 45
2. PKW-Kippanhänger nach Anspruch 1, **dadurch gekennzeichnet, dass** der Schalter aus einem Relais (14, 15) besteht. 45
3. PKW-Kippanhänger nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die drahtlose Fernsteuerung eine Funkfernsteuerung oder eine Anwendungssoftware oder eine Bluetooth-Verbindung ist. 50 55

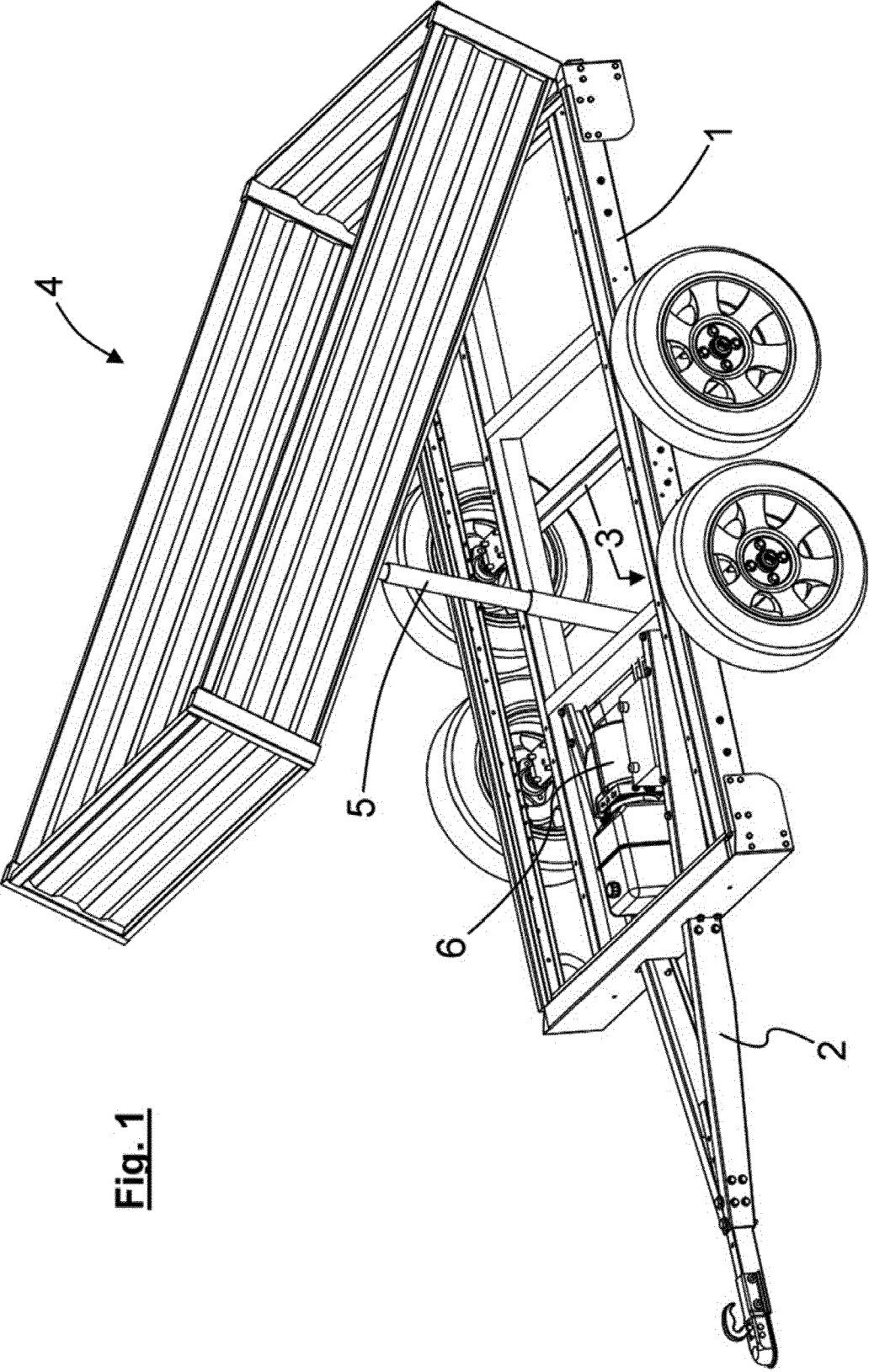


Fig. 1

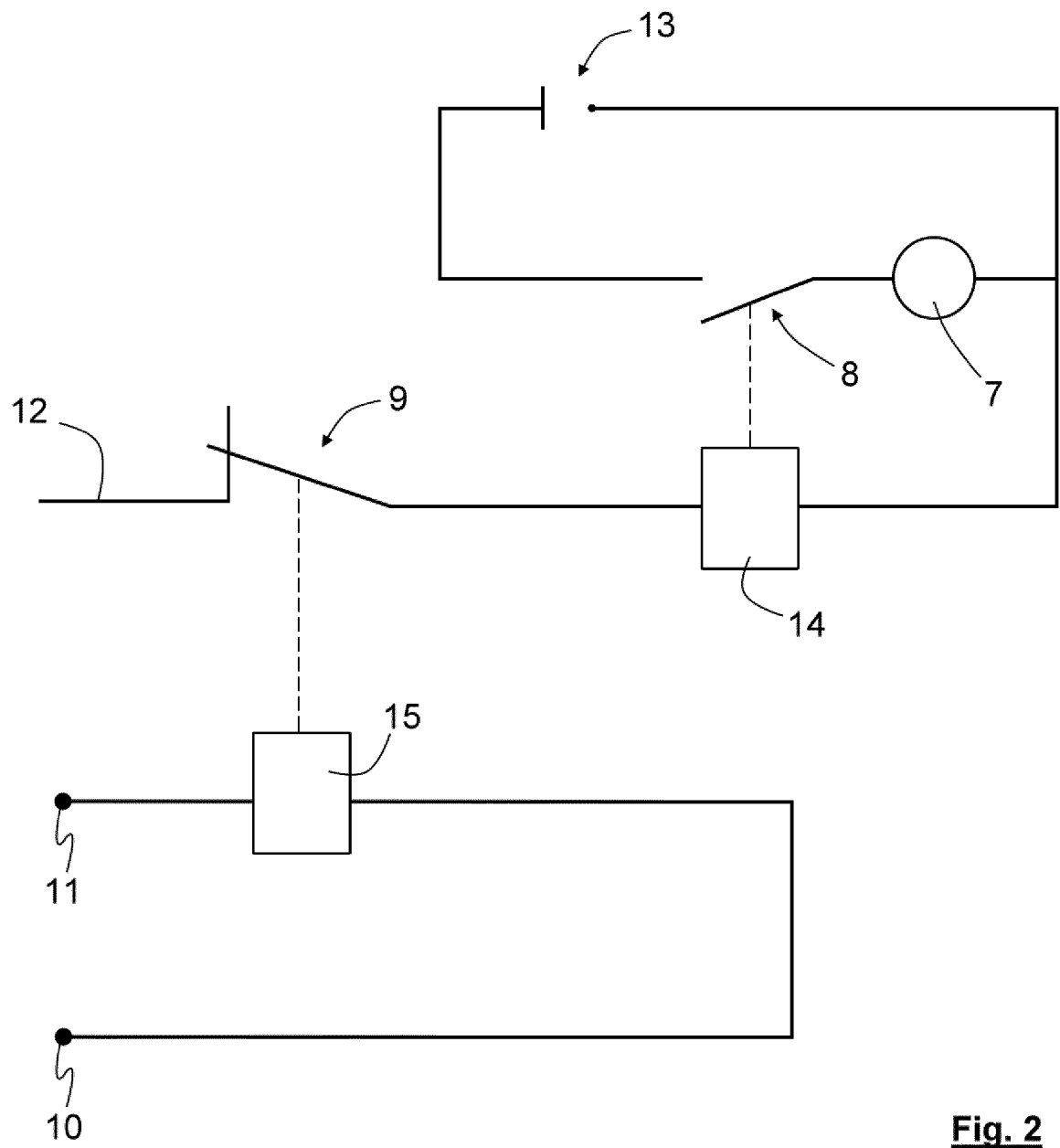


Fig. 2



EUROPÄISCHER RECHERCHENBERICHT

Nummer der Anmeldung

EP 22 16 6239

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EINSCHLÄGIGE DOKUMENTE			
Kategorie	Kennzeichnung des Dokuments mit Angabe, soweit erforderlich, der maßgeblichen Teile	Betrifft Anspruch	KLASSIFIKATION DER ANMELDUNG (IPC)
A	WO 2021/087198 A1 (MAHINDRA VEHICLE MFT LTD [US]) 6. Mai 2021 (2021-05-06) * Abbildungen * * Absatz [0028] - Absatz [0035] * -----	1-3	INV. B60P1/16
A	GB 2 473 653 A (NORTHEY KARL PETER [GB]; NORTHEY CHRISTINE LILLIAN [GB]) 23. März 2011 (2011-03-23) * das ganze Dokument *	1-3	
A	US 3 447 834 A (GROSSE-RHODE TONY W) 3. Juni 1969 (1969-06-03) * das ganze Dokument *	1-3	
A	DE 20 2018 005622 U1 (UNSINN FAHRZEUGTECHNIK GMBH [DE]) 14. Januar 2019 (2019-01-14) * das ganze Dokument *	1-3	
			RECHERCHIERTE SACHGEBIETE (IPC) B60P B60D B62D
Der vorliegende Recherchenbericht wurde für alle Patentansprüche erstellt			
Recherchenort Den Haag		Abschlußdatum der Recherche 26. August 2022	Prüfer Westland, Paul
KATEGORIE DER GENANNTEN DOKUMENTE X : von besonderer Bedeutung allein betrachtet Y : von besonderer Bedeutung in Verbindung mit einer anderen Veröffentlichung derselben Kategorie A : technologischer Hintergrund O : mündliche Offenbarung P : Zwischenliteratur		T : der Erfindung zugrunde liegende Theorien oder Grundsätze E : älteres Patentdokument, das jedoch erst am oder nach dem Anmeldedatum veröffentlicht worden ist D : in der Anmeldung angeführtes Dokument L : aus anderen Gründen angeführtes Dokument & : Mitglied der gleichen Patentfamilie, übereinstimmendes Dokument	

**ANHANG ZUM EUROPÄISCHEN RECHERCHENBERICHT
 ÜBER DIE EUROPÄISCHE PATENTANMELDUNG NR.**

EP 22 16 6239

5 In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten europäischen Recherchenbericht angeführten Patentedokumente angegeben.
 Die Angaben über die Familienmitglieder entsprechen dem Stand der Datei des Europäischen Patentamts am
 Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

26-08-2022

10	Im Recherchenbericht angeführtes Patentedokument		Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
	WO 2021087198	A1	06-05-2021	KEINE	

15	GB 2473653	A	23-03-2011	KEINE	

	US 3447834	A	03-06-1969	KEINE	

20	DE 202018005622	U1	14-01-2019	KEINE	

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Für nähere Einzelheiten zu diesem Anhang : siehe Amtsblatt des Europäischen Patentamts, Nr.12/82