

(12) STANDARD PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 2006346500 B2**

(54) Title
Side-by-side ATV

(51) International Patent Classification(s)
B62D 21/18 (2006.01)

(21) Application No: **2006346500**

(22) Date of Filing: **2006.12.19**

(87) WIPO No: **WO08/013564**

(30) Priority Data

(31) Number
11/494,890

(32) Date
2006.07.28

(33) Country
US

(43) Publication Date: **2008.01.31**

(44) Accepted Journal Date: **2012.05.17**

(71) Applicant(s)
Polaris Industries Inc.

(72) Inventor(s)
Tullemans, Marcus Johannes;White, Geoffrey G.;Safranski, Brian Michael;Sunsdahl, Larry Richard;Meyer, Alan A.;Plugge, Jason Carl;Deckard, Aaron David

(74) Agent / Attorney
Watermark Patent and Trade Marks Attorneys, Level 2 302 Burwood Road, Hawthorn, VIC, 3122

(56) Related Art
US5251713A
US6722463B1
US6820708B2
US66887182B2

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
31 January 2008 (31.01.2008)

PCT

(10) International Publication Number
WO 2008/013564 A1

(51) International Patent Classification:
B62D 21/18 (2006.01)

(74) Agent: **YERKESON, Douglas, A.**; Baker & Daniels LLP,
300 North Meridian Street, Suite 2700, Indianapolis, IN
46204 (US).

(21) International Application Number:
PCT/US2006/048369

(81) Designated States (*unless otherwise indicated, for every
kind of national protection available*): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS,
JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS,
LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY,
MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS,
RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(22) International Filing Date:
19 December 2006 (19.12.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
11/494,890 28 July 2006 (28.07.2006) US

(71) Applicant (*for all designated States except US*): **PO-
LARIS INDUSTRIES INC.** [US/US]; 2100 Highway 55,
Medina, MN 55340-9770 (US).

(84) Designated States (*unless otherwise indicated, for every
kind of regional protection available*): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT,
RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA,
GN, GQ, GW, ML, MR, NE, SN, TD, TG).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **SUNSDAHL,
Larry, Richard** [US/US]; 33211 310th Street, Roseau,
MN 56751 (US). **DECKARD, Aaron, David** [US/US];
28593 Lakeside Trail, Lindstrom, MN 55045 (US).
TULLEMANS, Marcus, Johannes [US/US]; 16578
Ashby Lane, Eden Prairie, MN 55346 (US). **PLUGGE,
Jason, Carl** [US/US]; 1282 127th Avenue Nw, Coon
Rapids, MN 55448 (US). **MEYER, Alan, A.** [US/US];
500 Dew Drop Lane, Center City, MN 55012 (US).
WHITE, Geoffrey, G. [US/US]; 2406 Beede Lake Trail,
St. Croix Falls, WI 54024 (US).

Published:

— with international search report

*For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.*

(54) Title: SIDE-BY-SIDE ATV

(57) Abstract: The present invention relates to all terrain vehicles (10) having at least a pair of laterally spaced apart seating surfaces (18a, 18b and 20a, 20b). More particularly, the present invention relates to trail compliant side-by-side all terrain vehicles (10).



WO 2008/013564 A1

SIDE-BY-SIDE ATV**Field of the Invention:**

The present invention relates to side-by-side all terrain vehicles having at least a pair of laterally spaced apart seating surfaces. More particularly, the present invention relates to trail compliant side-by-side all terrain vehicles.

Background of the Invention:

Generally, all terrain vehicles ("ATVs") and utility vehicles ("UVs") are used to carry one or two passengers and a small amount of cargo over a variety of terrains. Due to increasing recreational interest in ATVs, specialty ATVs, such as those used for trail riding, racing, and cargo hauling have entered the market place. Most ATVs include seating for up to two passengers which are either seated side-by-side or with the passenger positioned behind the driver of the ATV. Side-by-side ATVs, in which the driver and passenger are seated beside each other on laterally spaced apart seats, have become popular because of the ability to allow the passenger to share the driver's viewpoint and riding experience instead of being positioned behind the driver. Due to the side-by-side seating arrangement, most side-by-side ATVs have a width of at least 54 inches (137 centimeters). Increasing numbers of ATV riders are enjoying recreational trail riding through public lands including state parks and national forests. Most trails on such public lands have a mandated maximum width requirement to limit damage to the environment.

Any discussion of documents, devices, acts or knowledge in this specification is included to explain the context of the invention. It should not be taken as an admission that any of the material formed part of the prior art base or the common general knowledge in the relevant art in Australia on or before the priority date of the claims herein.

Summary of the Invention:

In accordance with a first aspect of the invention there is provided an all-terrain vehicle having a frame and a pair of laterally spaced-apart seating surfaces supported by the frame, the all-terrain vehicle including: a pair of front wheels adapted to support the frame above a ground surface; a pair of rear wheels spaced-apart from the pair of front wheels, the pair of rear wheels adapted to support the frame above a ground surface, the at least one pair of laterally spaced-apart seating surfaces positioned between the pair of front wheels and the pair of rear wheels; and an engine positioned longitudinally behind

the at least one pair of laterally spaced-apart seating surfaces; the engine being drivingly coupled to the front and rear wheels for driving the vehicle.

5 In accordance with a further aspect of the invention, there is provided an all-terrain vehicle having a frame and a pair of laterally spaced-apart seating surfaces supported by the frame, the all-terrain vehicle including: a pair of front wheels adapted to support the frame above a ground surface; a pair of rear wheels spaced-apart from the pair of front wheels, the pair of rear wheels adapted to support the frame above a ground surface, the at least one pair of laterally spaced-apart seating surfaces positioned between the pair of front wheels and the pair of rear wheels; an engine positioned 10 longitudinally behind the at least one pair of laterally spaced-apart seating surfaces; the engine being drivingly coupled to the front and rear wheels for driving the vehicle; and further including an upper brace coupled to the frame, the upper brace configured to be removed during installation of the engine within the frame.

15 In accordance with a further aspect of the present invention there is provided an all-terrain vehicle, including: a frame, including a front frame portion, a mid frame portion and a rear frame portion; a front suspension supported by the front frame portion; at least two front wheels coupled to the front suspension; a front torsion bar supported by the front frame and coupled to the front suspension; a front differential supported by the front frame portion and drivingly coupled to the front wheels; a seating area supported by the 20 mid frame portion, including side by side seats, having a seat back and a seat bottom, the seat bottom having a top seating surface and a bottom mounting surface; an engine supported by the frame, the engine including at least one cylinder having a cylinder head, said at least one cylinder being positioned rearwardly of the seating area and the top of the cylinder head of said at least one cylinder being positioned higher than the seat 25 bottom mounting surface; a transmission coupled to the engine and positioned rearwardly of the side by side seats; a rear suspension supported by the rear frame portion; at least two rear wheels coupled to the rear suspension; a rear torsion bar supported by the rear frame portion and coupled to the rear suspension; a rear differential supported by the rear frame portion and drivingly coupled to the rear wheels; 30 a front drive shaft extending between the transmission and the front differential for coupling the transmission to the front wheels; and a rear drive shaft extending between the transmission and the rear differential for coupling the transmission to the rear wheels.

5 In accordance with a further aspect of the invention there is provided an all-terrain vehicle including: a frame, including a front frame portion, a mid frame portion and a rear frame portion; a front suspension supported by the front frame portion; at least two front wheels coupled to the front suspension; a front torsion bar supported by the front frame and coupled to the front suspension; a front differential supported by the front frame portion and drivingly coupled to the front wheels; a seating area supported by the mid frame portion, including side by side seats; an engine supported by the frame; a transmission coupled to the engine, the transmission including a continuously variable transmission; a rear suspension supported by the rear frame portion; at least two rear wheels coupled to the rear suspension; a rear torsion bar supported by the rear frame portion and coupled to the rear suspension; a rear differential supported by the rear frame portion and drivingly coupled to the rear wheels; a front drive shaft extending between the transmission and the front differential for coupling the front wheels to the transmission; and a rear drive shaft extending between the transmission and the rear differential for coupling the transmission to the rear wheels.

“Comprises/comprising” when used in this specification is taken to specify the presence of stated features, integers, steps or components but does not preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

20 The above mentioned and other features of this invention, and the manner of attaining them, will become more apparent and the invention itself will be better understood by reference to the following description of embodiments of the invention taken in conjunction with the accompanying drawings.

5 **Brief Description of the Drawings:**

Fig. 1 is a perspective view of one embodiment of a side-by-side ATV;

Fig. 2 is a profile view of the side-by-side ATV shown in Fig. 1;

Fig. 3 is a front view of the ATV shown in Figs. 1 and 2;

Fig. 4 is a top plan view of the side-by-side ATV shown in Figs. 1 through 3;

10 Fig. 5 is a partial perspective view of the cab area of the side-by-side ATV shown in Figs. 1 through 4;

Fig. 6 is a partial profile view of the cab area shown in Fig. 5;

Fig. 7 is a partial perspective view of one embodiment of a guard rail that may be used on a side-by-side ATV, such as the side-by-side ATV shown in Fig. 1;

15 Fig. 8 is another embodiment of a guard rail that may be used on a side-by-side ATV, such as the side-by-side ATV shown in Fig. 1;

Fig. 9 is a bottom plan view of the side-by-side ATV shown in Figs. 1 through 4;

20 Fig. 10 is a partially exploded, perspective view of the front end of the ATV shown in Figs. 1 through 4;

Fig. 11 is a partially exploded, perspective view similar to Fig. 10 showing hood mounting details;

Fig. 12 is a cross-sectional view illustrating the hood mounting with the hood partially removed from the front panel;

25 Fig. 13 is a cross-sectional view similar to Fig. 12 with the hood coupled to the front panel;

5 Fig. 14 is a rear perspective view of the frame and the modular engine assembly of the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 15 is a partially exploded, rear perspective view of the frame and modular engine assemblies shown in Fig. 14;

10 Fig. 16 is an exploded perspective view of one embodiment of an engine mounting assembly that may be used on an ATV such as the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 17 is an exploded perspective view of another embodiment of an engine mounting assembly that may be used on an ATV such as the side-by-side ATV shown in Figs. 1 through 4;

15 Fig. 18 is an exploded perspective view of yet another embodiment of an engine mounting assembly that may be used on an ATV such as the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 19 is a partial front perspective view of the bottom side of the drive train components of the side-by-side ATV shown in Figs. 1 through 4;

20 Fig. 20 is a partially exploded rear view of components of the frame and rear suspension system of the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 21 is a rear view of the frame and suspension system of the ATV shown in Fig. 20;

25 Fig. 22 is a partial rear perspective view of a steering mechanism and front axle assembly that may be used on an ATV such as the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 23 is a partial front perspective view of the steering mechanism and front axle assembly of the ATV shown in Fig. 22;

5 Fig. 24 is a partial perspective view of one embodiment of a braking assembly that may be used on an ATV such as the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 25 is an elevated rear perspective view of the engine and clutch cooling components of the side-by-side ATV shown in Figs. 1 through 4;

10 Fig. 26 is a partial rear view of the engine and clutch cooling components shown in Fig. 25;

 Fig. 27 is a partial perspective view of the driver's side foot well area of the ATV shown in Figs. 1 through 4;

 Fig. 28 is an partial exploded view of a steering assembly that may be used
15 on an ATV such as the side-by-side ATV shown in Figs. 1 through 4;

 Fig. 29 is a side elevational view of the steering assembly of Fig. 28, showing the steering wheel in various tilted positions; and

 Fig. 30 is a partial perspective view of an adjustable grab bar that may be used on an ATV such as the side-by-side ATV shown in Figs. 1 through 4.

20 Corresponding reference characters indicate corresponding parts throughout the several views. Although the drawings represent embodiments of the present invention, the drawings are not necessarily to scale and certain features may be exaggerated in order to better illustrate and explain the present invention.

Detailed Description of Embodiments of the Invention

25 The embodiments disclosed below are not intended to be exhaustive or to limit the invention to the precise forms disclosed in the following detailed description. Rather, the embodiments are chosen and described so that others skilled in the art may utilize their teachings. For example, while the following description refers primarily to a ATV, certain features described herein may be applied to other
30 applications such as UVs, snowmobiles, motorcycles, mopeds, etc.

5 Referring initially to Fig. 1, one illustrative embodiment of side-by-side ATV 10 is shown. ATV 10 includes front end 12 and rear end 14, and a frame 15 which is supported above the ground surface by a pair of front tires 22a and wheels 24a and a pair of rear tires 22b and wheels 24b. ATV 10 includes a pair of laterally spaced-apart upper and lower seating surfaces 18a, 18b and 20a, 20b, respectively. The
10 upper seating surfaces 18a, 18b are configured to support the backs of sitting riders, while the lower seating surfaces 20a, 20b are configured to support the buttocks of sitting riders. In the illustrative embodiment, upper and lower seating surfaces 18a, 18b, and 20a, 20b form a bucket seat arrangement, however a bench style seat or any other style of seating structure may be used. Upper and lower seating surfaces
15 18 and 20 are positioned within cab 17 of ATV 10.

Protective cage 16 extends over cab 17 to assist in preventing injury to passengers of ATV 10 from passing branches or tree limbs, as well as, may act as a support in the event of a vehicle rollover. As shown in Figs. 1 through 4, protective cage 16 narrows as it extends upwardly to allow the driver and passenger easier
20 entry and exit of cab 17. Additionally, in some embodiments a cover including one or more of a roof, windshield and doors (not shown) may be attached to the protective cage 16 to block weathering elements such as wind, rain or snow. Cab 17 also includes front console 31, adjustable steering wheel 28, and shift lever 29. Front console 31 may include a tachometer, speedometer, or any other suitable
25 instrument. Front end 12 of ATV 10 includes front panel 67, hood 32, and front suspension assembly 26. Front suspension assembly 26 pivotally couples front wheels 24 to ATV 10. Rear end 14 of ATV 10 includes engine cover 19 which extends over modular engine assembly 34, as shown in Figs. 2, 14, and 15. Modular engine assembly 34 is illustratively positioned completely behind upper and
30 lower seating surfaces 18a, 18b, and 20a, 20b.

As shown in Fig. 2, front wheels 24 are supported for rotation by front axle 36. Similarly, rear wheels 24b are supported for rotation by rear axle 38. In the illustrative embodiment shown in Fig. 2, wheelbase A, which extends between the center of front axle 36 and the center of rear axle 38, is equal to about 77 inches

5 (195.6 centimeters). Seat height B is equal to the distance between a low point 21 of lower seating surfaces 20 and a bottom of the frame 15 when ATV 10 is at rest. In the illustrative embodiment, seat height B is equal to about 11.75 inches (29.8 centimeters). In the illustrative embodiment, the ratio of the wheelbase to the seat height, or distance A to distance B, is about 6.55 to 1. In other embodiments, not
10 shown, the ratio of the wheelbase to the seat height may be equal to other suitable ratios, however the present invention contemplates ATVs having a ratio of wheelbase to seat height greater than about 6.0 to 1. A wheelbase to seat height ratio greater than about 6.0 to 1 facilitates a relatively low vehicle center of gravity and further provides improved ergonomics, handling, and space utilization.

15 Referring now to Figs. 3 and 4, a front view and top plan view of ATV 10 is shown. In the illustrative embodiment, width C, which is defined as the overall width of ATV 10, extends between the outermost lateral points of ATV 10. In the illustrative embodiment, outer surfaces of tires 22 on the front and rear ends of ATV 10 define the outermost points. In other embodiments, width C may be measured
20 from the outer fenders of front panel 67. It may be appreciated that width C may be defined by both the outer surfaces of tires 22 and fenders of front panel 67, should the respective dimensions be substantially equal. In the illustrative embodiment, width C is about 50 inches. In other embodiments, ATV 10 may be constructed to other suitable widths, however the present invention contemplates ATVs having a
25 trail compliant width or less than about 54 inches.

Referring now to Fig. 5, a partial view of cab 17 of ATV 10 is shown. Lower seating surfaces 20 are coupled to base 41 of ATV 10. Foot well area 40 extends below base 41 and encloses each passenger's feet and lower leg portions. Foot well area 40 includes floorboard 42 and side panel 46 on each side of ATV 10.
30 Floorboard 42 includes an aperture 44 positioned to allow fluid to drain out of floorboard 42. Side panel 46 extends upwardly from floorboards 42 on each side of ATV 10. In the illustrative embodiment, side panels 46 extend upward about 4 inches (10.2 centimeters) from floorboards 42, however side panels 46 may be constructed to any suitable height. Side panels 46 and foot well areas 40 prevent

5 the feet and lower leg portions of the driver and passenger of ATV 10 from moving outside of cab 17 when ATV 10 is in motion, for example when traversing rough terrain. In other embodiments (not shown), side panels 46 may be removed to allow easier entry and exit into cab 17 of ATV 10.

Referring now to Fig. 7, an illustrative embodiment of a side-by-side ATV 48 is shown. ATV 48 includes driver's side seat 49, side panel 52, and engine cover 54. Tube 56 extends upward from engine cover 54 to form protective cage 16. Seat guard 50 is coupled between engine cover 54 and side panel 52 to prevent a passenger positioned on seat 49 from sliding laterally off of seat 49 during vigorous driving. Additionally, seat guard 50 may provide protection against passing external obstacles. Seat guard 50 may also be included on the passenger's side of ATV 48.

Referring now to Fig. 8, another illustrative embodiment of ATV 48 is shown including an additional safety bar 58. In this embodiment, safety bar 58 couples between tube 56 and seat guard 50 to further enclose a passenger in the cab area of ATV 48. Additionally, safety bar 58 may be used as a handle when entering or exiting ATV 48. Safety bar 58 may also be included on the passenger's side of ATV 48. Additionally, there may be a panel or restrictive member, such as a mesh netting, placed between one or more of seat guard 50, safety bar 58, tube 56 and side panel 52 to further restrict the driver's or passenger's appendages from exiting the vehicle during vigorous driving.

Referring now to Fig. 9, an illustrative bottom plan view of ATV 10 is shown. For simplicity, the floorboards and bottom side shielding have been removed. In this embodiment, driver's side 65 of ATV 10 is shown on the upper portion of Fig. 9 and passenger's side 63 is shown on the lower portion of Fig. 9. Longitudinal axis 66 separates driver's side 65 from passenger's side 63 and defines the longitudinal center line of ATV 10. In this embodiment, various relatively heavy components are positioned vertically proximate the frame 15 to lower the vehicle's center of gravity, thereby improving balance and stability. For example, fuel tank 62 is positioned under lower seating surface 20b on passenger's side 63 of ATV 10. Fuel tank 62 is supported by frame 15. As shown, fuel tank 62 is L-shaped, however any suitably

shaped fuel tank may be used. Positioning fuel tank 62 on passenger's side 63 improves the balance of ATV 10 when only a driver is present on driver's side 65 of ATV 10. Battery 64 is positioned under lower seating surface 20a on driver's side 65 of ATV 10. In this embodiment, battery 64 is positioned near axis 66 and
5 relatively low on the ATV 10, thereby improving balance. Positioning of battery 64 near the seating surface 20a also allows for easier serviceability and for reduced routing of lines to the engine assembly 34. As also shown in Fig. 9, the driveshaft 146 is shown positioned intermediate the seat surfaces 20a and 20b.

Referring now to Figs. 10-13, front end 12 of ATV 10 is shown in greater
10 detail. Front end 12 includes hood 32, which may be removably coupled to front panel 67. As illustrated, a hood mounting assembly includes a pair of plungers or pegs 95 which are removably received within cylindrical grommets 97. Plungers 95 are fixed near the rear corners of the hood 32, while grommets 97 are fixed to the front panel 67 near the rear corners of a storage area 68. In this embodiment,
15 plungers 95 and grommets 97 are illustratively formed of steel and a resilient material (such as an elastomer), respectively, however any suitable material may be used. The front of hood 32 includes a plurality of flanges 99a which are configured to cooperate with a Hp 99b formed within front panel 67, thereby defining a releasable hinge.

20 in this illustrative embodiment, storage area 68 and access panel 61 are positioned under hood 32. Storage area 68 may receive a tool kit, cargo net or any other suitable vehicle accessory for ATV 10. Access panel 61 may include any suitable engine or vehicle maintenance port or terminal, such as a radiator fill cap, battery charging terminals, oil fill plug, or transmission fill plug.

25 Referring now to Fig. 14, one illustrative embodiment of frame 15 of a side-by-side ATV such as ATV 10 shown in Fig. 1 is shown. Frame 15 includes inner rails 72, front crossmember 71, mid crossmember 73, and rear crossmember 77. Frame 15 also includes outer tubes 70 that define the outermost width of frame 15. Rear assembly 92 is coupled to upper frame rails 90 and cross-member 77
30 and is described in more detail below. The portion of frame 15 between mid crossmember 73 and rear crossmember 77 supports modular engine assembly 34 of

5 ATV 10. In this embodiment, modular engine assembly 34 may include a transmission 136 such as a continuously variable transmission, and a rear differential 132 prior to being installed in frame 15, as shown in Fig. 15.

Referring to Figs. 14 and 15, inner rails 72 of frame 15 are coupled together on a front end by crossmember 71 and on the rear end by rear crossmember 77.
10 Brackets 76 couple upper frame tubes 88, upper frame rails 90, vertical tubes 74, and outer tubes 70 together on each side of ATV 10. Outer tubes 70 are coupled to inner rails 72 by brackets 69. Vertical tubes 74 are coupled on a lower end to inner rails 72. Upper frame tubes 88 are coupled to support tubes 83 which are coupled on a lower end to inner rails 72. Upper frame rails 90 are coupled on a rear end to
15 cross tube 91.

As shown in Fig. 15, modular engine assembly 34 may be preassembled before being installed in frame 15. During the construction of frame 15, upper brace 78 is attached to frame 15 to provide dimensional stability during welding. During installation of modular engine assembly 34, upper brace 78 is removed from frame
20 15 and modular engine assembly 34 is placed on frame 15. Upper brace 78 is then reattached to frame 15. More particularly, after modular engine assembly 34 is positioned between upper frame rails 90 in frame 15, as shown in Fig. 14, upper brace 78 may be installed.

Upper brace 78 includes outer brackets 86, rear bracket 84, crossmember 80
25 and angular members 82. Angular members 82 are coupled together on an end by bracket 84 and on an opposing end by crossmember 80. Each bracket 86 is substantially U-shaped and includes apertures 85. U-shaped brackets 86 are adapted to overlap upper frame tubes 88. Apertures 85 in brackets 86 and apertures 87 in upper frame tubes 88 align and accept fasteners to secure upper brace 78 to
30 upper frame tubes 88. Bracket 84 includes apertures 81 which align with aperture 89 in cross tube 91 and may be secured using any suitable fasteners.

In this embodiment, modular engine assembly 34 is mounted on frame 15 of ATV 10 using a three position mounting system to allow modular engine assembly

5 34 to be dropped into frame 15 and bolted or attached as one unit. Illustrative embodiments of each of the three mounting assemblies are shown in Figs. 16 through 18. Referring now to Fig. 16, mounting system 94 positioned on the driver's side of modular engine assembly 34 and frame 15 is shown. Bracket 96 is mounted to modular engine assembly 34 prior to installation of modular engine assembly 34 in
10 frame 15. Lower bracket 102 is coupled to rail 75 of frame 15 and receives mounting plate 100. Mounting plate 100 is coupled to bracket 102 by fasteners 104.

During installation of modular engine assembly 34 into frame 15, bracket 96 is aligned with mounting plate 100 and fastener 98 is positioned in an aperture in bracket 96 and aperture 101 of mounting plate 100 to secure bracket 96 and
15 modular engine assembly 34 to frame 15. Similarly, mounting assembly 120, as shown in Fig. 18, is positioned on the passenger's side of modular engine assembly 34 and frame 15. Bracket 128 is coupled to frame 15. Mounting plate 126 is coupled to bracket 128 by fasteners 130. Bracket 122 is coupled to the passenger's side of modular engine assembly 34 and is positioned such that an aperture in
20 bracket 122 aligns with central aperture 127 of mounting plate 126 when modular engine assembly 34 is installed in frame 15. Fastener 124 extends through the aperture in bracket 122 and aperture 127 in mounting plate 126 to secure modular engine assembly 34 to frame 15.

Modular engine assembly 34 is also mounted to frame 15 by a third mounting
25 assembly shown in Figs. 14 and 17. Mounting assembly 106 includes bracket 108, side plates 116, and mounting plate 114. Bracket 108 couples to brackets 93 of rear assembly 92. Bracket 108 includes vertically extending plates 110 and is coupled to brackets 93 by extending fasteners (not shown) through apertures 109. Side plates 116 are coupled to rear differential 132 of engine assembly 34. Mounting plate 114
30 is coupled between side plates 116 by fasteners 118. During installation of modular engine assembly 34 in frame 15, vertically extending plates 110 of bracket 108 are positioned one each side of mounting plate 114. Fastener 112 is then positioned through apertures in vertically extending plates 110 and aperture 115 of mounting plate 114 to secure modular engine assembly 34 in frame 15..

5 Referring now to Fig. 19, a partial forward-facing, bottom side perspective view of the drivetrain components of ATV 10 is shown. Modular engine assembly 34 includes engine 133, transmission 136, and rear differential 132. In this embodiment, the crankshaft (not shown) of engine 133 is parallel with the fore/aft direction of ATV 10 and provides for a narrower overall vehicle width and improved center of gravity of ATV 10. In this embodiment, engine 133 is a 760 cc engine
10 producing about 50 horsepower. Engine 133 produces excellent acceleration characteristics and responsiveness. ATV 10 weighs about 950 pounds (430.9 kilograms) and has a power to weight ratio of about 0.053/1 (horsepower/pound). Any suitable engine may be used in ATV 10, and ATV 10 may be constructed to any
15 suitable weight, however the present invention contemplates ATVs having a power to weight ratio of at least 0.045/1 (horsepower/pound).

Rear differential 132 of modular engine assembly 34 is directly coupled to transmission 136 by housing 148 to maintain center distances and allow for easy assembly. In this illustrative embodiment, rear differential 132 is an electric rear
20 lockable differential, however any suitable rear differential or rear axle may be used. Output shaft 138 extends outward from transmission 136 toward the front of ATV 10 and rotates to power front wheels 24a of ATV 10. In this embodiment, ATV has on-demand all-wheel drive with switchable backdrive, however any suitable drivetrain such a two-wheel drive or four-wheel drive may be used.

25 As shown in Fig. 19, output shaft 138 extends under protective panel 134. Protective panel 134 is positioned behind upper and lower seating surfaces 18a, 18b and 20a, 20b and protects passengers in ATV 10 from moving parts of modular engine assembly 34, as well as, assists in shielding from noise. The extending end of output shaft 138 includes splined portion 140 which is adapted to engage the
30 interior circumference of coupler 142. Coupler 142 is coupled to universal joint 144. Universal joint 144 connects coupler 142 to front drive shaft 146 which powers the front wheels of ATV 10. Coupler 142 may move in a fore and aft direction on splined portion 140 of output shaft 138 while remaining engaged with splined portion 140. During vigorous driving, front drive shaft 146 may move in the fore and aft direction

- 5 causing coupler 142 to slide longitudinally on splined portion 140 of output shaft 138 while front drive shaft 146 remains rotationally coupled with output shaft 138.

Referring now to Figs. 20 and 21, components of the rear suspension of ATV 10 is shown. Rear frame assembly 92 is formed by down tubes 105, vertical tubes 107, rear brackets 160, front brackets 162, lower tubes 180, and cross tubes 182 and 184. Down tubes 105 are coupled to upper frame rails 90 and extend rearward. Lower tubes 180 are coupled to rear crossmember 77 on one end. The opposing ends of lower tubes 180 are coupled together by cross tube 182. Cross tube 182 supports hitch 164 which may be used to couple to a trailer or other device for towing behind ATV 10. The lower ends of down tubes 105 are coupled together by cross tube 184. Front brackets 162 and rear brackets 160 extend between lower tubes 180 and down tubes 105. Vertical tubes 107 extend downward from upper frame rails 90 and couple to down tubes 105. Each down tube 105 includes bracket 186. Similarly, each vertical tube 107 includes bracket 176.

Rear wheels 24b include inner hub assemblies 25. The lower ends of upper and lower control arms 172 and 170 are coupled to inner hub assemblies 25 of rear wheels 24b. The lower ends of dampeners 168 are also coupled to inner hub assemblies 25. The upper ends of upper and lower control arms 172 and 170 are pivotally coupled to front and rear brackets 162 and 160 on each side of ATV 10. Upper ends 178 of dampeners 168 are coupled to brackets 176 on vertical tubes 107. Stabilizer or torsion bar 174 is coupled to inner hub assemblies 25 by rods 171. More particularly, rods 171 have upper ends connected to opposing ends of torsion bar 174 and lower ends connected to lower control arms 170. Torsion bar 174 is coupled to brackets 186 on down tubes 105 and provides a torsional transverse connection between the lower control arms 170 of rear wheels 24b.

Rear wheels 24b may move vertically in an independent manner along a path defined by upper and lower control arms 172 and 170. For example, when ATV 10 encounters rough terrain, rear wheels 24b may move upward and downward to maintain contact with a ground surface. By positioning brackets 176, which couple to dampeners 168, on vertical tubes 107 of frame 15, the load path generated when

5 rear wheels 24b move upward is translated through vertically orientated frame members (vertical tubes 107) of frame 15. Additionally, torsion bar 174 provides interaction between the independent suspensions of the rear wheels 24b through respective control arms 170. As known in the art, during a turn, torsion bar 174 resists deflection of an outer rear wheel 24b due to centrifugal force by transmitting
10 deflection to the inner rear wheel 24b. These elements may improve the ride and handling characteristics of ATV 10.

Referring now to Figs. 22-24, components of the front suspension, including right front brake assembly 199 are shown. Front frame assembly 203 includes front tubes 204 coupled to an upper crossmember 205. Rear tubes 207 are positioned
15 rearwardly of the front tubes 204 and are coupled to angled braces 209 and crossmember 71 (Fig. 14). Upper brackets 211 are supported by front tubes 204 and braces 209, while lower brackets 213 are supported by lower tubes 215. The lower ends of upper and lower control arms 210 and 212 couple to inner hubs 25 of wheels 24a. Lower ends of steering arms 208 (commonly called tie rods), and
20 dampeners 217 are also coupled to inner hubs of wheels 24a. The upper ends of upper and lower control arms 210 and 212 are pivotally coupled to lower brackets on each side of ATV 10. Upper ends of dampeners 217 are pivotally coupled to bracket 223 extending between rear tubes 207. The control arms 210, 212 and dampeners 217 cooperate to define independent front suspensions for the right and left front
25 wheels 24a. More particularly, front wheels 24a may move vertically in an independent manner along a path defined by upper and lower control arms 210 and 212.

With further reference to Figs. 22 and 23, a stabilizer or torsion bar 214 is coupled to front tubes. Links or rods 219a and 219b are operably coupled to
30 opposing left and right ends of torsion bar 214, illustratively through left and right clamps 225a and 225b and torque bars 221a and 221b, respectively. Rods 219 are coupled to inner hub assemblies 25 of right and left front wheels 24a through upper control arms 210. In use, when a force is exerted on one of the right and left front wheels 24a during vehicle travel, the front suspension may transmit a corresponding

5 force on the other of the left and right front wheel 24a. For example, when an upward force is exerted on the left front wheel 24a due to, e.g., a bump or a turn, the corresponding upper and lower control arms 210 and 212 may move upward relative to the ATV 10. Such upward movement may urge the corresponding rod 219a upward, which may cause the corresponding end of the left torque bar 221a to move
10 upward. The left torque bar 221a may act as a lever, exerting a torque on the left end of the torsion bar 214.

The torsion bar 214 may include a torque transfer regulator (not shown), which determines how much of the torque exerted by the left torque bar 221a (or right torque bar 221b) is transferred to the right torque bar 221b (or left torque bar
15 221a). Clamps 225a and 225b may be repositioned or moved along torque bars 221a and 221b to change the suspension effect. In the current example, upward movement of the left torque bar 221a may cause upward movement of the right torque bar 221b, thereby urging the right rod 219b and connected control arms 210 and 212 upward. The upward movement of the right control arms 210 and 212 may
20 exert an upward force on the right front wheel 24a. Thus, the front suspension may exert on the right front wheel 24a a portion of the upward force that a travel surface exerts on the left front wheel 24a. While the current example involved a force exerted by the travel surface on the left front wheel 24a, the front suspension may operate in a similar manner when a force is exerted by the travel surface on the right
25 front wheel 24a. An illustrative embodiment torsion bar is disclosed in U.S. Patent Application Serial No. 11/340,301, filed January 26, 2006, which is expressly incorporated by reference herein.

For simplicity, only right front brake assembly 199 is shown in Figs. 22 and 23, however a similar brake assembly may be used for each wheel 24 of ATV 10.
30 Front brake assembly 199 is coupled to inner hub 25 of wheel 24. Front axle 206 is supported by inner hub assembly 25. As detailed above, upper control arms 210, lower control arms 212, and steering arms 208 couple to inner hubs 25 of wheels 24a. Steering arm 208 is positioned above and rearward of front axle 206 to allow caliper bracket 201 and caliper 200 to be positioned rearward or on the back side of

5 front axle 206. Control arm 210 is positioned above steering arm 208 to facilitate the relative positioning of steering arm 208 and hence, caliper bracket 201 and caliper 200. Caliper bracket 201 and brake disc 202 are also coupled to inner hub 25 of wheel 24. Brake caliper 200 is coupled to the back or rearward facing end of caliper bracket 201. The placement of brake caliper 200 on the rearward facing end of
10 caliper bracket 201 prevents mud and debris from piling up on top of caliper 200 as tire 22 rotates forward or counterclockwise. Placement of caliper 201 on the frontward facing side or end of brake disc 202 may require a wiper or housing to prevent mud and debris from tire 22 from piling up on caliper 200.

Referring now to Figs. 25 and 26, an elevated perspective view and a rear
15 profile view of engine cover 19 of ATV 10 is shown. Modular engine assembly 34 includes engine cooling intake 220 and clutch cooling intake 218. Intakes 218 and 220 extend upward through opening 216 in engine cover 19 and direct cooling air to clutch housing 135 and engine 133. Clutch housing 135 protects a clutch mechanism adapted to transmit power from engine 133 to transmission 136. Intakes
20 218 and 220 are positioned between driver and passenger upper seating surfaces 18 to collect air passing between upper seating surfaces 18a and 18b when ATV is driven in the forward direction. As ATV 10 increases in speed, more air passes between upper seating surfaces 18a and 18b and is collected by intakes 218 and 220.

25 Referring now to Fig. 27, a partial perspective view of the driver's side of cab 17 of ATV 10 is shown. As described above, cab 17 includes upper seating surface 18, lower seating surface 20, steering wheel 28 and front console 31. In this illustrative embodiment, accelerator 226 and brake pedal 224 are positioned in footwell 40 of cab 17.

30 Referring now to Fig. 28, an exploded view of a steering assembly that may be used on an ATV such as ATV 10 is shown. In this illustrative embodiment, steering wheel 28 may be tilted by pivoting about a pivot axis 227, as shown in Fig. 29. Illustratively, steering wheel 28 may be infinitely adjusted, i.e. in a continuous manner, throughout a predefined angular range of motion α . In the illustrated

- 5 embodiment, α is defined to be approximately 42 degrees. In a further illustrative embodiment, steering wheel 28 may be adjusted telescopically in a direction along a longitudinal axis 228.

Steering wheel 28 is coupled to rod 234 which extends through tilt bracket 30. Rod 234 is connected to coupler 242 which translates rotation of steering wheel 28 and rod 234 to universal joint 244. Universal joint 244 is coupled to an upper end of steering shaft 246. The lower end of steering shaft 246 is coupled to universal joint 248 which translates the rotation of steering shaft 246 to a front gearbox assembly 247 and steering arms 208 (Fig. 22) to turn front wheels 24. Tilt bracket 30 is pivotally coupled to bracket 250 by a fastener assembly 235, defining pivot axis 227. Fastener assembly 235 may include conventional bolts 235a, washers 235b, and nuts 235c. Bracket 250 includes lower arm 232. Lower end or mount 240 of adjustment device 230 is coupled to arm 232 of bracket 250. Upper end or mount 238 of adjustment device 230 is coupled to tabs 236 of tilt bracket 30. When steering wheel 28 is tilted upward, adjustment device 230 is extended and tilt bracket 30 is rotated upward. Conversely, when steering wheel 28 is tilted downward, adjustment device 230 is retracted and tilt bracket 30 is rotated downward.

In the illustrated embodiment, adjustment device 230 comprises a gas spring having a cylinder 252 and a movable piston rod 254. A lever 256 is operably coupled to the piston rod 254 and is configured to selectively block fluid flow within the cylinder 252. In operation, the lever 256 is in a rest position when it blocks fluid flow and locks the rod 254, and hence steering wheel 28, in position. Activation of the lever 256 permits fluid flow within the cylinder 252 and thus adjustment of the rod 254, and steering wheel 28. In one illustrative embodiment, adjustment device 230 comprises a Bloc-O-Lift[®] gas spring available from Stabilus.

Referring now to Fig. 30, an adjustable grab bar for a passenger riding in ATV 10 is shown. Adjustable grab bar 190, also shown in Figs. 22 and 23, is positioned in front dash panel 195 of ATV 10 and extends rearward toward a passenger seated in cab 17. Adjustable grab bar 190 includes handle portion 192, tubes 193 and 194, and locking mechanism 196. The passenger may telescopically adjust the position

5 of handle portion 192. Tube 193 may be extended out of and retracted within tube 194 to allow the passenger to adjust the position of handle portion 192 during ingress or egress from cab 17 of ATV 10. Locking mechanism 196 secures tube 193 and handle portion 192 in the desired position.

10 While this invention has been described as having an exemplary design, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An all-terrain vehicle having a frame and a pair of laterally spaced-apart seating surfaces supported by the frame, the all-terrain vehicle including: a pair of front wheels adapted to support the frame above a ground surface; a pair of rear wheels spaced-apart from the pair of front wheels, the pair of rear wheels adapted to support the frame above a ground surface, the at least one pair of laterally spaced-apart seating surfaces positioned between the pair of front wheels and the pair of rear wheels; and an engine positioned longitudinally behind the at least one pair of laterally spaced-apart seating surfaces; the engine being drivingly coupled to the front and rear wheels for driving the vehicle; and a transmission and driveshaft adapted to power at least one of the pair of front wheels, the transmission including a splined output shaft, the driveshaft including a coupler adapted to compliment the splined output shaft.
2. The all-terrain vehicle of claim 1 having a frame and a pair of laterally spaced-apart seating surfaces supported by the frame, the all-terrain vehicle including: a pair of front wheels adapted to support the frame above a ground surface; a pair of rear wheels spaced-apart from the pair of front wheels, the pair of rear wheels adapted to support the frame above a ground surface, the at least one pair of laterally spaced-apart seating surfaces positioned between the pair of front wheels and the pair of rear wheels; an engine positioned longitudinally behind the at least one pair of laterally spaced-apart seating surfaces; the engine being drivingly coupled to the front and rear wheels for driving the vehicle; and further including an upper brace coupled to the frame, the upper brace configured to be removed during installation of the engine within the frame.
3. The all-terrain vehicle of claim 1 or 2, further including a protective panel positioned between the pair of laterally spaced-apart seating surfaces and the engine.
4. The all-terrain vehicle of any one of the preceding claims, wherein the engine is coupled to the frame by a three point mounting system.
5. The all-terrain vehicle of any one of the preceding claims, wherein the frame includes a pair of vertical tubes and a rear assembly adapted to couple the pair of rear wheels to the frame, the rear assembly including a pair of upper control arms, a pair of lower control arms, and a pair of dampeners, the dampeners operably coupled to the pair of rear wheels and the vertical tubes of the frame.

6. The all-terrain vehicle of any one of the preceding claims, wherein the pair of front wheels are coupled to the frame by upper and lower control arms and a steering arm, the steering arm being positioned between the upper and lower control arms.

7. An all-terrain vehicle, including:

a frame, including a front frame portion, a mid frame portion and a rear frame portion;

a front suspension supported by the front frame portion;

at least two front wheels coupled to the front suspension;

a front torsion bar supported by the front frame and coupled to the front suspension;

a front differential supported by the front frame portion and drivingly coupled to the front wheels;

a seating area supported by the mid frame portion, including side by side seats, having a seat back and a seat bottom, the seat bottom having a top seating surface and a bottom mounting surface;

an engine supported by the frame, the engine including at least one cylinder having a cylinder head, said at least one cylinder being positioned rearwardly of the seating area and the top of the cylinder head of said at least one cylinder being positioned higher than the seat bottom mounting surface;

a transmission coupled to the engine and positioned rearwardly of the side by side seats;

a rear suspension supported by the rear frame portion;

at least two rear wheels coupled to the rear suspension;

a rear torsion bar supported by the rear frame portion and coupled to the rear suspension;

a rear differential supported by the rear frame portion and drivingly coupled to the rear wheels;

a front drive shaft extending between the transmission and the front differential for coupling the transmission to the front wheels; and

a rear drive shaft extending between the transmission and the rear differential for coupling the transmission to the rear wheels.

8. The all-terrain vehicle of claim 7, wherein the front drive shaft extends laterally intermediate the side by side seats.

9. The all-terrain vehicle of either claim 7 or 8, further including a cab receiving the pair of side by side seats, the cab including a center console.
10. The all-terrain vehicle of any one of claims 7 to 9, wherein the side by side seats are defined by a pair of bucket seats.
11. The all-terrain vehicle of any one of the preceding claims, wherein the vehicle width is less than 54 inches.
12. The all-terrain vehicle of claim 11, wherein the vehicle width is defined by the outer sides of the front wheels.
13. The all-terrain vehicle of any one of claims 7 to 12, further including a protective panel positioned between the side by seats and the engine.
14. The all-terrain vehicle of any one of the preceding claims, further defining a weight and a power to weight ratio, the power to weight ratio being equal to at least 0.045/1 horsepower/pound.
15. The all-terrain vehicle of any one of claims 7 to 9, further including a fuel tank, the side by side seats including a driver seating surface and a passenger seating surface, the fuel tank being positioned below the one of the passenger seating surface and driver seating surface.
16. The all-terrain vehicle of claim 15, further including a battery positioned vertically below the other one of the passenger seating surface and driver seating surface.
17. The all-terrain vehicle of any one of the preceding claims, further including an adjustable steering wheel adapted to actuate the pair of front wheels.
18. The all-terrain vehicle of claim 17, further including an adjustment device configured to lock the steering wheel in a selected position, the adjustment device being continuously adjustable within a range of motion.

19. An all-terrain vehicle including:
- a frame, including a front frame portion, a mid frame portion and a rear frame portion;
 - a front suspension supported by the front frame portion;
 - at least two front wheels coupled to the front suspension;
 - a front torsion bar supported by the front frame and coupled to the front suspension;
 - a front differential supported by the front frame portion and drivingly coupled to the front wheels;
 - a seating area supported by the mid frame portion, including side by side seats;
 - an engine supported by the frame;
 - a transmission coupled to the engine, the transmission including a continuously variable transmission;
 - a rear suspension supported by the rear frame portion;
 - at least two rear wheels coupled to the rear suspension;
 - a rear torsion bar supported by the rear frame portion and coupled to the rear suspension;
 - a rear differential supported by the rear frame portion and drivingly coupled to the rear wheels;
 - a front drive shaft extending between the transmission and the front differential for coupling the front wheels to the transmission; and
 - a rear drive shaft extending between the transmission and the rear differential for coupling the transmission to the rear wheels.
20. The all-terrain vehicle of claim 19, wherein the seating area includes side-by-side bucket seats having a seat back and a seat bottom.
21. The all-terrain vehicle of claim 20, wherein the bottom has a seating surface and a low point of the seating surface is below a top of the engine.
22. The all-terrain vehicle of any one of claims 19 to 21, further including a transmission shift lever extending through a floor board and positioned between the side by side seats.
23. The all-terrain vehicle of any one of claims 19 to 22, wherein the rear frame portion includes a lower rear frame portion and an upper rear frame portion.

24. The all-terrain vehicle of claim 23, wherein the lower rear frame portion includes lower cross members.

25. The all-terrain vehicle of either claim 23 or 24, wherein the upper rear frame portion includes at least one cross member.

26. The all-terrain vehicle of claim 25, wherein the upper rear frame portion at least partially extends over at least one of the engine or transmission.

27. The all-terrain vehicle of claim 26, wherein the upper rear frame portion further includes a rear brace positioned over the engine and transmission.

28. The all-terrain vehicle of claim 27, wherein the rear brace is coupled to the frame rear portion.

29. The all-terrain vehicle of any one of claims 23 to 28, wherein an engine cover is positioned over and is supported by the upper rear frame portion.

30. The all-terrain vehicle of any one of the preceding claims, further including an outer body panel supported by the frame.

31. The all-terrain vehicle of claim 30, wherein the outer body panel includes a front body panel and a hood.

32. The all-terrain vehicle of claim 31, further including a front storage area positioned under the hood.

33. The all-terrain vehicle of claim 19, further including a protective panel positioned between the pair of side by side seats and the engine.

34. The all-terrain vehicle of claim 33, wherein the front driveshaft extends under the protective panel.

35. The all-terrain vehicle of claim 34, further including a fuel tank, the side by side seats including a driver seating surface and a passenger seating surface, the fuel tank being positioned below one of the seating surfaces.

36. The all-terrain vehicle of claim 35, further including a battery positioned below the other of the seating surfaces.

37. The all-terrain vehicle of claim 36, wherein the front driveshaft extends laterally between the fuel tank and the battery.

38. An all-terrain vehicle substantially as hereinbefore described with reference to the accompanying drawings.

POLARIS INDUSTRIES INC.

WATERMARK PATENT & TRADE MARK ATTORNEYS

P31397AU00

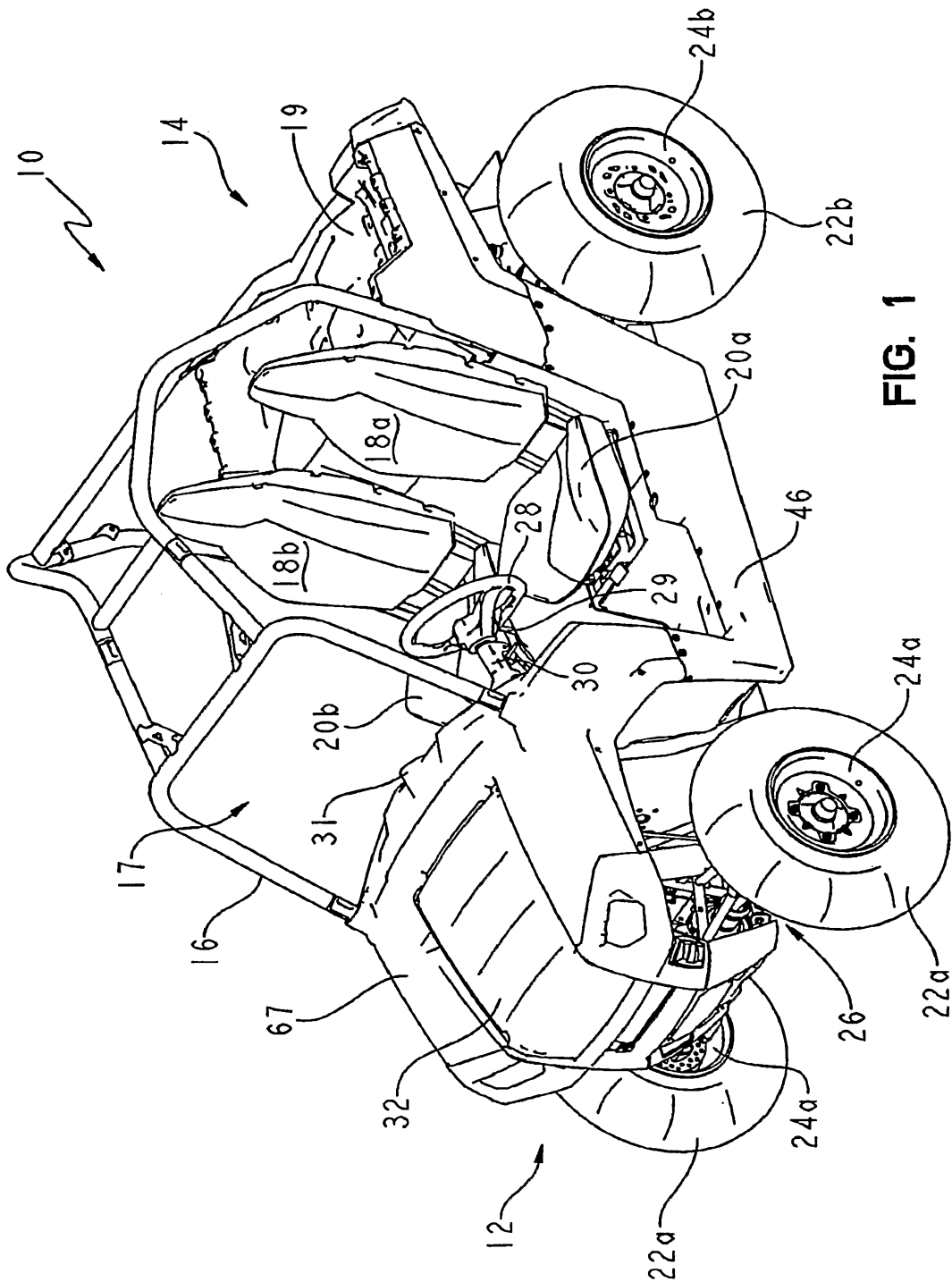


FIG. 1

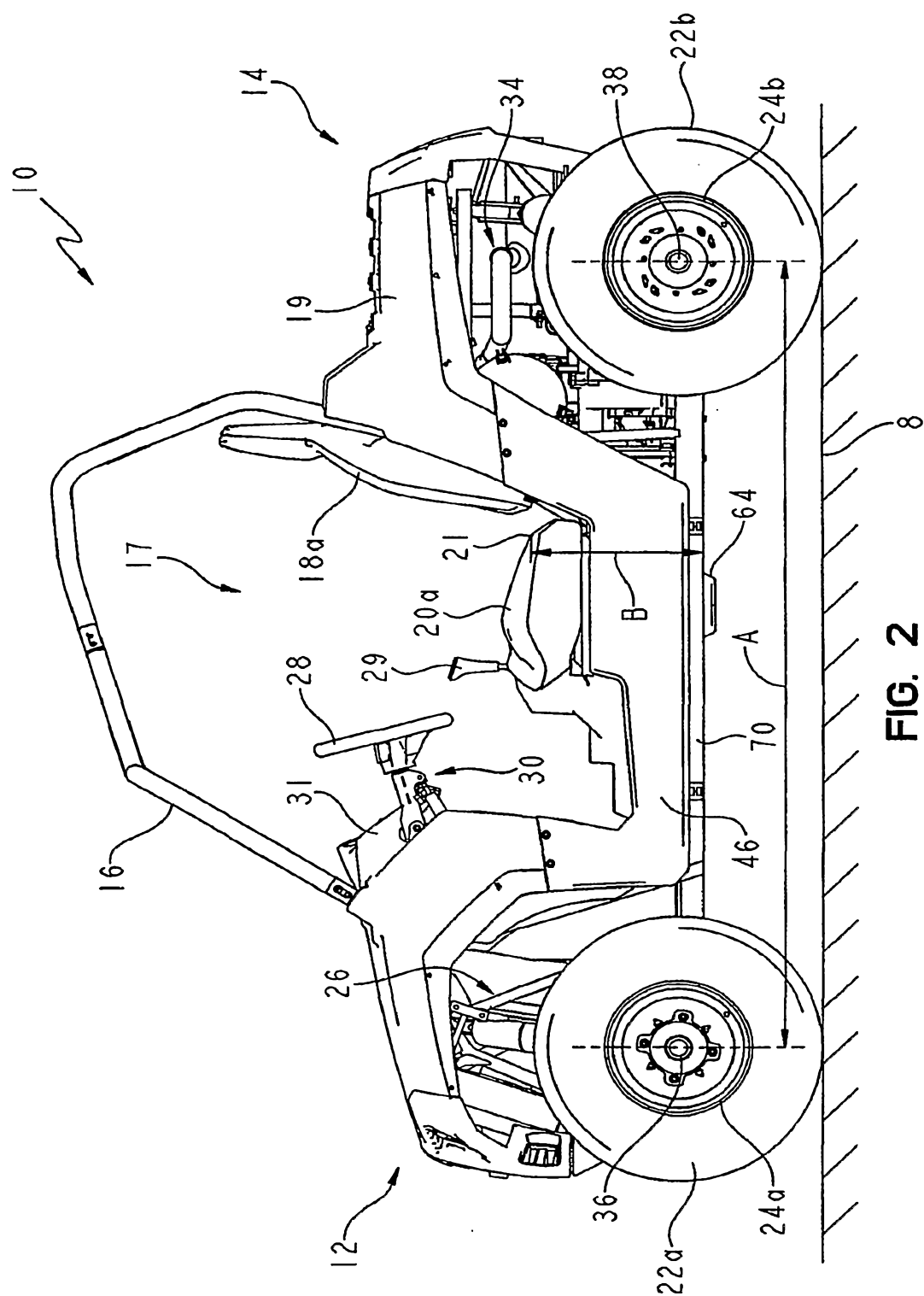


FIG. 2

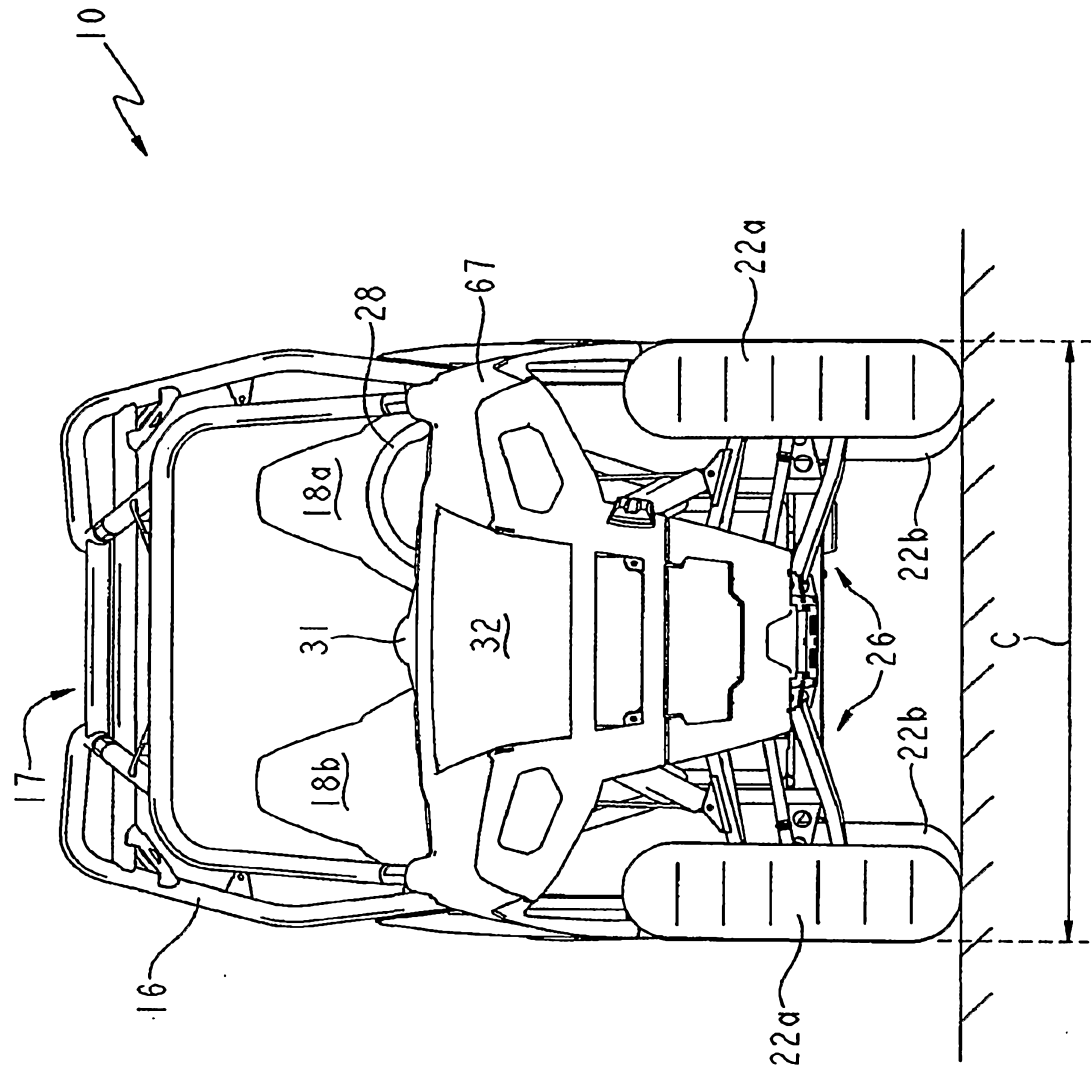


FIG. 3

4/27

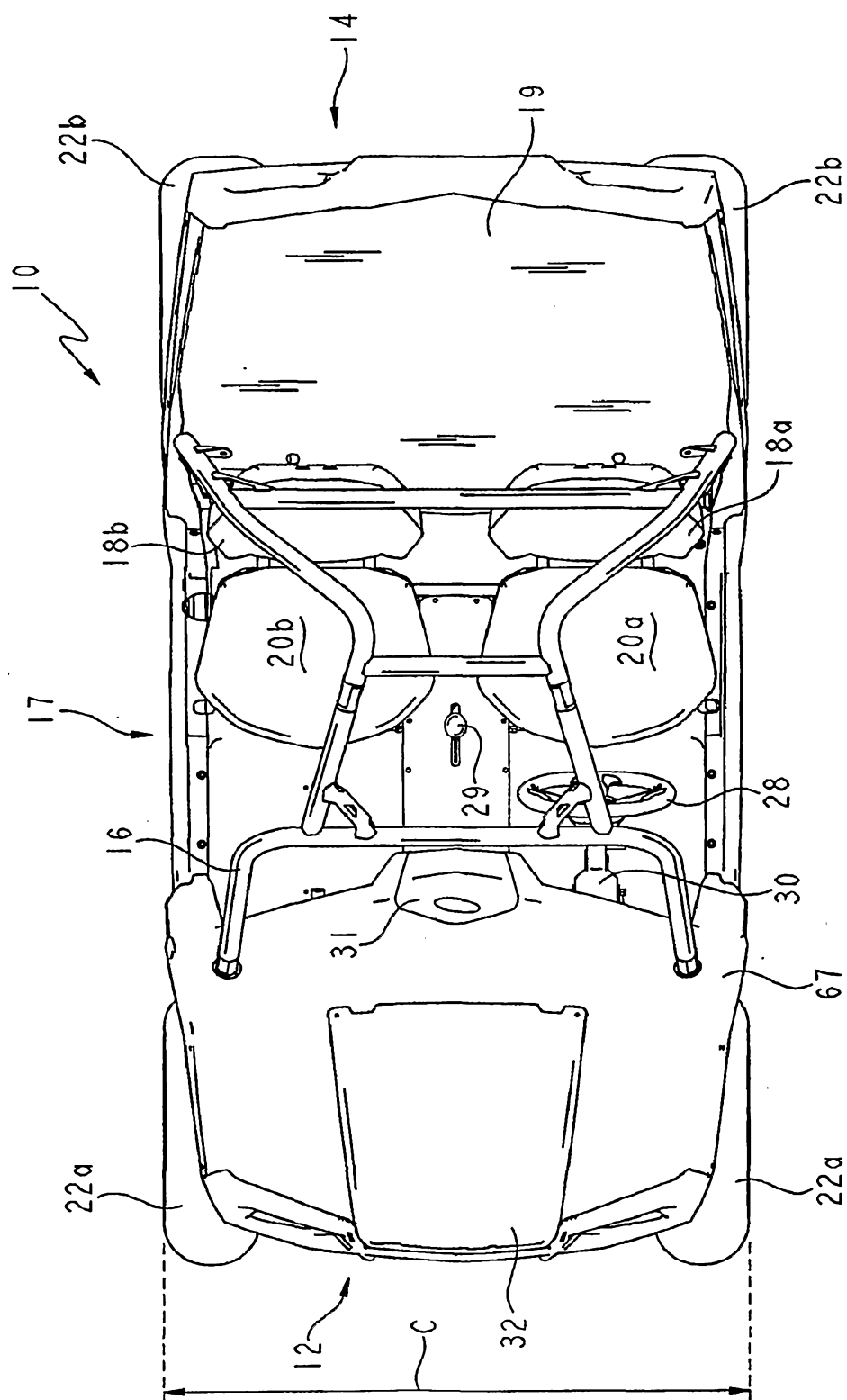


FIG. 4

5/27

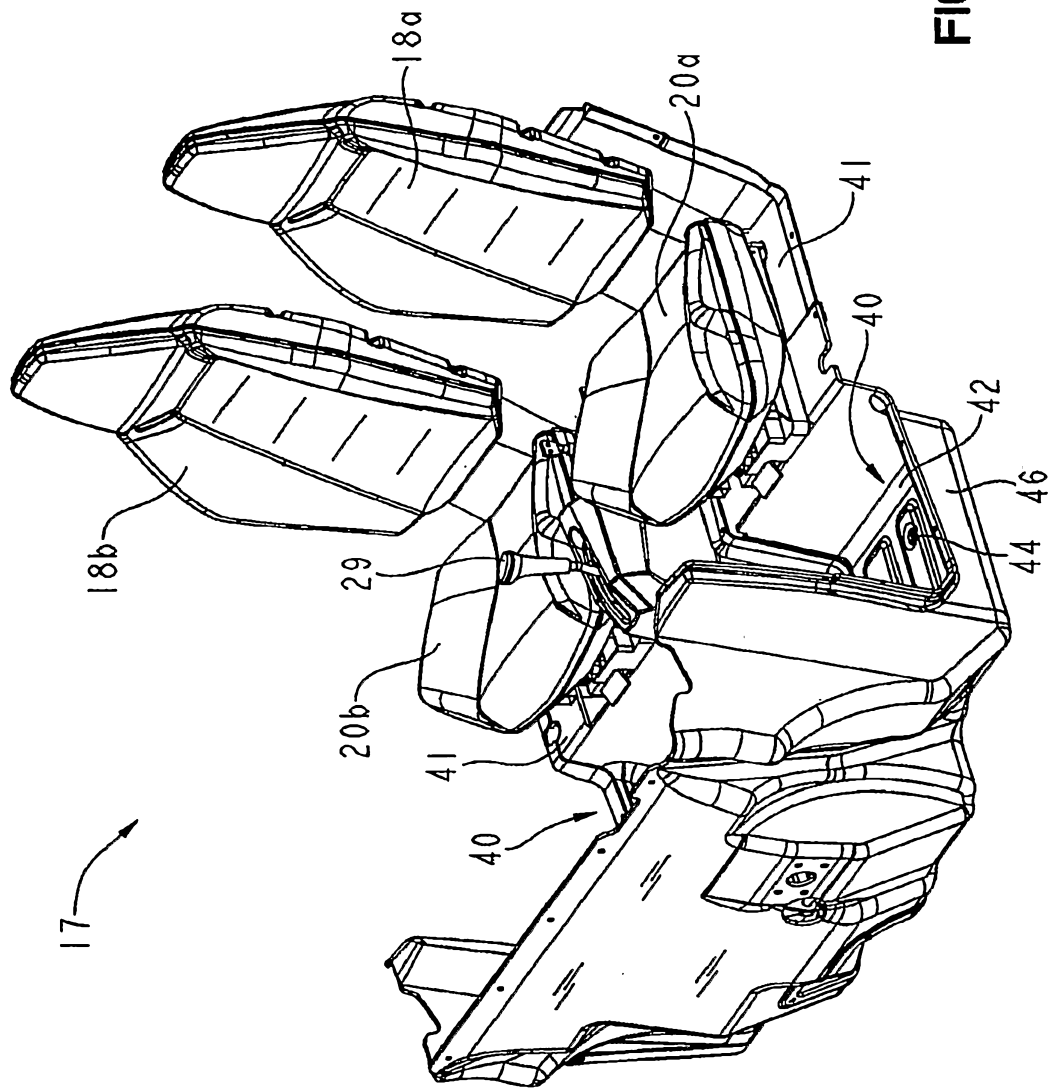


FIG. 5

6/27

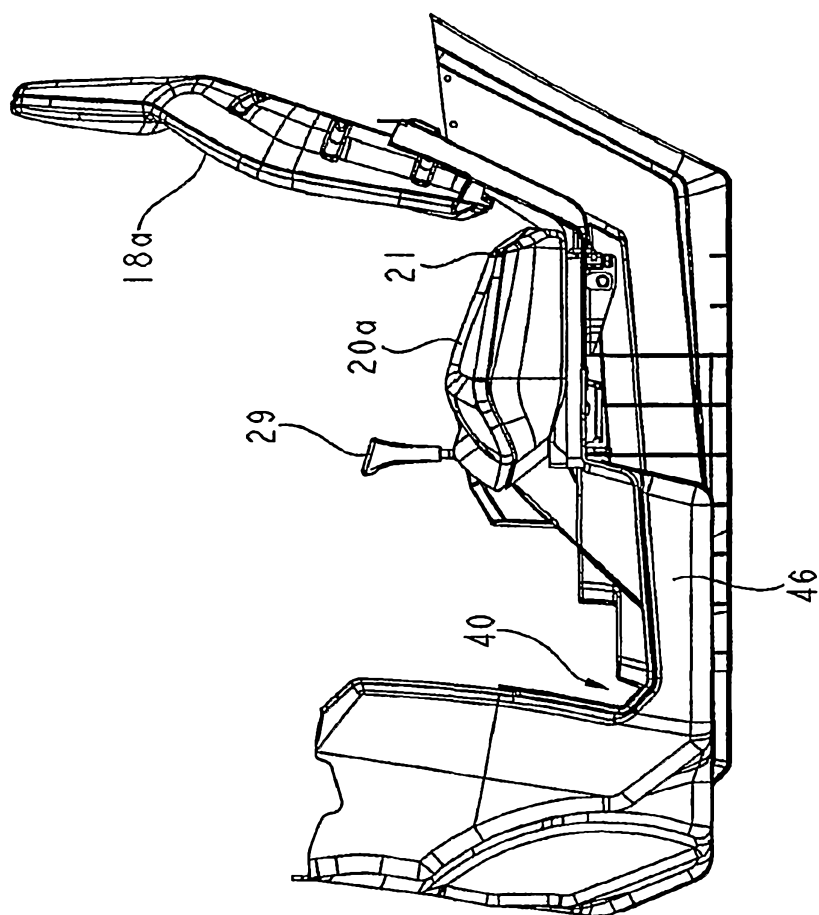


FIG. 6

7/27

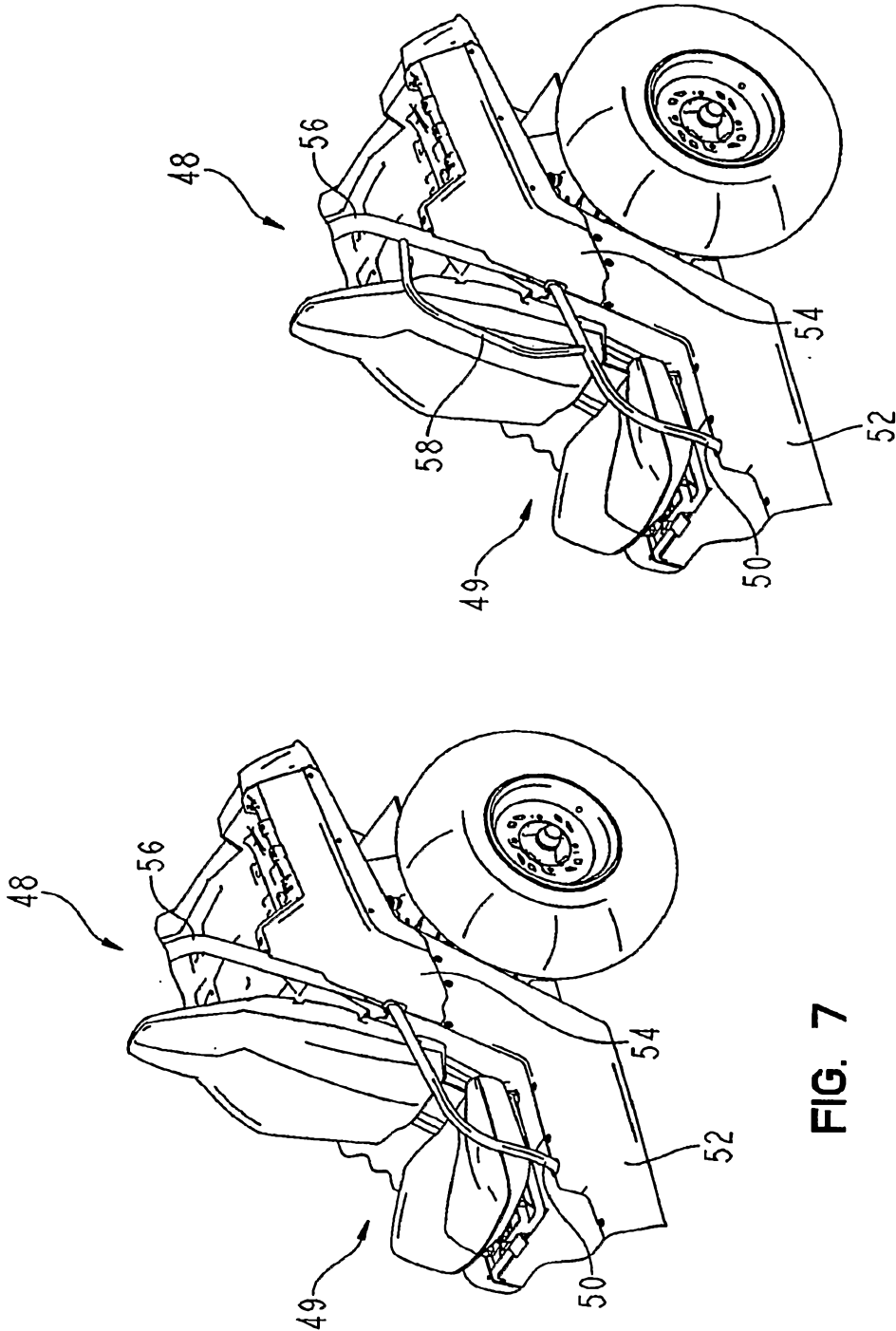
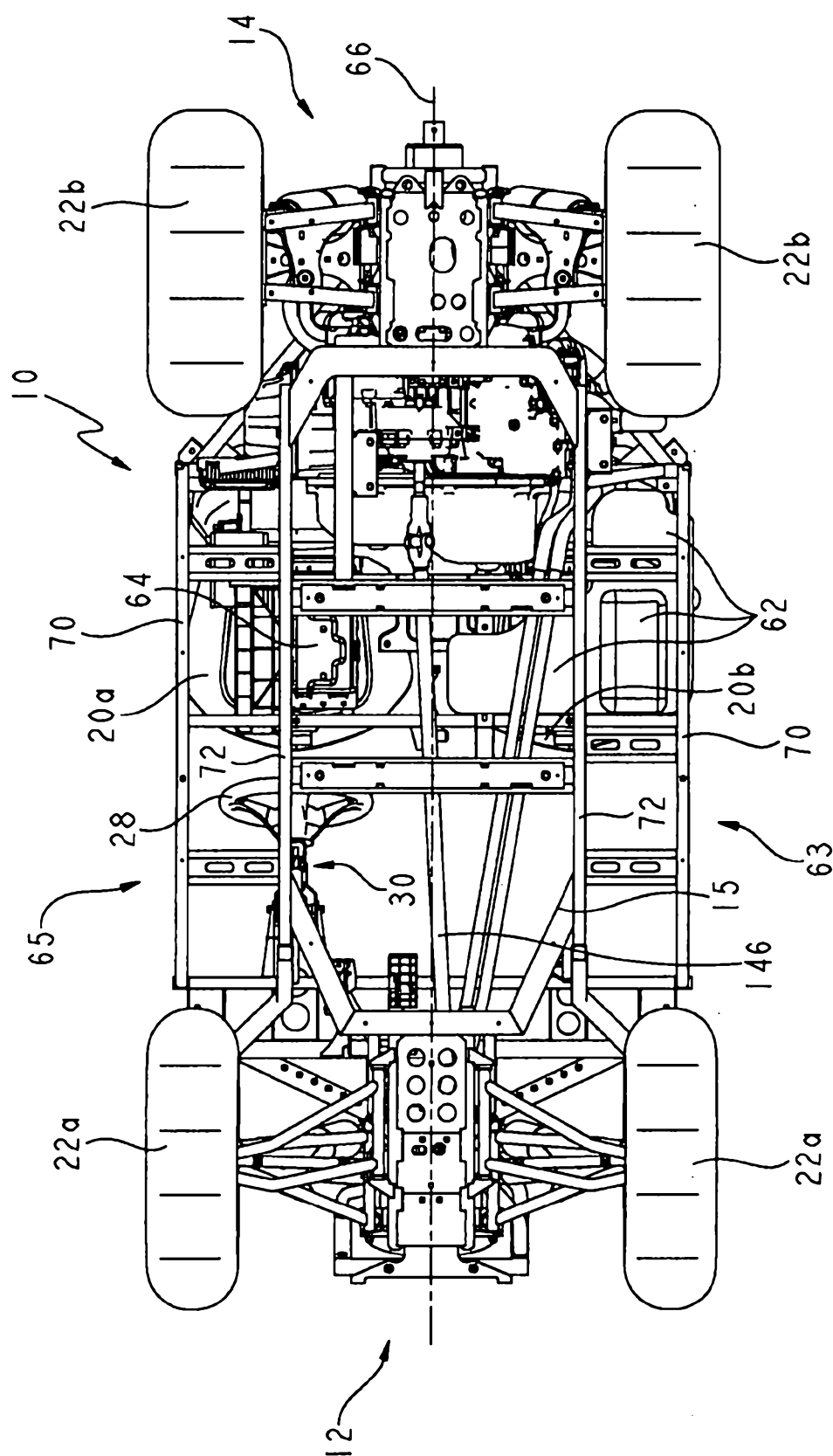


FIG. 8

FIG. 7



9. **Elig.**

9/27

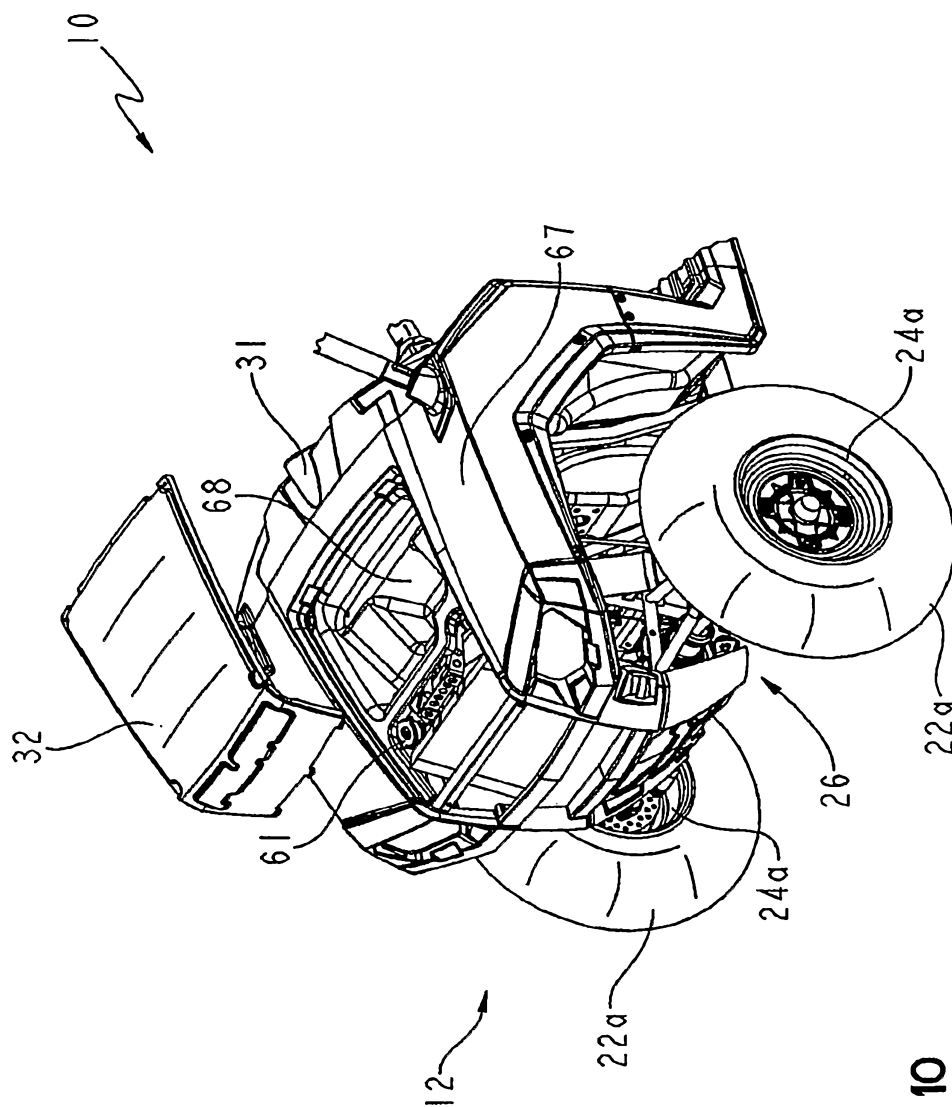


FIG. 10

10/27

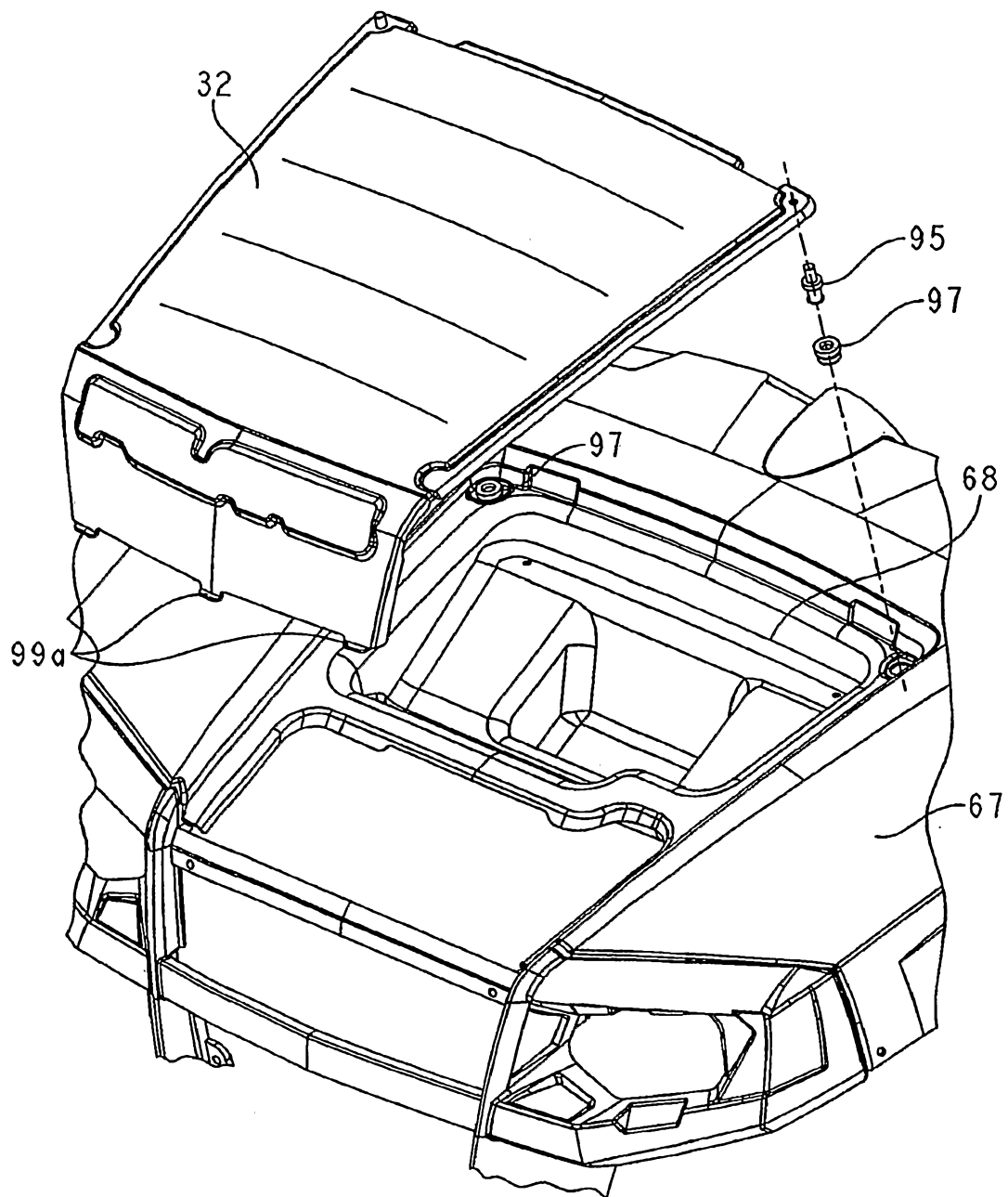


FIG. 11

11/27

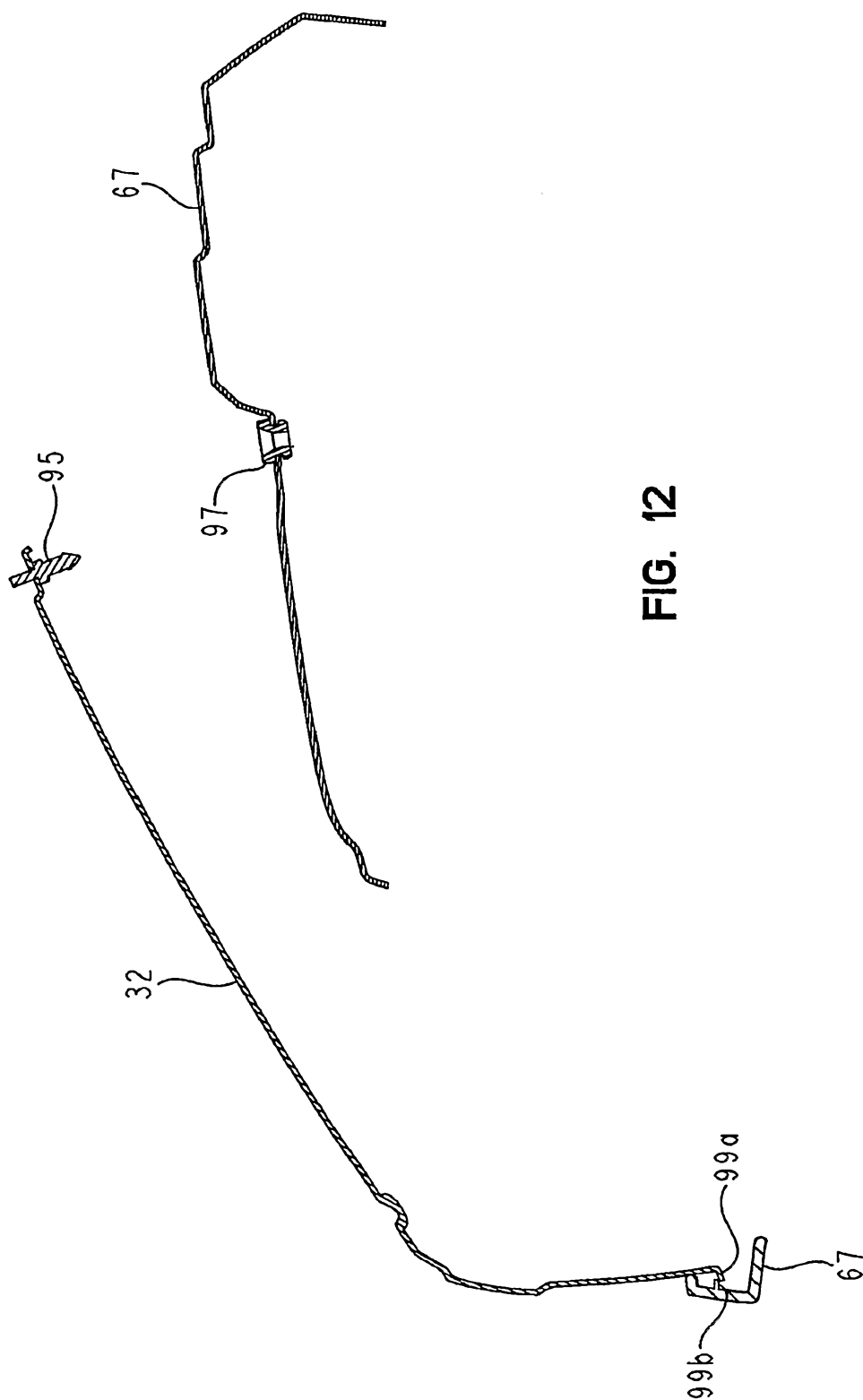


FIG. 12

12/27

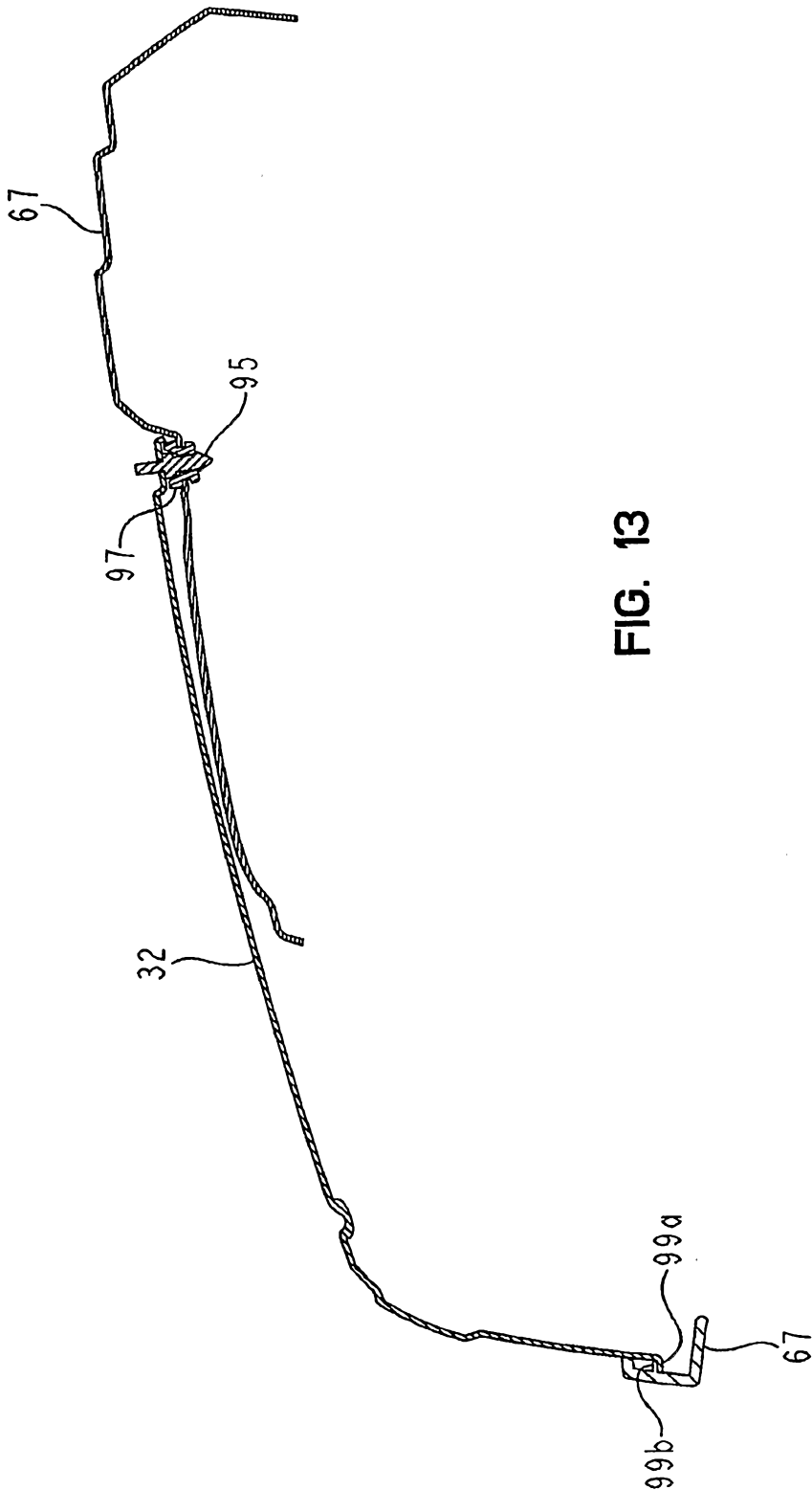


FIG. 13

13/27

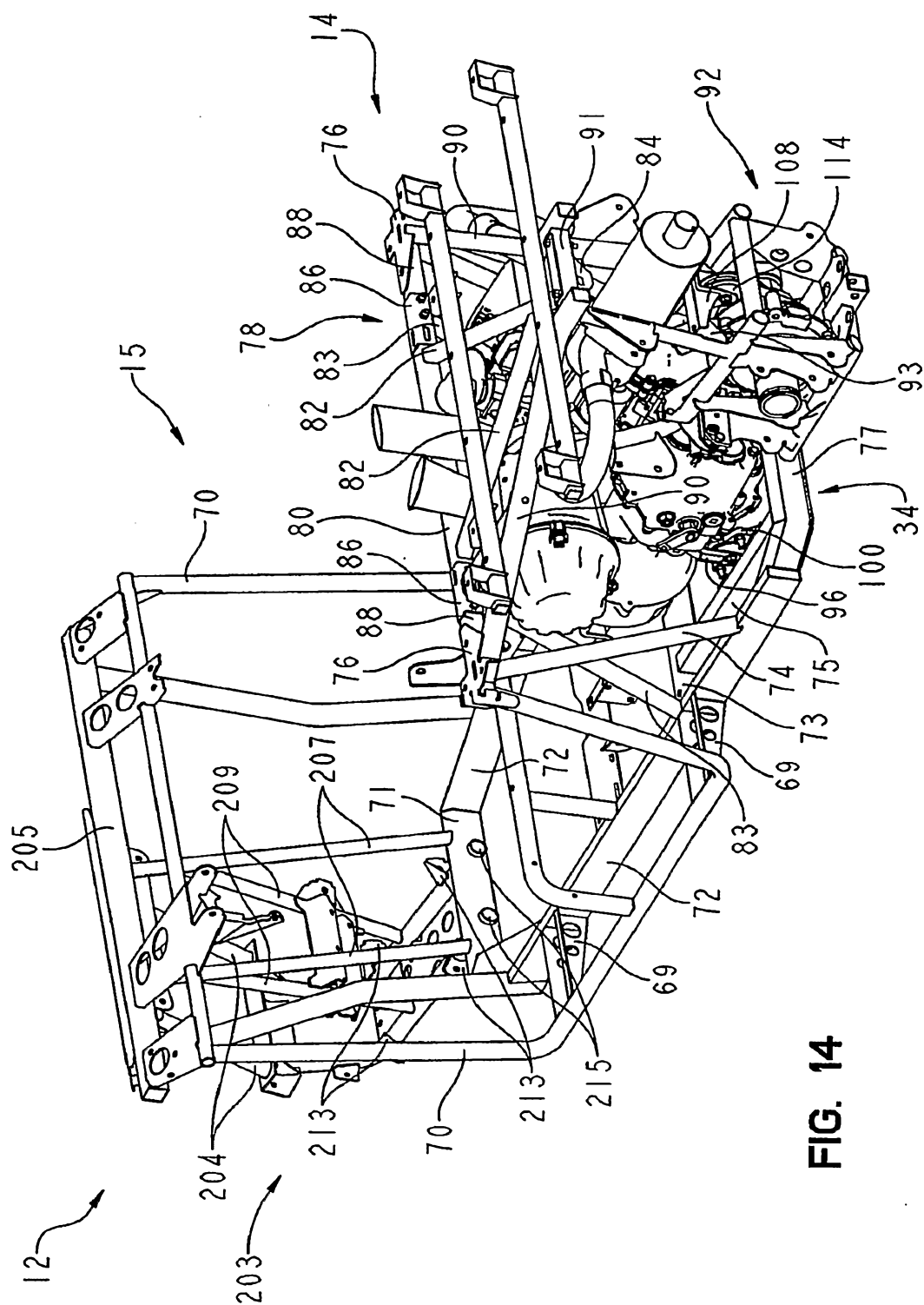


FIG. 14

14/27

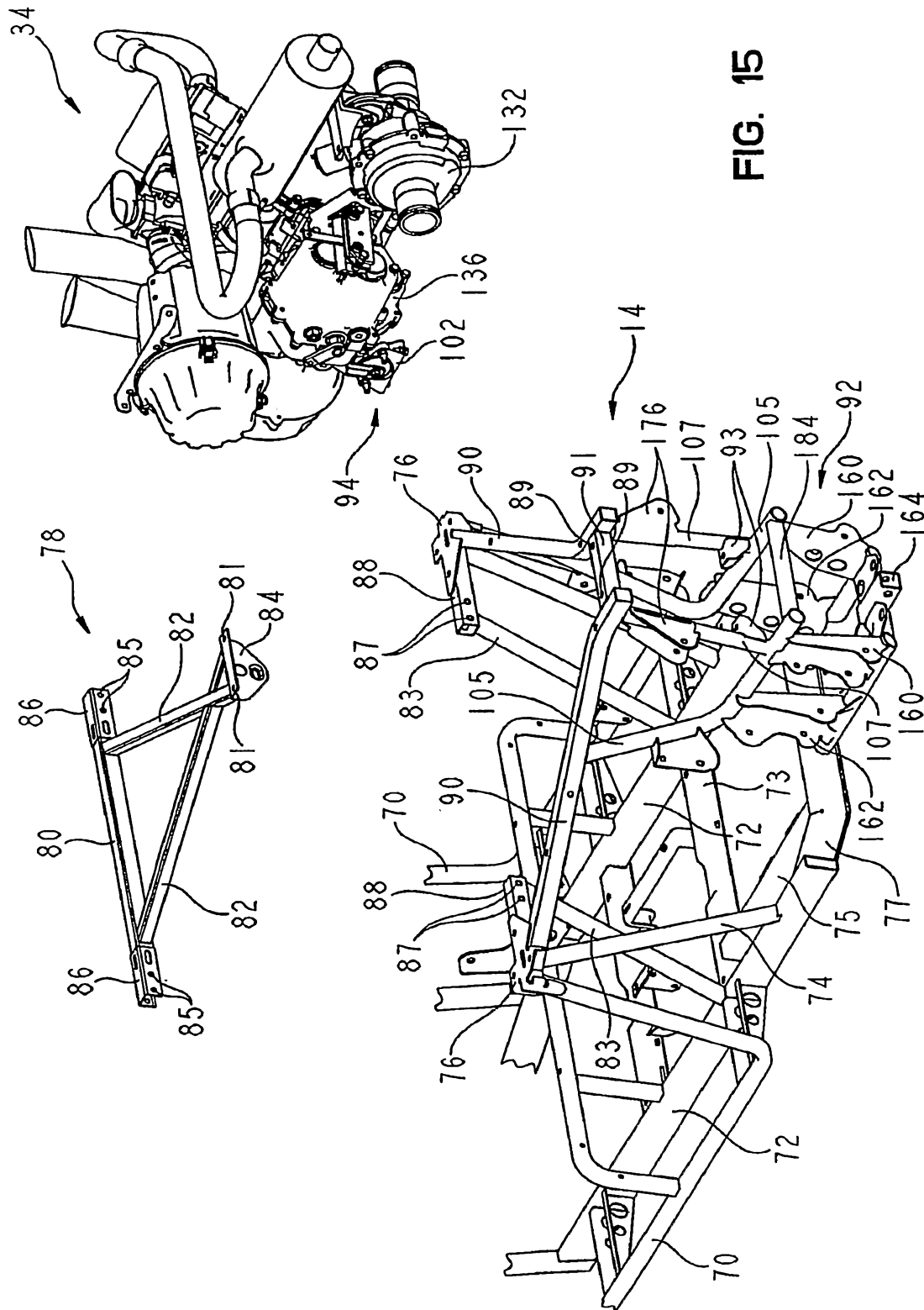


FIG. 15

15/27

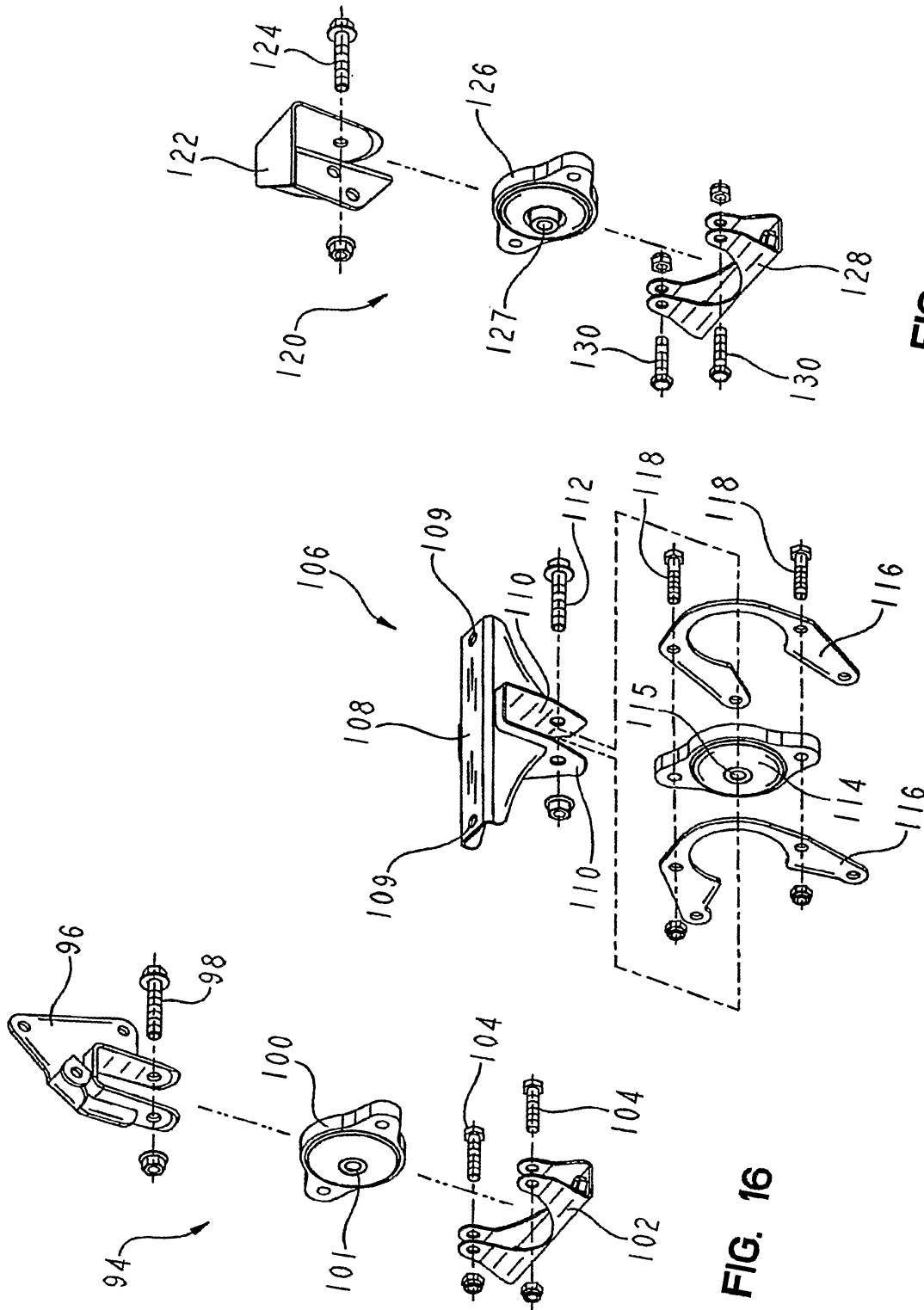


FIG. 18

FIG. 17

FIG. 16

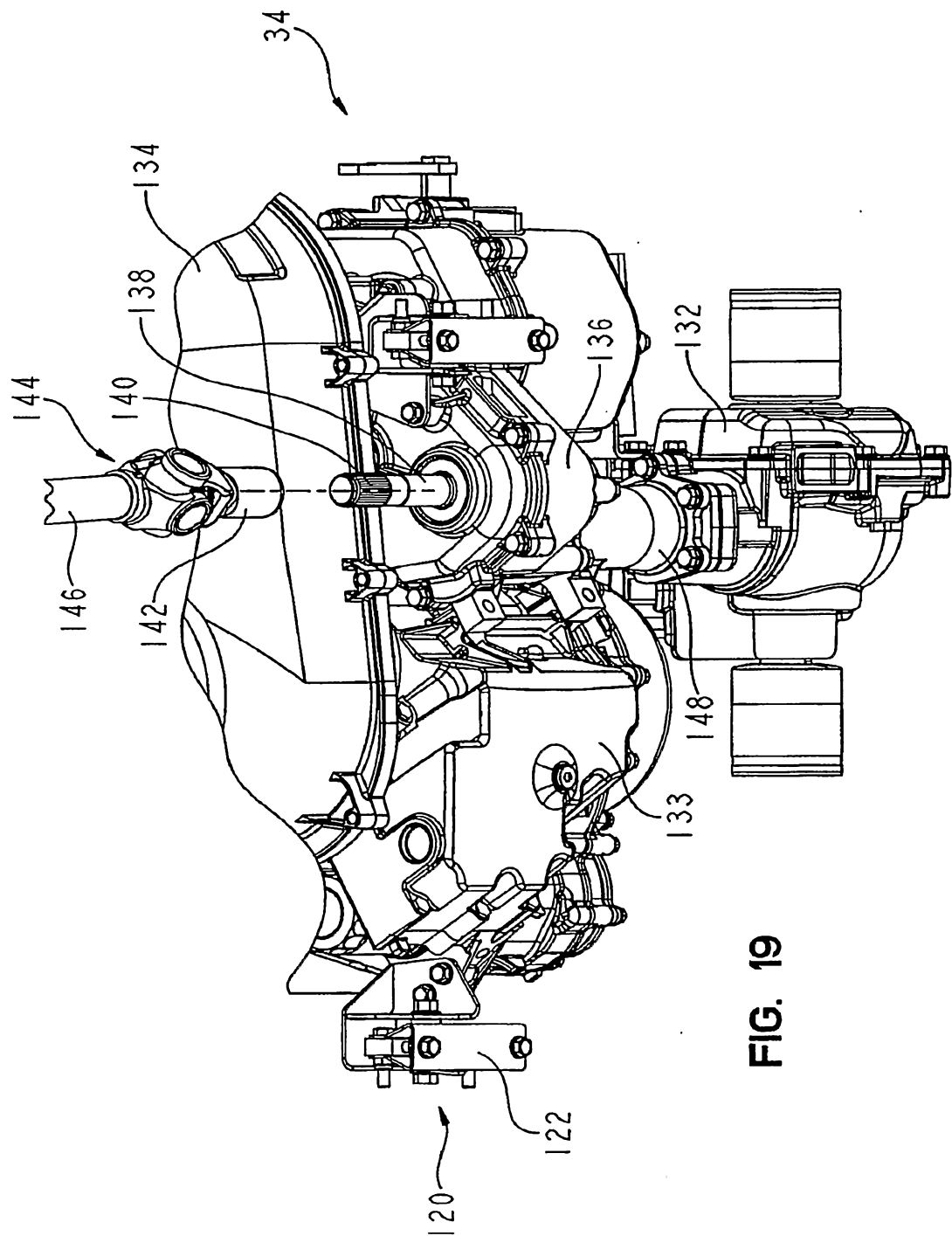


FIG. 19

17/27

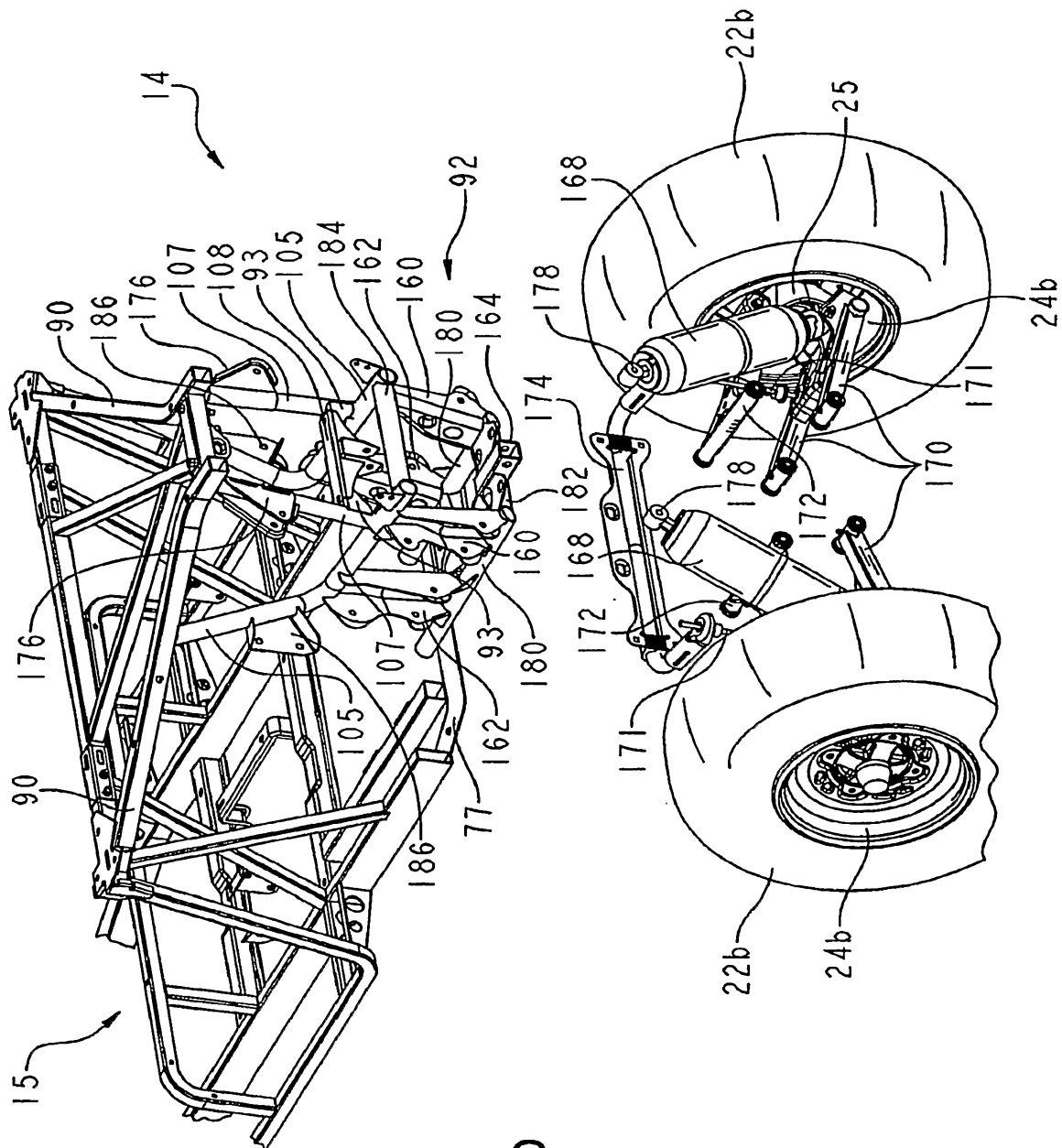


FIG. 20

18/27

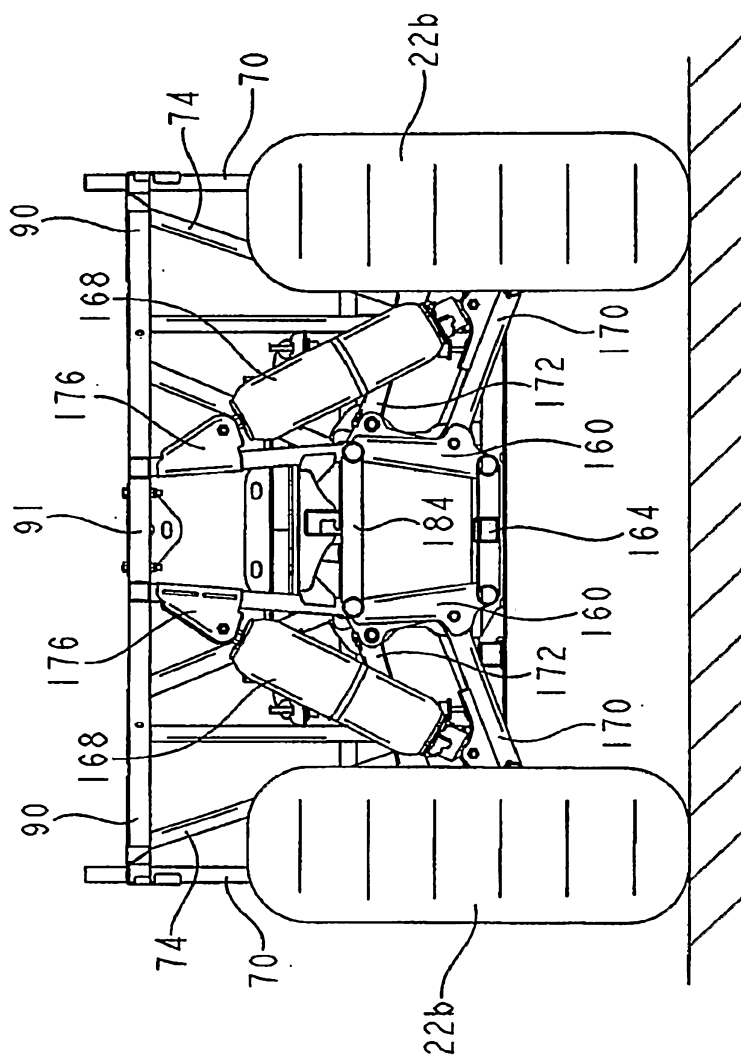


FIG. 21

19/27

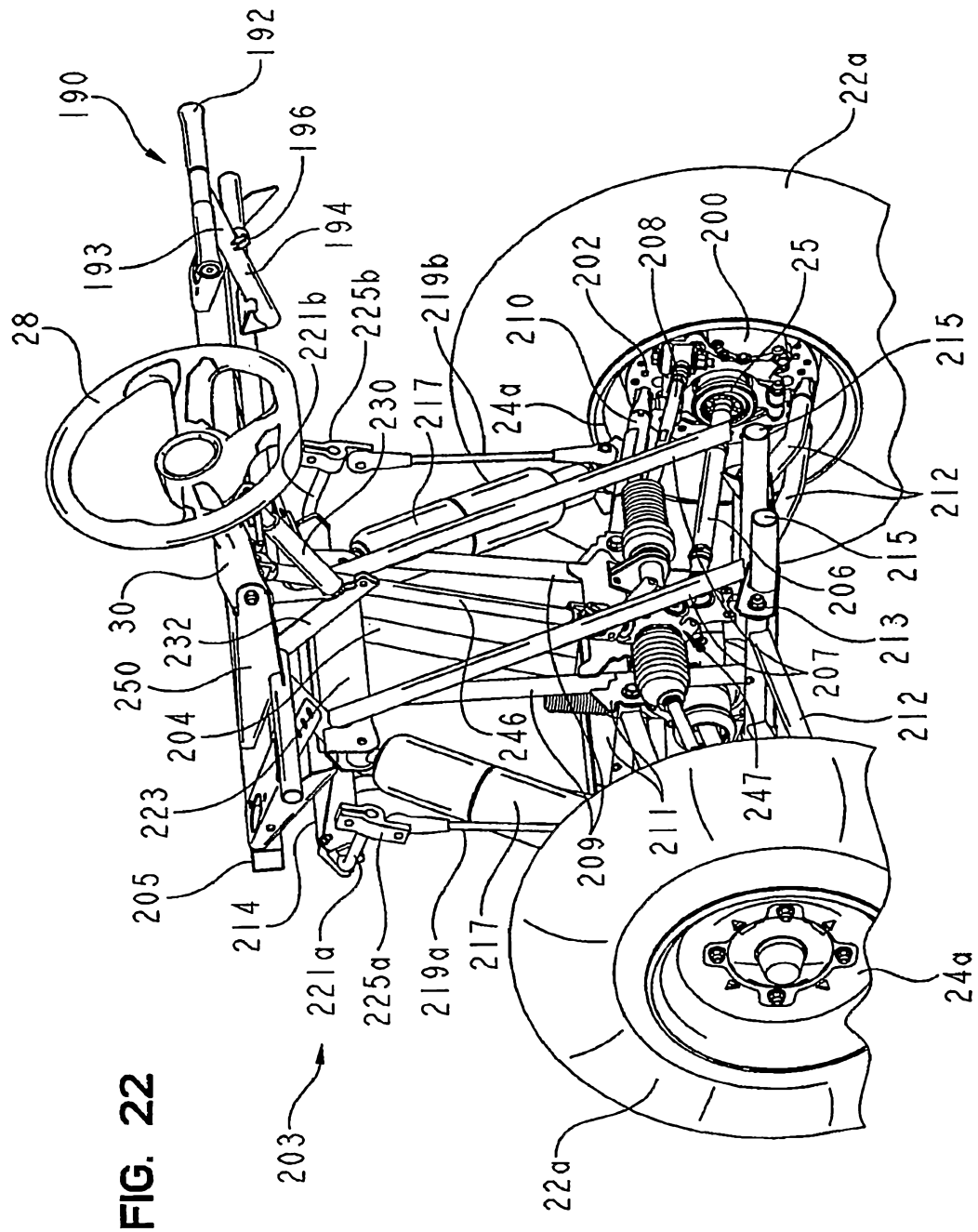
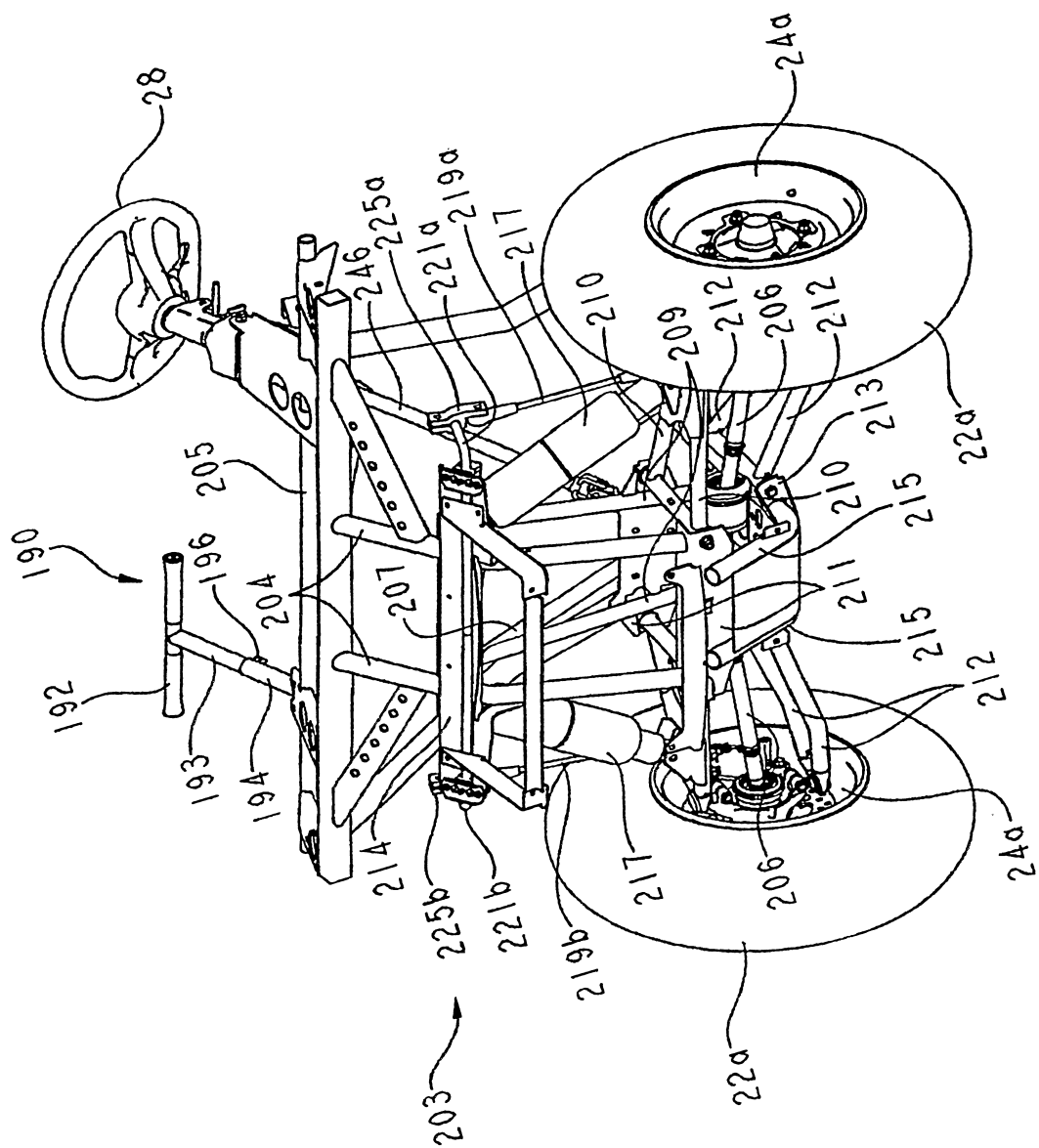


FIG. 22

20/27

FIG. 23



21/27

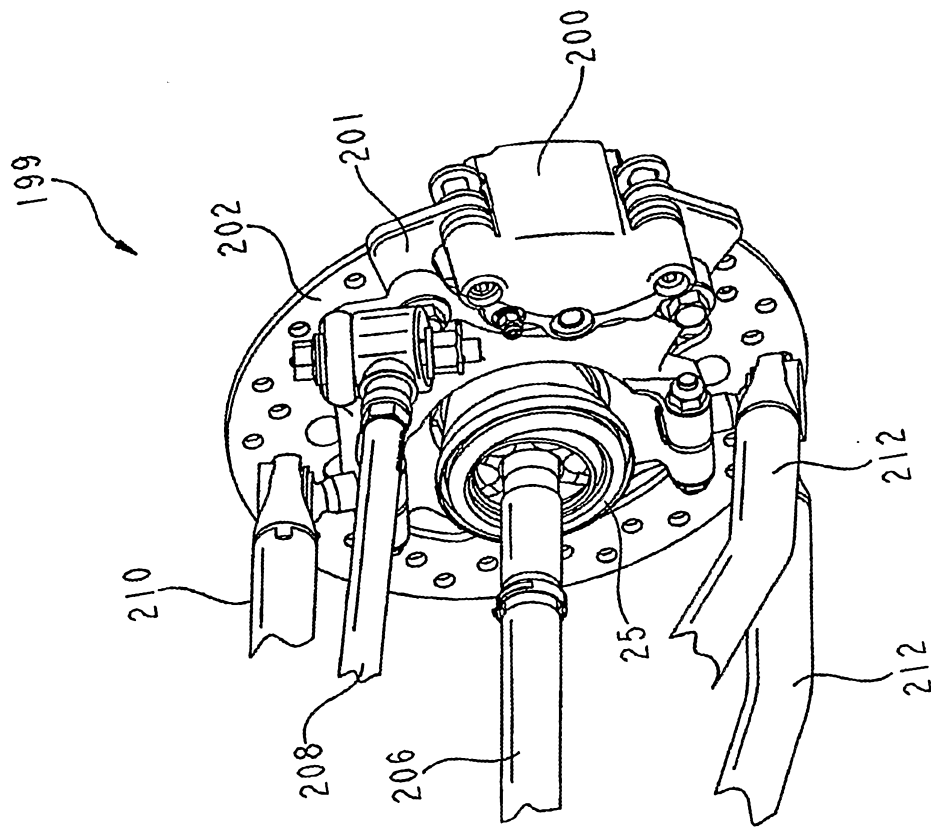


FIG. 24

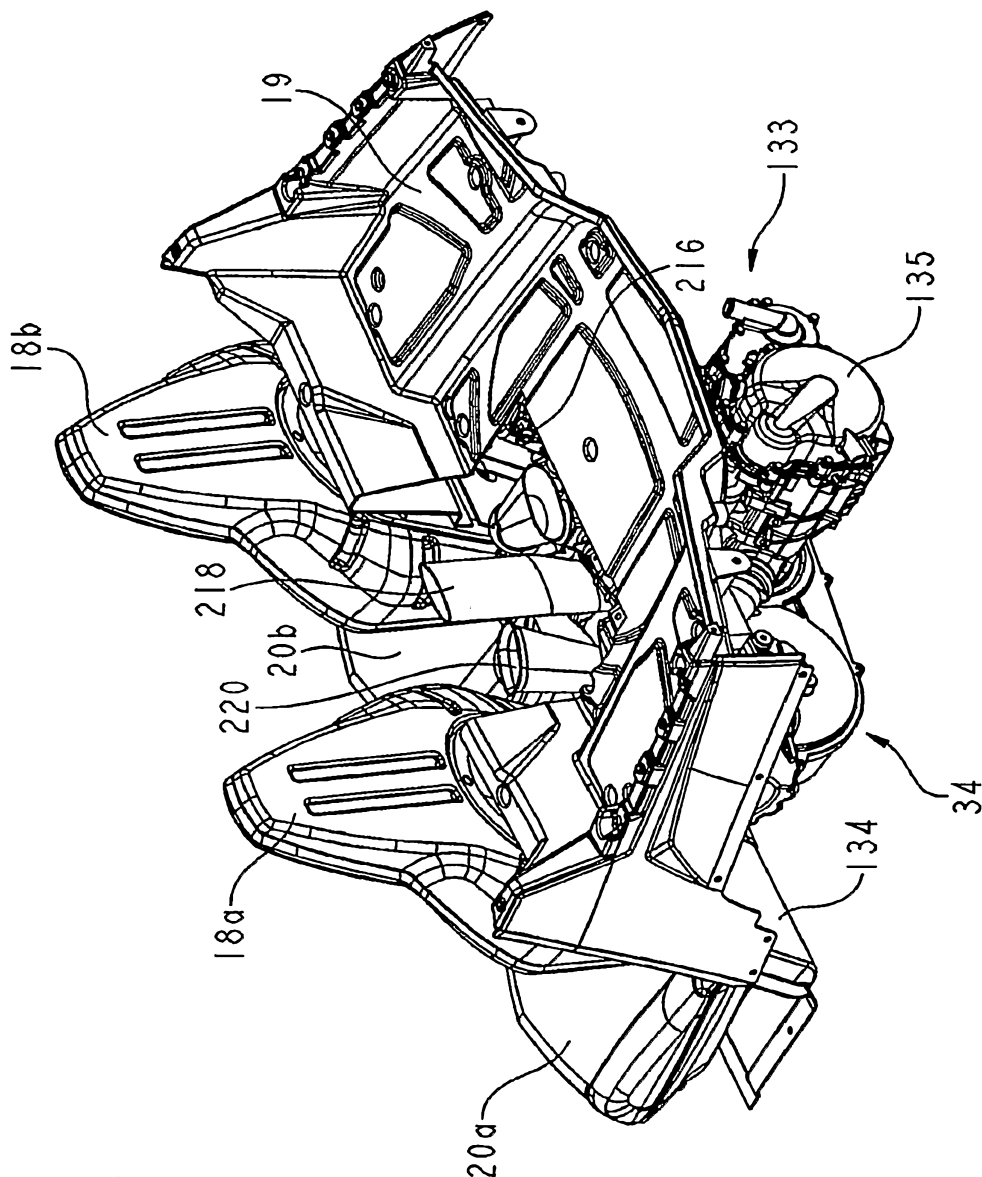


FIG. 25

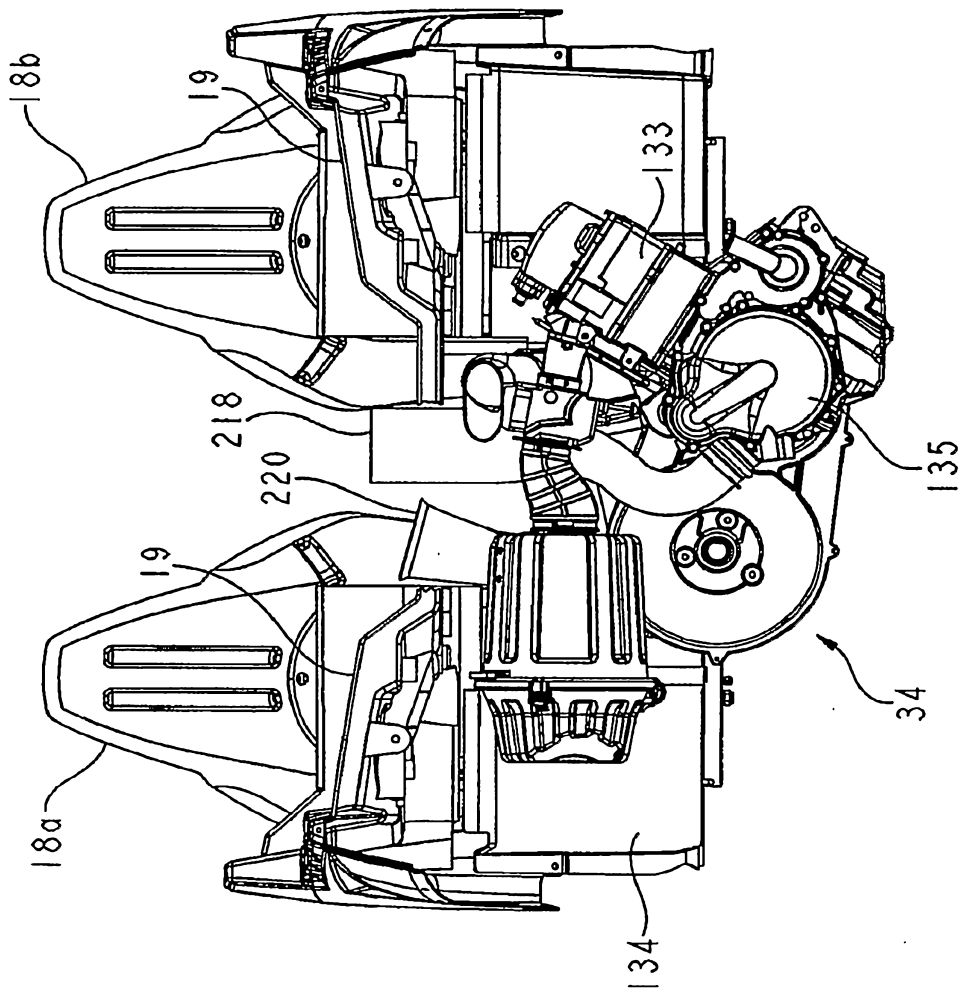


FIG. 26

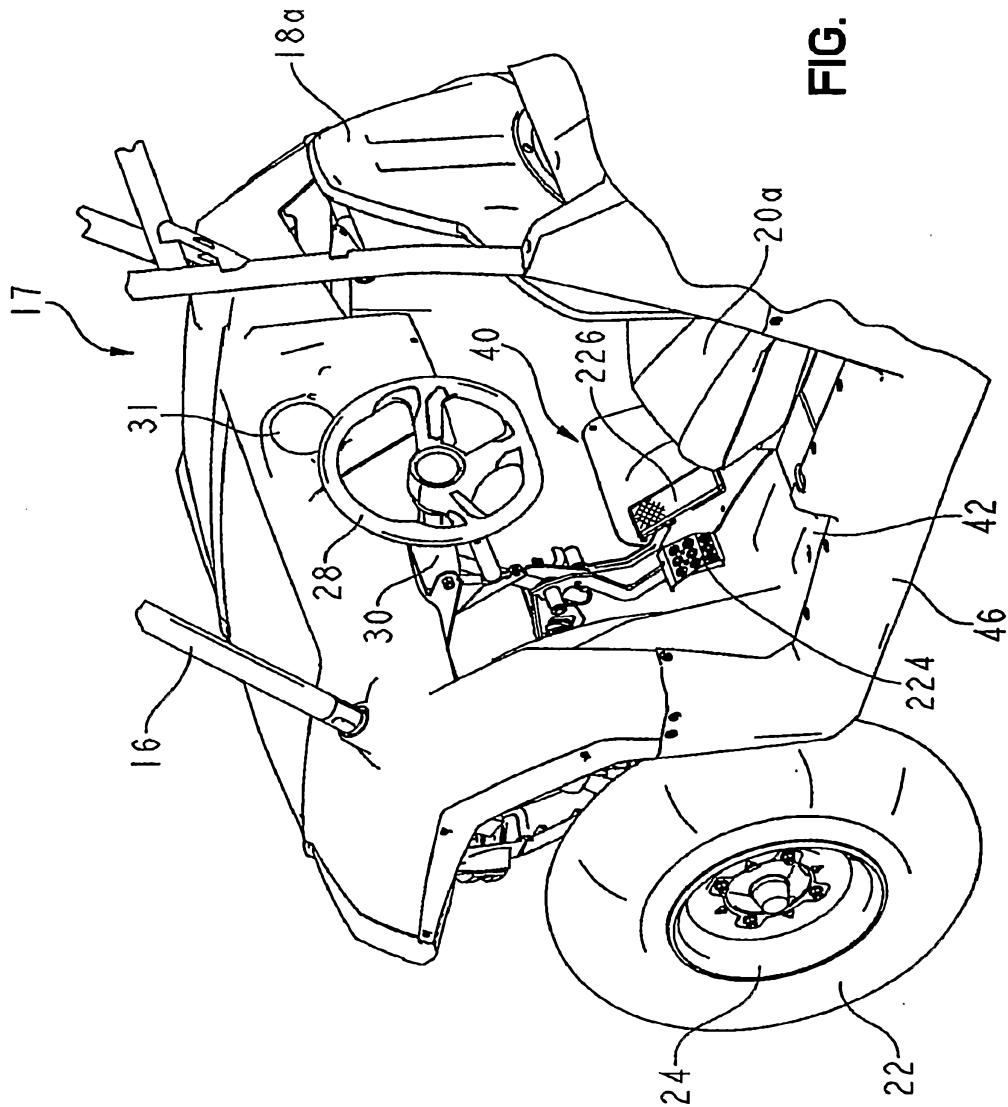


FIG. 27

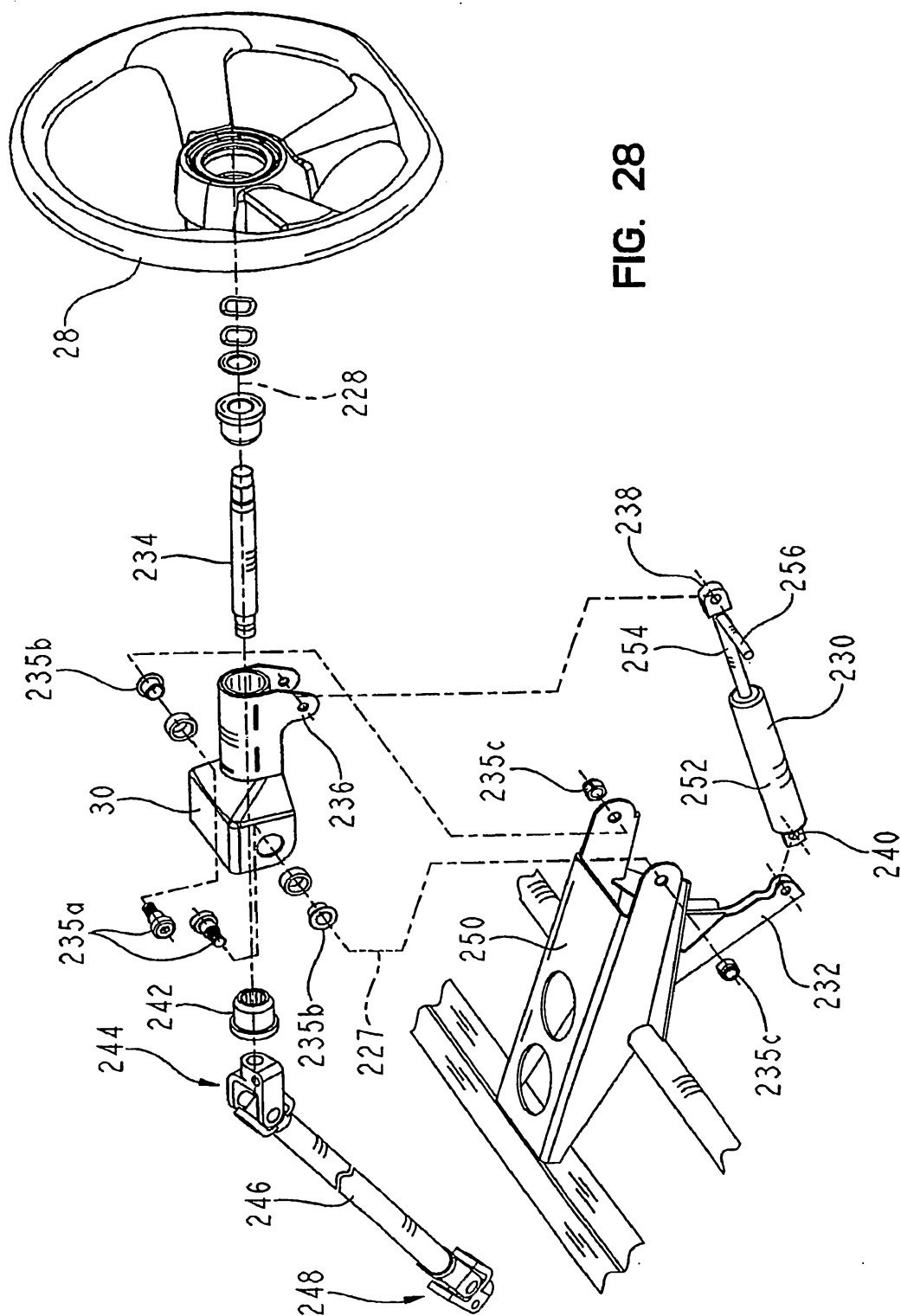


FIG. 28

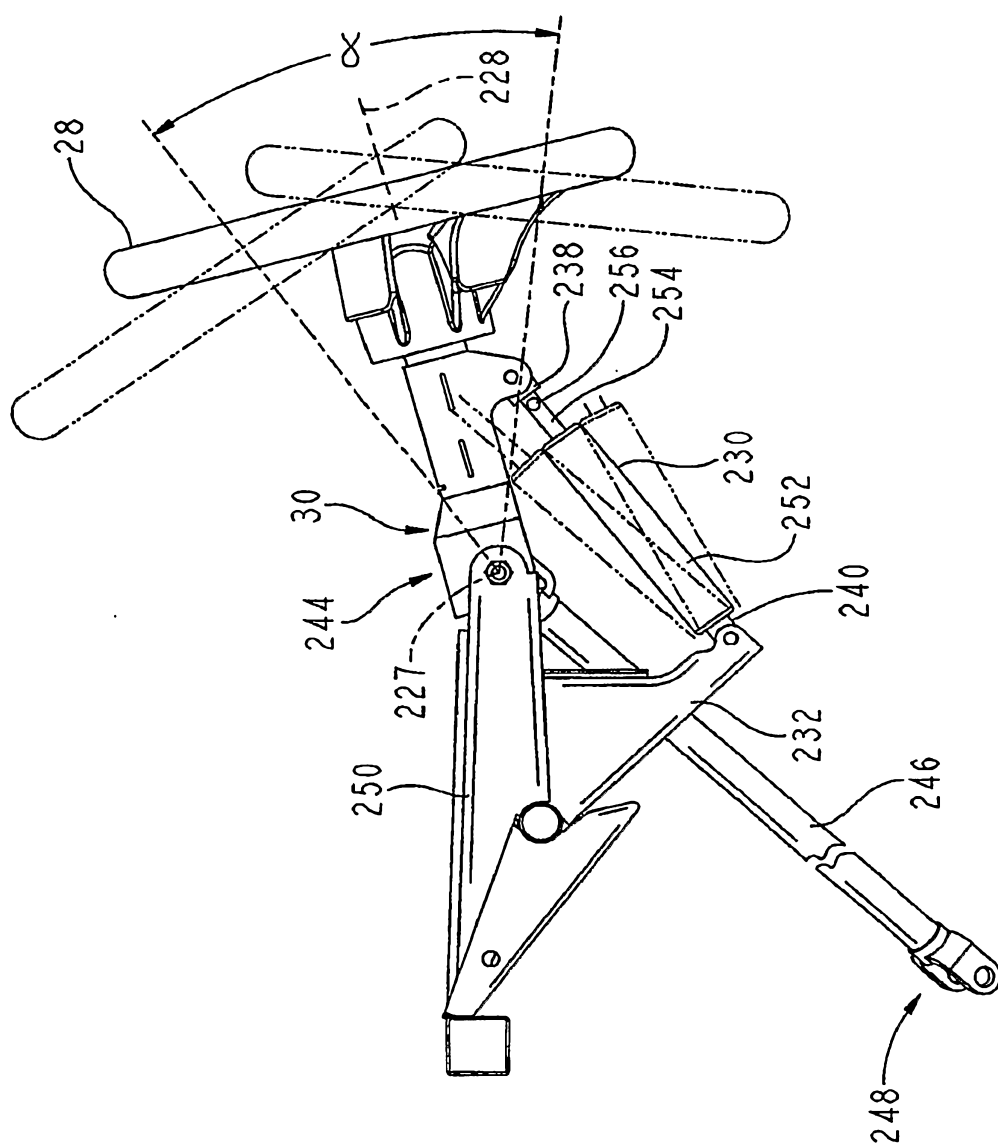


FIG. 29

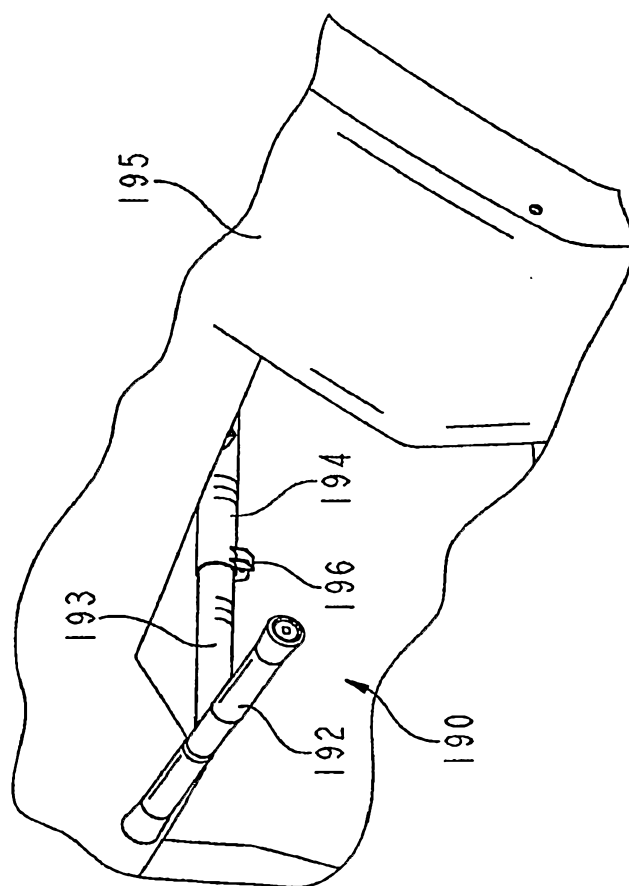


FIG. 30