



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

(10) **Patent No.:** **US 10,526,045 B2**  
(45) **Date of Patent:** **Jan. 7, 2020**

(54) **FRAME AND FRONT SUSPENSION ASSEMBLY FOR A SNOWMOBILE**

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 247 days.

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(21) Appl. No.: **15/470,188**

(22) Filed: **Mar. 27, 2017**

(65) **Prior Publication Data**

US 2017/0341711 A1 Nov. 30, 2017

**Related U.S. Application Data**

(60) Provisional application No. 62/343,072, filed on May 30, 2016.

(51) **Int. Cl.**  
**B62M 27/02** (2006.01)  
**B60G 3/20** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **B62M 27/02** (2013.01); **B60G 3/20** (2013.01); **B60G 2200/144** (2013.01); **B60G 2300/322** (2013.01); **B62M 2027/023** (2013.01); **B62M 2027/026** (2013.01); **B62M 2027/028** (2013.01)

(58) **Field of Classification Search**  
CPC ..... B62M 27/02; B62M 2027/026; B60G 2200/144

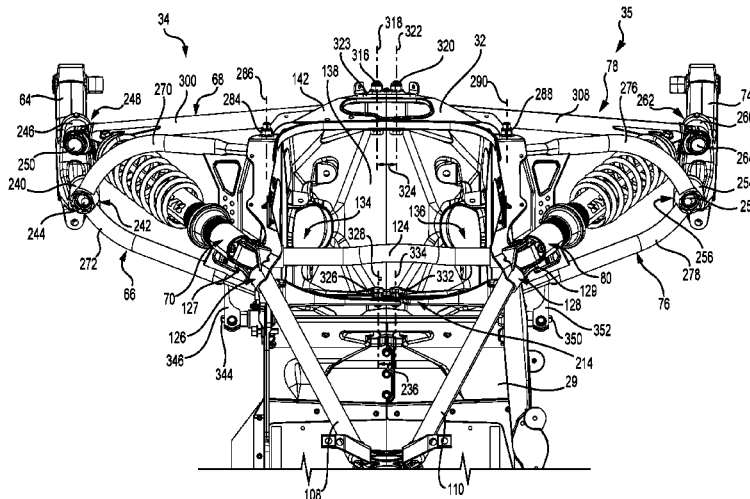
See application file for complete search history.

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(57) **ABSTRACT**

A snowmobile has a frame having a motor module, a tunnel connected to the motor module, a suspension module connected to the motor module, a motor, a handlebar, a ski operatively connected to the handlebar and a front suspension assembly operatively connecting the ski to the suspension module and to the motor module. The front suspension assembly has a suspension arm having a proximal end positioned longitudinally between the motor module and the suspension module. The proximal end pivots about a pivot axis extending through an interior portion of the suspension module. A proximal fastener passes through the proximal end of the suspension arm and extends from the interior portion of the suspension module to the motor module. The proximal fastener thereby pivotally connects the suspension arm to the suspension module and to the motor module about the pivot axis.

**18 Claims, 34 Drawing Sheets**



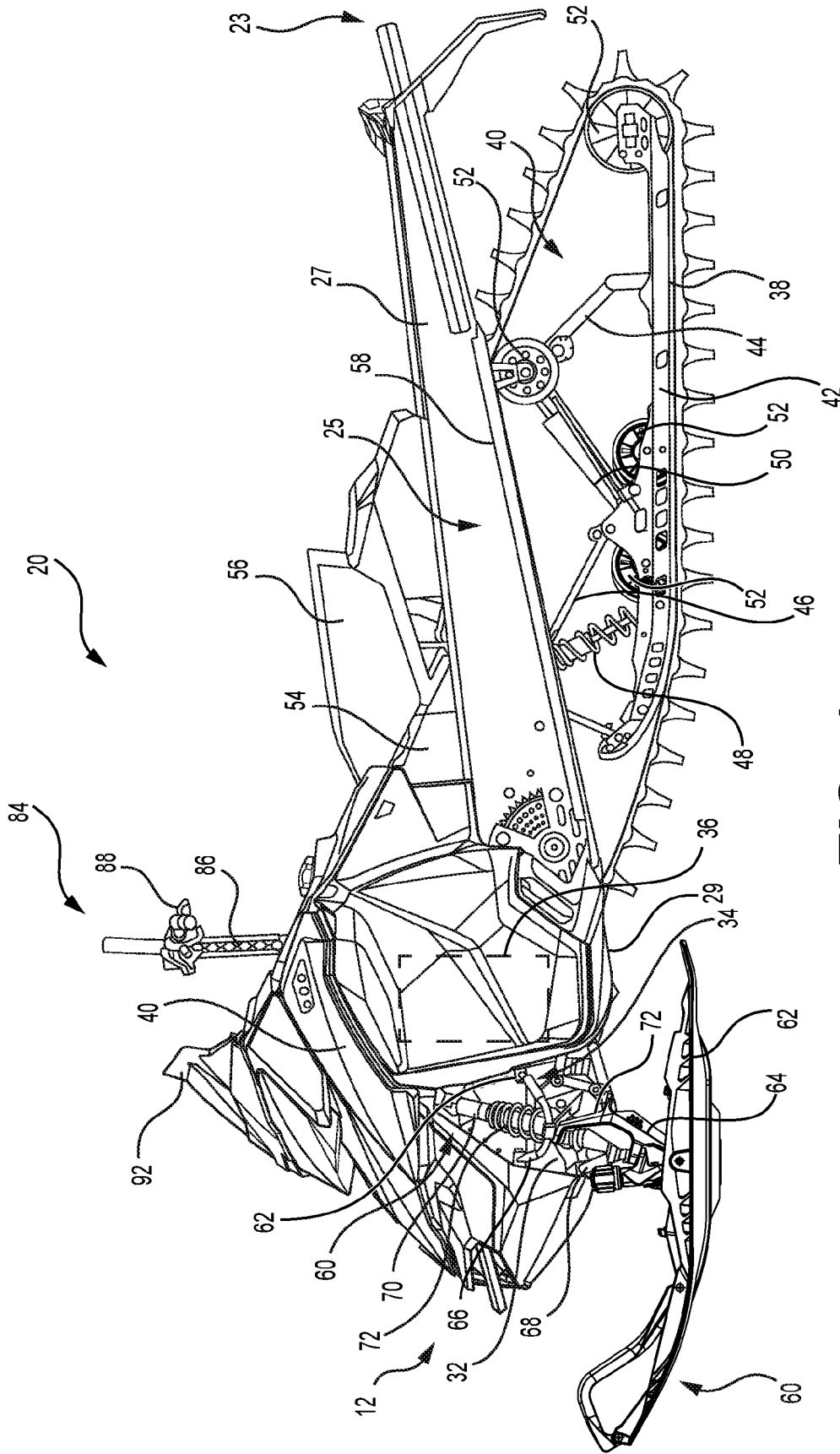
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**FIG. 1**

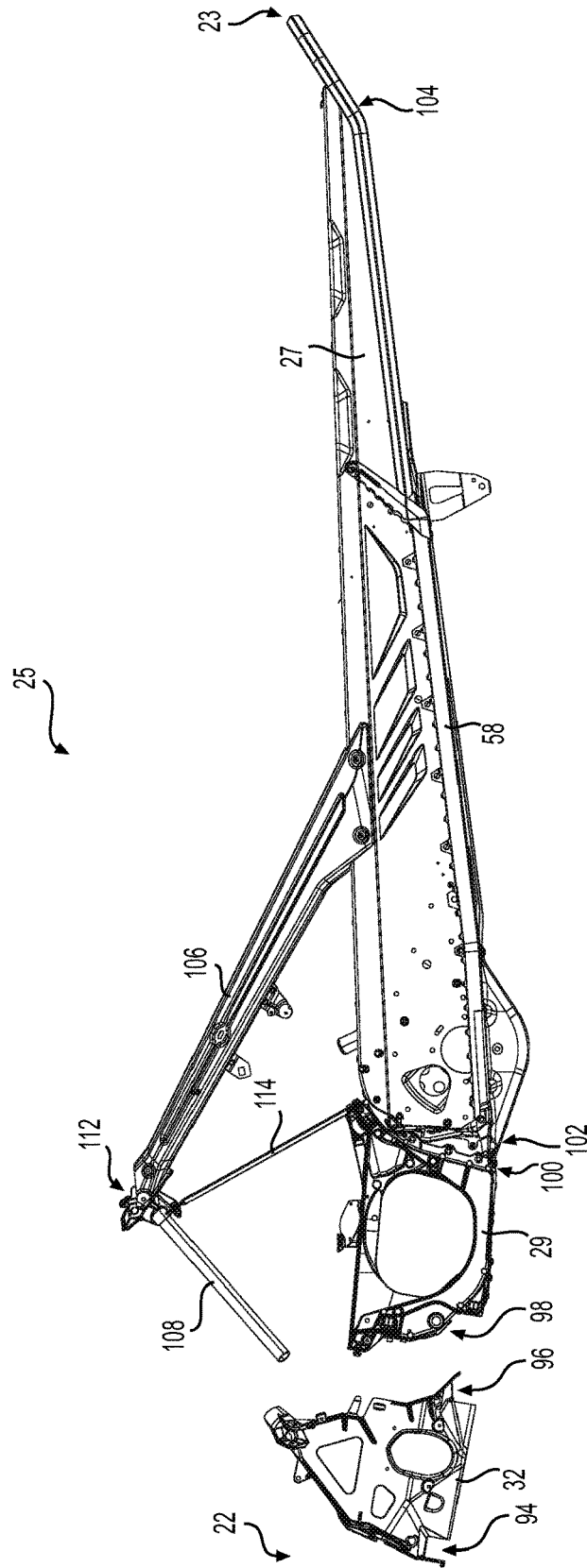
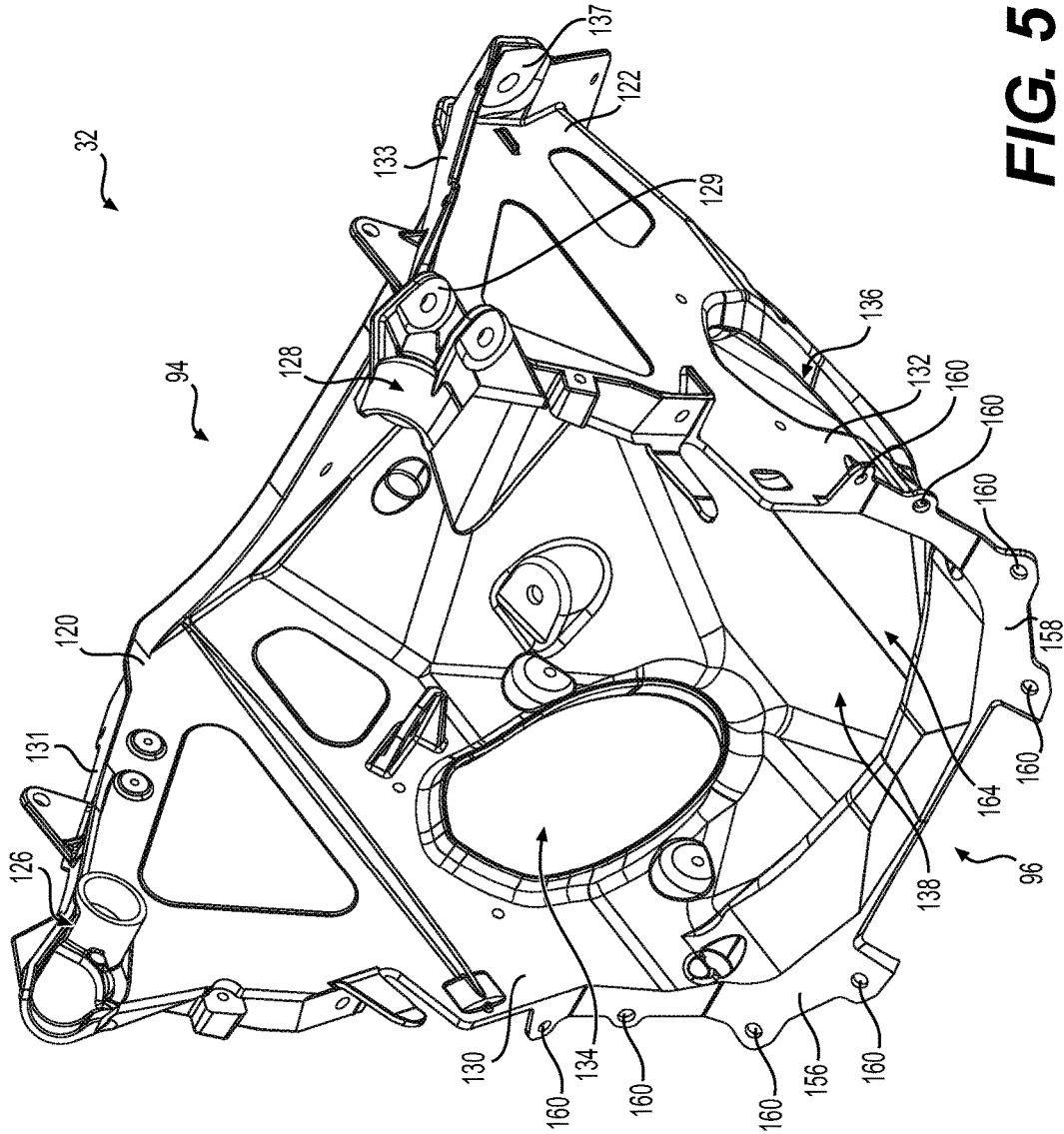


FIG. 2







**FIG. 5**

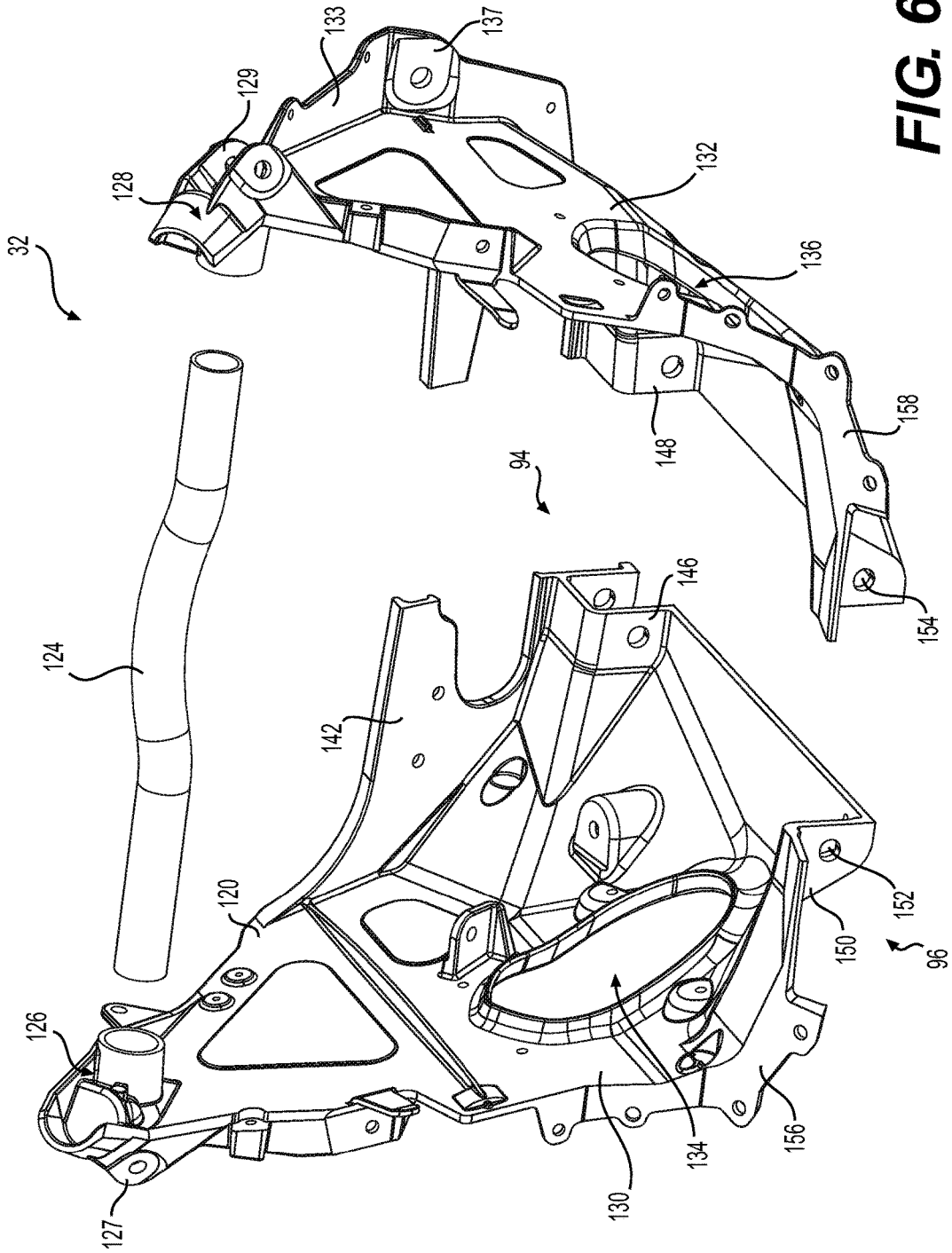


FIG. 6

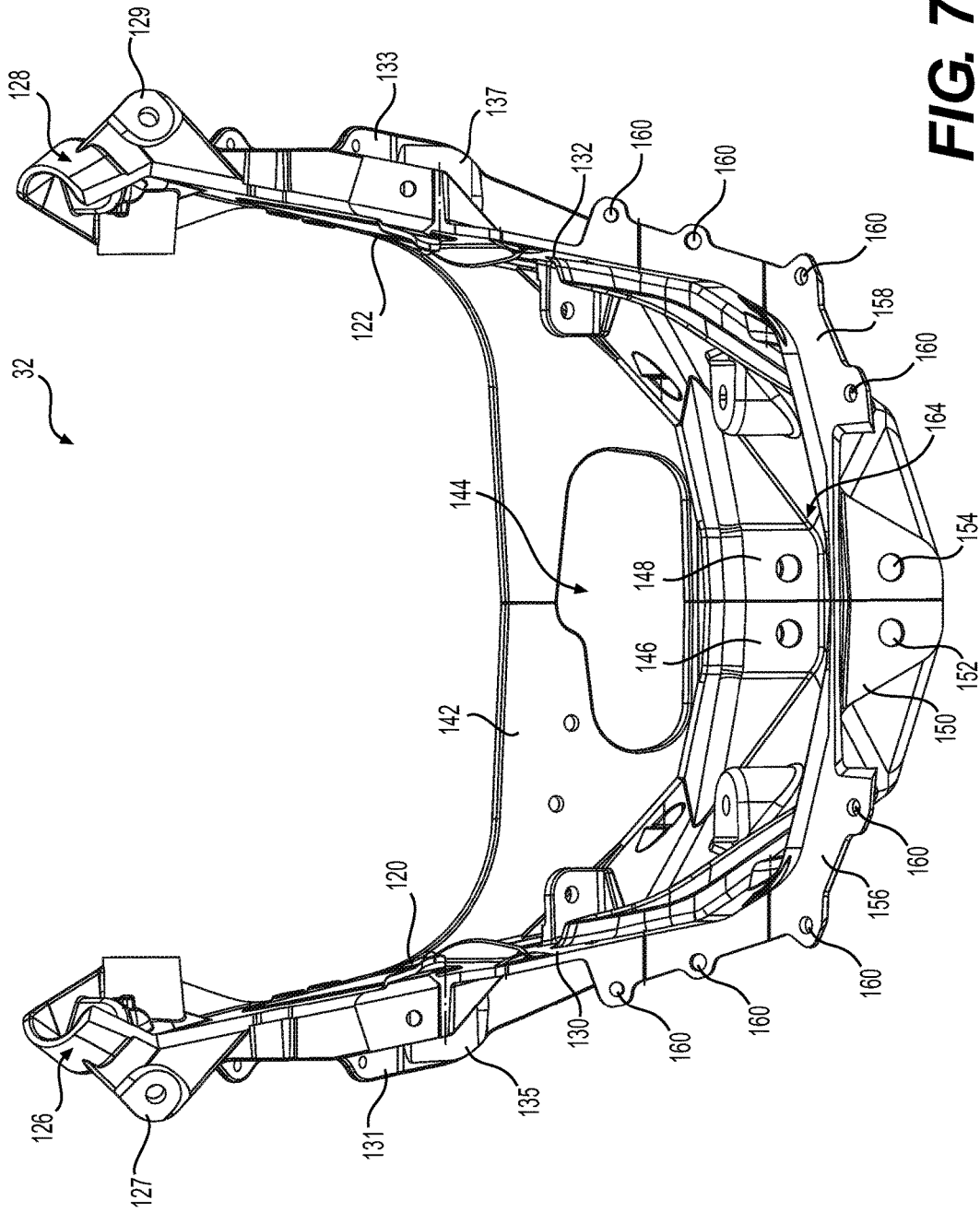
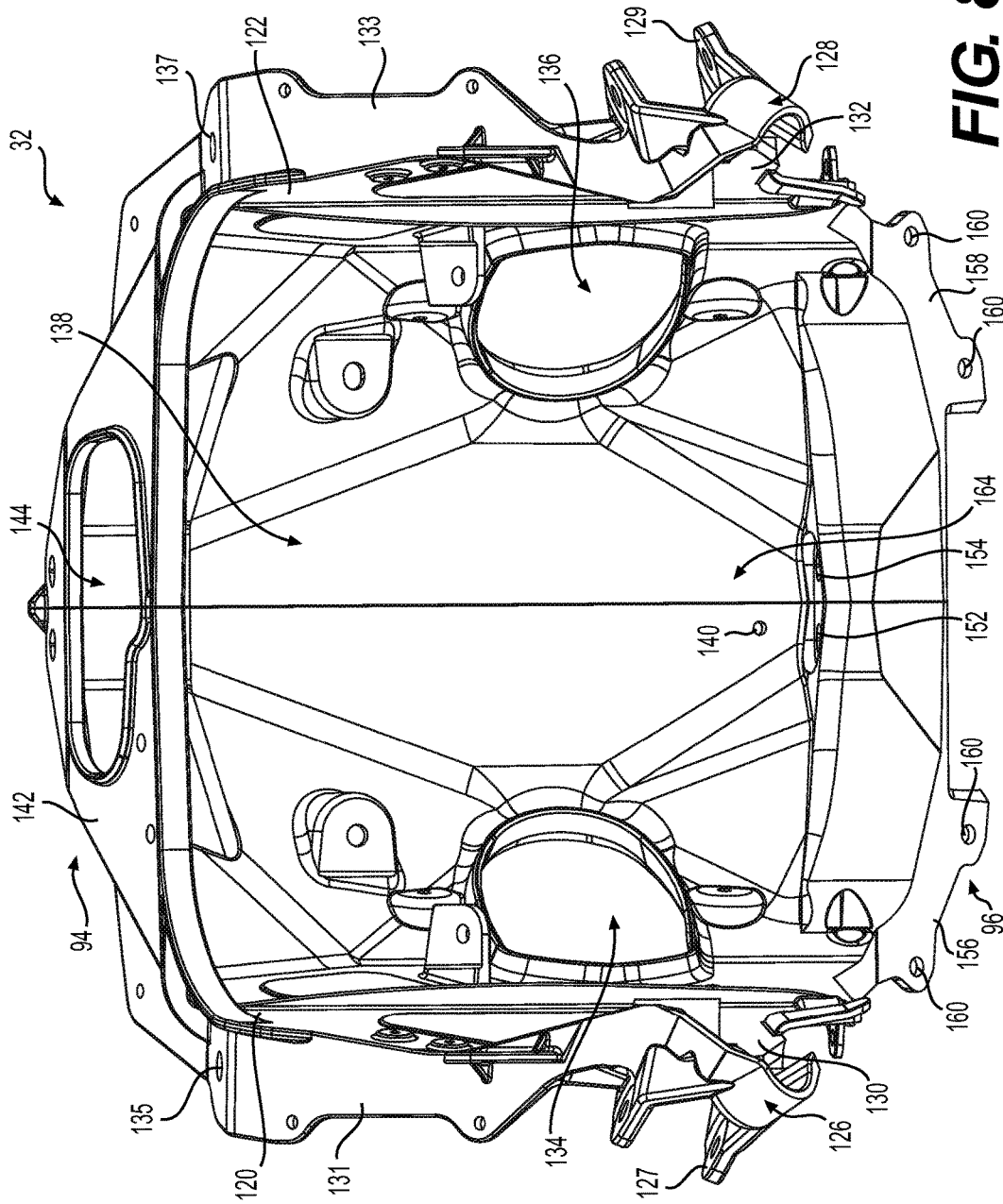


FIG. 7



**FIG. 8**

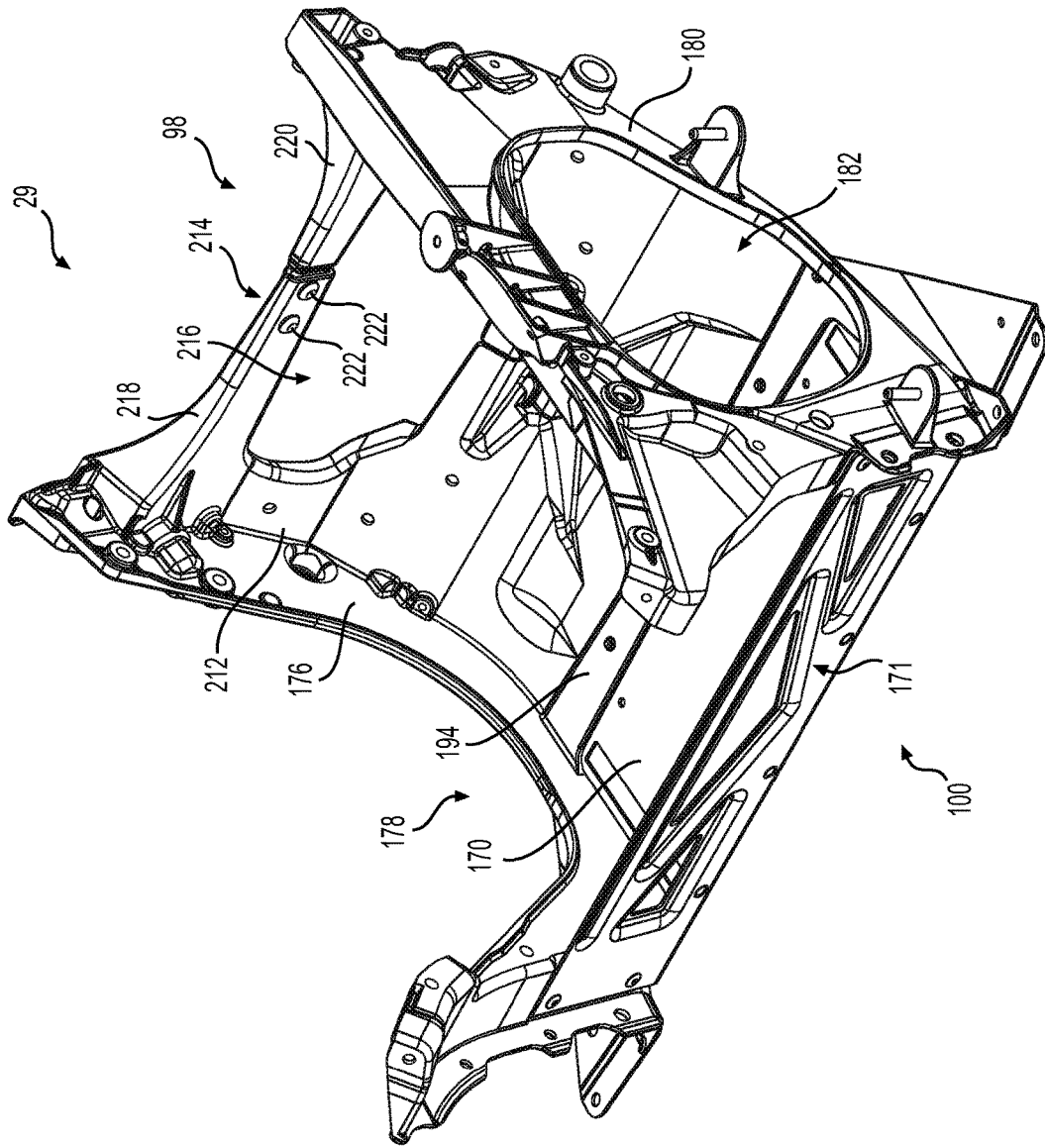


FIG. 9

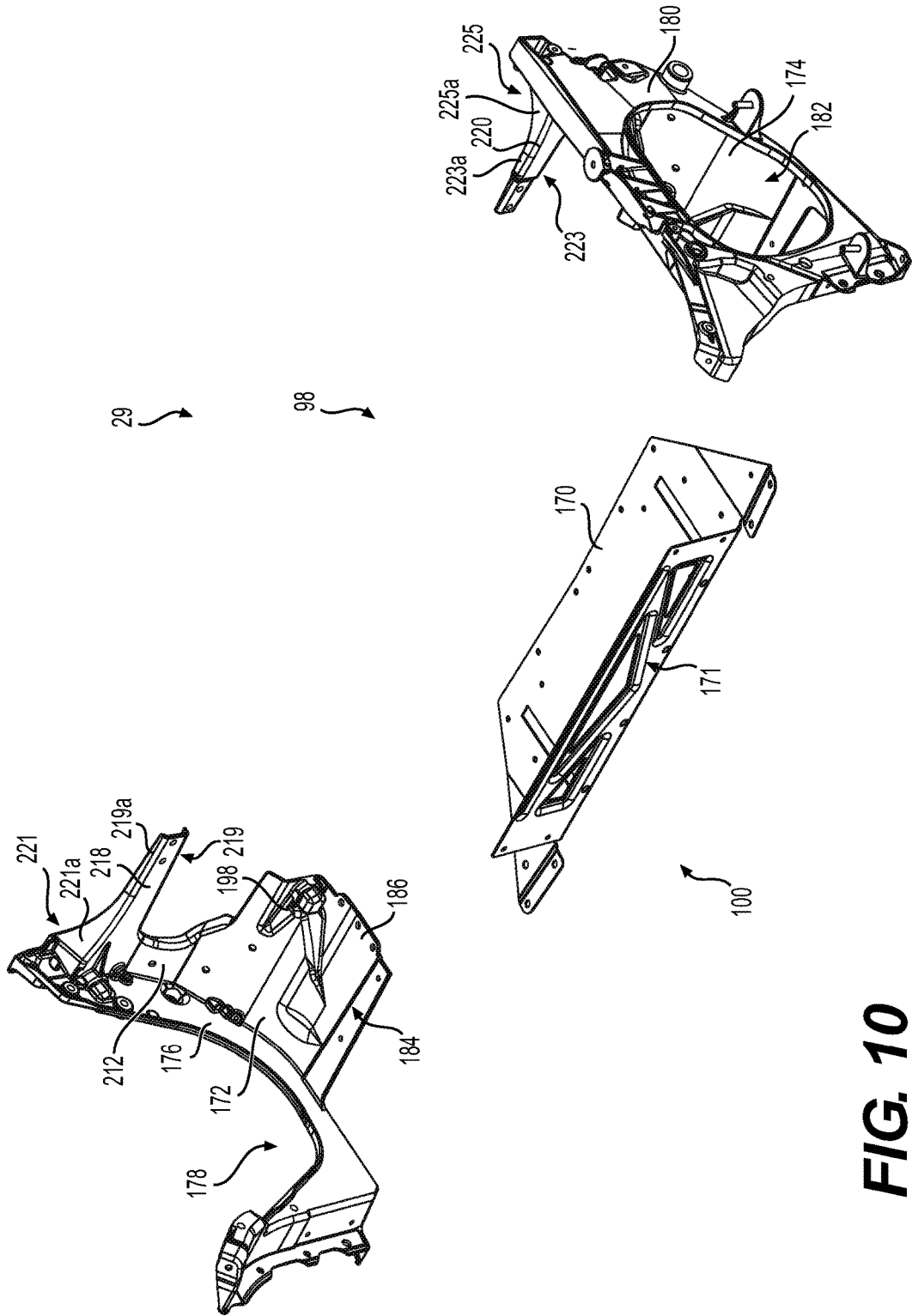
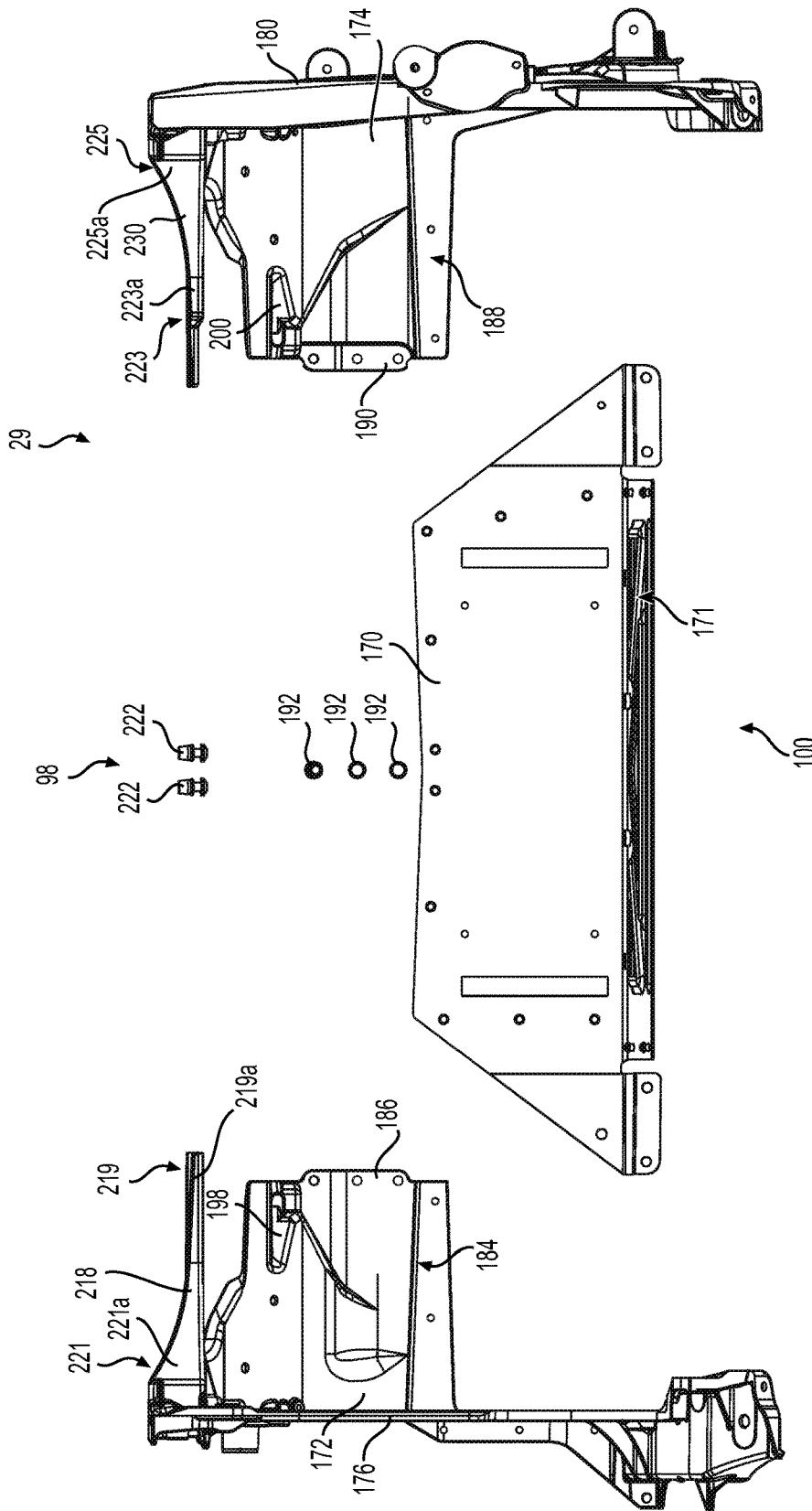
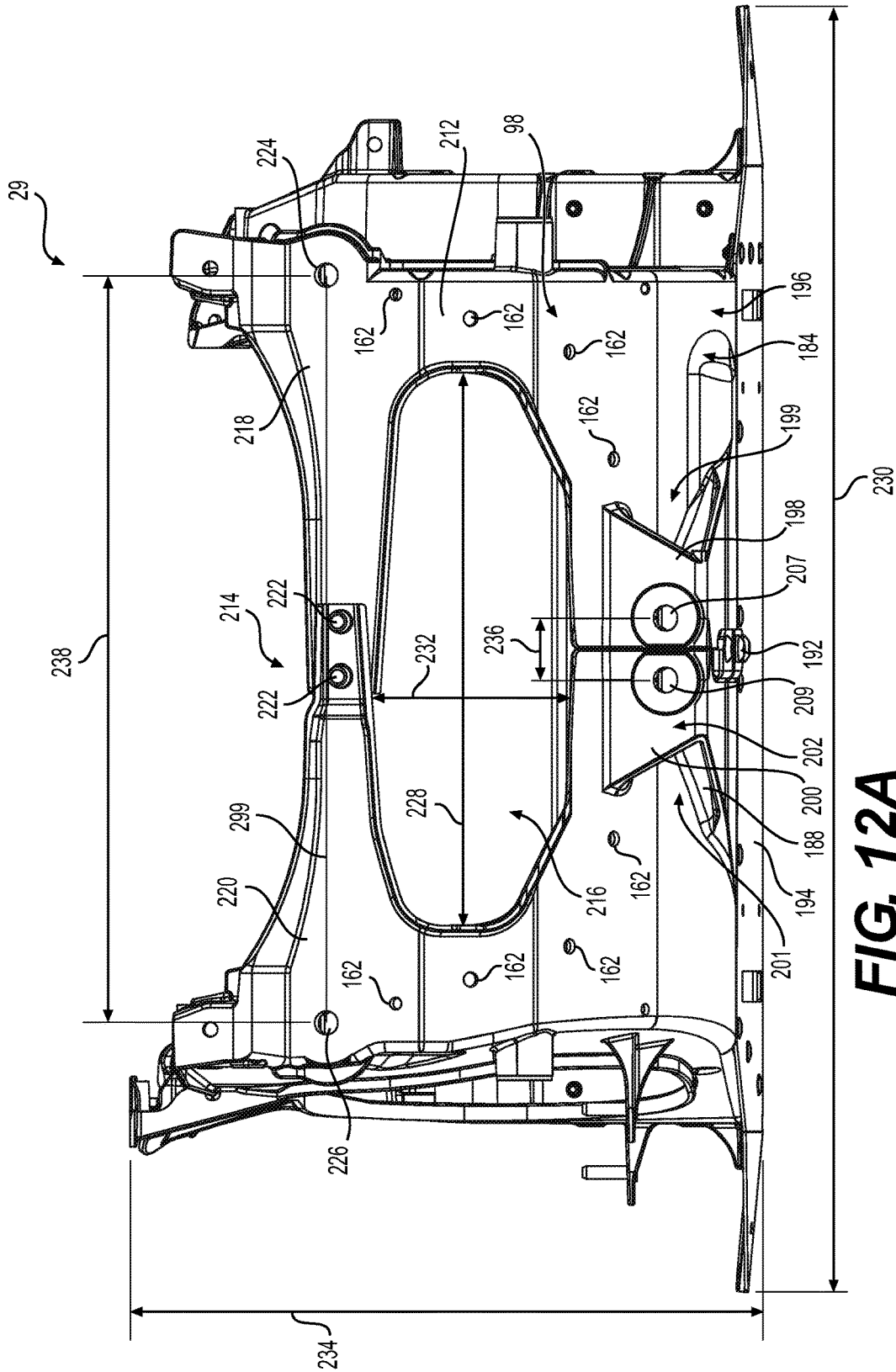


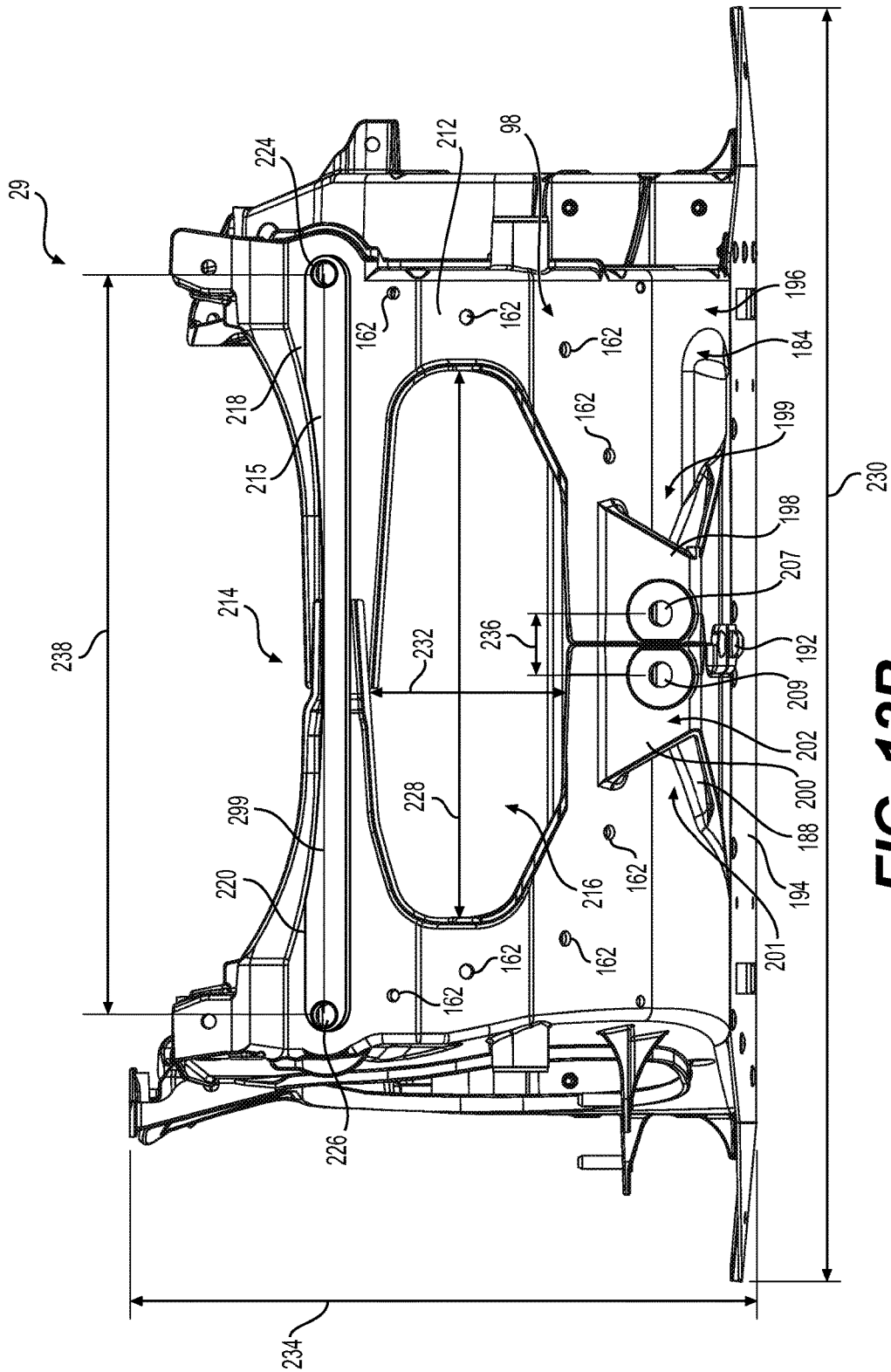
FIG. 10



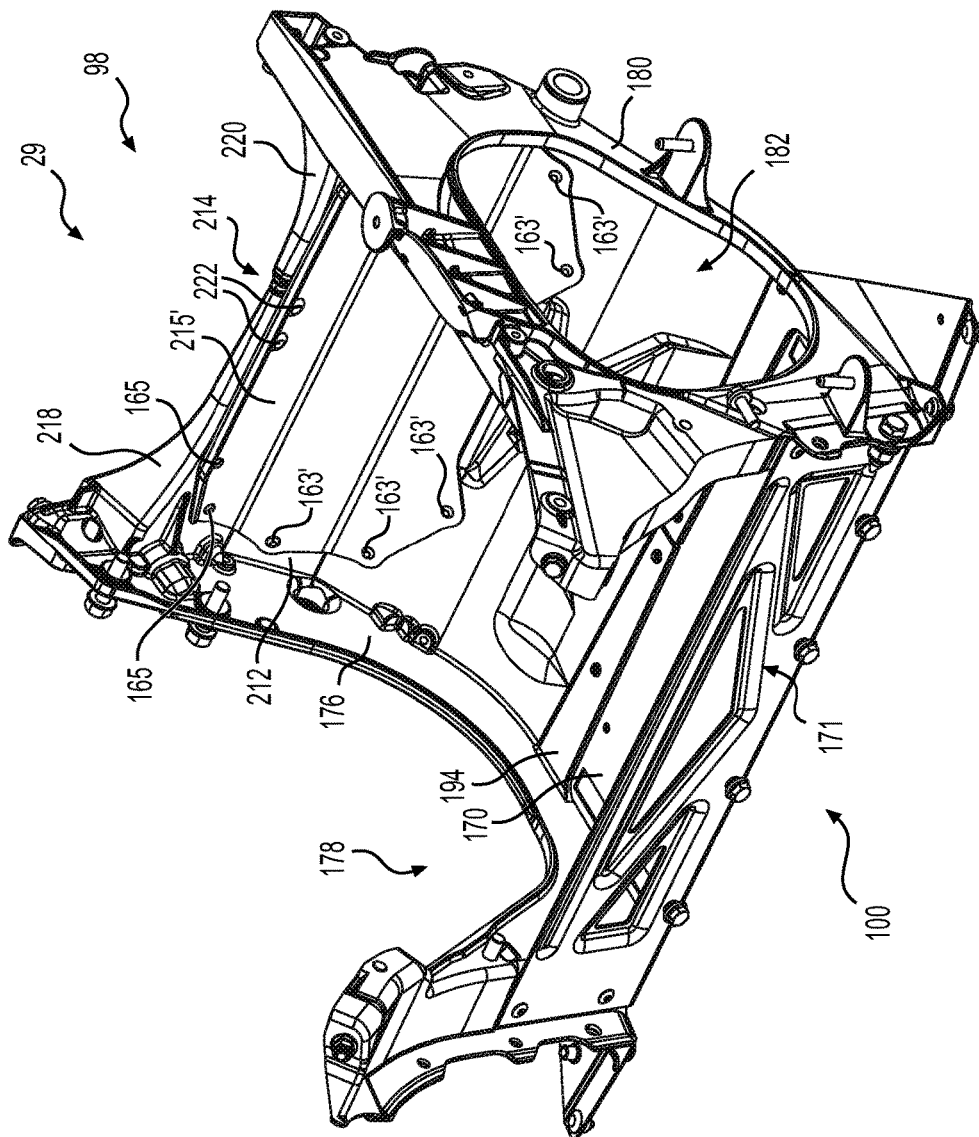
**FIG. 11**



**FIG. 12A**

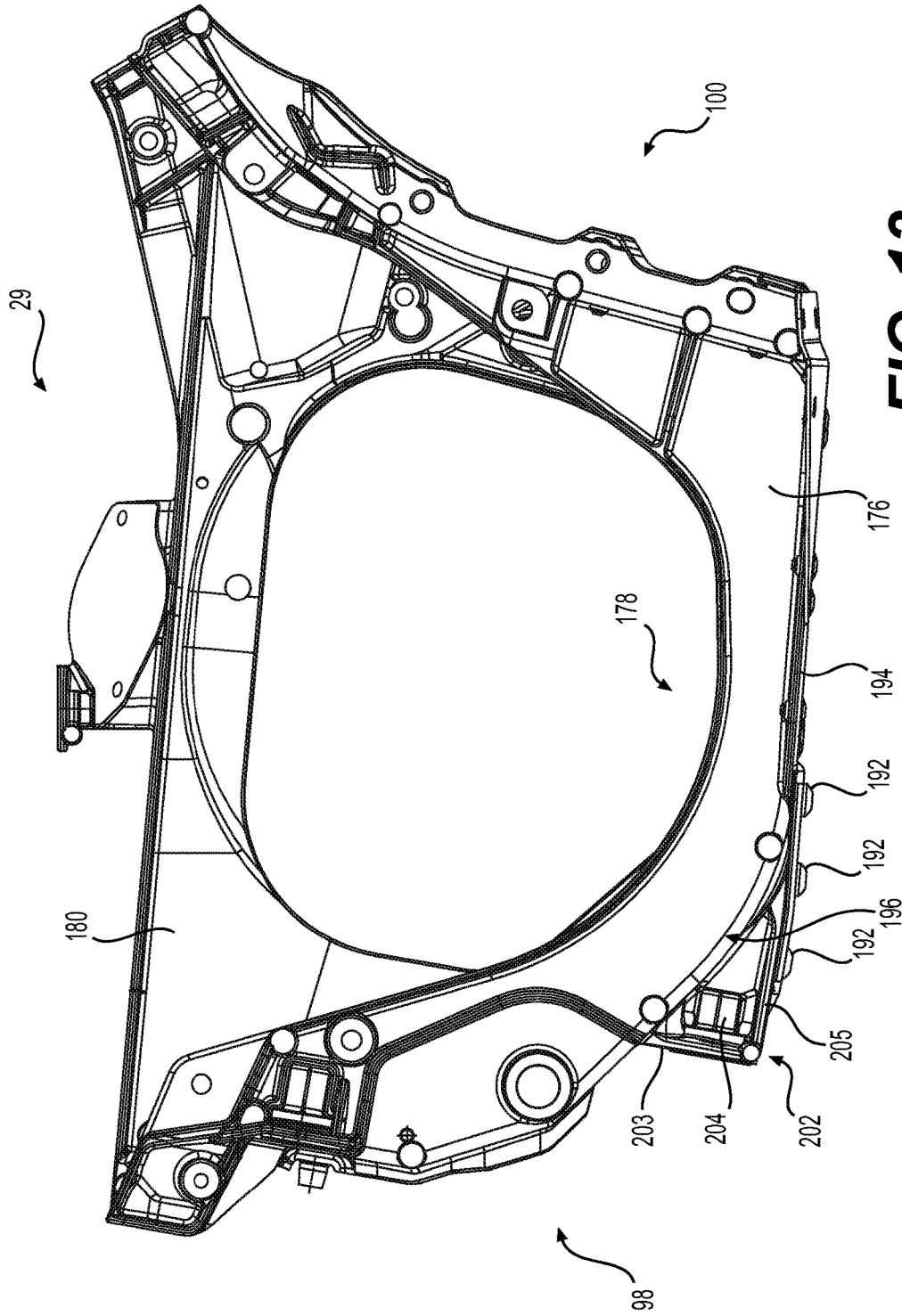


**FIG. 12B**

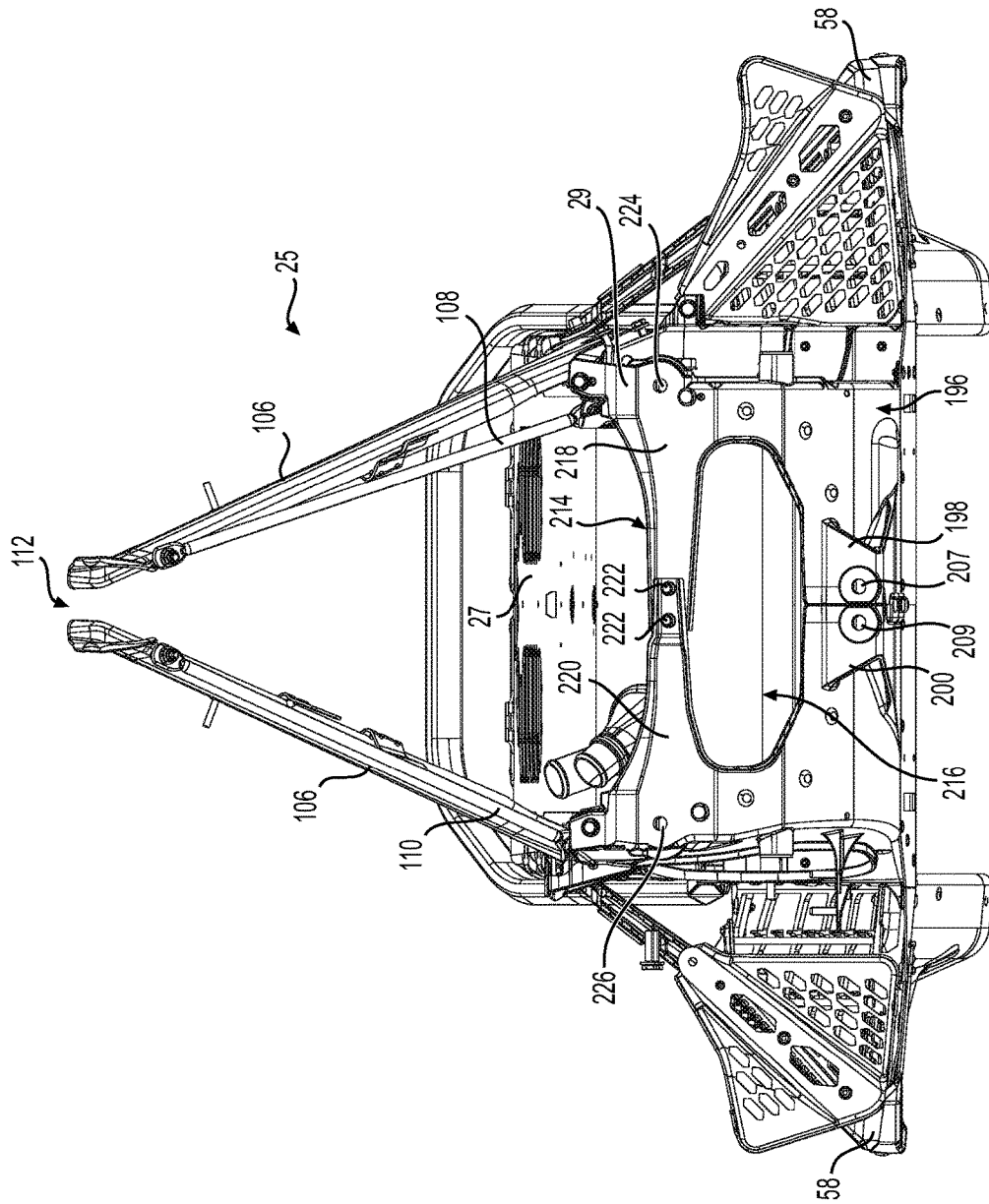


**FIG. 12C**

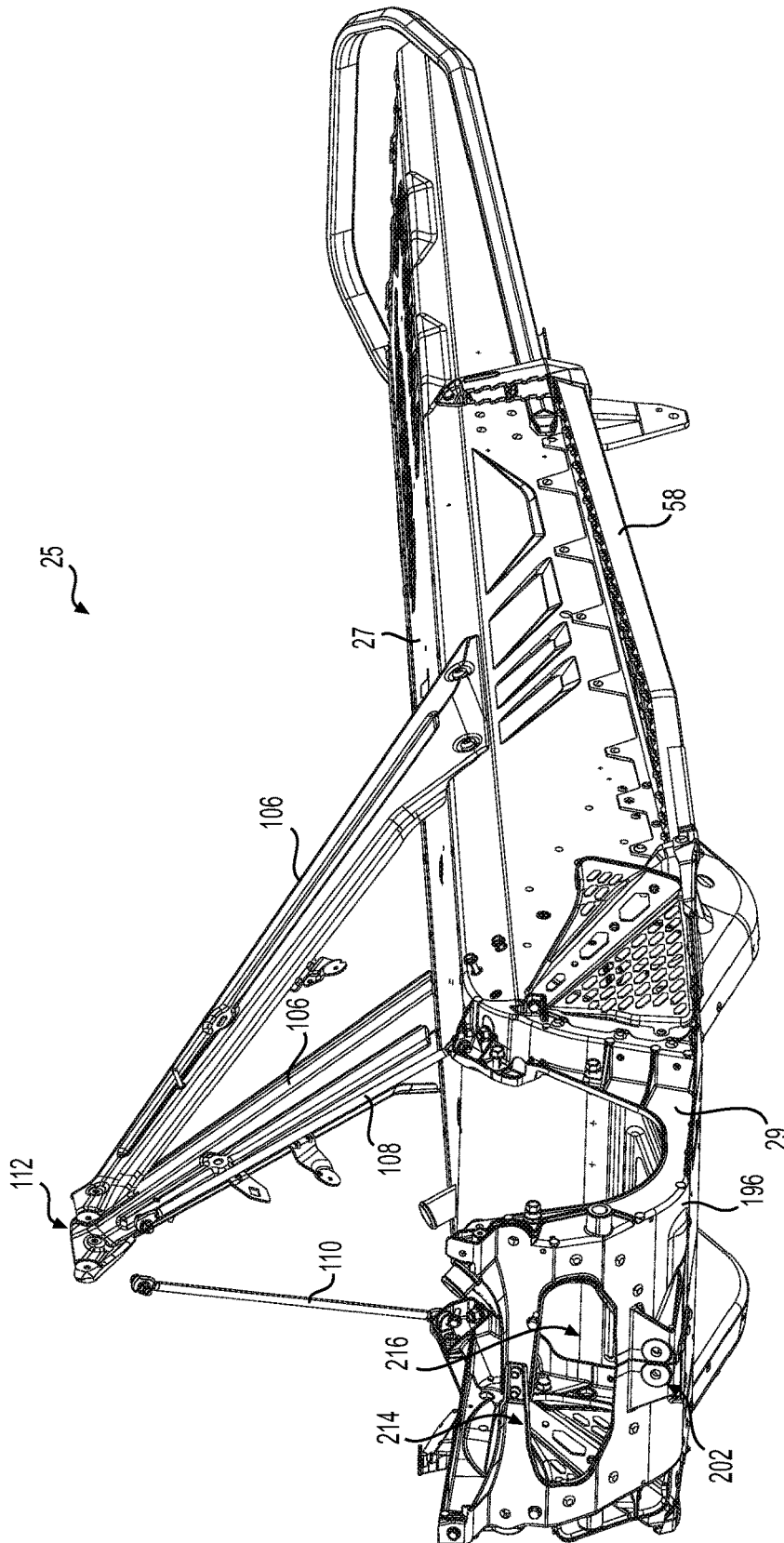




**FIG. 13**



**FIG. 14**



**FIG. 15**

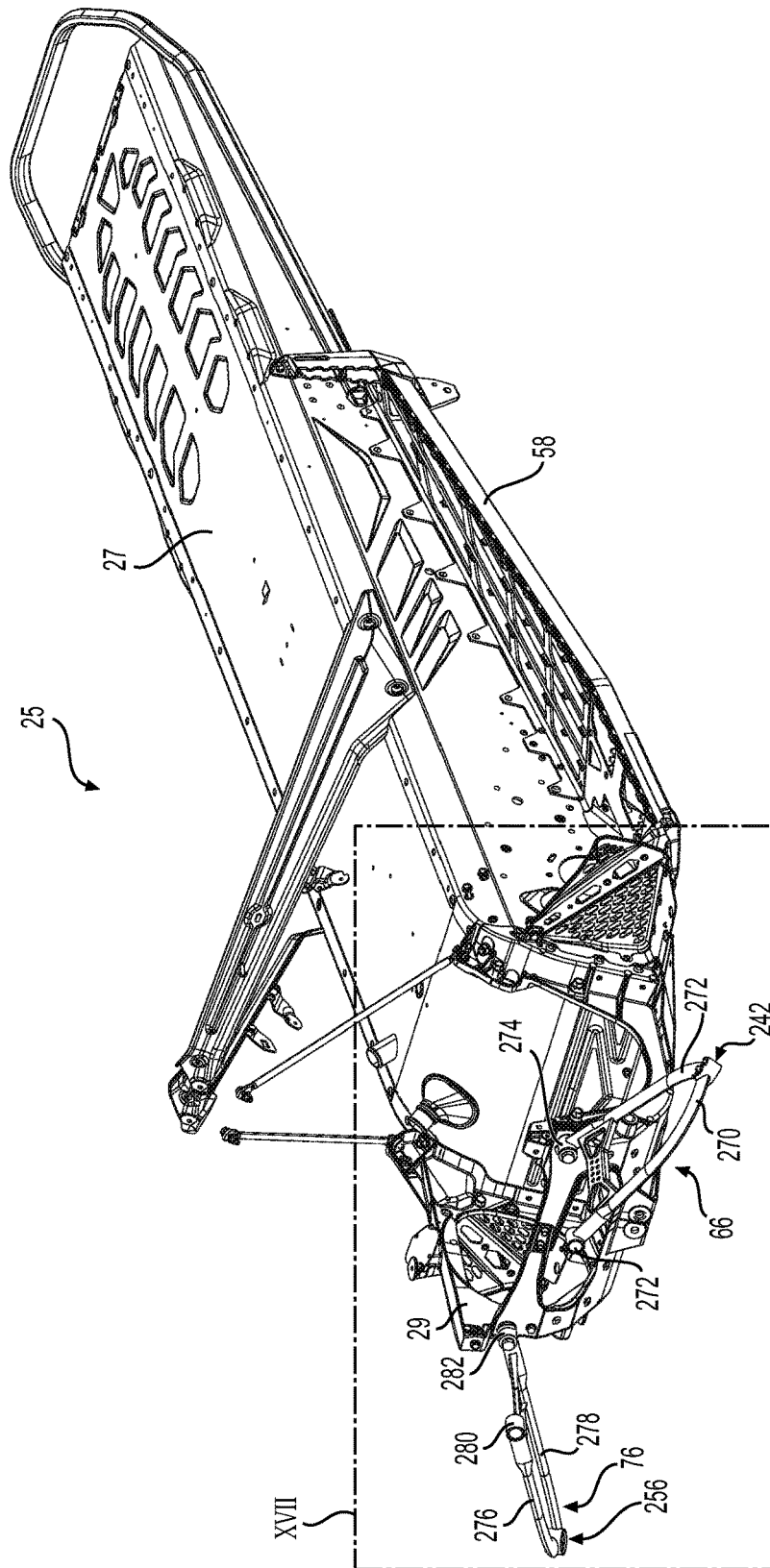


FIG. 16

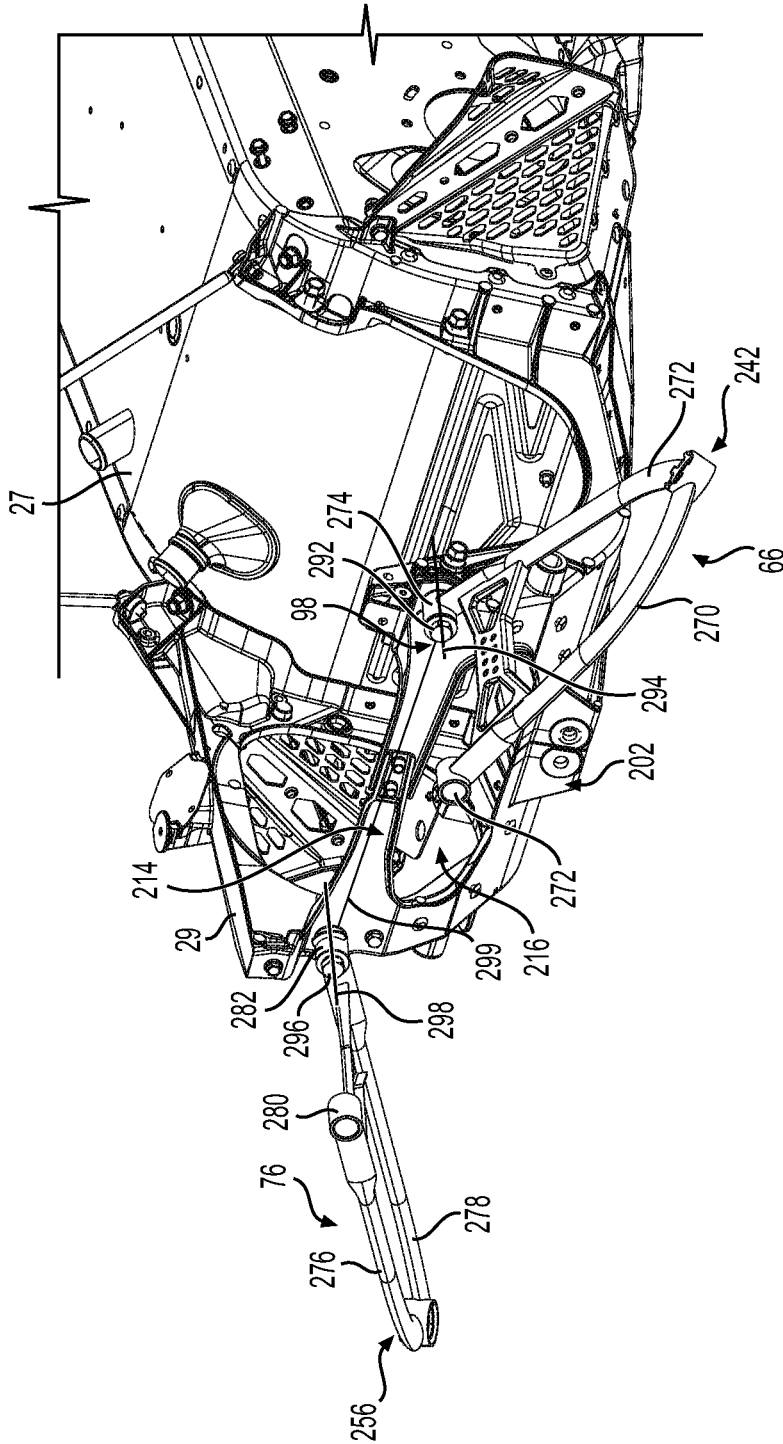


FIG. 17A

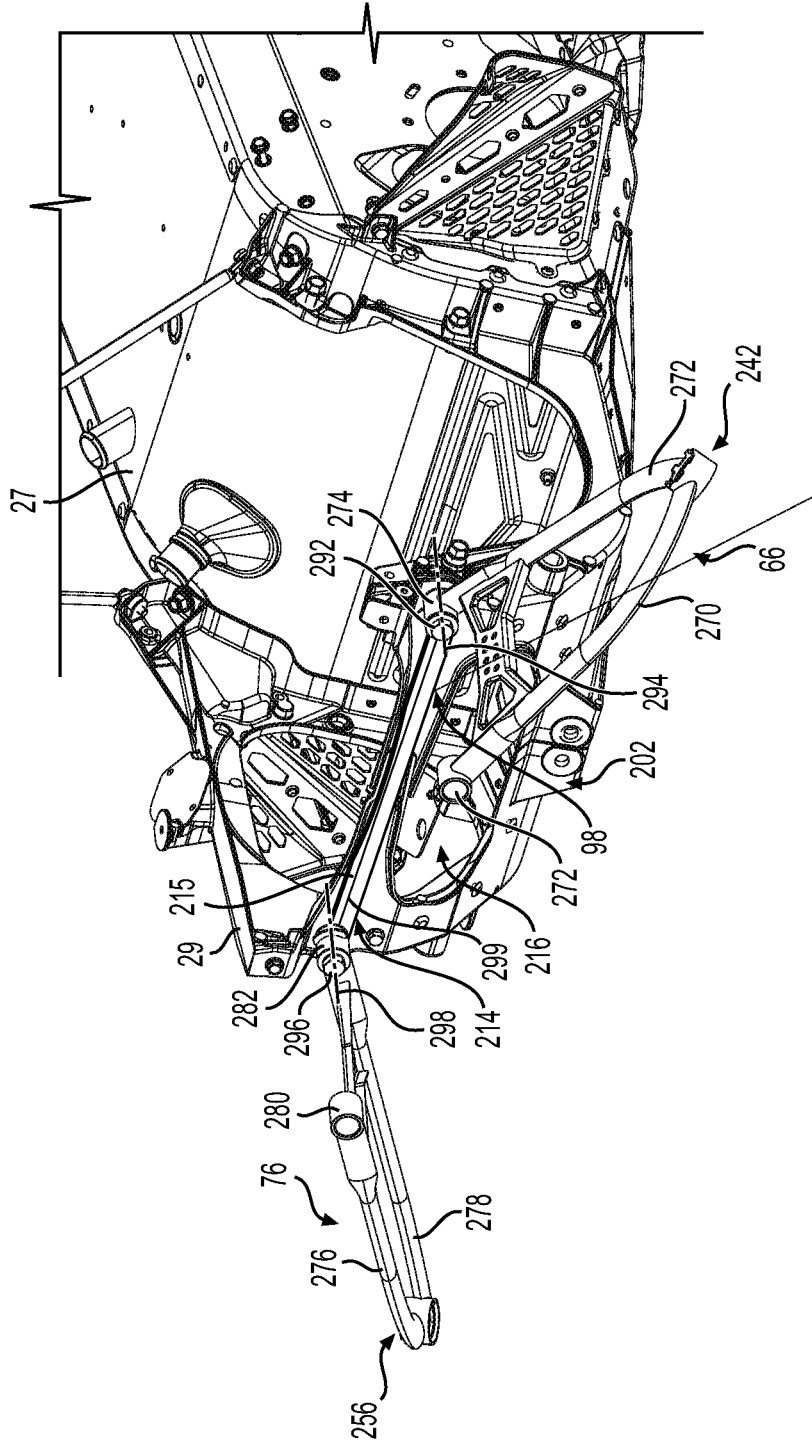


FIG. 17B

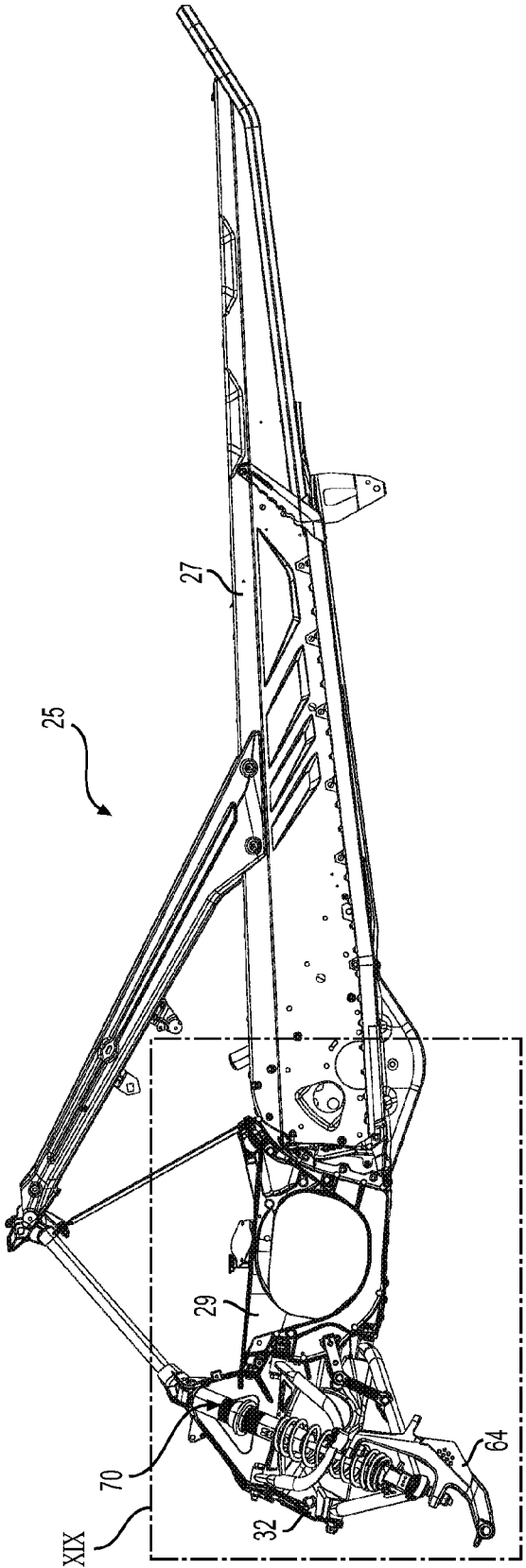


FIG. 18



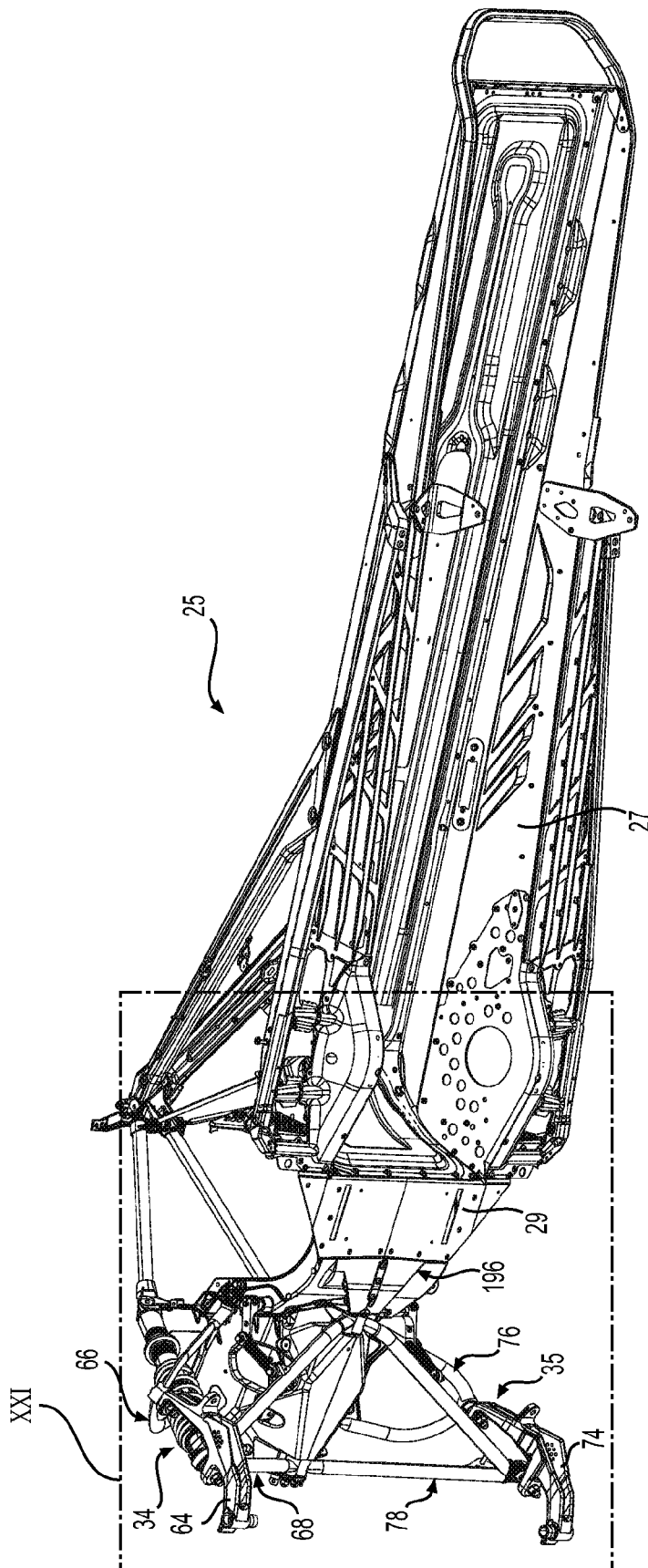


FIG. 20



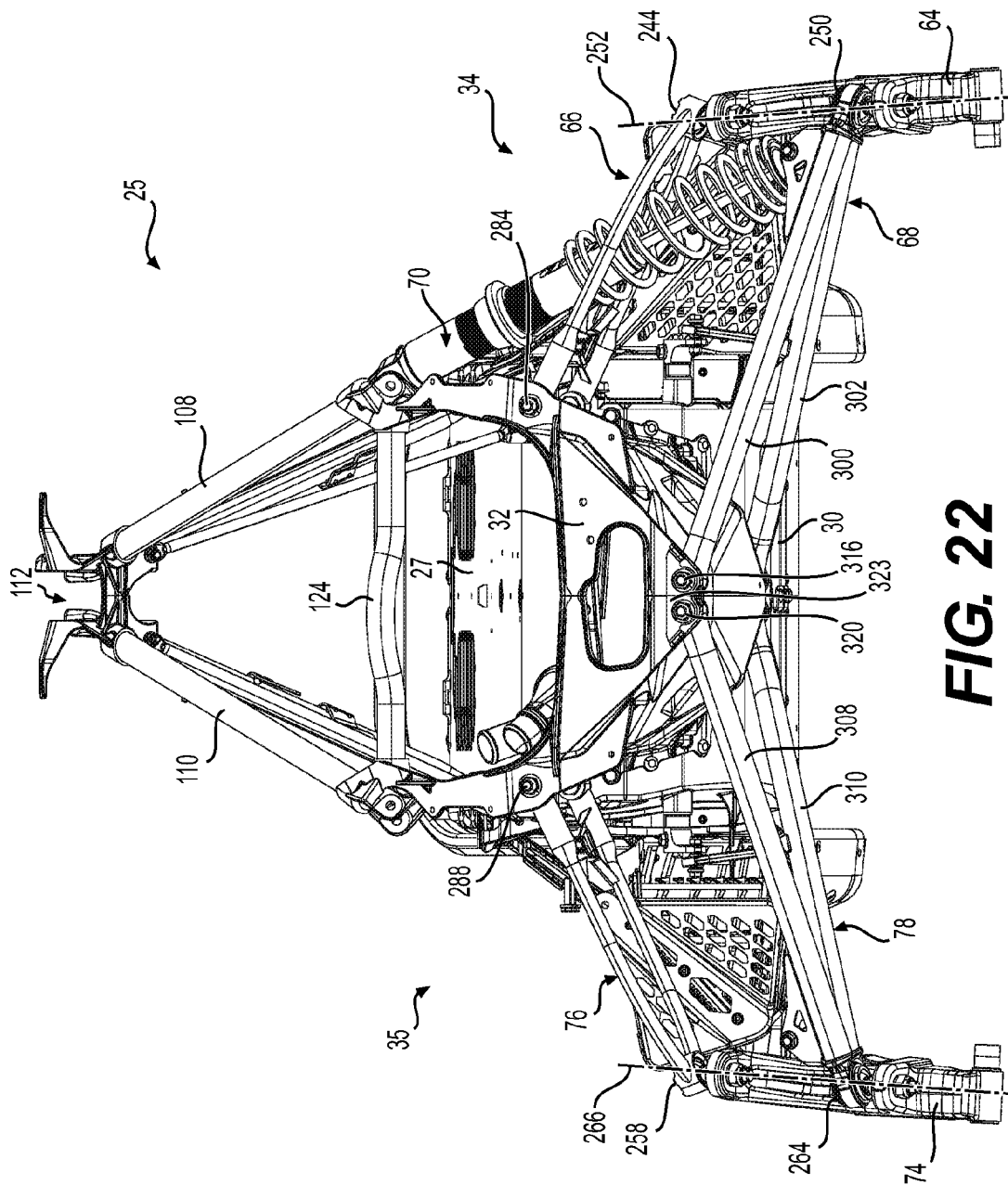
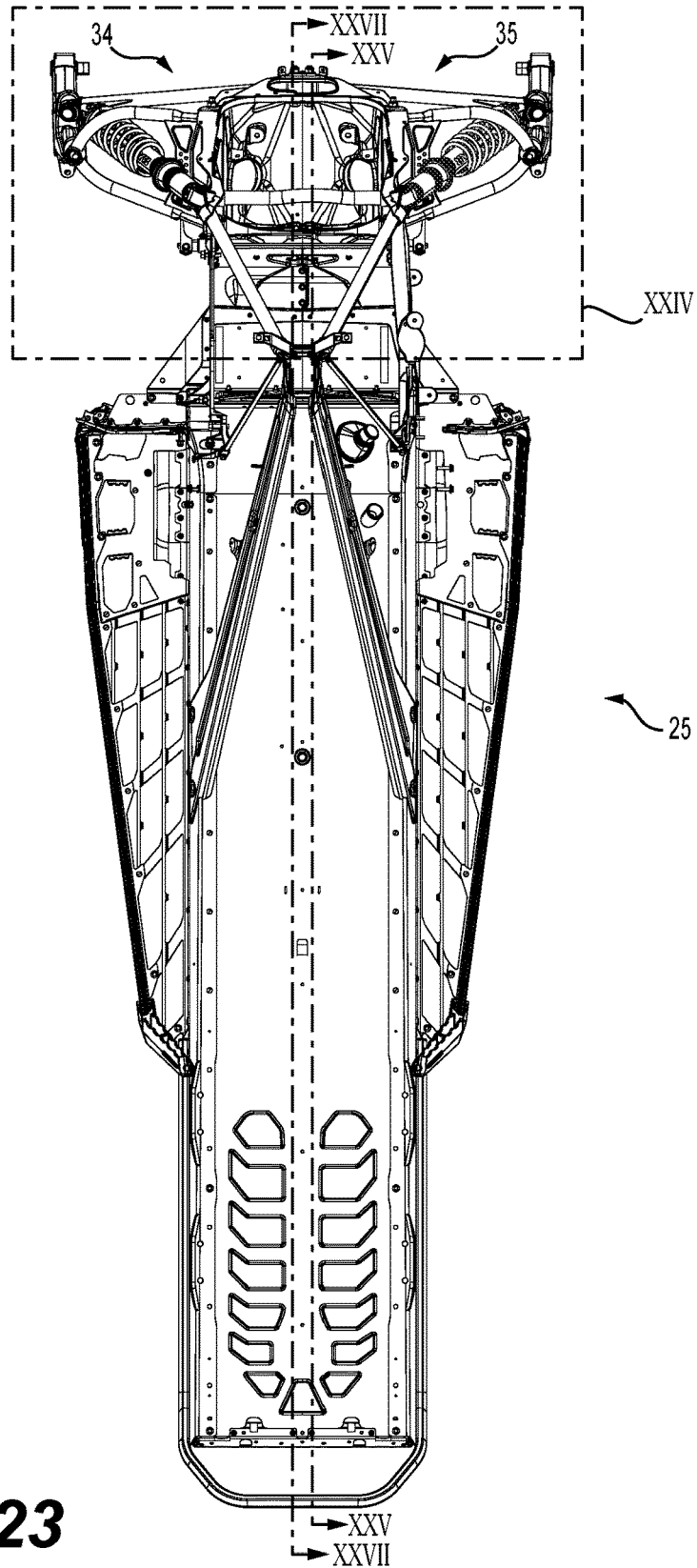


FIG. 22



**FIG. 23**



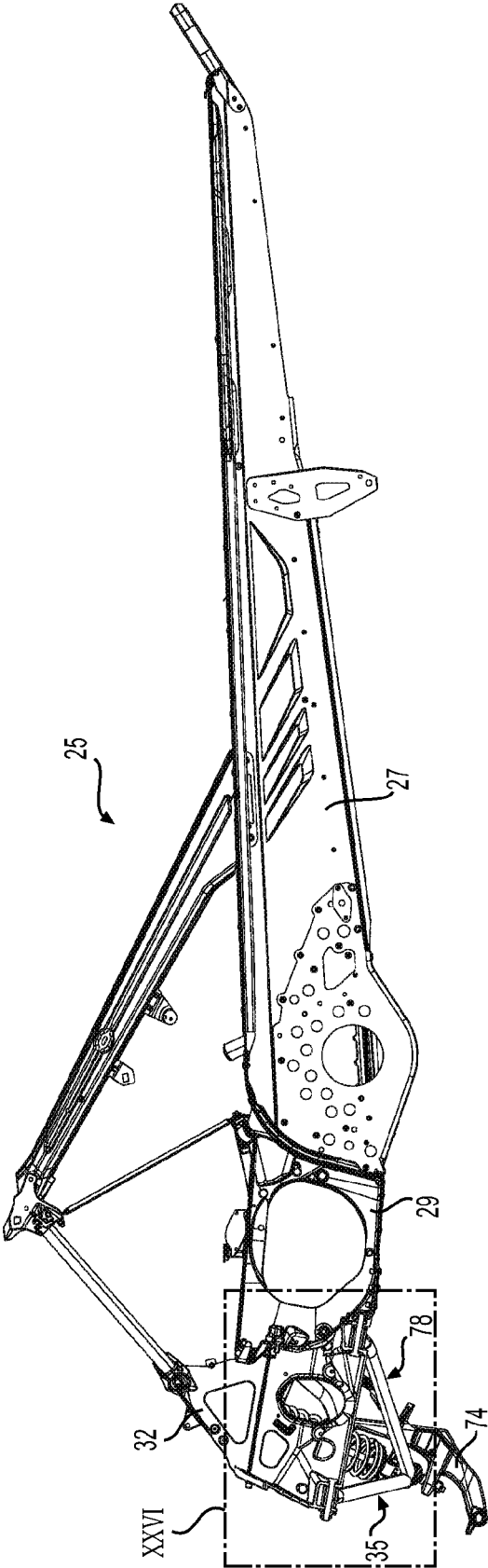


FIG. 25

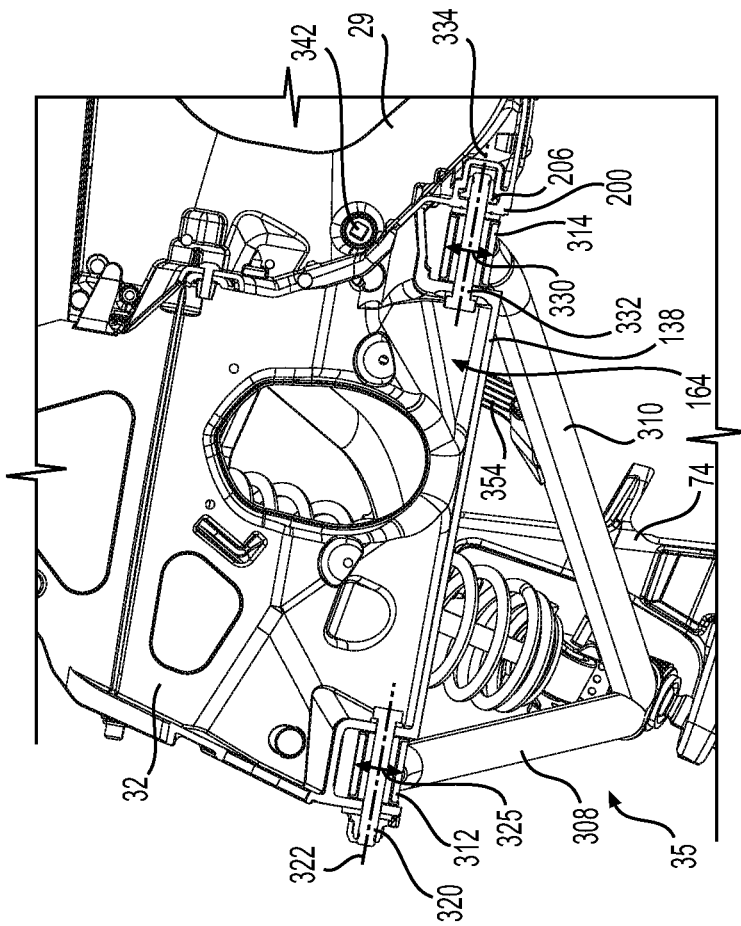
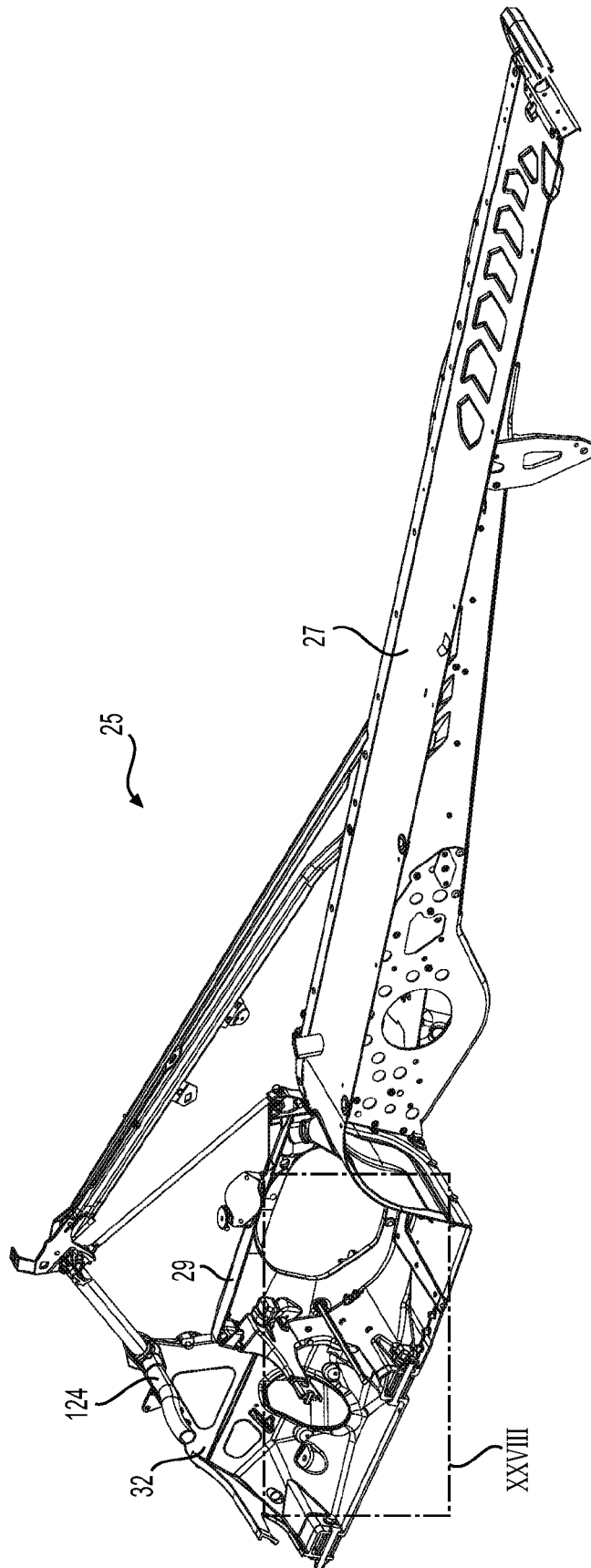
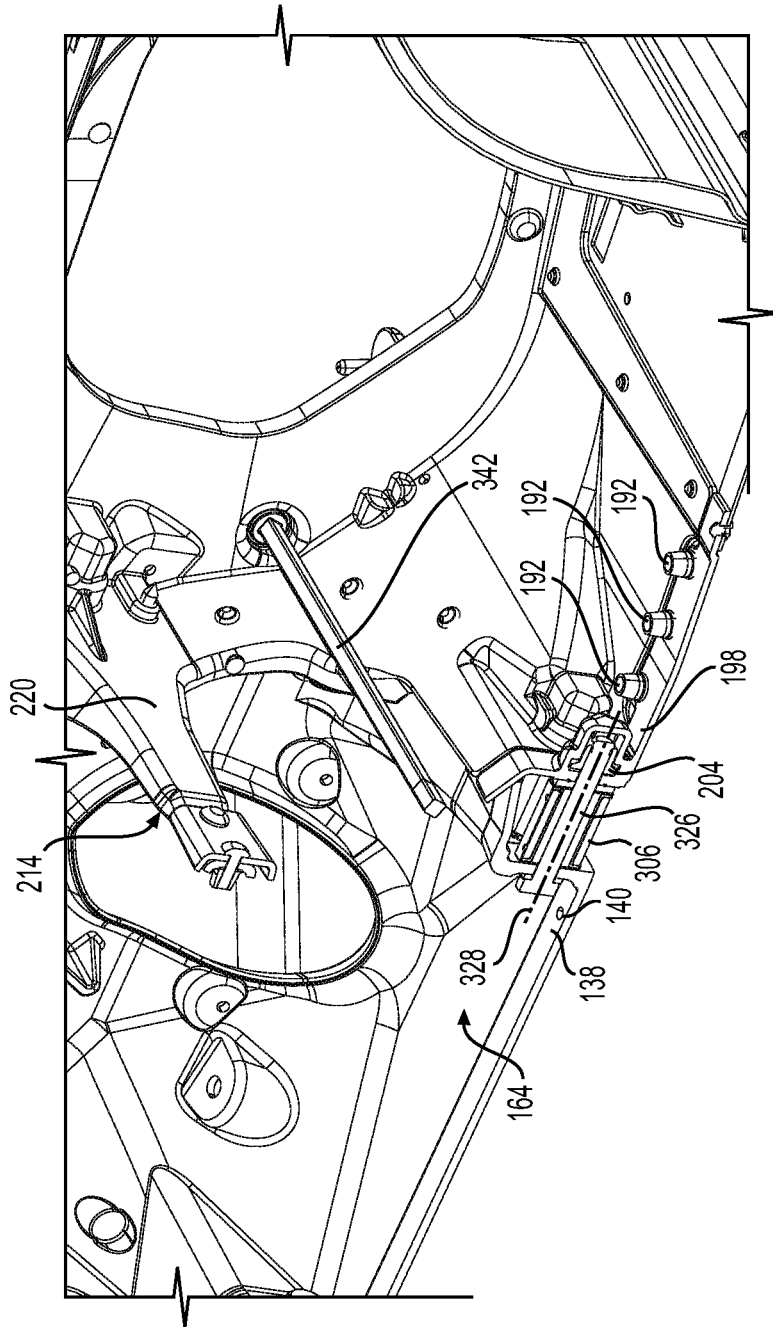


FIG. 26



**FIG. 27**



**FIG. 28**

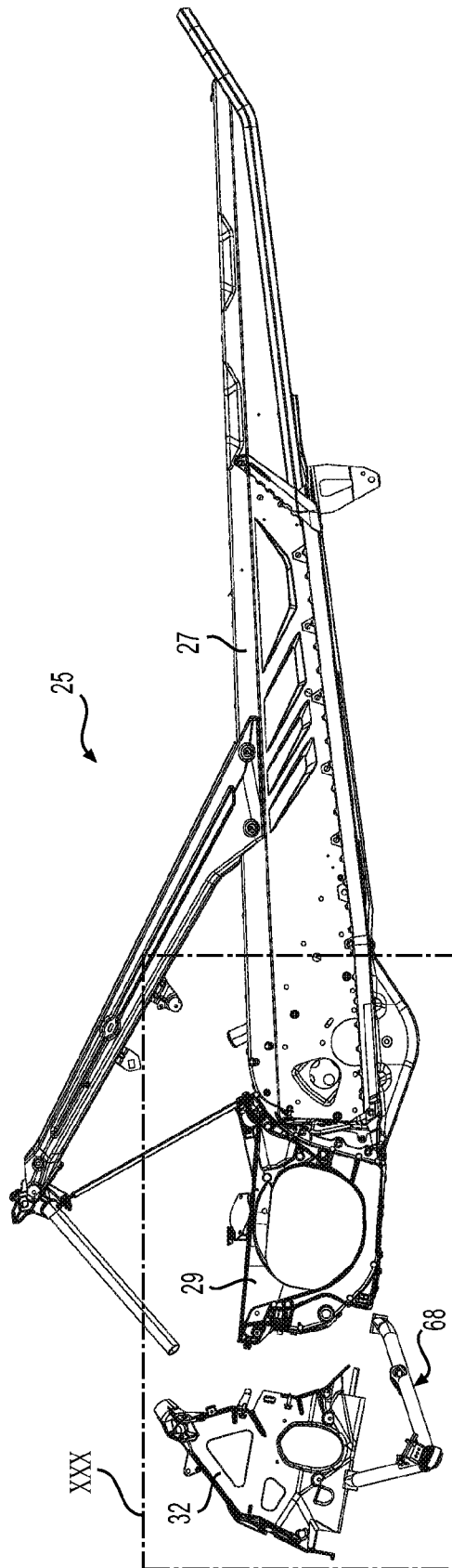
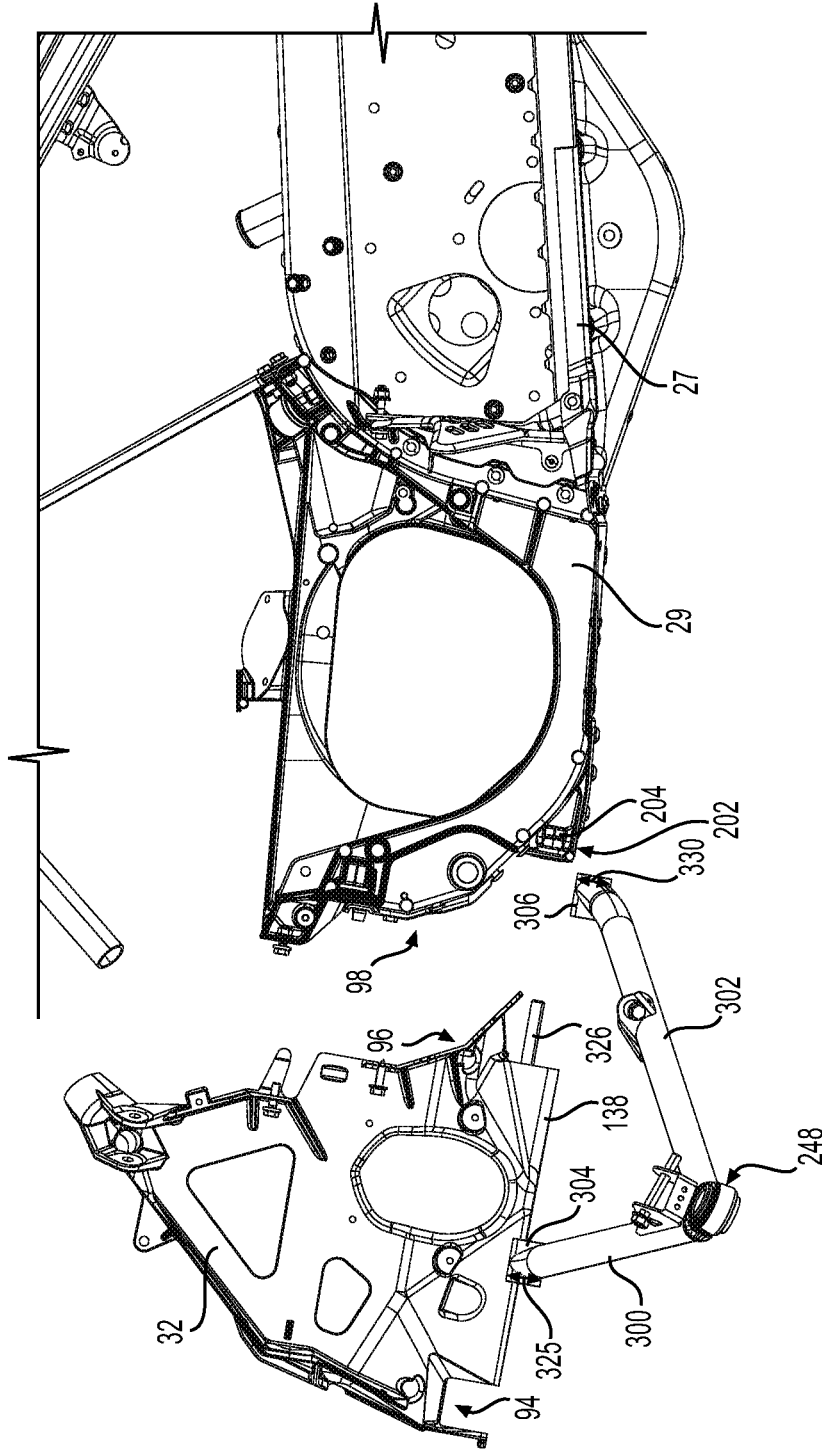


FIG. 29



**FIG. 30**

## FRAME AND FRONT SUSPENSION ASSEMBLY FOR A SNOWMOBILE

### CROSS-REFERENCE

The present application claims priority to U.S. Provisional Patent Application No. 62/343,072, filed May 30, 2016, the entirety of which is incorporated herein by reference.

### TECHNICAL FIELD

The present technology relates to the construction of snowmobiles. More specifically, the present technology relates to the construction of frames and front suspension assemblies for snowmobiles.

### BACKGROUND

The frame of a snowmobile typically includes a suspension module in a front portion of the frame for connecting a front suspension assembly between the skis and the frame, a motor module connected at the rear of the suspension module for receiving the motor of the snowmobile, and a tunnel connected at the rear of the motor module for connecting an endless track to the frame.

In some snowmobiles, the front suspension assembly is only connected to the suspension module, which is common when the front suspension assembly includes upper and lower suspension arms on both left and right sides. Such a construction is disclosed in U.S. Pat. No. 7,451,846 B2 for instance.

To withstand the forces encountered under normal operating conditions, the suspension module, the motor module and the tunnel and their respective parts are connected together using a plurality of fasteners and/or welds that adds significantly to the overall weight of the snowmobile. The manufacturing costs and complexity of the frame also increase as the number of fasteners and/or welds goes up.

Other components, such as cross members extending across the suspension module and/or the motor module, are sometimes provided to allow the suspension module and/or the motor module to withstand the forces applied to the frame by the suspension assemblies when the snowmobile travels through snow or when the skis impact the ground or other objects. These additional components further increase the weight of the snowmobile, its complexity, and its manufacturing costs.

Therefore, there is a desire for a frame and suspension assemblies for a snowmobile that address at least some of the inconveniences of the prior art.

### SUMMARY

For the purposes of the present application, terms related to spatial orientation such as forward, rearward, front, rear, upper, lower are as they would normally be understood by a rider of the snowmobile sitting thereon in a normal driving position with the snowmobile being upright and steered in a straight ahead direction. In addition, the term “proximal” refers to items or components that are positioned closer to a longitudinal centerline than items or components that are qualified as “distal”.

According to one aspect of the present technology, there is provided a snowmobile having a frame including a motor module, a tunnel connected to the motor module, and a suspension module connected to the motor module. The suspension module has an interior portion. The snowmobile

further has a motor received in the motor module, a handlebar connected to the frame, a ski operatively connected to the handlebar, an endless drive track operatively connected to the tunnel and to the motor, a front suspension assembly connected to the suspension module and to the motor module, the front suspension assembly connecting the ski to the suspension module and to the motor module. The front suspension assembly includes a suspension arm having a proximal end positioned longitudinally between the motor module and the suspension module. The proximal end pivots about a pivot axis extending through the interior portion of the suspension module. The front suspension assembly includes a proximal fastener passing through the proximal end of the suspension arm and extending from the interior portion of the suspension module to the motor module, the proximal fastener thereby pivotally connecting the suspension arm to the suspension module and to the motor module about the pivot axis.

In some implementations, the motor module has a bracket provided on a bottom wall of the motor module. The bracket is adapted to receive a nut for fastening the proximal fastener thereto, and the proximal fastener is fastened to the nut.

In some implementations, the suspension module is forward of the motor module, the suspension arm includes a front member and a rear member, and the rear member has the proximal end.

In some implementations, the ski is a front left ski, the front suspension assembly is a front left suspension assembly, the front left ski is operatively connected to the suspension module and to the motor module via the front left suspension assembly, the suspension arm is a left suspension arm, the proximal end is a left proximal end, the pivot axis is a left pivot axis, and the proximal fastener is a left proximal fastener. The snowmobile further includes a front right suspension assembly and a front right ski operatively connected to the suspension module and to the motor module via the front right suspension assembly. The front right suspension assembly includes a right suspension arm having a right proximal end positioned longitudinally between the motor module and the suspension module, the right proximal end pivoting about a right pivot axis extending through the interior portion of the suspension module, and a right proximal fastener passing through the right proximal end of the right suspension arm and extending from the interior portion of the suspension module to the motor module, the right proximal fastener thereby pivotally connecting the right suspension arm to the suspension module and to the motor module about the right pivot axis.

In some implementations, a distance between the left and right pivot axes is less than twice an outside diameter of one of the left and right proximal ends.

In some implementations, the motor module has a bracket extending from a bottom wall of the motor module. The snowmobile further has a left nut received in the bracket, the left proximal fastener is fastened to the left nut, a right nut received in the bracket, and the right proximal fastener is fastened to the right nut.

In some implementations, the left suspension arm includes a front left member and a rear left member. The rear left member has the left proximal end, the right suspension arm includes a front right member and a rear right member, the rear right member has the right proximal end.

In some implementations, the snowmobile further includes a torsion bar assembly including a torsion bar extending across the interior portion of the suspension module, a left linkage connecting a left end of the torsion bar

to the rear left member, and a right linkage connecting a right end of the torsion bar to the rear right member.

In some implementations, the snowmobile further has a left shock absorber assembly connected between the left suspension arm and the suspension module, and a right shock absorber assembly connected between the right suspension arm and the suspension module.

In some implementations, the left proximal end is a rear left proximal end. The left pivot axis is a rear left pivot axis. The left proximal fastener is a rear left proximal fastener. The front left member has a front left proximal end positioned below a front portion of the suspension module. The front left proximal end pivots about a front left pivot axis extending through the interior portion of the suspension module. The front left suspension assembly further includes a front left proximal fastener passing through the front left proximal end of the front left member and extending in the interior portion of the suspension module, the front left proximal fastener thereby pivotally connecting the front left member to the front portion of the suspension module. The right proximal end is a rear right proximal end. The right pivot axis is a rear right pivot axis. The right proximal fastener is a rear right proximal fastener. The front right member has a front right proximal end positioned below the front portion of the suspension module. The front right proximal end pivots about a front right pivot axis extending through the interior portion of the suspension module. The front right suspension assembly further includes a front right proximal fastener passing through the front right proximal end of the front right member and extending in the interior portion of the suspension module, the front right proximal fastener thereby pivotally connecting the front right member to the front portion of the suspension module.

In some implementations, a distance between the front left and right pivot axes is less than twice an outside diameter of one of the front left proximal end and the front right proximal end.

In some implementations, the left suspension arm is a lower left suspension arm. The front left suspension assembly further has an upper left suspension arm. The upper left suspension arm has upper front and rear left members. The upper left rear member has an upper left rear proximal end. The front left suspension assembly further has an upper left rear proximal fastener passing through the upper left rear proximal end and extending through the motor module, the upper left rear proximal fastener pivotally connecting the upper left rear member to the motor module. The right suspension arm is a lower right suspension arm. The front right suspension assembly further has an upper right suspension arm. The upper right suspension arm has upper front and rear right members. The upper right rear member has an upper right rear proximal end. The front right suspension assembly further has an upper right rear proximal fastener passing through the upper right rear proximal end and extending through the motor module, the upper right rear proximal fastener pivotally connecting the upper right rear member to the motor module.

In some implementations, the upper left front member has an upper left front proximal end. The front left suspension assembly further has an upper left front proximal fastener passing through the upper left front proximal end and extending through the suspension module, the upper left front proximal fastener pivotally connecting the upper left front member to the suspension module. The upper right front member has an upper right front proximal end. The front right suspension assembly further has an upper right front proximal fastener passing through the upper right front

proximal end and extending through the suspension module, the upper right front proximal fastener pivotally connecting the upper right front member to the suspension module.

In some implementations, the suspension module includes a left part and a right part. The left and right parts are connected together.

In some implementations, the motor module includes a left part and a right part. The left and right parts are connected together using at least one of bonding and fastening.

In some implementations, the left and right parts of the motor module are cast parts.

In some implementations, the front and rear left pivot axes are coaxial. The front and rear right pivot axes are coaxial. The front and rear left pivot axes are parallel to the front and rear right pivot axes.

In some implementations, the bottom wall of the motor module has a convex bottom face. The bracket includes a vertical portion extending downwardly from the convex bottom face and perpendicularly to the left and right pivot axes. The bracket further includes a horizontal portion extending rearwardly and perpendicularly to the vertical portion.

Implementations of the present technology each have at least one of the above-mentioned aspects, but do not necessarily have all of them. It should be understood that some aspects of the present technology that have resulted from attempting to attain the above-mentioned object may not satisfy this object and/or may satisfy other objects not specifically recited herein.

Additional and/or alternative features, aspects, and advantages of implementations of the present technology will become apparent from the following description, the accompanying drawings, and the appended claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the present technology, as well as other aspects and further features thereof, reference is made to the following description which is to be used in conjunction with the accompanying drawings, where:

FIG. 1 is a left side elevation view of a snowmobile;

FIG. 2 is a left side elevation view of a frame of the snowmobile of FIG. 1, with a suspension module separated therefrom;

FIG. 3 is a front, left side perspective view of the frame of FIG. 2;

FIG. 4 is a top plan view of the frame of FIG. 2;

FIG. 5 is a top, rear, right side perspective view of the suspension module of FIG. 2;

FIG. 6 is an exploded, top, rear, right side perspective view of the suspension module of FIG. 5, with a cross bar;

FIG. 7 is a rear elevation view of the suspension module of FIG. 5;

FIG. 8 is a top plan view of the suspension module of FIG. 5;

FIG. 9 is a top, rear, right side perspective view of a motor module;

FIG. 10 is an exploded, top, rear, right side perspective view of the motor module of FIG. 9, with fasteners omitted;

FIG. 11 is an exploded, top plan view of the motor module of FIG. 9;

FIG. 12A is a front elevation view of the motor module of FIG. 9;

FIG. 12B is a front elevation view of the motor module of FIG. 9 according to one variant having a plate connected thereto;

FIG. 12C is a top, rear, right side perspective view of the motor module of FIG. 9 according to another variant having an alternative implementation of a plate connected thereto;

FIG. 12D is a top, rear, right side perspective view of the motor module of FIG. 12C, with the plate disconnected from the motor module.

FIG. 13 is a left side elevation view of the motor module of FIG. 9;

FIG. 14 is a front elevation view of the frame of FIG. 2, with the suspension module omitted;

FIG. 15 is a front, left side perspective view of the frame portions of FIG. 14;

FIG. 16 is a top, front, left side perspective view of the frame of FIG. 14, with upper left and right suspension arms connected to the motor module;

FIG. 17A is an enlarged view of the portion XVII of the frame of FIG. 16;

FIG. 17B is an enlarged view of the portion XVII of the frame of FIG. 16 having the motor module presented in FIG. 12B;

FIG. 18 is a left side elevation view of the frame of FIG. 2, with the suspension module connected to the frame and front suspension assemblies connected to the frame;

FIG. 19 is an enlarged view of the portion XIX of the frame and suspension assemblies of FIG. 18;

FIG. 20 is a bottom, rear, left side perspective view of the frame of FIG. 18, with a right shock absorber assembly omitted;

FIG. 21 is an enlarged view of the portion XXI of the frame of FIG. 20;

FIG. 22 is a front elevation view of the frame of FIG. 18, with the right shock absorber assembly omitted;

FIG. 23 is a top plan view of the frame and front suspension assemblies of FIG. 18;

FIG. 24 is an enlarged view of the portion XXIV of the frame and front suspension assemblies of FIG. 23;

FIG. 25 is a cross-sectional view of the frame and front suspension assemblies of FIG. 18 taken along line XXV-XXV of FIG. 23;

FIG. 26 is an enlarged view of the portion XXVI of the frame and front suspension assemblies of FIG. 25;

FIG. 27 is top, rear, left side cross-sectional perspective view of the frame and front suspension assemblies of FIG. 18 taken along line XXVII-XXVII of FIG. 23;

FIG. 28 is an enlarged view of the portion XXVIII of the frame of FIG. 27;

FIG. 29 is a partially exploded left side elevation view of the frame of FIG. 2, with a lower left suspension arm; and

FIG. 30 is an enlarged view of portion XXX of the frame and the lower left suspension arm of FIG. 29.

#### DETAILED DESCRIPTION

Referring to FIGS. 1, 4 and 24, a snowmobile 20 will be described. The snowmobile 20 has a front end 22 and a rear end 23, which are defined consistently with the forward travel direction of the snowmobile 20. The snowmobile 20 includes a frame 25. The frame 25 includes a tunnel 27, a motor module 29 and a suspension module 32. A longitudinal centerline 37 (FIG. 4) extends between the front end 22 and the rear end 23 of the snowmobile 20 and splits the frame 25 into a left longitudinal side 39 and a right longitudinal side 41. For the purpose of the present application, the components that are qualified as “left” or “right” are positioned on the corresponding left longitudinal side 39 and right longitudinal side 41 of the frame 25.

Front left and right suspension assemblies 34, 35 are connected to the suspension module 32 and to the motor module 29 (FIGS. 21 and 24). The connection of the front left and right suspension assemblies 34, 35 to the suspension module 32 and to the motor module 29 will be described in detail below. A motor 36, which is schematically illustrated in FIG. 1, is received in the motor module 29. In the present implementation, the motor 36 is a two-stroke, two-cylinder, internal combustion engine. However, it is contemplated that other types of motors could be used such as, but not limited to, an electric motor or a four-stroke internal combustion engine.

An endless drive track 38 is disposed under the tunnel 27. The endless drive track 38 is operatively connected to the engine 36 through a continuously variable transmission (CVT, not shown) and other components not described herein. The endless drive track 38 is suspended for movement relative to the frame 25, by a rear suspension assembly 40. The rear suspension assembly 40 includes a pair of spaced apart slide rails 42, rear suspension arms 44, 46 and shock absorbers 48, 50. The slide rails 42 engage the internal side of the endless drive track 38. The rear suspension arms 44, 46 and the shock absorbers 48, 50 pivotally connect the tunnel 27 to the slide rails 42. The endless drive track 38 is driven to run about the rear suspension assembly 40 for propulsion of the snowmobile 20. A plurality of wheels 52 define the path over which the endless drive track 38 travels.

A fuel tank 54 is supported on top of the tunnel 27. A seat 56 is disposed on the fuel tank 54 and is adapted to support a rider. Two footrests 58 (FIG. 4) are positioned on opposite sides of the tunnel 27 below the seat 56 to support the rider's feet. The footrests 58 are integrally formed with the tunnel 27.

A left ski assembly 60 is positioned at the front end 22 of the snowmobile 20. A right ski assembly (not shown) is also positioned at the front end 22 of the snowmobile 20. The right ski assembly is, in some implementations, a mirror image of the left ski assembly 60.

The left ski assembly 60 includes a left ski 62 and a corresponding left ski leg 64. The left ski assembly 60 is operatively connected to the suspension module 32 and to the motor module 29 via the front left suspension assembly 34. The front left suspension assembly 34 includes an upper left suspension arm 66, a lower left suspension arm 68 and a left shock absorber assembly 70. The left shock absorber assembly 70 includes a left spring 72.

Referring to FIGS. 1 and 24, the right ski assembly (shown in part) includes a right ski (not shown) and a right ski leg 74 connected to the suspension module 32 and to the motor module 29 via the front right suspension assembly 35. The front right suspension assembly 35 includes an upper right suspension arm 76, a lower right suspension arm 78, and a right shock absorber assembly 80. The right shock absorber assembly 80 includes a right spring 82.

The left and right ski legs 64, 74 are pivotally connected to the corresponding upper and lower suspension arms 66, 68, 76, 78 respectively, and the corresponding shock absorber assembly 70, 80 is connected between the corresponding lower suspension arms 68, 78 and the suspension module 32 of the frame 25.

Referring to FIG. 1, a steering assembly 84 including a steering column 86 and a handlebar 88 is supported by the frame 25. The steering column 86 is attached at its upper end to the handlebar 88, which is positioned forward of the seat 56. The steering column 86 is operatively connected to the ski legs 64, 74 by steering rods 72 in order to steer the left

ski **62** and the right ski, and thereby the snowmobile **20**, when the handlebar **88** is turned.

Fairings **90** enclose the engine **36** and the CVT, and provide an external shell that protects the engine **36** and the CVT. The fairings **90** include a hood and one or more side panels that can be opened to allow access to the engine **36** and the CVT when this is required, for inspection or maintenance of the engine **36** and/or the CVT for example. A windshield **92** is connected to the fairings **90** forward of the handlebar **88**. It is contemplated that the windshield **92** could be attached directly to the handlebar **88**.

Referring to FIGS. **2** to **4**, the frame **25** of the snowmobile **20** will be described in more detail. The suspension module **32** is disposed near the front end **22** of the snowmobile **20**. The suspension module **32** has a front portion **94** and a rear portion **96**. The motor module **29** is disposed rearward of the suspension module **32**. The motor module **29** has a front portion **98** and a rear portion **100**. The front portion **98** of the motor module **29** abuts the rear portion **96** of the suspension module **32**. The connection between the motor module **29** and the suspension module **32** will be described in further detail below. The tunnel **27** is disposed rearward of the motor module **29**. The tunnel **27** has a front portion **102** and a rear portion **104**, the rear portion defining the rear end **23** of the snowmobile **20**. The rear portion **100** of the motor module **29** may be connected to the front portion **102** of the tunnel **27** by any suitable means known in the art. For example, the motor module **29** may be welded or bolted to the tunnel **27**. The tunnel **27** has rear frame members **106** connected to the tunnel **27** and extending to an apex **112** to which the steering column **86** is connected. Front left and right members **108**, **110** are connected to the suspension module **32** and extend to the apex **112**. Middle left and right members **114**, **116** are connected between the apex **112** and the motor module **29**.

Referring to FIGS. **5** to **8** and **24**, the suspension module **32** will be described in more detail. The suspension module **32** includes left and right parts **120**, **122**. The left and right parts **120**, **122** of the suspension module **32** are cast parts. Other manufacturing methods are also contemplated. The left and right parts **120**, **122** are connected together using welding or any other suitable connection technique known in the art. The suspension module **32** also includes a crossbar **124** extending between an upper left portion **126** and an upper right portion **128** of the suspension module **32**. The upper left portion **126** includes left tabs **127** for connecting the left shock absorber assembly **70** (FIG. **24**), and the upper right portion **128** includes right tabs **129** for connecting the right shock absorber assembly **80** (FIG. **24**). Below each upper portion **126**, **128**, the suspension module **32** has left and right side walls **130**, **132**. The left and right side walls **130**, **132** have a respective aperture **134**, **136** allowing passage of the left and right steering rods **72** (FIG. **1**) connecting the steering column **86** to the ski legs **64**, **74**. Left and right upper flanges **131**, **133** extend laterally from the left and right side walls **130**, **132** and include left and right tabs **135**, **137**.

When the left and right parts **120**, **122** of the suspension module **32** are connected, the suspension module **32** has a bottom wall **138** extending between the front portion **94** and the rear portion **96** of the suspension module **32**. A drain hole **140** is defined in the bottom wall **138** to drain water from the suspension module **32**.

As illustrated in FIGS. **5** to **8** and **24**, in the front portion **94**, the suspension module **32** has a front wall **142** with an aperture **144** defined therein. Below the front wall **142**, the suspension module **32** has lower front left and right tabs **146**,

**148**. In the rear portion **96**, the suspension module **32** has a rear wall **150** with left and right holes **152**, **154** defined therein. The rear portion **96** also includes rear left and right flanges **156**, **158** defining holes **160** allowing passage of fasteners (not shown) connecting the suspension module **32** to the motor module **29** as the motor module **29** has corresponding holes **162** defined on the front portion **98** of the motor module **29** (FIG. **12A**). The suspension module **32** could also be connected to the motor module **29** using any other suitable technique known in the art, such as welding. The left and right side walls **130**, **132**, the front and rear walls **142**, **150** and the bottom wall **138** define an interior portion **164** of the suspension module **32**.

Referring to FIGS. **9** to **13**, the motor module **29** will be described in more detail. The motor module **29** includes a bottom panel **170** and left and right parts **172**, **174**. The left and right parts **172**, **174** are connected to the bottom panel **170** using fasteners (not shown). The left and right parts **172**, **174** could be connected to the bottom panel **170** using any other suitable technique known in the art, such as bonding or welding. The left and right parts **172**, **174** are cast parts while the bottom panel **170** is made from sheet metal. Other manufacturing techniques are also contemplated. At the rear portion **100** of the motor module **29**, the bottom panel **170** has an upwardly extending portion **171** adapted to abut the front portion **102** of the tunnel **27** so that connection therebetween can be performed. The motor module **29** may be connected to the tunnel **27** by any suitable means known in the art. For example, the motor module **29** may be riveted to the tunnel **27**.

The left part **172** defines a left side wall **176** of the motor module **29**. The left side wall **176** defines a U-shaped recess **178** therein. The right part **174** defines a right side wall **180** of the motor module **29**. The right side wall **180** has an aperture **182** defined therein.

As best seen in FIGS. **10** and **11**, the left part **172** has a left bottom portion **184** and a left protrusion **186** extends from the left bottom portion **184** toward the right part **174**. The right part **174** has a right bottom portion **188** and a right protrusion **190** extends from the right bottom portion **188** toward the left part **172**. The left and right protrusions **186**, **190** overlap and are connected together using three fasteners **192**. In the present implementation, the fasteners **192** are huck bolts. It is contemplated that other fasteners could be used, and that more or less than three fasteners could be used. The bottom panel **170** and the left and right parts **172**, **174** are further connected together using at least one of bonding and fastening techniques known in the art. When connected together, the bottom panel **170** and the left and right parts **172**, **174** define a bottom wall **194** of the motor module **29**. The bottom wall **194** has a convex bottom face **196** toward the front portion **98** of the motor module **29** (FIG. **13**).

Referring to FIGS. **12A**, **12B** and **13**, forward of the bottom panel **170**, the left bottom portion **184** has a left bracket **198** extending on a bottom face **199** thereof. The right bottom portion **188** has a right bracket **200** extending on a bottom face **201** thereof. When the left and right parts **172**, **174** are connected together, the left bracket **198** and the right bracket **200** form a bracket **202** extending from the convex bottom face **196** of the bottom wall **194**. The bracket **202** has a vertical portion **203** extending downwardly from the convex bottom face **196** and the bracket **202** also has a horizontal portion **205** extending rearwardly and perpendicularly to the vertical portion **203**. The bracket **202** defines

a nut cavity **210** at the rear of the vertical portion **203**, above the horizontal portion **205** and below the convex bottom face **196**.

The left bracket **198** has a hole **207** defined in the vertical portion **203**. The left bracket **198** receives a left nut **204** (FIGS. **13** and **28**) in the nut cavity **210**. The right bracket **200** has a hole **209** defined in the vertical portion **203**. The right bracket **200** receives a right nut **206** (FIG. **26**) in the nut cavity **210**. Both the left nut **204** and the right nut **206** are held in place in the nut cavity **210** by surfaces in their corresponding left and right brackets **198**, **200** such that when a fastener, such as a bolt, is fastened thereto, there is no need to prevent rotation of the left and right nuts **204**, **206** using a tool. As illustrated in FIG. **13**, the vertical portion **203** extends perpendicularly to the fastening axes of the left and right nuts **204**, **206**, and the horizontal portion **205** extends rearwardly and perpendicularly to the vertical portion **203**. The horizontal portion **205** thus forms a portion of the bottom wall **194** of the motor module **29**.

Referring to FIGS. **9** to **12B**, the front portion **98** of the motor module **29** will be described in more detail. The front portion **98** includes a front wall **212** where are defined the holes **162** corresponding to the holes **160** defined in the suspension module **32** for connection of the motor module **29** to the suspension module **32** using fasteners (not shown). The front portion **98** also defines a cross member **214** and an aperture **216** below the cross member **214**. The cross member **214** is formed of a left cross member segment **218** formed integrally with an upper front portion of the left part **172**. The cross member **214** is further formed of a right cross member segment **220** formed integrally with an upper front portion of the right part **174**. The left and right cross member segments **218**, **220** are connected together using two fasteners **222**. It is contemplated that the left and right cross member segments **218**, **220** could be connected together using more or less than two fasteners **222**. It is also contemplated that the left and right cross member segments **218**, **220** could be connected using any other suitable technique known in the art, such as welding. The left and right cross member segments **218**, **220** have a C-shaped cross section (FIG. **10**). Other suitable cross section profiles, such as an I-shaped cross section, are contemplated.

Referring to FIG. **12B** illustrating one variant of the motor module **29**, the left and right cross member segments **218**, **220** are welded together and form the cross member **214**. A plate **215** is disposed longitudinally forward of the front portion **98** of the motor module **29** and connected to the cross member **214**. The plate **215** is shaped and configured to be received inside the C-shaped cross-section of the left and right cross member segments **218**, **220**. The plate **215** is connected to the left and right cross member segments **218**, **220** using fasteners, such as rivets. Any other suitable technique known in the art could be used to connect the plate **215** to the left and right cross member segments **218**, **220**, such as bonding or welding.

Referring to FIGS. **11** to **12B**, the left cross member segment **218** has a left proximal portion **219** and a left distal portion **221**. The left proximal portion **219** has a left proximal top portion **219a** and the left distal portion **221** has a left distal top portion **221a**. The left distal top portion **221a** is longitudinally longer than the left proximal top portion **219a**. Similarly, the right cross member segment **220** has a right proximal portion **223** and a right distal portion **225**. The right proximal portion **223** has a right proximal top portion **223a** and the right distal portion **225** has a right distal top portion **225a**. The right distal top portion **225a** is longitudinally longer than the right proximal top portion **223a**.

Toward the left and right distal portions **221**, **225** of the cross member **214**, left and right upper holes **224**, **226** are defined in the front wall **212** of the motor module **29**. Referring to FIG. **12B**, the plate **215** also has holes aligned with left and right upper holes **224**, **226**.

Referring to FIGS. **12C** and **12D** illustrating another variant of the motor module **29**, a plate **215'** is positioned longitudinally rearward of the cross member **214**. The plate **215'** covers the aperture **216** below the cross member **214**. In some implementations, the plate **215'** is made of sheet metal and is configured to conform to the profile of the front portion **98** of the motor module **29**. A plurality of holes **163** are defined on the plate **215'**. Each one of the holes **163** is aligned with a corresponding hole **162** defined in the motor module **29** and a corresponding hole **160** defined in the suspension module **32**. The plate **215'**, the motor module **29** and the suspension module **32** are connected together, at least partially, using fasteners **163'**. The upper portion of the plate **215'** includes holes **165** defined therein. The holes **165** are aligned with corresponding holes **162'** defined in the motor module **29**, such that fasteners (not shown) may be used to further connect the plate **215'** to the motor module **29**. The upper portion of the plate **215'** also includes two holes **165'** defined therein. The two holes **165'** allow passage of the two fasteners **222** used to connect together the left and right cross member segments **218**, **220**. As such, the plate **215'** is further connected to the motor module **29** by the two fasteners **222**. It is contemplated that the plate **215'** could be further connected to the motor module **29** using any other suitable technique known in the art, such as bonding or welding.

Referring back to FIG. **12A**, the aperture **216** defined in the front portion **98** of the motor module **29** has a width **228**. The width **228** is taken horizontally and perpendicularly to the longitudinal centerline **37** of the frame **25** of the snowmobile **20**. The motor module **29** has an overall width **230**. The overall width **230** of the motor module **29** is taken horizontally and perpendicularly to the longitudinal centerline **37** of the frame **25** of the snowmobile **20**. A ratio of the width **228** of the aperture **216** over the overall width **230** of the motor module **29** is 0.3 or more. In some implementations, the ratio is 0.4 or more.

In addition, the aperture **216** has a height **232**. The height **232** is taken vertically and perpendicularly to the longitudinal centerline **37** of the frame **25** of the snowmobile **20**. The motor module **29** has an overall height **234**. The overall height **234** of the motor module **29** is taken vertically and perpendicularly to the longitudinal centerline **37** of the frame **25** of the snowmobile **20**. A ratio of the height **232** of the aperture **216** over the overall height **234** of the motor module **29** is 0.25 or more. In some implementations, the ratio is 0.28 or more.

Still referring to FIG. **12A**, holes **207**, **209** are separated by a center-to-center distance **236**. The upper holes **224**, **226** are separated by a distance **238**. A ratio of the distance **236** over the distance **238** is 0.1 or less. In some implementations, the ratio is 0.08 or less. A ratio of the width **228** of the aperture **216** over the distance **238** is 1.25 or more. In some implementations, the ratio is 1.30 or more.

With reference to FIGS. **14** to **30**, the left and right front suspension assemblies **34**, **35** and their connection to the motor module **29** and to the suspension module **32** will be described in more detail.

The left and right front suspension assemblies **34**, **35** are connected to the left and right ski legs **64**, **74**. An upper front tab **240** of the left ski leg **64** is connected to the upper left suspension arm **66** at a distal end **242** thereof through a ball

joint 244 (FIG. 24). A lower front tab 246 of the left ski leg 64 is connected to the lower left suspension arm 68 at a distal end 248 thereof through a ball joint 250. The left ski leg 64 may pivot and rotate with respect to a left ski leg pivot axis 252 passing through the ball joints 244, 250 (FIG. 22). Similarly, an upper front tab 254 of the right ski leg 74 is connected to the upper right suspension arm 76 at a distal end 256 thereof through a ball joint 258 (FIG. 24). A lower front tab 260 of the right ski leg 74 is connected to the lower right suspension arm 78 at a distal end 262 thereof through a ball joint 264. The right ski leg 74 may pivot and rotate with respect to a right ski leg pivot axis 266 passing through the ball joints 258, 264 (FIG. 22).

The upper left suspension arm 66 has upper left front and rear members 270, 272 meeting at the distal end 242. The upper left front member 270 includes an upper left front proximal end 272 (FIG. 19), and the upper left rear member 272 includes an upper left rear proximal end 274 (FIG. 17). Similarly, the upper right suspension member 76 has upper right front and rear members 276, 278 meeting at the distal end 256. The upper right front member 276 includes an upper right front proximal end 280 (FIG. 17), and the upper right rear member 278 includes an upper right rear proximal end 282.

The upper left front proximal end 272 is connected to the suspension module 32 by an upper left front proximal fastener 284 passing through the upper left front proximal end 272 and extending through the left tab 135 of the suspension module 32 (FIG. 8). The upper left front proximal fastener 284 pivotally connects the upper left front member 270 to the suspension module 32 about an upper front left pivot axis 286 (FIG. 24). Similarly, the upper right front proximal end 280 is connected to the suspension module 32 by an upper right front proximal fastener 288 passing through the upper right front proximal end 280 and extending through the right tab 137 of the suspension module 32 (FIG. 8). The upper right front proximal fastener 288 pivotally connects the upper right front member 276 to the suspension module 32 about an upper front right pivot axis 290.

The upper left rear proximal end 274 is positioned longitudinally forward of the front portion 98 of the motor module 29 (FIG. 17). The upper left rear proximal end 274 is connected to the motor module 29 by an upper left rear proximal fastener 292 passing through the upper left rear proximal end 274 and extending through the upper left hole 224 of the motor module 29 (FIG. 12A). The upper left rear proximal fastener 292 pivotally connects the upper left rear member 272 to the motor module 29 about an upper rear left pivot axis 294 (FIGS. 17 and 19). Similarly, the upper right rear proximal end 282 is positioned longitudinally forward of the front portion 98 of the motor module 29 (FIG. 17). The upper right rear proximal end 282 is connected to the motor module 29 by an upper right rear proximal fastener 296 (FIG. 17) passing through the upper right rear proximal end 282 and extending through the upper right hole 226 of the motor module 29 (FIG. 12A). The upper right rear proximal fastener 296 pivotally connects the upper right rear member 278 to the motor module 29 about an upper rear right pivot axis 298 (FIG. 19). Referring to FIGS. 12A and 17A, it can be seen that a line 299 extending from the upper rear left pivot axis 294 to the upper rear right pivot axis 298 is completely contained in the cross member 214.

Referring to the variant of the motor module 29 shown in FIGS. 12B and 17B, the plate 215 is disposed rearward of the upper left rear proximal end 274 and the upper right rear proximal end 282. The plate 215 is further connected to the

cross member 214 of the motor module 29 upon connection of the upper left rear proximal end 274 using the upper left rear proximal fastener 292 and the upper right rear proximal end 282 using the upper right rear proximal fastener 296. Such connection of the plate 215 is complementary to its fastened connection to the motor module 29 described above. In some embodiments, the plate 215 is further connected to the motor module 29 using the upper left rear proximal fastener 292 and the upper right rear proximal fastener 296. The plate 215 extends laterally between the upper rear left pivot axis 294 and the upper rear right pivot axis 298. In the variant shown in FIG. 17B where the plate 215 is connected to the cross member 214, modifications to at least one of the motor module 29, the upper left rear proximal end 274, the upper right rear proximal end 282, the upper left rear proximal fastener 292 and the upper right rear proximal fastener 296 are contemplated to take into account the thickness of the plate 215 so that the configuration of the left and right front suspension arms 66, 76 presented in FIG. 17B remain similar to the left and right front suspension arms 66, 76 presented in FIG. 17A. Referring to FIGS. 12B and 17B, the line 299 extending between the upper left hole 224 and the upper right hole 226 is completely contained in the cross member 214 and in the plate 215.

The lower left suspension arm 68 has lower left front and rear members 300, 302 meeting at the distal end 248 (FIGS. 24 and 30). The lower left front member 300 includes a lower left front proximal end 304, and the lower left rear member 302 includes a lower left rear proximal end 306. Similarly, the lower right suspension member 78 has lower right front and rear members 308, 310 meeting at the distal end 262 (FIG. 24). The lower right front member 308 includes a lower right front proximal end 312 (FIG. 21), and the lower right rear member 310 includes a lower right rear proximal end 314.

The lower left front proximal end 304 is positioned below the front portion 94 of the suspension module 32 and longitudinally forward of the bottom wall 138 of the suspension module 32. The lower left front proximal end 304 is connected to the suspension module 32 by a lower left front proximal fastener 316 passing through the lower left front proximal end 306 and extending through the lower front left tabs 146 of the suspension module 32 (FIGS. 6, 22 and 24). The lower left front proximal fastener 316 extends in the interior portion 164, above the bottom wall 138 of the suspension module 32 (FIGS. 19 and 24). The lower left front proximal fastener 316 pivotally connects the lower left front member 300 to the suspension module 32 about a lower front left pivot axis 318 (FIGS. 19 and 24). The lower front left pivot axis 318 extends through the interior portion 164, above the bottom wall 138 of the suspension module 32 (FIG. 19). Similarly, the lower right front proximal end 312 is positioned below the front portion 94 of the suspension module 32 and longitudinally forward of the bottom wall 138 of the suspension module 32. The lower right front proximal end 312 is connected to the suspension module 32 by a lower right front proximal fastener 320 (FIG. 22) passing through the lower right front proximal end 312 and extending through the lower front right tab 148 of the suspension module 32 (FIGS. 6, 22 and 24). The lower right front proximal fastener 320 extends in the interior portion 164, above the bottom wall 138 of the suspension module 32. The lower right front proximal fastener 320 pivotally connects the lower right front member 308 to the suspension module 32 about a lower front right pivot axis 322 (FIG. 24). The lower front right pivot axis 322 extends through the interior portion 164, above the bottom wall 138 of the

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suspension module 32 (FIG. 26). Referring to FIGS. 22 and 24, a plate 323 is connected to the front portion 94 of the suspension module 32. The plate 323 is disposed forward of the lower front left and right tabs 146, 148 shown in FIG. 6. The plate 323 extends laterally and has holes defined therein for receiving the lower front left and right proximal fasteners 316, 320. It is contemplated that the plate 323 could also be welded to the suspension module 32.

Referring to FIGS. 24, 26 and 30, a distance 324 between the lower front left and right pivot axes 318, 322 is less than twice an outside diameter 325 of one of the lower front left proximal end 304 and the lower right front proximal end 312. As the lower front left proximal end 304 and the lower right front proximal end 312 are cylindrical, the outside diameter 325 is measured as shown in FIGS. 26 and 30.

The lower left rear proximal end 306 is positioned longitudinally between the motor module 29 and the suspension module 32 (FIGS. 21 and 28 to 30). The lower left rear proximal end 306 is connected to the suspension module 32 and to the motor module 29 by a lower left rear proximal fastener 326 passing through the lower left rear proximal end 306 and extending in the interior portion 164, above the bottom wall 138 of the suspension module 32. More particularly, the lower left rear proximal fastener 326 extends from the interior portion 164 of the suspension module 32, through the hole 152 (FIG. 7), through the lower left rear proximal end 306, to the left bracket 198 through the hole 207 (FIG. 12A) and is fastened to the left nut 204. The lower left rear proximal fastener 326 pivotally connects the lower left rear member 302 to the suspension module 32 and to the motor module 29 about a lower rear left pivot axis 328. The lower rear left pivot axis 328 extends through the interior portion 164, above the bottom wall 138 of the suspension module 32 (FIG. 28). Similarly, the lower right rear proximal end 314 is positioned longitudinally between the motor module 29 and the suspension module 32 (FIGS. 21, 25 and 26). The lower right rear proximal end 314 is connected to the suspension module 32 and to the motor module 29 by a lower right rear proximal fastener 332 passing through the lower right rear proximal end 314 and extending in the interior portion 164, above the bottom wall 138 of the suspension module 32. More particularly, the lower right rear proximal fastener 332 extends from the interior portion 164 of the suspension module 32, through the hole 154 (FIG. 7), through the lower right rear proximal end 314, to the right bracket 200 through the hole 209 (FIG. 12A) and is fastened to the right nut 206. The lower right rear proximal fastener 332 pivotally connects the lower right rear member 310 to the suspension module 32 and to the motor module 29 about a lower rear right pivot axis 334. The lower rear right pivot axis 334 extends through the interior portion 164, above the bottom wall 138 of the suspension module 32 (FIG. 26).

The lower left rear proximal fastener 326 and the lower right rear proximal fastener 332 connect the corresponding lower left rear member 302 and lower right rear member 310 to the suspension module 32 and to the motor module 29. The lower left rear proximal fastener 326 and the lower right rear proximal fastener 332 also connect the suspension module 32 and the motor module 29 together.

Referring to FIG. 12A, the distance 236 corresponds to a distance between the lower left and right rear pivot axes 328, 334 (FIG. 24). The distance 236 is less than twice an outside diameter 330 (FIGS. 26 and 30) of one of the lower left and right rear proximal ends 306, 314. As the lower rear left

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proximal end 306 and the lower right rear proximal end 314 are cylindrical, the outside diameter 330 is measured as shown in FIGS. 26 and 30.

Referring to FIG. 24, the lower front and rear left pivot axes 318, 328 are coaxial. Similarly, the lower front and rear right pivot axes 322, 334 are coaxial. In addition, the lower front and rear left pivot axes 318, 328 are parallel to the lower front and rear right pivot axes 322, 334.

Referring to FIGS. 19, 24, 26 and 28, the snowmobile 20 further has a torsion bar assembly 340. The torsion bar assembly 340 includes a torsion bar 342. The torsion bar 342 extends across the motor module 29. A left end 344 of the torsion bar 342 is connected to an upper left linkage 346 which is connected to a lower left linkage 348. The lower left linkage 348 is connected to the lower left rear member 302. A right end 350 of the torsion bar 342 is connected to an upper right linkage 352 which is connected to a lower right linkage 354 (FIGS. 21 and 26). The lower right linkage 354 is connected to the lower right rear member 310.

Modifications and improvements to the above-described implementations of the present may become apparent to those skilled in the art. The foregoing description is intended to be exemplary rather than limiting. The scope of the present is therefore intended to be limited solely by the scope of the appended claims.

What is claimed is:

1. A snowmobile comprising:
  - a frame comprising:
    - a motor module;
    - a tunnel connected to the motor module; and
    - a suspension module connected to the motor module, the suspension module having an interior portion;
  - a motor received in the motor module;
  - a handlebar connected to the frame;
  - a ski operatively connected to the handlebar;
  - an endless drive track operatively connected to the tunnel and to the motor;
  - a front suspension assembly connected to the suspension module and to the motor module, the front suspension assembly connecting the ski to the suspension module and to the motor module, the front suspension assembly comprising:
    - a suspension arm having a proximal end positioned longitudinally between the motor module and the suspension module, the proximal end pivoting about a pivot axis extending through the interior portion of the suspension module; and
    - a proximal fastener passing through the proximal end of the suspension arm and extending from the interior portion of the suspension module to the motor module, the proximal fastener thereby pivotally connecting the suspension arm to the suspension module and to the motor module about the pivot axis.
2. The snowmobile according to claim 1, wherein:
  - the motor module has a bracket provided on a bottom wall of the motor module;
  - the bracket is adapted to receive a nut for fastening the proximal fastener thereto; and
  - the proximal fastener is fastened to the nut.
3. The snowmobile according to claim 1, wherein:
  - the suspension module is forward of the motor module;
  - the suspension arm comprises a front member and a rear member; and
  - the rear member has the proximal end.
4. The snowmobile according to claim 1, wherein:
  - the ski is a front left ski;

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the front suspension assembly is a front left suspension assembly;  
 the front left ski is operatively connected to the suspension module and to the motor module via the front left suspension assembly;  
 the suspension arm is a left suspension arm;  
 the proximal end is a left proximal end;  
 the pivot axis is a left pivot axis;  
 the proximal fastener is a left proximal fastener;  
 the snowmobile further comprises:  
     a front right suspension assembly; and  
     a front right ski operatively connected to the suspension module and to the motor module via the front right suspension assembly, the front right suspension assembly comprising:  
         a right suspension arm having a right proximal end positioned longitudinally between the motor module and the suspension module, the right proximal end pivoting about a right pivot axis extending through the interior portion of the suspension module; and  
         a right proximal fastener passing through the right proximal end of the right suspension arm and extending from the interior portion of the suspension module to the motor module, the right proximal fastener thereby pivotally connecting the right suspension arm to the suspension module and to the motor module about the right pivot axis.

5. The snowmobile according to claim 4, wherein a distance between the left and right pivot axes is less than twice an outside diameter of one of the left and right proximal ends.

6. The snowmobile according to claim 4, wherein:  
 the left suspension arm comprises a front left member and a rear left member, the rear left member has the left proximal end; and  
 the right suspension arm comprises a front right member and a rear right member, the rear right member has the right proximal end.

7. The snowmobile according to claim 6, further comprising a torsion bar assembly comprising:  
 a torsion bar extending across the interior portion of the suspension module;  
 a left linkage connecting a left end of the torsion bar to the rear left member; and  
 a right linkage connecting a right end of the torsion bar to the rear right member.

8. The snowmobile according to claim 6, wherein:  
 the left proximal end is a rear left proximal end;  
 the left pivot axis is a rear left pivot axis;  
 the left proximal fastener is a rear left proximal fastener;  
 the front left member has a front left proximal end positioned below a front portion of the suspension module;  
 the front left proximal end pivots about a front left pivot axis extending through the interior portion of the suspension module;  
 the front left suspension assembly further comprises a front left proximal fastener passing through the front left proximal end of the front left member and extending in the interior portion of the suspension module, the front left proximal fastener thereby pivotally connecting the front left member to the front portion of the suspension module;  
 the right proximal end is a rear right proximal end;  
 the right pivot axis is a rear right pivot axis;

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the right proximal fastener is a rear right proximal fastener;  
 the front right member has a front right proximal end positioned below the front portion of the suspension module;  
 the front right proximal end pivots about a front right pivot axis extending through the interior portion of the suspension module; and  
 the front right suspension assembly further comprises a front right proximal fastener passing through the front right proximal end of the front right member and extending in the interior portion of the suspension module, the front right proximal fastener thereby pivotally connecting the front right member to the front portion of the suspension module.

9. The snowmobile according to claim 8, wherein a distance between the front left and right pivot axes is less than twice an outside diameter of one of the front left proximal end and the front right proximal end.

10. The snowmobile according to claim 8, wherein:  
 the front and rear left pivot axes are coaxial;  
 the front and rear right pivot axes are coaxial; and  
 the front and rear left pivot axes are parallel to the front and rear right pivot axes.

11. The snowmobile according to claim 4, wherein:  
 the motor module has a bracket extending from a bottom wall of the motor module;  
 the snowmobile further comprises:  
     a left nut received in the bracket;  
     the left proximal fastener is fastened to the left nut;  
     a right nut received in the bracket; and  
     the right proximal fastener is fastened to the right nut.

12. The snowmobile according to claim 11, wherein:  
 the bottom wall of the motor module has a convex bottom face;  
 the bracket comprises a vertical portion extending downwardly from the convex bottom face and perpendicularly to the left and right pivot axes; and  
 the bracket further comprises a horizontal portion extending rearwardly and perpendicularly to the vertical portion.

13. The snowmobile according to claim 4, further comprising:  
 a left shock absorber assembly connected between the left suspension arm and the suspension module; and  
 a right shock absorber assembly connected between the right suspension arm and the suspension module.

14. The snowmobile according to claim 4, wherein:  
 the left suspension arm is a lower left suspension arm;  
 the front left suspension assembly further has an upper left suspension arm;  
     the upper left suspension arm has upper front and rear left members;  
     the upper left rear member has an upper left rear proximal end;  
 the front left suspension assembly further has an upper left rear proximal fastener passing through the upper left rear proximal end and extending through the motor module, the upper left rear proximal fastener pivotally connecting the upper left rear member to the motor module;  
 the right suspension arm is a lower right suspension arm;  
 the front right suspension assembly further has an upper right suspension arm;  
     the upper right suspension arm has upper front and rear right members;

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the upper right rear member has an upper right rear proximal end; and  
the front right suspension assembly further has an upper right rear proximal fastener passing through the upper right rear proximal end and extending through the motor module, the upper right rear proximal fastener pivotally connecting the upper right rear member to the motor module.  
15. The snowmobile according to claim 14, wherein:  
the upper left front member has an upper left front proximal end;  
the front left suspension assembly further has an upper left front proximal fastener passing through the upper left front proximal end and extending through the suspension module, the upper left front proximal fastener pivotally connecting the upper left front member to the suspension module;  
the upper right front member has an upper right front proximal end; and

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the front right suspension assembly further has an upper right front proximal fastener passing through the upper right front proximal end and extending through the suspension module, the upper right front proximal fastener pivotally connecting the upper right front member to the suspension module.  
16. The snowmobile according to claim 1, wherein:  
the suspension module comprises a left part and a right part; and  
the left and right parts are connected together.  
17. The snowmobile according to claim 1, wherein:  
the motor module comprises a left part and a right part;  
and  
the left and right parts are connected together using at least one of bonding and fastening.  
18. The snowmobile according to claim 17, wherein the left and right parts of the motor module are cast parts.

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