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**Gauthier et al.**

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(54) **CONTINUOUSLY VARIABLE TRANSMISSION MOUNTING ASSEMBLY**

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This patent is subject to a terminal disclaimer.

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(22) Filed: **Nov. 18, 2013**

**Related U.S. Application Data**

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(60) Provisional application No. 61/441,057, filed on Feb. 9, 2011.

(51) **Int. Cl.**  
**B62M 27/00** (2006.01)  
**B62M 27/02** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **B62M 27/02** (2013.01)

(58) **Field of Classification Search**  
USPC ..... 180/190, 191, 192  
See application file for complete search history.

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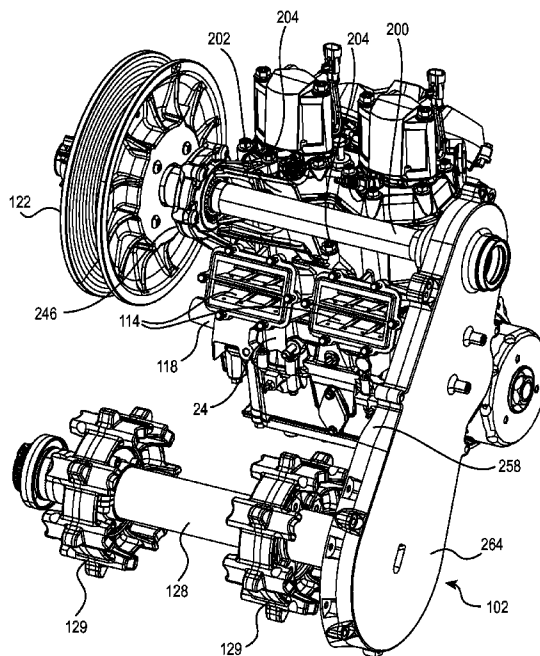
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(57) **ABSTRACT**

A snowmobile has a frame with an engine compartment and a tunnel, a front suspension, at least one ski, an engine, a bracket having a first portion joined to the engine and a second portion having an aperture defined therein, an output shaft, a countershaft passing through the aperture, a motion decoupler disposed around the countershaft and being supported by the second portion of the bracket, the countershaft being rotationally supported in the motion decoupler, a driving pulley disposed on the output shaft, a driven pulley disposed on the countershaft, a drive belt looped around the driving and driven pulleys, and an endless drive track. The driving pulley, the driven pulley and the drive belt together form a continuously variable transmission.

**21 Claims, 21 Drawing Sheets**



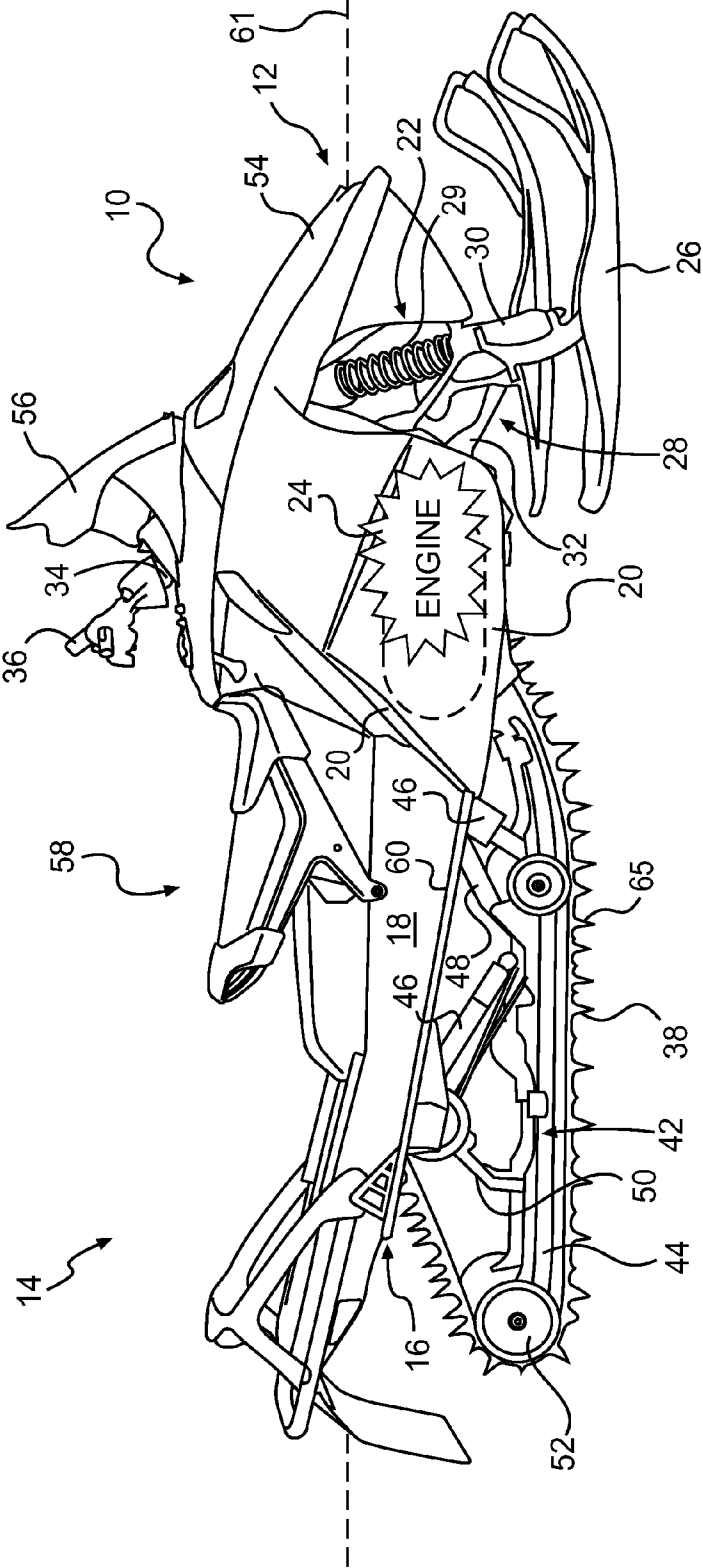


FIG. 1

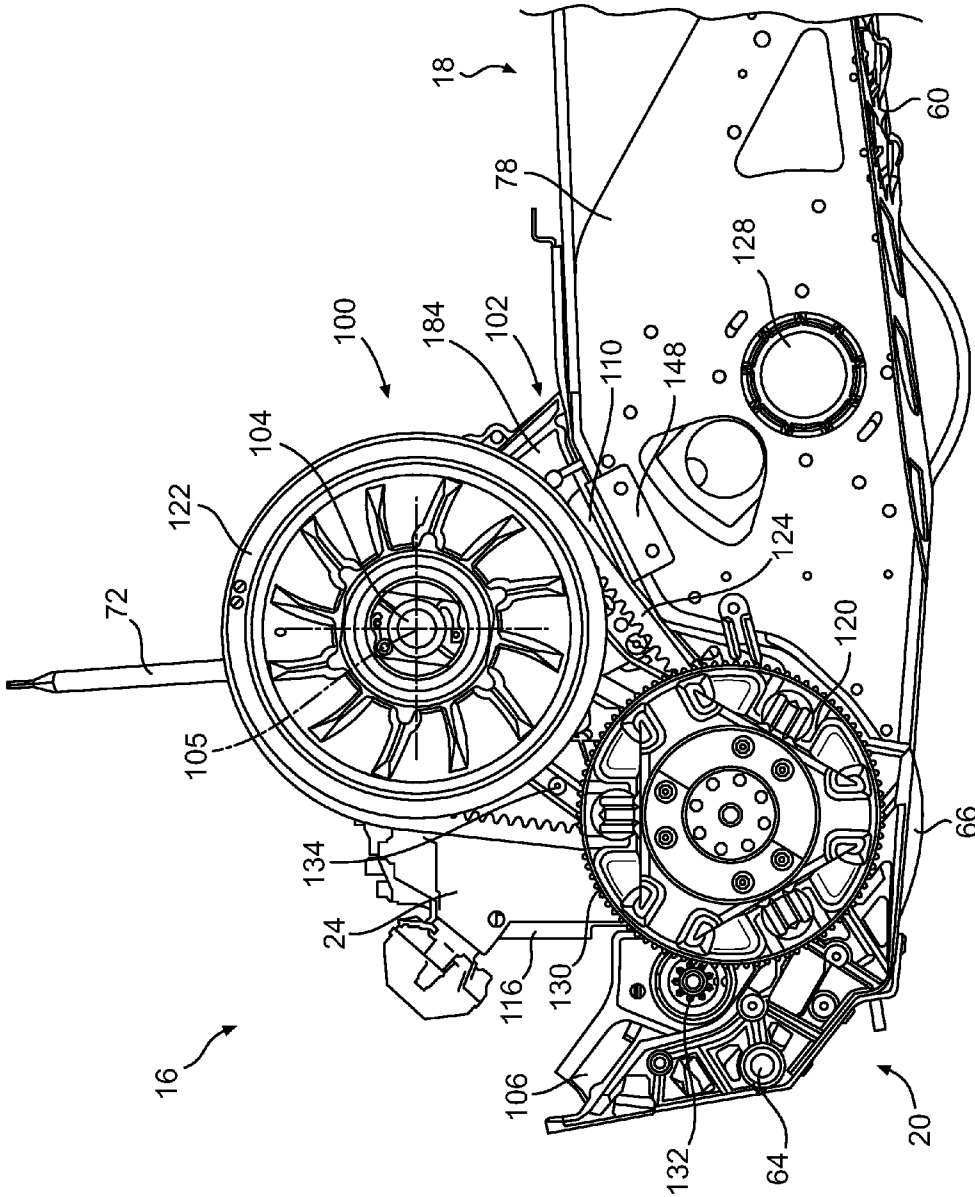


FIG. 2

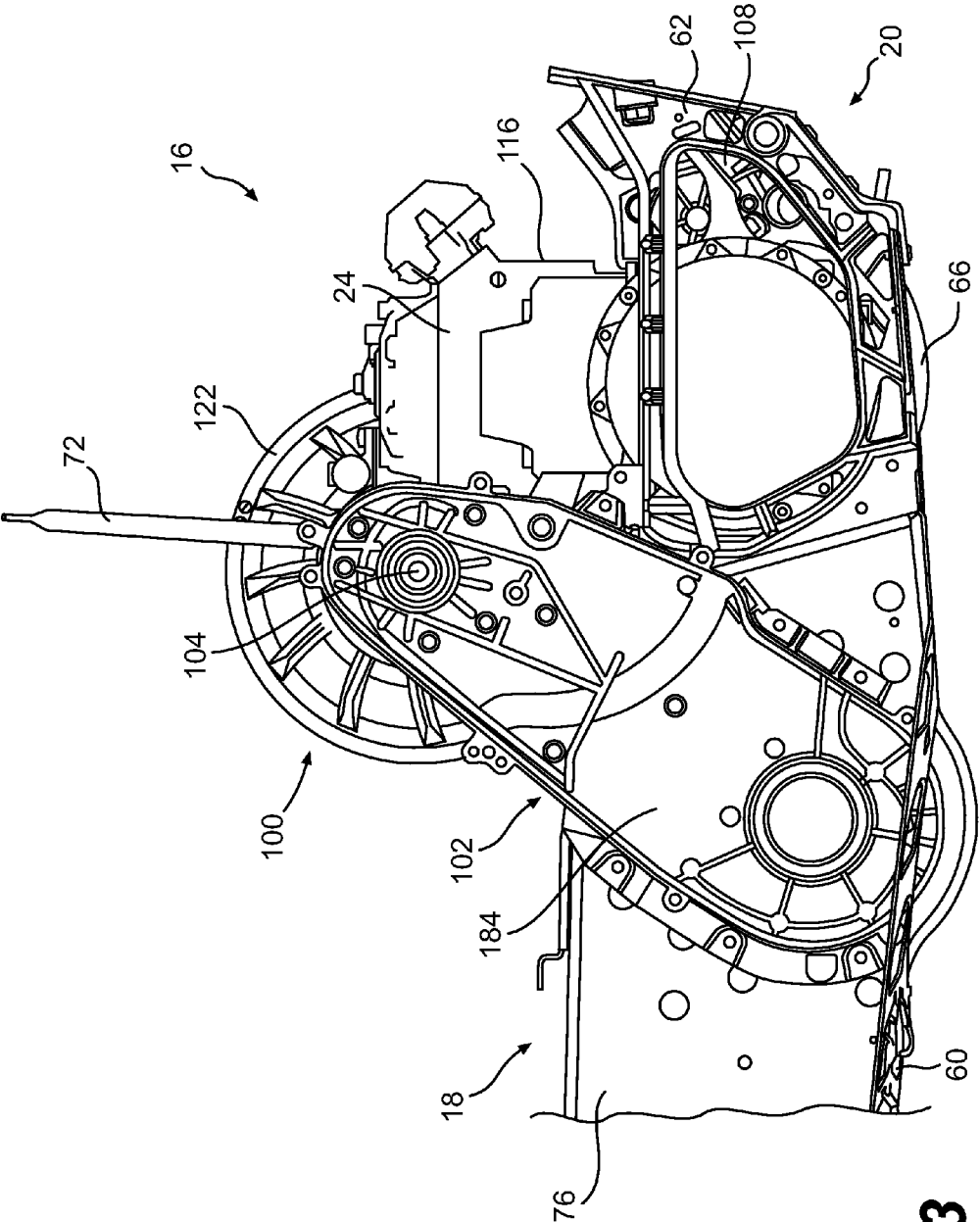
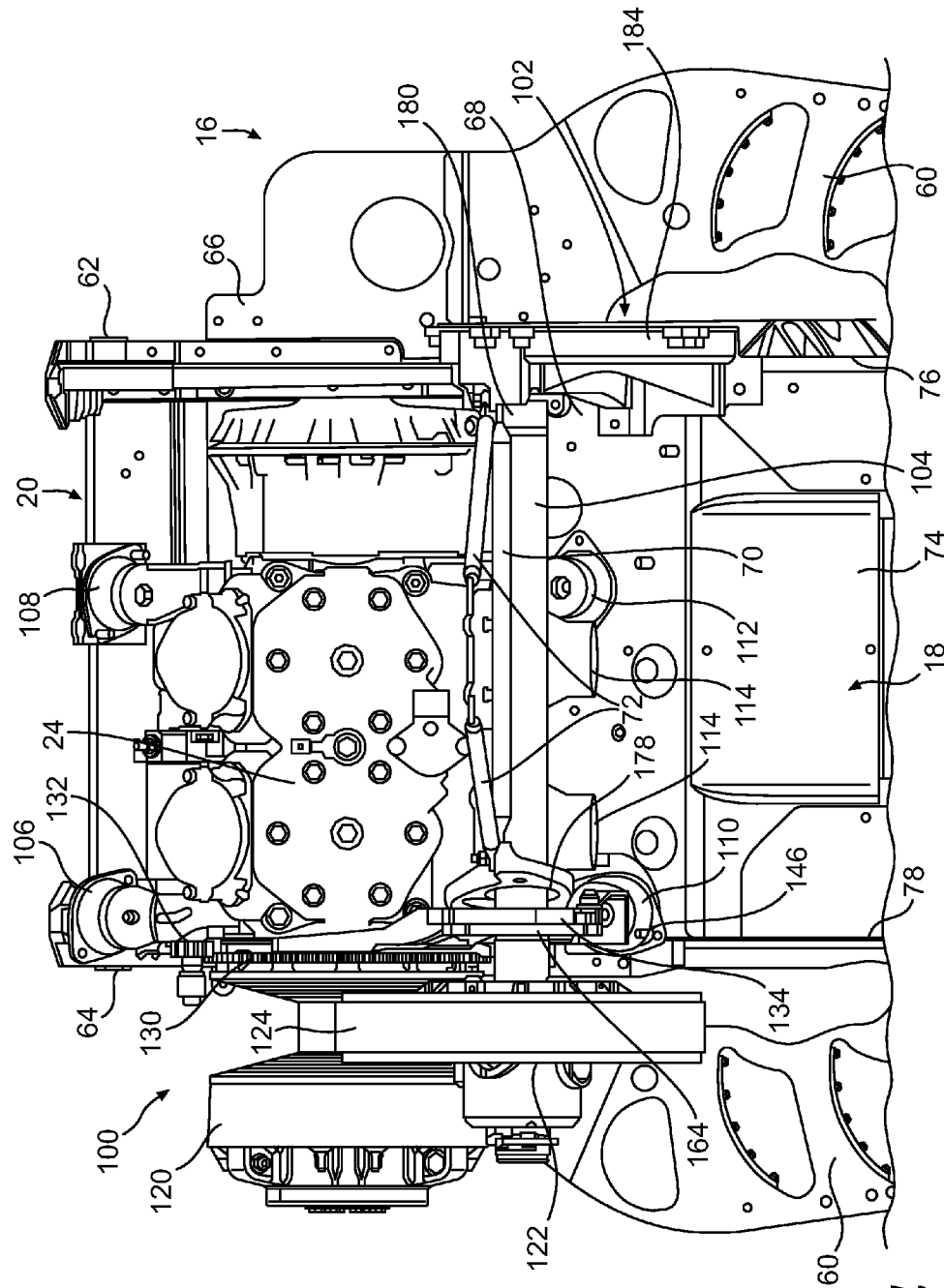


FIG. 3



**FIG. 4**

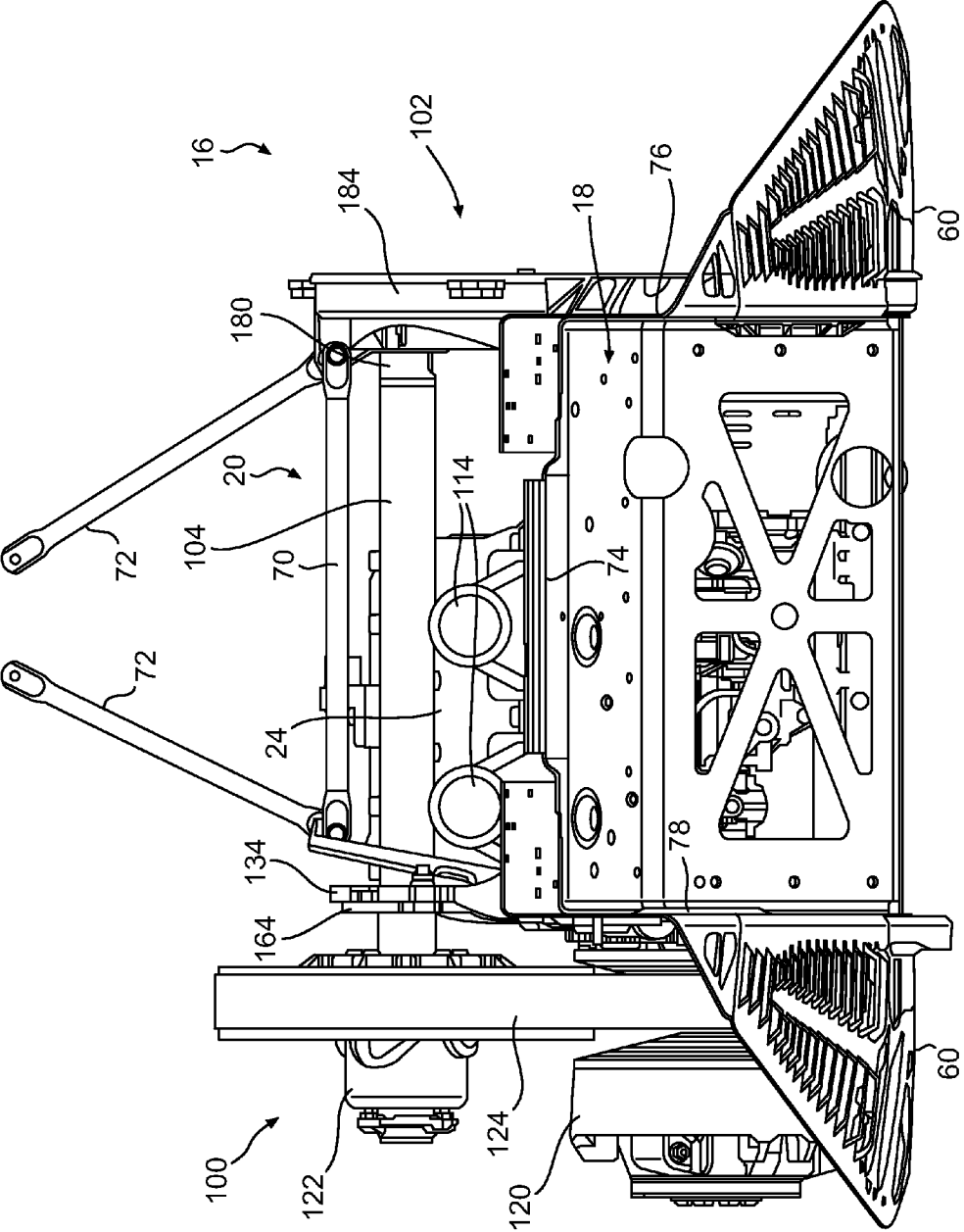
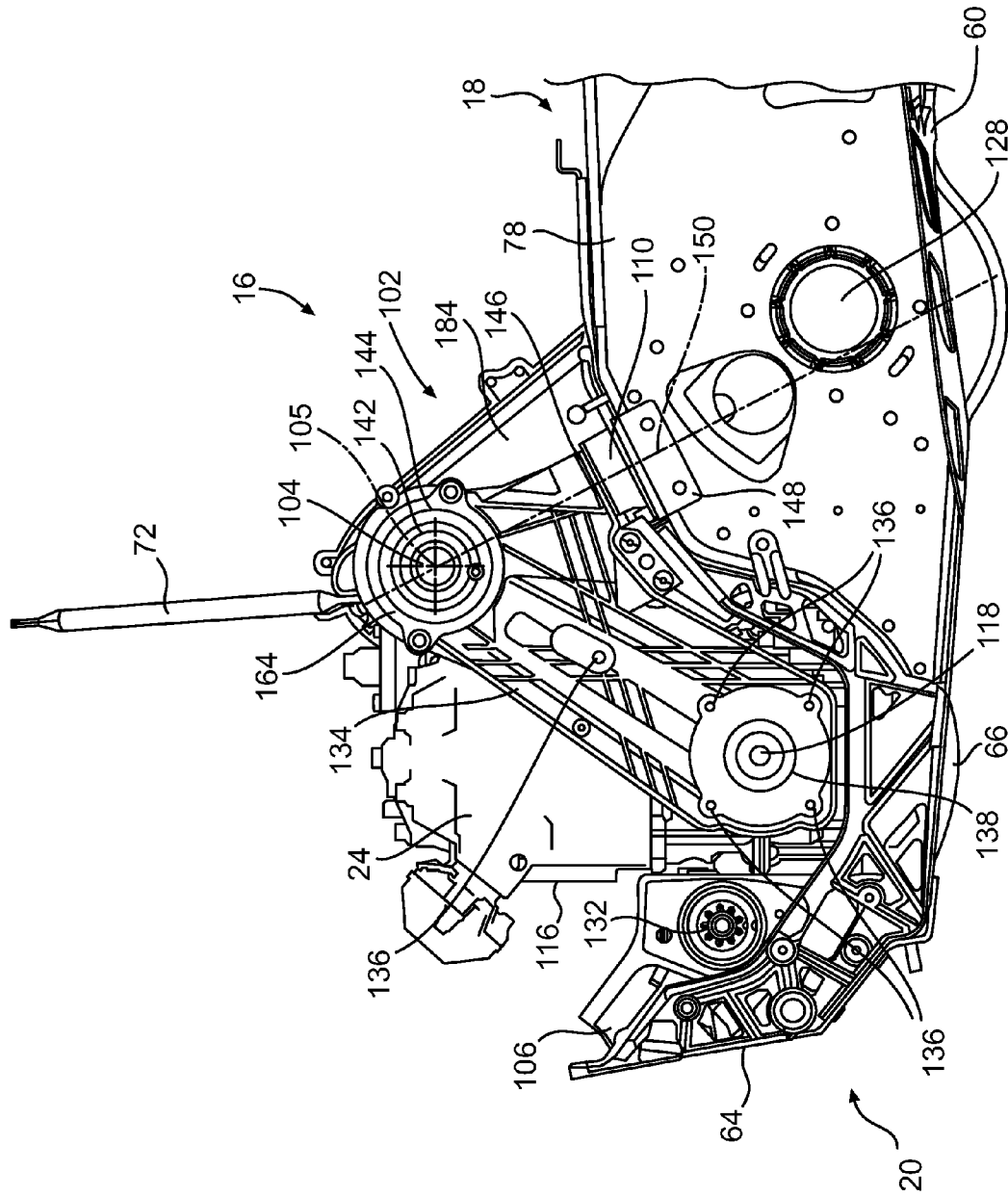


FIG. 5





**FIG. 7**

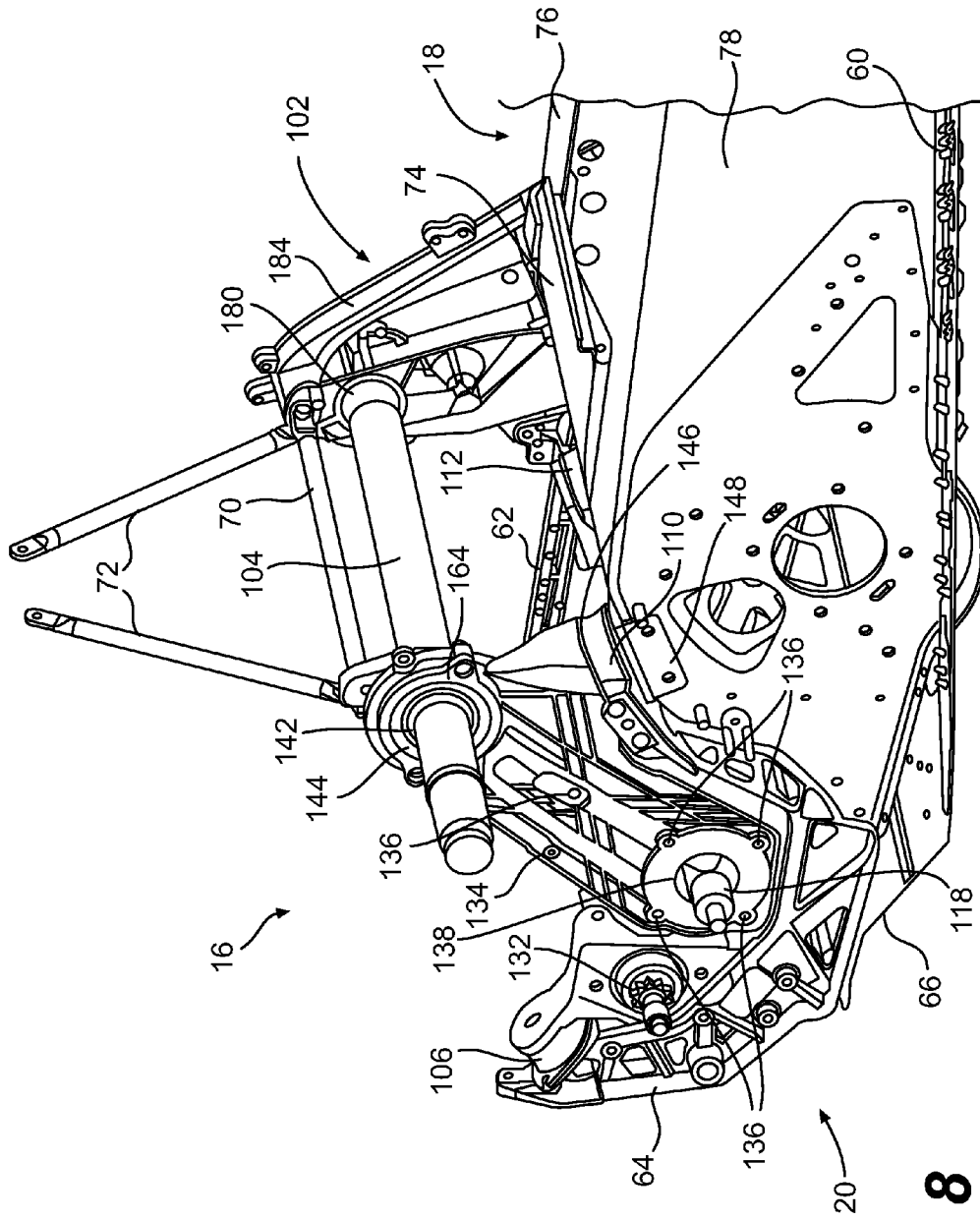
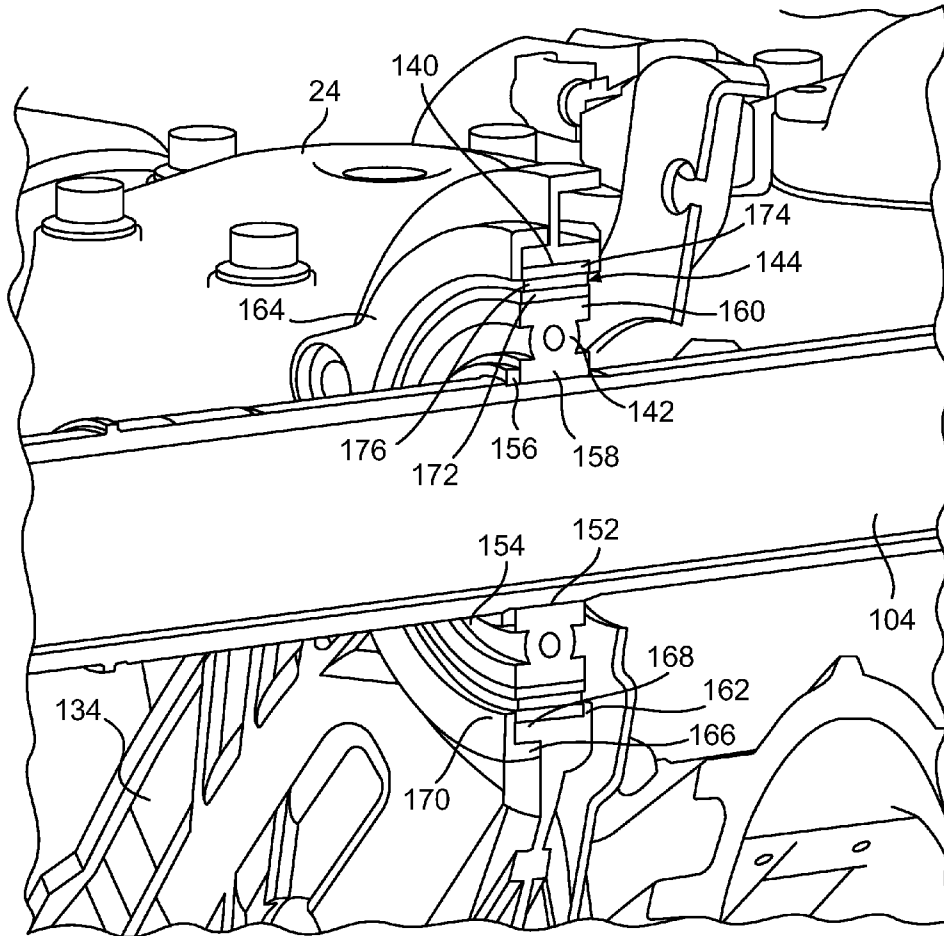


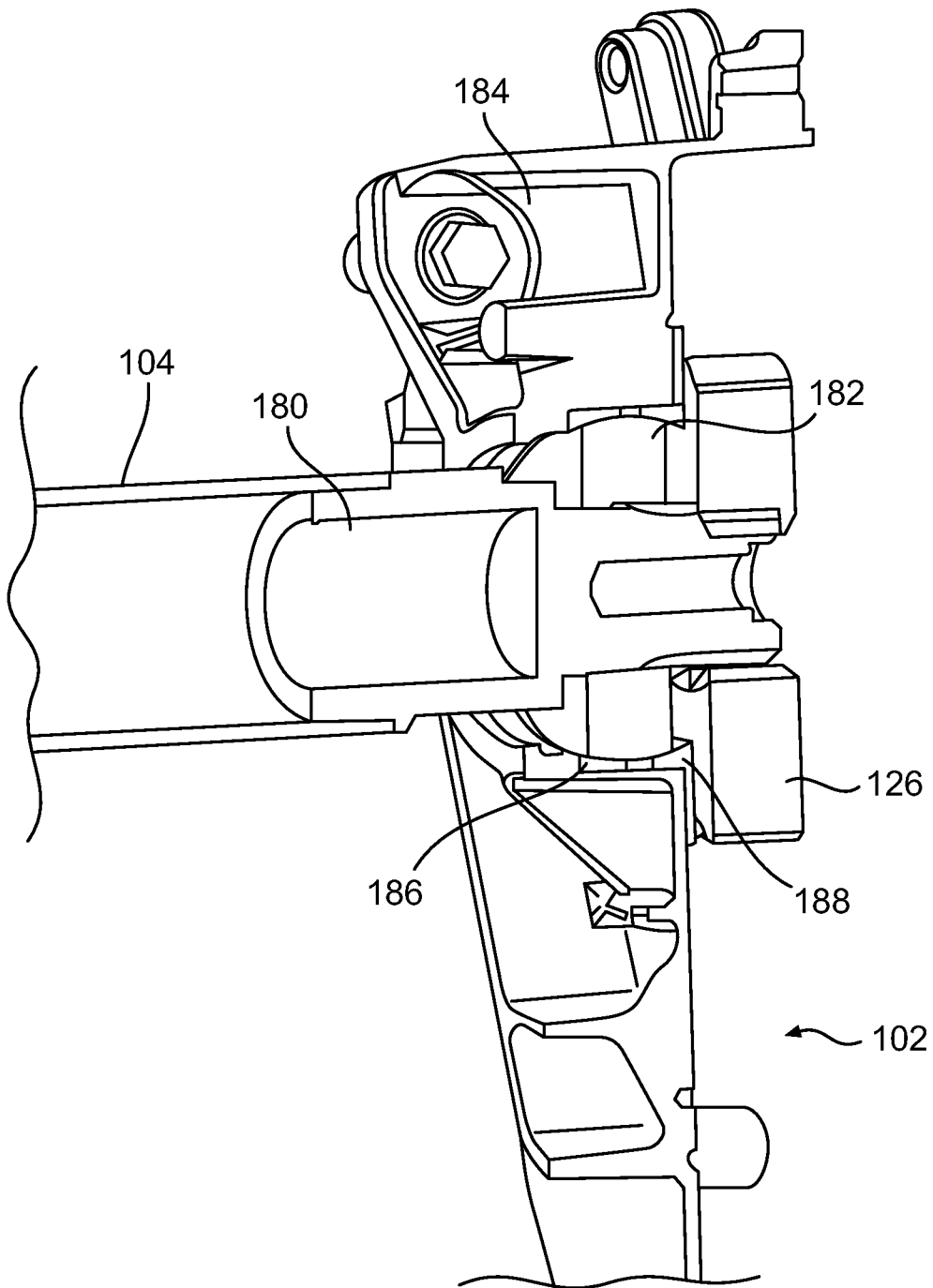
FIG. 8



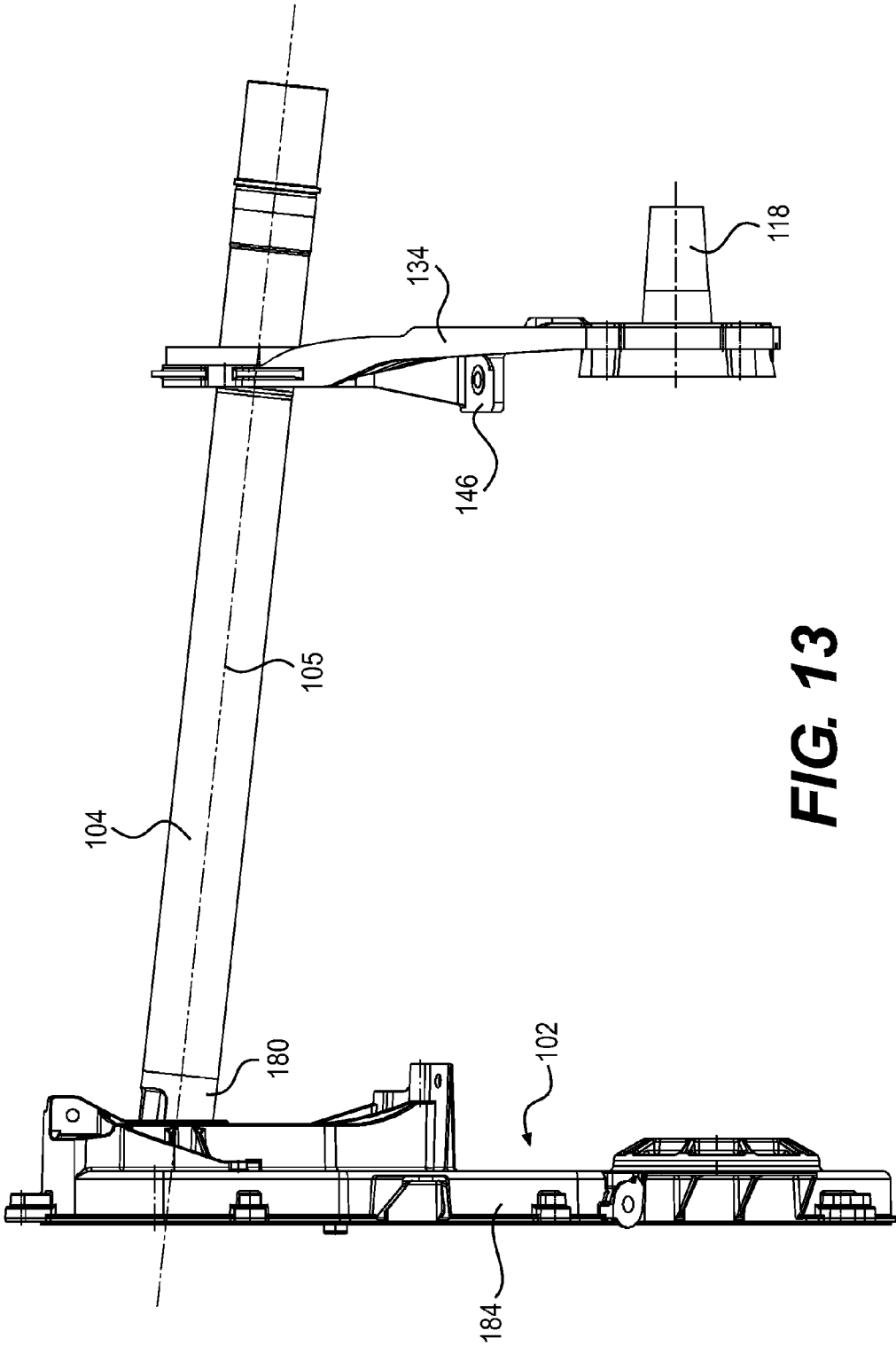




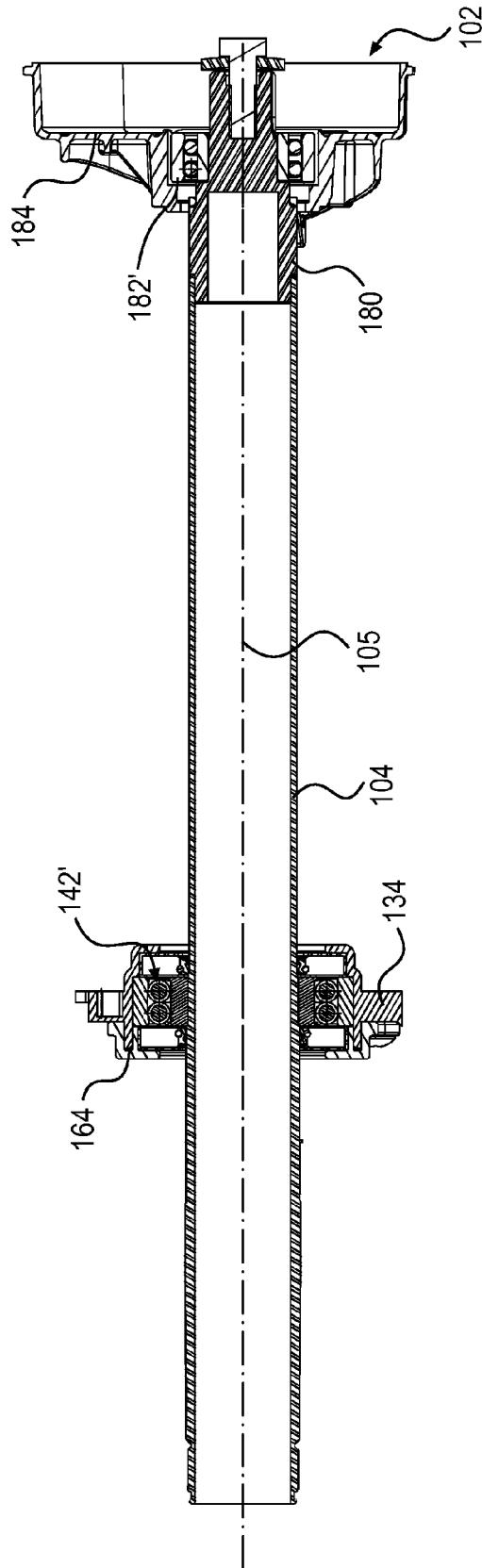
**FIG. 11**



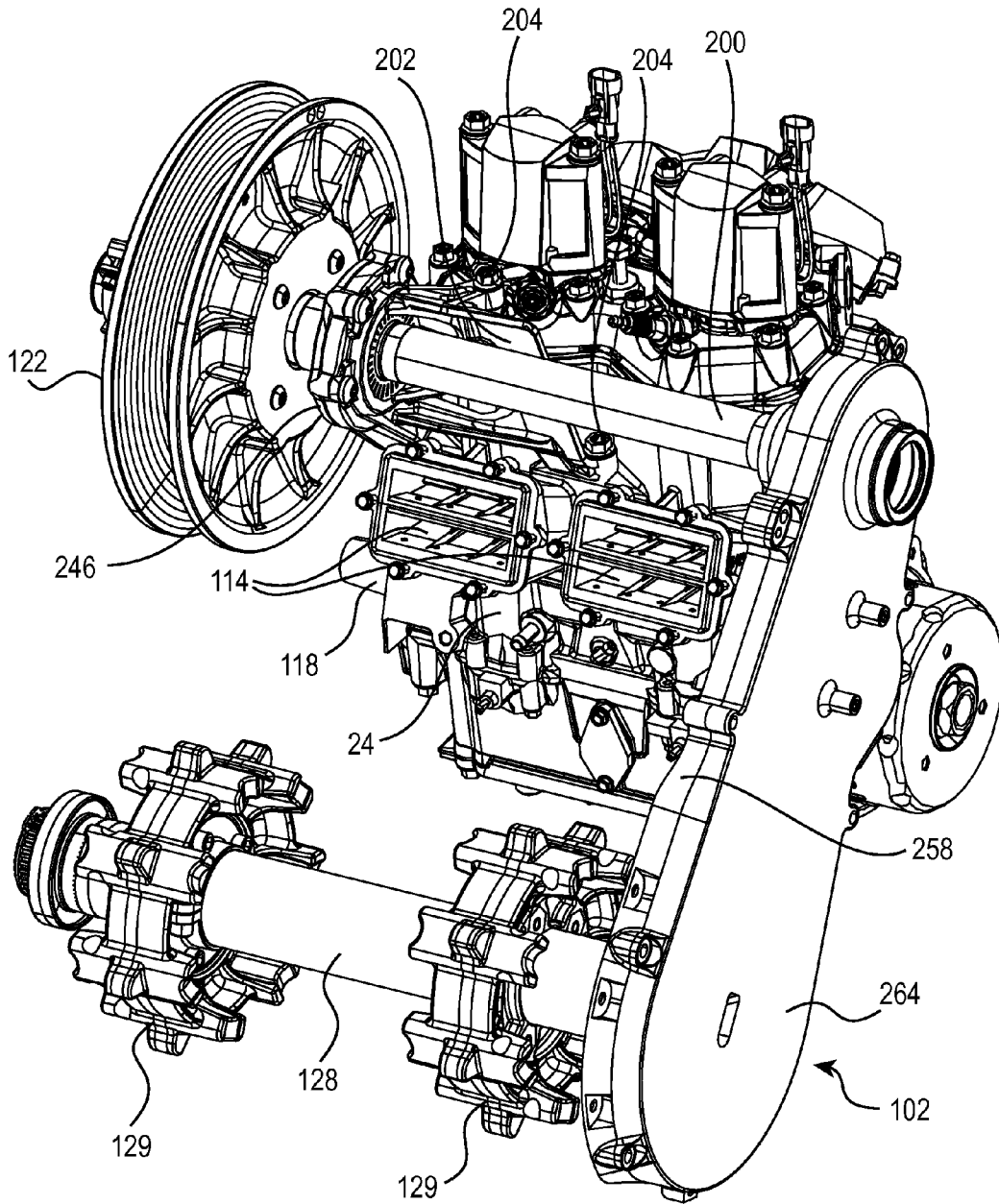
**FIG. 12**



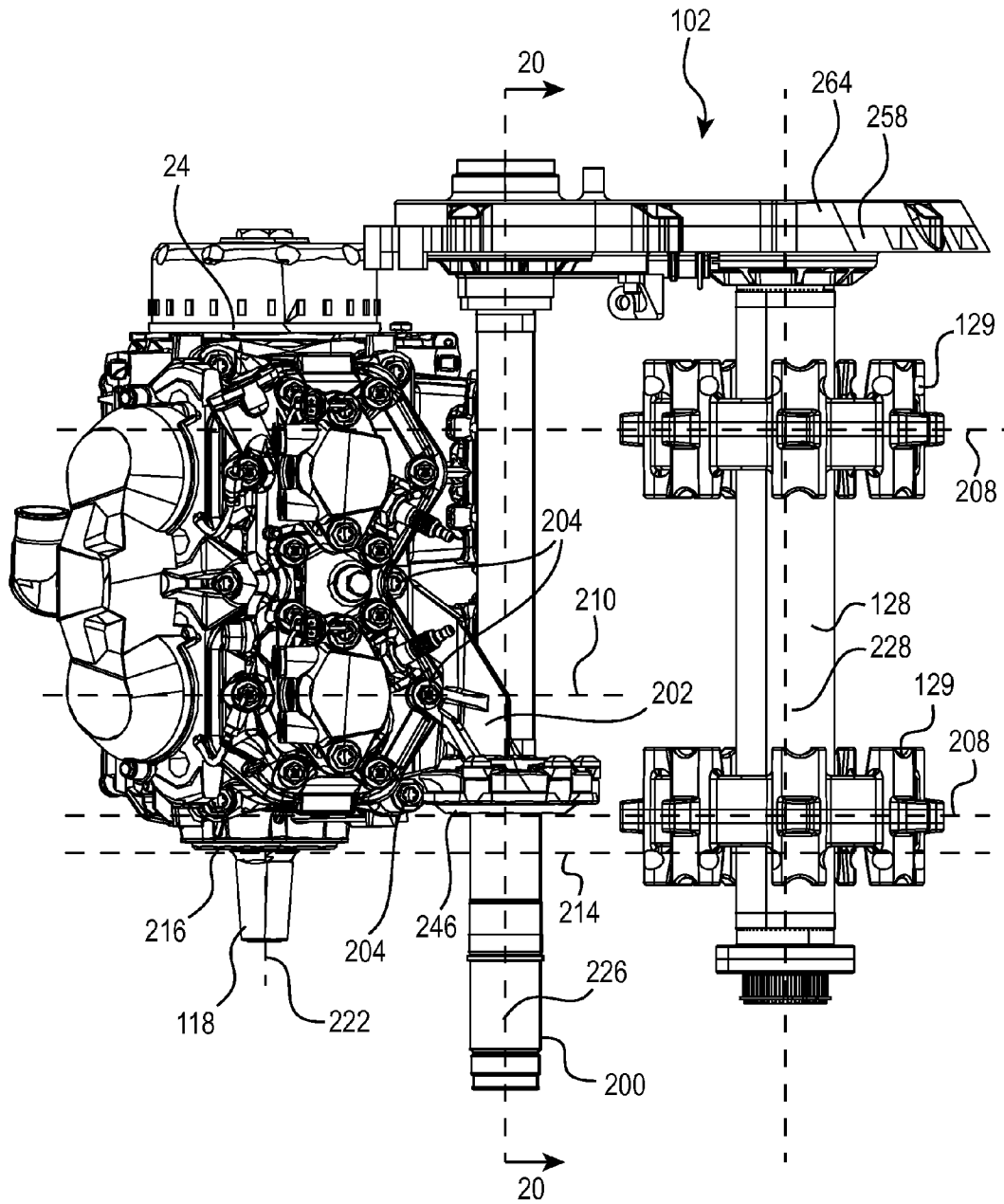
**FIG. 13**



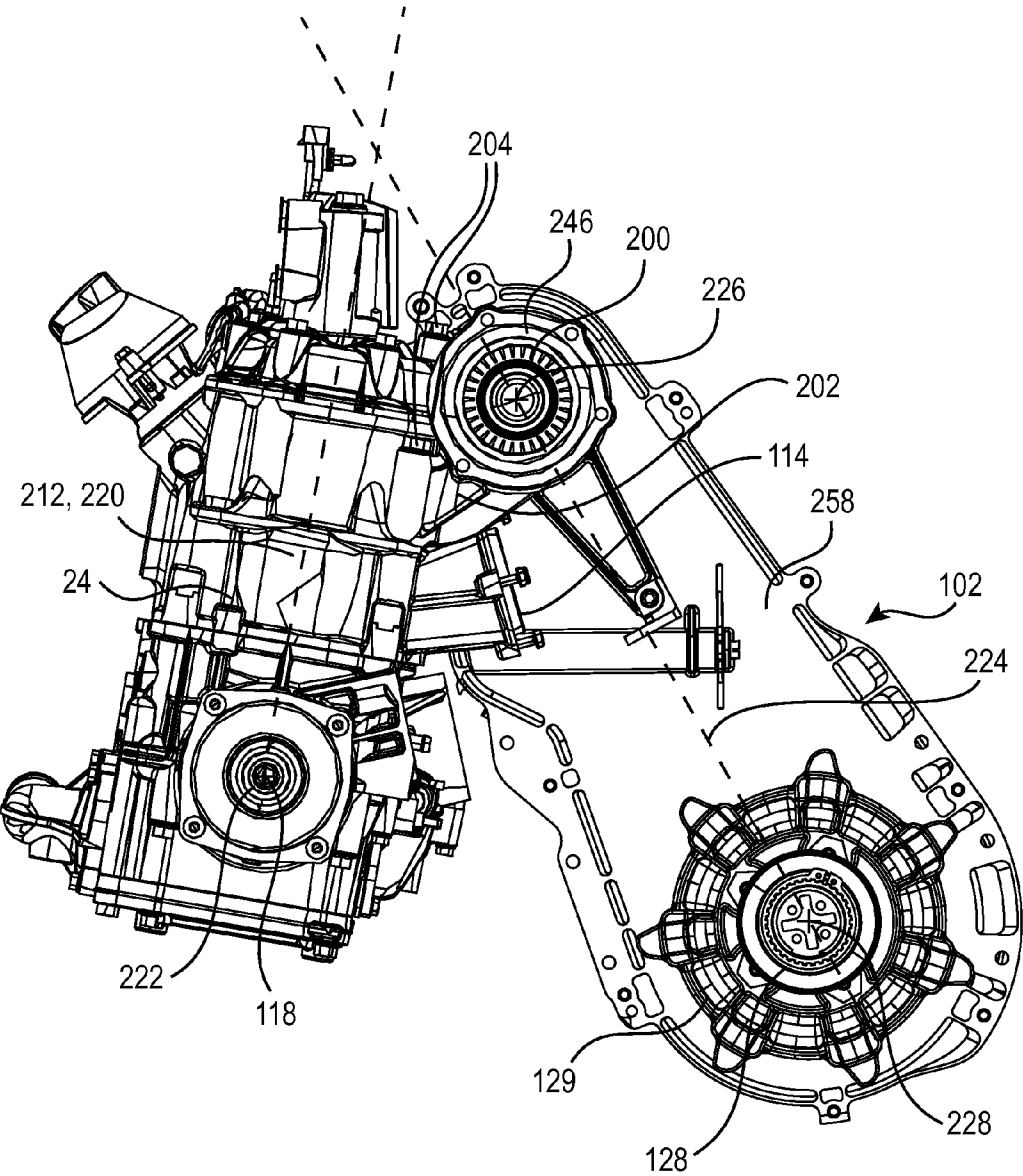
**FIG. 14**



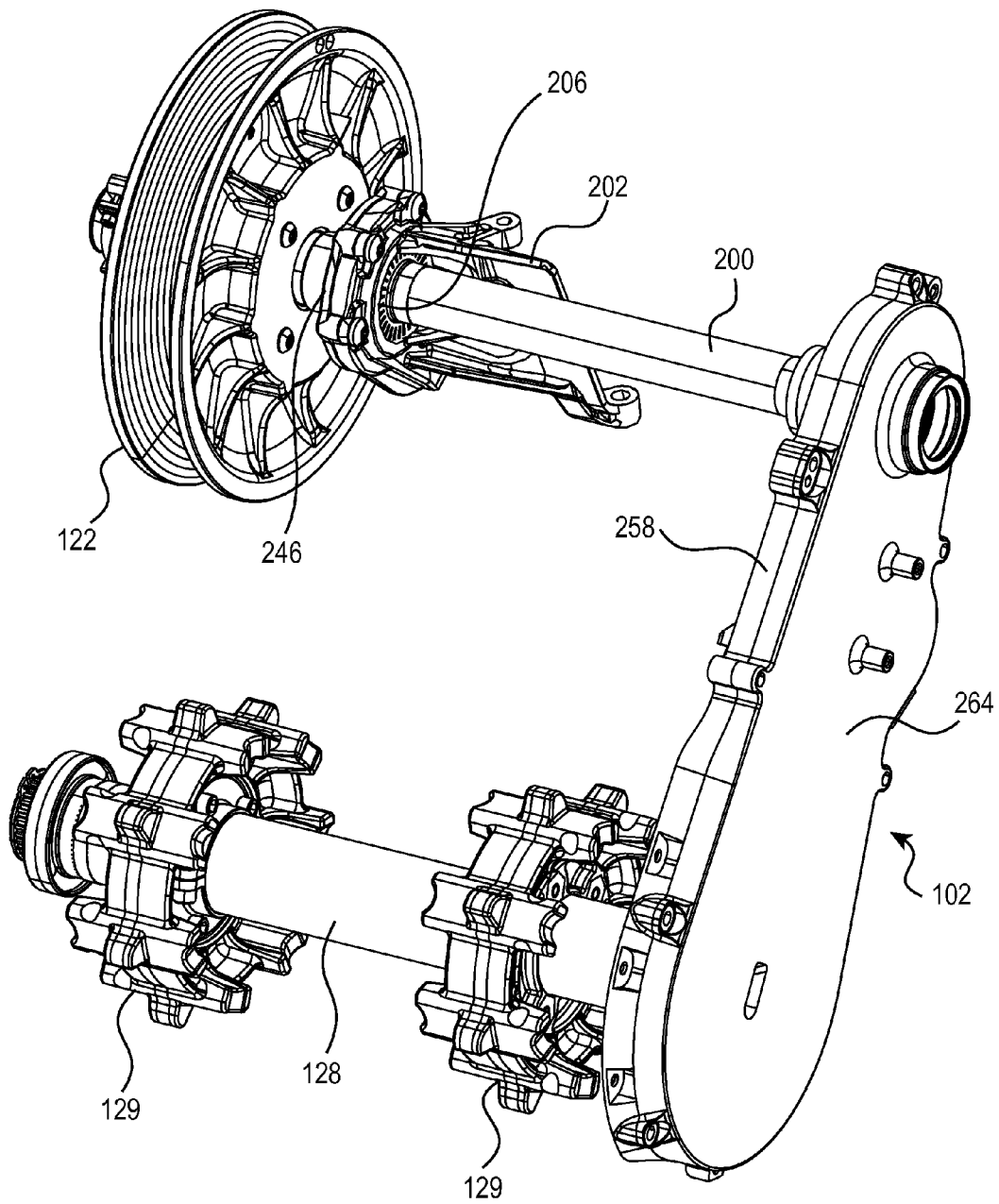
**FIG. 15**



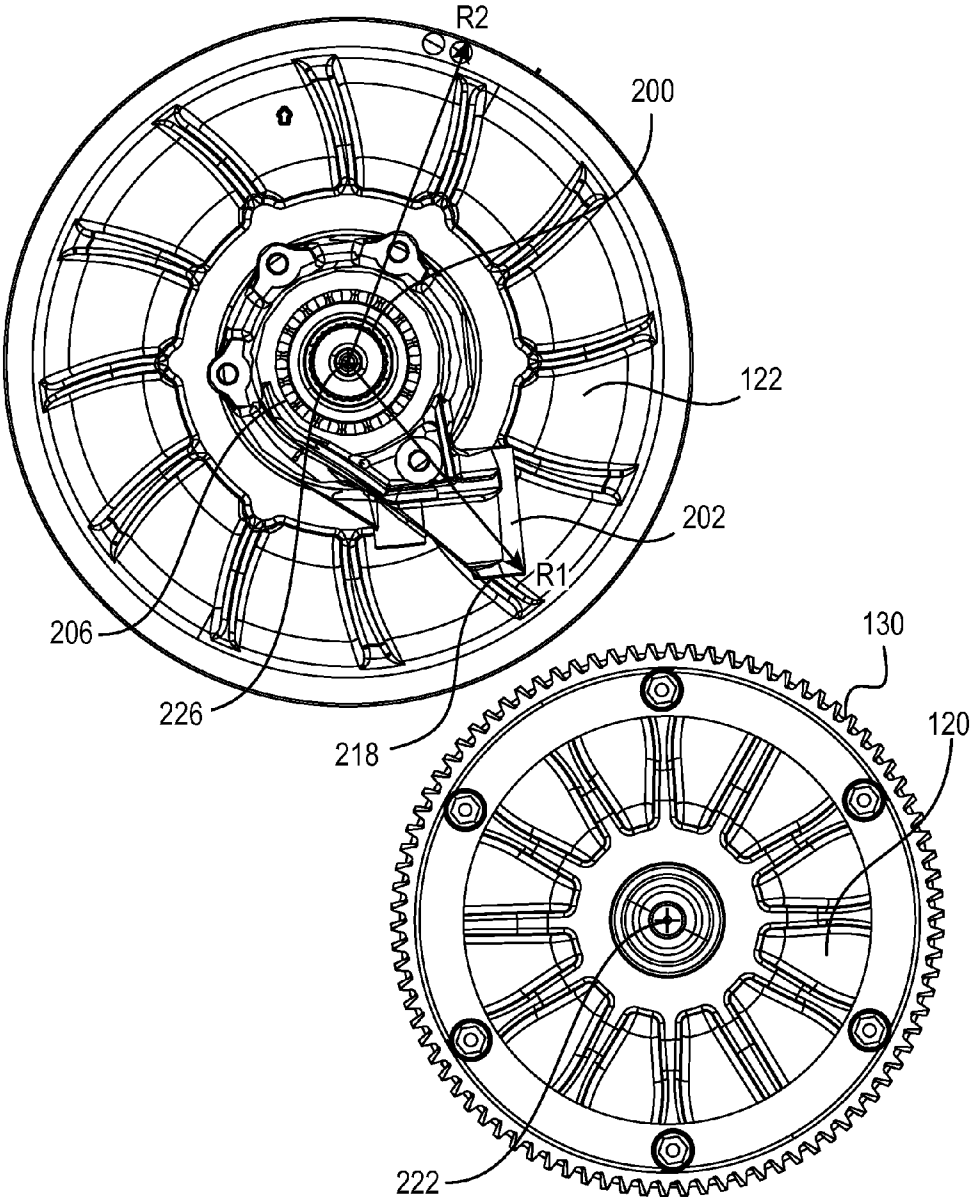
**FIG. 16**



**FIG. 17**



**FIG. 18**



**FIG. 19**

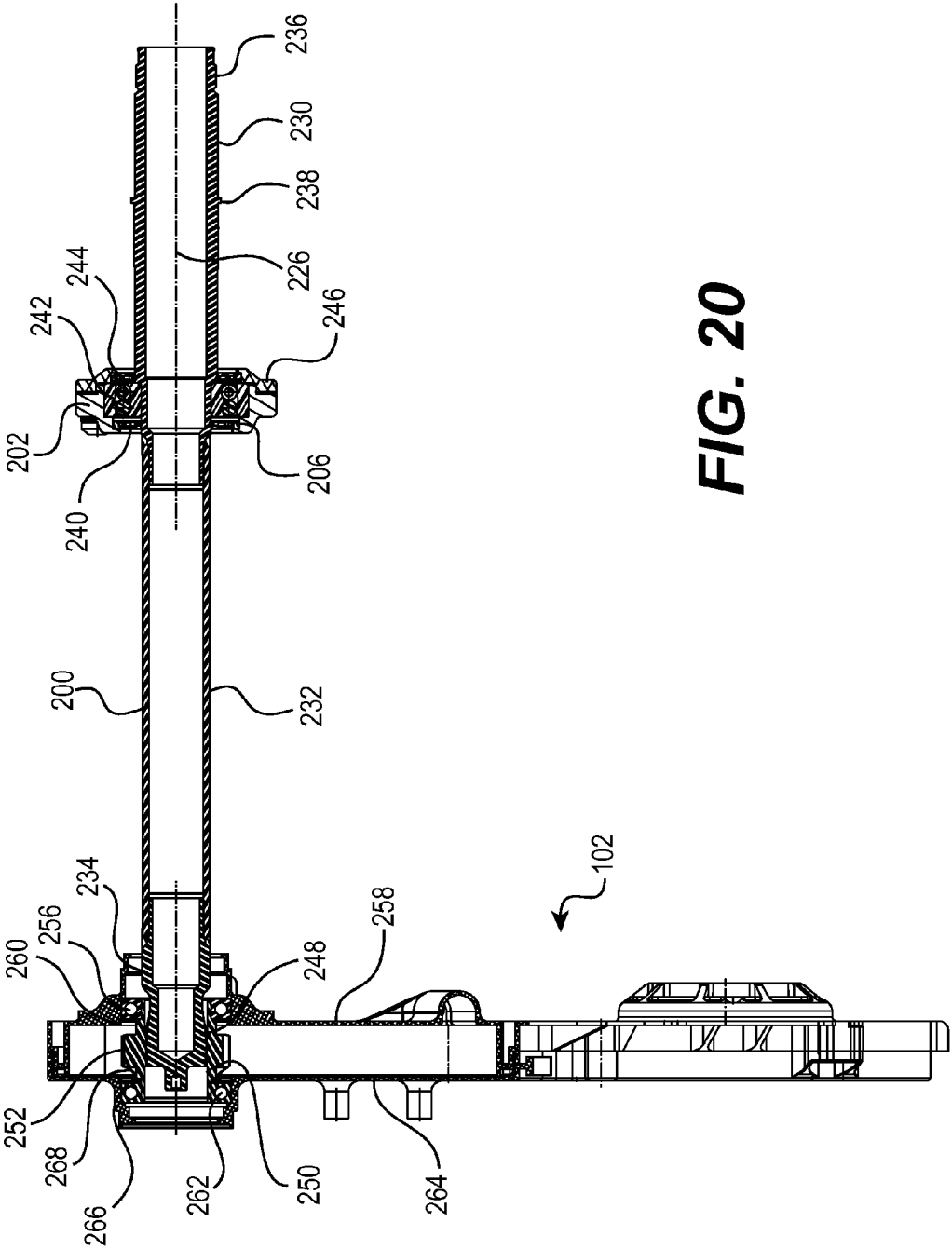
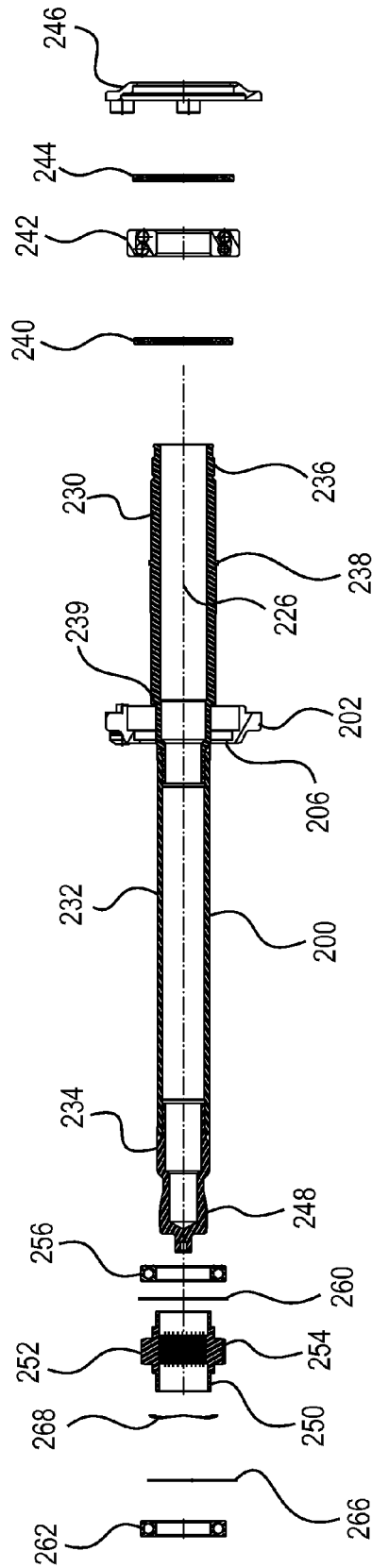


FIG. 20



**FIG. 21**

1

## CONTINUOUSLY VARIABLE TRANSMISSION MOUNTING ASSEMBLY

### CROSS-REFERENCE

The present application is a Continuation-In-Part of U.S. patent application Ser. No. 13/369,775, filed Feb. 9, 2012, which claims priority to U.S. Patent Application No. 61/441,057, filed Feb. 9, 2011, the entirety of both of which is incorporated herein by reference.

### FIELD OF THE INVENTION

The present invention relates to a continuously variable transmission mounting assembly and vehicles incorporating same.

### BACKGROUND

Snowmobiles are typically provided with a continuously variable transmission (CVT) to transmit power from the engine of the vehicle to the endless drive track, while changing the speed ratio between the engine and the endless drive track. Advantages of CVTs include smoother acceleration and improved fuel efficiency when compared to other types of transmissions.

Conventionally, snowmobiles have a pair of skis and an endless drive track for propelling the snowmobile, both of which are mounted to a frame of the snowmobile. The frame includes an engine compartment which conventionally has left and right sides, a bottom, a rear (bulkhead), and a front portion. The engine compartment supports power pack components such as an engine, an exhaust pipe, a muffler, a reduction gearing, and a CVT. The frame also includes a tunnel rearward of the engine compartment below which the endless drive track is disposed. The CVT has a driving pulley mounted to an output shaft of the engine, a driven pulley, and a belt looped around the two pulleys. The driven pulley is mounted to a countershaft and has a portion thereof which extends next to a side of the tunnel. The countershaft is operatively connected to the endless drive track so as to drive the endless drive track. U.S. Pat. No. 7,997,372, issued Aug. 16, 2011, the entirety of which is incorporated herein by reference, describes the above features of a snowmobile in more details.

The engine is usually mounted to the engine compartment through rubber mounts to reduce the transmission of vibrations from the engine to the frame. As a result, during operation, the engine moves relative to the frame. Therefore, the engine's output shaft, driving pulley and their common axis of rotation also move relative to the frame. The countershaft is rigidly supported near the engine compartment through bearings; as such its axis of rotation, which is also the axis of rotation of the driven pulley, does not move relative to the frame. As would be understood, this means that the axis of rotation of the driving pulley moves relative to the axis of rotation of the driven pulley. Therefore, the tension and alignment of the belt looped around the driving and driven pulleys changes due to these variations between the axes of rotation of the pulleys. This negatively affects the transfer of torque from the driving pulley to the driven pulley and may cause premature wear of the belt.

One possible solution to the above consists in mounting the engine to the engine compartment by using stiffer engine mounts. However, this results in more vibrations being transferred from the engine to the frame.

2

Therefore, there is a need for a snowmobile having a CVT mounting assembly which helps reduce the amount of vibration transferred to the frame.

There is also a need for a snowmobile having a CVT mounting assembly which reduces the variations in the distance between the driving and driven pulleys resulting from engine movement relative to the frame of the snowmobile.

### SUMMARY

It is an object of the present invention to ameliorate at least some of the inconveniences present in the prior art.

In one aspect, a snowmobile has a frame. The frame includes an engine compartment, and a tunnel rearward of the engine compartment. A front suspension is connected to the frame. At least one ski is connected to the front suspension. An engine is disposed in the engine compartment. A bracket has a first portion joined to the engine and a second portion having an aperture defined therein. An output shaft is driven by the engine. A countershaft passes through the aperture. A motion decoupler is disposed around the countershaft. The motion decoupler is supported by the second portion of the bracket. The countershaft is rotationally supported in the motion decoupler. A driving pulley is disposed on the output shaft and rotates therewith. A driven pulley is disposed on the countershaft and rotates therewith. A drive belt is looped around the driving and driven pulleys to transfer torque from the driving pulley to the driven pulley. The driving pulley, the driven pulley and the drive belt together form a continuously variable transmission. An endless drive track is disposed below the tunnel for propelling the snowmobile. The endless drive track is operatively connected to the countershaft.

In a further aspect, the driving and driven pulleys are disposed on a first side of the engine. A reduction gearing is operatively connected to the countershaft on a second side of the engine opposite the first side.

In an additional aspect, a drive axle is disposed in the tunnel. The drive axle is operatively connected to the reduction gearing for driving the endless drive track.

In a further aspect, the countershaft is disposed rearwardly of the output shaft.

In an additional aspect, the motion decoupler is a self-aligning ball bearing.

In a further aspect, a cap is fastened to the second portion of the bracket. The motion decoupler is disposed between the cap and the second portion of the bracket.

In an additional aspect, the first portion of the bracket is fastened to a rear of the engine.

In a further aspect, the first portion of the bracket is fastened to a cylinder block of the engine.

In an additional aspect, a radial distance from a center of the countershaft to an interface between the first portion of the bracket and the engine is less than a radius of a driven pulley.

In a further aspect, a projection of the bracket onto a longitudinally extending vertical plane is disposed inside of a circumference of a projection of the driven pulley onto the longitudinally extending vertical plane.

In an additional aspect, a projection of the bracket onto a longitudinally extending vertical plane is disposed outside of a circumference of a projection of the driving pulley onto the longitudinally extending vertical plane.

In a further aspect, a drive axle is disposed in the tunnel. The drive axle is operatively connected to the countershaft. Two sprocket wheels are carried by the drive axle for driving the endless drive track. The bracket is disposed laterally between a first longitudinally extending vertical plane passing through a center of one of the two sprocket wheels and a

second longitudinally extending vertical plane passing through a center of another one of the two sprocket wheels.

In an additional aspect, the engine has at least one cylinder having a cylinder axis. The output shaft extends through a surface of the engine. The first portion of the bracket is fastened to the engine at a position laterally between a first plane and a second plane. The first plane is a longitudinally extending vertical plane separating a portion of the output shaft disposed outside the engine from a portion of the output shaft disposed inside the engine. The second plane is a longitudinally extending vertical plane containing the cylinder axis of one of the at least one cylinder being nearest to the surface.

In a further aspect, a drive axle is disposed in the tunnel. The drive axle is operatively connected to the countershaft. The drive axle is rotatable about a drive axle axis. The engine has at least one cylinder having a cylinder axis. The countershaft is rotatable about a countershaft axis. The output shaft is rotatable about an output shaft axis. The first portion of the bracket is fastened to the engine at a position longitudinally between a first plane and a second plane. The first plane is a laterally extending plane containing output shaft axis and the cylinder axis of the at least one cylinder. The second plane is a laterally extending plane containing the countershaft axis and the drive axle axis.

In an additional aspect, the first portion of the bracket is fastened to the engine at a plurality of positions, each of the plurality of positions being longitudinally between the first plane and the second plane.

In a further aspect, a reduction gearing is operatively connected to the countershaft. The reduction gearing has an input member having internal splines. The countershaft has external crown splines engaging the internal splines of the input member and allowing for axial deviation of the axis of the countershaft relative to the input member.

In an additional aspect, the input member has a cylindrical sleeve and a sprocket connected to the cylindrical sleeve. The cylindrical sleeve has the internal splines.

In a further aspect, at least one bearing is disposed between the cylindrical sleeve and a housing of the reduction gearing.

In an additional aspect, a spring washer is disposed around the cylindrical sleeve between one of the at least one bearing and the sprocket.

In a further aspect, the countershaft has an axis of rotation. The motion decoupler allows for at least one of axial deviation and inclination of the axis of the countershaft relative to the bracket.

For purposes of this application, terms related to spatial orientation such as forwardly, rearwardly, upwardly, downwardly, left, and right, are as they would normally be understood by a driver of the vehicle sitting thereon in a normal riding position.

Embodiments of the present invention each have at least one of the above-mentioned object and/or aspects, but do not necessarily have all of them. It should be understood that some aspects of the present invention 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 embodiments of the present invention 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 invention, 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 right side elevation view of a snowmobile;

FIG. 2 is a left side elevation view of a forward portion of a frame and a power pack of the snowmobile of FIG. 1, with portions of the frame removed for clarity;

FIG. 3 is a right side elevation view of the forward portion of the frame and the power pack of FIG. 2;

FIG. 4 is a top plan view of the forward portion of the frame and the power pack of FIG. 2;

FIG. 5 is a rear elevation view of the frame and the power pack of the snowmobile of FIG. 1, with portions of the frame removed for clarity;

FIG. 6 is a front elevation view of the frame and the power pack of FIG. 5;

FIG. 7 is a left side elevation view of the forward portion of the frame and the power pack of FIG. 2, with the CVT removed for clarity;

FIG. 8 is a perspective view taken from a rear left side of the forward portion of the frame and the power pack of FIG. 7, with the engine removed for clarity;

FIG. 9 is a perspective view taken from a rear left side of the engine, countershaft and reduction gearing of the snowmobile of FIG. 1;

FIG. 10 is a partial cross-section of the engine, countershaft and reduction gearing of FIG. 9 taken through a vertical plane passing through a center of the countershaft;

FIG. 11 is a close-up view of portion A-A of FIG. 10;

FIG. 12 is a close-up view of portion B-B of FIG. 10;

FIG. 13 is a front elevation view of the countershaft, the reduction gearing and a bracket of the snowmobile of FIG. 1 shown with the countershaft inclined as a result of movement of the engine;

FIG. 14 is a cross-section of an alternative embodiment of the countershaft, the reduction gearing and the bracket of the snowmobile of FIG. 1 taken through a horizontal plane passing through the center of the countershaft;

FIG. 15 is a perspective view taken from a rear, right side of an alternative embodiment of a power pack of the snowmobile of FIG. 1 with the driving pulley removed;

FIG. 16 is a top plan view of the power pack of FIG. 15 with the driving pulley removed;

FIG. 17 is left side elevation view of the power pack of FIG. 15 with the driving pulley removed;

FIG. 18 is a perspective view taken from a rear, right side of the power pack of FIG. 15 with the driving pulley and the engine removed;

FIG. 19 is a right side elevation view of a driving pulley, a driven pulley, a countershaft and a bracket supporting the countershaft of the power pack of FIG. 15;

FIG. 20 is a cross-sectional view of the countershaft, the bracket supporting the countershaft and of a reduction gearing of the power pack of FIG. 15 taken through line 20-20 of FIG. 16; and

FIG. 21 is a partially exploded, cross-sectional view of the countershaft and associated component of the power pack of FIG. 15.

### DETAILED DESCRIPTION

Aspects of the present continuously variable transmission mounting assembly will be described with respect to a snowmobile 10. However it is contemplated that aspects of the present continuously variable transmission mounting assembly could also be applied to other types of vehicles provided with CVTs.

As seen in FIG. 1, the snowmobile 10 includes a forward end 12 and a rearward end 14 that are defined consistently with a travel direction of the snowmobile 10. The snowmobile 10 includes a frame 16 that includes a tunnel 18 and an engine compartment 20 as described in greater detail below. A front suspension 22 is connected to the frame. The tunnel 18 generally consists of one or more pieces of sheet metal bent to form an inverted U-shape. The tunnel 18 extends rearwardly along the longitudinal centerline 61 of the snowmobile 10 and is connected at the front to the engine compartment 20. An engine 24, which is schematically illustrated in FIG. 1, is carried by the engine compartment 20 of the frame 16. A steering assembly (not indicated) is provided, in which two skis 26 are positioned at the forward end 12 of the snowmobile 10 and are attached to the front suspension 22 through a pair of front suspension assemblies 28. Each front suspension assembly 28 includes a ski leg 30, a pair of A-arms 32 and a shock absorber 29 for operatively connecting the respective skis 26 to a steering column 34. Other types of front suspension assemblies 28 are contemplated, such as a swing-arm or a telescopic suspension. A steering device in the form of handlebar 36, positioned forward of a rider, is attached to the upper end of the steering column 34 to allow the rider to rotate the ski legs 30 and thus the skis 26, in order to steer the snowmobile 10. U.S. Pat. No. 8,037,961, issued Oct. 18, 2011, the entirety of which is incorporated by reference, provides additional details regarding a steering assembly and front suspension assemblies suitable for the snowmobile 10.

An endless drive track 65 is positioned at the rear end 14 of the snowmobile 10. The endless drive track 65 is disposed generally under the tunnel 18, and is operatively connected to the engine 24 as will be described in greater detail below. The endless drive track 65 is driven to run about a rear suspension assembly 42 for propelling the snowmobile 10. The rear suspension assembly 42 includes a pair of slide rails 44 in sliding contact with the endless drive track 65. The rear suspension assembly 42 also includes one or more shock absorbers 46 which may further include a coil spring (not shown) surrounding the individual shock absorbers 46. Suspension arms 48 and 50 are provided to attach the slide rails 44 to the frame 16. One or more idler wheels 52 are also provided in the rear suspension assembly 42.

At the front end 12 of the snowmobile 10, fairings 54 enclose the engine 24, thereby providing an external shell that not only protects the engine 24, but also make the snowmobile 10 more aesthetically pleasing. The fairings 54 include a hood (not indicated) and one or more side panels that can be opened to allow access to the engine 24 when this is required, for example, for inspection or maintenance of the engine 24. In the particular snowmobile 10 shown in FIG. 1, the side panels can be opened along a vertical axis to swing away from the snowmobile 10. A windshield 56 is connected to the fairings 54 near the front end 12 of the snowmobile 10 or alternatively directly to the handlebar 36. The windshield 56 acts as a wind screen to lessen the force of the air on the rider while the snowmobile 10 is moving.

A straddle-type seat 58 is positioned atop the frame 16. A rear portion of the seat 58 may include a storage compartment or can be used to accommodate a passenger seat (not indicated). Two footrests 60 are positioned on opposite sides of the snowmobile 10 below the seat 58 to accommodate the driver's feet.

The configuration of engine compartment 20 will now be described with respect to FIGS. 2 to 8. The engine compartment 20 includes a right side wall 62, a left side wall 64, and an engine compartment bottom 66. The side walls 62, 64 are generally vertical and generally parallel to the longitudinal

centerline 61. The engine compartment bottom 66 is generally horizontal and extends transversely between and beyond the side walls 62, 66. A bulkhead 68 (FIG. 4) has one side connected to a rear portion of the right side wall 62, the other side connected to a rear portion of the left side wall 64, and a bottom connected to a rear portion of the engine compartment bottom 66. The right and left side walls 62, 64, the engine compartment bottom 66, and the bulkhead 68 are made from bent sheet metal or by casting, and are connected to each other by fasteners such as rivets or bolts. As seen in FIGS. 4 and 6, the engine 24 is disposed transversely between the right and left side walls 62, 64 and forwardly of the bulkhead 68.

The upper portion of the engine compartment 20 has a number of frame members that form together a pyramidal-like structure that enhances the torsional and structural rigidity of the frame 16. Of these, only a rear cross-member 70 (see FIG. 5) and a pair of columns 72 are shown for clarity. The frame members are made of aluminum tubing, but other structures and materials are also contemplated.

The engine compartment 20 has other elements and features not described herein for simplicity and clarity, such as, but not limited to, a front sub-frame member connected to the side walls 62, 64 forwardly thereof which is used to connect the front suspension assemblies 28.

The tunnel 18 of the frame 16 is made of three parts. The tunnel 18 has a central tunnel portion 74, a right side tunnel portion 76, and a left side tunnel portion 78.

The central tunnel portion 74 is disposed generally horizontally and has an integrated heat exchanger (not shown) that is used to cool the engine coolant. It is contemplated that the heat exchanger could be fastened to a bottom of the central tunnel portion 74 or could be disposed elsewhere on the frame 16. The front portion of the central tunnel portion 74 is connected to a rear portion of the bulkhead 68 via fasteners. It is contemplated that the front portion of the central tunnel portion 74 could alternatively be connected to a rear portion of the bulkhead 68 by welding. The right and left side tunnel portions 76, 78 are disposed generally vertically and each have a footrest 60 extending outwardly from a bottom portion thereof. The right side tunnel portion 76 and the left side tunnel portion 78 are connected to the central tunnel portion 74 via flanges extending inwardly from a top of the side tunnel portions 76, 78.

A power pack for powering the endless drive track 65 will now be described with reference to FIGS. 2 to 10. The power pack includes, but is not limited to, the engine 24, a variable ratio belt transmission system, also known as a continuously variable transmission or CVT 100, a reduction gearing 102, and a countershaft 104.

The engine 24 is a two cylinder, two-cycle internal combustion engine. It is contemplated that the engine 24 could be of any other type, such as a four-cycle internal combustion engine. The engine 24 is disposed in the engine compartment 20 and rests on vibration dampers 106, 108, 110, 112 (best seen in FIG. 4) to reduce the transmission of vibrations from the engine 24 to the frame 16. The vibration dampers 106, 108, 110 and 112 are rubber mounts. As best seen in FIG. 9, the engine 24 has a plurality of air intakes 114 (one per cylinder) on a rear side thereof. An air intake manifold (not shown) is connected to the rear side of the engine 24 so as to fluidly communicate with the air intakes 114. Two air intake controllers (not shown) fluidly communicate with the air intake manifold. It is contemplated that only one air intake controller could be used. The air intake controllers each comprise a valve (not shown) that controls the flow of air to the engine 24. It is contemplated that the air control devices could be in the form of a carburetor or a throttle body. A plurality of

exhaust ports 116 (one per cylinder, see FIG. 6) is disposed on a front side of the engine 24. An exhaust system (not shown) fluidly communicates with the engine 24 to exhaust the gases from the combustion process. The engine 24 comprises a crankshaft (not shown) that drives an output shaft 118 (see FIG. 9). The crankshaft and output shaft 118 are coaxial and rotate about a common horizontally disposed axis that extends generally transversely to the longitudinal centerline 61 of the snowmobile 10. It is contemplated that the crankshaft and output shaft 118 could be offset from one another and could also rotate at different speeds relative to one another. It is also contemplated that the crankshaft and the output shaft 118 could be integrally formed as a single shaft. As would be known by those skilled in the art, the engine 24 includes other systems, such as the fuel and electrical systems, but these have not been illustrated or described herein for simplicity.

As can be seen in FIGS. 2 and 6, the CVT 100 is disposed on a left side of the engine 24 and includes a driving pulley 120 coupled to rotate with the output shaft 118 of the engine 24 and a driven pulley 122 coupled to the left end of the transversely mounted countershaft 104. The manner in which the countershaft 104 is supported in the engine compartment 20 will be described in greater detail below. As can be seen, the countershaft 104 traverses the width of the engine compartment 20. The countershaft 104 is disposed rearwardly of the engine 24, vertically higher than the air intakes 114. The countershaft 104 is also disposed vertically higher than the tunnel 18. In this position of the countershaft 104, the driven pulley 122 is in proximity to the driving pulley 120, which ensures a good torque transfer from the driving pulley 120 to the driven pulley 122.

The driving pulley 120 of the CVT 100 is coupled to rotate with the output shaft 118 of the engine 24 and includes a pair of opposed frustoconical belt drive sheaves (one fixed sheave and one moving sheave) between which the drive belt 124 is located. The sheaves are biased apart, and the driving pulley 120 incorporates a centrifugally operated mechanism that acts to urge the moving sheave towards the fixed sheave with a force that increases with increasing output shaft speed so that as the engine speed increases, the reduction ratio of the CVT 100 decreases. The driven pulley 122 is coupled to rotate with the countershaft 104 and includes a pair of frustoconical belt drive sheaves between which the drive belt 124 is located. The driven pulley 122 reacts to the torque from the endless drive track 65 by separation of its sheaves which allows the drive belt 124 to engage the driven pulley 122 at a diameter that is progressively reduced as the torque increases or that is progressively increased as the torque decreases. When the driving pulley 120 increases its diameter, the driven pulley 122 decreases its effective diameter and vice versa, thus keeping the drive belt 124 in tension. The drive belt 124 is made of rubber, but it is contemplated that it could be made of metal.

A reduction gearing 102 is disposed on a right side of the engine 24. The right end of the countershaft 104 is connected to an input member of the reduction gearing 102. The input member of the reduction gearing 102 consists of a small sprocket 126 (see FIG. 10) connected to the countershaft 104 as will be described in greater detail below. An output member of the reduction gearing 102 is connected to a front drive axle 128 (FIG. 2). The output member consists of sprocket (not shown) that is larger than the sprocket of the input member and is connected to the drive axle 128. The output member is driven via a chain (not shown) by the input member. It is also contemplated that the output member could be driven via gears by the input member. The input member, the output member, and the chain are enclosed within the housing of the

reduction gearing 102. The front drive axle 128 is disposed in the tunnel 18 and carries sprocket wheels 129 (shown in the embodiment of FIG. 15) that form a driving connection with the endless drive track 65. The output shaft 118, the countershaft 104, and the front drive axle 128 are arranged such that the countershaft 104 is disposed rearwardly of the output shaft 118 and forwardly of the front drive axle 128.

It is contemplated that the reduction gear 102 could be disposed on the left side of the engine 24 and that the CVT 100 could be disposed on the right side of the engine 24.

The driving pulley 120 rotates at the same speed as the output shaft 118 of the engine 24. The speed of rotation of the countershaft 104 is determined in accordance with the instantaneous ratio of the CVT 100. The drive axle 128 rotates at a lower speed than the countershaft 104 since the reduction gearing 102 has a reduction ratio.

As best seen in FIG. 4, the fixed sheave of the driving pulley 120 has a ring gear 130 connected thereto. The ring gear 130 engages a gear 132 disposed forwardly thereof. The gear 132 is selectively driven by a starter motor (not shown). To start the engine 24, the starter motor turns the gear 132, which in turn turns the ring gear 130. The ring gear 130 then drives the output shaft 118 and crankshaft which cause the initial movement of the pistons of the engine 24 necessary to start the engine 24.

Turning now to FIGS. 7 to 12, the CVT mounting assembly will be described in more detail. As can be seen in FIG. 7, a bracket 134 is joined to the engine 24. More specifically, a lower portion of the bracket 134 is rigidly fastened by five fasteners 136 to the crankcase of the engine 24 on a left side of the engine 24. It is contemplated that the lower portion of the bracket 134 could be joined to another portion of the engine 24. It is also contemplated that the bracket 134 could be integrally formed with the casing of the engine 24 or some other portion of the engine 24. As can be seen, the lower portion of the bracket 134 defines an aperture 138 through which the output shaft 118 extends. The driving pulley 120 is mounted on the output shaft 118 such that the bracket 134 is disposed between the driving pulley 120 and the engine 24. It is contemplated that no aperture 138 could be defined in the bracket 134, in which case the output shaft 118 would not extend through the bracket 134 and the bracket 134 would be joined to the engine 24 at a position that would not interfere with the output shaft 118.

From its lower portion, the bracket 134 extends upwardly and rearwardly to its upper portion. The upper portion of the bracket 134 defines an aperture 140 (FIG. 11) through which the countershaft 104 extends. The driven pulley 122 is mounted on the portion of the countershaft 104 which extends to the left of the bracket 134. As will be described in greater detail below and as best seen in FIG. 11, a bearing 142 is disposed around the countershaft and a motion decoupler, in the form of bearing damper 144, is disposed around the bearing 142 to rotationally support the countershaft in the aperture 140.

As best seen in FIG. 7, the vibration damper 110 used to connect the engine 24 to the frame 16 is mounted between the upper portion of the bracket 134 and a top of the tunnel 18, rearwardly of the countershaft 104 and forwardly of the front drive axle 128. More specifically, the vibration damper 110 is fastened at one end thereof to a leg 146 extending from the bracket 134 and at the other end to an L-shaped bracket 148. The bracket 148 is fastened to the left side tunnel portion 78 and is supported by the bulkhead 68. The vibration damper 110 is generally shaped like a conical frustum. Note that the other vibration dampers 106, 108 and 112 are similarly shaped. The vibration damper 110 is positioned between the

bracket **134** and the tunnel **18** such that a central axis **150** of the vibration damper **110** passes near the axis of rotation **105** of countershaft **104** and in front of the front drive axle **128**. However, it is contemplated that the central axis **150** of the vibration damper **110** could pass through the countershaft **104** further away from the axis **105** thereof.

Turning now to FIG. **11**, the connection of the countershaft **104** to the bracket **134** will be described in more detail. As can be seen, the countershaft **104** is hollow and has steps **152**, **154** defined on an outer surface thereof. A ring **156** is mounted over step **152** and abuts the side of the step **154**. The bearing **142**, which in the present embodiment is a ball bearing, is press-fitted on the step **152** and the inner race **158** of the bearing **142** abuts the side of the ring **156**.

The motion decoupler (bearing damper **144**) is mounted radially between the bearing **142** and the side of the aperture **140** to compensate for axial deviation and inclination of the axis **105** of the countershaft **104** resulting from movement of the engine **24**, and therefore the bracket **134**, relative to the reduction gearing **102** to which the other end of the countershaft **104** is connected. An example of such a deviation is shown in FIG. **13**. The bearing damper **144** is press-fitted on the outer race **160** of the bearing **142**, such that the bearing **142** is disposed radially between the countershaft **104** and the bearing damper **144**. The outer surface of the bearing damper is slide-fitted in contact with the sides of the aperture **140**. The bearing damper **144** is held axially between a flange **162** formed by the bracket **134** and a cap **164**. The cap **164** is disposed around the aperture **140** and is fastened to the bracket **134**. The cap **164** has an L-shaped cross-section. The lateral leg **166** of the cap **164** is disposed around a circular flange **168** of the bracket **134** which is disposed around the aperture **140**. The vertical leg **170** of the cap **164** extends over the aperture to retain the bearing damper **144** axially.

The bearing damper **144** consists of two metal rings **172**, **174** and a rubber ring **176**. The inner metal ring **172** is press-fitted on the outer race **160** of the bearing **142**. The rubber ring **176** is disposed around the inner metal ring **172**. The outer metal ring **174** is disposed around the rubber ring **176**, radially between the rubber ring **176** and the side of the aperture **140**. The outer metal ring **174** is the part of the bearing damper **144** that is disposed axially between the flange **162** and the leg **170** of the cap **164**. In the present embodiment, the rubber ring **176** has a thickness of approximately 2 mm (approximately 0.07874 inch). However, it should be understood that the thickness of the rubber ring **176** to be selected depends on the amount of axial deviation and inclination of the axis **105** of the countershaft **104** that is expected and permissible without surpassing the capabilities of the bearing **142**, the forces resulting from this movement, and the viscoelastic and other material properties of the type of rubber being used.

It is contemplated that the motion decoupler could be a device other than the bearing damper **144**. In the embodiment shown in FIG. **14**, the bearing **142** and the bearing damper **144** have been replaced by a self-aligning ball bearing **142'** which integrates the functions of a bearing and of a motion decoupler. One example of a self-aligning ball bearing **142'** is the NSK **1208** self-aligning ball bearing. It is also contemplated that the bearing damper **144** could have a different structure than the one describe above. It is also contemplated that the motion decoupler could be mounted around the countershaft **104** with the bearing **142** disposed radially between the motion decoupler and the side of the aperture **140**. It is also contemplated that two motion decouplers could be provided: one radially between the bearing **142** and the countershaft **104** and one radially between the bearing **142** and the side of the aperture **140**.

Turning back to FIG. **4**, it can be seen that from the bracket **134**, the countershaft **104** passes through an aperture **178** in the frame **16** as it extends towards the right of the snowmobile **10**. It should be noted that the aperture **178** is sufficiently large that the countershaft **104** does not come in contact with the side of the aperture **178**. As best seen in FIGS. **10** and **12**, the right end of the countershaft **104** receives a sprocket shaft **180**. One end of the sprocket shaft **180** is inserted in the countershaft **104** and the sprocket shaft **180** is press-fitted in the countershaft **104** and is welded to the countershaft **104**. The other end of the sprocket shaft **180** is splined and extends inside the reduction gearing **102**. The sprocket **126** has internal splines and is mounted on the splined end of the sprocket shaft **180**. A spherical bearing **182** rotationally connects the sprocket shaft **180**, and therefore the countershaft **104**, to the housing **184** of the reduction gearing **102**. The spherical bearing **182** allows for inclination of the axis **105** of the countershaft **104**, and example of which is shown in FIG. **13**. As can be seen, the spherical bearing **182** is disposed on the sprocket shaft **180** axially between the sprocket **126** and the end of the countershaft **104**. The spherical bearing **182** is held on the housing **184** by two caps **186**, **188**. It is contemplated that the spherical bearing **182** could be replaced by a ball bearing and a bearing damper like the bearing **142** and the bearing damper **144** previously described to allow for axial deviation and/or inclination of the axis **105** of the countershaft **104**. In the embodiment shown in FIG. **14**, the spherical bearing **182** has been replaced by a self-aligning ball bearing **182'**.

Turning now to FIGS. **15** to **21**, an alternative embodiment of a power pack of the snowmobile **10** will be described. Elements of this power pack that are similar to those of the power pack described above have been labeled with the same reference number.

In this power pack, the driven pulley **122** is coupled to a left end of a transversely mounted countershaft **200**. The countershaft **200** traverses the width of the engine compartment **20**. The countershaft **200** is disposed rearwardly of the engine **24**, vertically higher than the air intakes **114**. The countershaft **200** is also disposed vertically higher than the tunnel **18**. In this position of the countershaft **200**, the driven pulley **122** is in proximity to the driving pulley **120**, which ensures a good torque transfer from the driving pulley **120** to the driven pulley **122**. The right end of the countershaft **200** is connected to an input member of the reduction gearing **102** as will be described in greater detail below.

A bracket **202** is fastened to a rear of the engine **24** by three fasteners **204** (FIG. **16**). More specifically, the middle fastener **204** fastens the lower portion of the bracket **202** to the cylinder head of the engine **24** and the other two fasteners **204** fasten the lower portion **204** to the cylinder block of the engine **24**. It is contemplated that more or less fasteners **204** could be used and that the fasteners **204** could be fastened to the engine **24** at positions other than those illustrated. From its lower portion, the bracket **202** extends upwardly and rearwardly to its upper portion. The upper portion of the bracket **202** defines an aperture **206** (FIG. **19**) through which the countershaft **200** extends. The driven pulley **122** is mounted on the portion of the countershaft **200** which extends to the left of the bracket **202**.

As best seen in FIG. **16**, the bracket **202** is disposed laterally between the two longitudinally extending vertical **208** planes passing through the centers of the sprocket wheels **129**. As can also be seen in FIG. **16**; the bracket **202** is disposed more toward a left of the engine **24**. The upper portion of the bracket **202** is disposed laterally between a longitudinally extending vertical plane **210** containing the cylinder axis **212** (FIG. **17**) and another longitudinally

11

extending vertical plane **214** separating the portion of the output shaft **118** disposed outside the engine **24** from the portion of the output shaft **118** disposed inside the engine **24**. In other words, the plane **214** is the longitudinally extending vertical plane that contains the surface **216** of the engine **24** through which the output shaft **24** extends. The left fastener **204** fastening the bracket **202** to the engine **24** is also disposed laterally between the planes **210** and **214**, the right fastener **204** is disposed laterally between the plane **210** and the right plane **208**, and the plane **210** passes through the middle fastener **204**.

The bracket **202** is shorter than the bracket **134** of the previous embodiment. As can be seen in FIG. **19**, the greatest radial distance **R1** from the center of the countershaft **200** to an interface **218** between the bracket **202** and the engine **24** is less than a radius **R2** of the driven pulley **122**. As such, a projection of the bracket **202** onto a longitudinally extending vertical plane (the drawing sheet of FIG. **19** for example) is disposed inside of a circumference of a projection of the driven pulley **122** onto the plane and outside of a circumference of a projection of the driving pulley **120** onto the plane. As can be seen in FIG. **17**, in the longitudinal direction, the fasteners **204** are all disposed between a laterally extending plane **220** containing the cylinder axis **212** and the output shaft axis **222** (i.e. the axis about which the output shaft **118** rotates) and a laterally extending plane **224** containing the countershaft axis **226** (i.e. the axis about which the countershaft **200** rotates) and the drive axle axis **228** (i.e. the axis about which the drive axle **128** rotates).

With reference to FIGS. **20** and **21**, the countershaft **200** and its connections to the reduction gearing **102**, the driven pulley **122** and the bracket **202** will be described.

The countershaft **200** is made of three hollow shafts **230**, **232**, **234**. The right end of the left shaft **230** is press-fitted in the left end of the middle shaft **232** and the shafts **230**, **232** are welded together. Similarly, the left end of the right shaft **234** is press-fitted in the right end of the middle shaft **232** and the shafts **232**, **234** are welded together.

The left end of the left shaft **230** defines splines **236**. The driven pulley **122** has internal splines that engaging the splines **236** of the shaft **230** such that the driven pulley **122** and the countershaft **200** rotate together. The driven pulley **122** abuts a ring **238** formed on the shaft **230**.

The shaft **230** also has a step **239** (FIG. **21**). A bearing seal **240** is press-fit on the shaft **230** and abuts the step **239**. A motion decoupler in the form of a self-aligning ball bearing **242** is press-fit on the shaft **230** and abuts the bearing seal **240**. Another bearing seal **244** is press-fit on the shaft **230** and abut the self-aligning ball bearing **242** such that the self-aligning ball bearing **242** is laterally between the bearing seals **240**, **244**. The outer races of the bearing seals **240** and of the self-aligning ball bearing **242** are press-fit inside the aperture **206** defined by the bracket **202**. A cap **246** defining a central aperture is disposed around the shaft **230** and is fastened to the upper portion of the bracket **202** such that the bearing seals **240**, **244** and the self-aligning ball bearing **242** are disposed between the cap **246** and the upper portion of the bracket **202** in a space defined by the shaft **230**, the upper portion of the bracket **202** and the cap **246**. The outer race of the bearing seal **244** is press-fit inside the aperture defined by the cap **246**. The motion decoupler (i.e. the self-aligning ball bearing **242**) compensates for axial deviation and inclination of the axis **226** of the countershaft **200** resulting from movement of the engine **24**, and therefore the bracket **202**, relative to the reduction gearing **102** to which the countershaft **200** is connected.

The right end of the shaft **234** has external crown splines **248**. In the present embodiment, the input member of the

12

reduction gearing **102** is a cylindrical sleeve **250** with an integrally formed sprocket **252**. It is contemplated that the sprocket **252** could be press-fit and welded or otherwise connected to the sleeve **250** such that the sprocket **252** and the sleeve **250** rotate together. The sleeve **250** has internal splines **254** (FIG. **21**) that engage the external crown splines **248** of the shaft **234**. As a result, the sleeve **250** and sprocket **252** rotate together with the countershaft **200**. Also, the crown splines **248** allow for axial deviation and inclination of the axis **226** of the countershaft **200** relative to the sleeve **250**. A ball bearing **256** is disposed between the left end of the sleeve **250** and a left side **258** of the housing of the reduction gearing **102**. A washer **260** is disposed around the sleeve **250** between the ball bearing **256** and the sprocket **252**. A ball bearing **262** is disposed between the right end of the sleeve **250** and a right side **264** of the housing of the reduction gearing. A washer **266** is disposed around the sleeve **250** between the ball bearing **262** and the sprocket **252**. A spring washer **268** is disposed around the sleeve **250** between the washer **266** and the sprocket **252**. The sleeve **250** can move slightly in the lateral direction, but the spring washer **268** biases it toward the position shown in FIG. **20**. In the present embodiment, the spring washer **268** is a wave washer. It is contemplated that other types of spring washers could be used, such as, for example, a Belleville washer, a curved washer, a conical washer, or a finger washer. It is also contemplated that the spring washer **268** could be disposed between the washer **260** and the sprocket **262**, or that an additional spring washer could be disposed in this position.

Modifications and improvements to the above-described embodiments of the present invention 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 invention is therefore intended to be limited solely by the scope of the appended claims.

What is claimed is:

1. A snowmobile comprising:

a frame, the frame including:

an engine compartment; and

a tunnel rearward of the engine compartment;

a front suspension connected to the frame;

at least one ski connected to the front suspension;

an engine disposed in the engine compartment;

a bracket having a first portion joined to the engine and a second portion having an aperture defined therein;

an output shaft driven by the engine;

a countershaft passing through the aperture;

a motion decoupler disposed around the countershaft, the motion decoupler being supported by the second portion of the bracket, and the countershaft being rotationally supported in the motion decoupler;

a driving pulley disposed on the output shaft and rotating therewith;

a driven pulley disposed on the countershaft and rotating therewith;

a drive belt looped around the driving and driven pulleys to transfer torque from the driving pulley to the driven pulley,

the driving pulley, the driven pulley and the drive belt together forming a continuously variable transmission; and

an endless drive track disposed below the tunnel for propelling the snowmobile, the endless drive track being operatively connected to the countershaft.

2. The snowmobile of claim 1, wherein the motion decoupler is a self-aligning ball bearing.

13

3. The snowmobile of claim 1, further comprising a cap fastened to the second portion of the bracket, the motion decoupler being disposed between the cap and the second portion of the bracket.

4. The snowmobile of claim 1, wherein the first portion of the bracket is fastened to a rear of the engine. 5

5. The snowmobile of claim 4, wherein the first portion of the bracket is fastened to a cylinder block of the engine.

6. The snowmobile of claim 1, wherein a radial distance from a center of the countershaft to an interface between the first portion of the bracket and the engine is less than a radius of a driven pulley. 10

7. The snowmobile of claim 1, wherein a projection of the bracket onto a longitudinally extending vertical plane is disposed inside of a circumference of a projection of the driven pulley onto the longitudinally extending vertical plane. 15

8. The snowmobile of claim 1, further comprising:

a drive axle disposed in the tunnel, the drive axle being operatively connected to the countershaft; and two sprocket wheels carried by the drive axle for driving the endless drive track; 20

wherein the bracket is disposed laterally between a first longitudinally extending vertical plane passing through a center of one of the two sprocket wheels and a second longitudinally extending vertical plane passing through a center of another one of the two sprocket wheels. 25

9. The snowmobile of claim 1, wherein:

the engine has at least one cylinder having a cylinder axis; the output shaft extends through a surface of the engine; and 30

wherein the first portion of the bracket is fastened to the engine at a position laterally between a first plane and a second plane,

the first plane being a longitudinally extending vertical plane separating a portion of the output shaft disposed outside the engine from a portion of the output shaft disposed inside the engine, and 35

the second plane being a longitudinally extending vertical plane containing the cylinder axis of one of the at least one cylinder being nearest to the surface. 40

10. The snowmobile of claim 1, further comprising a drive axle disposed in the tunnel, the drive axle being operatively connected to the countershaft, the drive axle being rotatable about a drive axle axis; 45

wherein: the engine has at least one cylinder having a cylinder axis;

the countershaft being rotatable about a countershaft axis;

the output shaft being rotatable about an output shaft axis; 50

the first portion of the bracket is fastened to the engine at a plurality of positions, each of the plurality of positions being longitudinally between a first plane and a second plane, 55

the first plane being a laterally extending plane containing output shaft axis and the cylinder axis of the at least one cylinder, and

the second plane being a laterally extending plane containing the countershaft axis and the drive axle axis. 60

11. The snowmobile of claim 1, further comprising a reduction gearing operatively connected to the countershaft, the reduction gearing having a sprocket;

wherein the countershaft has external crown splines engaging the sprocket via internal splines and allowing for axial deviation of the axis of the countershaft relative to the sprocket. 65

14

12. The snowmobile of claim 1, further comprising: a reduction gearing operatively connected to the countershaft, the reduction gearing having a sprocket; and a spherical bearing disposed between the countershaft and a housing of the reduction gearing, the spherical bearing allowing for axial deviation and/or inclination of the countershaft relative to the sprocket.

13. The snowmobile of claim 1, wherein: the countershaft has an axis of rotation; and the motion decoupler allows for at least one of axial deviation and inclination of the axis of the countershaft relative to the bracket.

14. The snowmobile of claim 1, further comprising a vibration damper disposed between the bracket and the frame.

15. The snowmobile of claim 14, wherein the vibration damper is disposed below and rearward of the countershaft.

16. The snowmobile of claim 14, wherein the driving and driven pulleys are disposed on a first side of the engine; and further comprising:

a reduction gearing operatively connected to the countershaft on a second side of the engine opposite the first side; and

a drive axle disposed in the tunnel, the drive axle being operatively connected to the reduction gearing for driving the endless drive track;

wherein a central axis of the damper passes in front of the drive axle.

17. A snowmobile comprising:

a frame, the frame including:

an engine compartment; and

a tunnel rearward of the engine compartment;

a front suspension connected to the frame;

at least one ski connected to the front suspension;

an engine disposed in the engine compartment;

a bracket having a first portion joined to the engine and a second portion having an aperture defined therein;

a countershaft passing through the aperture;

a vibration damper disposed between the bracket and the frame, the vibration damper being disposed below and rearward of the countershaft;

a driving pulley operatively connected to the engine;

a driven pulley disposed on the countershaft and rotating therewith;

a drive belt looped around the driving and driven pulleys to transfer torque from the driving pulley to the driven pulley,

the driving pulley, the driven pulley and the drive belt together forming a continuously variable transmission; and

an endless drive track disposed below the tunnel for propelling the snowmobile, the endless drive track being operatively connected to the countershaft.

18. A snowmobile comprising:

a frame, the frame including:

an engine compartment; and

a tunnel rearward of the engine compartment;

a front suspension connected to the frame;

at least one ski connected to the front suspension;

an engine disposed in the engine compartment;

a bracket having a first portion joined to the engine and a second portion having an aperture defined therein;

an output shaft driven by the engine;

a countershaft passing through the aperture, the countershaft defining a countershaft axis;

a self-aligning bearing disposed around the countershaft, the self-aligning bearing being supported by the second portion of the bracket, the countershaft being supported

in the self-aligning bearing, the self-aligning bearing  
 allowing for at least one of axial deviation and inclina-  
 tion of the countershaft axis relative to the bracket;  
 a driving pulley disposed on the output shaft and rotating  
 therewith; 5  
 a driven pulley disposed on the countershaft and rotating  
 therewith;  
 a drive belt looped around the driving and driven pulleys to  
 transfer torque from the driving pulley to the driven  
 pulley, 10  
 the driving pulley, the driven pulley and the drive belt  
 together forming a continuously variable transmission;  
 and  
 an endless drive track disposed below the tunnel for prop-  
 elling the snowmobile, the endless drive track being 15  
 operatively connected to the countershaft.

**19.** The snowmobile of claim **18**, further comprising a  
 vibration damper disposed between the bracket and the  
 frame.

**20.** The snowmobile of claim **19**, wherein the vibration 20  
 damper is disposed below and rearward of the countershaft.

**21.** The snowmobile of claim **19**, wherein the driving and  
 driven pulleys are disposed on a first side of the engine; and  
 further comprising:

a reduction gearing operatively connected to the coun- 25  
 tershaft on a second side of the engine opposite the  
 first side; and

a drive axle disposed in the tunnel, the drive axle being  
 operatively connected to the reduction gearing for  
 driving the endless drive track; 30

wherein a central axis of the damper passes in front of the  
 drive axle.

\* \* \* \* \*