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(54) **ELECTRONIC STEERING ASSIST SYSTEMS FOR SNOWMOBILES**

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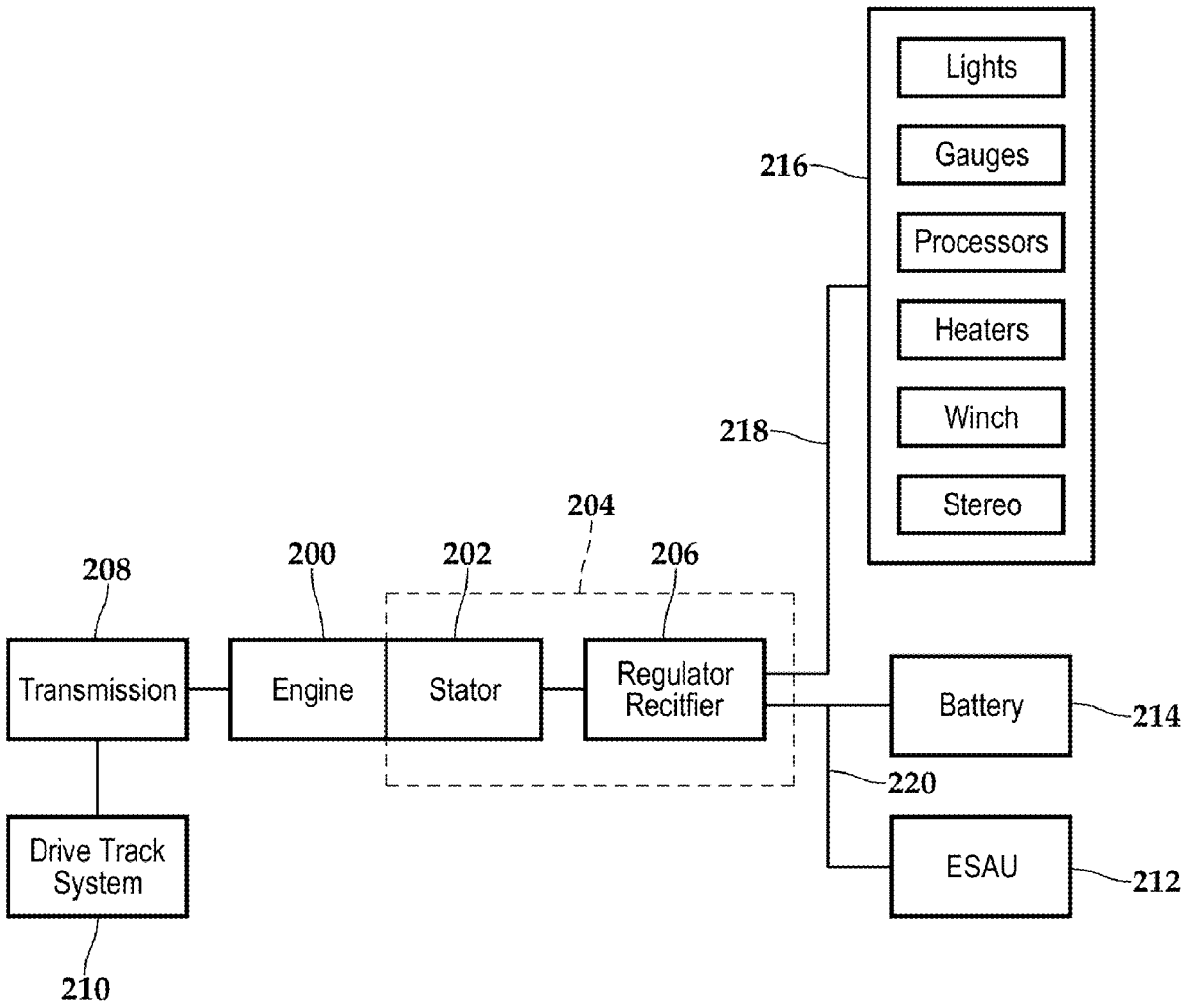
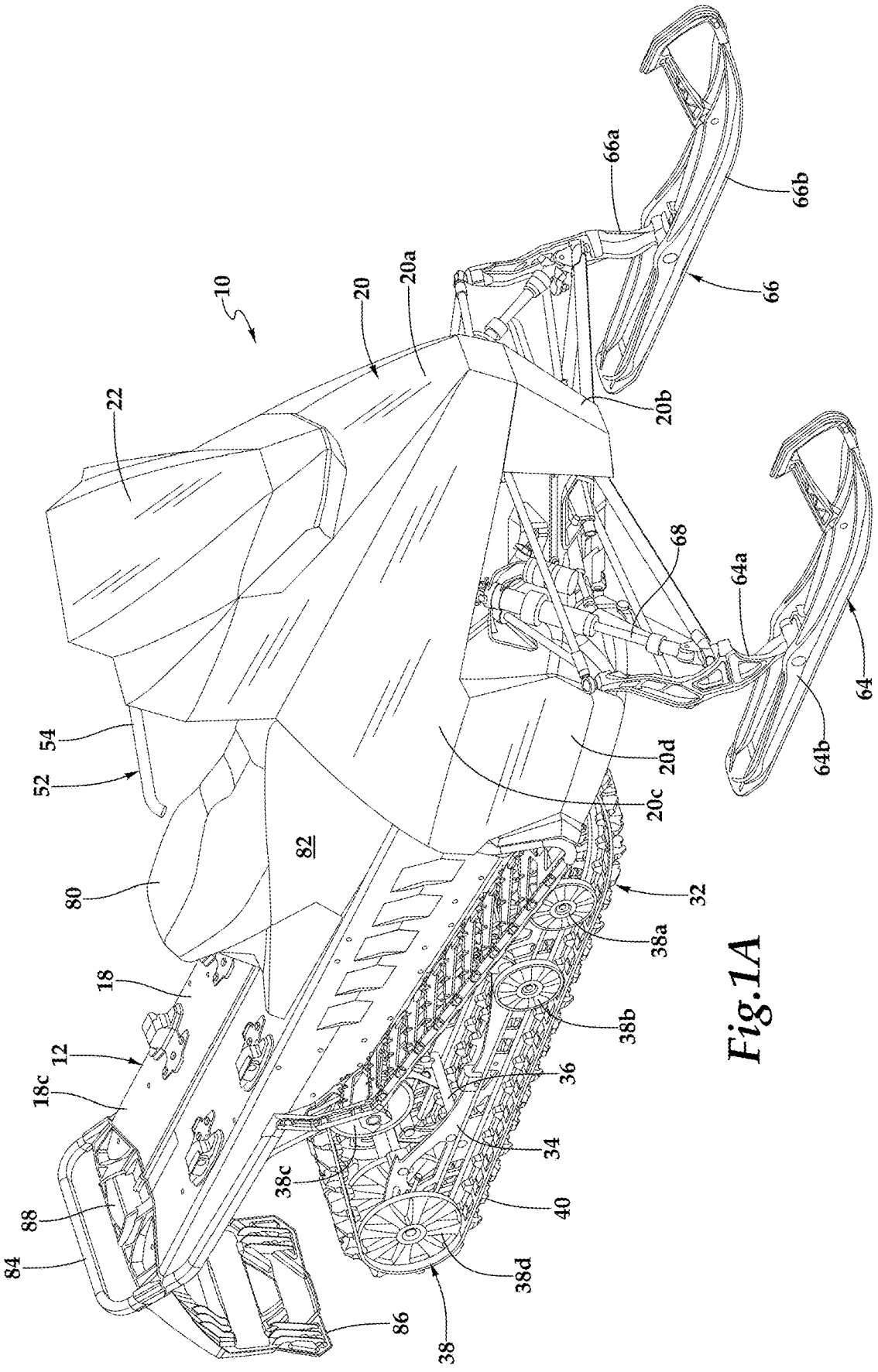
(57) **ABSTRACT**

A snowmobile has a ski system and a drive track system including an endless track configured to provide ground propulsion for the snowmobile. An internal combustion engine is configured to provide torque and rotational energy to the drive track system. A stator system is operably associated with the engine. The stator system is configured to output first and second direct currents. At least one electrical load component is positioned in a first circuit associated with the first direct current. A steering system is operatively coupled to the ski system. The steering system includes an electronic steering assist unit that is positioned in a second circuit associated with the second direct current.

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18c

Fig.1A

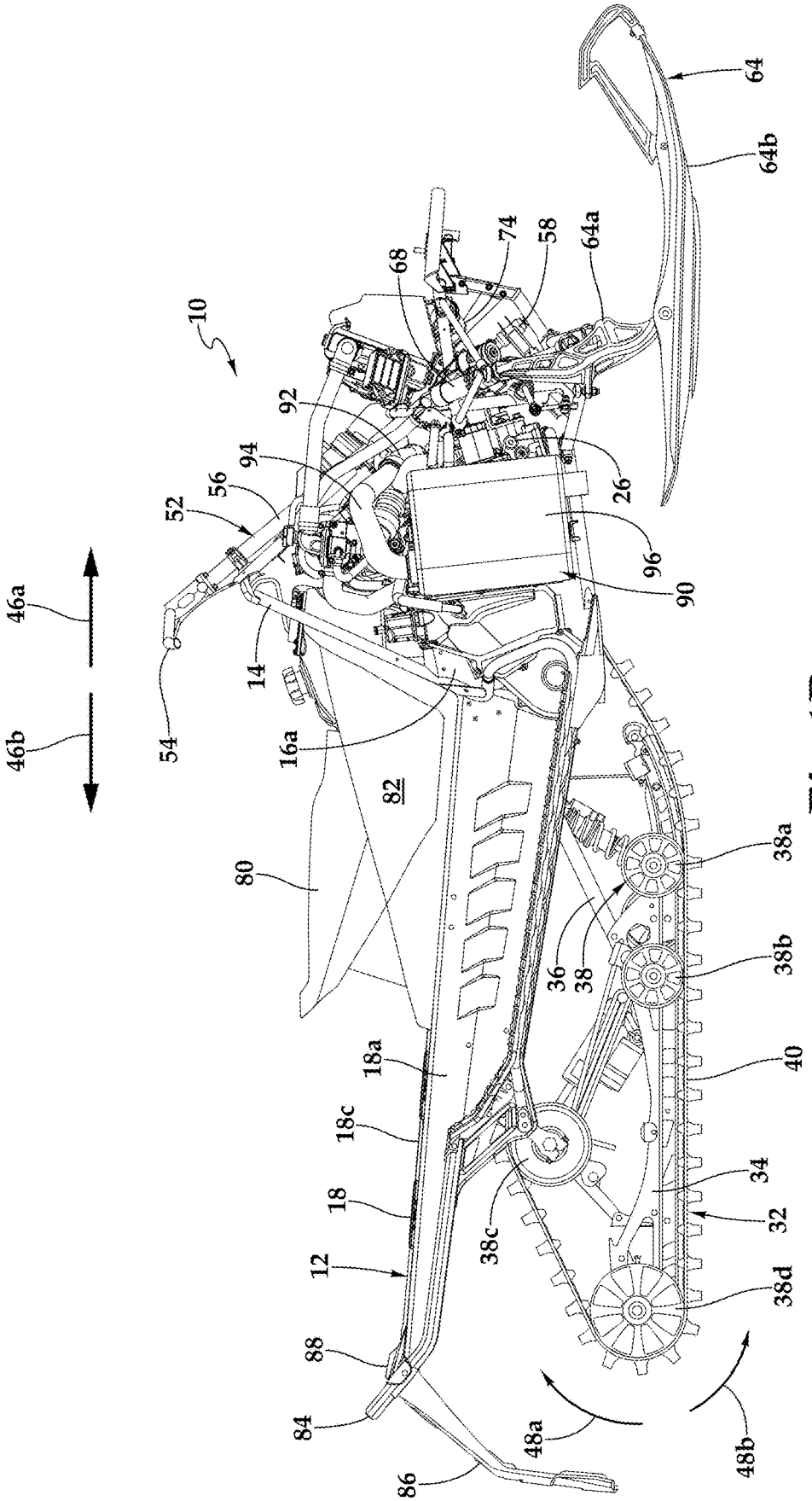
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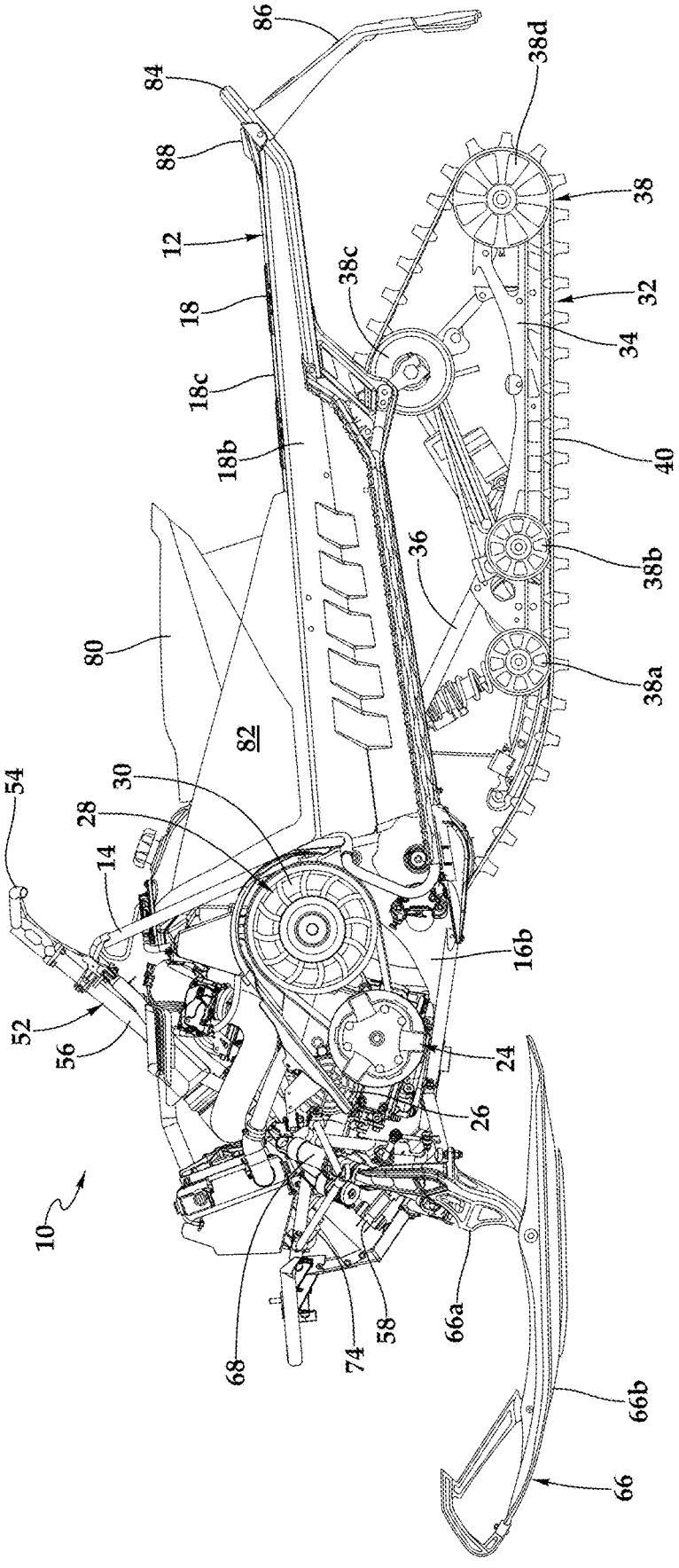
Fig.1B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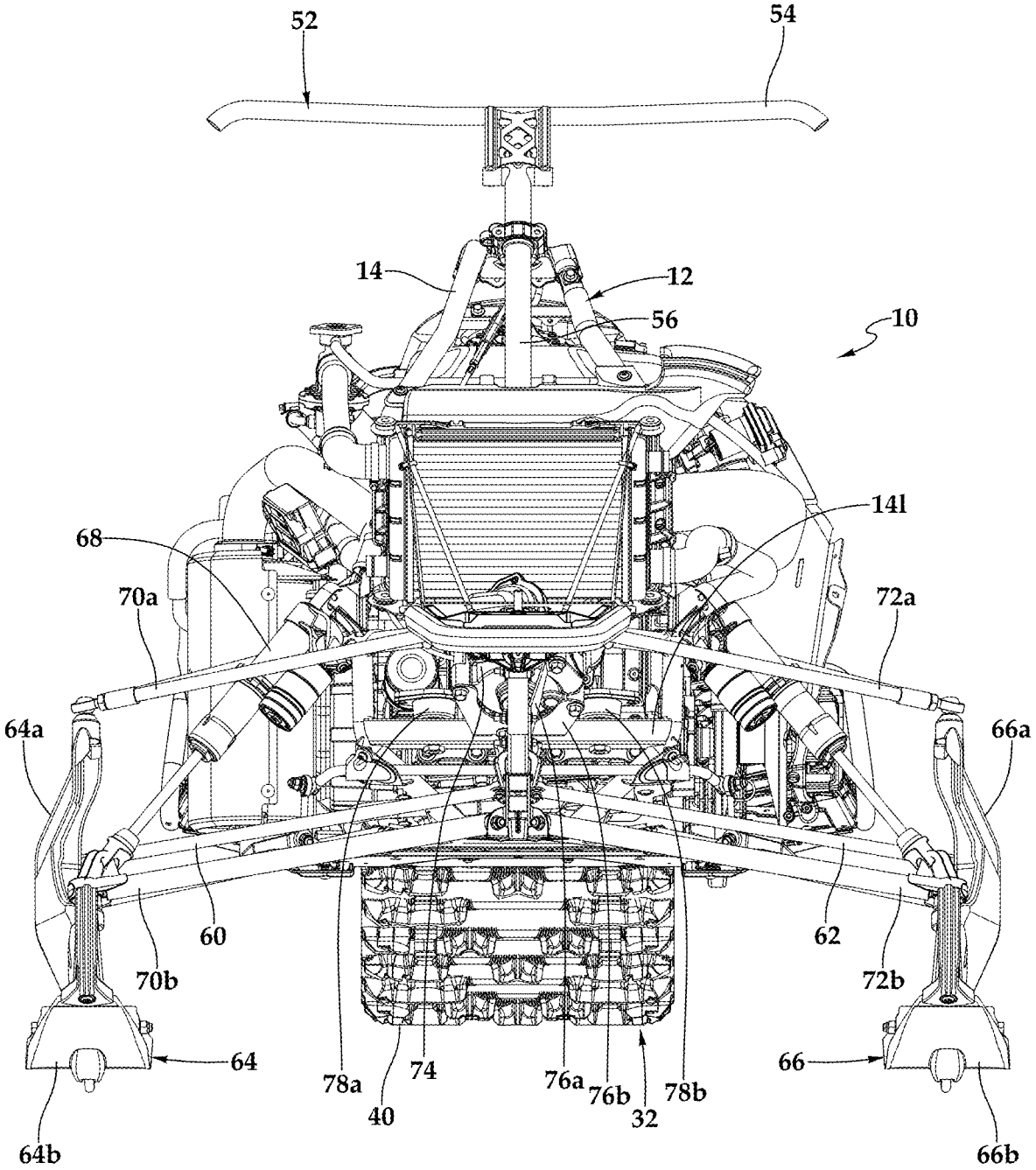
66

Fig.1C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66b

Fig.1D

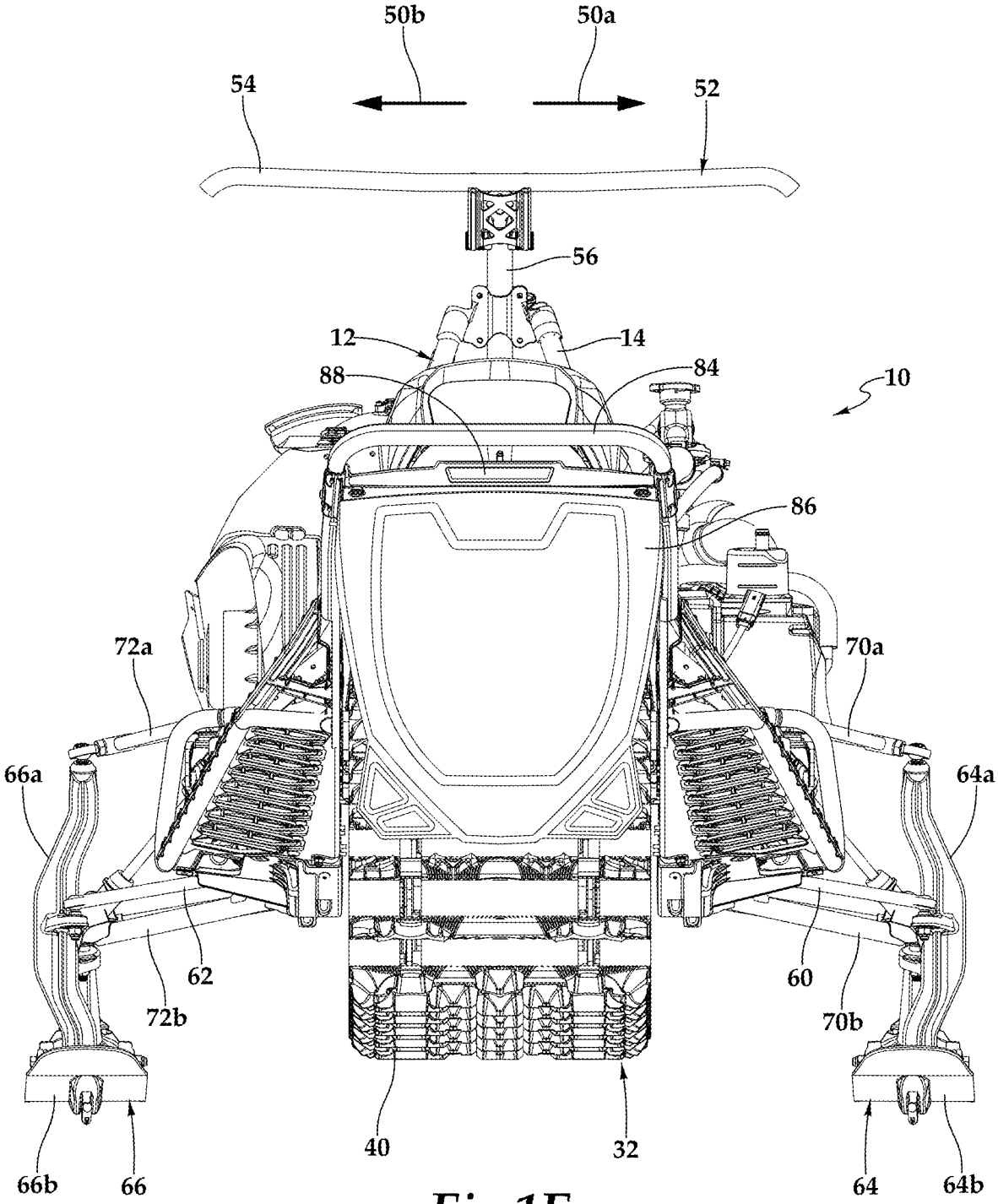
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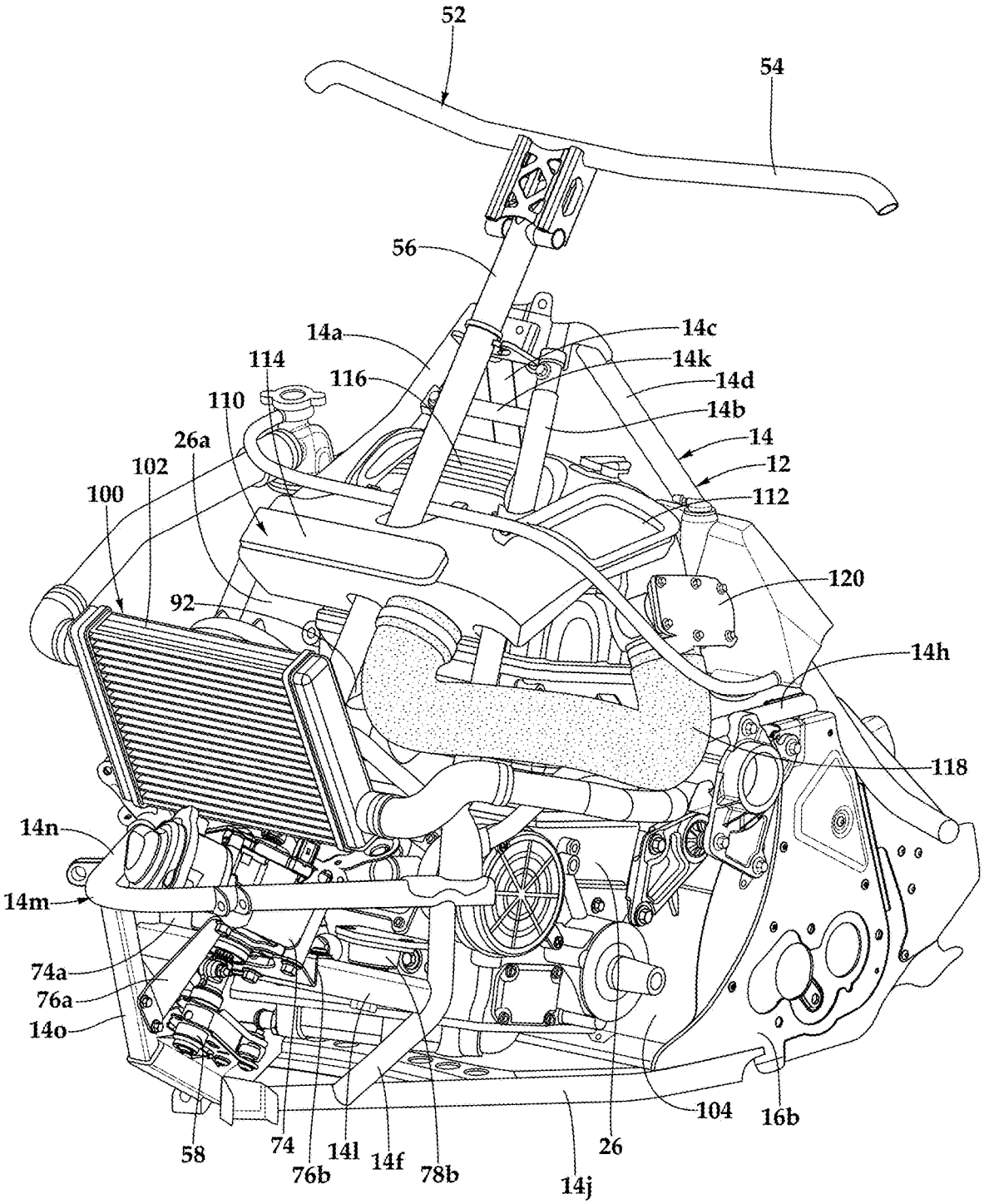
Fig.1E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14j

Fig.2

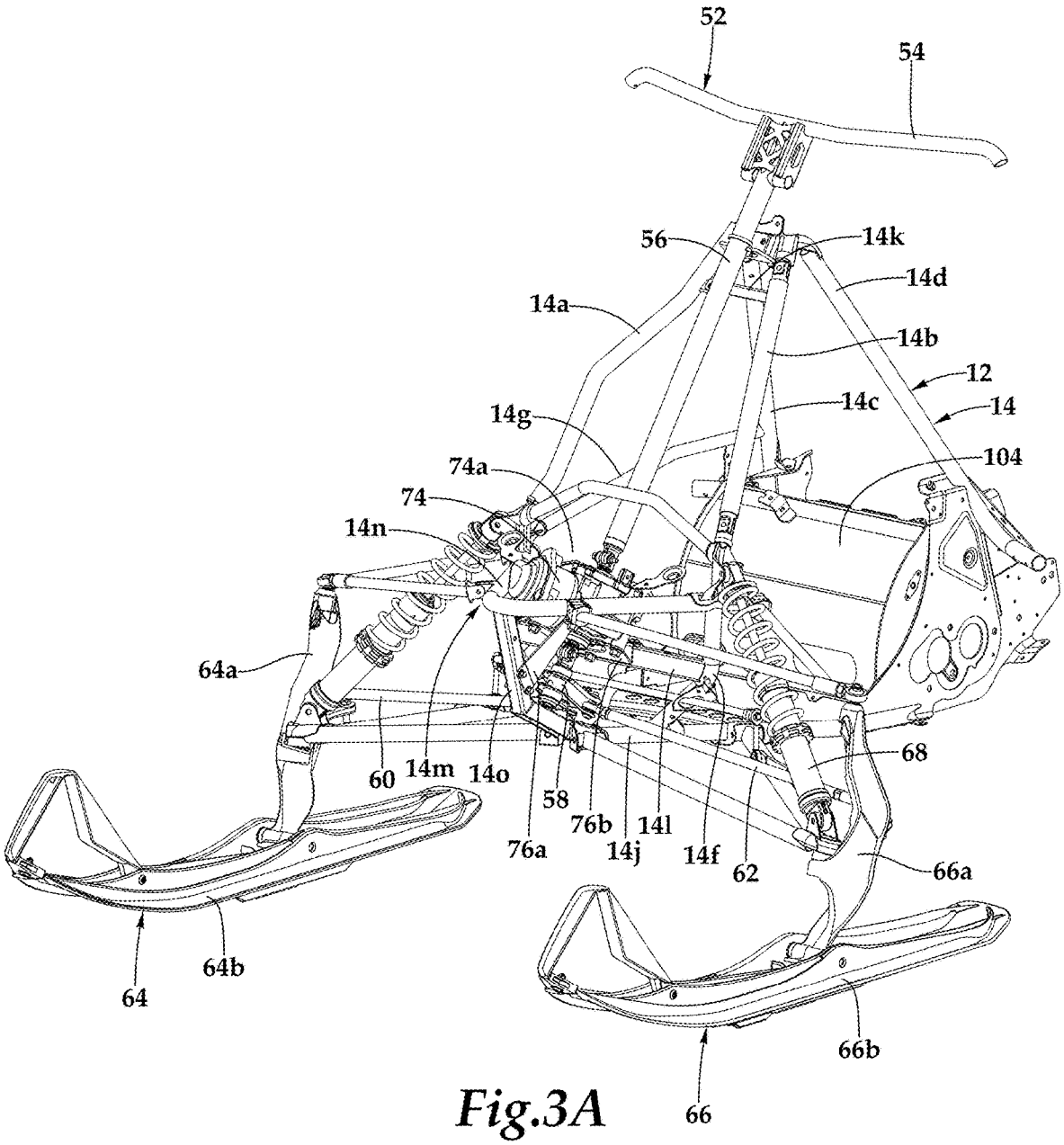
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Fig.3A

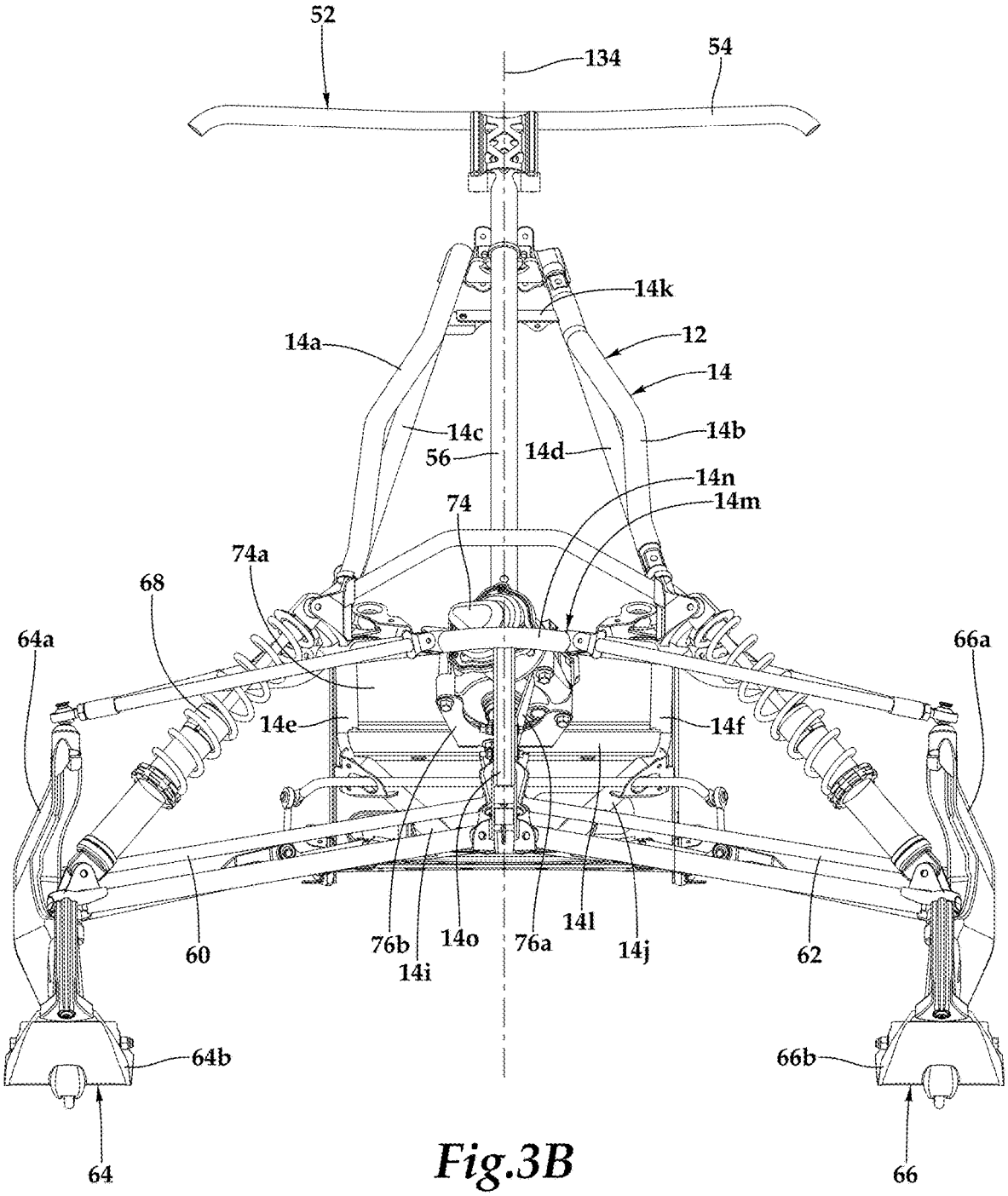
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Fig.3B

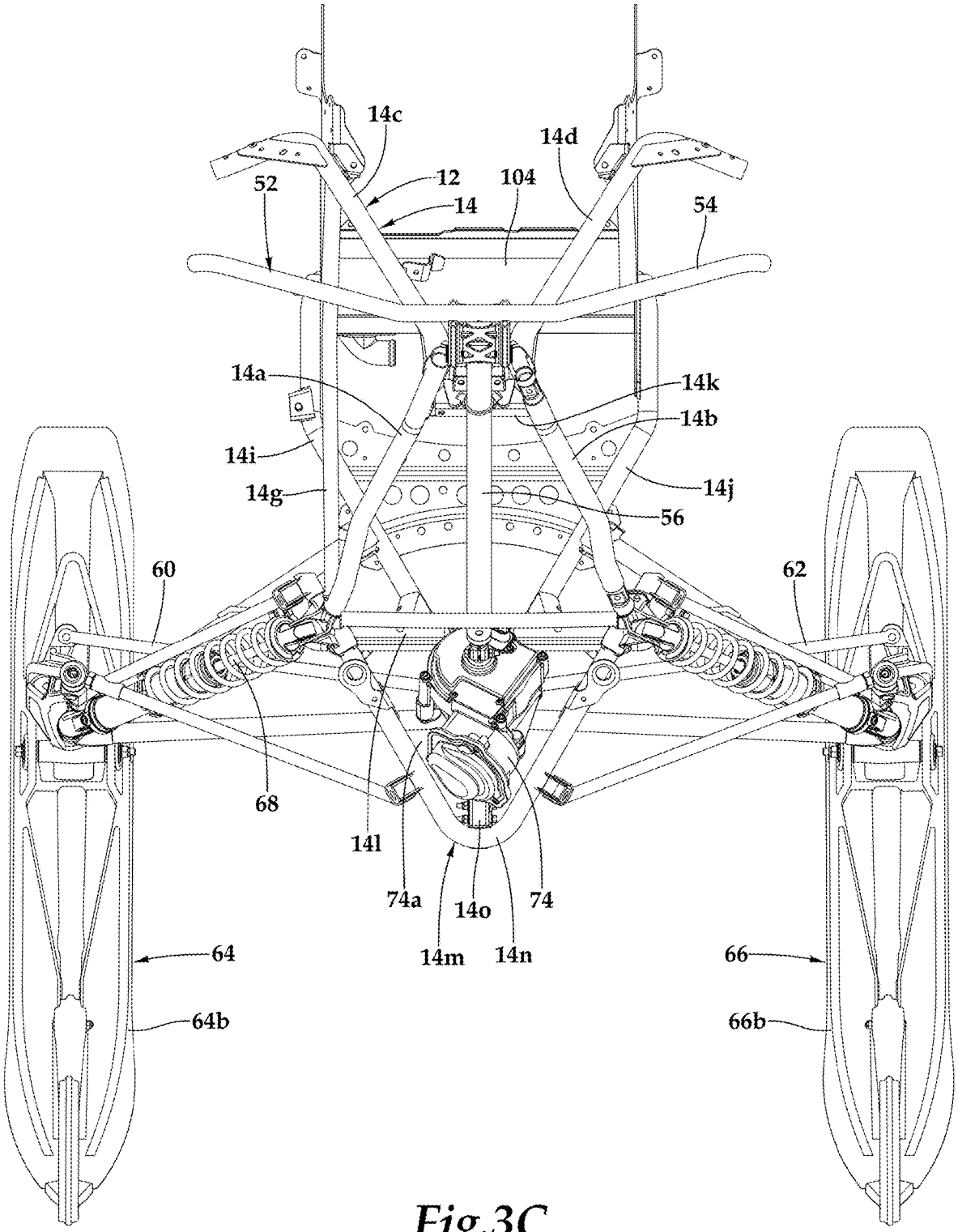
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Fig.3C

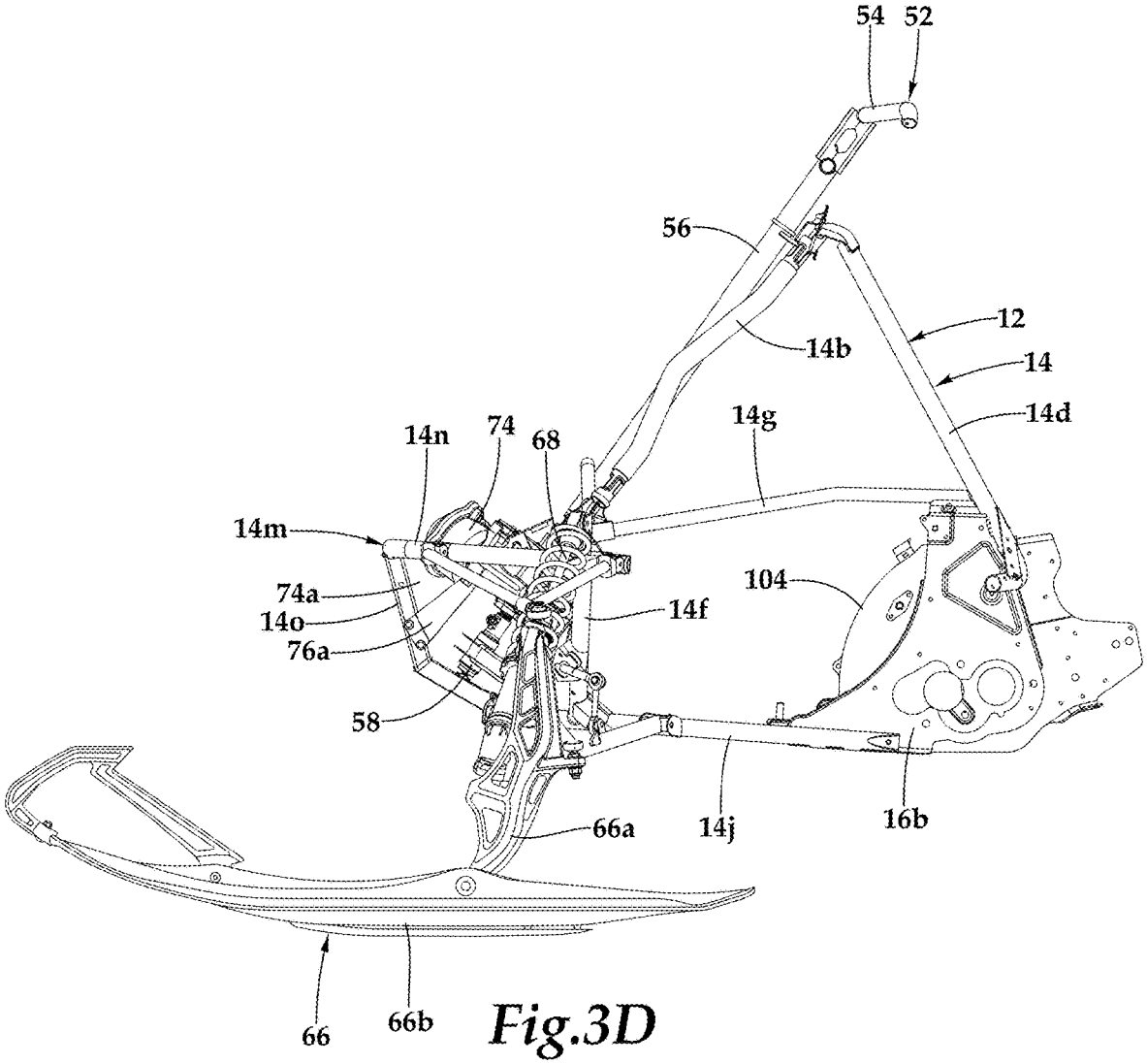
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Fig.3D

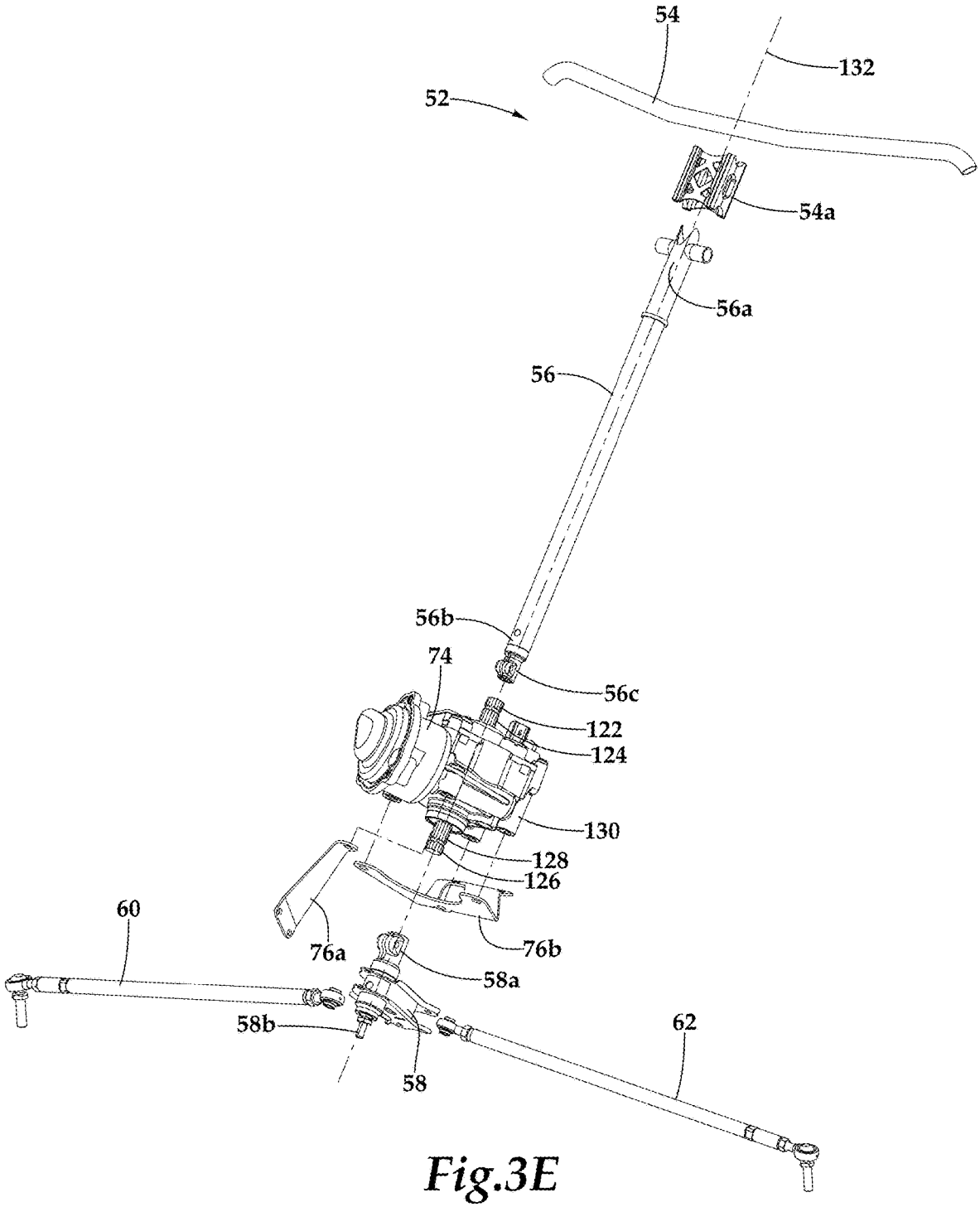
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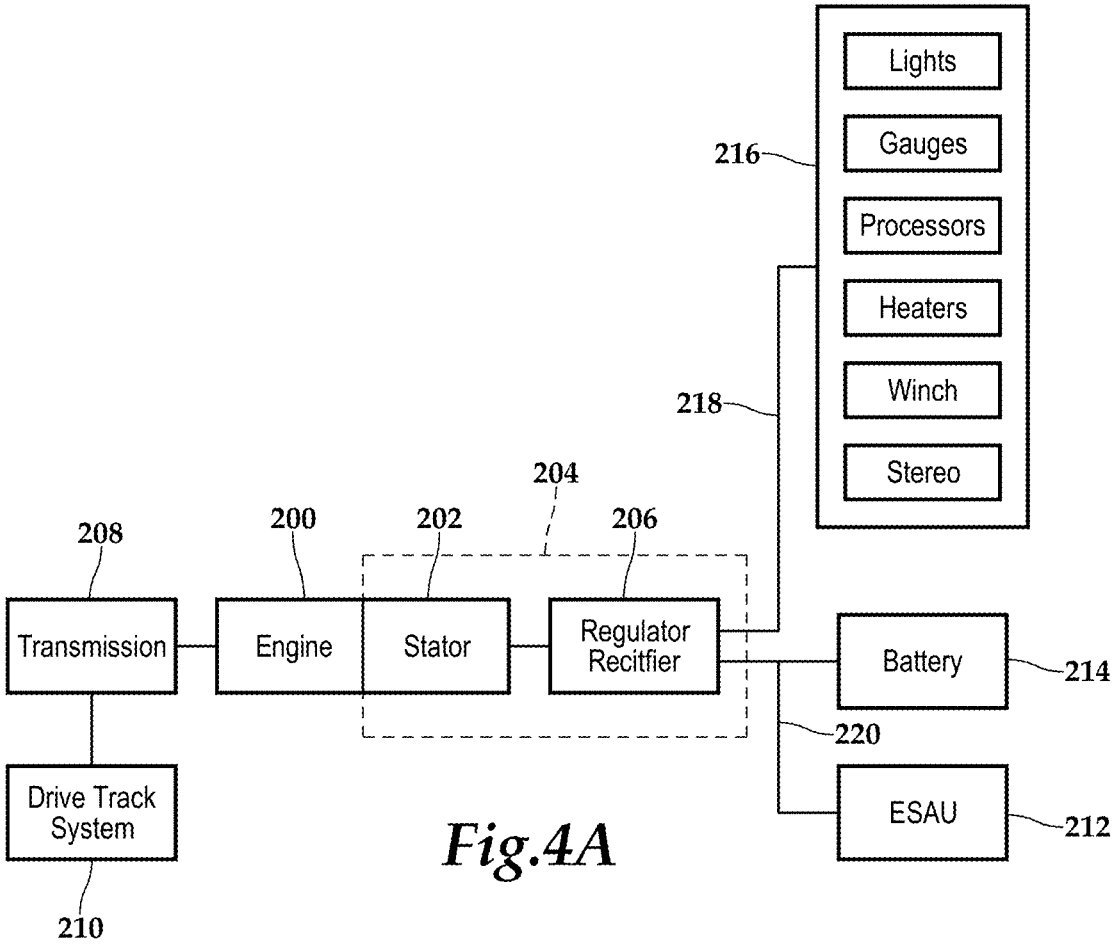
Fig.3E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Drive Track System
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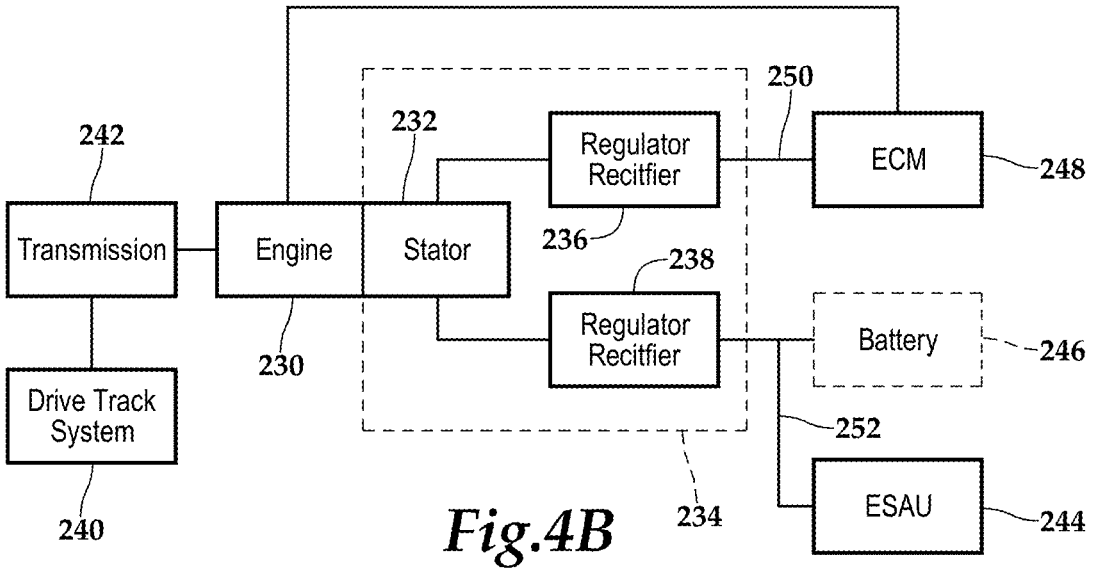
Fig.4A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Drive Track System
234
ESAU
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Fig.4B

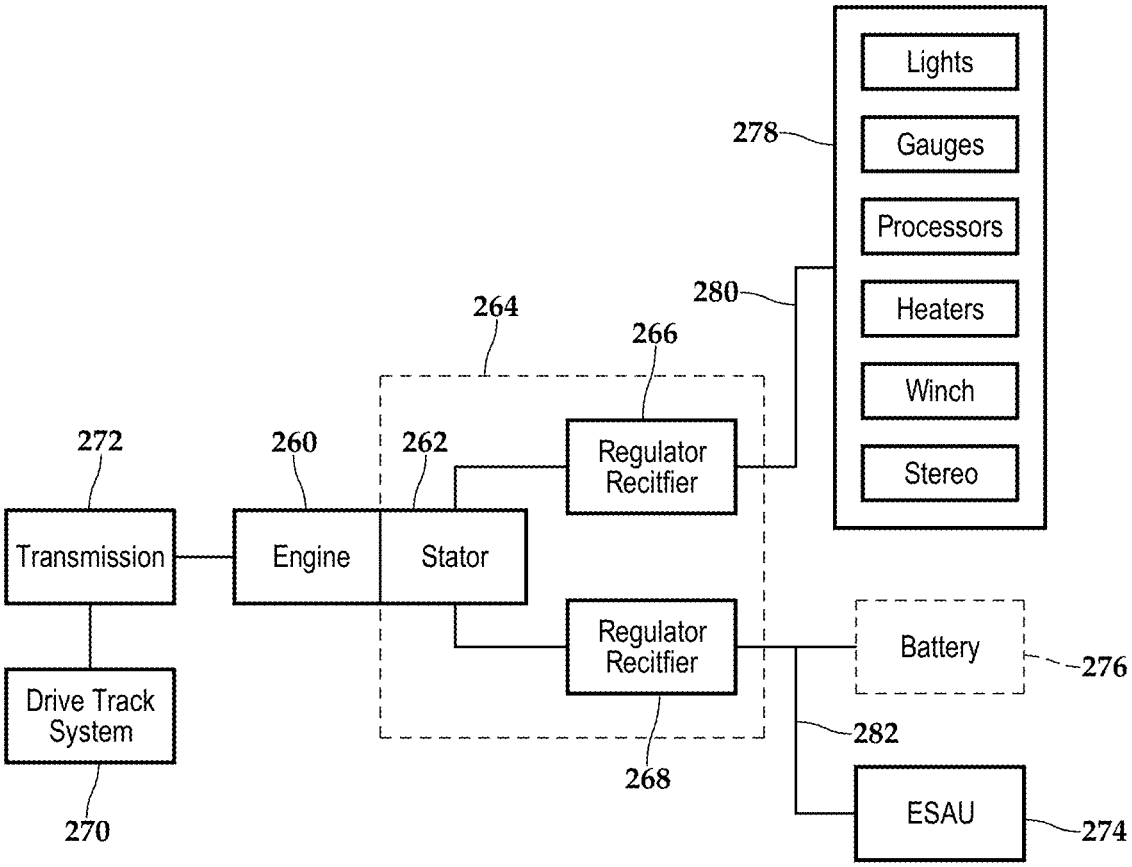
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Fig.4C

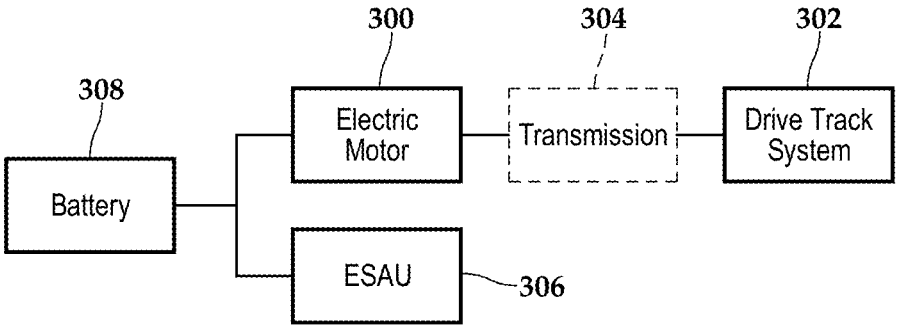

Fig.5A

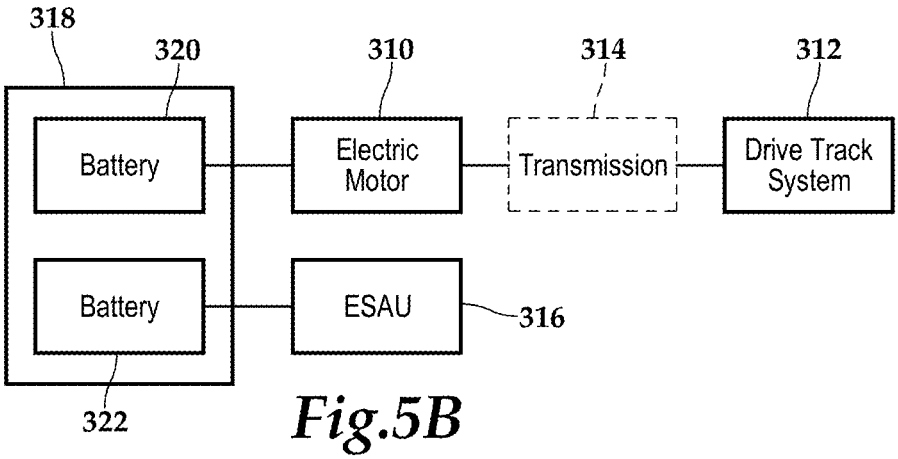

Fig.5B

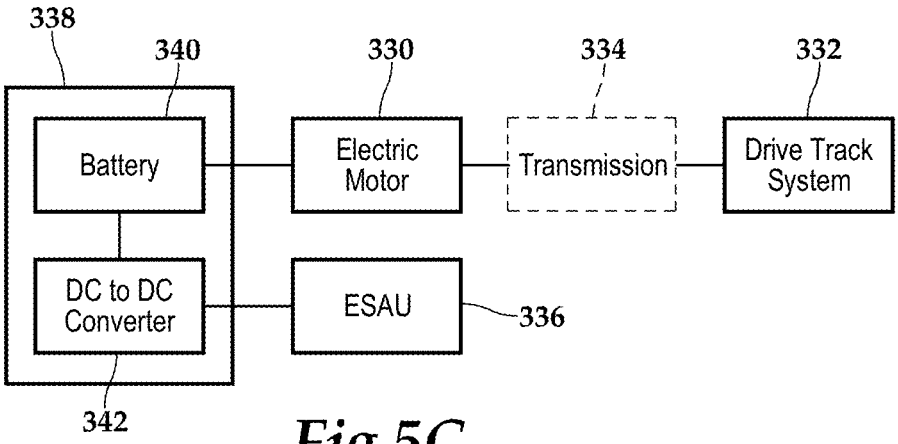

Fig.5C

ELECTRONIC STEERING ASSIST SYSTEMS FOR SNOWMOBILES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Application No. 63/604,023, filed Nov. 29, 2023 the entire contents of which are hereby incorporated by reference.

TECHNICAL FIELD OF THE DISCLOSURE

[0002] The present disclosure relates, in general, to electronic steering assist systems for use on land vehicles and, in particular, to electronic steering assist systems for use on snowmobiles that include an electronic steering assist unit that is electrically isolated from other electrical load components of the snowmobile.

BACKGROUND

[0003] Snowmobiles are popular land vehicles used for transportation and recreation in cold and snowy conditions. Certain snowmobiles are designed for specific applications such as trail, utility, mountain, race and crossover, to name a few. Snowmobiles typically include a chassis that supports various components of the snowmobile such as an engine, a continuously variable transmission and a ground-engaging endless drive track disposed in a longitudinally extending tunnel. The engine and transmission power the drive track to enable ground propulsion for the vehicle. A rider controls the operation of the snowmobile using a steering system that typically includes a handlebar assembly, a steering column, a steering arm assembly, a pair of tie rods and a pair ski assemblies that provide flotation for the front of the snowmobile over the snow. Some snowmobiles utilize an electronic steering assist unit which can improve the handling of the snowmobile, reduce fatigue associated with driving the snowmobile and allow the snowmobile to be driven more aggressively. It has been found, however, that the intermittent power demand of the electronic steering assist unit can create voltage fluctuations that may adversely affect other electrical load components of the snowmobile that draw current generated by a stator that is integrated with the engine. Accordingly, a need has arisen for improved electronic steering assist systems for snowmobiles that overcome these and other drawbacks.

SUMMARY

[0004] In a first aspect, the present disclosure is directed to a snowmobile having a ski system and a drive track system including an endless track configured to provide ground propulsion for the snowmobile. An internal combustion engine is configured to provide torque and rotational energy to the drive track system. A stator system is operably associated with the engine. The stator system is configured to output first and second direct currents. At least one electrical load component is positioned in a first circuit associated with the first direct current. A steering system is operatively coupled to the ski system. The steering system includes an electronic steering assist unit that is positioned in a second circuit associated with the second direct current.

[0005] In certain embodiments, the engine may be a two-stroke engine. In some embodiments, the at least one electrical load component may be an engine control module. In other embodiments, the at least one electrical load component may be one or more of lights, gauges, computer processors, heaters, a winch and a stereo. In certain embodiments, the stator system may include a stator and a regulator rectifier such that the stator outputs an alternating current to the regulator rectifier and the regulator rectifier outputs the first direct current to the first circuit and the second direct current to the second circuit. In such embodiments, a battery may be positioned in parallel with the electronic steering assist unit in the second circuit with the battery configured to be charged by the second direct current and with the battery configured as a store of energy for the electronic steering assist unit such that an intermittent high power demand of the electronic steering assist unit is satisfied by drawing current from the battery.

[0006] In some embodiments, the stator system may include a stator, a first regulator rectifier and a second regulator rectifier such that the stator outputs a first alternating current to the first regulator rectifier and a second alternating current to the second regulator rectifier and such that the first regulator rectifier outputs the first direct current to the first circuit and the second regulator rectifier outputs the second direct current to the second circuit. In such embodiments, a battery may be positioned in parallel with the electronic steering assist unit in the second circuit with the battery configured to be charged by the second direct current and with the battery configured as a store of energy for the electronic steering assist unit such that an intermittent high power demand of the electronic steering assist unit is satisfied by drawing current from the battery. In certain embodiments, the first and second direct currents may be at the same voltage. In other embodiments, the first and second direct currents may be at different voltages. In some embodiments, a battery may be configured to be charged by the second direct current. In such embodiments, the battery may be positioned in parallel with the electronic steering assist unit in the second circuit and configured as a store of energy for the electronic steering assist unit such that an intermittent high power demand of the electronic steering assist unit is satisfied by drawing current from the battery.

[0007] In a second aspect, the present disclosure is directed to a snowmobile having a ski system and a drive track system including an endless track configured to provide ground propulsion for the snowmobile. An electric motor is configured to provide torque and rotational energy to the drive track system. A steering system is operatively coupled to the ski system. The steering system includes an electronic steering assist unit. A power supply is configured to supply electric power to the electric motor and the electronic steering assist unit.

[0008] In some embodiments, the power supply may include a battery having an output voltage with both the electric motor and the electronic steering assist unit operating at the output voltage. In certain embodiments, the output voltage of the battery may be at least 48 volts such as between 48 volts and 300 volts. In some embodiments, the electric motor may operate at a first voltage and the electronic steering assist unit may operate at a second voltage that is less than the first voltage. In such embodiments, the power supply may include a first battery having an output voltage of the first voltage and a second battery having an output voltage of the second voltage. Also, in such embodiments, the first voltage may be between 48 volts and 300 volts, and the second voltage may be about 12 volts. In

certain embodiments, the electric motor may operate at a first voltage and the electronic steering assist unit may operate at a second voltage that is less than the first voltage. In such embodiments, the power supply may include a battery having an output voltage of the first voltage and a DC to DC converter electrically coupled between the battery and the electronic steering assist unit that converters the first voltage to the second voltage. In such embodiments, the first voltage may be between 48 volts and 300 volts, and the second voltage may be about 12 volts.

[0009] In a third aspect, the present disclosure is directed to a method of electrically isolating an electronic steering assist unit from at least one electrical load component of a snowmobile. The method includes outputting first and second direct currents from a stator system operably associated with an internal combustion engine; positioning the at least one electrical load component in a first circuit associated with the first direct current; and positioning the electronic steering assist unit in a second circuit associated with the second direct current.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] For a more complete understanding of the features and advantages of the present disclosure, reference is now made to the detailed description along with the accompanying figures in which corresponding numerals in the different figures refer to corresponding parts and in which:

[0011] FIGS. **1**A-**1**E are selected views of a snowmobile having a steering system including an electronic steering assist unit in accordance with embodiments of the present disclosure;

[0012] FIG. **2** is an isometric view of a forward portion of a snowmobile having a steering system including an electronic steering assist unit in accordance with embodiments of the present disclosure;

[0013] FIGS. **3**A-**3**E are selected views of a steering system for a snowmobile including an electronic steering assist unit in accordance with embodiments of the present disclosure;

[0014] FIGS. **4**A-**4**C are block diagrams of various electrical system configurations for a snowmobile having a steering system including an electronic steering assist unit in accordance with embodiments of the present disclosure; and

[0015] FIGS. **5**A-**5**C are block diagrams of various electrical system configurations for a snowmobile having a steering system including an electronic steering assist unit in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0016] While the making and using of various embodiments of the present disclosure are discussed in detail below, it should be appreciated that the present disclosure provides many applicable inventive concepts, which can be embodied in a wide variety of specific contexts. The specific embodiments discussed herein are merely illustrative and do not delimit the scope of the present disclosure. In the interest of clarity, all features of an actual implementation may not be described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0017] In the specification, reference may be made to the spatial relationships between various components and to the spatial orientation of various aspects of components as the devices are depicted in the attached drawings. However, as will be recognized by those skilled in the art after a complete reading of the present disclosure, the devices, members, apparatuses, and the like described herein may be positioned in any desired orientation. Thus, the use of terms such as "above," "below," "upper," "lower" or other like terms to describe a spatial relationship between various components or to describe the spatial orientation of aspects of such components should be understood to describe a relative relationship between the components or a spatial orientation of aspects of such components, respectively, as the devices described herein may be oriented in any desired direction. As used herein, the term "coupled" may include direct or indirect coupling by any means, including by mere contact or by moving and/or non-moving mechanical connections.

[0018] Referring to FIGS. **1**A-**1**E in the drawings, a land vehicle depicted as a snowmobile is schematically illustrated and generally designated **10**. Structural support for snowmobile **10** is provided by a chassis **12** that includes a forward frame assembly **14**, a right side plate member **16***a*, a left side plate member **16***b* and a longitudinally extending tunnel **18**. Forward frame assembly **14** (see also FIGS. **2** and **3**A-**3**D) is formed from interconnected tubular members such as round and hollow tubular members comprised of metal, metal alloy, polymeric materials, fiber reinforced polymer composites and/or combinations thereof that are coupled together by welds, bolts, pins or other suitable fastening means. In the illustrated embodiment, forward frame assembly **14** includes a right-forward spar **14***a*, a left-forward spar **14***b*, a right-aft spar **14***c*, a left-aft spar **14***d*, right truss **14***e*, a left truss **14***f*, a right-upper beam **14***g*, a left-upper beam **14***h*, a right-lower beam **14***i*, a left-lower beam **14***j*, an upper cross member **14***k*, a lower cross member **14***l* and a nose frame assembly **14***m* including a nose rail **14***n* and a nose truss **14***o*. Plate members **16***a*, **16***b* are coupled to and preferably welded to forward frame assembly **14** such that forward frame assembly **14** and plate members **16***a*, **16***b* form a welded frame assembly. Tunnel **18** is coupled to forward frame assembly **14** and/or plate members **16***a*, **16***b* with welds, bolts, rivets or other suitable means. In the illustrated embodiment, tunnel **18** includes a right sidewall **18***a*, a left sidewall **18***b* and a top panel **18***c*. Tunnel **18** may be integrally formed or may consist of multiple members that are coupled together with welds, bolts, rivets or other suitable means. Plate members **16***a*, **16***b* and tunnel **18** may be formed from sheet metal, metal alloy, fiber reinforced polymer or other suitable material or combination of materials.

[0019] Various components of snowmobile **10** are assembled on or around forward frame assembly **14**. One or more body panels **20** cover and protect the various components of snowmobile **10** including parts of forward frame assembly **14**. For example, a hood panel **20***a*, a nose panel **20***b*, an upper right side panel **20***c* and a lower right side panel **20***d* shield underlying componentry from the snow and terrain. Similarly, an upper left side panel and a lower left side panel (not visible) also shield underlying componentry

from the snow and terrain. In the illustrated embodiment, snowmobile **10** has a windshield **22** that shields the rider of snowmobile **10** from snow, terrain and frigid air during operation. Even through snowmobile **10** has been described and depicted as including specific body panels **20**, it should be understood by those having ordinary skill in the art that a snowmobile of the present disclosure may include any number of body panels in any configuration to provide the shielding functionality. In addition, it should be understood by those having ordinary skill in the art that the right side and the left side of snowmobile **10** will be with reference to a rider of snowmobile **10** with the right side of snowmobile **10** corresponding to the right side of the rider and the left side of snowmobile **10** corresponding to the left side of the rider.

[0020] Body panels **20** have been removed from snowmobile **10** in FIGS. **1**B-**1**E to reveal the underlying components of snowmobile **10**. For example, snowmobile **10** has a powertrain **24** that includes an engine **26** and a drivetrain **28** both of which are coupled to forward frame assembly **14**. Engine **26** resides in an engine bay **26***a* formed within forward frame assembly **14**. In the illustrated embodiment, engine **26** is a two-stroke, three cylinder engine that is aftwardly tilted and has air intake inlets on the aftward side of engine **26** and exhaust outlets on the forward side of engine **26**. In other embodiments, an engine of the present disclosure may be a four-stroke engine, an electric motor, a hybrid engine or other prime mover. In addition, an engine of the present disclosure may have more than or less than three cylinders, may be vertically mounted or mounted with a forward tilt and/or may have air intake inlets or exhaust outlets in other locations. In the illustrated embodiment, engine **26** is an internal combustion engine such as a naturally aspirated internal combustion engine or a forced induction internal combustion engine that includes, for example, one or more turbochargers and/or superchargers. Engine **26** includes a generator (not visible), such as a three phase permanent magnet generator, which is integrated with engine **26** wherein a flywheel that has permanent magnets attached thereto is rotated by the engine crankshaft about a stator having copper wire coils wrapped around a steel core to generate an alternating current output. This generator will be referred to herein as a stator. The stator may be a multi output stator such as a dual output stator that generates multiple alternating current outputs. The stator is part of a stator system that includes one or more regulator rectifiers that convert the alternating current to direct current. In addition, the regulator rectifiers stabilize the variable voltage produced by the stator and provide a constant voltage output that matches the voltage requirements of the electric load components associated therewith. Drivetrain **28** also includes a transmission **30**, such as a continuously variable transmission, an electrically variable transmission or other suitable transmission type for varying the ratio of the engine output speed to the drive track input speed.

[0021] A drive track system **32** is at least partially disposed within and/or below tunnel **18** and is in contact with the ground to provide ground propulsion for snowmobile **10**. Torque and rotational energy are provided to drive track system **32** from engine **26** via drivetrain **28**. Drive track system **32** includes a track frame **34**, an internal suspension **36**, a plurality of idler wheels **38** such as idler wheels **38***a*, **38***b*, **38***c*, **38***d* and an endless track **40**. Track frame **34** may be coupled to forward frame assembly **14** via a swing arm having a coil spring, a rigid strut, a torsion spring, an elastomeric member or any other suitable coupling configuration. Endless track **40** is driven by a track drive sprocket via a track driveshaft (not visible) that is rotated responsive to torque provided from powertrain **24**. Endless track **40** rotates around track frame **34** and idler wheels **38** to propel snowmobile **10** in either the forward direction, as indicated by arrow **46***a*, or the backwards direction, as indicated by arrow **46***b* in FIG. **1**B. When viewed from the right side of snowmobile **10**, endless track **40** rotates around track frame **34** and idler wheels **38** in the clockwise direction, as indicated by arrow **48***a*, to propel snowmobile **10** in the forward direction **46***a*. Endless track **40** rotates around track frame **34** and idler wheels **38** in the counterclockwise direction, as indicated by arrow **48***b*, to propel snowmobile **10** in the backward direction **46***b*. The forward and backward directions also represent the longitudinal direction of snowmobile **10** with the lateral direction of snowmobile **10** being normal thereto and represented by the rightward direction, as indicated by arrow **50***a*, and the leftward direction, as indicated by arrow **50***b* in FIG. **1**E. The backward direction may also be referred to herein as the aftward direction.

[0022] Snowmobile **10** has a steering system **52** that includes a handlebar assembly **54**, a steering column **56**, a steering arm assembly **58**, a right tie rod **60**, a left tie rod **62**, a right ski assembly **64** including a right spindle **64***a* and a right ski **64***b*, and left ski assembly **66** including a left spindle **66***a* and a left ski **66***b*. Right ski assembly **64** and left ski assembly **66** may be referred to collectively as the ski system of snowmobile **10**. Snowmobile **10** has a front suspension assembly **68** that is coupled between forward frame assembly **14** and ski assemblies **64**, **66** to provide front end support for snowmobile **10**. In addition, right ski assembly **64** is coupled to forward frame assembly **14** by upper and lower A-arms **70***a*, **70***b*, and left ski assembly **66** is coupled to forward frame assembly **14** by upper and lower A-arms **72***a*, **72***b*. Steering system **52** enables the rider to steer snowmobile **10** by rotating handlebar assembly **54** which causes ski assemblies **64**, **66** to pivot. In the illustrated embodiment, the pivoting of ski assemblies **64**, **66** responsive to rotation of handlebar assembly **54** is assisted by an electric power steering system (EPS) depicted as electronic steering assist unit **74**. As best seen in FIG. **2**, electronic steering assist unit **74** is positioned within an electronic steering assist unit bay **74***a* defined by nose assembly **14***m*. Electronic steering assist unit **74** is coupled to forward frame assembly **14** via a nose bracket **76***a* that is coupled between electronic steering assist unit **74** and nose truss **14***o* and an aft bracket **76***b* that is coupled between electronic steering assist unit **74** and lower cross member **14***l*. As best seen in FIGS. **1**D and **2**, lower cross member **14***l* is positioned between electronic steering assist unit **74** and engine **26**. In this position, lower cross member **14***l* resiliently supports engine **26** via right-front engine mount **78***a* and left-front engine mount **78***b*. Aft bracket **76***b* for electronic steering assist unit **74** is coupled to lower cross member **14***l* between right-front engine mount **78***a* and left-front engine mount **78***b*.

[0023] The rider controls snowmobile **10** from a seat **80** that is position atop a fuel tank **82**, above tunnel **18**, aft of handlebar assembly **54** and aft of forward frame assembly **14**. Snowmobile **10** has a lift bumper **84** that is coupled to an aft end of tunnel **18** that enables a person to lift the rear

end of snowmobile **10** in the event snowmobile **10** becomes stuck or needs to be repositioned when it is not moving. Snowmobile **10** has a snow flap **86** that deflects snow emitted by endless track **40**. In the illustrated embodiment, snow flap **86** is coupled to lift bumper **84**. In other embodiments, a snow flap may be coupled directly to tunnel **18**. A taillight housing **88** is also coupled to lift bumper **84** and houses a taillight of snowmobile **10**. Snowmobile **10** has an exhaust system **90** that includes an exhaust manifold **92** that is coupled to one or more exhaust outlets on the forward side of engine **26**, an exhaust duct **94** and a muffler **96**. Exhaust system **90** is configured to direct high-temperature exhaust gases away from engine **26** and the rider of snowmobile **10**. As exhaust system **90** including exhaust manifold **92** is coupled to the forward side of engine **26**, the forward side of engine **26** may be referred to herein as the hot side of engine **26** due to the hot temperatures associated with engine exhaust. The aftward side of engine **26** is concomitantly considered the cool side of engine **26** as hot exhaust system components are located opposite and/or remote therefrom.

[0024] It should be appreciated that snowmobile **10** is merely illustrative of a variety of vehicles that can implement the embodiments disclosed herein. Other vehicle implementations can include motorcycles, snow bikes, all-terrain vehicles (ATVs), utility vehicles, recreational vehicles, scooters, automobiles, mopeds, straddle-type vehicles and the like. As such, those skilled in the art will recognize that the embodiments disclosed herein can be integrated into a variety of vehicle configurations. It should be appreciated that even though ground-based vehicles are particularly well-suited to implement the embodiments of the present disclosure, airborne vehicles and devices such as aircraft can also implement the embodiments.

[0025] Referring additionally to FIG. **2** of the drawings, further details of snowmobile **10** will now be discussed. In the illustrated embodiments, engine **26** is an aftwardly tilted engine such that an upper portion of engine **26** is aft of a lower portion of engine **26**. For example, engine **26** is aftwardly tilted between five degrees and twenty degrees from vertical such as about ten degrees from vertical. It should be understood by those having ordinary skill in the art that engine **26** could have other aftwardly tilted angles both less than five degrees or greater than twenty degrees from vertical. Snowmobile **10** has an engine cooling system **100** that includes a radiator **102** and an arcuate heat exchanger **104**. Radiator **102** is coupled to forward frame assembly **14** and more specifically, radiator **102** is coupled to and positioned above nose assembly **14***m* of forward frame assembly **14**. In this location, radiator **102** is positioned forward of engine **26** and is tilted forward such that an upper portion of radiator **102** is forward of a lower portion of radiator **102**. Radiator **102** is configured to remove heat from a fluid circulating therethrough responsive to air passing through radiator **102** from the front side of radiator **102** to the rear side of radiator **102**. An arcuate heat exchanger **104** is coupled to a forward portion of tunnel **18** and to forward frame assembly **14**. In this location, arcuate heat exchanger **104** is positioned aft of engine **26** and below fuel tank **82**. Arcuate heat exchanger **104** is configured to remove heat from a fluid circulating therethrough responsive to snow in tunnel **18**. For example, during operation of snowmobile **10**, endless track **40** kicks snow toward an inner surface of arcuate heat exchanger **104** which is configured to retain at least a portion of this snow. Heat from the fluid circulating through arcuate heat exchanger **104** is transferred to the retained snow causing the retained snow to melt. As discussed herein, electronic steering assist unit **74** is positioned within electronic steering assist unit bay **74***a* defined by nose assembly **14***m* with nose bracket **76***a* coupled between electronic steering assist unit **74** and nose truss **14***o* and aft bracket **76***b* coupled between electronic steering assist unit **74** and lower cross member **14***l*. In this position, electronic steering assist unit **74** is positioned forward of engine **26** and below radiator **102** with at least a portion of electronic steering assist unit **74** forward of radiator **102**.

[0026] In the illustrated embodiment, engine **26** has an air intake system **110** that receives air from the atmosphere and distributes the air to each of the cylinders of engine **26**. More specifically, air intake system **110** includes an air inlet **112** that feeds air into an airbox **114** that is positioned generally forward and generally above engine **26**. Air from airbox **114** is routed to an air intake plenum **116** positioned above engine **26** via an air duct **118**. The volume of air delivered to air intake plenum **116** from airbox **114** is controlled via a throttle valve assembly **120**. Air intake plenum **116** is configured to damp the air flow prior to distribution of the air to the cylinders of engine **26** via air intake runners that extend downwardly and aftwardly from air intake plenum **116** and couple to one or more air inlets positioned on the aftward side of engine **26**.

[0027] Referring additionally to FIGS. **3**A-**3**E of the drawings, further details relating to steering system **52** of snowmobile **10** will now be disclosed. As discussed herein, steering system **52** includes handlebar assembly **54**, steering column **56**, steering arm assembly **58**, right tie rod **60**, left tie rod **62**, right ski assembly **64** including right spindle **64***a* and right ski **64***b*, and left ski assembly **66** including left spindle **66***a* and left ski **66***b*. In addition, steering system **52** includes electronic steering assist unit **74**. In the illustrated embodiment, steering column **56** is a straight steering column formed as a non-segmented single post that is positioned forward of upper cross member **14***k* and along a centerline of snowmobile **10**. In other embodiments, the steering column may be a segmented straight steering column that has upper and lower posts, a bent steering column including, for example, a universal joint between upper and lower posts, an articulated steering column that has multiple posts routed around other snowmobile components using multiple joints, a laterally offset steering column that extends downwardly, forwardly and laterally from the handlebar assembly to the lower steering assembly or other suitable connection between the handlebar assembly and the lower steering assembly. As best seen in FIG. **3**E, steering column **56** has an upper end **56***a* and lower end **56***b*. Upper end **56***a* of steering column **56** is coupled to handlebar assembly **54** via a handlebar bracket **54***a*. Lower end **56***b* of steering column **56** includes a splined coupler **56***c* that may be integral with or coupled to lower end **56***b* of steering column **56**. Splined coupler **56***c* receives an input shaft **122** having input splines **124** therein to couple lower end **56***b* of steering column **56** to electronic steering assist unit **74**. Steering arm assembly **58** includes a splined coupler **58***a* that receives an output shaft **126** having output splines **128** therein such that electronic steering assist unit **74** is coupled directly to steering arm assembly **58** without a steering column post or other extension positioned therebetween. In other embodiments, a steering column post or other extension may be positioned between electronic steering assist

unit **74** and steering arm assembly **58**. Steering arm assembly **58** is coupled to the proximal ends tie rods **60**, **62**. The distal ends of tie rods **60**, **62** are respectively coupled to ski assemblies **64**, **66** such that rotation of handlebar assembly **54** by the rider of snowmobile **10**, together with the assist of electronic steering assist unit **74**, causes ski assemblies **64**, **66** to pivot, thus turning snowmobile **10**. A lower end **58***b* of steering arm assembly **58** is received within a bearing assembly (not visible) of nose truss **14***o* such that steering arm assembly **58** is operable to rotate relative thereto.

[0028] Electronic steering assist unit **74** includes an outer housing **130** that contains the working components thereof including, for example, an electric motor, a torque sensor, a controller and a torsion bar that couples input shaft **122** to output shaft **126**. In other embodiments, an electronic steering assist unit may have an alternate shaft configuration including, for example, a single piece shaft design. Outer housing **130** is fixed against rotation relative to forward frame assembly **14** by brackets **76***a*, **76***b*. In operation, the input torque applied from handlebar assembly **54** via steering column **56** on input shaft **122** is measured by the torque sensor. Input torque data is then provided to the controller from the torque sensor. Based upon the input torque data and additional factors such as the speed of snowmobile **10**, the controller commands the electric motor to provide an output assist torque to output shaft **126** that is additive to the input torque applied to output shaft **126** from input shaft **122** via the torsion bar. The use of electronic steering assist unit **74** improves the handling of snowmobile **10**, reduces fatigue associated with driving snowmobile **10** and can allow snowmobile **10** to be driven more aggressively. In addition, coupling electronic steering assist unit **74** directly to steering arm assembly **58** has numerous advantages over prior snowmobile steering systems that have electronic steering assist units including lowering the center of gravity of snowmobile **10** by positioning the electronic steering assist unit at a lowermost location of the steering column. In addition, coupling electronic steering assist unit **74** directly to steering arm assembly **58**, together with using a straight steering column **56** and having a common axis of rotation **132** shared by handlebar assembly **54**, steering column **56**, electronic steering assist unit **74** and steering arm assembly **58** that is positioned along a centerline **134** (see FIG. **3**B) of snowmobile **10**, reduces the number of parts required in steering system **52** and reduces the complexity of steering system **52**, which improves the overall reliability of snowmobile **10**.

[0029] Referring now to FIGS. **4**A-**4**C of the drawings, various electrical system configurations for snowmobiles that are representative of snowmobile **10** and have an electronic steering assist unit, will now be disclosed. In FIG. **4**A, a snowmobile includes an engine **200**, such as a two-stroke engine, which is operably associated with a stator **202** that is used to generate an alternating current output. In the illustrated embodiment, stator **202** is a component within stator system **204** that also includes a regulator rectifier **206** that is operable to convert the alternating current output generated by stator **202** to multiple isolated direct current outputs that have constant voltages which stabilizes the variable voltage output produced by stator **202**. In other stator system embodiments, the regulator functionality and the rectifier functionality could be accomplished in separate components. Likewise, in other stator system embodiments, a regulator rectifier may produce a single direct current output that may be split into multiple isolated direct current outputs by a separate component including, for example, a diode. Engine **200** is operably coupled to a transmission **208**, such as a continuously variable transmission or an electrically variable transmission, which is operable to vary the ratio of the engine output speed to the track drive input speed. Transmission **208** is coupled to a drive track system **210** that includes an endless track driven by a track drive sprocket and a track driveshaft such that the endless track provides ground propulsion for the snowmobile. The snowmobile includes a steering system having a steering column that extends between a handlebar assembly and a ski system that provides front end ground support for the snowmobile. The steering system also includes an electronic steering assist unit **212** that is operably coupled to the steering column. The snowmobile also includes a battery **214** and a variety of electrical load components depicted as electrically powered accessories **216** including, for example, lights; gauges; computer processors for controllers, communication systems, GPS systems and the like; heaters such as hand warmers and seat warmers; a winch; a stereo and/or other components that are powered by electricity. Battery **214** may provide power to certain snowmobile components when engine **200** is operating. In addition, battery **214** may provide power to various snowmobile components when engine **200** is not operating such as to memory devices, a clock and snowmobile gauges as well as power to start the snowmobile.

[0030] Accessories **216** are designed to operate at a particular voltage, such as 12 VDC, and may be damaged or malfunction if the voltage within the accessory circuit **218** fluctuates significantly above or significantly below the design voltage. An electrical load component such as electronic steering assist unit **212** that has a high power demand as well as an intermittent power demand may tend to cause voltage fluctuations within the circuit in which it resides that can adversely affect other electrical load components within that circuit. The present embodiment avoids such voltage fluctuations in accessory circuit **218** by positioning electronic steering assist unit **212** in a separate circuit, denoted as electronic steering assist unit circuit **220**, that is isolated from accessory circuit **218**. Specifically, the output current from regulator rectifier **206** that powers accessory circuit **218** is not in communication with the output current that powers electronic steering assist unit circuit **220**. Instead, the output current from regulator rectifier **206** that charges battery **214** also powers electronic steering assist unit **212**. In the illustrated embodiment, battery **214** and electronic steering assist unit **212** are positioned in parallel within electronic steering assist unit circuit **220** enabling battery **214** to act as a store of energy for electronic steering assist unit **212** such that the intermittent high power demand of electronic steering assist unit **212** may be satisfied by drawing current from battery **214** when such demand exceeds the output from regulator rectifier **206**. This unique configuration electrically separates accessory circuit **218** from electronic steering assist unit circuit **220**, thereby isolating the intermittent power demand of electronic steering assist unit **212** from accessories **216** and protecting accessories **216** from voltage fluctuations.

[0031] In FIG. **4**B, a snowmobile includes an engine **230**, such as a two-stroke engine, which is operably associated with a stator **232** that is used to generate multiple alternating current outputs. In the illustrated embodiment, stator **232** is a dual output stator and is a component within stator system

234 that also includes a regulator rectifier 236 and a regulator rectifier 238. In other embodiments, the stator could have three, four or more alternating current outputs used to independently power various components or groups of components such as the accessories, an engine control module, the fuel pump, the fuel injectors or other engine or snowmobile systems. Engine 230 is operably coupled to a drive track system 240 via a transmission 242. The snowmobile includes a steering system having a steering column that extends between a handlebar assembly and a ski system. The steering system also includes an electronic steering assist unit 244 that is operably coupled to the steering column. The snowmobile also includes a battery 246 that may optionally be positioned in parallel with electronic steering assist unit 244 such that the output current from regulator rectifier 238 that charges battery 246 also powers electronic steering assist unit 244 with battery 246 acting as a store of energy for electronic steering assist unit 244 such that the intermittent high power demand of electronic steering assist unit 244 may be satisfied by drawing current from battery 246. Alternatively, battery 246 may be on another circuit that does not include electronic steering assist unit 244. The snowmobile includes an electrical load component depicted as engine control module 248 that manages and controls various functions of engine 230 to optimize performance, fuel efficiency and emissions such as regulating fuel injection, ignition timing and the air-fuel mixture as well as monitoring and responding to sensor data.

[0032] In the illustrated embodiment, engine control module 248 operates at a first voltage, such as 5 VDC, while electronic steering assist unit 244 operates at a second voltage, such as 12 VDC. To provide the multiple output voltages required by engine control module 248 and electronic steering assist unit 244, stator 232 has two separate coils such that stator 232 is operable to generate two output currents. In the present example, stator 232 has an engine control module coil that outputs an AC voltage to regulator rectifier 236 that in turn supplies 5 VDC to engine control module circuit 250. In addition, stator 232 has an electronic steering assist unit coil that outputs an AC voltage to regulator rectifier 238 that in turn supplies 12 VDC to electronic steering assist unit circuit 252. The present embodiment avoids voltage fluctuations in engine control module 248 by positioning engine module 248 and electronic steering assist unit 244 in separate circuits. This unique configuration not only allows engine control module 248 and electronic steering assist unit 244 to operate at different voltages, but also electrically separates engine control module circuit 250 from electronic steering assist unit circuit 252, thereby isolating the intermittent power demand of electronic steering assist unit 244 from engine control module 248. It should be noted that the engine control module may send trigger signals to power on and off the electronic steering assist units of the present disclosure. In addition, the engine control module may provide controller functionality for the electronic steering assist units of the present disclosure. In some embodiments, the electronic steering assist units of the present disclosure may be powered on and off manually enabling both a power steering mode and a manual steering mode for the snowmobile.

[0033] In FIG. 4C, a snowmobile includes an engine 260, such as a two-stroke engine, which is operably associated with a stator 262 that is used to generate two alternating current outputs. In the illustrated embodiment, stator 262 is a dual output stator and is a component within stator system 264 that also includes a regulator rectifier 266 and a regulator rectifier 268. Engine 260 is operably coupled to a drive track system 270 via a transmission 272. The snowmobile includes a steering system having a steering column that extends between a handlebar assembly and a ski system. The steering system also includes an electronic steering assist unit 274 that is operably coupled to the steering column. The snowmobile also includes a battery 276 that may optionally be positioned in parallel with electronic steering assist unit 274 such that the output current from regulator rectifier 268 that charges battery 276 also powers electronic steering assist unit 274 with battery 276 acting as a store of energy for electronic steering assist unit 274 such that the intermittent high power demand of electronic steering assist unit 274 may be satisfied by drawing current from battery 276. Alternatively, battery 276 may be on another circuit that does not include electronic steering assist unit 274. The snowmobile includes a variety of electrical load components depicted as accessories 278 including, for example, lights; gauges; computer processors for controllers, communication systems, GPS systems and the like; heaters such as hand warmers and seat warmers; a winch; a stereo and/or other components that are powered by electricity.

[0034] In the illustrated embodiment, accessories 278 and electronic steering assist unit 274 may operates at the same or different voltages. In either case, stator 262 has an accessories coil that outputs an AC voltage to regulator rectifier 266 that in turns supplies the desired voltage, such as 12 VDC, to accessories circuit 280. In addition, stator 262 has an electronic steering assist unit coil that outputs an AC voltage to regulator rectifier 268 that in turn supplies the desired voltage, such as 12 VDC, to electronic steering assist unit circuit 282. As such, the present embodiment avoids voltage fluctuations in accessories 278 by positioning accessories 278 and electronic steering assist unit 274 in separate circuits. This unique configuration not only allows accessories 278 and electronic steering assist unit 244 to operate at different voltages (if desired), but also electrically separates accessories circuit 280 from electronic steering assist unit circuit 282, thereby isolating the intermittent power demand of electronic steering assist unit 274 from accessories 278.

[0035] Referring now to FIGS. 5A-5C of the drawings, various electrical system configurations for snowmobiles that are representative of snowmobile 10 and has an electronic steering assist unit, will now be disclosed. In FIG. 5A, a snowmobile includes an electric motor 300 that operates at a design voltage of, for example, at least 48 VDC such as between 48 VDC and 300 VDC. Electric motor 300 is operably coupled to a drive track system 302 that includes an endless track driven by a track drive sprocket and a track driveshaft such that the endless track provides ground propulsion for the snowmobile. An optional transmission 304 may be positioned between electric motor 300 and drive track system 302. The snowmobile includes a steering system having a steering column that extends between a handlebar assembly and a ski system that provides front end ground support for the snowmobile. The steering system also includes an electronic steering assist unit 306 that is operably coupled to the steering column. The snowmobile has a power supply that includes, for example, a plurality of battery cells and a battery management system, depicted as battery 308 that has a suitable capacity and voltage for operating electric motor 300 for a desired period of time. In

the illustrated embodiment, electronic steering assist unit **306** operates at the same voltage as electric motor **300**, such as 48 VDC, enabling electronic steering assist unit **306** and electric motor **300** to reside in the same circuit. Battery **308** is configured to maintain a substantially constant output voltage with variations in load current such that the intermittent power demands of electronic steering assist unit **306** and electric motor **300** tend not to cause voltage fluctuations within the circuit and thus, electronic steering assist unit **306** and electric motor **300** need not be isolated from one another on separate circuits.

[0036] In FIG. **5**B, a snowmobile includes an electric motor **310** that operates at a design voltage of, for example, at least 48 VDC such as between 48 VDC and 300 VDC. Electric motor **310** is operably coupled to a drive track system **312** via an optional transmission **314**. The snowmobile includes a steering system having a steering column that extends between a handlebar assembly and a ski system that provides front end ground support for the snowmobile. The steering system also includes an electronic steering assist unit **316** that is operably coupled to the steering column. Electronic steering assist unit **316** operates at a design voltage of, for example, 12 VDC. The snowmobile has a power supply **318** that includes, for example, a high voltage battery **320** and a low voltage battery **322**. In the illustrated embodiment, battery **320** supplies electric power to electric motor **310** while battery **322** supplies electric power to electronic steering assist unit **316**. In this manner, each of electric motor **310** and electronic steering assist unit **316** may operate at a desired voltage.

[0037] In FIG. **5**C, a snowmobile includes an electric motor **330** that operates at a design voltage of, for example, at least 48 VDC such as between 48 VDC and 300 VDC. Electric motor **330** is operably coupled to a drive track system **332** via an optional transmission **334**. The snowmobile includes a steering system having a steering column that extends between a handlebar assembly and a ski system that provides front end ground support for the snowmobile. The steering system also includes an electronic steering assist unit **336** that is operably coupled to the steering column. Electronic steering assist unit **336** operates at a design voltage of, for example, 12 VDC. The snowmobile has a power supply **338** that includes, for example, a high voltage battery **340** and a voltage converter depicted as DC to DC converter **342**. In the illustrated embodiment, battery **340** supplies electric power to electric motor **330** at the high voltage level and supplies electric power to electronic steering assist unit **336** at the lower voltage level via DC to DC converter **342**. In this manner, each of electric motor **330** and electronic steering assist unit **336** may operate at a desired voltage.

[0038] The foregoing description of embodiments of the disclosure has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of the disclosure. The embodiments were chosen and described in order to explain the principals of the disclosure and its practical application to enable one skilled in the art to utilize the disclosure in various embodiments and with various modifications as are suited to the particular use contemplated. For example, numerous combinations of the features disclosed herein will be apparent to persons skilled in the art including the combining of features described in different and diverse embodiments, implementations, contexts, applications and/or figures. Other substitutions, modifications, changes and omissions may be made in the design, operating conditions and arrangement of the embodiments without departing from the scope of the present disclosure. Such modifications and combinations of the illustrative embodiments as well as other embodiments will be apparent to persons skilled in the art upon reference to the description. It is, therefore, intended that the appended claims encompass any such modifications or embodiments.

What is claimed is:

1. A snowmobile having a ski system, the snowmobile comprising:

a drive track system including an endless track configured to provide ground propulsion for the snowmobile;

an internal combustion engine configured to provide torque and rotational energy to the drive track system;

a stator system operably associated with the engine, the stator system configured to output first and second direct currents;

at least one electrical load component positioned in a first circuit associated with the first direct current; and

a steering system operatively coupled to the ski system, the steering system including an electronic steering assist unit;

wherein, the electronic steering assist unit is positioned in a second circuit associated with the second direct current.

2. The snowmobile as recited in claim **1** wherein, the engine is a two-stroke engine.

3. The snowmobile as recited in claim **1** wherein, the at least one electrical load component is an engine control module.

4. The snowmobile as recited in claim **1** wherein, the at least one electrical load component includes one or more of lights, gauges, computer processors, heaters, a winch and a stereo.

5. The snowmobile as recited in claim **1** wherein, the stator system further comprises a stator and a regulator rectifier;

wherein, the stator outputs an alternating current to the regulator rectifier; and

wherein, the regulator rectifier outputs the first direct current to the first circuit and the second direct current to the second circuit.

6. The snowmobile as recited in claim **5** further comprising a battery positioned in parallel with the electronic steering assist unit in the second circuit;

wherein, the battery is configured to be charged by the second direct current; and

wherein, the battery is configured as a store of energy for the electronic steering assist unit such that an intermittent high power demand of the electronic steering assist unit is satisfied by drawing current from the battery.

7. The snowmobile as recited in claim **1** wherein, the stator system further comprises a stator, a first regulator rectifier and a second regulator rectifier;

wherein, the stator outputs a first alternating current to the first regulator rectifier and a second alternating current to the second regulator rectifier; and

wherein, the first regulator rectifier outputs the first direct current to the first circuit and the second regulator rectifier outputs the second direct current to the second circuit.

8. The snowmobile as recited in claim **7** further comprising a battery positioned in parallel with the electronic steering assist unit in the second circuit;

wherein, the battery is configured to be charged by the second direct current; and

wherein, the battery is configured as a store of energy for the electronic steering assist unit such that an intermittent high power demand of the electronic steering assist unit is satisfied by drawing current from the battery.

9. The snowmobile as recited in claim **1** wherein, the first and second direct currents are at the same voltage.

10. The snowmobile as recited in claim **1** wherein, the first and second direct currents are at different voltages.

11. The snowmobile as recited in claim **1** further comprising a battery that is configured to be charged by the second direct current.

12. The snowmobile as recited in claim **11** wherein, the battery is positioned in parallel with the electronic steering assist unit in the second circuit; and

wherein, the battery is configured as a store of energy for the electronic steering assist unit such that an intermittent high power demand of the electronic steering assist unit is satisfied by drawing current from the battery.

13. A snowmobile having a ski system, the snowmobile comprising:

a drive track system including an endless track configured to provide ground propulsion for the snowmobile;

an electric motor configured to provide torque and rotational energy to the drive track system;

a steering system operatively coupled to the ski system, the steering system including an electronic steering assist unit; and

a power supply configured to supply electric power to the electric motor and the electronic steering assist unit.

14. The snowmobile as recited in claim **13** wherein, the power supply further comprises a battery having an output voltage; and

wherein, both the electric motor and the electronic steering assist unit operate at the output voltage.

15. The snowmobile as recited in claim **14** wherein, the output voltage of the battery is between 48 volts and 300 volts.

16. The snowmobile as recited in claim **13** wherein, the electric motor operates at a first voltage and the electronic steering assist unit operates at a second voltage that is less than the first voltage; and

wherein, the power supply further comprises a first battery having an output voltage of the first voltage and a second battery having an output voltage of the second voltage.

17. The snowmobile as recited in claim **16** wherein, the first voltage is between 48 volts and 300 volts; and

wherein, the second voltage is about 12 volts.

18. The snowmobile as recited in claim **13** wherein, the electric motor operates at a first voltage and the electronic steering assist unit operates at a second voltage that is less than the first voltage; and

wherein, the power supply further comprises a battery having an output voltage of the first voltage and a DC to DC converter electrically coupled between the battery and the electronic steering assist unit, the DC to DC converter configured to convert the first voltage to the second voltage.

19. The snowmobile as recited in claim **18** wherein, the first voltage is between 48 volts and 300 volts; and

wherein, the second voltage is about 12 volts.

20. A method of electrically isolating an electronic steering assist unit from at least one electrical load component of a snowmobile, the method comprising:

outputting first and second direct currents from a stator system operably associated with an internal combustion engine;

positioning the at least one electrical load component in a first circuit associated with the first direct current; and

positioning the electronic steering assist unit in a second circuit associated with the second direct current.

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