US 20250026444A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0026444 A1**

Sibilleau et al. (43) **Pub. Date: Jan. 23, 2025**

(54) **STEERING SYSTEMS FOR SNOWMOBILES**

(71) Applicant: **Arctic Cat Inc.**, Thief River Falls, MN (US)

(72) Inventors: **Guy L. Sibilleau**, Roseau, MN (US); **David L. Vigen**, Thief River Falls, MN (US)

(73) Assignee: **Arctic Cat Inc.**, Thief River Falls, MN (US)

(21) Appl. No.: **18/669,805**

(22) Filed: **May 21, 2024**

Related U.S. Application Data

(60) Provisional application No. 63/528,374, filed on Jul. 22, 2023.

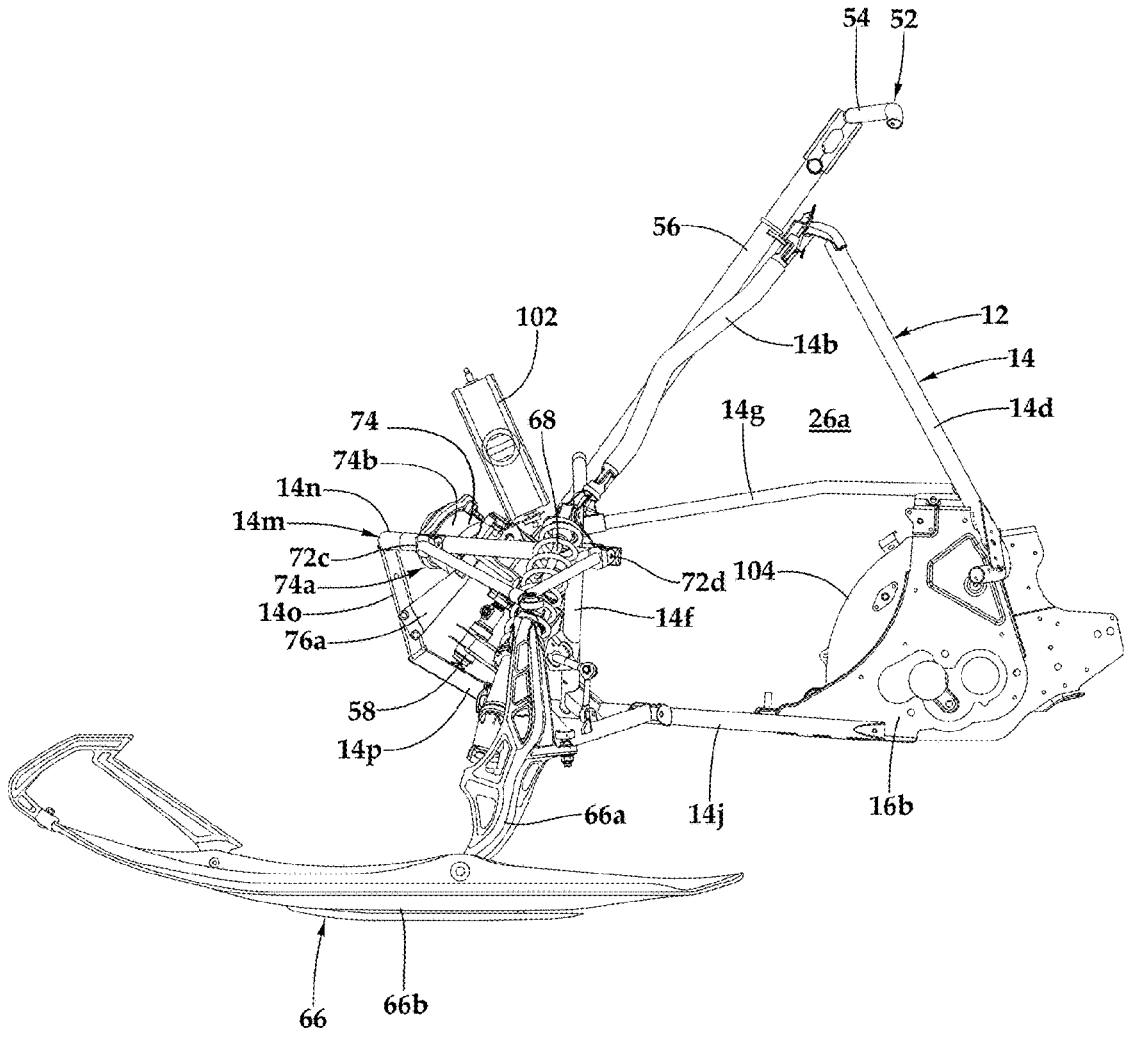
Publication Classification

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

(52) **U.S. Cl.**
CPC ***B62M 27/02*** (2013.01); *B62M 2027/023* (2013.01); *B62M 2027/025* (2013.01); *B62M 2027/028* (2013.01)

(57) **ABSTRACT**

A steering system for a snowmobile includes a handlebar assembly and a steering column that has upper and lower ends. The upper end of the steering column is coupled to the handlebar assembly. The lower end of the steering column is coupled to an input shaft of an electronic steering assist unit. An output shaft of the electronic steering assist unit is coupled directly to a steering arm assembly. First and second tie rods respectively couple the steering arm assembly to first and second ski assemblies such that turning the handlebar assembly, together with the assistance of the electronic steering assist unit, causes the ski assemblies to pivot. The steering column and the electronic steering assist unit share a common axis of rotation that is positioned along a centerline of the snowmobile.



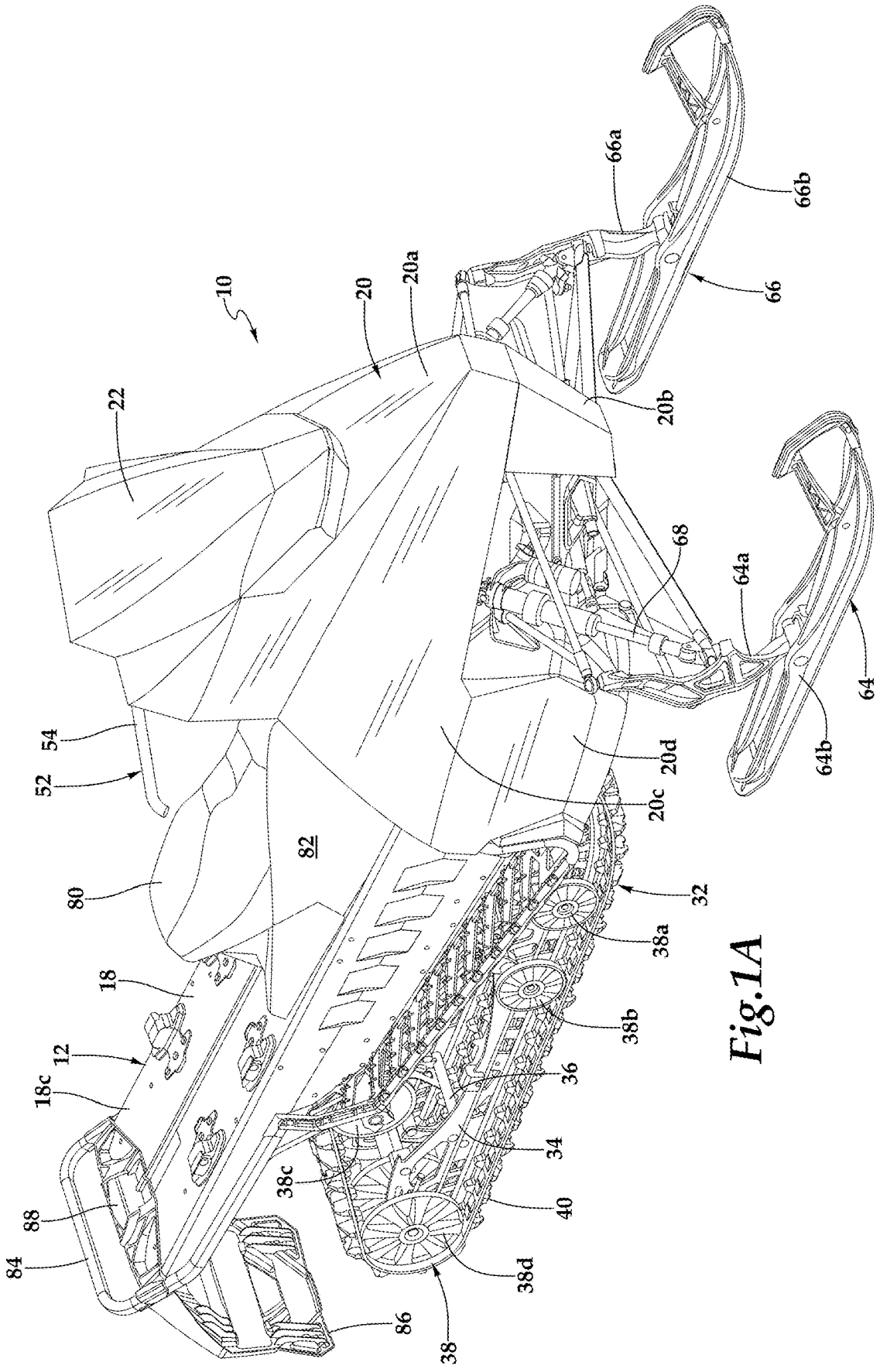

10
12
18
18c
20
20a
20b
20c
20d
22
32
34
36
38
38a
38b
38c
38d
40
52
54
64
64a
64b
66
66a
66b
68
80
82
84
86
88

Fig.1A

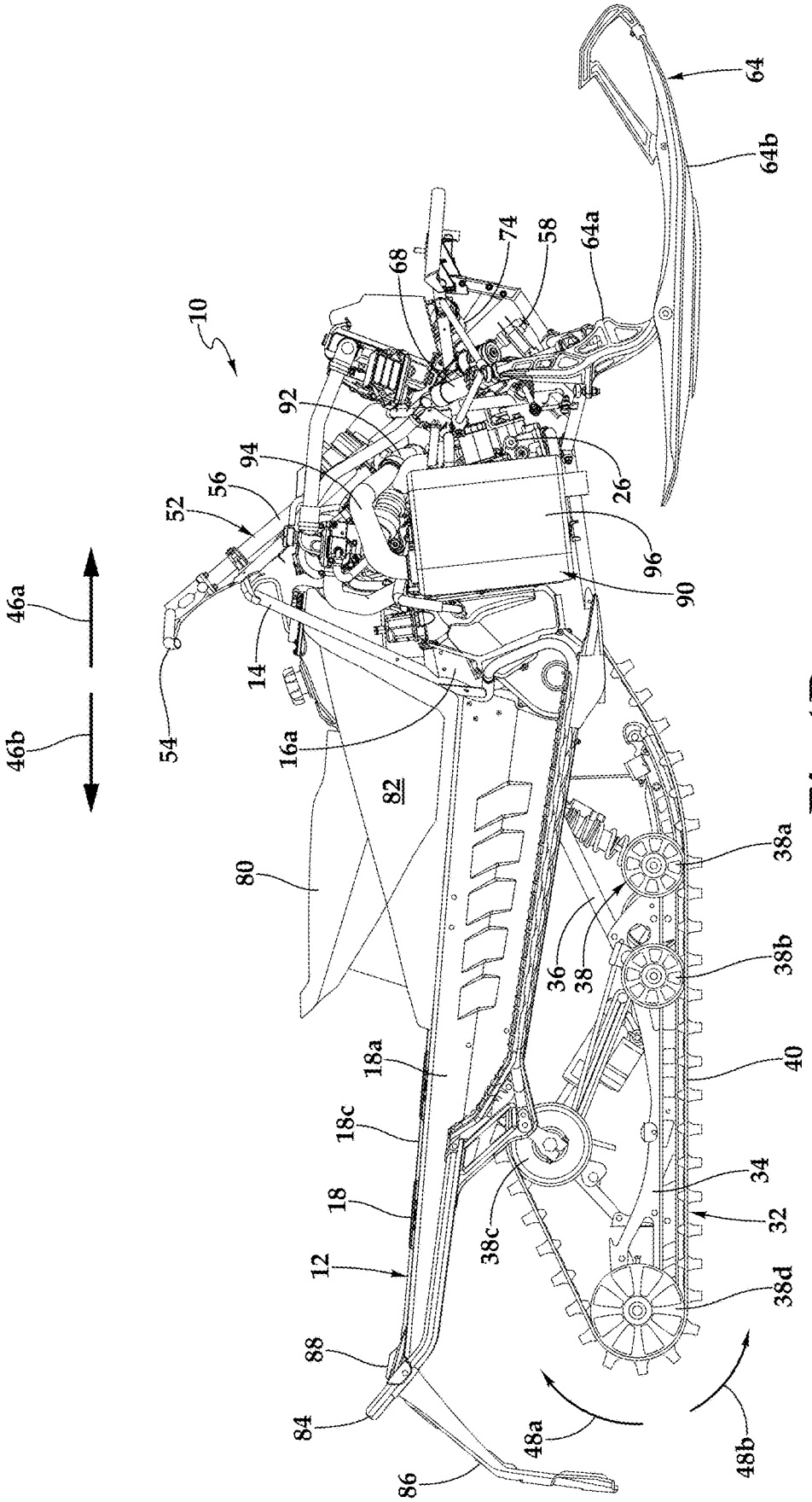

64
64b
64a
74
58
68
10
92
94
56
52
26
96
90
46a
46b
54
14
16a
82
80
38a
38b
36
38
18a
18c
18
12
38c
34
32
40
38d
88
84
86
48a
48b

Fig.1B

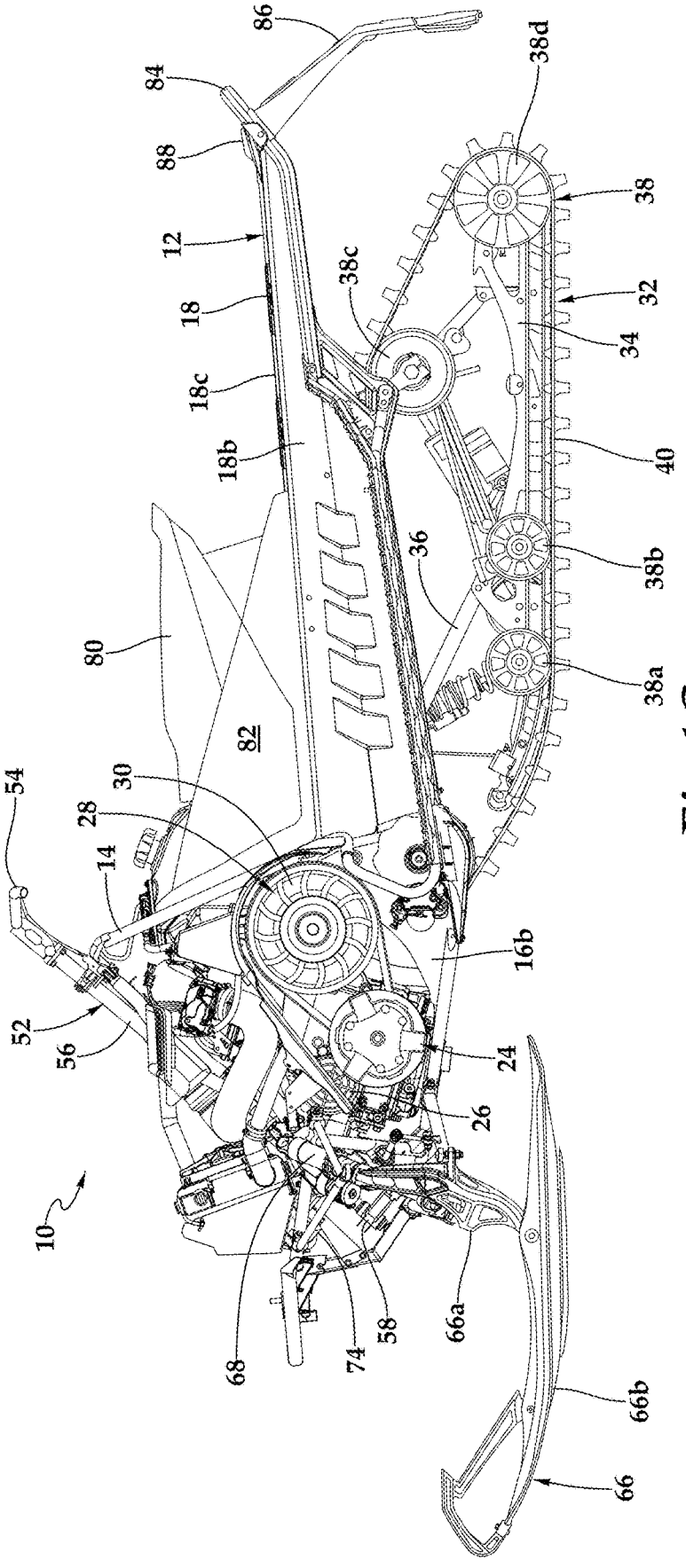

86
84
88
12
18
18c
18b
38d
38
38c
32
34
40
36
38b
38a
80
82
54
30
28
14
16b
52
56
24
26
10
68
74
58
66a
66b
66

Fig.1C

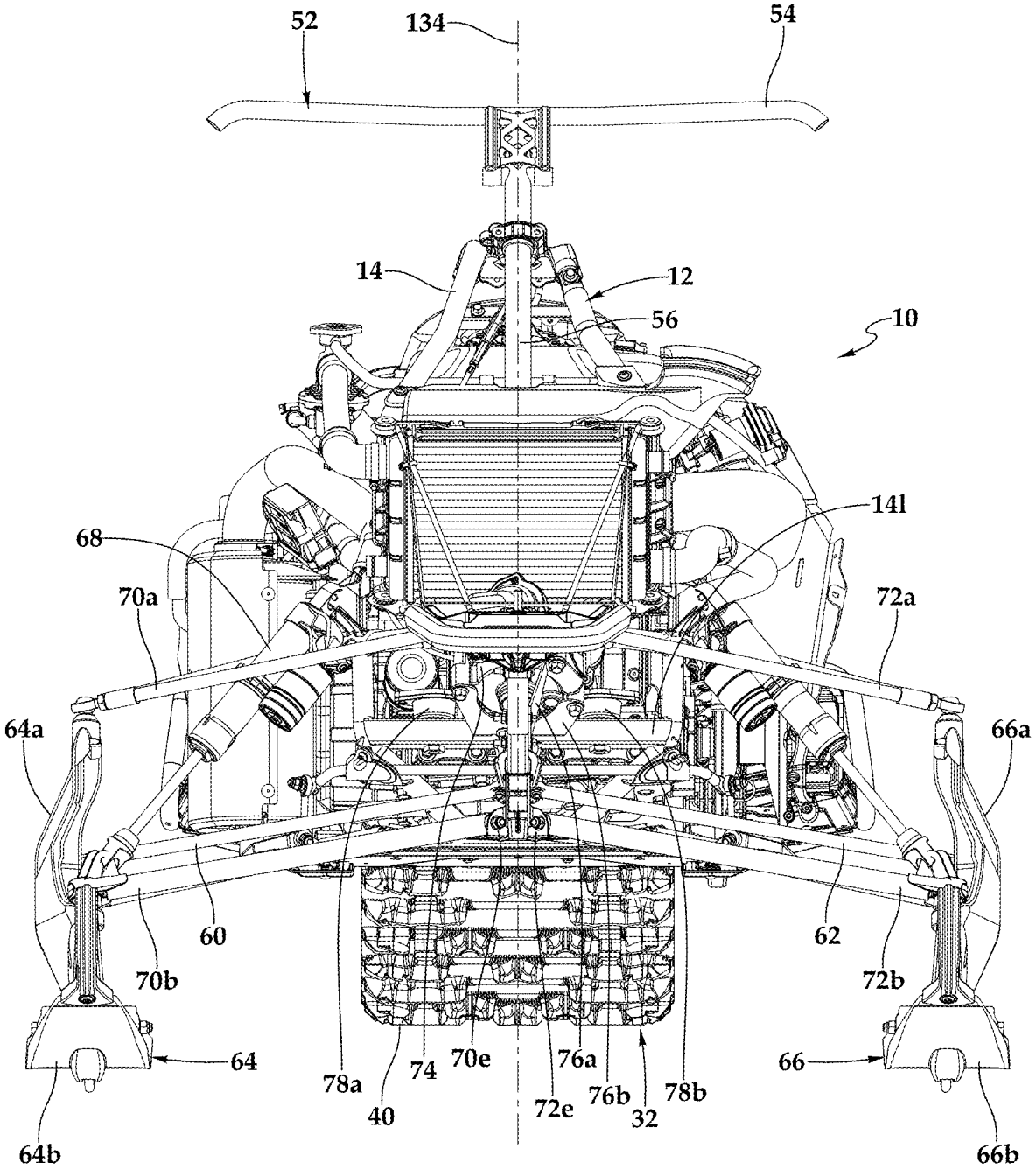

52
134
54
14
12
56
10
141
68
70a
72a
64a
66a
60
62
70b
72b
64
66
78a
74
70e
76a
72e
76b
32
78b
40
64b
66b

Fig.1D

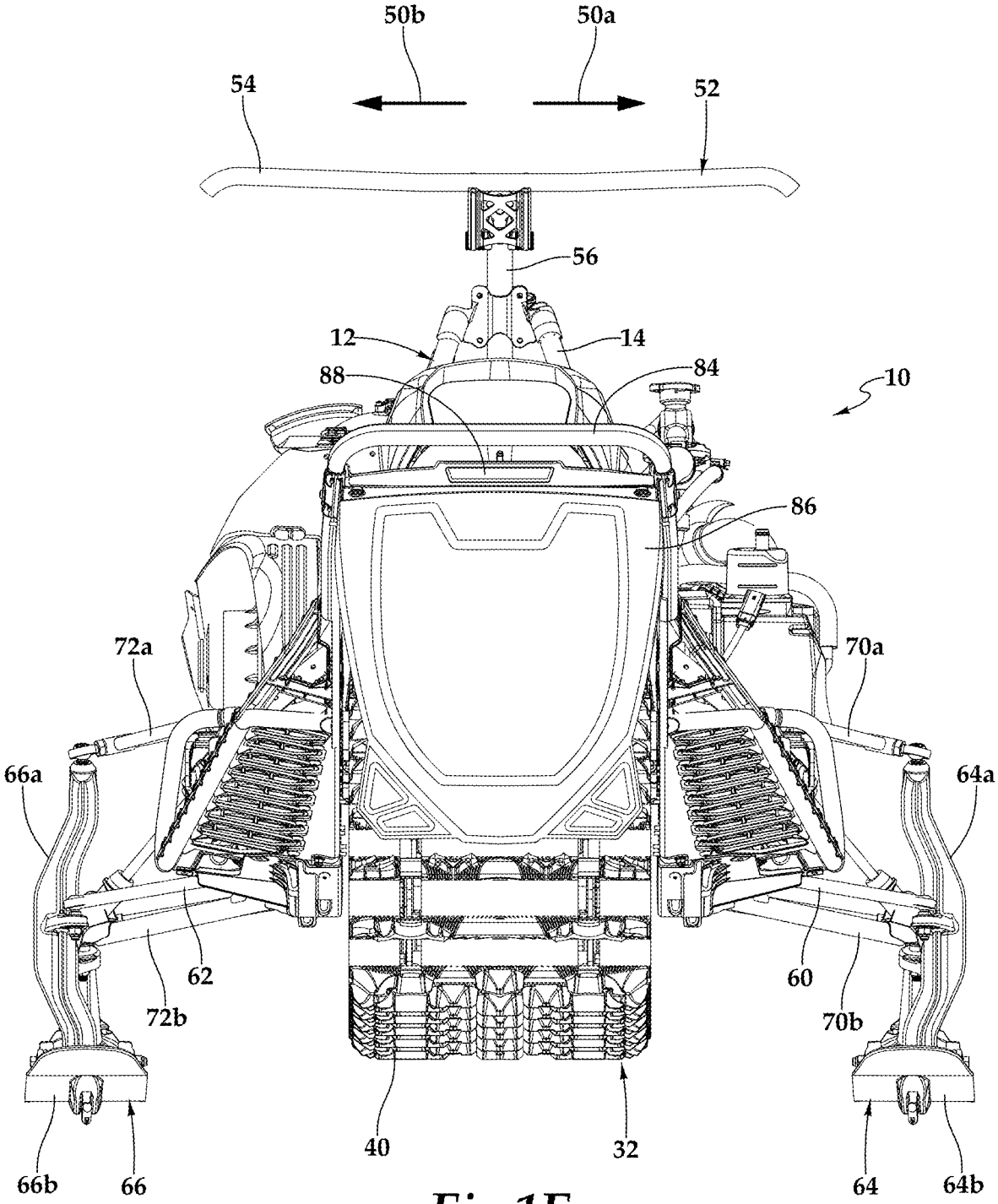

50b
50a
54
52
56
12
14
88
84
10
86
72a
70a
66a
64a
62
60
72b
70b
40
32
66b
66
64
64b

Fig.1E

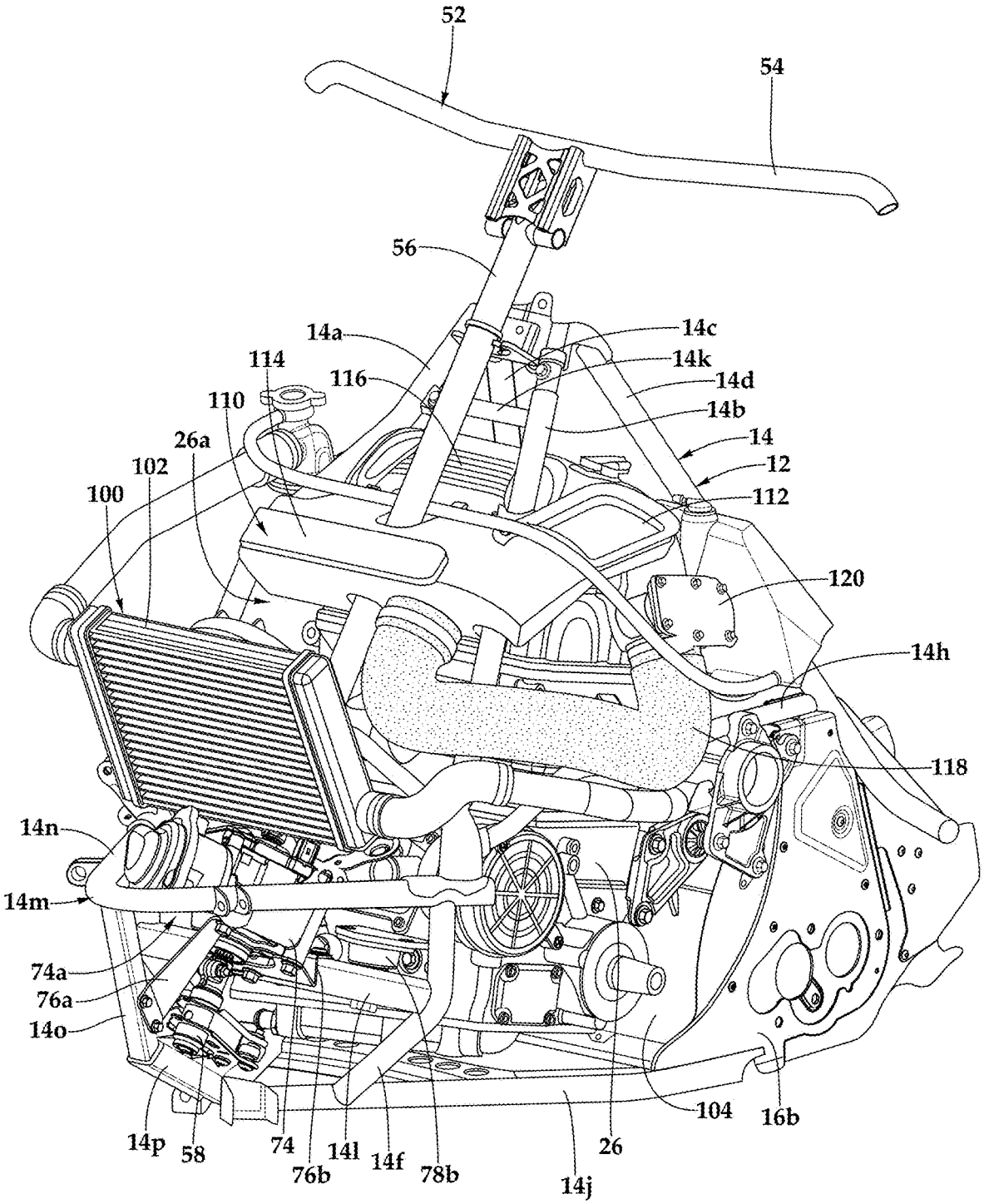

52
54
56
14a
14c
114
14k
116
14d
110
14b
26a
14
102
12
100
112
120
14h
118
14n
14m
74a
76a
14o
14p
58
74
76b
14l
14f
78b
14j
26
104
16b

Fig.2A

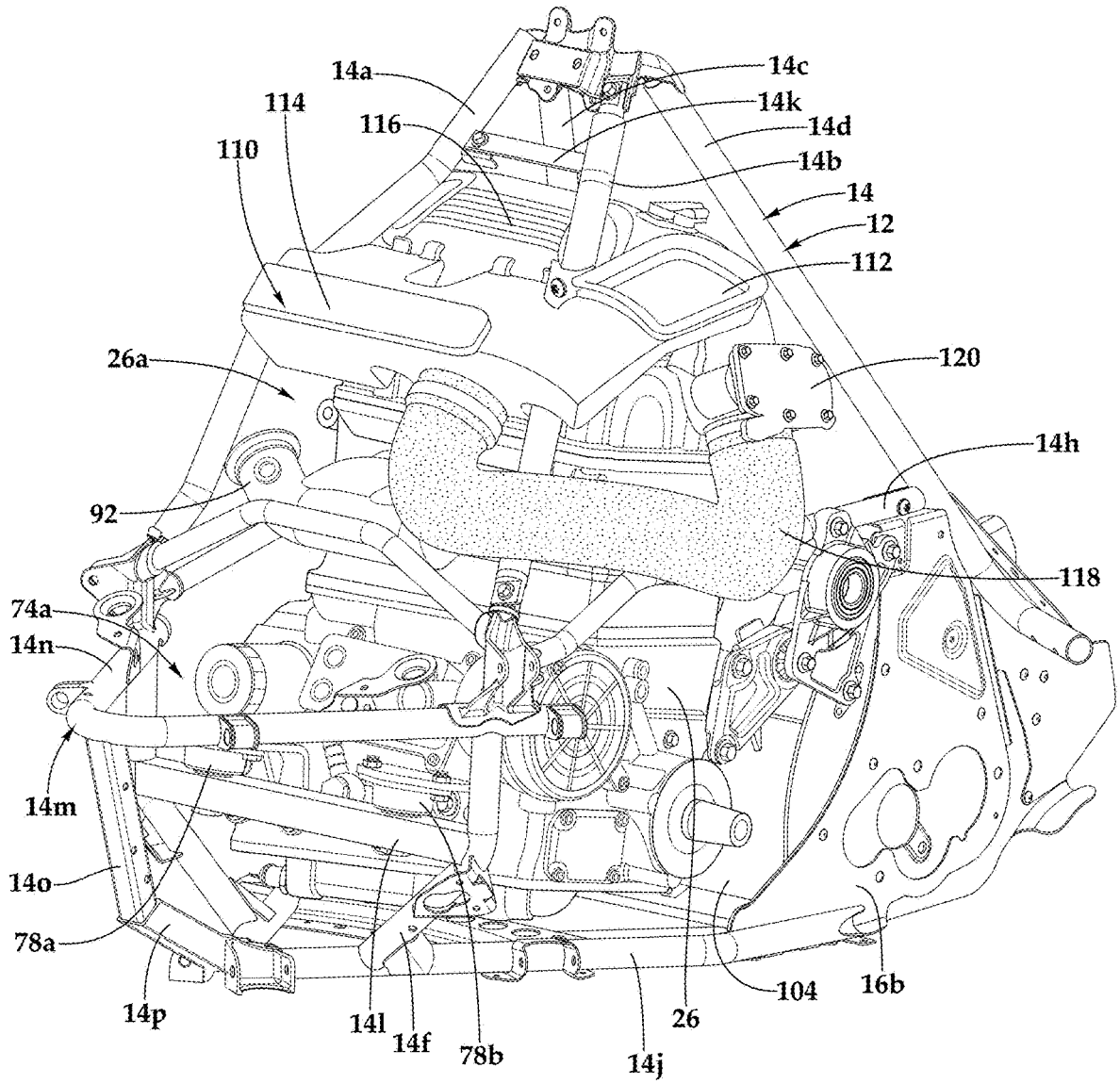

14a
14c
114
14k
116
14d
110
14b
14
12
112
26a
120
14h
92
118
74a
14n
14m
14o
78a
14p
14l
14f
78b
14j
26
104
16b

Fig.2B

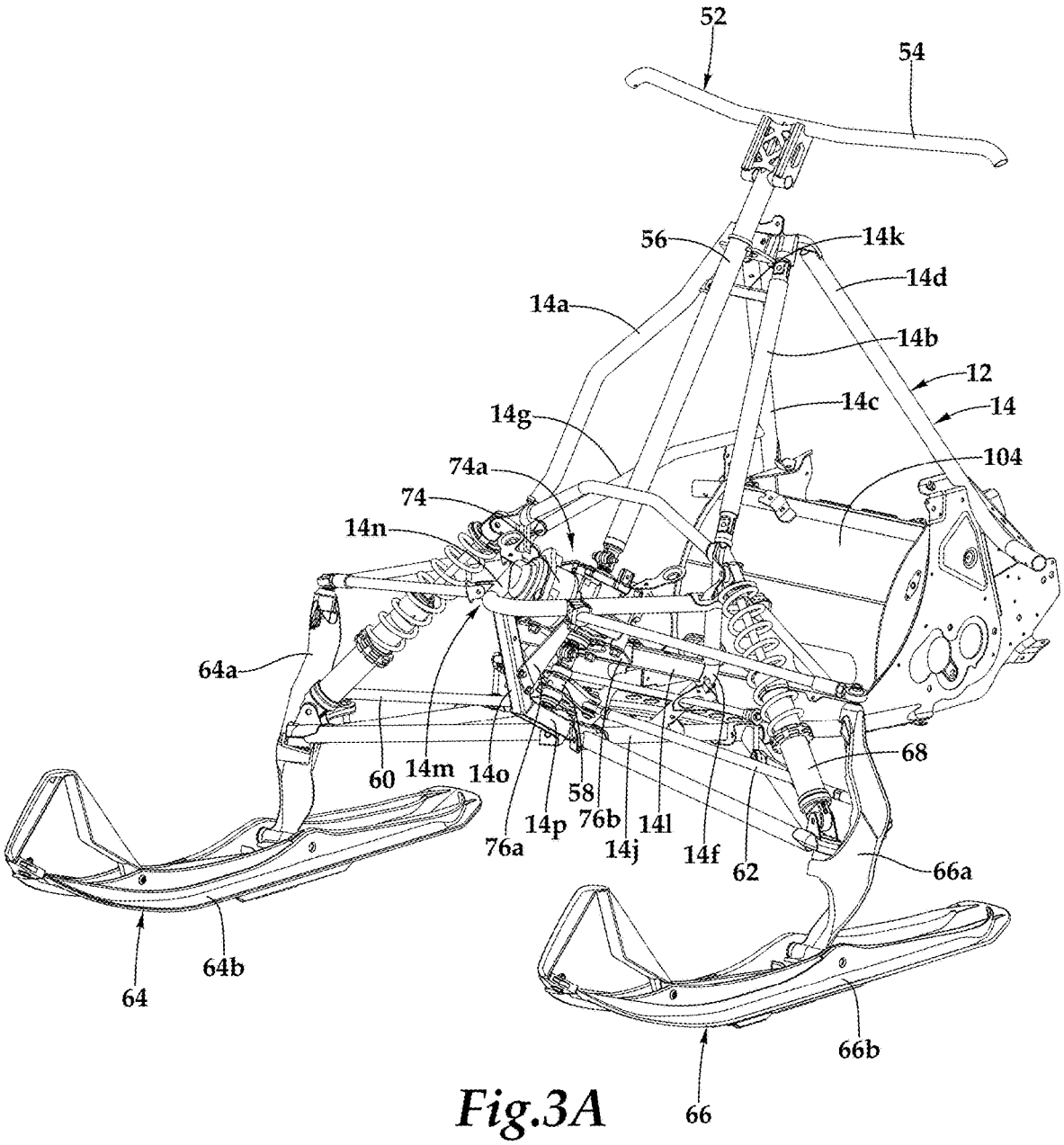

52
54
56
14k
14d
14a
14b
12
14c
14
14g
104
74a
74
14n
64a
68
60
14m
14o
58
14p
76b
14l
76a
14j
14f
62
66a
64
64b
66b
66

Fig.3A

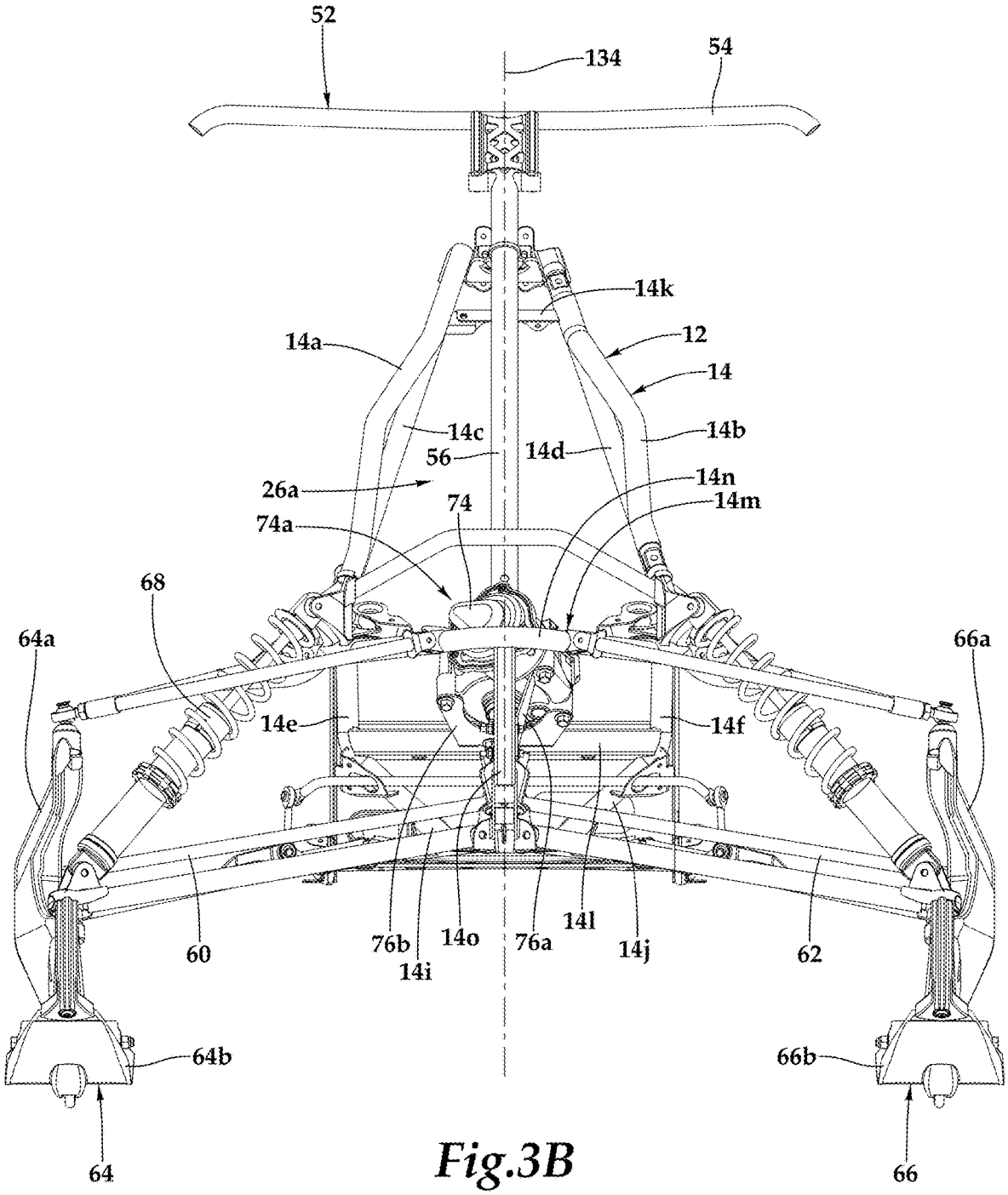

52
134
54
14k
14a
12
14
14c
14b
56
14d
14n
26a
74
14m
74a
68
64a
66a
14e
14f
60
76b
14o
76a
14l
14j
62
14i
64b
66b
64
66

Fig.3B

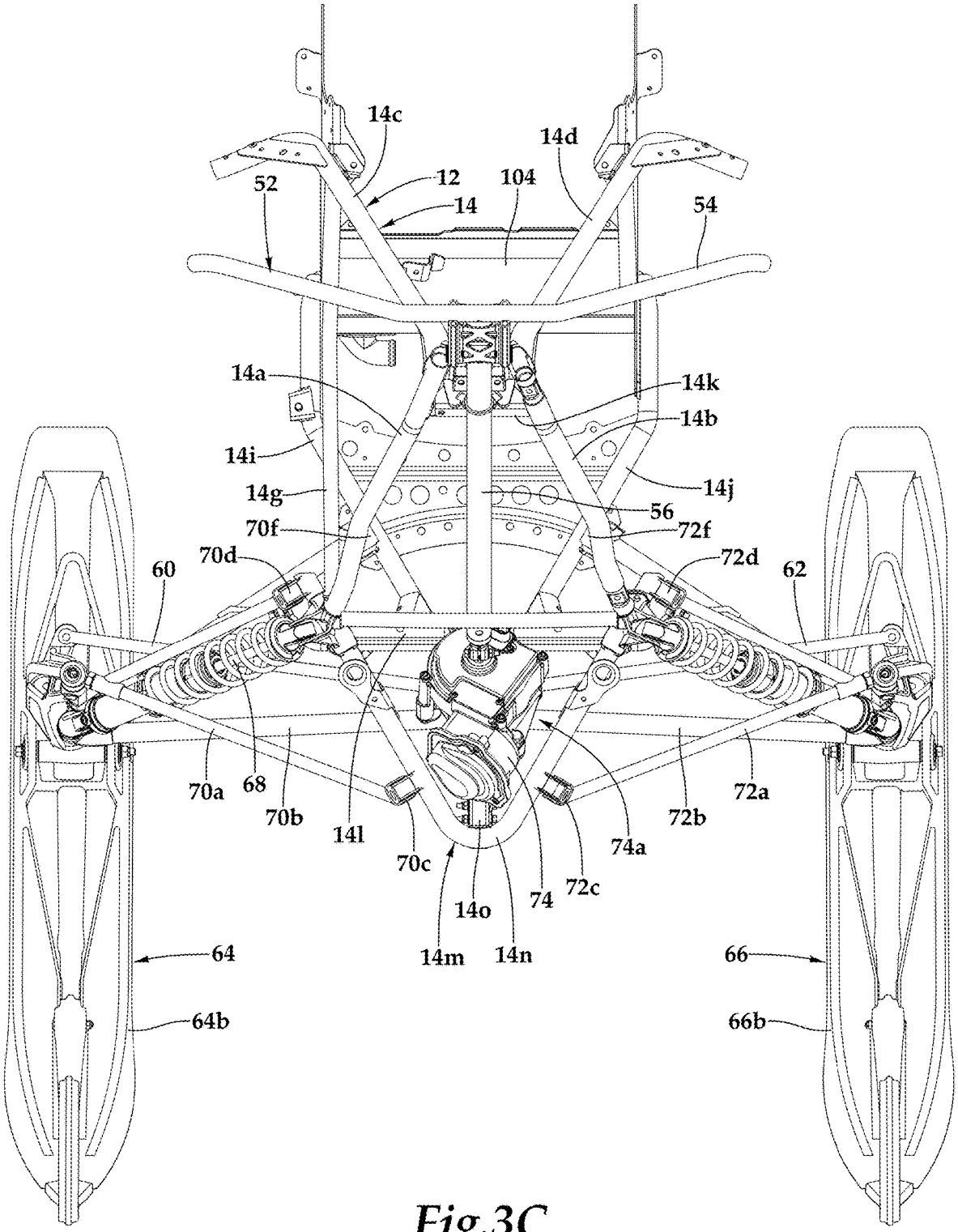

14c
14d
12
104
52
14
54
14a
14k
14b
14i
14j
14g
56
70f
72f
70d
72d
60
62
70a
68
70b
14l
70c
74a
72b
72a
74
72c
14o
14m
14n
64
66
64b
66b

Fig.3C

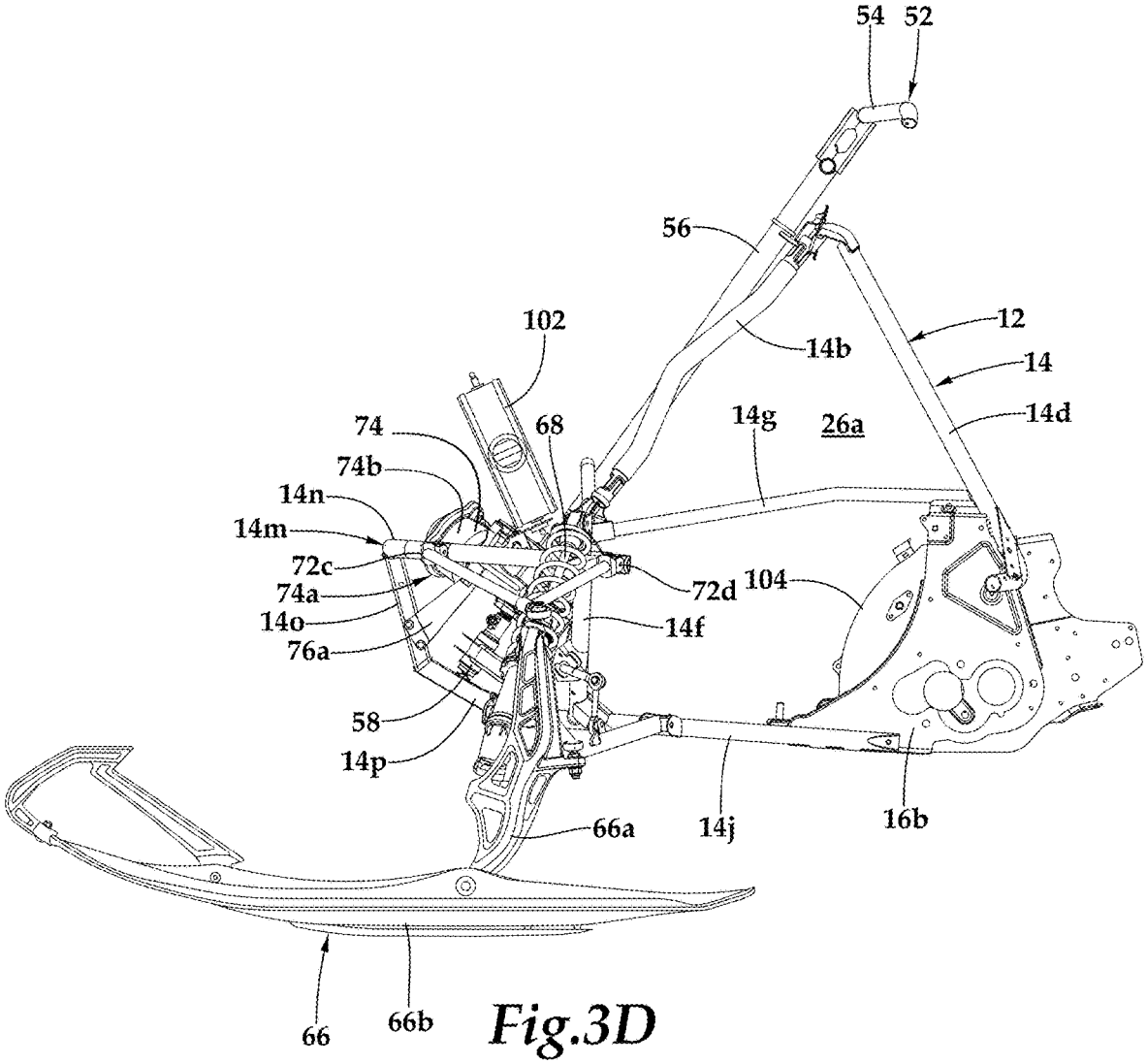

54
52
56
102
14b
12
14
14d
74
68
14g
26a
74b
14n
14m
72c
74a
14o
76a
72d
104
14f
58
14p
66a
14j
16b
66
66b

Fig.3D

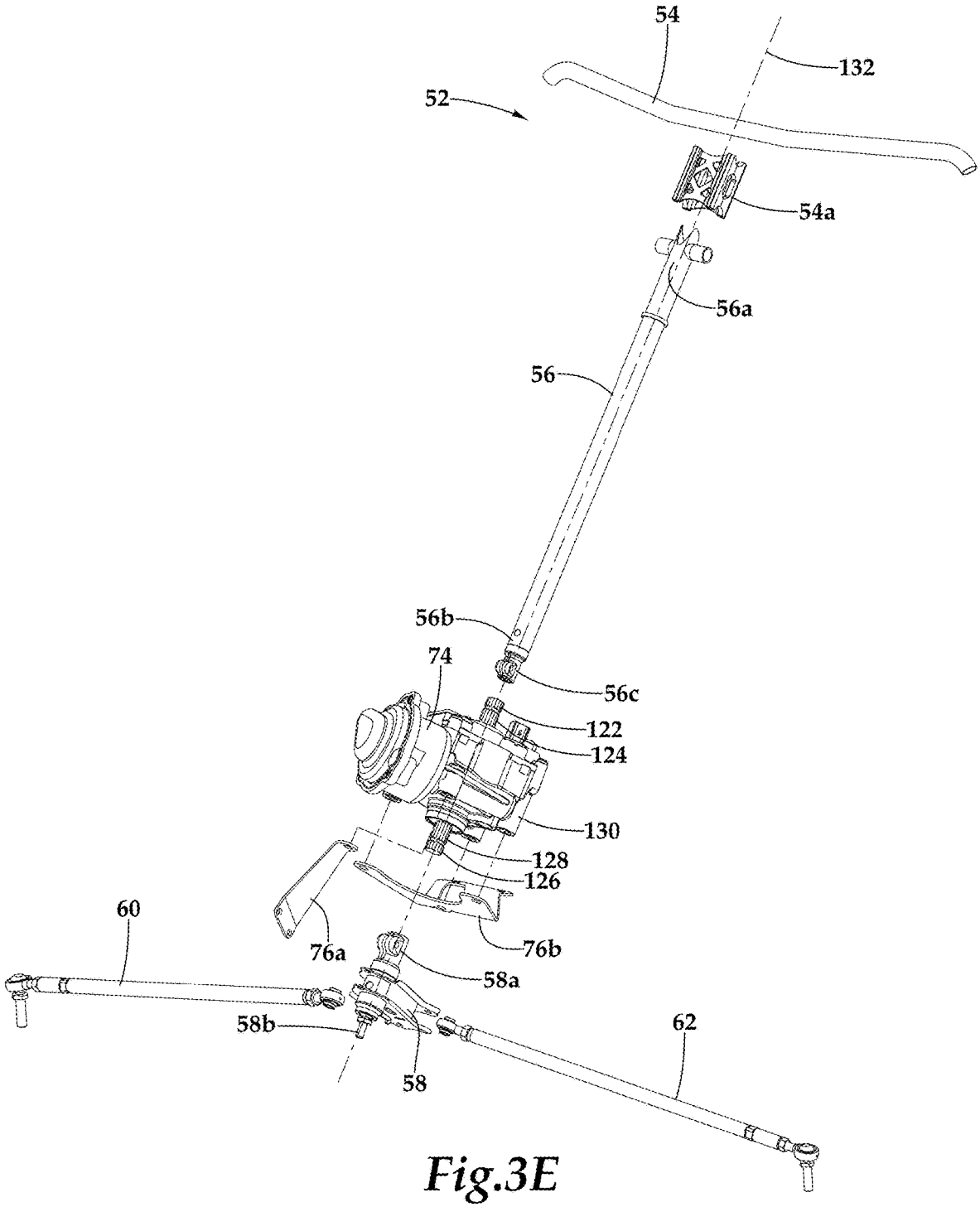

54
132
52
54a
56a
56
56b
74
56c
122
124
130
128
126
60
76a
76b
58a
58b
62
58

Fig.3E

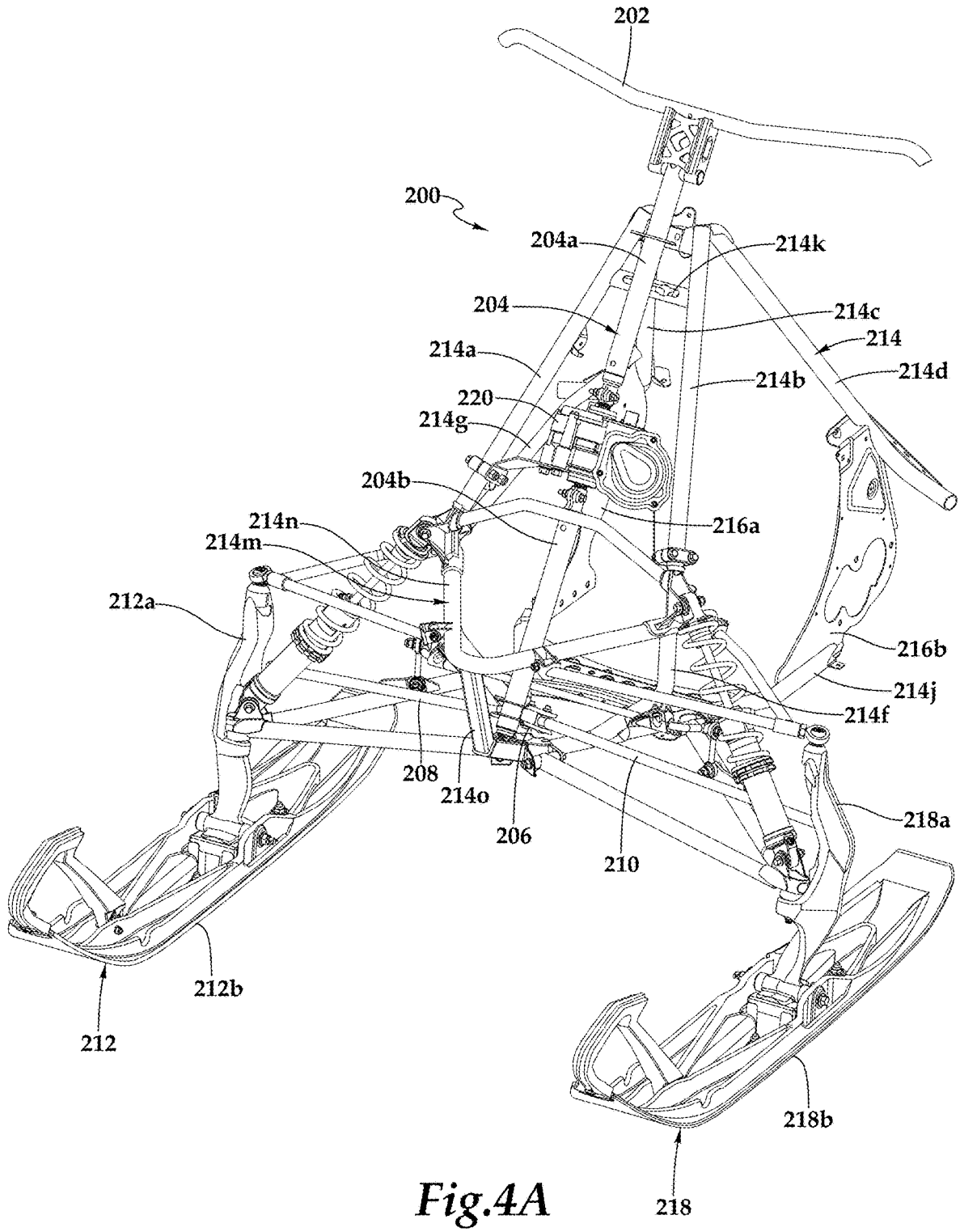

202
200
204a
214k
204
214c
214
214a
214d
214b
220
214g
204b
216a
214n
214m
212a
216b
214j
214f
208
214o
206
210
218a
212b
212
218b
218

Fig.4A

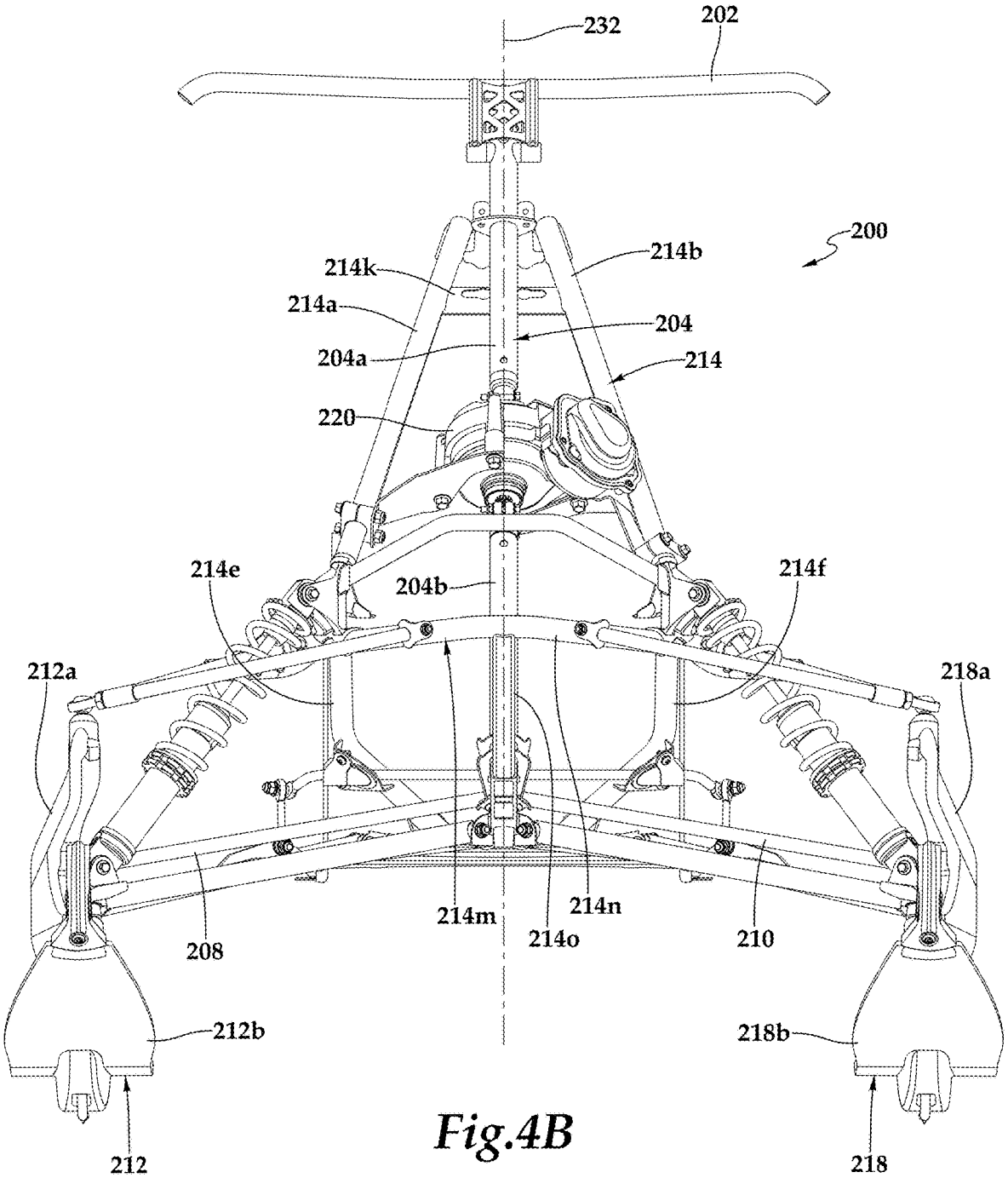

232
202
200
214b
214k
214a
204
204a
214
220
214e
204b
214f
212a
218a
214m
214n
214o
208
210
212b
218b
212
218

Fig.4B

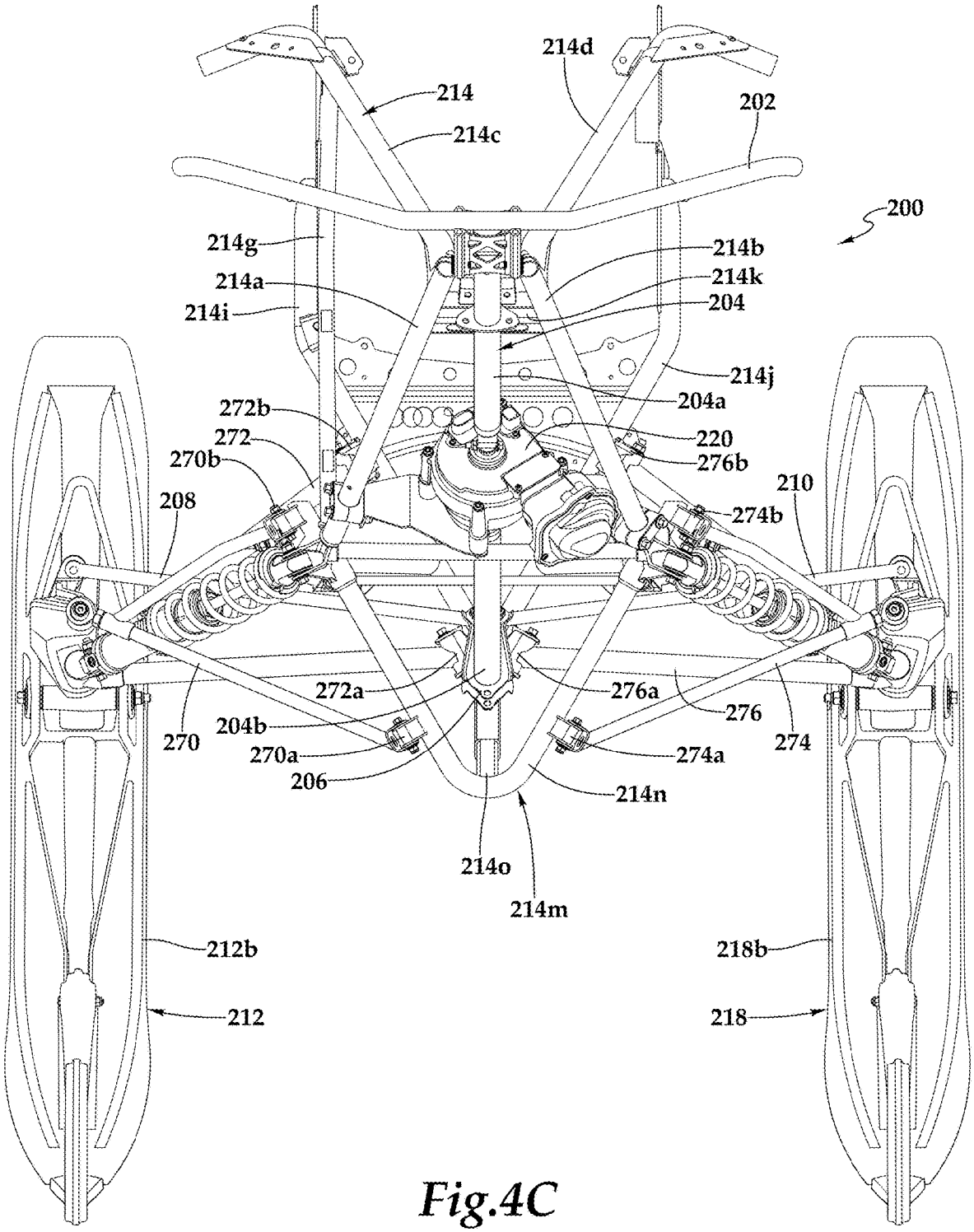

214d
214
202
214c
200
214g
214b
214a
214k
214i
204
214j
204a
272b
220
272
276b
270b
210
208
274b
272a
276a
276
270
204b
274
270a
274a
206
214n
214o
214m
212b
218b
212
218

Fig.4C

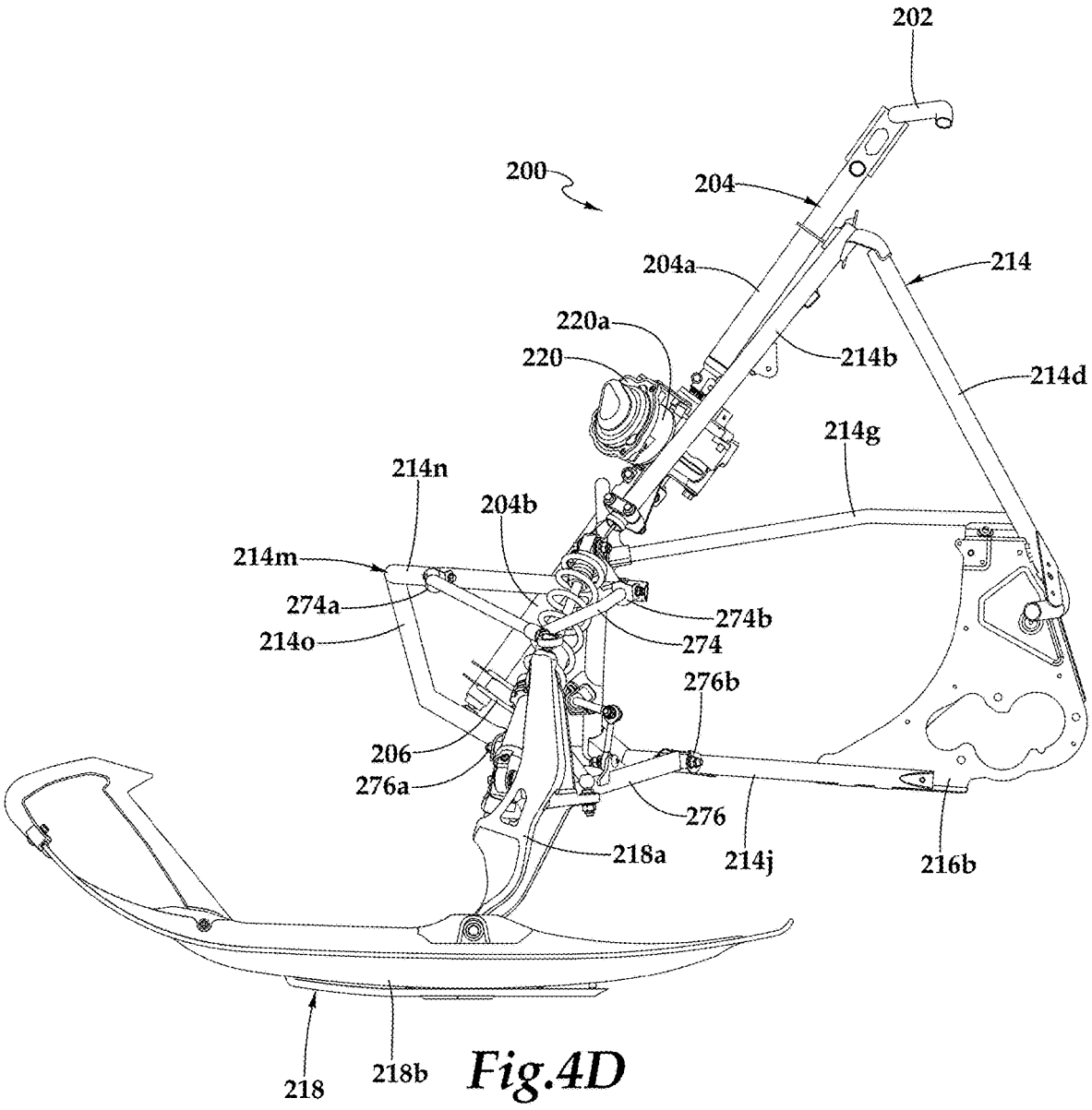

202
200
204
204a
214
220a
220
214b
214d
214g
214n
204b
214m
274a
214o
274b
274
276b
206
276a
276
218a
214j
216b
218
218b

Fig.4D

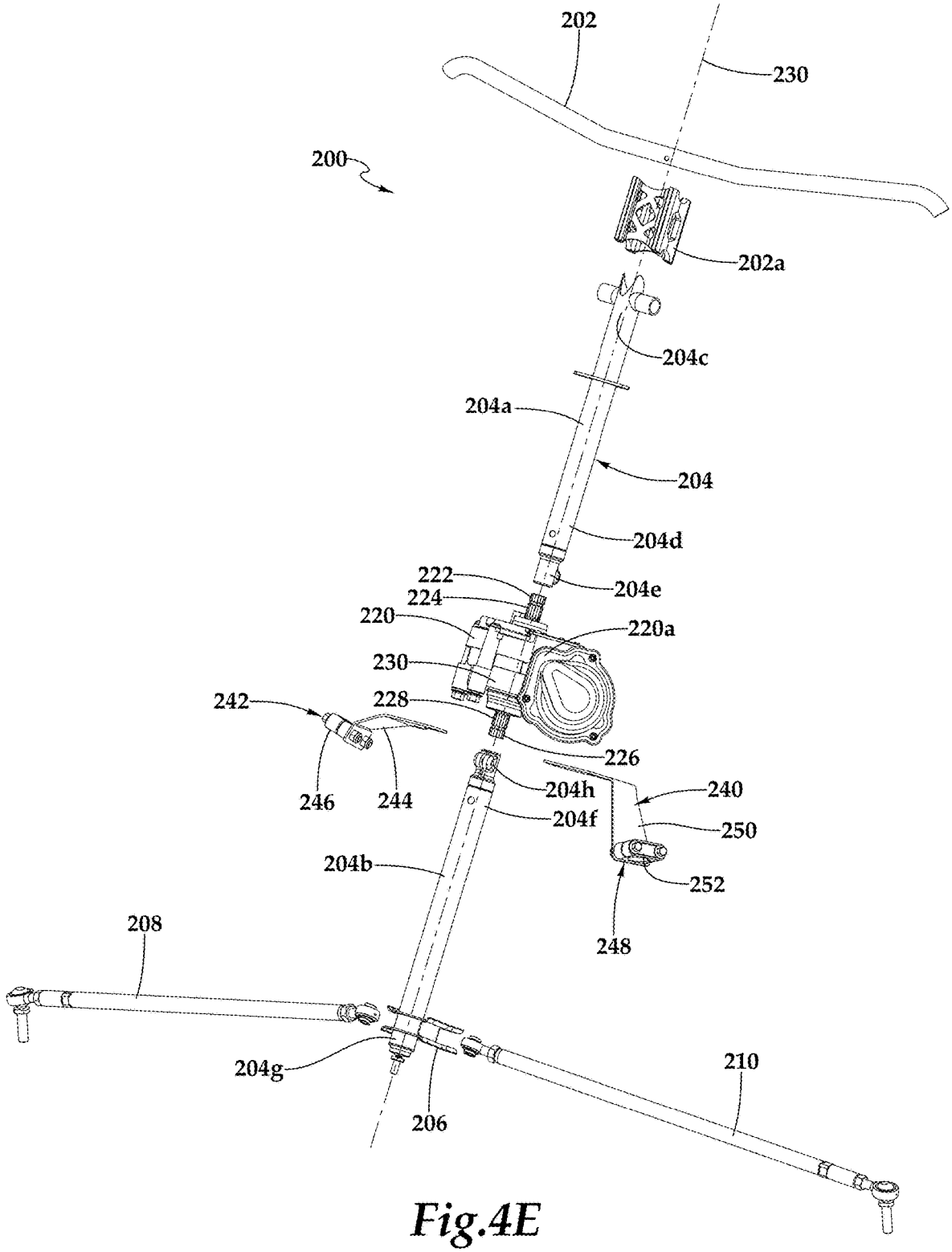

202
230
200
202a
204c
204a
204
204d
222
204e
224
220
220a
230
242
228
226
204h
240
246
244
204f
250
204b
252
248
208
204g
210
206

Fig.4E

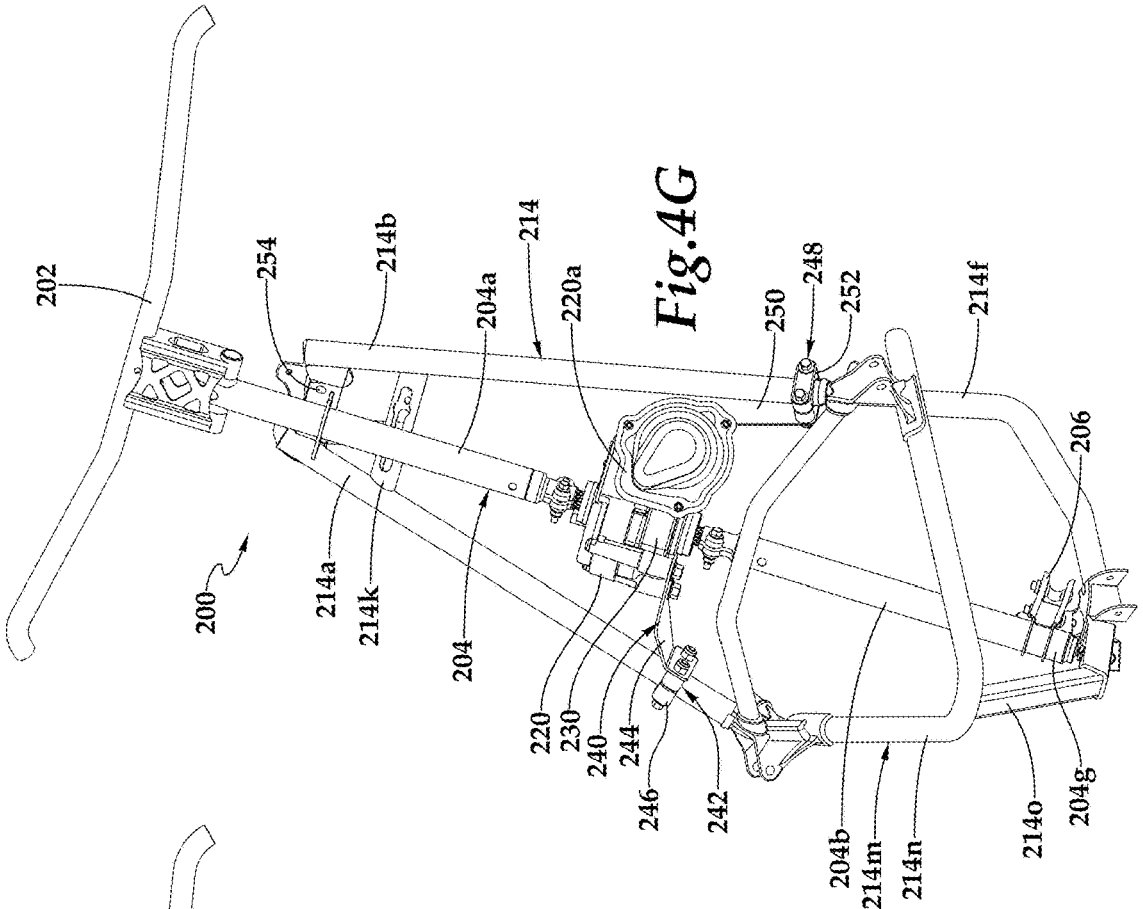

202
254
214b
204a
214
220a
250
248
252
214f
206
200
214a
214k
204
220
230
240
244
246
242
204b
214m
214n
214o
204g

Fig.4G

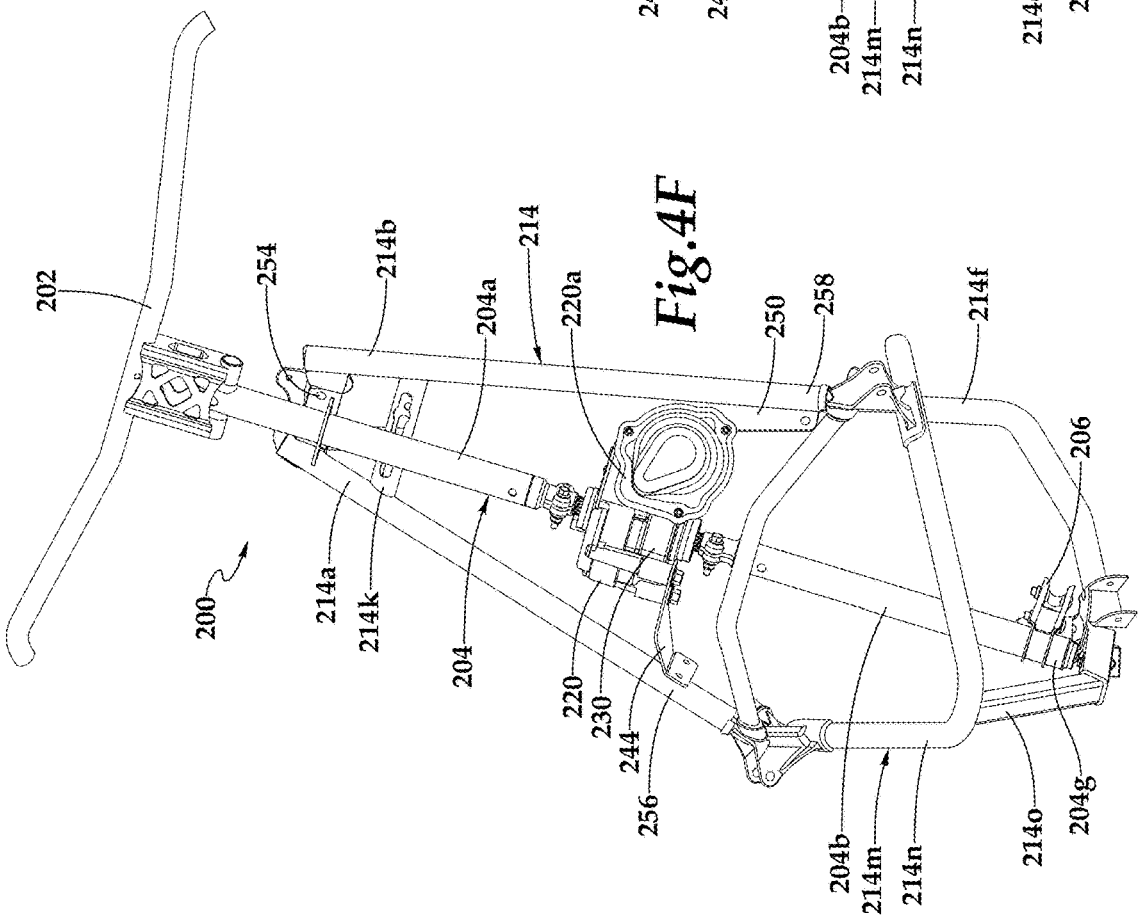

202
254
214b
204a
214
220a
250
258
214f
206
200
214a
214k
204
220
230
244
256
204b
214m
214n
214o
204g

Fig.4F

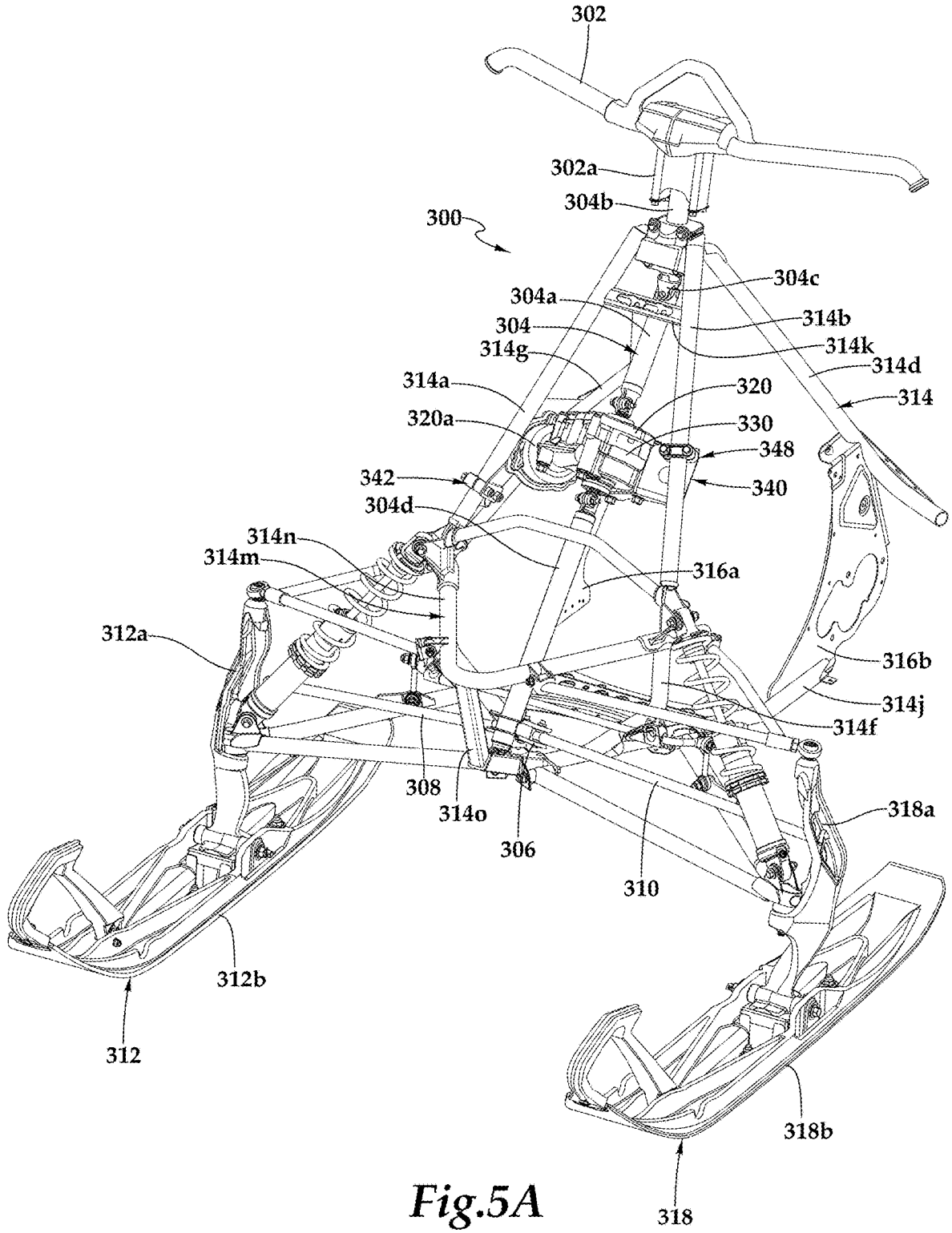

302
302a
304b
300
304c
304a
314b
304
314k
314g
314d
314a
320
314
320a
330
348
342
340
304d
314n
314m
316a
312a
316b
314j
314f
308
314o
306
318a
310
312b
312
318b
318

Fig.5A

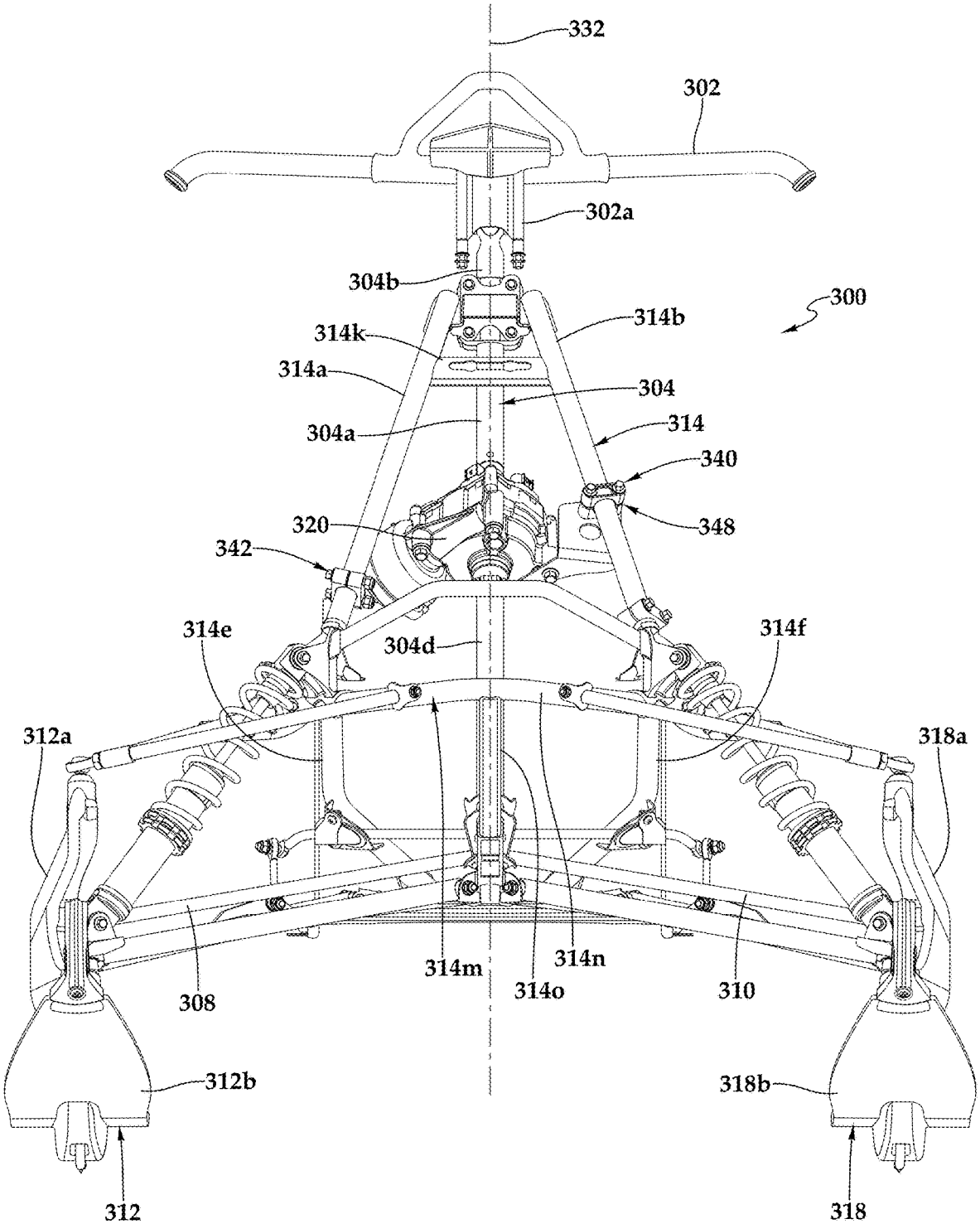

332
302
302a
304b
300
314b
314k
314a
304
304a
314
340
320
348
342
314e
304d
314f
312a
318a
314m
314n
314o
308
310
312b
318b
312
318

Fig.5B

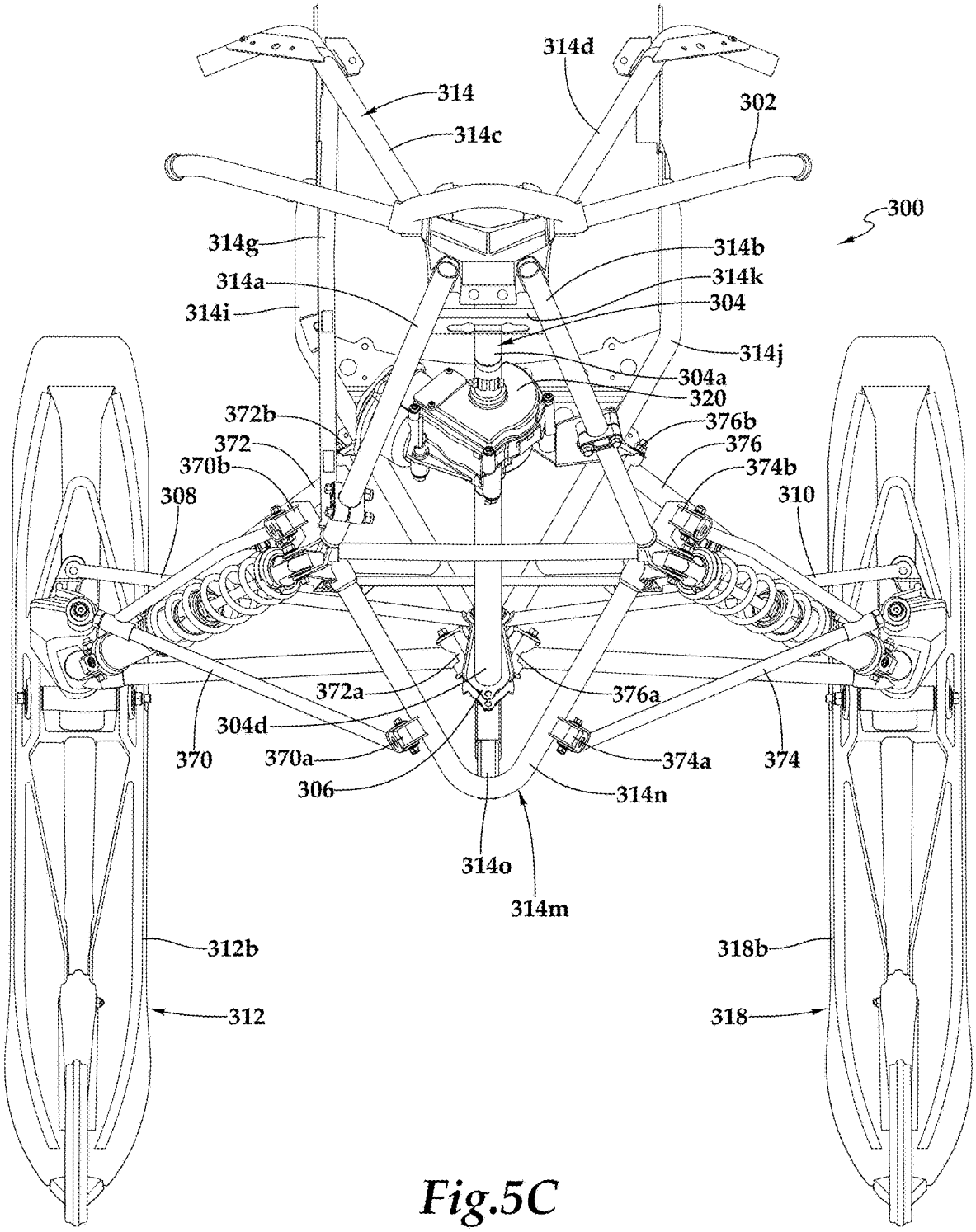

314d
314
302
314c
300
314g
314b
314a
314k
314i
304
314j
304a
320
372b
376b
372
376
370b
374b
308
310
372a
376a
304d
370
370a
374a
374
306
314n
314o
314m
312b
318b
312
318

Fig.5C

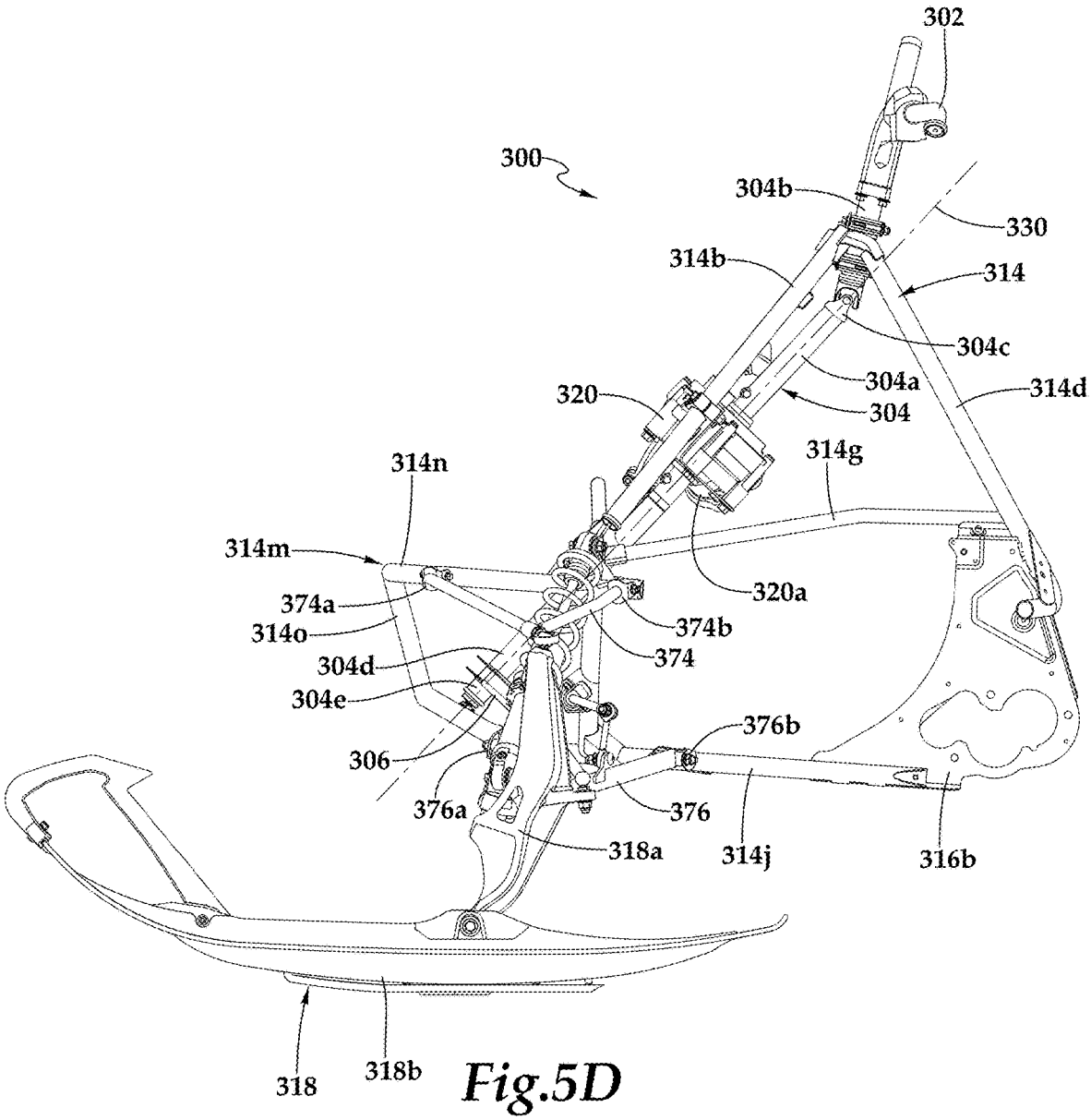

302
300
304b
330
314b
314
304c
320
304a
314d
304
314g
314n
314m
320a
374a
374b
314o
374
304d
304e
376b
306
376a
376
318a
314j
316b
318
318b

Fig.5D

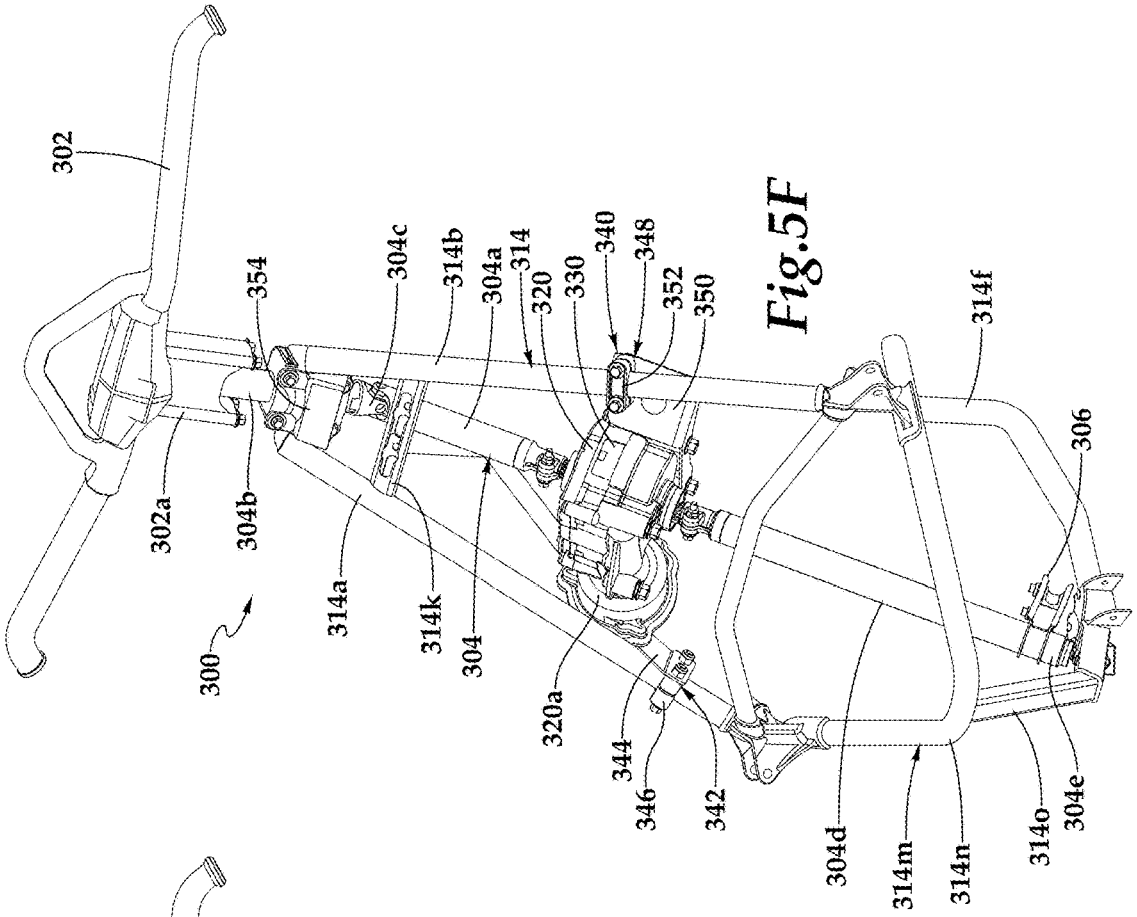

302
354
304c
314b
304a
314
320
330
340
348
352
350
314f
306
302a
304b
314a
314k
304
320a
344
346
342
304d
314m
314n
314o
304e
300

Fig.5F

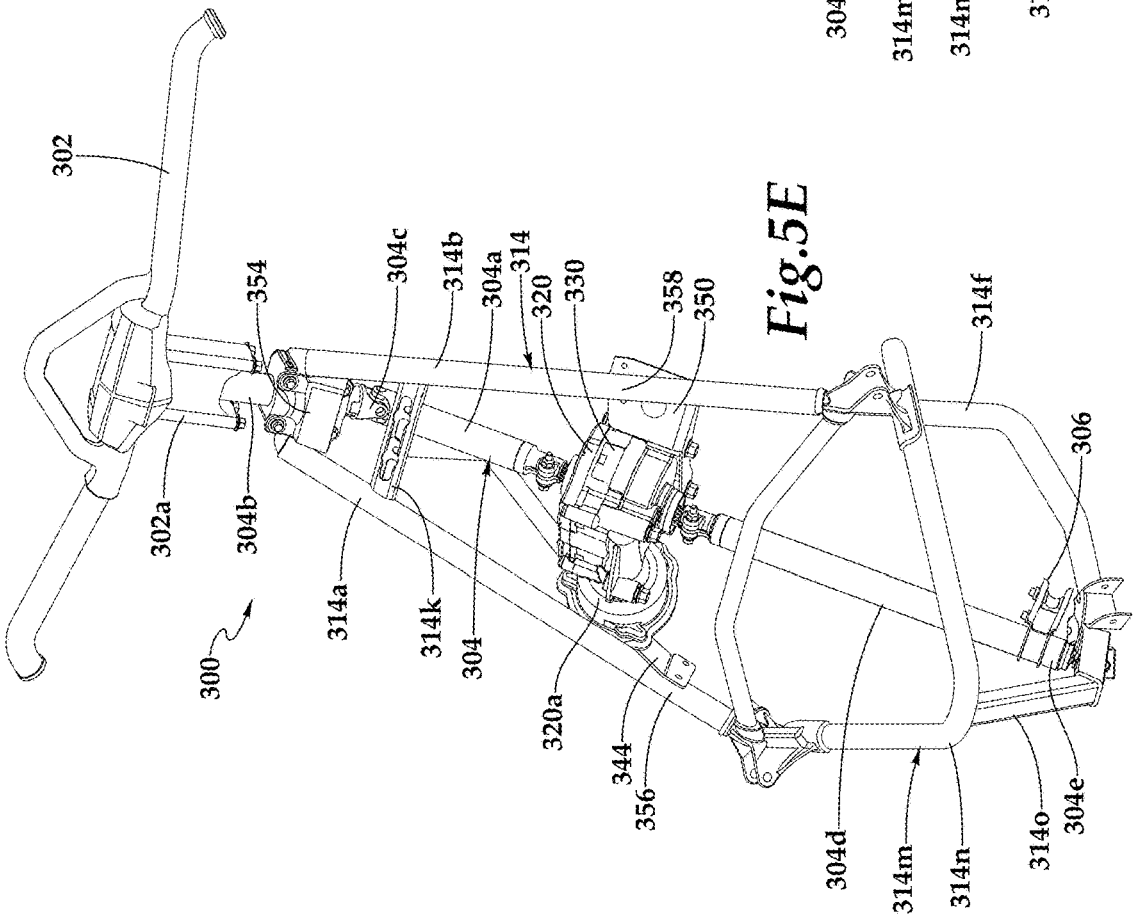

302
354
304c
314b
304a
314
320
330
358
350
314f
306
302a
304b
314a
314k
304
320a
344
356
304d
314m
314n
314o
304e
300

Fig.5E

STEERING SYSTEMS FOR SNOWMOBILES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Application No. 63/528,374, filed Jul. 22, 2023 the entire contents of which is incorporated by reference herein for all purposes.

TECHNICAL FIELD OF THE DISCLOSURE

[0002] The present disclosure relates, in general, to steering systems for use on land vehicles and, in particular, to steering systems for use on snowmobiles that include a steering column and an electronic steering assist unit that share a common axis of rotation that is positioned along the centerline 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 articulated steering column in which multiple posts are routed around other snowmobile components using joints that allow for changes in direction. Other snowmobiles utilize a straight steering column that is routed not only downwardly and forwardly from the handlebar assembly but also laterally from the handlebar assembly to avoid other snowmobile components. Both the articulated steering columns and the laterally offset steering columns require additional linkages to return the steering system to the center of the snowmobile for proper operation of the tie rods and the ski assemblies. It has been found, however, that such steering systems for snowmobiles are overly complex and add unnecessary weight to the snowmobile. Accordingly, a need has arisen for improved steering systems for snowmobiles that overcome these and other drawbacks associated with the current steering systems.

SUMMARY

[0004] In a first aspect, the present disclosure is directed to a steering system for a snowmobile. The steering system includes a handlebar assembly and a steering column that has upper and lower ends. The upper end of the steering column is coupled to the handlebar assembly. The lower end of the steering column is coupled to an input shaft of an electronic steering assist unit. A steering arm assembly is coupled directly to an output shaft of the electronic steering assist unit. A first tie rod has proximal and distal ends wherein, the proximal end is coupled to the steering arm assembly and the distal end is coupled to a first ski assembly. A second tie rod has proximal and distal ends wherein, the proximal end is coupled to the steering arm assembly and the distal end is coupled to a second ski assembly. The steering column and the electronic steering assist unit share a common axis of rotation that is positioned along a centerline of the snowmobile.

[0005] In some embodiments, the steering column may be a straight steering column formed as a non-segmented single post. In certain embodiments, the input shaft of the electronic steering assist unit may have input splines and the lower end of the steering column may be coupled to the input splines of the electronic steering assist unit. In some embodiments, the output shaft of the electronic steering assist unit may have output splines and the steering arm assembly may be coupled directly to the output splines of the electronic steering assist unit. In certain embodiments, the snowmobile may include a forward frame assembly and the electronic steering assist unit may be coupled to the forward frame assembly. In such embodiments, the forward frame assembly may include an upper cross member and the steering column may be positioned forward of the upper cross member. Also, in such embodiments, the forward frame assembly may include a nose frame assembly that defines an electronic steering assist unit bay and the electronic steering assist unit may be positioned within the electronic steering assist unit bay. In addition, the electronic steering assist unit may be coupled to the nose frame assembly.

[0006] In some embodiments, the snowmobile may include a heat exchanger and the electronic steering assist unit may be positioned below of the heat exchanger. In certain embodiments, the snowmobile may include an engine and the electronic steering assist unit may be positioned forward of the engine. In some embodiments, the snowmobile may include an engine and a heat exchanger. In such embodiments, the heat exchanger and the electronic steering assist unit may be positioned forward of the engine and the electronic steering assist unit may be positioned below of the heat exchanger. In certain embodiments, the snowmobile may include a forward frame assembly and an engine. In such embodiments, the forward frame assembly may include a lower cross member that is positioned between the engine and the electronic steering assist unit with the engine and the electronic steering assist unit coupled to the lower cross member. For example, the engine may be coupled to the lower cross member via first and second engine mounts and the electronic steering assist unit may be coupled to the lower cross member via a mounting bracket that is positioned between the first and second engine mounts. In some embodiments, the forward frame assembly may include a nose frame assembly and a lower cross member. In such embodiments, the electronic steering assist unit may be coupled between the nose frame assembly and the lower cross member.

[0007] In a second aspect, the present disclosure is directed to a snowmobile having a chassis that includes a forward frame assembly. An engine is coupled to the forward frame assembly. A steering system of the snowmobile includes a handlebar assembly and a steering column that has upper and lower ends. The upper end of the steering column is coupled to the handlebar assembly. The lower end of the steering column is coupled to an input shaft of an electronic steering assist unit. A steering arm assembly is coupled directly to an output shaft of the electronic steering assist unit. A first tie rod has proximal and distal ends

wherein, the proximal end is coupled to the steering arm assembly and the distal end is coupled to a first ski assembly. A second tie rod has proximal and distal ends wherein, the proximal end is coupled to the steering arm assembly and the distal end is coupled to a second ski assembly. The steering column and the electronic steering assist unit share a common axis of rotation that is positioned along a centerline of the snowmobile.

[0008] In certain embodiments, the engine may be an aftwardly tilted four-stroke engine. In some embodiments, the forward frame assembly may include a lower cross member that is positioned between the engine and the electronic steering assist unit. In such embodiments, the engine may be coupled to the lower cross member via first and second engine mount and the electronic steering assist unit may be coupled to the lower cross member via a mounting bracket that is positioned between the first and second engine mounts. In certain embodiments, the forward frame assembly may include a nose frame assembly that defines an electronic steering assist unit bay, the electronic steering assist unit may be positioned within the electronic steering assist unit bay and coupled to the nose frame assembly. In some embodiments, a heat exchanger may be coupled to the forward frame assembly such that the heat exchanger and the electronic steering assist unit are positioned forward of the engine and the electronic steering assist unit is positioned below of the heat exchanger.

[0009] In a third aspect, the present disclosure is directed to a snowmobile including a forward frame assembly with an engine coupled thereto. A steering column has upper and lower ends with the upper end of the steering column coupled to a handlebar assembly. The steering column is positioned along a centerline of the snowmobile. An electronic steering assist unit is coupled to a lower end of the steering column. A steering arm assembly is coupled to a lower end of the electronic steering assist unit.

[0010] In certain embodiments, the engine may be an aftwardly tilted four-stroke engine that includes one or more air intake inlets positioned on an aftward side of the engine and one or more exhaust outlets positioned on a forward side of the engine. In some embodiments, a heat exchanger may be positioned above the electronic steering assist unit. In such embodiments, at least a portion of the electronic steering assist unit may be positioned forward of the heat exchanger.

[0011] In a fourth aspect, the present disclosure is directed to a snowmobile including a forward frame assembly defining an engine bay and an electronic steering assist unit bay positioned forward of the engine bay. An engine is positioned in the engine bay. A tunnel is coupled to the forward frame assembly and positioned aft of the engine bay. A steering system includes a handlebar assembly, a steering column and a steering arm assembly. The steering column has a first end coupled to the handlebar assembly and a second end extending forward and downward from the first end. An electronic steering assist unit is at least partially positioned in the electronic steering assist unit bay. The electronic steering assist unit includes an input shaft coupled to the second end of the steering column and an output shaft coupled to the steering arm assembly. A heat exchanger is positioned above the electronic steering assist unit bay and forward of the engine bay.

[0012] In certain embodiments, the forward frame assembly may include a nose frame assembly that at least partial defines the electronic steering assist unit bay and a cross member positioned between the engine bay and the electronic steering assist unit bay. In such embodiments, the engine and the electronic steering assist unit may each be coupled to the cross member. In some embodiments, the nose frame assembly may include forward upper A-arm mounts and aft upper A-arm mounts. In such embodiments, the heat exchanger and at least a portion of the electronic steering assist unit may be positioned between the forward upper A-arm mounts and the aft upper A-arm mounts. In certain embodiments, the electronic steering assist unit may include a motor that is positioned at a forward end of the nose frame assembly. In such embodiments, the motor may at least partially extend above the electronic steering assist unit bay and forward of the heat exchanger. In some embodiments, the steering column may extend along a centerline of the vehicle and the electronic steering assist unit may be positioned along the centerline of the vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] 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:

[0014] FIGS. **1**A-**1**E are schematic illustrations of a snowmobile having a steering system including an electronic steering assist unit positioned along the centerline of the snowmobile in accordance with embodiments of the present disclosure;

[0015] FIGS. **2**A-**2**B are an isometric view of a forward portion of a snowmobile in accordance with embodiments of the present disclosure;

[0016] 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;

[0017] FIGS. **4**A-**4**G are selected views of a steering system for a snowmobile including an electronic steering assist unit in accordance with embodiments of the present disclosure; and

[0018] FIGS. **5**A-**5**F are selected views of a steering system for a snowmobile including an electronic steering assist unit in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0019] 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 neverthe-

less be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0020] 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.

[0021] 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 longitudinally extending tunnel **18**. Forward frame assembly **14** (see also FIGS. **2** and **3**A-**3**D) may be 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*, a 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*. Forward frame assembly also includes a pivot mount joint **14***p* that couples to and is preferably welded to right-lower beam **14***i*, left-lower beam **14***j* and nose truss **14***o*. Pivot mount joint **14***p* may be of the type disclosed in commonly-owned U.S. patent application Ser. No. 18/103,879, the entire contents of which is incorporated by reference herein for all purposes. A right side plate member **16***a* and a left side plate member **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 side panel **18***a*, a left side panel **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.

[0022] 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.

[0023] 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 bay **26***a* is defined by right-forward spar **14***a*, left-forward spar **14***b*, right-aft spar **14***c*, left-aft spar **14***d*, right truss **14***e*, left truss **14***f*, right-upper beam **14***g*, left-upper beam **14***h*, right-lower beam **14***i*, left-lower beam **14***j* and lower cross member **14***l*. In this position, tunnel **18** is positioned aft of engine bay **26***a*. In the illustrated embodiment, engine **26** is a four-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 two-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. Drivetrain **28** 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.

[0024] 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.

[0025] 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*. 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**. An upper A-arm **70***a* couples right ski assembly **64** to nose rail **14***n* of forward frame assembly **14** at upper A-arm mounts **70***c*, **70***d* (see also FIG. **3**C). In addition, a lower A-arm **70***b* couples right ski assembly **64** to forward frame assembly **14** at lower A-arm mounts **70***e*, **70***f*. An upper A-arm **72***a* couples left ski assembly **66** to nose rail **14***n* of forward frame assembly **14** at upper A-arm mounts **72***c*, **72***d* (see also FIG. **3**C). In addition, a lower A-arm **72***b* couples left ski assembly **66** to forward frame assembly **14** at lower A-arm mounts **72***e*, **72***f*. Upper A-arm mounts **70***c*, **72***c* may collectively be referred to herein as forward upper A-arm mounts **70***c*, **72***c*. Upper A-arm mounts **70***d*, **72***d* may collectively be referred to herein as aft upper A-arm mounts **70***d*, **72***d*. Lower A-arm mounts **70***e*, **72***e* may collectively be referred to herein as forward lower A-arm mounts **70***e*, **72***e*. Lower A-arm mounts **70***f*, **72***f* may collectively be referred to herein as aft lower A-arm mounts **70***f*, **72***f*.

[0026] 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 at least partially positioned within an electronic steering assist unit bay **74***a* that is defined by right truss **14***e*, left truss **14***f*, a forward portion of right-lower beam **14***i*, a forward portion of left-lower beam **14***j*, lower cross member **14***l*, nose rail **14***n*, nose truss **14***o* and pivot mount joint **14***p*. As lower cross member **14***l* helps to define both engine by **26***a* and electronic steering assist unit bay **74***a*, lower cross member **14***l* is considered to be positioned between engine bay **26***a* and electronic steering assist unit bay **74***a*. In this location, at least a portion of electronic steering assist unit **74** is positioned between forward upper A-arm mounts **70***c*, **72***c* and aft upper A-arm mounts **70***d*, **72***d* of nose rail **14***n*. Also, as best seen in FIG. **3**C, radiator **102** is positioned between forward upper A-arm mounts **70***c*, **72***c* and aft upper A-arm mounts **70***d*, **72***d* of nose rail **14***n*. 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 **140** and an aft bracket **76***b* that is coupled between electronic steering assist unit **74** and lower cross member **141**. As best seen in FIGS. **1**D and **2**, lower cross member **141** is positioned between electronic steering assist unit **74** and engine **26**. In this position, lower cross member **141** 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*. Nose bracket **76***a* provides primary support for electronic steering assist unit **74** while aft bracket **76***b* prevents relative rotation between electronic steering assist unit **74** and forward frame assembly **14**. As best seen in FIG. **3**C, electronic steering assist unit **74** includes a motor **74***b* that is positioned at a forward portion of nose frame assembly **14***m*. In this location, motor **74***b* at least partially extends above electronic steering assist unit bay **74***a* and forward of radiator **102**.

[0027] 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.

[0028] 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.

[0029] 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 and greater than twenty degrees from vertical. In the illustrated embodiment, a cooling system **100** includes a forward heat exchanger **102**, depicted as a radiator **102**, and an arcuate heat exchanger **104**. In other embodiments, a cooling system for a snowmobile may not include a forward heat exchanger, the forward heat exchanger may be an intercooler or the forward heat exchanger may include both a radiator and an intercooler. In the illustrated embodiment, radiator **102** is coupled to forward frame assembly **14** and more specifically, radiator **102** is coupled to and positioned about a centerline **134** of snowmobile **10** above electronic steering assist unit bay **74***a* and forward of engine bay **26***a*. Radiator **102** 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** and then into engine bay **26***a*. 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 at least partially positioned within electronic steering assist unit bay **74***a* with nose bracket **76***a* coupled between electronic steering assist unit **74** and nose truss **140** and with aft bracket **76***b* coupled between electronic steering assist unit **74** and lower cross member **141**. 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**.

[0030] 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 body valve assembly **120**. Air intake plenum **116** is configured to dampen 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**.

[0031] 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**. 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*. As best seen in FIG. **3**E, steering column **56** has an upper end **56***a* and lower end **56***b* that extends is forward and downward from upper end **56***a*. 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. 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 pivot mount joint **14***p* such that steering arm assembly **58** is operable to rotate relative thereto.

[0032] 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**. 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**.

[0033] Referring now to FIGS. **4**A-**4**G of the drawings, an embodiment of a steering system for a snowmobile, such as snowmobile **10** or a snowmobile having a two-stroke engine that is aftwardly tilted and has air intake inlets on the aftward side of the engine and exhaust outlets on the forward side of the engine, will now be discussed. Steering system **200** includes a handlebar assembly **202**, a steering column **204**, a steering arm assembly **206**, a right tie rod **208**, a left tie rod **210**, a right ski assembly **212** including a right spindle **212***a* and a right ski **212***b*, and a left ski assembly **218** including a left spindle **218***a* and a left ski **218***b*. In addition, steering system **200** includes an electric power steering system depicted as an electronic steering assist unit **220**. Steering system **200** is coupled to a forward frame assembly **214** that includes a right-forward spar **214***a*, a left-forward spar **214***b*, a right-aft spar **214***c*, a left-aft spar **214***d*, right truss **214***e*, a left truss **214***f*, a right-upper beam **214***g*, a left-upper beam (not installed in the illustrated embodiment), a right-lower beam **214***i*, a left-lower beam **214***j*, an upper cross member **214***k* and a nose frame assembly **214***m* including a nose rail **214***n* and a nose truss **214***o*. Plate members **216***a*, **216***b* are coupled to and preferably welded to forward frame assembly **214** such that forward frame assembly **214** and plate members **216***a*, **216***b* form a welded frame assembly. Right ski assembly **212** is coupled to forward frame assembly **214** by an upper A-arm **270** at forward and aftward mounting points **270***a*, **270***b* and by a lower A-arm **272** at forward and aftward mounting points **272***a*, **272***b*. Likewise, left ski assembly **218** is coupled to forward frame assembly **214** by an upper A-arm **274** at forward and aftward mounting points **274***a*, **274***b* and by a lower A-arm **276** at forward and aftward mounting points **276***a*, **276***b*.

[0034] In the illustrated embodiments, steering column **204** is a straight steering column formed from an upper post **204***a* that is positioned forward of upper cross member **214***k* and a lower post **204***b*. As best seen in FIG. **4**E, upper post **204***a* of steering column **204** has an upper end **204***c* and lower end **204***d*. Upper end **204***c* of upper post **204***a* is coupled to handlebar assembly **202** via a handlebar bracket **202***a*. Lower end **204***d* of upper post **204***a* includes a splined coupler **204***e* that may be integral with or coupled to lower end **204***d* of upper post **204***a*. Splined coupler **204***e* receives an input shaft **222** having input splines **224** therein to couple lower end **204***d* of upper post **204***a* to electronic steering assist unit **220**. Lower post **204***b* of steering column **204** has an upper end **204***f* and lower end **204***g*. Upper end **204***f* of lower post **204***b* includes a splined coupler **204***h* that may be integral with or coupled to upper end **204***f* of lower post **204***b*. Splined coupler **204***h* receives an output shaft **226** having output splines **228** therein to couple upper end **204***f* of lower post **204***b* to electronic steering assist unit **220**. Steering arm assembly **206** is coupled to lower end **204***g* of lower post **204***b*. Steering arm assembly **206** is coupled to the proximal ends tie rods **208**, **210**. The distal ends of tie rods **208**, **210** are respectively coupled to ski assemblies **212**, **218** such that rotation of handlebar assembly **202** by the rider of the snowmobile, together with the assist of electronic steering assist unit **220**, causes ski assemblies **212**, **218** to pivot, thus turning the snowmobile. Lower end **204***g* of lower post **204***b* is received within a bearing assembly (not visible) of nose truss **2140** such that lower post **204***b* is operable to rotate relative thereto.

[0035] Electronic steering assist unit **220** includes an outer housing **230** that contains the working components thereof including, for example, an electric motor **220***a*, a torque sensor, a controller and a torsion bar that couples input shaft **222** to output shaft **226**. In operation, the input torque applied from handlebar assembly **202** via upper post **204***a* on input shaft **222** 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 the snowmobile, the controller commands electric motor **220***a* to provide an output assist torque to output shaft **226** that is additive to the input torque applied to output shaft **226** from input shaft **222** via the torsion bar. The use of electronic steering assist unit **220** improves the handling of the snowmobile, reduces fatigue associated with driving the snowmobile and can allow the snowmobile to be driven more aggressively. In addition, using steering system **200** that has a common axis of rotation **230** shared by handlebar assembly **202**, steering column **204**, electronic steering assist unit **220** and steering arm assembly **206** that is positioned along a centerline **232** (see FIG. **4**B) of the snowmobile, reduces the number of parts required in steering system **200** and reduces the complexity of steering system **200**, which improves the overall reliability of the snowmobile.

[0036] To prevent a torque pre-load on electronic steering assist unit **220**, the present embodiment utilizes a floating mounting system **240** to couple electronic steering assist unit **220** to forward spars **214***a*, **214***b*. For example, a torque pre-load on electronic steering assist unit **220** could cause the torque sensor to sense the presence of an input torque even when no input torque is being applied from handlebar assembly **202** via upper post **204***a* on input shaft **222**. Likewise, a torque pre-load on electronic steering assist unit **220** could cause the torque sensor to sense an inaccurate input torque applied from handlebar assembly **202** via upper post **204***a* on input shaft **222**. In either case, the phantom presence of an input torque or a distorted input torque causes erroneous input torque data to be provided to the controller from the torque sensor. This erroneous input torque data then causes the controller to send erroneous commands to electric motor **220***a* causing erroneous output assist torque to be applied to output shaft **226**. To prevent such a torque pre-load on electronic steering assist unit **220**, the vertical position of electronic steering assist unit **220** is determined by steering column **204** and not by predetermined mounting points on either of forward spars **214***a*, **214***b* such as predrilled holes in forward spars **214***a*, **214***b* or pre-welded supports on forward spars **214***a*, **214***b*.

[0037] In the present embodiment, floating mounting system **240** is used to couple electronic steering assist unit **220** to forward spars **214***a*, **214***b*. Floating mounting system **240** includes a right floating clamp assemblies **242** that is formed from a right mounting bracket **244** and a right clamp **246**, and a left floating clamp assemblies **248** that is formed from a left mounting bracket **250** and a left clamp **252** wherein, clamps **246**, **252** are depicted as pillow block clamps. During installation, steering column **204**, electronic steering assist unit **220** and steering arm assembly **206** are preferably preassembled then positioned along centerline **232** of the snowmobile with lower end **204***g* of lower post **204***b* received within a bearing assembly (not visible) of nose

truss **2140** and upper post **204***a* received on a forward side of steering column mount **254**, as best seen in FIG. **4**F. Right mounting bracket **244** and left mounting bracket **250** may be part of the preassembly or may be bolted on to outer housing **230** of electronic steering assist unit **220** after steering column **204**, electronic steering assist unit **220** and steering arm assembly **206** have been received by forward frame assembly **214**. In either case, once coupled to electronic steering assist unit **220**, right mounting bracket **244** aligns with a nonpredetermined location **256** of right-forward spar **214***a* and left mounting bracket **250** aligns with a nonpredetermined location **258** of left-forward spar **214***b*.

[0038] Next, right clamp **246** is used to couple right mounting bracket **244** to right-forward spar **214***a* at nonpredetermined location **256** and left clamp **252** is used to couple left mounting bracket **250** to left-forward spar **214***b* at nonpredetermined location **258**, as best seen in FIG. **4**G. In the clamped orientation, outer housing **230** is fixed against rotation relative to forward frame assembly **214**. As nonpredetermined locations **256**, **258** that clamps **246**, **252** couple brackets **244**, **250** to spars **214***a*, **214***b* are not constrained by predrilled holes or pre-welded supports, torque pre-load caused by misalignment of electronic steering assist unit **220** is prevented. Specifically, due to manufacturing tolerances and/or assembly tolerances associated with forward frame assembly **214**, predrilled holes or prewelded supports could deviate from the design position by enough to cause misalignment of electronic steering assist unit **220** that introduces torque pre-load on electronic steering assist unit **220** when electronic steering assist unit **220** is coupled to spars **214***a*, **214***b* at such predrilled holes or pre-welded supports. The use of floating mounting system **240** prevents such misalignment, and thus torque pre-load on electronic steering assist unit **220** when electronic steering assist unit **220** is coupled to spars **214***a*, **214***b*. It should be noted that the vertical position of clamp **246** on spar **214***a* is different than, and in this case higher than, the vertical position of clamp **252** on spar **214***b*. In the illustrated embodiment, once electronic steering assist unit **220** is clamped to spars **214***a*, **214***b*, electronic steering assist unit **220** is positioned forward of the engine with electric motor **220***a* of electronic steering assist unit **220** is positioned forward of spars **214***a*, **214***b*, as best seen in FIG. **4**D. In addition, electric motor **220***a* of electronic steering assist unit **220** is positioned generally above the engine, forward of the muffler, above an inlet to an exhaust duct of the exhaust system, outboard of the inlet to an exhaust duct and/or within a curved portion of the exhaust duct. Further, at least a portion of electronic steering assist unit **220** is positioned forward of aftward mounting point **270***b*, **274***b* of upper A-arms **270**, **274** and forward of aftward mounting point **272***b*, **276***b* of lower A-arms **272**, **276**.

[0039] Referring now to FIGS. **5**A-**5**F of the drawings, an embodiment of a steering system for a snowmobile, such as snowmobile **10** or a snowmobile having a two-stroke engine that is aftwardly tilted and has air intake inlets on the aftward side of the engine and exhaust outlets on the forward side of the engine, will now be discussed. Steering system **300** includes a handlebar assembly **302**, a steering column **304**, a steering arm assembly **306**, a right tie rod **308**, a left tie rod **310**, a right ski assembly **312** including a right spindle **312***a* and a right ski **312***b*, and a left ski assembly **318** including a left spindle **318***a* and a left ski **318***b*. In addition, steering system **300** includes an electronic steering assist unit **320**. Steering system **300** is coupled to a forward frame assembly **314** that includes a right-forward spar **314***a*, a left-forward spar **314***b*, a right-aft spar **314***c*, a left-aft spar **314***d*, right truss **314***e*, a left truss **314***f*, a right-upper beam **314***g*, a left-upper beam (not installed in the illustrated embodiment), a right-lower beam **314***i*, a left-lower beam **314***j*, an upper cross member **314***k* and a nose frame assembly **314***m* including a nose rail **314***n* and a nose truss **314***o*. Plate members **316***a*, **316***b* are coupled to and preferably welded to forward frame assembly **314** such that forward frame assembly **314** and plate members **316***a*, **316***b* form a welded frame assembly. Right ski assembly **312** is coupled to forward frame assembly **314** by an upper A-arm **370** at forward and aftward mounting points **370***a*, **370***b* and by a lower A-arm **372** at forward and aftward mounting points **372***a*, **372***b*. Likewise, left ski assembly **318** is coupled to forward frame assembly **314** by an upper A-arm **374** at forward and aftward mounting points **374***a*, **374***b* and by a lower A-arm **376** at forward and aftward mounting points **376***a*, **376***b*.

[0040] In the illustrated embodiments, steering column **304** is a bent steering column formed from an upper post **304***a* that is positioned aft of upper cross member **314***k*, a handlebar post **304***b* that is coupled to upper post **304***a* via a universal joint **304***c* and a lower post **304***d*. Handlebar post **304***b* of steering column **304** has an upper end coupled to handlebar assembly **302** via a handlebar bracket **302***a*. A lower end of upper post **304***a* includes a splined coupler that receives an input shaft that has input splines therein to couple the lower end of upper post **304***a* to electronic steering assist unit **320**. Lower post **304***d* of steering column **304** has an upper end that includes a splined coupler that receives an output shaft that has output splines therein to couple the upper end of lower post **304***d* to electronic steering assist unit **320**. Steering arm assembly **306** is coupled to lower end **304***e* of lower post **304***d*. Steering arm assembly **306** is coupled to the proximal ends tie rods **308**, **310**. The distal ends of tie rods **308**, **310** are respectively coupled to ski assemblies **312**, **318** such that rotation of handlebar assembly **302** by the rider of the snowmobile, together with the assist of electronic steering assist unit **320**, causes ski assemblies **312**, **318** to pivot, thus turning the snowmobile. Lower end **304***e* of lower post **304***d* is received within a bearing assembly (not visible) of nose truss **3140** such that lower post **304***d* is operable to rotate relative thereto.

[0041] Electronic steering assist unit **320** includes an outer housing **330** that contains the working components thereof including, for example, an electric motor **320***a*, a torque sensor, a controller and a torsion bar that couples the input shaft to the output shaft of electronic steering assist unit **320**. In operation, the input torque applied from handlebar assembly **302** via handlebar post **304***b* and upper post **304***a* on the input shaft of electronic steering assist unit **320** 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 the snowmobile, the controller commands electric motor **320***a* to provide an output assist torque to the output shaft of electronic steering assist unit **320** that is additive to the input torque applied to the output shaft from the input shaft via the torsion bar. The use of electronic steering assist unit **320** improves the handling of the snowmobile, reduces fatigue associated with driving the snowmobile and can allow the

snowmobile to be driven more aggressively. In addition, using steering system **300** that has a common axis of rotation **330** (see FIG. **5**D) shared by steering column **304**, electronic steering assist unit **320** and steering arm assembly **306** that is positioned along a centerline **332** (see FIG. **5**B) of the snowmobile, reduces the number of parts required in steering system **300** and reduces the complexity of steering system **300**, which improves the overall reliability of the snowmobile.

[0042] To prevent a torque pre-load on electronic steering assist unit **320**, the present embodiment utilizes a floating mounting system **340** to couple electronic steering assist unit **320** to forward spars **314***a*, **314***b*. Floating mounting system **340** includes a right floating clamp assemblies **342** that is formed from a right mounting bracket **344** and a right clamp **346**, and a left floating clamp assemblies **348** that is formed from a left mounting bracket **350** and a left clamp **352** wherein, clamps **346**, **352** are depicted as pillow block clamps. During installation, steering column **304**, electronic steering assist unit **320** and steering arm assembly **306** are preferably preassembled then positioned along centerline **332** of the snowmobile with lower end **304***e* of lower post **304***d* received within a bearing assembly (not visible) of nose truss **3140** and handlebar post **304***b* received on an aftward side of steering column mount **354**, as best seen in FIG. **5**E. Right mounting bracket **344** and left mounting bracket **350** may be part of the preassembly or may be bolted on to outer housing **330** of electronic steering assist unit **320** after steering column **304**, electronic steering assist unit **320** and steering arm assembly **306** have been received by forward frame assembly **314**. In either case, once coupled to electronic steering assist unit **320**, right mounting bracket **344** aligns with a nonpredetermined location **356** of right-forward spar **314***a* and left mounting bracket **350** aligns with a nonpredetermined location **358** of left-forward spar **314***b*.

[0043] Next, right clamp **346** is used to couple right mounting bracket **344** to right-forward spar **314***a* at nonpredetermined location **356** and left clamp **352** is used to couple left mounting bracket **350** to left-forward spar **314***b* at nonpredetermined location **358**, as best seen in FIG. **5**F. In the clamped orientation, outer housing **330** is fixed against rotation relative to forward frame assembly **314**. As nonpredetermined locations **356**, **358** that clamps **346**, **352** couple brackets **344**, **350** to spars **314***a*, **314***b* are not constrained by predrilled holes or pre-welded supports, torque pre-load caused by misalignment of electronic steering assist unit **320** is prevented. It should be noted that the vertical position of clamp **346** on spar **314***a* is different than, and in this case lower than, the vertical position of clamp **352** on spar **314***b*. In the illustrated embodiment, once electronic steering assist unit **320** is clamped to spars **314***a*, **314***b*, electronic steering assist unit **320** is positioned forward of the engine with electric motor **320***a* of electronic steering assist unit **320** is positioned aftward of spars **314***a*, **314***b*, as best seen in FIG. **5**D. In addition, electric motor **320***a* of electronic steering assist unit **320** is positioned generally above the engine, between the muffler and steering column **304**, above an inlet to an exhaust duct of the exhaust system and/or closer to an outlet of the exhaust duct than the inlet of the exhaust duct. Further, at least a portion of electronic steering assist unit **320** is positioned forward of aftward mounting points **372***b*, **376***b* of lower A-arms **372**, **376**.

[0044] Forward frame assembly **214** of FIGS. **4**A-**4**G and forward frame assembly **314** of FIGS. **5**A-**5**F may represent a common forward frame assembly used as part of multiple snowmobile models that have different configurations. As illustrated herein, for example, steering system **200** of FIGS. **4**A-**4**G includes straight steering column **204** that is positioned forward of upper cross member **214***k* and forward of steering column mount **254** that may be preferable for high performance snowmobiles while steering system **300** of FIGS. **5**A-**5**F includes a bent steering column **304** that is positioned aft of upper cross member **314***k* and aft of steering column mount **354** that may be preferrable for mountain snowmobiles.

[0045] 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 steering system for a snowmobile, the steering system comprising:

a handlebar assembly;

a steering column having upper and lower ends, the upper end of the steering column coupled to the handlebar assembly;

an electronic steering assist unit having input and output shafts, the input shaft coupled to the lower end of the steering column;

a steering arm assembly coupled directly to the output shaft of the electronic steering assist unit;

a first tie rod having proximal and distal ends, the proximal end of the first tie rod coupled to the steering arm assembly;

a second tie rod having proximal and distal ends, the proximal end of the second tie rod coupled to the steering arm assembly;

a first ski assembly coupled to the distal end of the first tie rod; and

a second ski assembly coupled to the distal end of the second tie rod;

wherein, the steering column and the electronic steering assist unit share a common axis of rotation that is positioned along a centerline of the snowmobile.

2. The steering system as recited in claim **1** wherein, the snowmobile includes a forward frame assembly; and

wherein, the electronic steering assist unit is coupled to the forward frame assembly.

3. The steering system as recited in claim **1** wherein, the snowmobile includes a forward frame assembly;

wherein, the forward frame assembly includes a nose frame assembly defining an electronic steering assist unit bay; and

wherein, the electronic steering assist unit is at least partially positioned within the electronic steering assist unit bay.

4. The steering system as recited in claim **1** wherein, the snowmobile includes a heat exchanger; and

wherein, the electronic steering assist unit is positioned below of the heat exchanger.

5. The steering system as recited in claim **1** wherein, the snowmobile includes an engine; and

wherein, the electronic steering assist unit is positioned forward of the engine.

6. The steering system as recited in claim **1** wherein, the snowmobile includes an engine and a heat exchanger;

wherein, the heat exchanger and the electronic steering assist unit are positioned forward of the engine; and

wherein, the electronic steering assist unit is positioned below of the heat exchanger.

7. The steering system as recited in claim **1** wherein, the snowmobile includes a forward frame assembly and an engine;

wherein, the forward frame assembly includes a lower cross member that is positioned between the engine and the electronic steering assist unit;

wherein, the engine is coupled to the lower cross member; and

wherein, the electronic steering assist unit is coupled to the lower cross member.

8. The steering system as recited in claim **7** wherein, the engine is coupled to the lower cross member via first and second engine mounts; and

wherein, the electronic steering assist unit is coupled to the lower cross member via a mounting bracket that is positioned between the first and second engine mounts.

9. The steering system as recited in claim **1** wherein, the snowmobile includes a forward frame assembly;

wherein, the forward frame assembly includes a nose frame assembly and a lower cross member; and

wherein, the electronic steering assist unit is coupled between the nose frame assembly and the lower cross member.

10. A snowmobile comprising:

a chassis including a forward frame assembly;

an engine coupled to the forward frame assembly;

a handlebar assembly;

a steering column having upper and lower ends, the upper end of the steering column coupled to the handlebar assembly;

an electronic steering assist unit coupled to the forward frame assembly, the electronic steering assist unit having input and output shafts, the input shaft coupled to the lower end of the steering column;

a steering arm assembly coupled directly to the output shaft of the electronic steering assist unit;

a first tie rod having proximal and distal ends, the proximal end of the first tie rod coupled to the steering arm assembly;

a second tie rod having proximal and distal ends, the proximal end of the second tie rod coupled to the steering arm assembly;

a first ski assembly coupled to the distal end of the first tie rod; and

a second ski assembly coupled to the distal end of the second tie rod;

wherein, the steering column and the electronic steering assist unit share a common axis of rotation that is positioned along a centerline of the snowmobile.

11. The snowmobile as recited in claim **10** wherein, the engine is an aftwardly tilted four-stroke engine.

12. The snowmobile as recited in claim **10** wherein, the forward frame assembly includes a lower cross member that is positioned between the engine and the electronic steering assist unit;

wherein, the engine is coupled to the lower cross member via first and second engine mount; and

wherein, the electronic steering assist unit is coupled to the lower cross member via a mounting bracket that is positioned between the first and second engine mounts.

13. The snowmobile as recited in claim **10** wherein, the forward frame assembly includes a nose frame assembly defining an electronic steering assist unit bay;

wherein, the electronic steering assist unit is at least partially positioned within the electronic steering assist unit bay; and

wherein, the electronic steering assist unit is coupled to the nose frame assembly.

14. The snowmobile as recited in claim **10** further comprising a heat exchanger coupled to the forward frame assembly;

wherein, the heat exchanger and the electronic steering assist unit are positioned forward of the engine; and

wherein, the electronic steering assist unit is positioned below of the heat exchanger.

15. A snowmobile comprising:

a forward frame assembly defining an engine bay and an electronic steering assist unit bay positioned forward of the engine bay;

an engine positioned in the engine bay;

a tunnel coupled to the forward frame assembly, the tunnel positioned aft of the engine bay;

a steering system including a handlebar assembly, a steering column and a steering arm assembly, the steering column having a first end coupled to the handlebar assembly and a second end extending forward and downward from the first end;

an electronic steering assist unit at least partially positioned in the electronic steering assist unit bay, the electronic steering assist unit including an input shaft coupled to the second end of the steering column and an output shaft coupled to the steering arm assembly; and

a heat exchanger positioned above the electronic steering assist unit bay and forward of the engine bay.

16. The snowmobile as recited in claim **15** wherein, the forward frame assembly includes a nose frame assembly that at least partial defines the electronic steering assist unit bay;

wherein, the forward frame assembly includes a cross member positioned between the engine bay and the electronic steering assist unit bay; and

wherein, the engine and the electronic steering assist unit are each coupled to the cross member.

17. The snowmobile as recited in claim **16** wherein, the nose frame assembly includes forward upper A-arm mounts and aft upper A-arm mounts; and

wherein, the heat exchanger and at least a portion of the electronic steering assist unit are positioned between the forward upper A-arm mounts and the aft upper A-arm mounts.

18. The snowmobile as recited in claim **16** wherein, the electronic steering assist unit includes a motor; and

wherein, the motor is positioned at a forward end of the nose frame assembly.

19. The snowmobile as recited in claim **18** wherein, the motor at least partially extends above the electronic steering assist unit bay and forward of the heat exchanger.

20. The snowmobile as recited in claim **15** wherein, the steering column extends along a centerline of the vehicle; and

wherein, the electronic steering assist unit is positioned along the centerline of the vehicle.

* * * * *