US 20250083770A1

(19) United States
(12) Patent Application Publication
(10) Pub. No.: US 2025/0083770 A1
(43) Pub. Date: Mar. 13, 2025
Sibilleau et al.

(54) **ENGINE MOUNTING SYSTEMS FOR SNOWMOBILES**

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(21) Appl. No.: **18/745,703**

(22) Filed: **Jun. 17, 2024**

Related U.S. Application Data

(60) Provisional application No. 63/537,179, filed on Sep. 7, 2023.

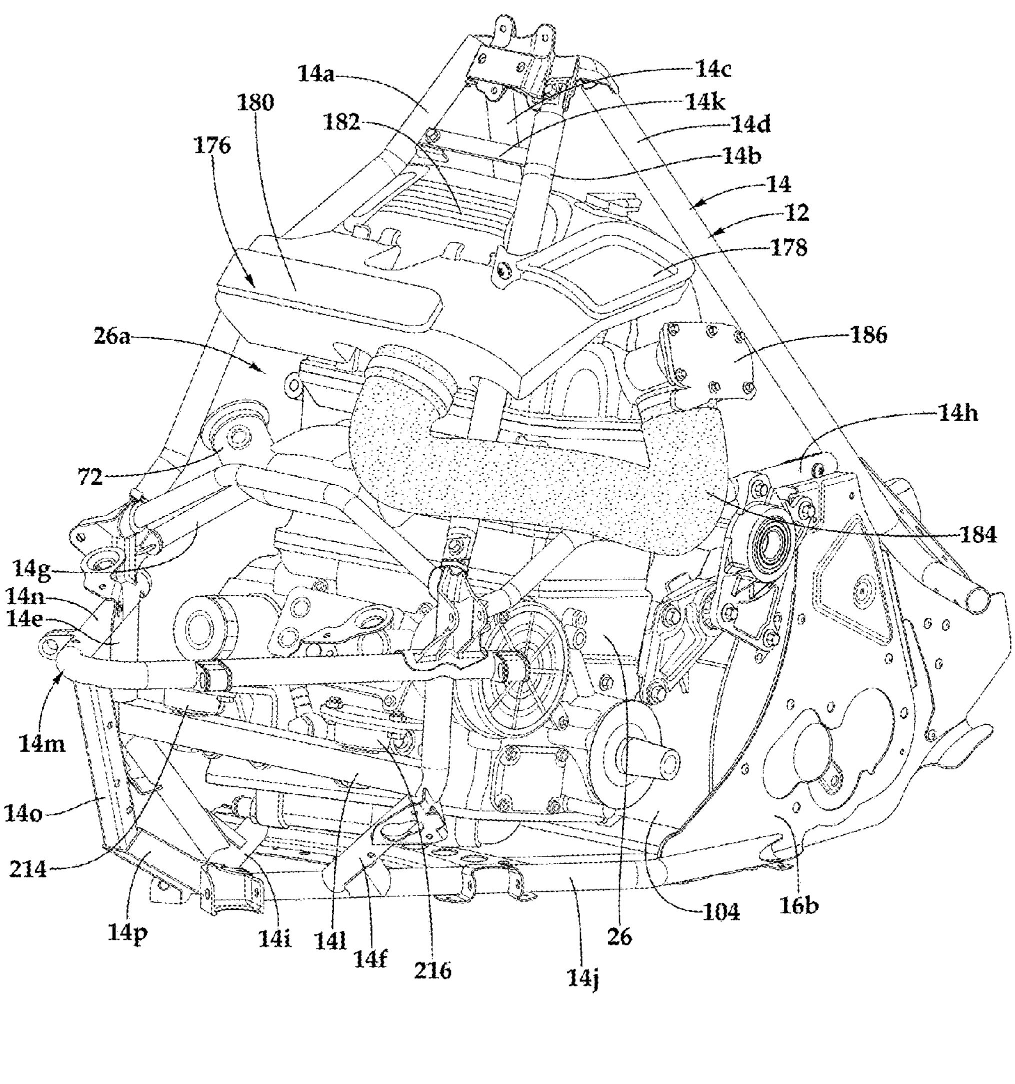
Publication Classification

(51) **Int. Cl.**
B62M 27/02 (2006.01)
B62J 41/00 (2006.01)
F02B 75/02 (2006.01)

(52) **U.S. Cl.**
CPC ***B62M 27/02*** (2013.01); ***B62J 41/00*** (2020.02); ***F02B 75/02*** (2013.01); *B62M 2027/023* (2013.01); *B62M 2027/028* (2013.01); *F02B 2075/027* (2013.01)

(57) **ABSTRACT**

A snowmobile includes a forward frame assembly defining an engine bay. The forward frame assembly includes a nose frame assembly having a nose frame cross member positioned forward of the engine bay. An engine is positioned within the engine bay. A tunnel is coupled to the forward frame assembly and is positioned aft of the engine bay. A heat exchanger is coupled to a forward end of the tunnel. At least one aftward engine mount is configured to couple the engine to the heat exchanger. At least one forward engine mount is configured to couple the engine to the nose frame cross member. The at least one aftward engine mount has a mount axis that is oriented in a substantially radial direction relative to an axis of rotation of a track driveshaft.



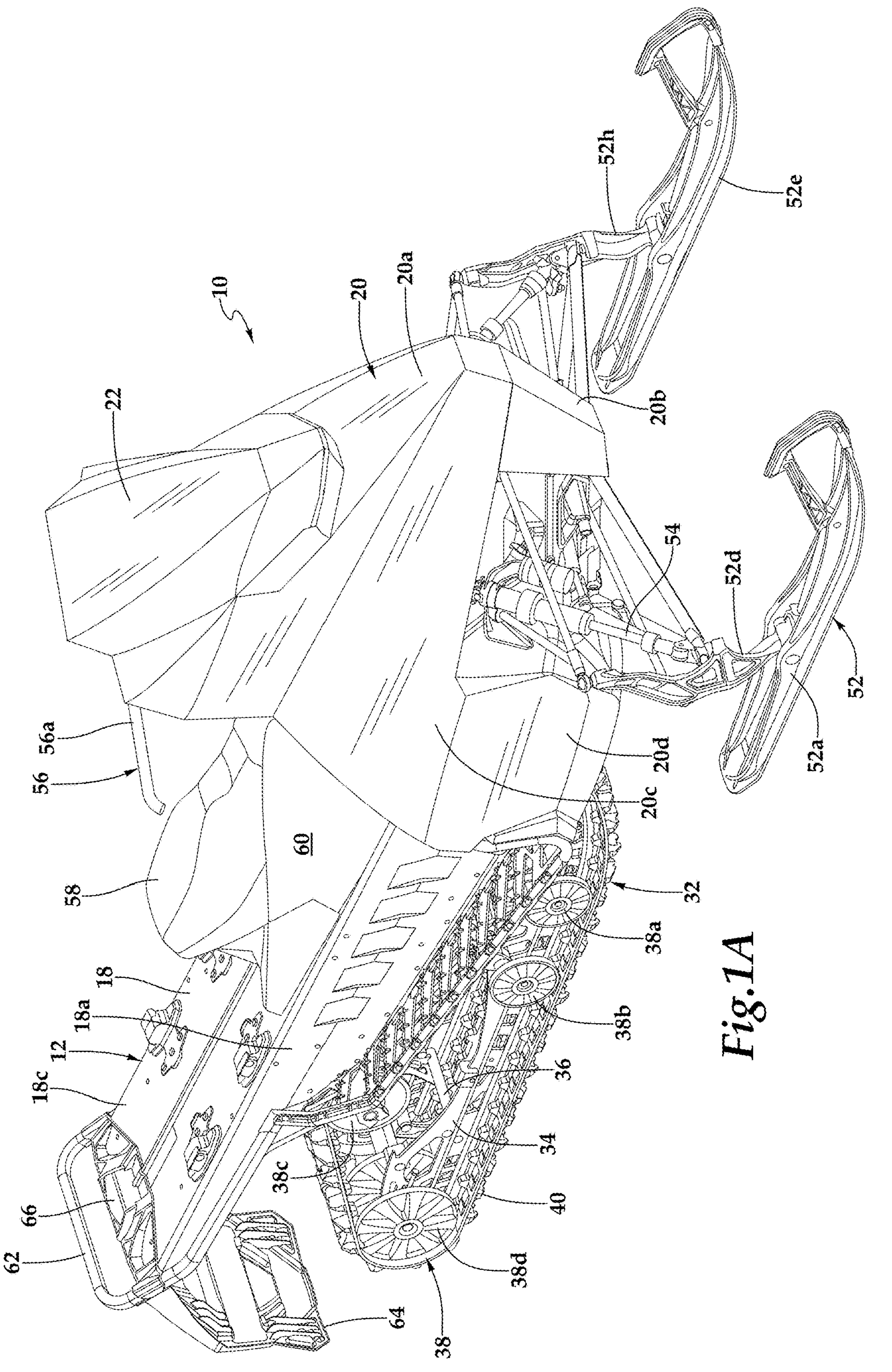

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Fig.1A

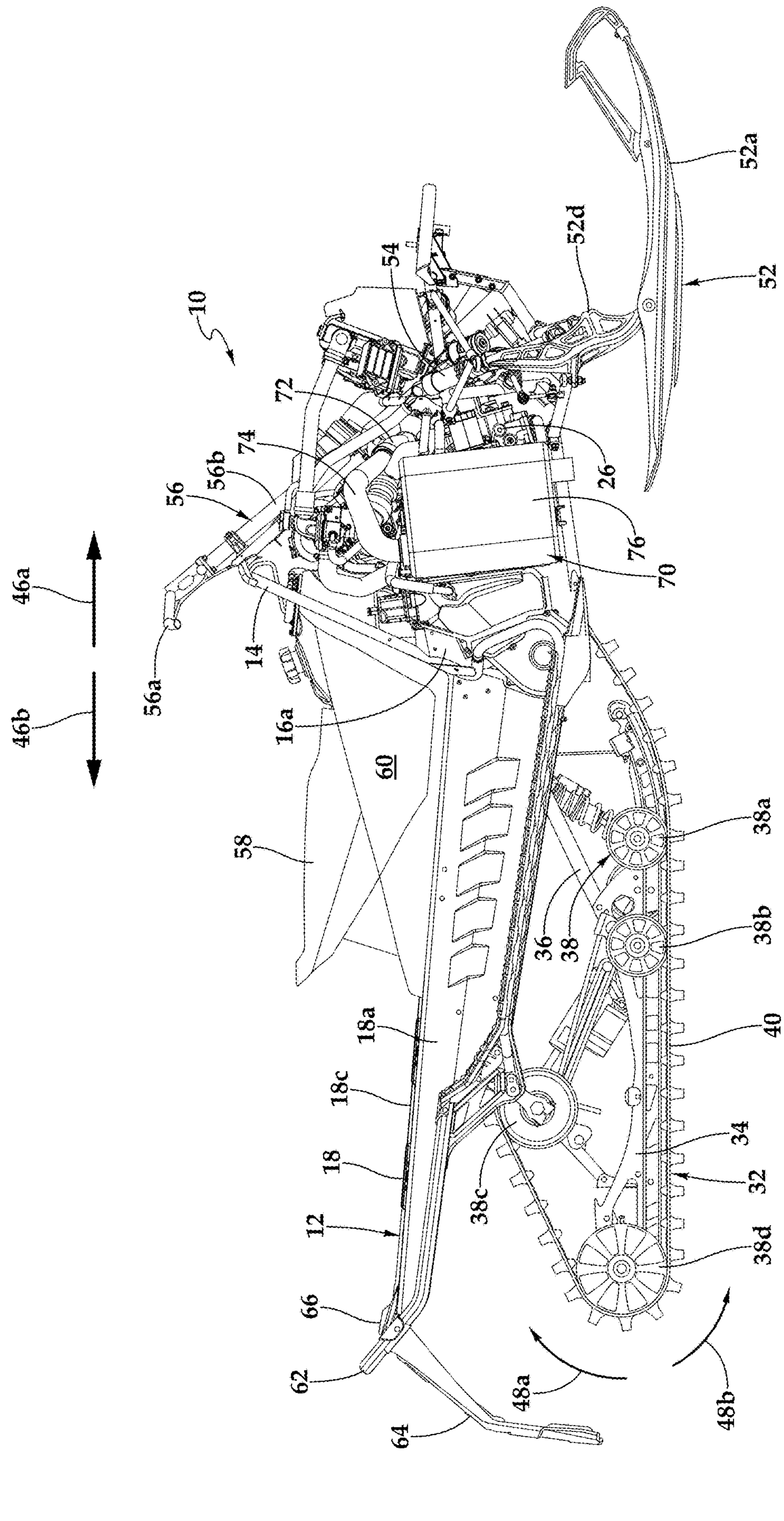
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Fig.1B

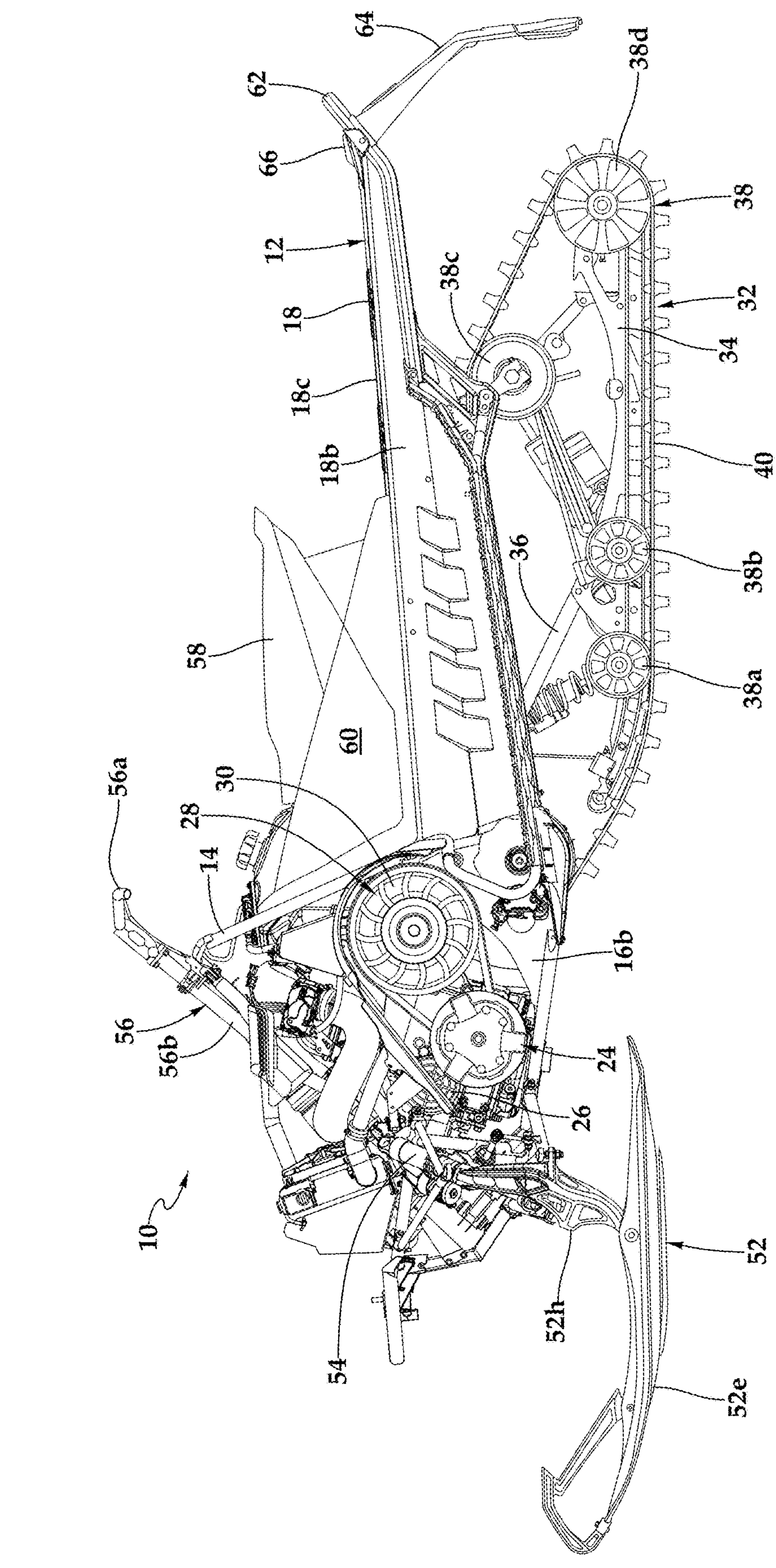
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Fig.1C

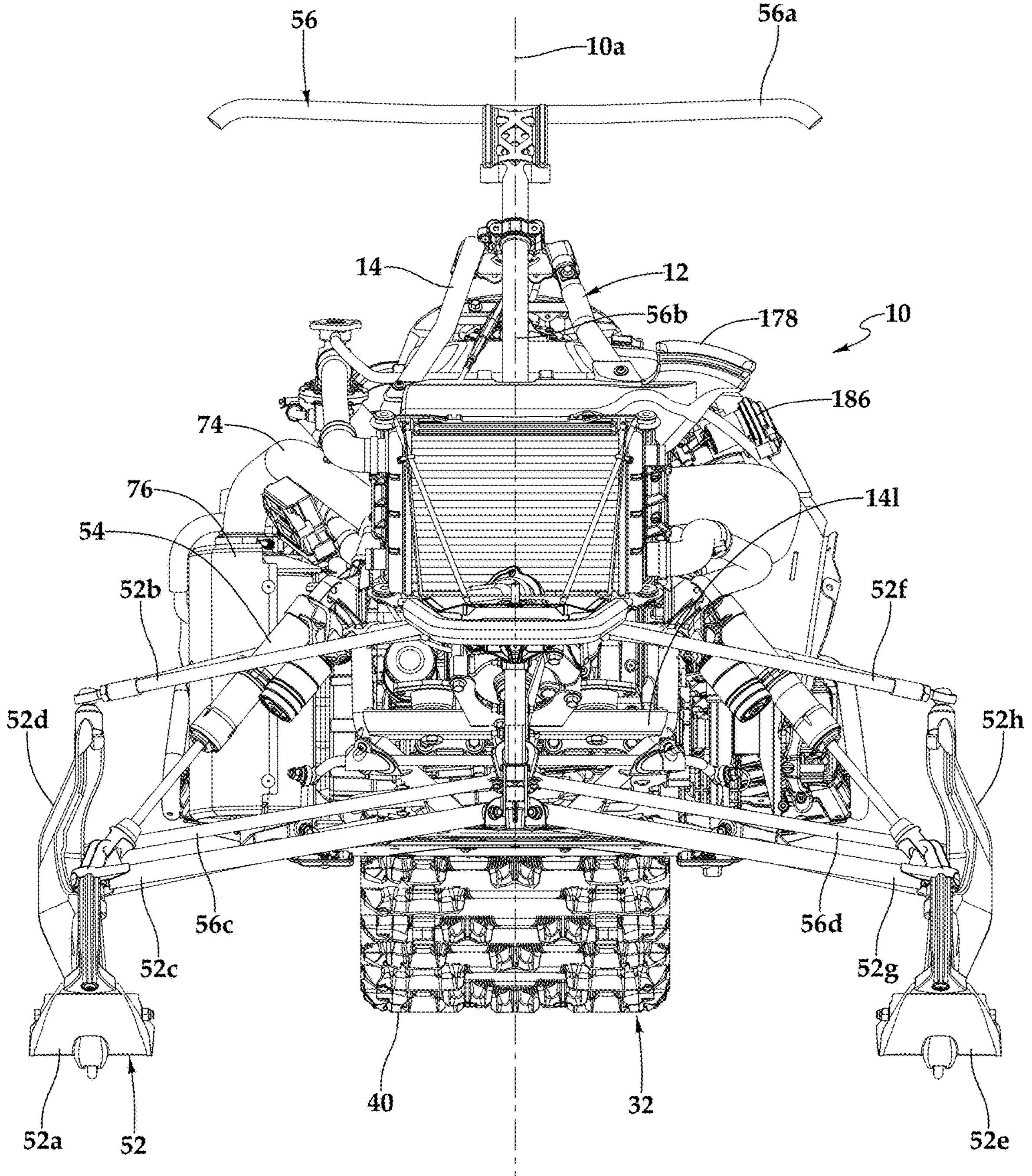
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Fig.1D

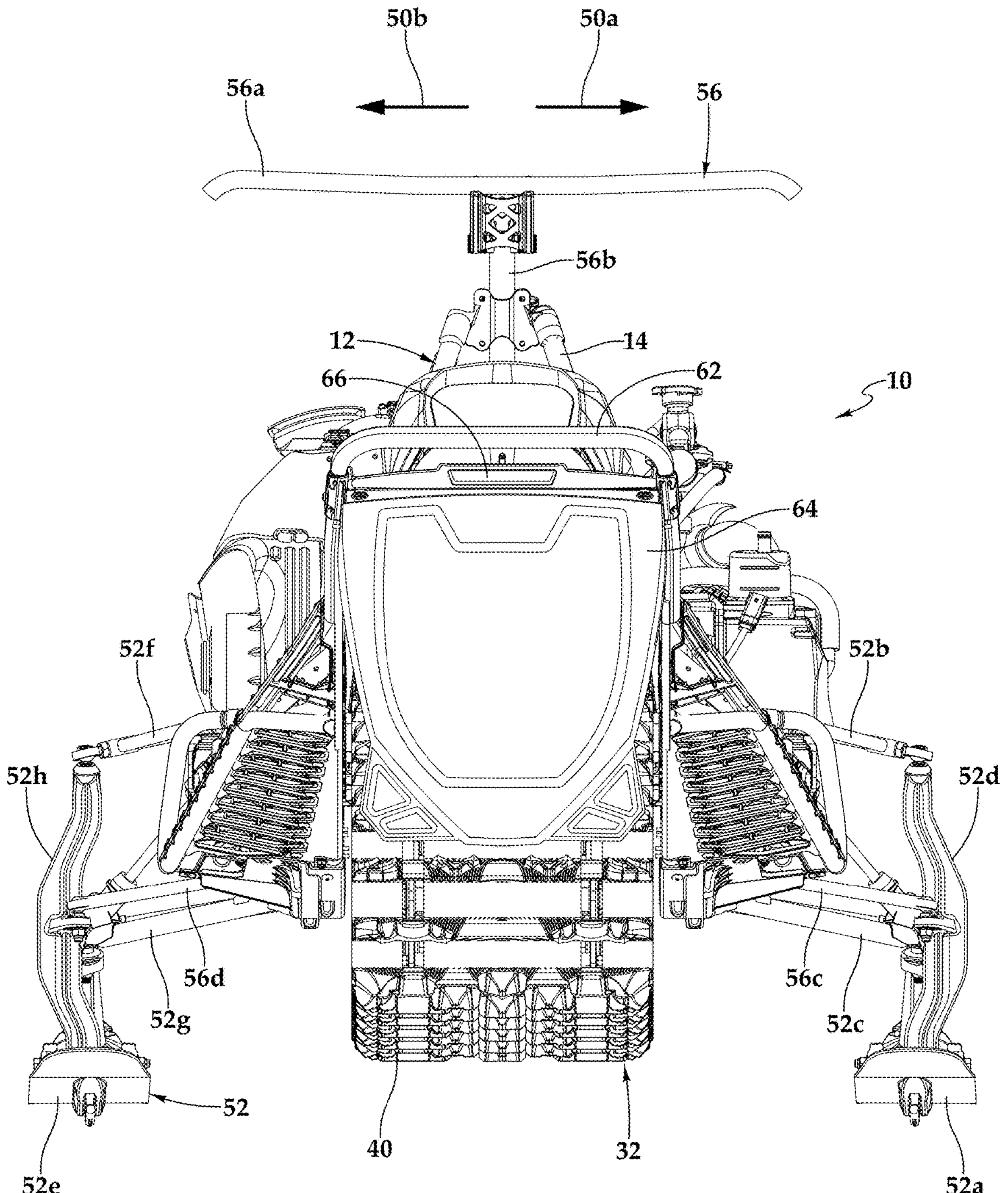
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Fig.1E

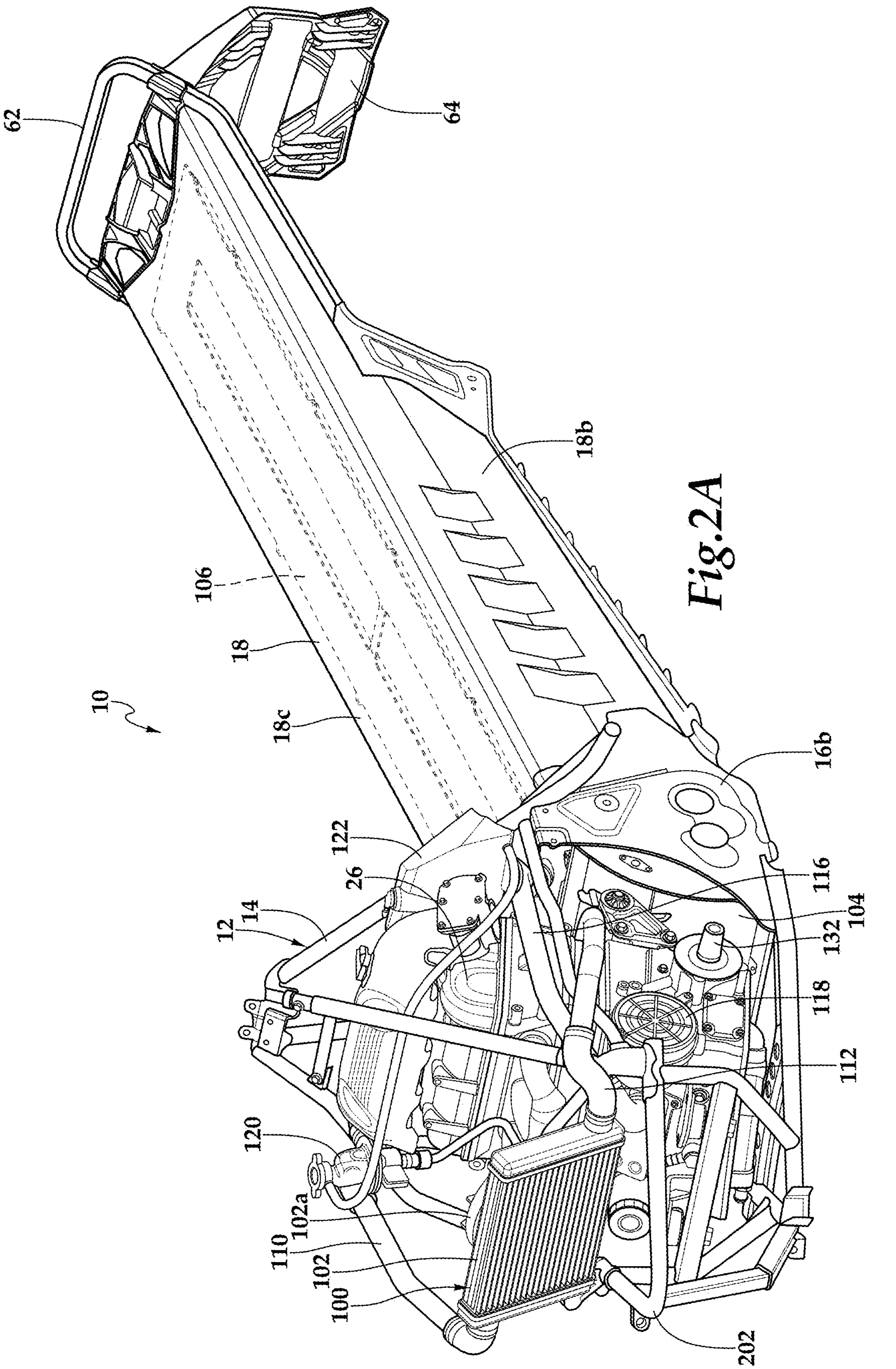
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Fig.2A

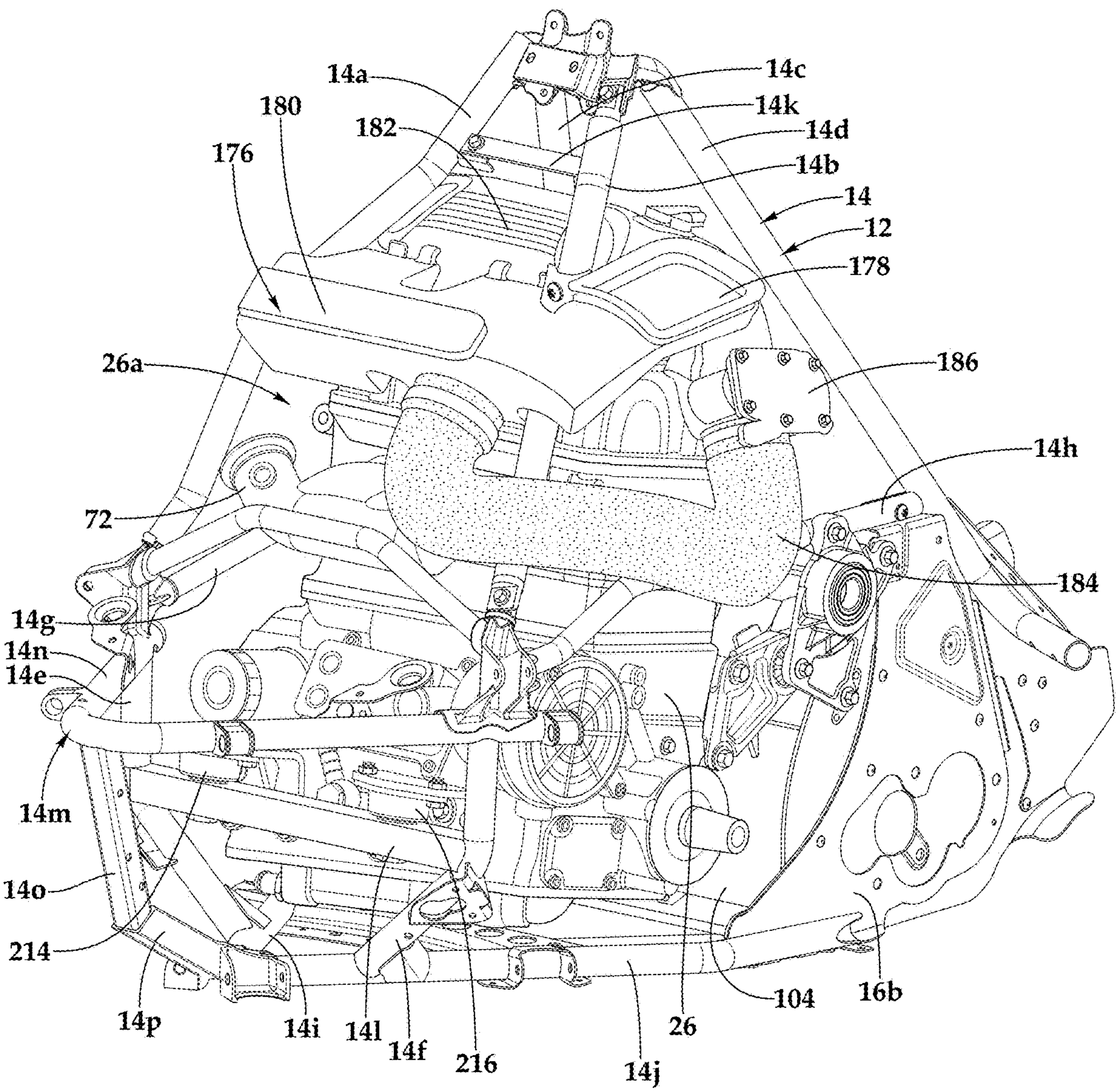
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Fig.2B

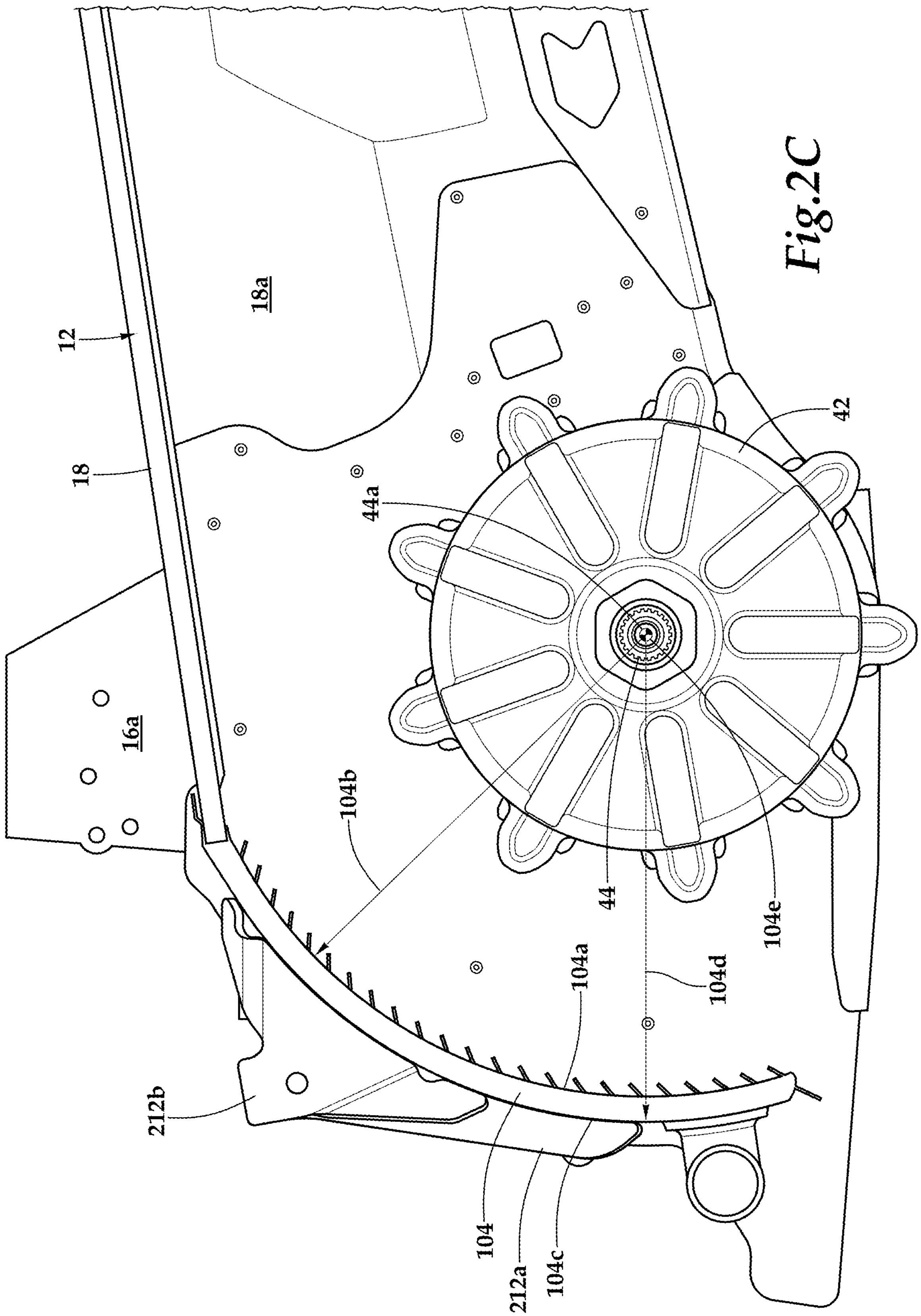


Fig.2C

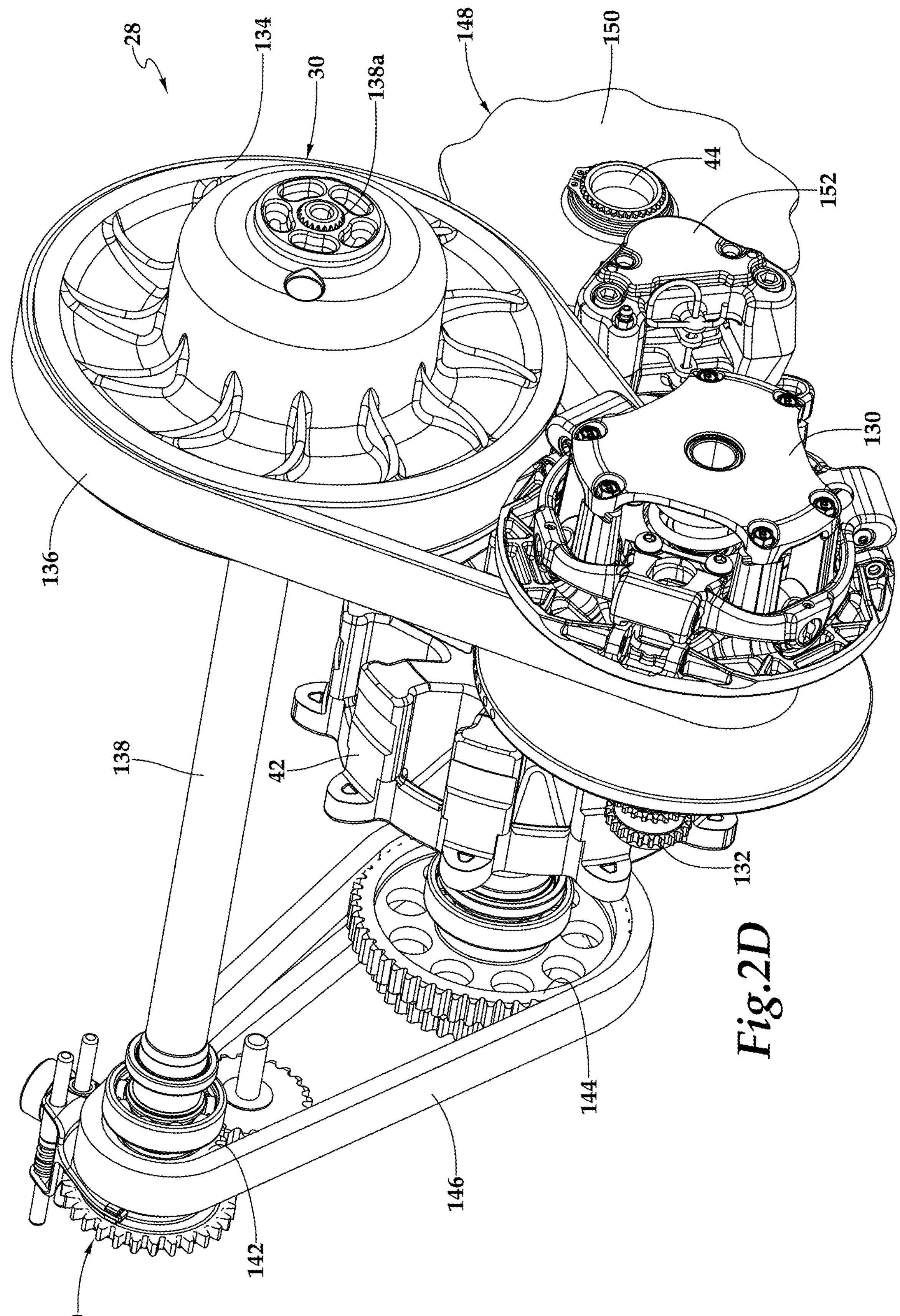


Fig.2D

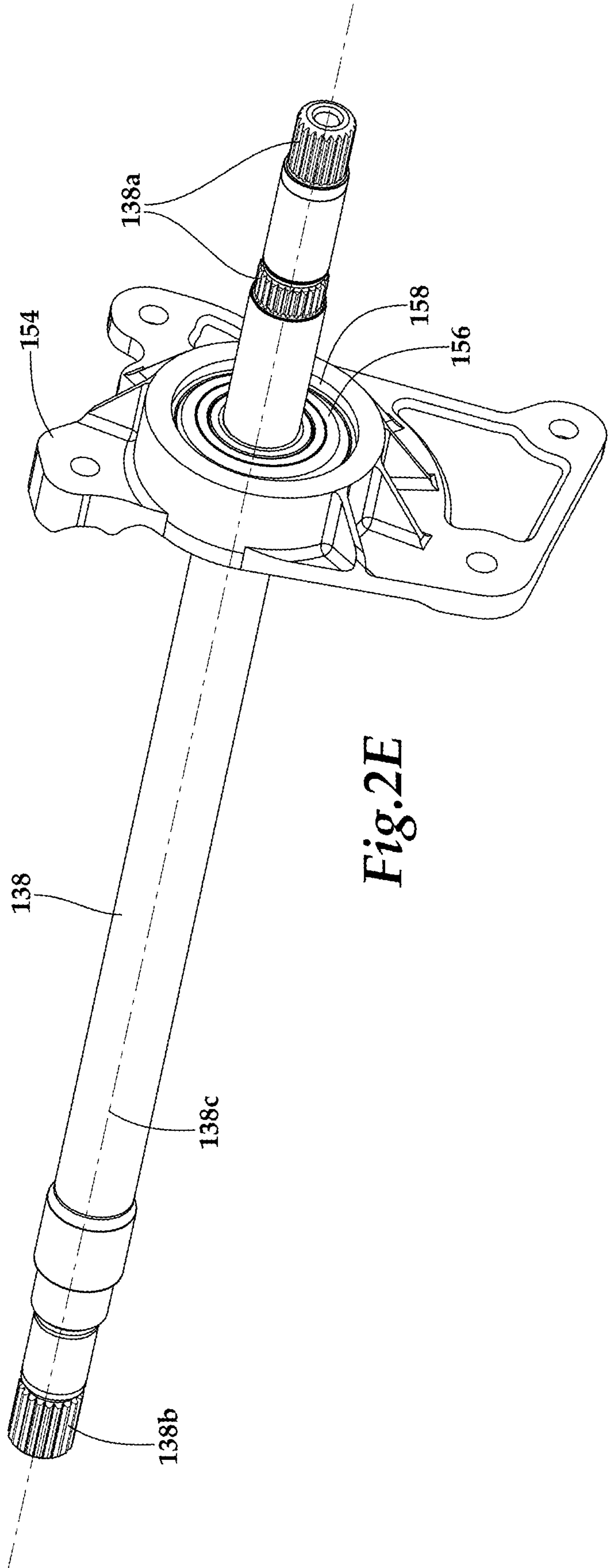
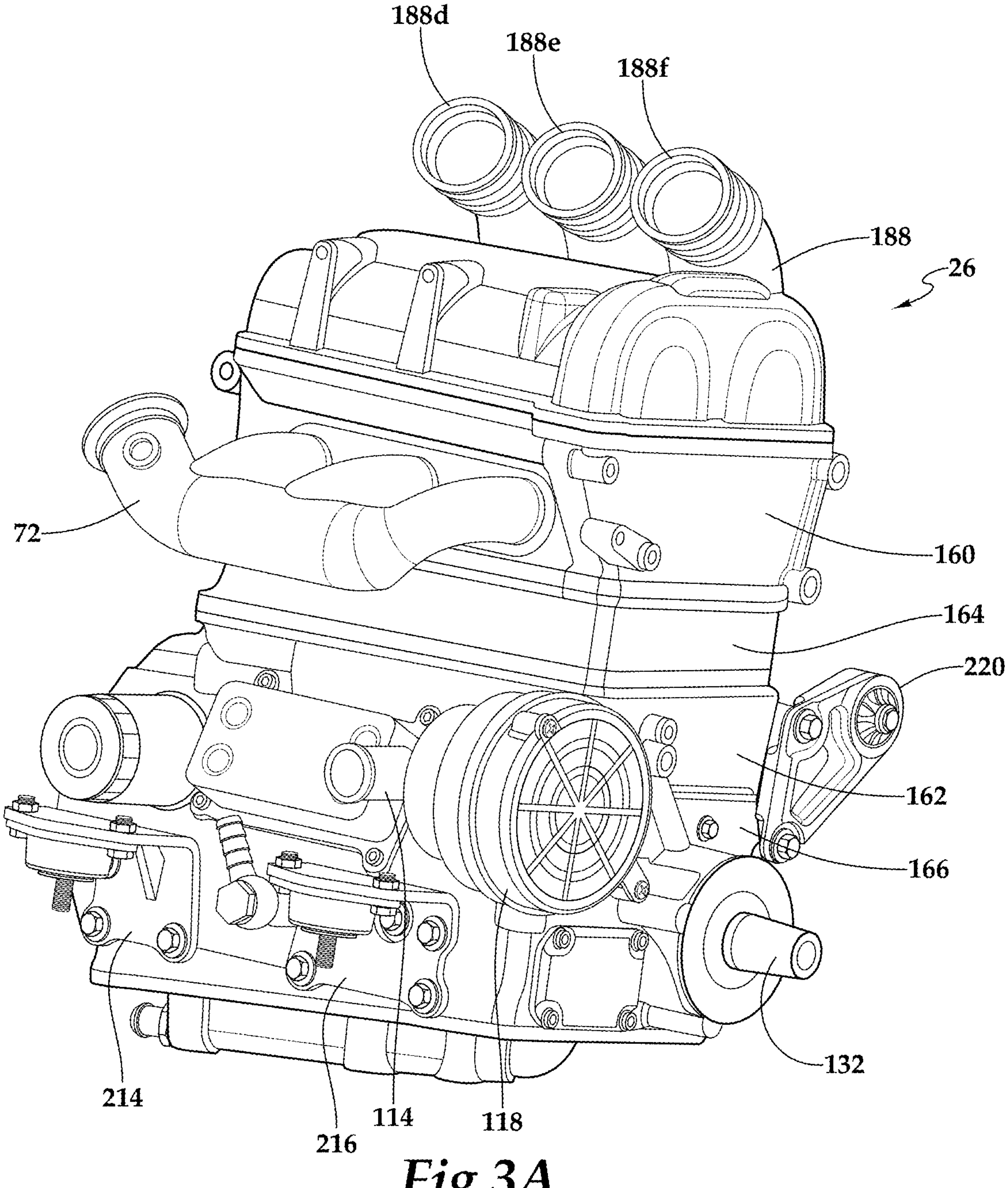


Fig.2E



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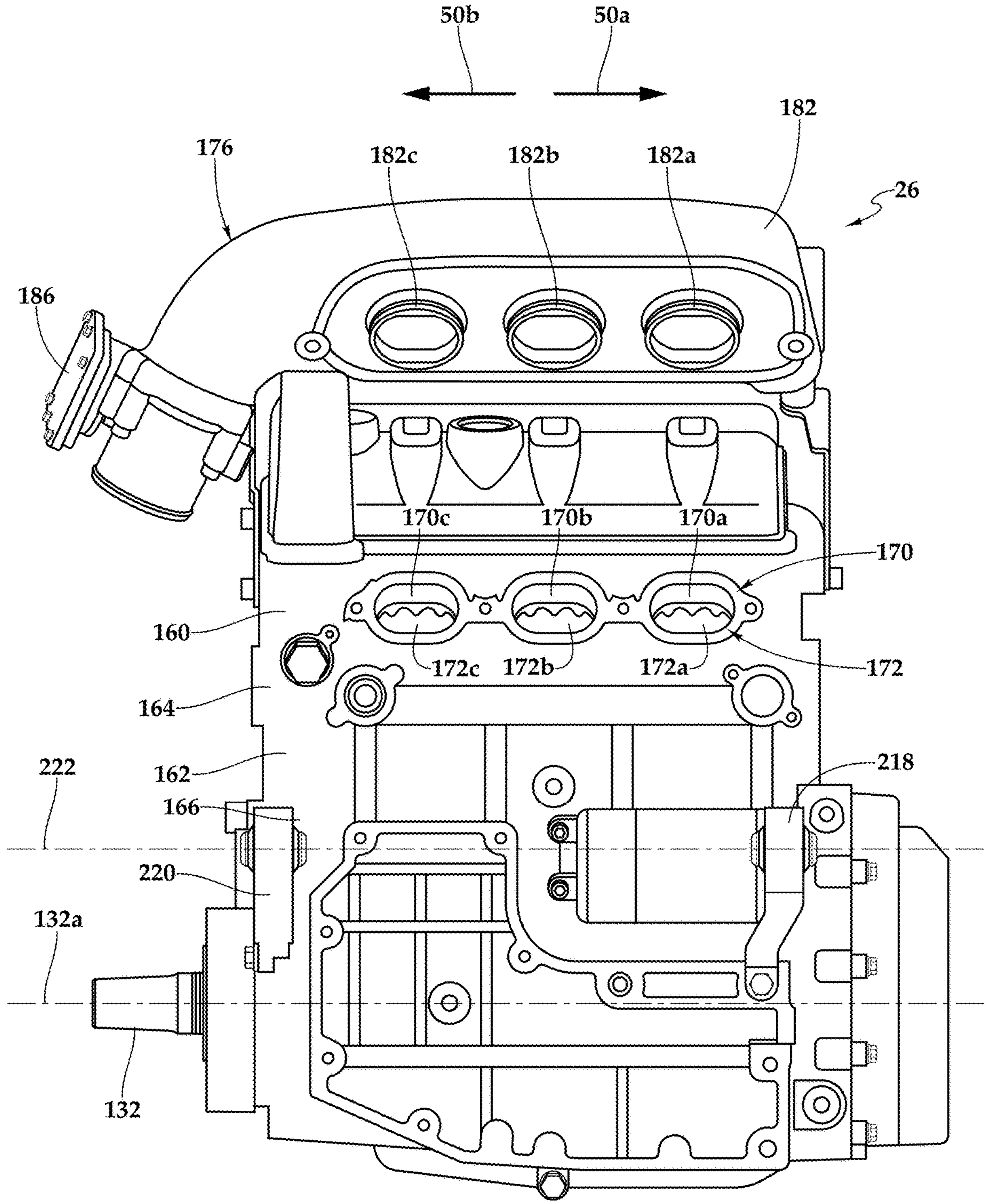
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Fig.3B

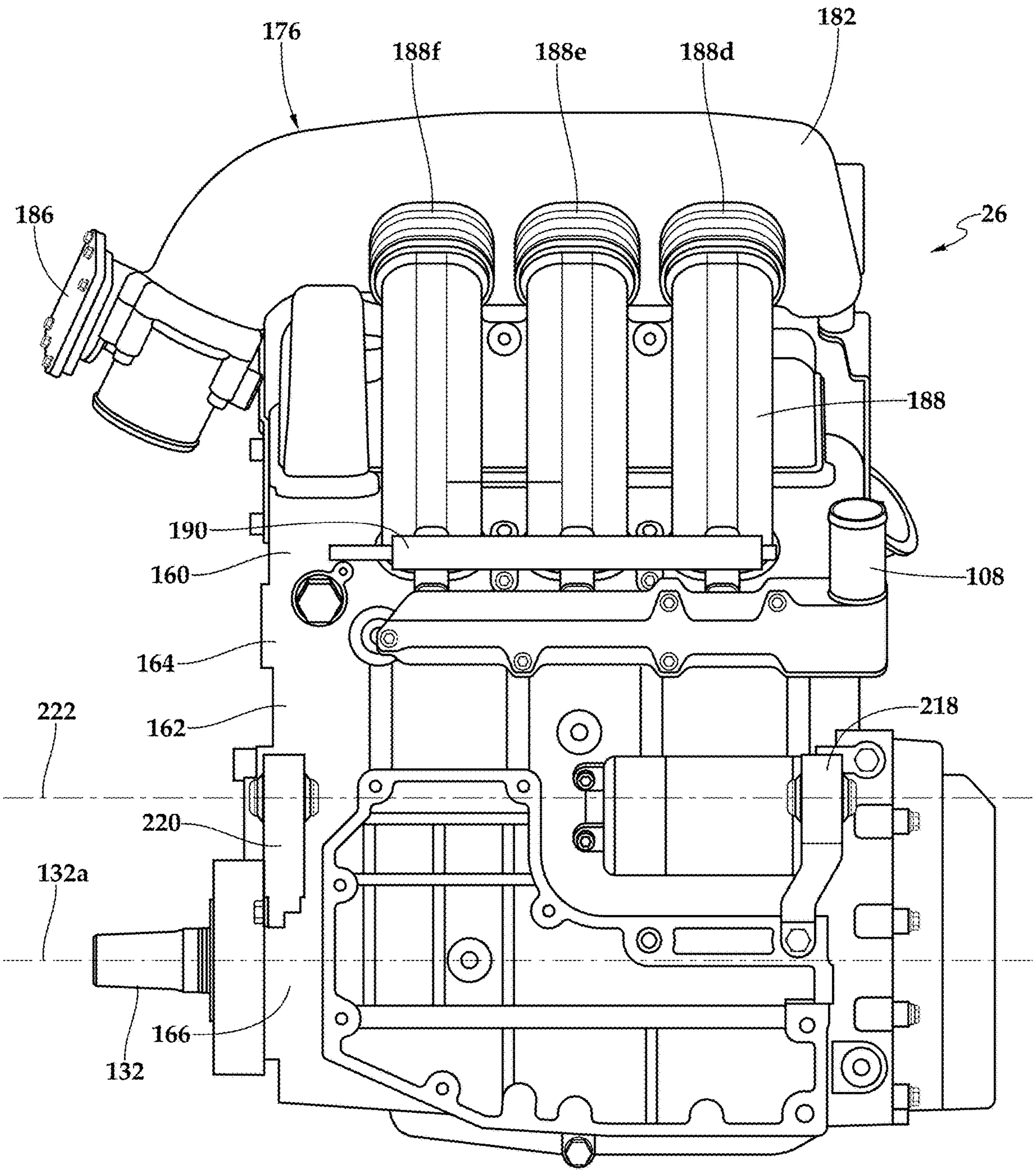
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Fig.3C

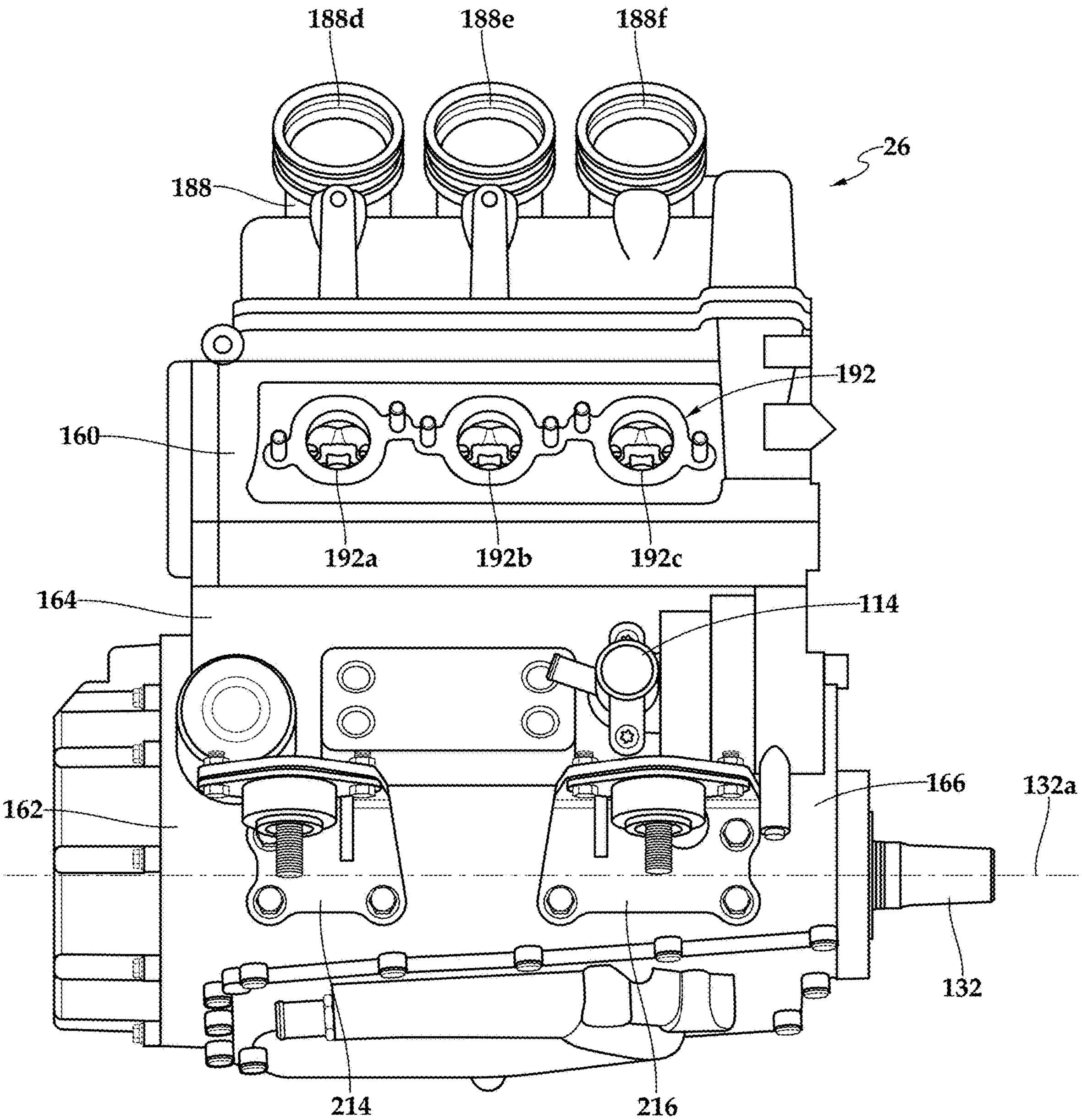
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Fig.3D

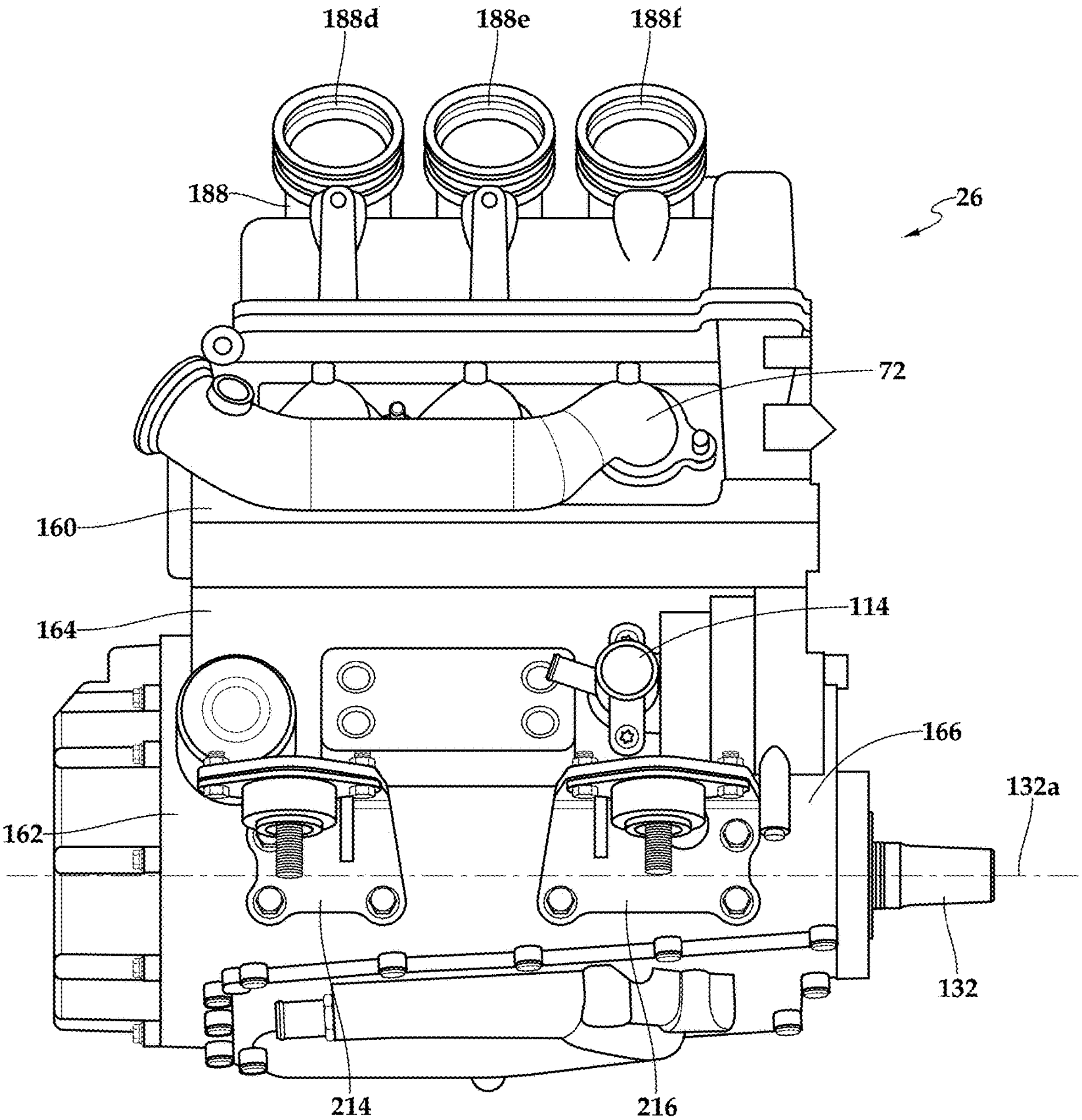

Fig.3E

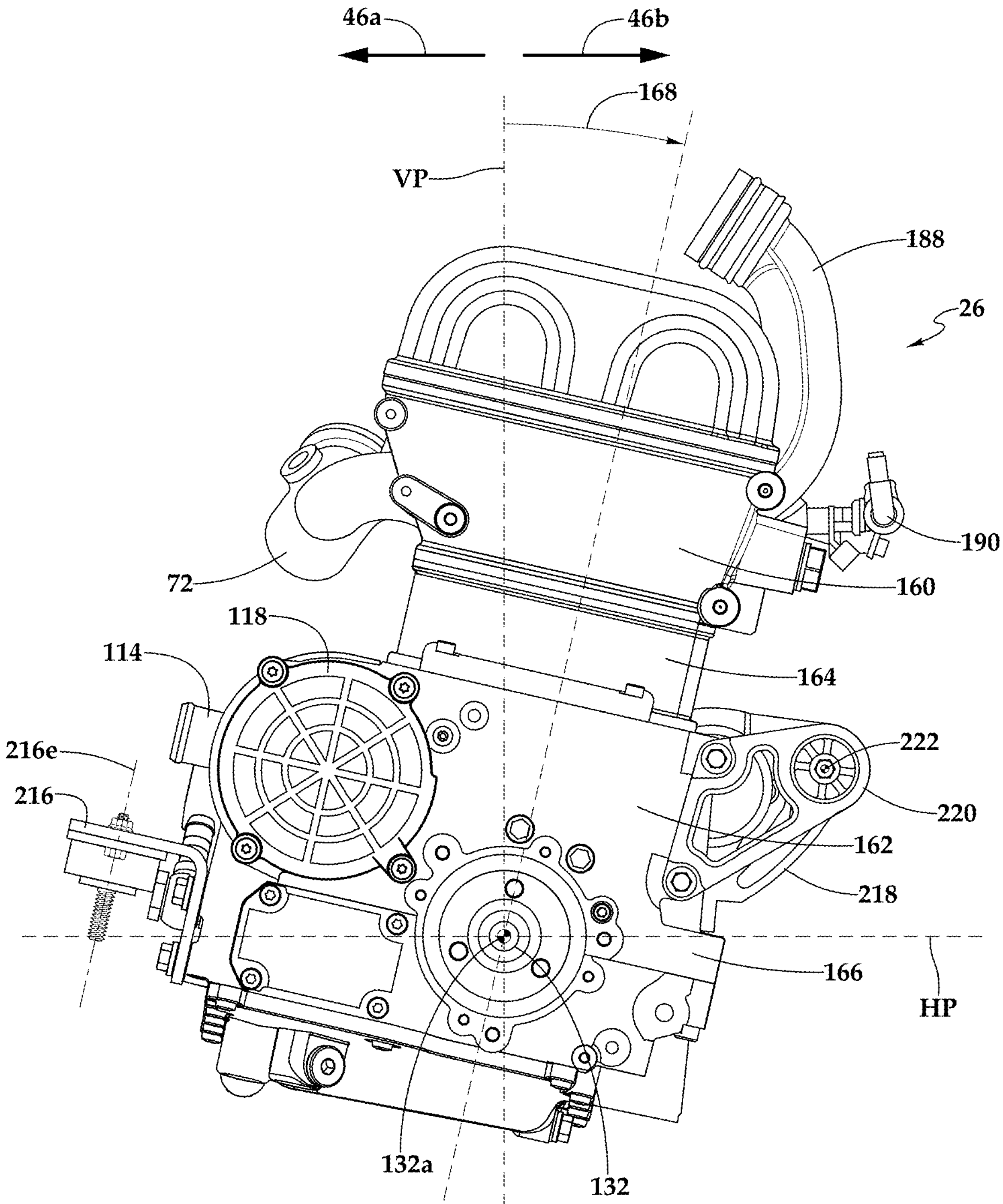
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Fig.3F

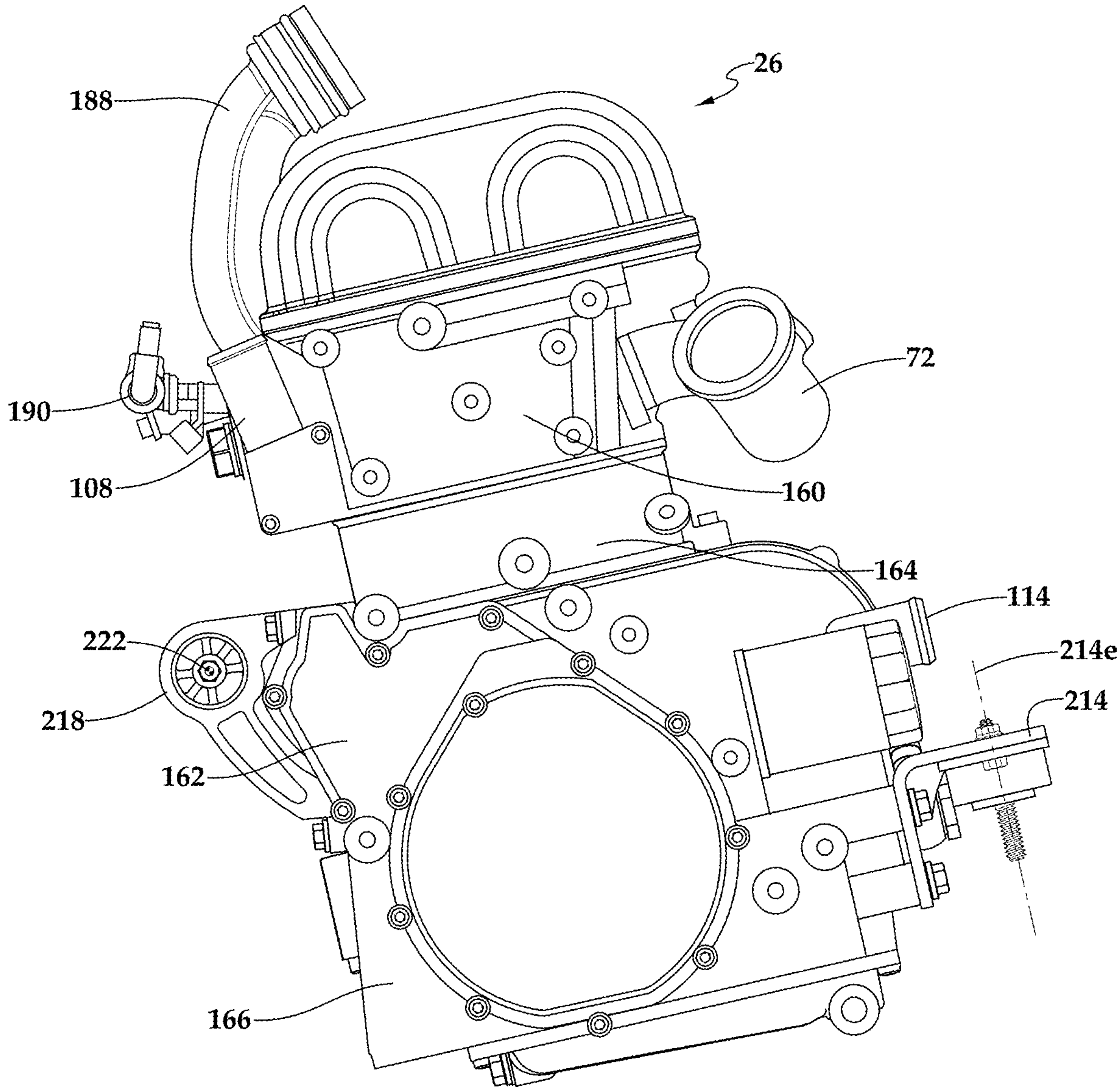

Fig.3G

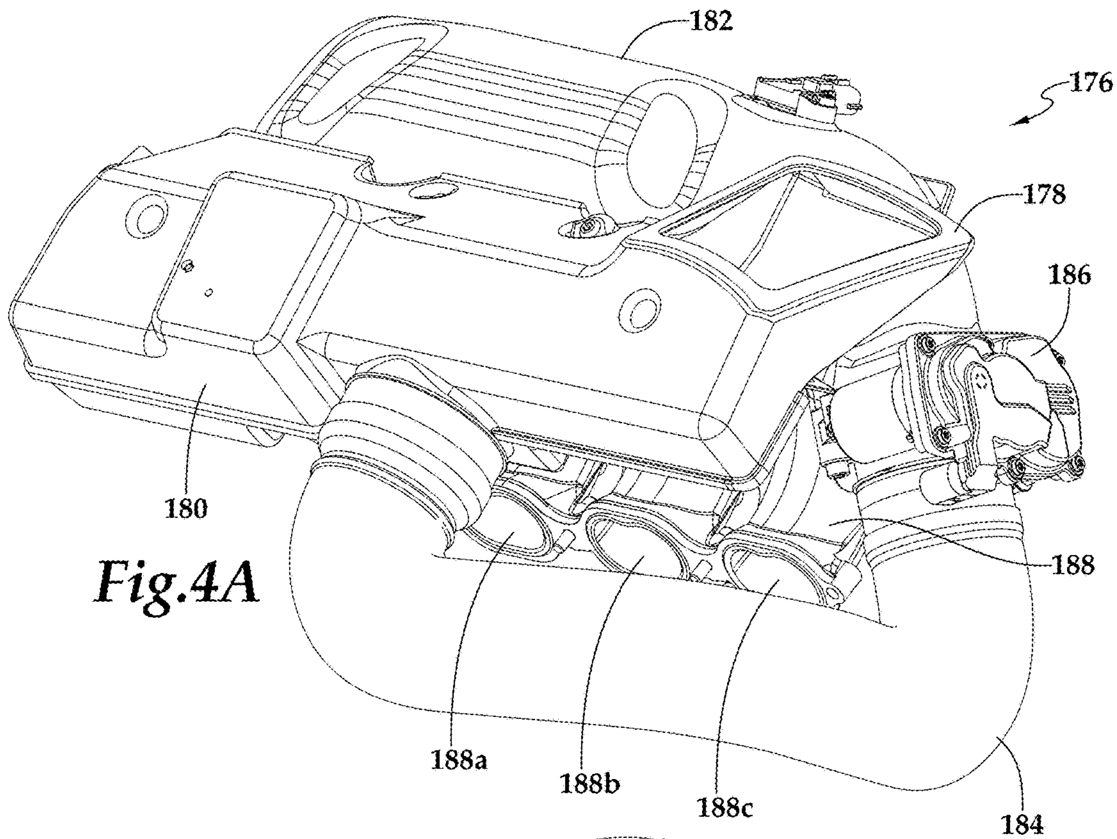
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Fig.4A

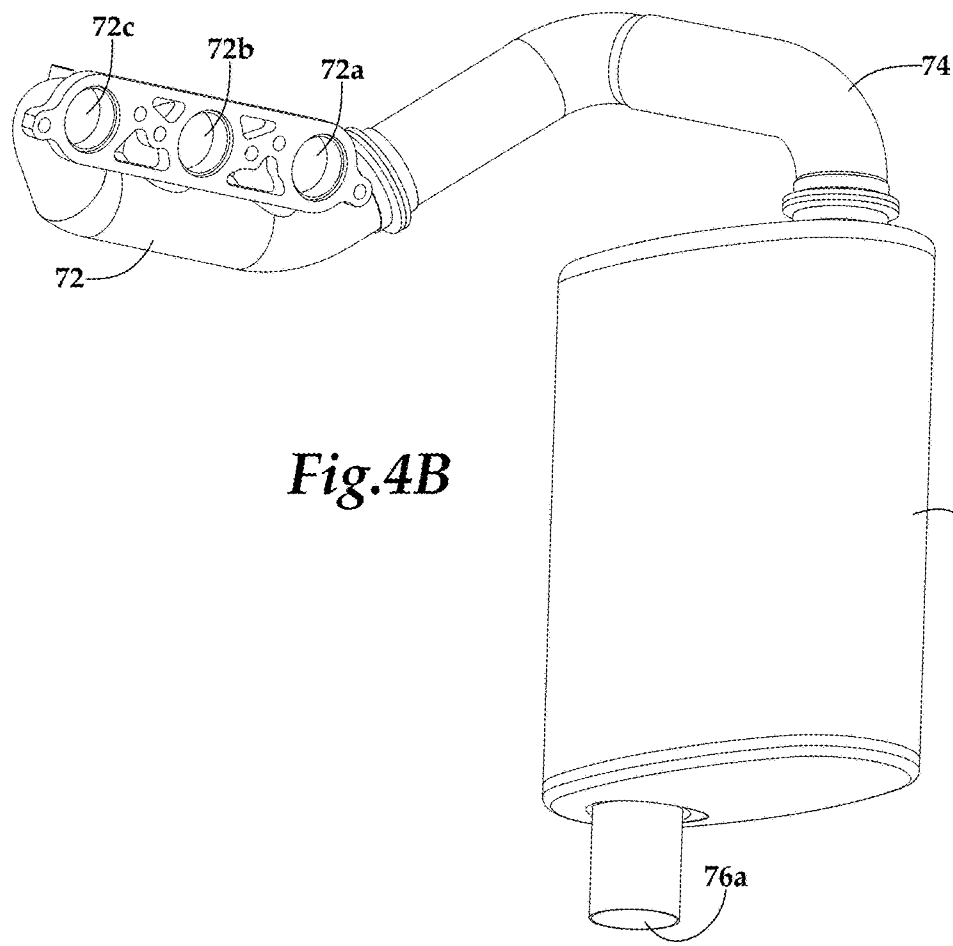
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Fig.4B

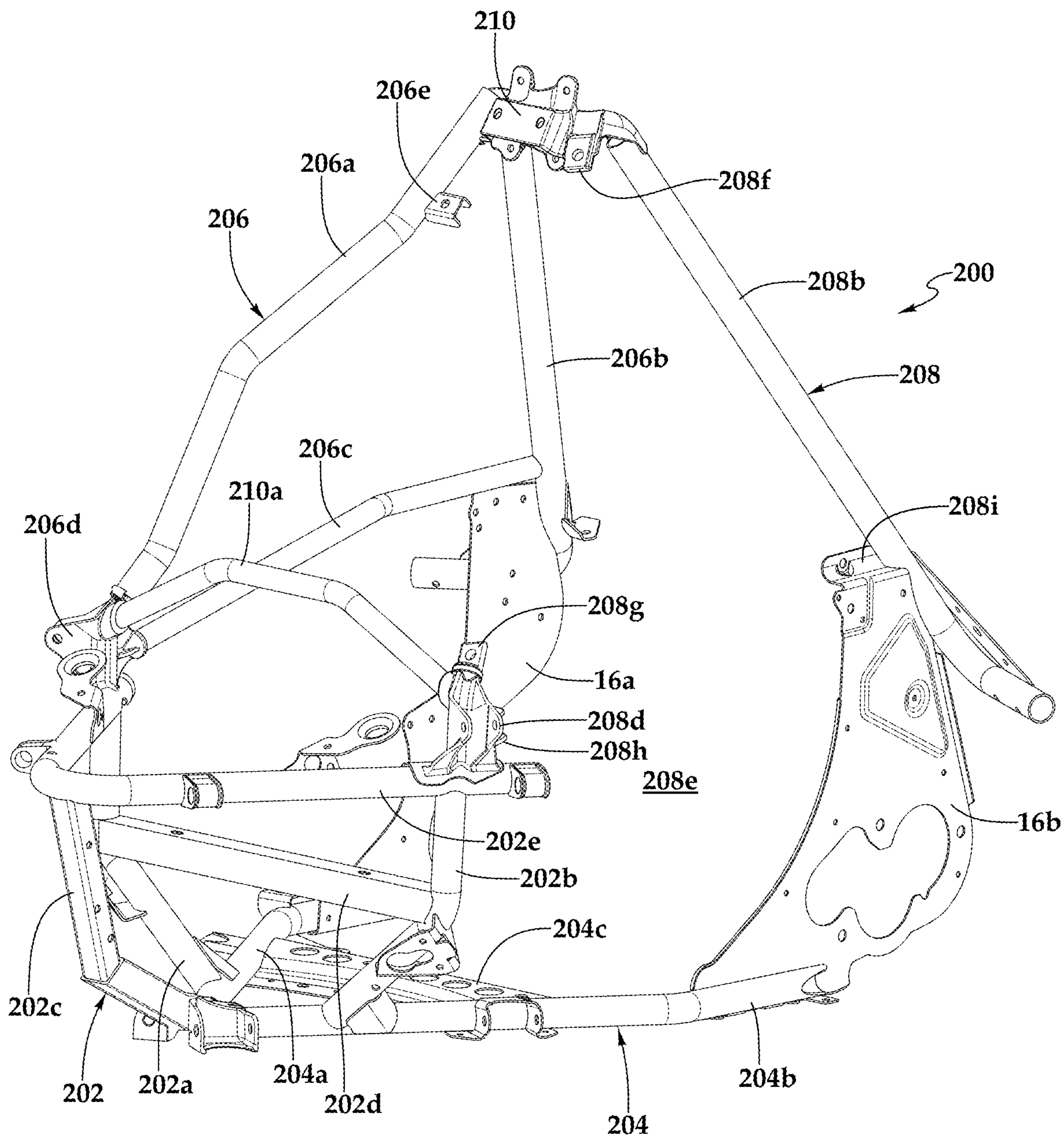
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Fig.5A

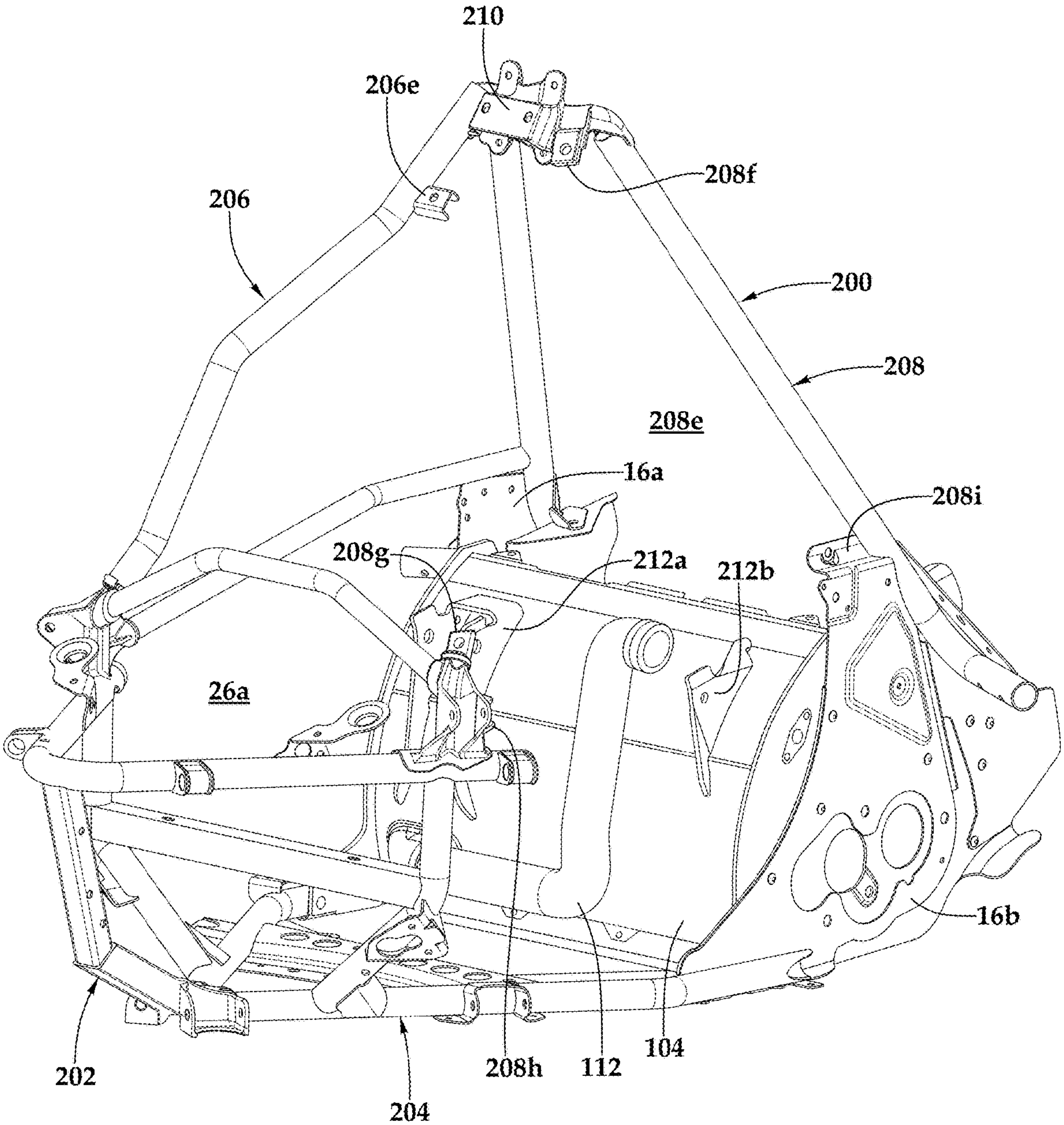
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Fig.5B

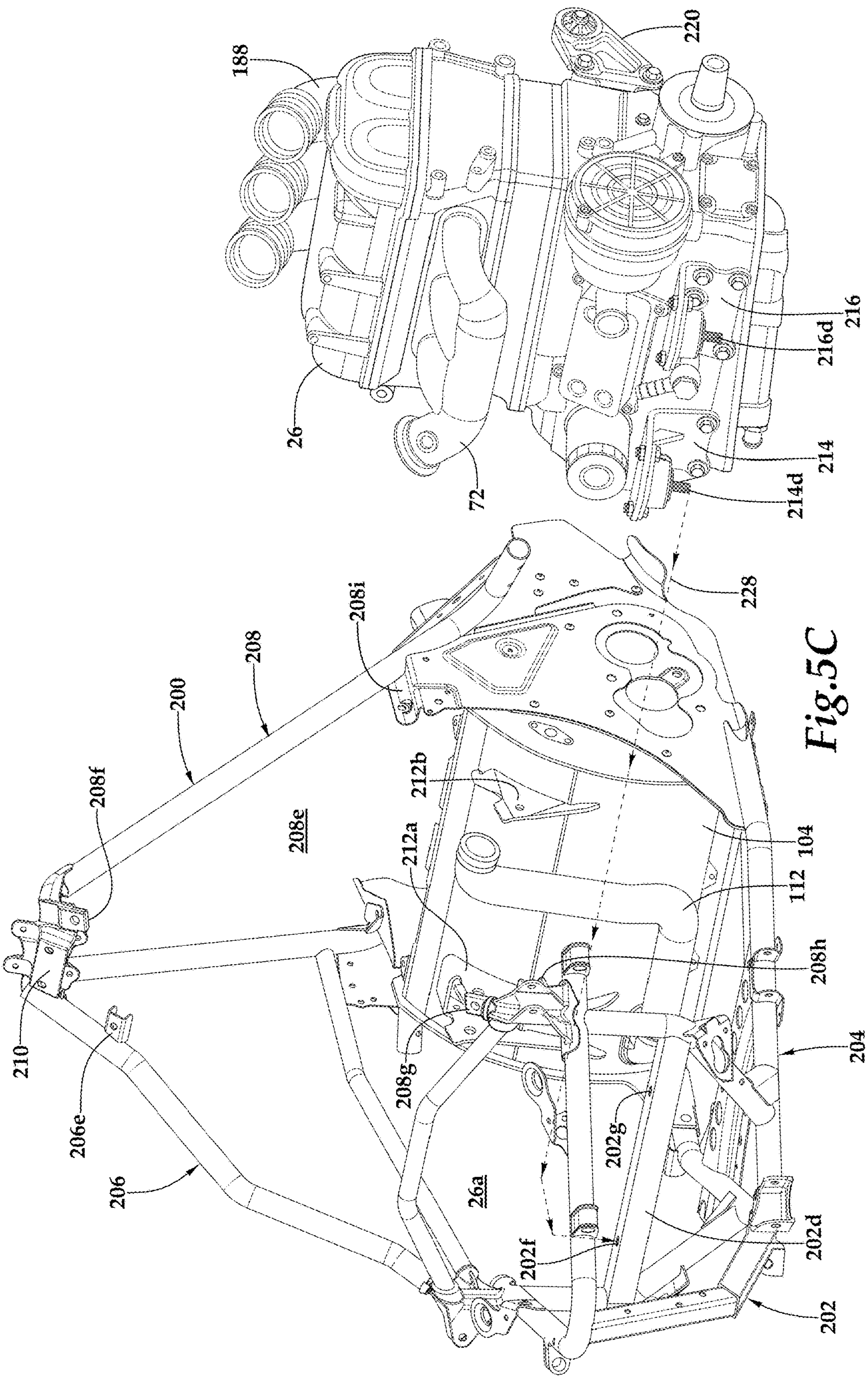
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Fig.5C

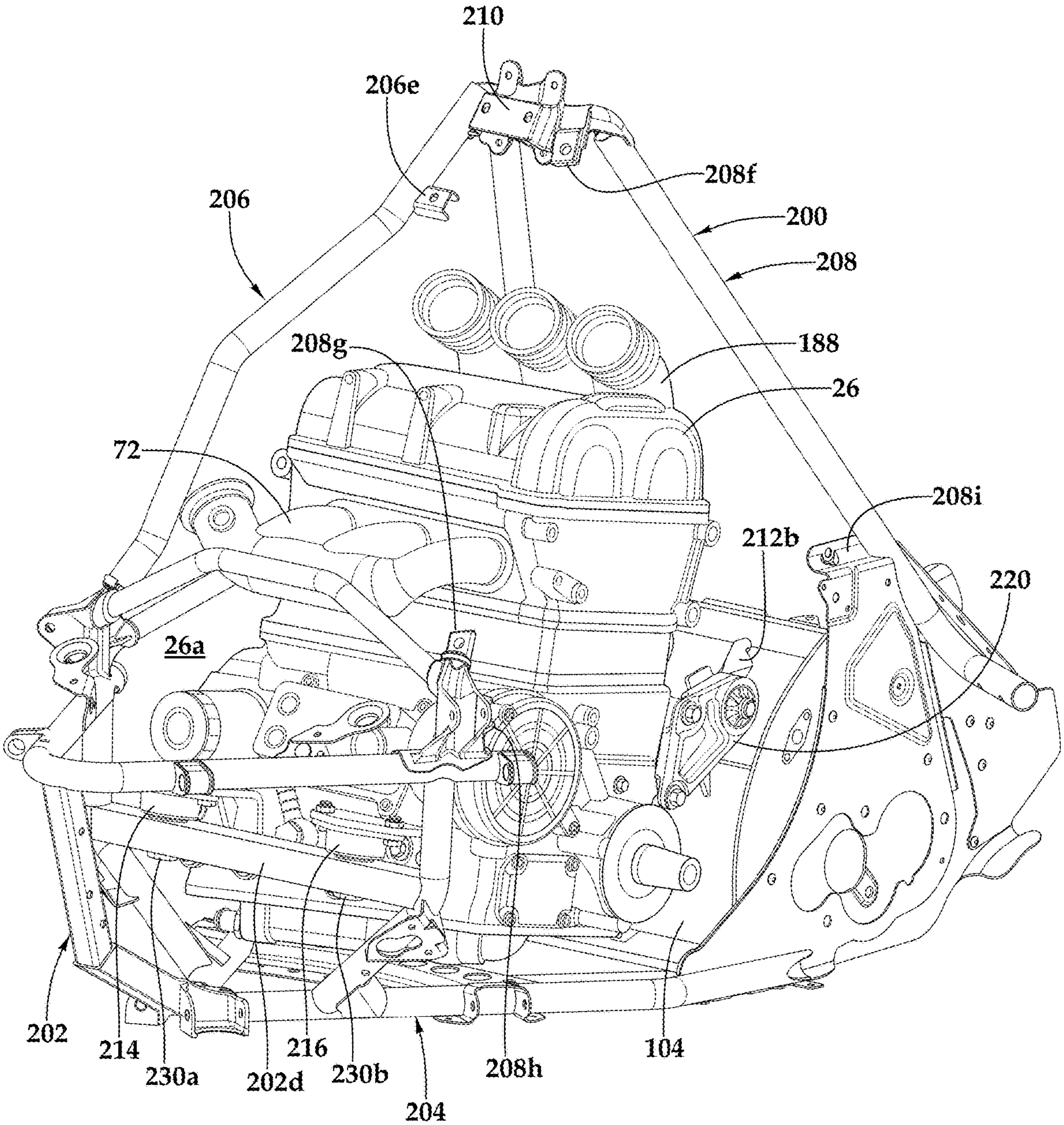
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Fig.5D

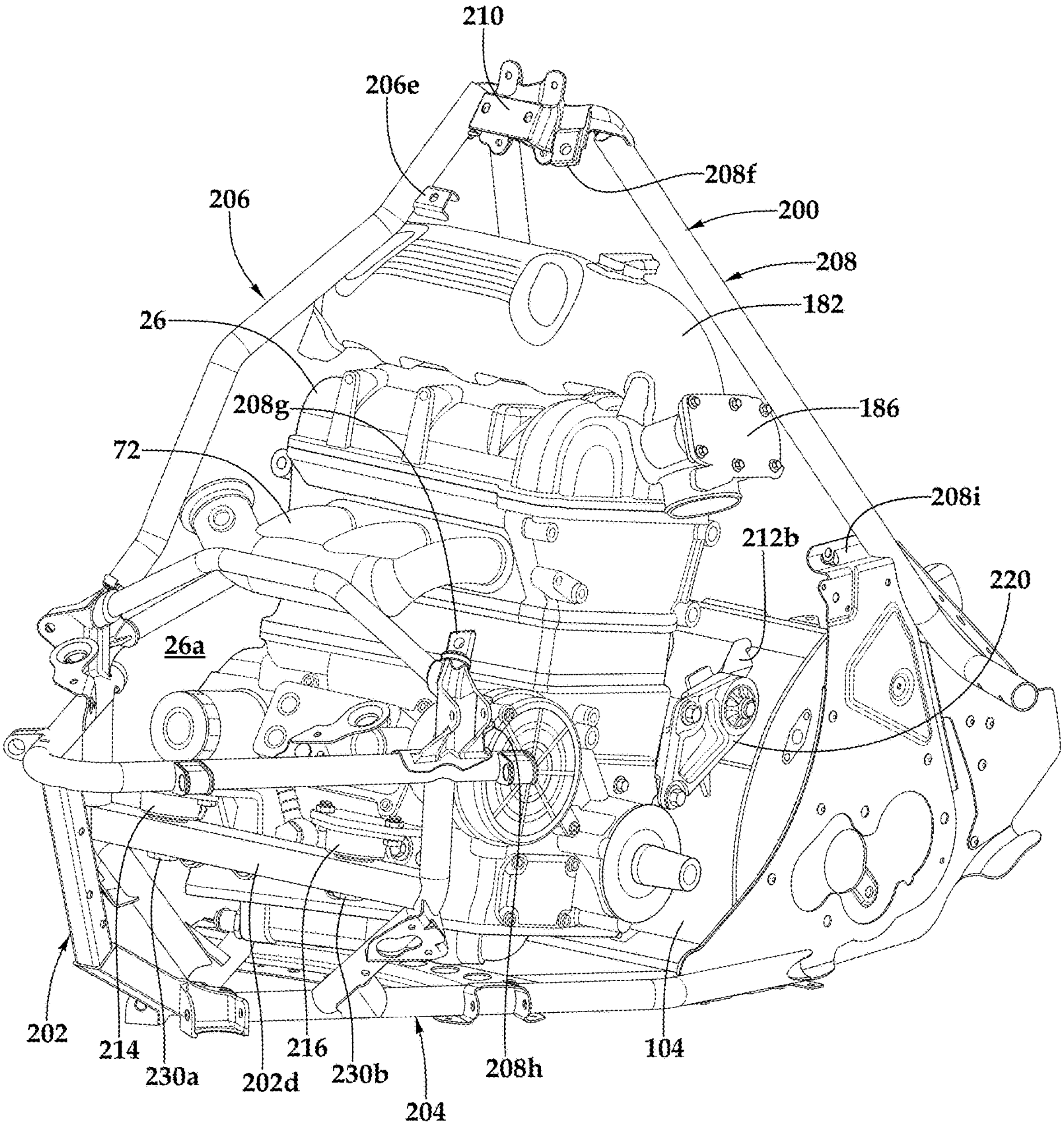
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Fig.5E

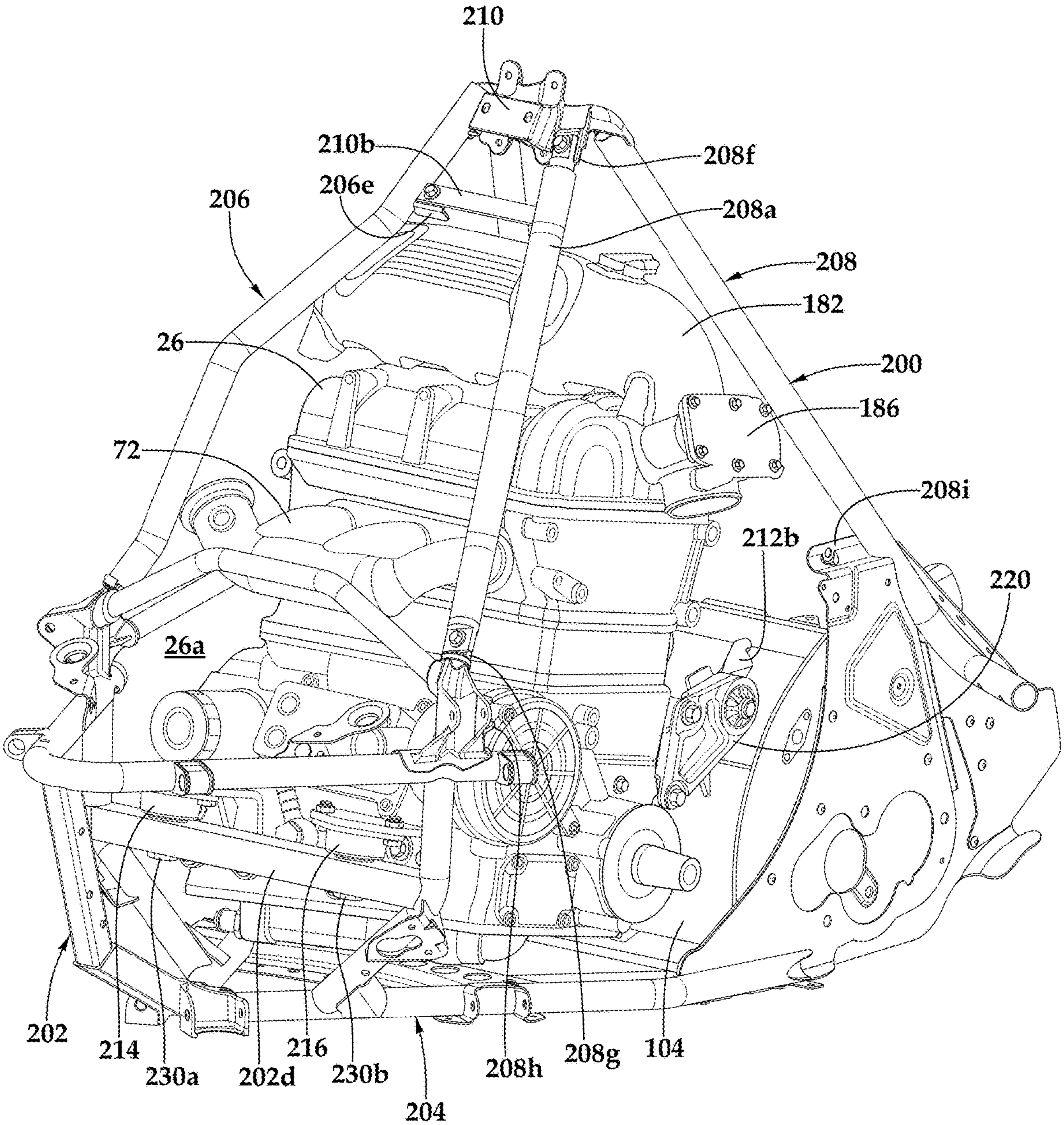
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Fig.5F

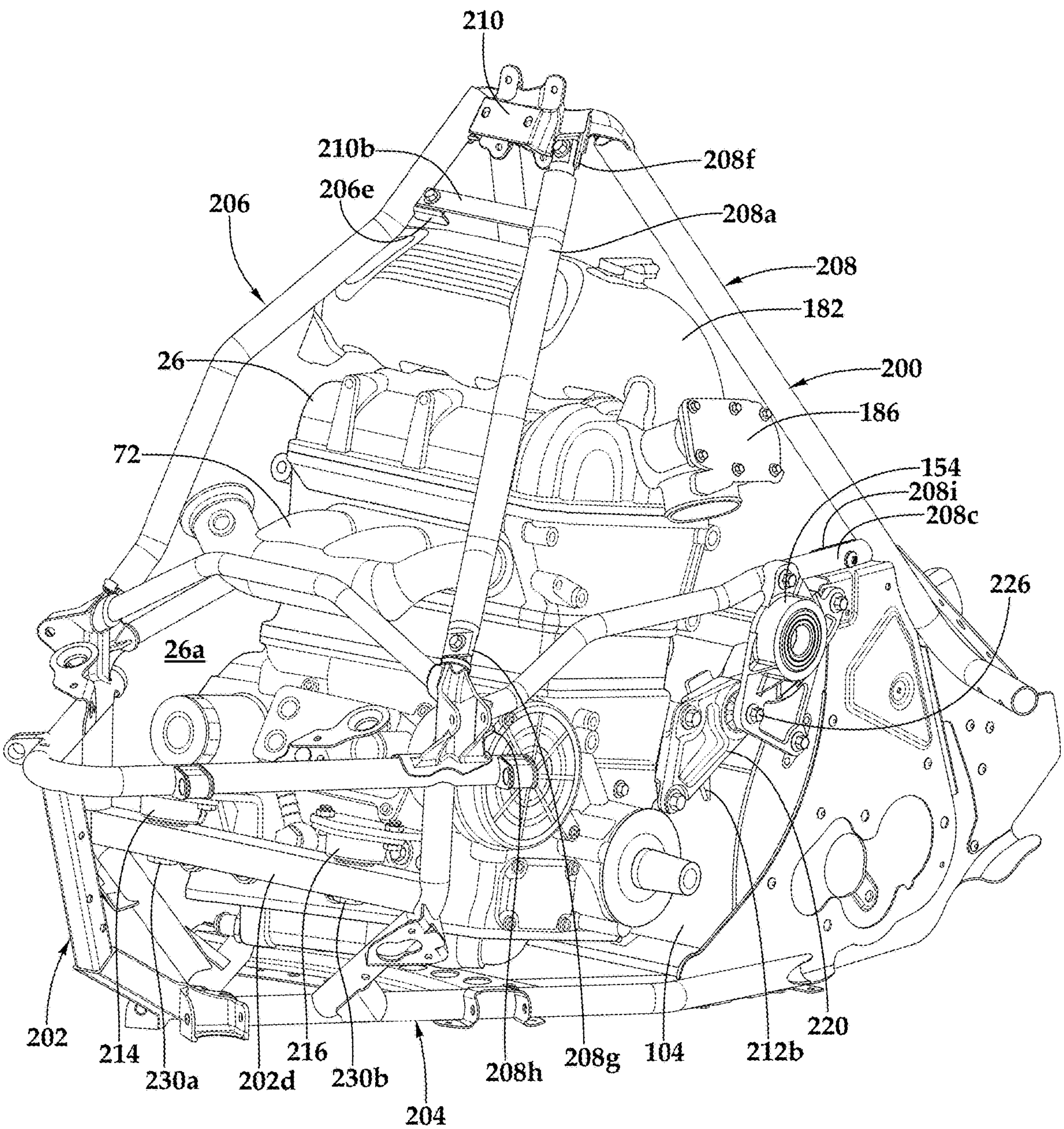
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Fig.5G

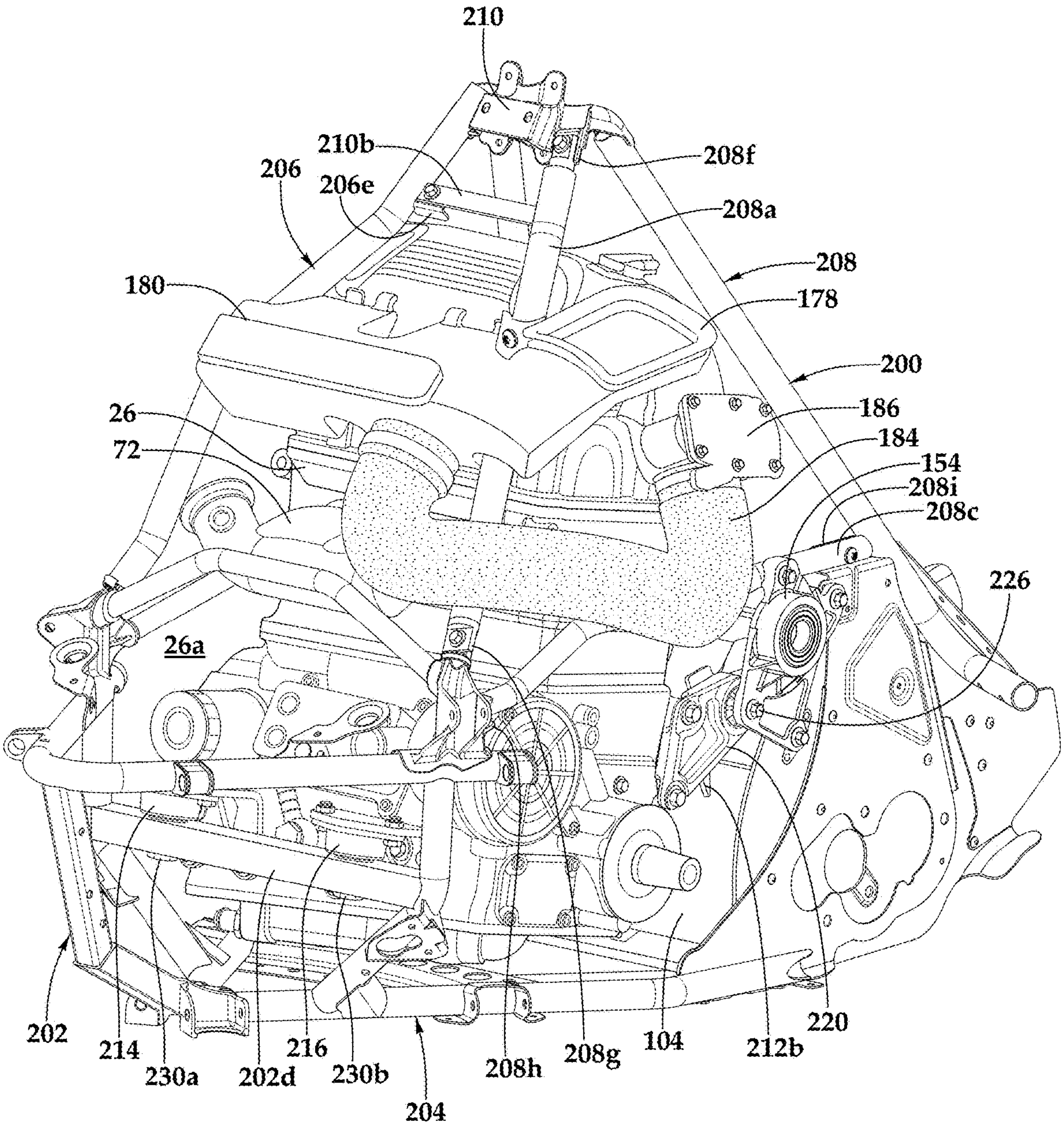
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Fig.5H

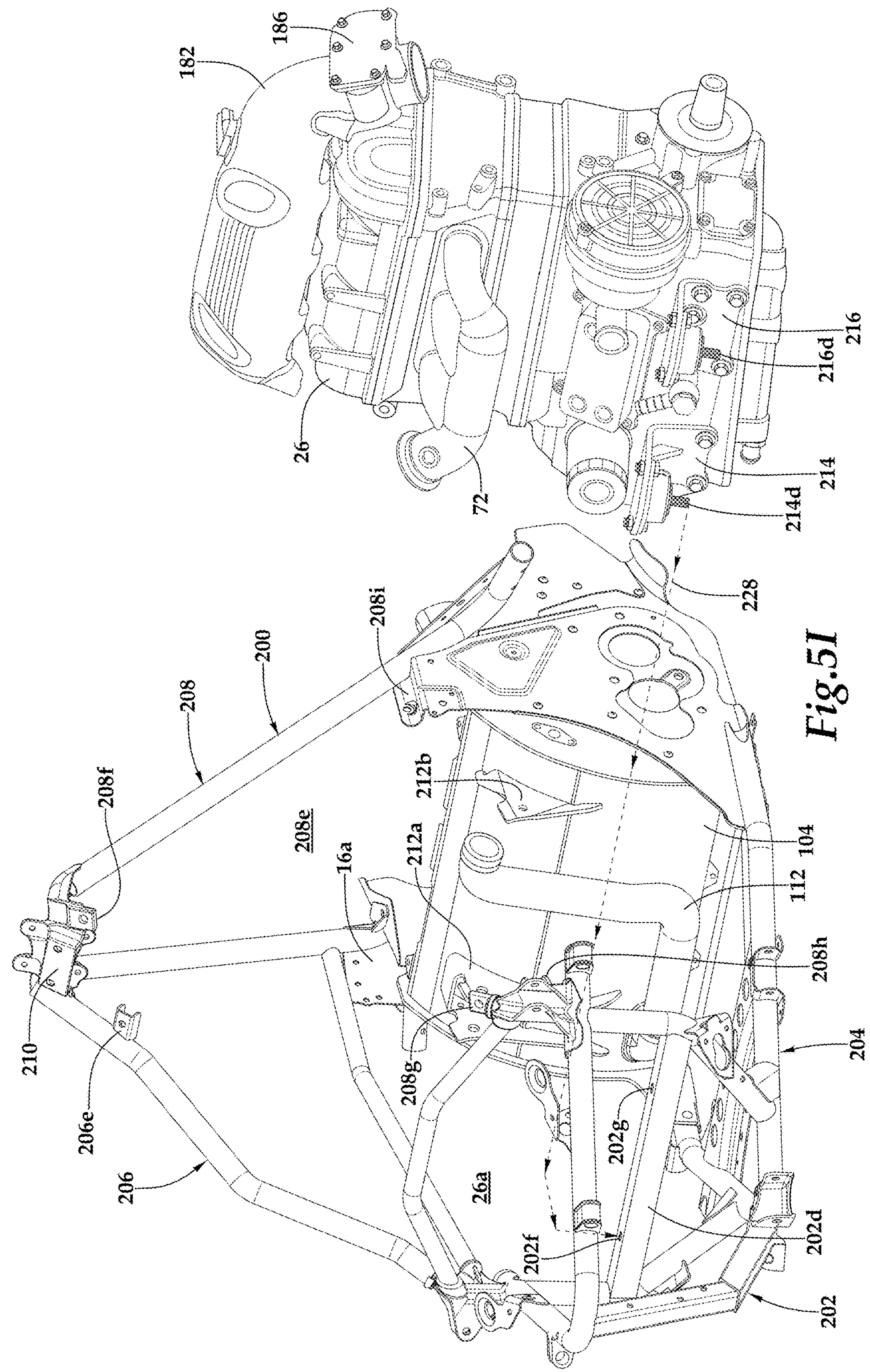
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Fig.5I

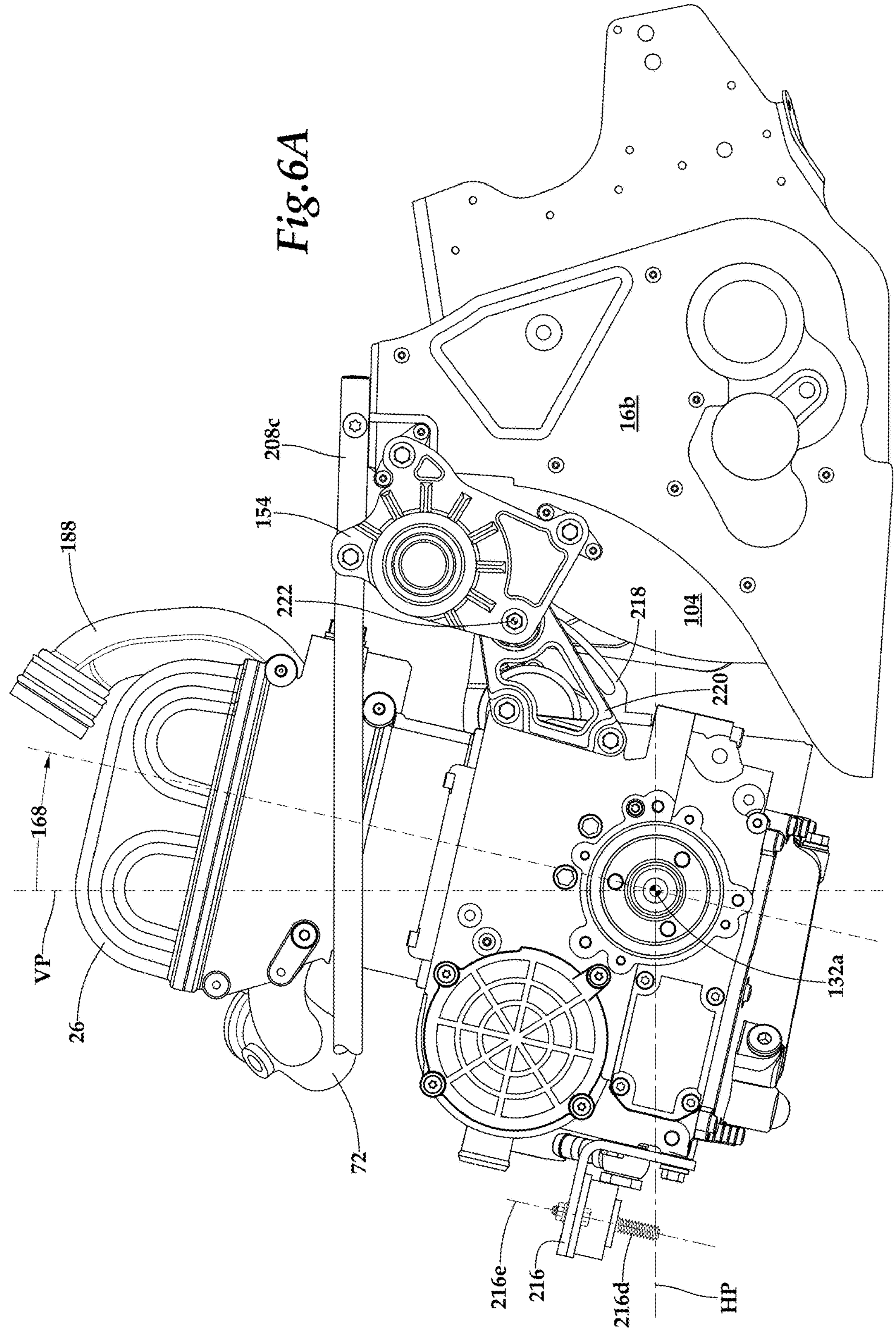
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Fig.6A

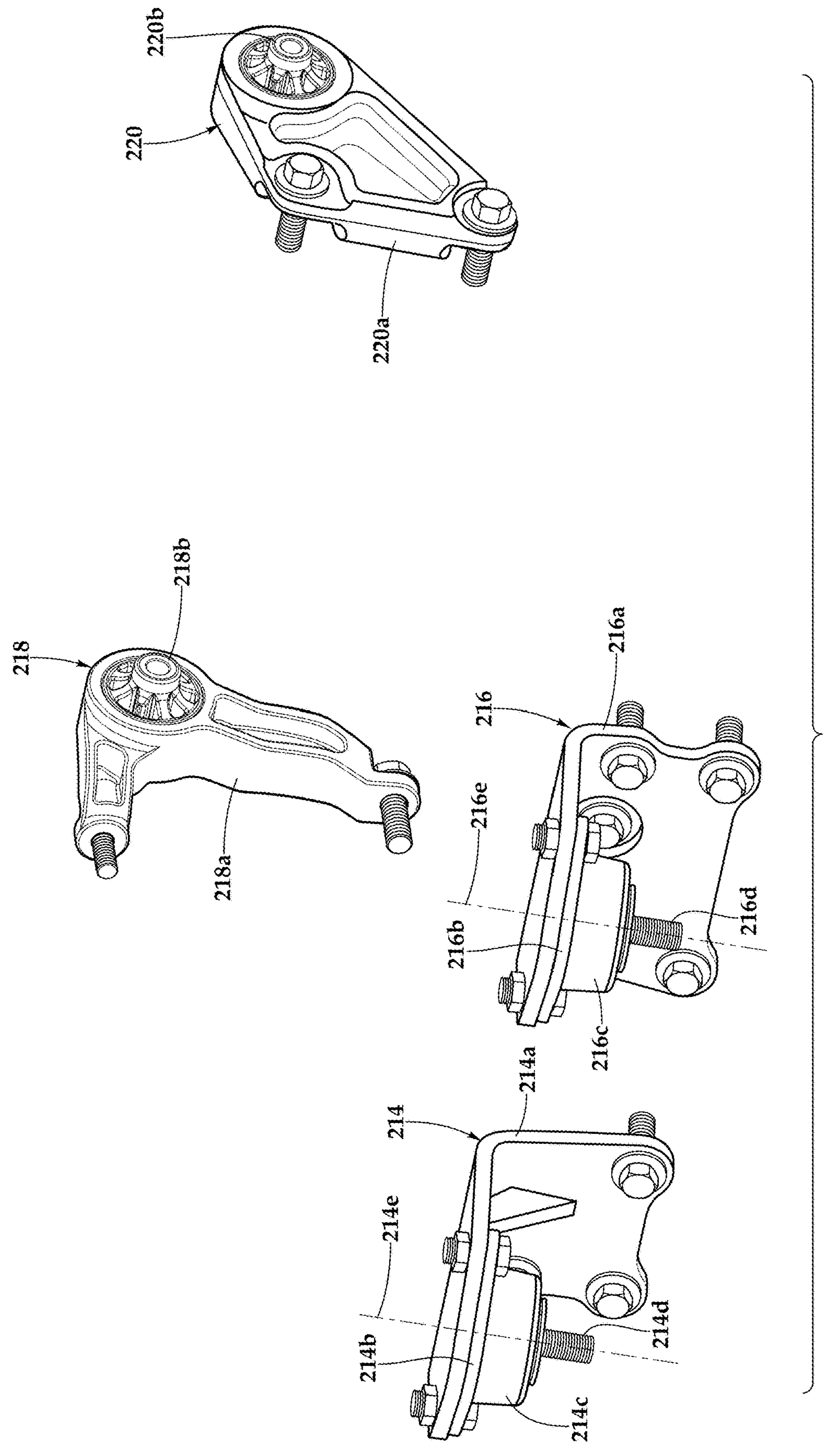
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Fig.6B

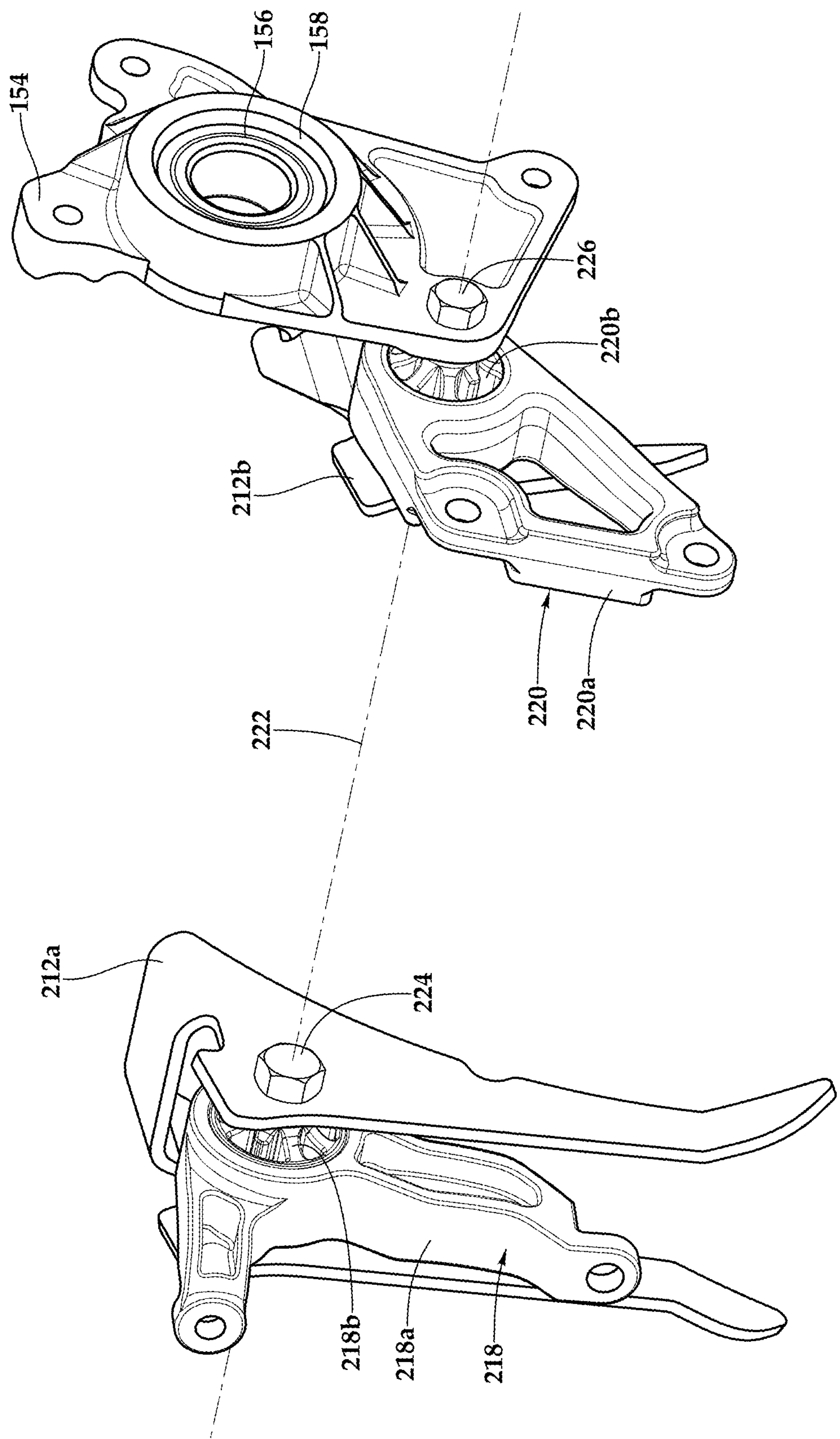

Fig.6C

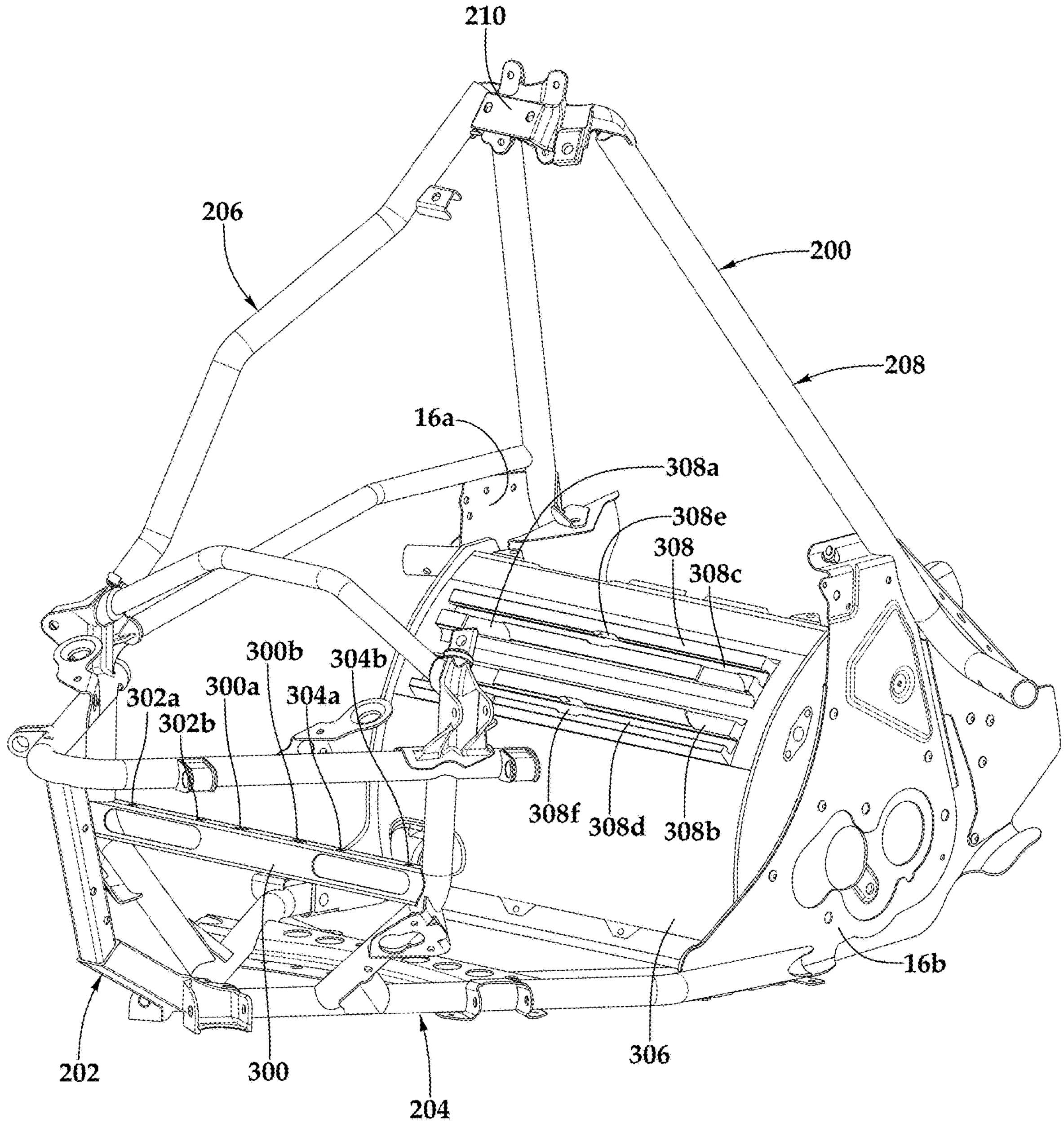
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Fig.7A

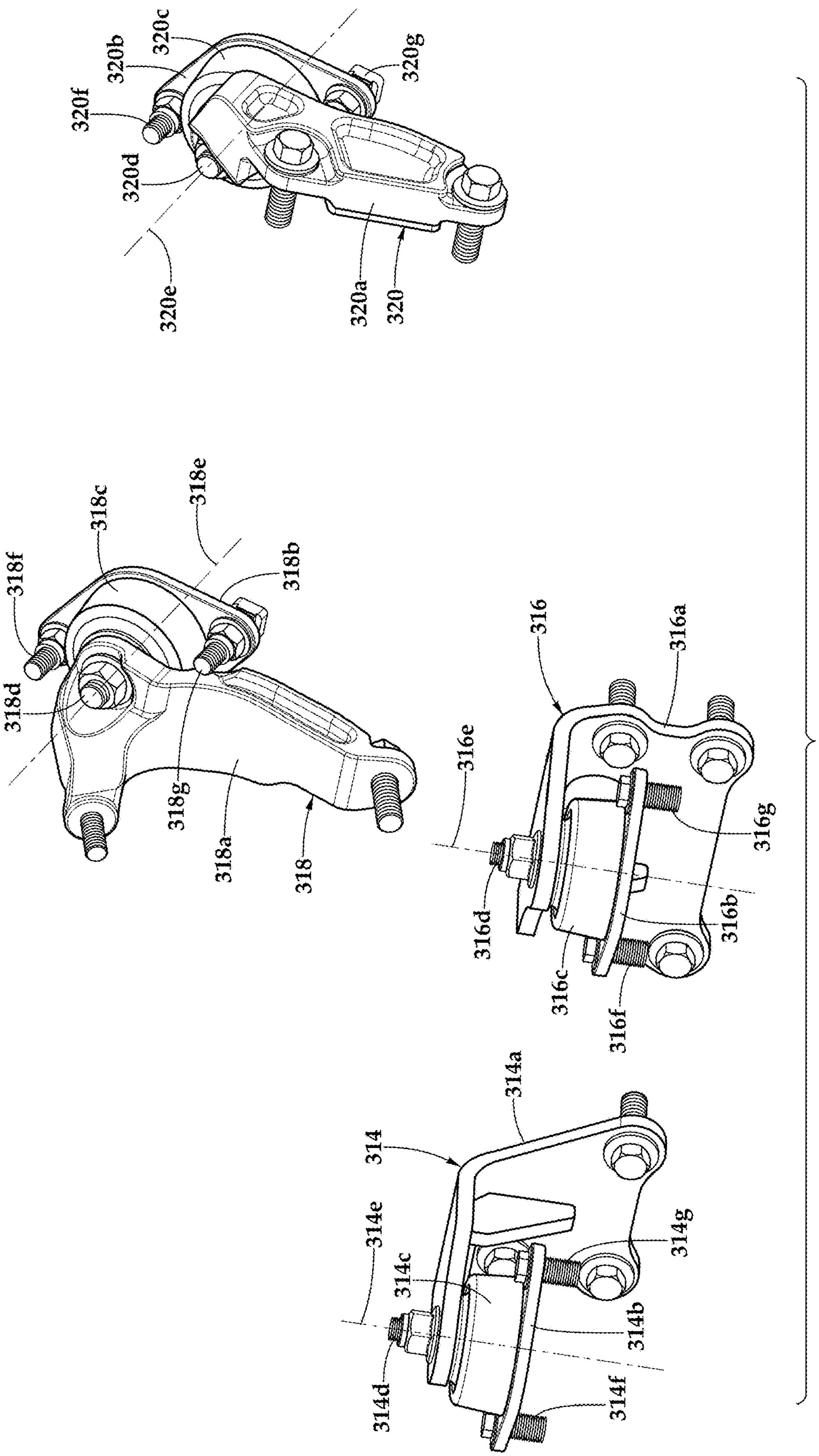

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Fig.7B

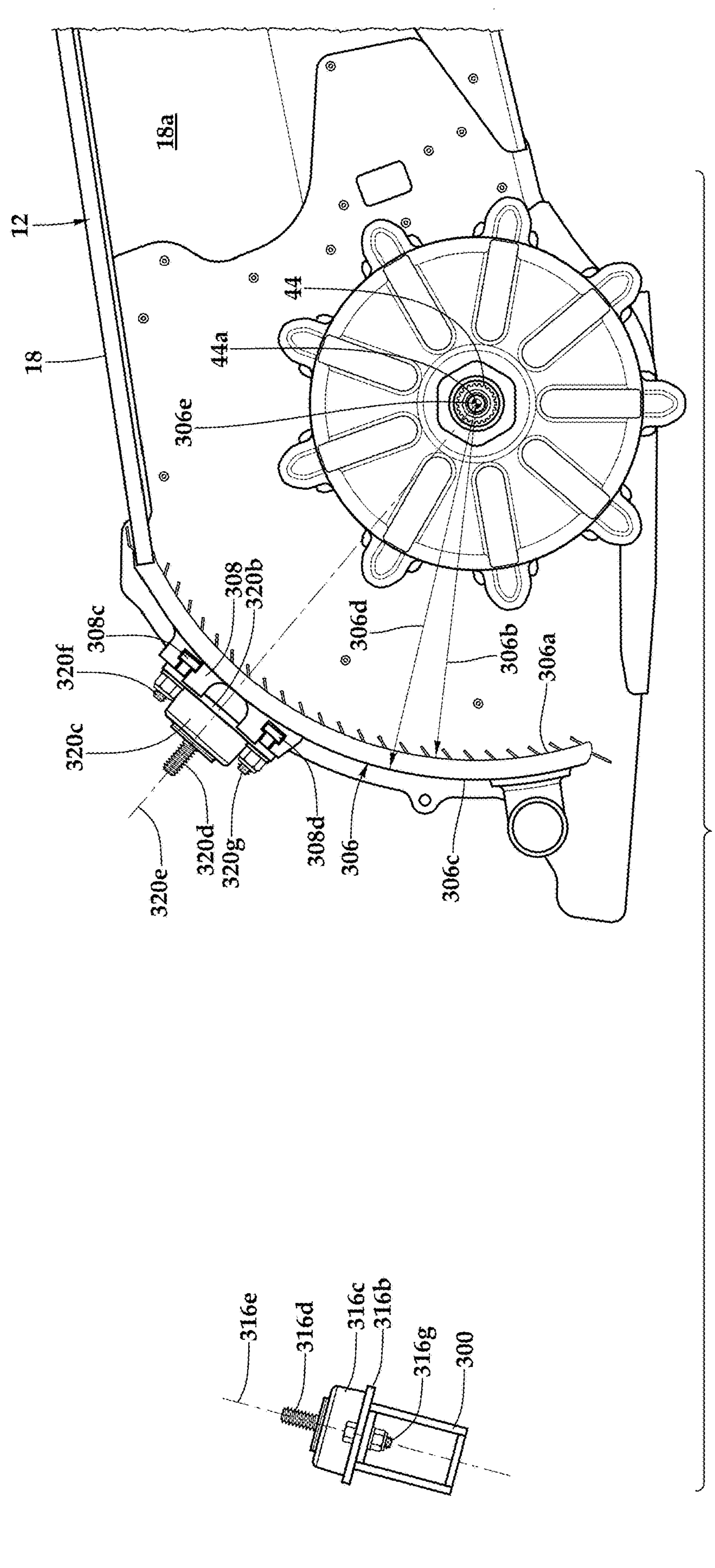
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Fig.7C

ENGINE MOUNTING SYSTEMS FOR SNOWMOBILES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims the benefit of U.S. Provisional Application No. 63/537,179, filed Sep. 7, 2023, the entire contents of which are incorporated by reference herein for all purposes.

TECHNICAL FIELD OF THE DISCLOSURE

[0002] The present disclosure relates, in general, to engine mounting systems for use on land vehicles and, in particular, to engine mounting systems for use on snowmobiles in which a four-stroke internal combustion engine is resiliently mounted in an aftwardly tilted orientation between a nose frame cross member and a heat exchanger.

BACKGROUND

[0003] Snowmobiles are popular recreational vehicles used in snowy and icy environments. Snowmobiles may be designed for specific applications such as trail, utility, mountain, race and crossover, to name a few. Snowmobiles typically include a pair of ski assemblies coupled to the forward end of a chassis that provide for the maneuverability of the snowmobile during these various winter activities. In addition, snowmobiles typically include a ground-engaging endless drive track disposed in an aftwardly extending tunnel of the chassis, with the length and design of the drive track contributing to the stability, flotation, agility, responsiveness and overall performance of the snowmobile. Power is delivered to the drive track from a powertrain that is coupled to the chassis and typically includes an engine and a transmission, such as a continuously variable transmission. The engine used in conventional snowmobiles is typically a two-stroke internal combustion engine due to the compact size and efficient design of such engines. While two-stroke engines are considered to have a high power-to-weight ratio, they also tend to produce undesirable pollution due to the direct mixing of fuel and oil. Four-stroke internal combustion engines, on the other hand, have higher fuel efficiency, generate lower emissions, produce less noise and have a simplified refueling process, which not only reduces the cost and environmental impact of operations, but also enhances the enjoyment of the riding experience on snowmobiles having such engines.

SUMMARY

[0004] In a first aspect, the present disclosure is directed to a snowmobile that has a forward frame assembly defining an engine bay. The forward frame assembly includes a nose frame assembly having a nose frame cross member positioned forward of the engine bay. An engine is positioned within the engine bay. A tunnel is coupled to the forward frame assembly and is positioned aft of the engine bay. A heat exchanger is coupled to a forward end of the tunnel. At least one aftward engine mount configured to couple the engine to the heat exchanger. At least one forward engine mount configured to couple the engine to nose frame cross member.

[0005] In some embodiments, the forward frame assembly may include a base frame assembly that is coupled to the nose frame assembly such that the engine is suspended above the base frame assembly by the aftward and forward engine mounts. In certain embodiments, the engine may be a four-stroke engine that has exhaust ports on a forward side of the engine and intake ports positioned on an aft side of the engine. In some embodiments, the at least one aftward engine mount may be first and second aftward engine mounts configured to couple the engine to the heat exchanger. In certain embodiments, at least one aftward engine mount may be configured to couple the engine to the forward frame assembly. In some embodiments, each of the aftward engine mounts may include an aperture having a vibration damper disposed therein. In certain embodiments, the aftward engine mounts may damp vibration between the engine and the heat exchanger and the forward engine mounts may damp vibration between the engine and the forward frame assembly. In some embodiments, the aftward engine mounts may be above the forward engine mounts. In certain embodiments, the aftward engine mounts may be outboard of the forward engine mounts.

[0006] In some embodiments, the first aftward engine mount may have a mount axis that is substantially horizontal, the second aftward engine mount may have a mount axis that is substantially horizontal, the first forward engine mount may have a mount axis that is substantially parallel to the aftward tilt angle of the engine and the second forward engine mount may have a mount axis that is substantially parallel to the aftward tilt angle of the engine. In certain embodiments, the mount axes of the first and second aftward engine mounts may extend in a lateral direction including, for example, in a common lateral direction. In some embodiments, the mount axes of the first and second aftward engine mounts may extend substantially normal to the mount axes of the first and second forward engine mounts. In certain embodiments, first and second mounting brackets may be coupled to the heat exchanger such that the first and second aftward engine mounts may be respectively coupled to the first and second mounting brackets. In some embodiments, a driven shaft may be operatively coupled to the engine and a bearing hub may be coupled to the chassis with the bearing hub supporting a bearing assembly. In such embodiments, the driven shaft may be rotatably coupled to the bearing hub by the bearing assembly and the bearing hub may be coupled to the first aftward engine mount. Also, in such embodiments, a first mounting bracket may be coupled to the heat exchanger such that the first aftward engine mount may be coupled between the first mounting bracket and the bearing hub.

[0007] In certain embodiments, a drive track system may be at least partially disposed within the tunnel with the drive track system including a track driveshaft having an axis of rotation. In such embodiments, the first aftward engine mount may have a mount axis that is oriented in a substantially radial direction relative to the axis of rotation of the track driveshaft, the second aftward engine mount may have a mount axis that is oriented in a substantially radial direction relative to the axis of rotation of the track driveshaft, the first forward engine mount may have a mount axis that is substantially parallel to the aftward tilt angle of the engine and the second forward engine mount may have a mount axis that is substantially parallel to the aftward tilt angle of the engine. In some embodiments, the heat exchanger may include a mounting system positioned on a forward wall of the heat exchanger with the aftward engine mounts coupled to the mounting system. In certain embodiments, the heat exchanger may include a mounting system integrally formed on the forward wall of the heat exchanger with the aftward engine mounts coupled to the mounting system. In some embodiments, the heat exchanger may include mounting rails positioned on the forward wall of the heat exchanger with the aftward engine mounts coupled to the mounting rails. In certain embodiments, the heat exchanger may include mounting rails integrally formed on the forward wall of the heat exchanger with the aftward engine mounts coupled to the mounting rails. In some embodiments, the mounting rails may include first and second recessed mounting locations configured to respectively receive the first and second aftward engine mounts therein. In certain embodiments, each of the first and second aftward engine mounts may include a mounting flange such that the mounting flanges of the first and second aftward engine mounts are respectively received in the first and second recessed mounting locations. In some embodiments, the mounting rails may include upper and lower slots, the mounting flange of the first aftward engine mount may be coupled to first recessed mounting location using first upper and lower bolts that are respectively secured within the upper and lower slots and the mounting flange of the second aftward engine mount may be coupled to second recessed mounting location using second upper and lower bolts that are respectively secured within the upper and lower slots.

[0008] In a second aspect, the present disclosure is directed to a snowmobile that has a forward frame assembly defining an engine bay. The forward frame assembly includes a nose frame assembly having a nose frame cross member positioned forward of the engine bay. An engine is positioned within the engine bay and has an aftward tilt angle relative to a vertical plane. A tunnel is coupled to the forward frame assembly and is positioned aft of the engine bay. A drive track system is positioned at least partially within the tunnel. The drive track system includes a track driveshaft having an axis of rotation. A heat exchanger is coupled to a forward end of the tunnel. The heat exchanger includes a mounting system positioned on a forward wall of the heat exchanger, such as mounting rails integrally formed on a forward wall of the heat exchanger. First and second forward engine mounts couple the engine to nose frame cross member. First and second aftward engine mounts couple the engine to the mounting system. Each of the aftward engine mounts has a mount axis that is oriented in a substantially radial direction relative to the axis of rotation of the track driveshaft.

[0009] In a third aspect, the present disclosure is directed to a forward frame assembly for a snowmobile. The forward frame assembly includes a welded frame assembly that has a base frame assembly with a nose frame assembly that is welded thereto. A first side frame assembly is welded to the base frame assembly and the nose frame assembly. The first side frame assembly includes a first forward spar. A fixed portion of a second side frame assembly is welded to the base frame assembly and the nose frame assembly. A steering column mount is welded between the first side frame assembly and the fixed portion of the second side frame assembly. The forward frame assembly also has a separable portion of the second side frame assembly that is couplable to the fixed portion of the second side frame assembly with non-permanent fasteners. The separable portion of the second side frame assembly includes a second forward spar.

[0010] In certain embodiments, the base frame assembly may include first and second base beams and a base cross member welded to the first and second base beams. In some embodiments, the nose frame assembly may include first, second and third nose trusses, a nose frame cross member welded to the first and second nose trusses and a nose rail welded to each of the first, second and third nose trusses. In such embodiments, each of the first, second and third nose trusses may be welded to the base frame assembly. In certain embodiments, the first side frame assembly may include a first joint welded to the first forward spar, a first upper beam welded to the first joint, a first aft spar welded to the first upper beam and a first plate member welded to the first aft spar. In such embodiments, the first joint may be welded to the nose frame assembly and the first plate member may be welded to the base frame assembly. In some embodiments, the fixed portion of the second side frame assembly may include a top flange, a second joint having an upper flange and an aft flange, a second aft spar and a second plate member that is welded to the second aft spar and has an upper flange. In such embodiments, the top flange and the second aft spar may be welded to the steering column mount, the second joint may be welded to the nose frame assembly and/or the second plate member may be welded to the base frame assembly.

[0011] In certain embodiments, the separable portion of the second side frame assembly may include a second upper beam that is couplable to the aft flange of the second joint and to the upper flange of the second plate member with non-permanent fasteners and the second forward spar may be couplable to the upper flange of the second joint and to the top flange with non-permanent fasteners. In some embodiments, an upper cross member may be welded to the second forward spar and the first forward spar may include a lateral flange. In such embodiments, the upper cross member may be couplable to the lateral flange of the first forward spar with a non-permanent fastener. In certain embodiments, each of the first forward spar and the second forward spar may be a bent spar such that the first forward spar and the second forward spar are bent in a forward direction to provide engine clearance.

[0012] In a fourth aspect, the present disclosure is directed to a snowmobile having a chassis that includes a forward frame assembly coupled to a tunnel. A heat exchanger is coupled to a forward end of the tunnel such that the forward frame assembly and the heat exchanger defining an engine bay. An engine is positioned within the engine bay and is coupled to the forward frame assembly and the heat exchanger. The forward frame assembly includes a welded frame assembly that has a base frame assembly with a nose frame assembly that is welded thereto. A first side frame assembly is welded to the base frame assembly and the nose frame assembly. The first side frame assembly includes a first forward spar. A fixed portion of a second side frame assembly is welded to the base frame assembly and the nose frame assembly. A steering column mount is welded between the first side frame assembly and the fixed portion of the second side frame assembly. The forward frame assembly also includes a separable portion of the second side frame assembly that is couplable to the fixed portion of the second side frame assembly with non-permanent fasteners. The separable portion of the second side frame assembly includes a second forward spar.

[0013] In some embodiments, the first side frame assembly may include a first plate member and the fixed portion of the second side frame assembly may include second plate member. In such embodiments, the heat exchanger may be coupled between the first and second plate members. In certain embodiments, the nose frame assembly may include a nose frame cross member. In such embodiments, the engine may be coupled between the nose frame cross member and the heat exchanger.

[0014] In a fifth aspect, the present disclosure is directed to a method for assembling a snowmobile. The method includes providing a welded frame assembly including a base frame assembly, a nose frame assembly welded to the base frame assembly, the nose frame assembly including a nose frame cross member, a first side frame assembly welded to the base frame assembly and the nose frame assembly, the first side frame assembly including a first forward spar, a fixed portion of a second side frame assembly welded to the base frame assembly and the nose frame assembly and a steering column mount welded between the first side frame assembly and the fixed portion of the second side frame assembly; forming an engine bay by coupling a heat exchanger to the first side frame assembly and the fixed portion of the second side frame assembly; suspending an engine within the engine bay above the base frame assembly by coupling the engine to the nose frame cross member and the heat exchanger; and coupling a separable portion of the second side frame assembly to the fixed portion of the second side frame assembly with non-permanent fasteners, the separable portion of the second side frame assembly including a second forward spar.

[0015] In some embodiments, the method may include providing a base frame assembly having first and second base beams and a base cross member welded to the first and second base beams; providing a nose frame assembly having first, second and third nose trusses, the nose frame cross member welded to the first and second nose trusses, a nose rail welded to each of the first, second and third nose trusses with each of the first, second and third nose trusses welded to the base frame assembly; and/or providing a first side frame assembly having a first joint welded to the first forward spar, a first upper beam welded to the first joint, a first aft spar welded to the first upper beam and a first plate member welded to the first aft spar, with the first joint welded to the nose frame assembly and the first plate member welded to the base frame assembly.

[0016] In certain embodiments, the method may include providing a fixed portion of the second side frame assembly having a top flange, a second joint having an upper flange and an aft flange, a second aft spar and a second plate member welded to the second aft spar and having an upper flange with the top flange and the second aft spar welded to the steering column mount, the second joint welded to the nose frame assembly and the second plate member welded to the base frame assembly; coupling the second forward spar to the upper flange of the second joint and to the top flange with the non-permanent fasteners; coupling a second upper beam to the aft flange of the second joint and to the upper flange of the second plate member with the non-permanent fasteners; and/or coupling an upper cross member that is welded to the second forward spar to a lateral flange of the first forward spar with the non-permanent fastener.

[0017] In some embodiments, the method may include having a fluid conduit coupled to a forward side of the heat exchanger. In certain embodiments, the method may include having first and second engine mounting brackets on a forward side of the heat exchanger or having engine mounting rails on the forward side of the heat exchanger. In some embodiments, the method may include laterally inserting the engine into the welded frame assembly through a window in the fixed portion of the second side frame assembly; shifting the engine forward relative to the welded frame assembly; and lowering the engine onto the nose frame cross member. In certain embodiments, the method may include coupling two forward engine mounts to the nose frame cross member and coupling at least one aft engine mount to the heat exchanger. In other embodiments, the method may include coupling two forward engine mounts to the nose frame cross member and coupling two aft engine mounts to the heat exchanger. In certain embodiments, the method may include inserting studs of two forward engine mounts through openings of the nose frame cross member as the engine is lowered relative to the welded frame assembly.

[0018] In some embodiments, the method may include having an exhaust manifold and an air runner assembly coupled to the engine prior to inserting the engine into the welded frame assembly. In such embodiments, the method may include coupling an air plenum to the air runner assembly after suspending the engine within the engine bay and before coupling the separable portion of the second side frame assembly to the fixed portion of the second side frame assembly; coupling an airbox to the first and second forward spars; and coupling an air duct between the airbox and the air plenum with the air duct routed forward of and outboard of the second forward spar. In certain embodiments, the method may include having an exhaust manifold, an air runner assembly and an air plenum coupled to the engine prior to inserting the engine into the welded frame assembly. In some embodiments, the method may include positioning the engine within the engine bay with an aftward tilt angle relative to a vertical plane and with forward and aft engine mounts located above a crankshaft of the engine.

[0019] In a sixth aspect, the present disclosure is directed to a snowmobile including a forward frame assembly with an engine coupled to and positioned at least partially within the forward frame assembly. The engine has a plurality of intake ports positioned on an aft side of the engine and a plurality of exhaust ports positioned on a forward side of the engine. An air intake system includes an air inlet and a plurality of air outlets. The air intake system is coupled to the engine such that each of the air outlets is configured to provide air to one of the intake ports. An exhaust system includes a plurality of exhaust inlets and an exhaust outlet. The exhaust system is coupled to the engine such that each of the exhaust inlets is configured to receive exhaust from one of the exhaust ports.

[0020] In certain embodiments, the engine may have an aftward tilt angle relative to a vertical plane. In some embodiments, the air intake system may include an airbox that is coupled to the forward frame assembly and is positioned forward of the engine. In such embodiments, the air inlet may be positioned outboard of the forward frame assembly and may be configured to provide air to the airbox. In certain embodiments, the air intake system may include an air plenum that is positioned on top of the engine and at least partially within the forward frame assembly. In some embodiments, the air intake system may include a throttle valve assembly that is coupled to the air plenum and may be positioned laterally and outboard of the engine. In such embodiments, the throttle valve assembly may also be positioned below the air inlet. In certain embodiments, the air intake system may include an air duct that is coupled between the airbox and the throttle valve assembly with the air duct routed forward and outboard of the forward frame assembly. In some embodiments, the air intake system may include an air runner assembly that is coupled between the air plenum and the engine with the air runner assembly including the plurality of air outlets. In such embodiments, the air runner assembly may extend aftward and downward from the air plenum.

[0021] In certain embodiments, the exhaust system may include an exhaust manifold that is coupled to the engine with the exhaust manifold including the exhaust inlets. In some embodiments, the exhaust system may include a muffler that is positioned laterally and outboard of the engine with an exhaust duct coupled between the exhaust manifold and the muffler. In certain embodiments, the air intake system may include a throttle valve assembly positioned laterally and outboard of a first side of the engine and the exhaust system may include a muffler positioned laterally and outboard of a second side of the engine that is opposite the first side of the engine. In some embodiments, the throttle valve assembly may be positioned outboard of a first side of the forward frame assembly and the muffler may be positioned outboard of a second side of the forward frame assembly that is opposite the first side of the forward frame assembly.

[0022] In a seventh aspect, the present disclosure is directed to a snowmobile including a forward frame assembly with an engine coupled thereto. The engine has an aftward tilt angle relative to a vertical plane. The engine also has a plurality of intake ports positioned on an aft side of the engine and a plurality of exhaust ports positioned on a forward side of the engine. An air intake system is coupled to the engine. The air intake system includes an air inlet positioned outboard of the forward frame assembly, an airbox coupled to the air inlet and positioned forward of the engine, an air plenum positioned on top of the engine, a throttle valve assembly coupled to the air plenum and positioned laterally and outboard of a first side of the engine, the air runner assembly including a plurality of air outlets each of which is configured to provide air to one of the intake ports. An exhaust system is coupled to the engine. The exhaust system includes an exhaust manifold having a plurality of exhaust inlets each of which is configured to receive exhaust from one of the exhaust ports and a muffler including an exhaust outlet positioned laterally and outboard of a second side of the engine that is opposite of the first side. Each of the engine, the air plenum, the air runner assembly and the exhaust manifold is at least partially disposed within the forward frame assembly.

[0023] In certain embodiments, the throttle valve assembly may be positioned below the air inlet. In some embodiments, the air runner assembly may extend aftward and downward from the air plenum. In certain embodiments, the throttle valve assembly may be positioned outboard of a first side of the forward frame assembly and the muffler may be positioned outboard of a second side of the forward frame assembly that is opposite the first side of the forward frame assembly. In some embodiments, a heat exchanger may be coupled to the forward frame assembly forward of the engine. In such embodiments, the heat exchanger may be tilted forward such that an upper portion of the heat exchanger is forward of a lower portion of the heat exchanger. Also, in such embodiments, at least a portion of the air duct may be positioned between the heat exchanger and the engine and/or at least a portion of the exhaust manifold may be positioned between the heat exchanger and the engine. In certain embodiments, the muffler may be positioned aft of the heat exchanger.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] 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:

[0025] FIGS. **1**A-**1**E are schematic illustrations of a snowmobile in accordance with embodiments of the present disclosure;

[0026] FIGS. **2**A-**2**E are schematic illustrations of various systems for a snowmobile in accordance with embodiments of the present disclosure;

[0027] FIGS. **3**A-**3**G are schematic illustrations of an engine for a snowmobile in accordance with embodiments of the present disclosure;

[0028] FIGS. **4**A-**4**B are isometric views of an air intake system and an exhaust system for a snowmobile in accordance with embodiments of the present disclosure;

[0029] FIGS. **5**A-**5**I are schematic illustrations of sequential steps for assembling a snowmobile in accordance with embodiments of the present disclosure;

[0030] FIGS. **6**A-**6**C are schematic illustrations of an engine mounting system for a snowmobile in accordance with embodiments of the present disclosure; and

[0031] FIGS. **7**A-**7**C are schematic illustrations of an engine mounting system for a snowmobile in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

[0032] 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.

[0033] 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.

[0034] 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** and a longitudinally extending tunnel **18**. Forward frame assembly **14** (see also FIG. **2**B) 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 are 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.

[0035] 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.

[0036] 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, as best seen in FIG. **1**C, 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* (see also FIG. **2**B) 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* and lower cross member **14***l* is positioned forward of engine bay **26***a*. Engine **26** may be any type of engine such as a four-stroke engine, a two-stroke engine, an electric motor, a hybrid engine system or other prime mover. In the illustrated embodiment, engine **26** is an aftwardly tilted, three cylinder, four-stroke, internal combustion engine that is naturally aspirated. In other embodiments, engine **26** may be vertically mounted, forwardly tilted, have more or less than three cylinders, be a supercharged internal combustion engine or a turbo charged internal combustion engine. 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.

[0037] 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 **42** via a track driveshaft **44** (see also FIGS. **2**C, **2**D) 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.

[0038] Snowmobile **10** has a ski system **52** and a front suspension assembly **54** that provide front end support for snowmobile **10**. Ski system **52** includes a right ski **52***a* that is coupled to forward frame assembly **14** by upper and lower A-arms **52***b*, **52***c* and right spindle **52***d*. Ski system **52** also includes a left ski **52***e* that is coupled to forward frame assembly **14** by upper and lower A-arms **52***f*, **52***g* and left spindle **52***h*. Skis **52***a*, **52***e* are interconnected to a steering system **56** including a handlebar assembly **56***a*, a steering column **56***b*, a right tie rod **56***c* and a left tie rod **56***d* that enable the rider to steer snowmobile **10**. For example, when handlebar assembly **56***a* is rotated, skis **52***a*, **52***e* responsively pivot to turn snowmobile **10**. The rider controls snowmobile **10** from a seat **58** that is position atop a fuel tank **60**, above tunnel **18**, aft of handlebar assembly **56***a* and aft of forward frame assembly **14**. Snowmobile **10** has a lift bumper **62** 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 **64** that deflects snow emitted by endless track **40**. In the illustrated embodiment, snow flap **64** is coupled to lift bumper **62**. In other embodiments, a snow flap may be coupled directly to tunnel **18**. A taillight housing **66** is also coupled to lift bumper **62** and houses a taillight of snowmobile **10**. Snowmobile **10** has an exhaust system **70** (see also FIG. **4**B) that includes an exhaust manifold **72** that is coupled to the forward side of engine **26**, an exhaust duct **74** and a muffler **76** that is positioned laterally and outboard of engine **26** as well as outboard of forward frame assembly **14** and engine bay **26***a*. Exhaust system **70** is configured to direct high-temperature exhaust gases away from engine **26** and the rider of snowmobile **10**.

[0039] 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.

[0040] Referring additionally to FIGS. **2**A-**2**B of the drawings, additional details regarding snowmobile **10** will now be discussed. In the illustrated embodiment, snowmobile **10** has an engine cooling system **100** that includes a forward heat exchanger **102**, depicted as a radiator **102**, that is coupled to forward frame assembly **14**. 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 and positioned above a nose frame assembly **202** (see also FIG. **5**A) of forward frame assembly **14**. In this location, radiator **102** is positioned forward of engine **26** and muffler **76** 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**. In the illustrated embodiment, radiator **102** includes a fan **102***a* that may be selectively operated to help air move through radiator **102**. Engine cooling system **100** also includes an arcuate heat exchanger **104** that is coupled to a forward portion of tunnel **18**. In this location, arcuate heat exchanger **104** is positioned aft of engine **26**. 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 **104***a* 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.

[0041] Engine cooling system **100** further includes a tunnel heat exchanger **106** that is positioned along a top portion of tunnel **18**. Tunnel heat exchanger **106** 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 upper surface of tunnel **18**, a portion of which sticks to this surface which is in thermal communication with tunnel heat exchanger **106**. Heat from the fluid circulating through tunnel heat exchanger **106** is transferred to the retained snow causing the retained snow to melt. It is note that snow flap **64** helps to retain snow in tunnel **18** which aids in the snow sticking to the upper surface of tunnel **18**. Together, radiator **102**, arcuate heat exchanger **104** and tunnel heat exchanger **106** form a cooling circuit that is in fluid communication with engine **26**. More specifically, radiator **102** is coupled to a fluid discharge port **108** (see also FIG. **3**C) on the aftward side of engine **26** via a fluid conduit **110**. Radiator **102** is also coupled to arcuate heat exchanger **104** via a fluid conduit **112**. Arcuate heat exchanger **104** is coupled to tunnel heat exchanger **106** via a direct coupling (not visible). Tunnel heat exchanger **106** is coupled to a fluid inlet port **114** (see also FIGS. **3**A, **3**D) on the forward side of engine **26** via a fluid conduit **116**. Fluid is circulated through the cooling circuit by a water pump **118** of engine **26**. In the illustrated embodiment, fluid circulates through the cooling circuit sequentially from engine **26** to radiator **102** then to arcuate heat exchanger **104** then to tunnel heat exchanger **106** before returning to engine **26**. Engine cooling system **100** also includes a thermostat **120** that monitors the temperature of the fluid exiting engine **26** and an expansion chamber **122** that is fluidically positioned between tunnel heat exchanger **106** and engine **26**.

[0042] Referring next to FIGS. **2**C-**2**D of the drawings, drivetrain **28** will be discussed in greater detail. Drivetrain **28** includes transmission **30**, depicted as a continuously variable transmission, which includes a drive pulley **130** that receives torque and rotational energy from engine **26** via engine driveshaft **132**, a driven pulley **134** and a drive belt **136** that is looped around drive pulley **130** and driven pulley **134** to transfer torque from drive pulley **130** to driven pulley **134**. The use of a continuously variable transmission has the advantages of continuously changing its gear ratio such that at any engine speed, the continuously variable transmission is configured to operate at peak performance. This is achieved by varying the width of drive pulley **130** and driven pulley **134** depending on the power requirement of snowmobile **10**. In operation, when one of drive pulley **130** and driven pulley **134** gets larger, the other of drive pulley **130** and driven pulley **134** gets smaller. Since neither drive pulley **130**, driven pulley **134** nor drive belt **136** are fixed, continuously variable transmission is configured to provide an infinite number of gear ratios.

[0043] Driven pulley **134** provides torque and rotational energy to a driven shaft **138**. In the illustrated embodiment, driven shaft **138** includes multiple splined sections including input splines **138***a* and output splines **138***b*. Input splines **138***a* are in mesh with splines within driven pulley **134** such that operation of transmission **30** rotates driven shaft **138**. Output splines **138***b* are in mesh with splines within drive assembly **140** that is depicted as a reduction drive assembly that is shiftable been a forward mode and a reverse mode which determines the direction **48***a* or **48***b* (see also FIG. **1**B) that endless track **40** rotates around track frame **34** and idler wheels **38** and thus the direction **46***a* or **46***b* of travel of snowmobile **10**. Drive assembly **140** includes a drive pulley **142** that receives torque and rotational energy from driven shaft **138**, a driven pulley **144** and a drive belt **146** that is looped around drive pulley **142** and driven pulley **144** to transfer torque from drive pulley **142** to driven pulley **144**. Driven pulley **144** provides torque and rotational energy to track driveshaft **44** that has a splined coupling with track drive sprocket **42** that drives endless track **40** around track frame **34** and idler wheels **38** to propel snowmobile **10**. Track driveshaft **44** also has a splined coupling with a disc-and-caliper braking system **148** that includes a brake disc **150** and a brake caliper **152** used to provide a stopping force for snowmobile **10**. Driven shaft **138** has an axis of rotation **138***c* and is received within a driven shaft bearing hub **154** that is rigidly coupled to chassis **12** and/or heat exchanger **104** (see also FIG. **5**G). Driven shaft **138** is rotatably coupled to bearing hub **154** via a bearing assembly **156**, such as a ball bearing assembly, which is received within a bearing aperture **158** of bearing hub **154**. Bearing hub **154** rigidly supports driven shaft **138** allowing driven shaft **138** to transfer torque and rotational energy from transmission **30** to drive assembly **140**. In other embodiments, support for driven shaft **138** may be provided by a torque control link that also maintains a stable center to center distance between the drive pulley and the driven pulley of the continuously variable transmission such as the torque control link described in commonly owned U.S. Patent Application 63/612,191, filed Dec. 19, 2023, the entire contents of which are incorporated by reference for all purposes.

[0044] Referring now to FIGS. **3**A-**3**G of the drawings, engine **26** and various components of the air intake system and the exhaust system will now be discussed. Engine **26** is an internal combustion engine that converts thermal energy into mechanical energy to drive the moving parts snowmobile **10**, thereby enabling motion. Engine **26** has a cylinder head **160** and an engine block **162** that includes a cylinder block **164** and a crankcase **166** which houses crankshaft **132**. As best seen in FIG. **3**F, when engine **26** is installed within snowmobile **10**, engine **26** has an aftward tilt angle relative to a vertical plane VP, as indicated by arrow **168**, when snowmobile **10** is resting on a horizontal surface, as illustrated in FIGS. **1**B-**1**C. In the illustrated embodiment, the aftward tilted angle is between five degrees and thirty degrees relative to vertical plane VP such as between ten degrees and twenty degrees relative to vertical plane VP. It should be understood by those having ordinary skill in the art that engine **26** could have other aftward tilted angles both less than five degrees and greater than thirty degrees relative to vertical plane VP. As best seen in FIG. **3**B, the aft side of engine **26** include a plurality of intake ports **170** through which an air and fuel mixture enters engine **26**. More specifically, engine **26** includes a right intake port **170***a* that supplies the air and fuel mixture to a right cylinder **172***a*, a center intake port **170***b* that supplies the air and fuel mixture to a center cylinder **172***b* and a left intake port **170***c* that supplies the air and fuel mixture to a left cylinder **172***c*.

[0045] Referring additionally to FIG. **4**A of the drawings, engine **26** has an air intake system **176** that receives air from the atmosphere and distributes the air to cylinders **172** of engine **26**. More specifically, air intake system **176** includes an air inlet **178** that is positioned outboard of forward frame assembly **14** (see also FIG. **5**H) that feeds air into an airbox **180** that is positioned generally forward and generally above engine **26**. Air from airbox **114** is routed to an air plenum **182** via an air duct **184**. Air plenum **182** is positioned on top of engine **26**. The volume of air delivered to air plenum **182** from airbox **180** is controlled via a throttle valve assembly **186** that is positioned outboard of forward frame assembly **14** and has, for example, a single throttle valve disposed therein. Air plenum **182** is configured to damp the air flow prior to distribution to cylinders **172** via an air runner assembly **188**. Air runner assembly **188** include the air outlets of air intake system **176**; namely, right air outlet **188***a*, center air outlet **188***b* and left air outlet **188***c*. As best seen by comparison of FIG. **3**B and FIG. **3**C, air runner assembly **188** is coupled between air plenum **182** and engine **26**. In the illustrated embodiment, air runner assembly **188** is coupled to each of air discharge ports **182***a*, **182***b*, **182***c* of air plenum **182** via air inlet ports **188***d*, **188***e*, **188***f* of air runner assembly **188**. Air runner assembly **188** is coupled to engine **26** such that right air outlet **188***a* is aligned with right intake port **170***a*, center air outlet **188***b* is aligned with center intake port **170***b* and left air outlet **188***c* is aligned with left intake port **170***c*. Fuel for engine **26** is supplied from fuel tank **60** via a fuel rail **190** that is coupled to air runner assembly **188** and includes a multi-point fuel injector system that is configured to inject fuel into each of cylinder **172***a*, **172***b*, **172***c* of engine **26** respectively through right air outlet **188***a*, center air outlet **188***b* and left air outlet **188***c* of air runner assembly **188**.

[0046] As best seen in FIG. **3**D, the forward side of engine **26** include a plurality of exhaust ports **192** through which high-temperature exhaust gases produced by the combustion of the air and fuel mixture are expelled. More specifically, engine **26** includes a right exhaust port **192***a*, a center exhaust port **192***b* and a left exhaust port **192***c*. Referring additionally to FIG. **4**B of the drawings, engine **26** has an exhaust system **70** that includes an exhaust manifold **72**, an exhaust duct **74** and a muffler **76** including an exhaust outlet **76***a*. Exhaust system **70** is configured to direct high-temperature exhaust gases away from engine **26** and the rider of snowmobile **10**. As best seen by comparison of FIG. **3**D and FIG. **3**E, exhaust manifold **72** is coupled to engine **26** such that exhaust inlets **72***a*, **72***b*, **72***c* are aligned with exhaust ports **192***a*, **192***b*, **192***c*. In the illustrated embodiment, exhaust manifold **72** that is coupled to the forward side of engine **26**, which is the hot side of engine **26** due to the hot temperatures associated with engine exhaust. The aft 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.

[0047] Referring now to FIGS. **5**A-**5**I of the drawings, aspects of forward frame assembly **14** and assembly methods for a snowmobile will now be discussed. In FIG. **5**A, a welded frame assembly **200** is depicted that includes a plurality of tubular frame members and plate members that are welded together to form a single assembly weldment. Producing welded frame assembly **200** increases the efficiency of manufacturing snowmobiles by enabling large subassemblies to be preassembled and by reducing the number of parts such as fastener needed for assembly. In addition, welded frame assembly **200** may be used as a major subassembly in numerous snowmobile models, for example, welded frame assembly **200** may be used in certain snowmobiles designed for mountain operations and in certain snowmobiles designed for high performance operation. In the illustrated embodiment, welded frame assembly **200** includes nose frame assembly **202**, a base frame assembly **204**, a right side frame assembly **206** and a fixed portion of a left side frame assembly **208** as well as a steering column mount **210**. Nose frame assembly **202** is welded to base frame assembly **204**. Right side frame assembly **206** is welded to base frame assembly **204** and nose frame assembly **202**. The fixed portion of left side frame assembly **208** is welded to base frame assembly **204** and nose frame assembly **202**. Steering column mount **210** is welded between right side frame assembly **206** and the fixed portion of left side frame assembly **208**.

[0048] In the illustrated embodiment, base frame assembly **204** include a right base frame beam **204***a*, a left base frame beam **204***b* and a base frame cross member **204***c* that is welded between right and left base frame beams **204***a*, **204***b*. Nose frame assembly **202** includes a right nose truss **202***a*, a left nose truss **202***b*, a center nose truss **202***c*, a nose frame cross member **202***d* and a nose rail **202***e*. Right nose truss **202***a* is welded to right base frame beam **204***a*. Left nose truss **202***b* is welded to left base frame beam **204***b*. Center nose truss **202***c* is welded to right base frame beam **204***a* and left base frame beam **204***b*. Nose frame cross member **202***d* is welded between right nose truss **202***a* and left nose truss **202***b*. Nose rail **202***e* is welded to each of right nose truss **202***a*, left nose truss **202***b* and center nose truss **202***c*. Right side frame assembly **206** including a right side forward spar **206***a*, a right side aftward spar **206***b*, a right side upper beam **206***c*, a right side joint **206***d*, a lateral flange **206***e* and right side plate member **16***a*. Right side joint **206***d* is welded to nose rail **202***e*, right side forward spar **206***a* is welded between right side joint **206***d* and steering column mount **210**, right side aftward spar **206***b* is welded to steering column mount **210**, right side upper beam **206***c* is welded between right side joint **206***d* and right side aftward spar **206***b*, lateral flange **206***e* is welded to right side forward spar **206***a* and right side plate member **16***a* is welded to right side aftward spar **206***b*, right side upper beam **206***c* and right base frame beam **204***a*.

[0049] The fixed portion of left side frame assembly **208** includes a left side aftward spar **208***b*, a left side joint **208***d* and left side plate member **16***b*. Left side joint **208***d* is welded to nose rail **202***e*, left side aft spar **208***b* is welded to steering column mount **210**, and left side plate member **16***b* is welded to left side aft spar **208***b* and left base frame beam **204***b*. In the illustrated embodiment, the fixed portion of left side frame assembly **208** includes a top flange **208***f* that is welded to or integral with steering column mount **210**, an upper flange **208***g* and an aft flange **208***h* that are welded to or integral with left side joint **208***d* and an upper flange **208***i* that is welded to or integral with left side plate member **16***b*. As discussed herein, the fixed portion of left side frame assembly **208** includes an engine installation window **208***e* that is disposed between left side joint **208***d*, left side aftward spar **208***b* and left side plate member **16***b*. A lower forward cross member **210***a* is welded between right side joint **206***d* and left side joint **208***d*. In this configuration, welded frame assembly **200** provides efficiency to the construction of snowmobile **10**.

[0050] As best seen in the comparison of FIGS. **5**A and **5**B, prior to installing engine **26** into welded frame assembly **200**, arcuate heat exchanger **104** is coupled to welded frame assembly **200** using rivets or other suitable connection means by coupling the side panels of arcuate heat exchanger **104** to right side plate member **16***a* and left side plate member **16***b* of welded frame assembly. Arcuate heat exchanger **104** has an arcuate inner surface **104***a* which has a substantially constant radius of curvature **104***b* and an arcuate outer wall **104***c* which has a substantially constant radius of curvature **104***d*. Radii of curvature **104***b*, **104***d* share a common center of curvature **104***e* that is coincident with an axis of rotation **44***a* of track driveshaft **44** (see also FIG. **2**B). The configuration of arcuate heat exchanger **104** not only improves its snow receiving and retention functionality but also minimizes the space requirements of arcuate heat exchanger **104**, thereby enlarging engine bay **26***a* which is substantially defined within the subassembly of arcuate heat exchanger **104** and welded frame assembly **200**. In fact, the curvature of arcuate heat exchanger **104** allows for the preassembly of an aft portion of fluid conduit **112** that fluidically couples radiator **110** to arcuate heat exchanger **104**. In addition, right mounting bracket **212***a* and left mounting bracket **212***b* are welded to outer wall **104***c* of arcuate heat exchanger **104**.

[0051] Once heat exchanger **104** has been coupled to welded frame assembly **200**, engine **26** may now be positioned within engine bay **26***a* as best seen in the progression of FIGS. **5**C-**5**D. In FIG. **5**C, an engine preassembly preferably includes engine **26** with exhaust manifold **72** and air runner assembly **188** installed thereon. Also, preinstalled on engine **26** is an engine mounting system that includes a right forward engine mount **214**, a left forward engine mount **216**, a right aftward engine mount **218** and a left aftward engine mount **220** (see also FIGS. **3**A-**3**G and **6**B). In other embodiments, one or more of right forward engine mount **214**, left forward engine mount **216**, right aftward engine mount **218** and left aftward engine mount **220** may be coupled to engine **26** after engine **26** has been positioned within welded frame assembly **200**. In such embodiments, all or a portion of right forward engine mount **214** and/or left forward engine mount **216** may be coupled to nose frame cross member **202***d* prior to being coupled to engine **26**. Likewise, all or a portion of right aftward engine mount **218** and/or left aftward engine mount **220** may be coupled to heat exchanger **104** and/or welded frame assembly **200** prior to being coupled to engine **26**. In the illustrated embodiments, right forward engine mount **214** includes an angled bracket **214***a* that is bolted to a forward side of engine **26**, a mounting flange **214***b* that is bolted to angled bracket **214***a*, a vibration damper **214***c* that is coupled to mounting flange **214***b* and a mounting stud **214***d* having a mount axis **214***e*. Left forward engine mount **216** includes an angled bracket **216***a* that is bolted to engine **26**, a mounting flange **216***b* that is bolted to angled bracket **216***a*, a vibration damper **216***c* that is coupled to mounting flange **216***b* and a mounting stud **216***d* having a mount axis **216***e*. Right aftward engine mount **218** has a body **218***a* that is bolted to an aftward side of engine **26** and a vibration damper **218***b* that is received within an aperture of body **218***a*. Left aftward engine mount **220** has a body **220***a* that is bolted to the right side of engine **26** and a vibration damper **220***b* that is received within an aperture of body **220***a*. Right aftward engine mount **218** and left aftward engine mount **220** share a common mount axis **222** when right aftward engine mount **218** is coupled to right mounting bracket **212***a* via bolt **224** and left aftward engine mount **220** is coupled to left mounting bracket **212***b* and driven shaft bearing hub **154** via bolt **226**, as best seen in FIG. **6**C.

[0052] As best seen in FIG. **5**C, engine **26** is laterally inserted into welded frame assembly **200** through window **208***e* of the fixed portion of left side frame assembly **208** as indicated by the laterally extending portion of engine installation path arrow **228** that originates at the tip of mounting stud **214***d* and serves as a reference. Engine **26** is positioned to provide suitable clearance between right forward engine mount **214** and left forward engine mount **216** with forward components of welded frame assembly **200** and to provide suitable clearance between right aftward engine mount **218** and left aftward engine mount **220** with fluid conduit **112**, right mounting bracket **212***a* and left mounting bracket **212***b*. Once engine **26** is disposed within welded frame assembly **200**, engine **26** is shifted forward to vertically align mounting stud **214***d* with mounting hole **202***f* of nose frame cross member **202***d* and to vertically align mounting stud **216***d* with mounting hole **202***g* of nose frame cross member **202***d*, as indicated by the forwardly extending portion of engine installation path arrow **228**. Engine **26** is now lowered to insert mounting stud **214***d* into mounting hole **202***f* of nose frame cross member **202***d* and to insert mounting stud **216***d* into mounting hole **202***g* of nose frame cross member **202***d*, as indicated by the downwardly extending portion of engine installation path arrow **228**. This lowering of engine **26** also aligns right aftward engine mount **218** with right mounting bracket **212***a* and left aftward engine mount **220** with left mounting bracket **212***b*.

[0053] Engine **26** is now secured to welded frame assembly **200** and heat exchanger **104** at three points; namely, nut **230***a* secures right forward engine mount **214** to nose frame cross member **202***d*, nut **230***b* secures left forward engine mount **216** to nose frame cross member **202***d* and bolt assembly **224** secures right aftward engine mount **218** to right mounting bracket **212***a* (see also FIG. **6**C). Left aftward engine mount **220** may remain unsecured from left mounting bracket **212***b* until a later stage of assembly or left aftward engine mount **220** may be temporarily secured to left mounting bracket **212***b*. In this position within engine bay **26***a*, engine **26** is suspended above base frame assembly **204** with suitable clearance therewith such as between 10 millimeters and 50 millimeters or about 30 millimeters between a lower surface of engine **26** and an upper surface of base frame assembly **204**. In other embodiments, engine **26** could be suspended above base frame assembly **204** by less than 10 millimeters or more than 50 millimeters.

[0054] With engine **26** positioned within engine by **26***a* and suspended above base frame assembly **204**, non-preinstalled components of air intake system **176** may now be assembled onto engine **26**. As best seen in FIG. **5**E, air plenum **182** is positioned on top of engine **26** with throttle valve assembly **186** preinstalled therewith or subsequently coupled thereto. As discussed herein, air plenum **182** is coupled to air runner assembly **188** such that air inlet ports **188***d*, **188***e*, **188***f* of air runner assembly **188** are aligned with air discharge ports **182***a*, **182***b*, **182***c* of air plenum **182**. In this orientation, throttle valve assembly **186** is positioned laterally outboard of engine **26** and laterally outboard of forward frame assembly **14** (see also FIG. **1**D). With air plenum **182** and throttle valve assembly **186** in place, addition frame members can now be installed on welded frame assembly **200**. Specifically, the separable portion of left side frame assembly **208** can be installed to the fixed portion of the left side frame assembly **208** with non-permanent fasteners.

[0055] As best seen in FIG. **4**F, the separable portion of the left side frame assembly **208** includes a left side forward spar **208***a* that is coupled between top flange **208***f* and upper flange **208***g* with non-permanent fasteners depicted as bolts. In the illustrated embodiments, an upper cross member **210***b* is welded to left side forward spar **208***a* and is now coupled to lateral flange **206***e* with a non-permanent fastener depicted as a bolt. As best seen in FIG. **4**G, the separable portion of the left side frame assembly **208** also includes a left side upper beam **208***c* that is coupled between aft flange **208***h* of left side joint **208***d* and upper flange **208***i* of plate member **16***b* with non-permanent fasteners depicted as bolts. With the installation of left side forward spar **208***a*, upper cross member **210***b* and left side upper beam **208***c*, the assembly for forward frame assembly **14** is complete. It should be noted that the use of left side frame assembly **208** having the separable portion not only enables engine installation through window **208***e* but also enhances engine servicing by providing improved access to engine **26** by removing one or more of the separable frame parts. In addition, it should be noted that right side forward spar **206***a* and left side forward spar **208***a* of forward frame assembly **14** are bent spars and more particularly are spars bent in the forward direction to provide additional space for engine **26** and other snowmobile components within forward frame assembly **14**.

[0056] In addition, FIG. **5**G depicts the installation of bearing hub **154** to the left outboard side of chassis **12**. More particularly bearing hub **154** is coupled to left side upper beam **208***c* of forward frame assembly **14** via a fastener depicted as a bolt, coupled to left side plate member **16***b* via a fastener depicted as a bolt and coupled to left side end cap of heat exchanger **104** via a fastener depicted as a bolt. Bearing hub **154** is also coupled to aft mounting bracket **212***b* via a fastener depicted as bolt **226** that has mount axis **222** (see also FIG. **6**C). Left aftward engine mount **220** is partially disposed between bracket **212***b* and bearing hub **154** such that bolt **226** resiliently supports left aftward engine mount **220** therebetween. In the illustrated embodiment, left aftward engine mount **220** and bracket **212***b* are positioned between longitudinal centerline **10***a* of snowmobile **10** and bearing hub **154**. Once left aftward engine mount **220** is secured, engine **26** now has four points of support resiliently provided by right forward engine mount **214**, left forward engine mount **216**, right aftward engine mount **218** and left aftward engine mount **220**. It is noted that the installation of bearing hub **154** may be delayed until installation of drivetrain **28** but is being shown here for the purposes of fully disclosing the mounting of engine **26**.

[0057] As best seen in FIG. **5**H, additional components of air intake system **176** have been installed. Specifically, airbox **180** has been coupled to forward frame assembly **14** and air duct **184** has been coupled between airbox **180** and throttle valve assembly **186**. In this configuration, air inlet **178** that is positioned outboard of forward frame assembly **14** and above throttle valve assembly **186**. Airbox **180** is positioned generally forward and generally above engine **26**. Air duct **184** is routed forward and outboard of left side forward spar **208***a*. This generally completes the assembly of air intake system **176** on engine **26**. It should be understood by those having ordinary skill in the art that even though specific preassemblies of snowmobile systems have been depicted and described, and even though a particular order of installation has been depicted and described, other preassemblies and other installation orders are made possible with the use of welded frame assembly **200**.

[0058] For example, as best seen in FIG. **5**I, an engine preassembly includes engine **26** with exhaust manifold **72**, air runner assembly **188** (not visible) and air plenum **182** together with throttle valve assembly **186** installed thereon. Also, preinstalled on engine **26** is a portion of the engine mounting system that includes right forward engine mount **214**, left forward engine mount **216** and right aftward engine mount **218** (not visible). Compared to the engine preassembly of FIG. **5**C, the present engine preassembly includes air plenum **182** and throttle valve assembly **186** but excludes left aftward engine mount **220**. As before, engine **26** is laterally inserted welded frame assembly **200** through window **208***e* of the fixed portion of left side frame assembly **208** as indicated by the laterally extending portion of engine installation path arrow **228** that originates at the tip of mounting stud **214***d*. Once engine **26** is disposed within welded frame assembly **200**, engine **26** is shifted forward to vertically align mounting stud **214***d* with mounting hole **202***f* of nose frame cross member **202***d* and to vertically align mounting stud **216***d* with mounting hole **202***g* of nose frame cross member **202***d*, as indicated by the forwardly extending portion of engine installation path arrow **228**. Engine **26** is now lowered to insert mounting stud **214***d* into mounting hole **202***f* of nose frame cross member **202***d* and to insert mounting stud **216***d* into mounting hole **202***g* of nose frame cross member **202***d*, as indicated by the downwardly extending portion of engine installation path arrow **228**. This lowering of engine **26** also aligns right aftward engine mount **218** with right mounting bracket **212***a*. Engine **26** may now be secured to welded frame assembly **200** and heat exchanger **104** at three points; namely, nut **230***a* secures right forward engine mount **214** to nose frame cross member **202***d*, nut **230***b* secures left forward engine mount **216** to nose frame cross member **202***d* and bolt assembly **224** secures right aftward engine mount **218** to right mounting bracket **212***a*. The remaining components of forward frame assembly **14** and air intake system **176** may now be installed in a manner similar to that described above with reference to FIGS. **5**F-**5**H with the added step of installing left aftward engine mount **220** to the left side of engine **26**.

[0059] Referring additionally to FIGS. **6**A-**6**C in the drawings, additional details regarding an engine mounting system will now be described. Right mounting bracket **212***a* and left mounting bracket **212***b* are welded to the forward face of arcuate heat exchanger **104** (see also FIG. **5**B). Right mounting bracket **212***a* forms a clevis sized to receive right aftward engine mount **218** therein. Right aftward engine mount **218** includes vibration damper **218***b* that is received within an aperture of body **218***a*. Bolt **224** is used to resiliently secure right aftward engine mount **218** within right mounting bracket **212***a* such that mount axis **222** of bolt **224** extends substantially horizontally through the center of vibration damper **218***b* in the lateral direction. Bearing hub **154** and left mounting bracket **212***b* are positioned to form gap therebetween that is sized to receive left aftward engine mount **220** therein. Left aftward engine mount **220** includes vibration damper **220***b* that is received within an aperture of body **220***a*. Bolt **226** is used to resiliently secure left aftward engine mount **220** between bearing hub **154** and left mounting bracket **212***b* such that mount axis **222** of bolt **226**, which is common to bolt **224**, extends substantially horizontally through the center of vibration damper **220***b* in the lateral direction. Due to the resilient nature of vibration dampers **218***b*, **220***b*, vibration transfer from engine **26** to heat exchanger **102**, bearing hub **154** and thus to driven shaft **128** is reduced and/or eliminated.

[0060] Nose frame assembly **202** including nose frame cross member **202***d* having openings **202***f*, **202***g* (see also FIG. **5**C). Right forward engine mount **214** includes vibration damper **214***c* and mounting stud **214***d* used to resiliently secure right forward engine mount **214** to nose frame cross member **202***d* such that mount axis **214***e* of mounting stud **214***d* extends in a direction that is substantially parallel to aftward tilt angle **168** of engine **26**. Likewise, left forward engine mount **216** includes vibration damper **216***c* and mounting stud **216***d* used to resiliently secure left forward engine mount **216** to nose frame cross member **202***d* such that mount axis **216***e* of mounting stud **216***d* extends in a direction that is substantially parallel to aftward tilt angle **168** of engine **26**. Due to the resilient nature of vibration dampers **214***c*, **216***c*, vibration transfer from engine **26** to forward frame assembly **14** is reduced and/or eliminated. In this configuration, mount axes **214***e*, **216***e* of forward engine mounts **214**, **216** are substantially normal to mount axis **222** of aftward engine mounts **218**, **220**. Also, in this configuration, aftward engine mounts **218**, **220** are positioned outboard and above forward engine mounts **214**, **216**. In addition, forward engine mounts **214**, **216** and aftward engine mounts **218**, **220** are positioned above a horizontal plane HP including crankshaft **132**.

[0061] Referring next to FIGS. **7**A-**7**C of the drawings, a second embodiment of an engine mounting system will now be discussed. In FIG. **7**A, welded frame assembly **200** includes nose frame assembly **202**, a base frame assembly **204**, a right side frame assembly **206** and a fixed portion of a left side frame assembly **208** as well as a steering column mount **210**. Each of the frame assemblies remains the same as discussed herein except that nose frame assembly **202** includes a modified nose frame cross member **300** that is designed for mounting a plurality of snowmobile components thereto. For example, nose frame cross member **300** includes a pair of central openings **300***a*, **300***b* for receiving bolts therethrough that are configured for coupling a snowmobile component to nose frame cross member **300** in between the right and left forward engine mounts such as the electronic steering assist unit that is coupled to the nose frame cross member of the forward frame assembly described in commonly owned U.S. patent application Ser. No. 18/669,805, filed May 21, 2024, the entire contents of which are incorporated by reference herein for all purposes. In addition, nose frame cross member **300** includes a pair of right openings **302***a*, **302***b* and a pair of left openings **304***a*, **304***b* for receiving bolts therethrough for coupling the right and left forward engine mounts to nose frame cross member **300**.

[0062] An arcuate heat exchanger **306** is coupled to tunnel **18** and welded frame assembly **200** using rivets or other suitable connection means including by coupling the end caps of arcuate heat exchanger **306** to right side plate member **16***a* and left side plate member **16***b* of welded frame assembly **200**. Arcuate heat exchanger **306** has an arcuate inner surface **306***a* which has a substantially constant radius of curvature **306***b* and an arcuate outer wall **306***c* which has a substantially constant radius of curvature **306***d*. Radii of curvature **306***b*, **306***d* share a common center of curvature **306***e* that is coincident with axis of rotation **44***a* of track driveshaft **44**. Arcuate heat exchanger **306** includes a mounting system depicted as mounting rails **308** that are preferably formed integrally with outer wall **306***c* using, for example, an extrusion process followed by a machining process and thus does not require welding of non-integral brackets to the forward side of outer wall **306***c*. Mounting rails **308** include a right recessed mounting location **308***a* and a left recessed mounting location **308***b* that may be machined into mounting rails **308** to receive the right and left aftward engine mounts therein. Mounting rails **308** also include upper and lower slots **308***c*, **308***d* sized to receive and secure bolt heads therein such that the right and left aftward engine mounts can be coupled thereto.

[0063] The present engine mounting system includes a right forward engine mount **314**, a left forward engine mount **316**, a right aftward engine mount **318** and a left aftward engine mount **320**. In the illustrated embodiments, right forward engine mount **314** includes an angled bracket **314***a* that is bolted to a forward side of engine **26**. A mounting flange **314***b* and a vibration damper **314***c* are secured to angled bracket **314***a* with a bolt **314***d* along mounting axis **314***e*. Mounting flange **314***b* is coupled to nose frame cross member **300** with bolts **314***f*, **314***g* that extend through right openings **302***a*, **302***b* to resiliently secure right forward engine mount **314** to nose frame cross member **300** such that mount axis **314***e* extends in a direction that is substantially parallel to aftward tilt angle **168** of engine **26** (see also FIG. 3F). More specifically, to install right forward engine mount **314** to nose frame cross member **300**, mounting flange **314***b* and vibration damper **314***c* are positioned relative to nose frame cross member **300** and coupled thereto with bolts **314***f*, **314***g*. Angled bracket **314***a* may be preinstalled on engine **26** and coupled to mounting flange **314***b* and vibration damper **314***c* upon positioning of engine **26** within welded frame assembly **200**.

[0064] Left forward engine mount **316** includes an angled bracket **316***a* that is bolted to a forward side of engine **26**. A mounting flange **316***b* and a vibration damper **316***c* are secured angled bracket **316***a* with a bolt **316***d* along mounting axis **316***e*. Mounting flange **316***b* is coupled to nose frame cross member **300** with bolts **316***f*, **316***g* that extend through left openings **304***a*, **304***b* to resiliently secure left forward engine mount **316** to nose frame cross member **300** such that mount axis **316***e* extends in a direction that is substantially parallel to aftward tilt angle **168** of engine **26**, as best seen in FIG. 7C. More specifically, to install left forward engine mount **316** to nose frame cross member **300**, mounting flange **316***b* and vibration damper **316***c* are positioned relative to nose frame cross member **300** and coupled thereto with bolts **316***f*, **316***g*. Angled bracket **316***a* may be preinstalled on engine **26** and coupled to mounting flange **316***b* and vibration damper **316***c* upon positioning of engine **26** within welded frame assembly **200**. Due to the resilient nature of vibration dampers **314***c*, **316***c*, vibration transfer from engine **26** to nose frame cross member **300** and thus to welded frame assembly **200** is reduced and/or eliminated. It is noted that the bolt openings in angled bracket **314***a*, **316***a* may be oversized to allow certain tolerance during engine installation such that bolts **314***d*, **316***d* may pass therethrough even when there is slight misalignment of engine **26** relative thereto and to allow for proper alignment of engine **26** in the longitudinal direction.

[0065] Right aftward engine mount **318** has a body **318***a* that is bolted to an aftward side of engine **26**. A mounting flange **318***b* and a vibration damper **318***c* are secured to body **318***a* with a bolt **318***d* along mounting axis **318***e*. Mounting flange **318***b* is coupled to mounting rails **308** with bolts **318***f*, **318***g*. More specifically, to install right aftward engine mount **318** to mounting rails **308**, mounting flange **318***b* and vibration damper **318***c* are positioned relative to mounting rails **308** such that the head of bolt **318***f* is received within a central opening **308***e* of upper slot **308***c* and the head of bolt **318***g* is received within a central opening **308***f* of lower slot **308***d*. Mounting flange **318***b* and vibration damper **318***c* are then moved toward and properly aligned with right recessed mounting location **308***a* such that mounting flange **318***b* can be received within right recessed mounting location **308***a*. Thereafter, bolts **318***f*, **318***g* are tightened to secure mounting flange **318***b* and vibration damper **318***c* in place within right recessed mounting location **308***a*. Body **318***a* may be preinstalled on engine **26** and coupled to mounting flange **318***b* and vibration damper **318***c* upon positioning of engine **26** within welded frame assembly **200**.

[0066] Left aftward engine mount **320** has a body **320***a* that is bolted to features on an aftward side of engine **26**. A mounting flange **320***b* and a vibration damper **320***c* are secured to body **320***a* with a bolt **320***d* along mounting axis **320***e*. Mounting flange **320***b* is coupled to mounting rails **308** with bolts **320***f*, **320***g*. More specifically, to install left aftward engine mount **320** to mounting rails **308**, mounting flange **320***b* and vibration damper **320***c* are positioned relative to mounting rails **308** such that the head of bolt **320***f* is received within central opening **308***e* of upper slot **308***c* and the head of bolt **320***g* is received within central opening **308***f* of lower slot **308***d*. Mounting flange **320***b* and vibration damper **320***c* are then moved toward and properly aligned with left recessed mounting location **308***b* such that mounting flange **320***b* can be received within left recessed mounting location **308***b*. Thereafter, bolts **320***f*, **320***g* are tightened to secure mounting flange **320***b* and vibration damper **320***c* in place within left recessed mounting location **308***b*. Body **320***a* may be preinstalled on engine **26** and coupled to mounting flange **320***b* and vibration damper **320***c* upon positioning of engine **26** within welded frame assembly **200**.

[0067] As best seen in FIG. 7C, once mounting flange **320***b* is secured to mounting rails **308** within left recessed mounting location **308***b* and with bolts **320***f*, **320***g*, mount axis **320***e* extends through heat exchanger **306** in a radial direction relative to axis of rotation **44***a* of track driveshaft **44**. Likewise, when mounting flange **318***b* is secured to mounting rails **308** within right recessed mounting location **308***a* and with bolts **318***f*, **318***g*, mount axis **318***e* extends through heat exchanger **306** in a radial direction relative to axis of rotation **44***a* of track driveshaft **44**. In the illustrated embodiment, the recessed shapes of mounting locations **308***a*, **308***b* conform to the shapes of mounting flanges **318***b*, **320***b* such that mounting flanges **318***b*, **320***b* properly locate therein during fastening of mounting flanges **318***b*, **320***b* to mounting rails **308**, installation of engine **26** and operation of aftward engine mounts **318**, **320**. In addition, mounting locations **308***a*, **308***b* together with mounting flanges **318***b*, **320***b* provide positive mounting locations to ensure proper alignment of engine **26** in the lateral direction within welded frame assembly **200**. It is noted that the bolt openings in bodies **318***a*, **320***a* may be oversized to allow certain tolerance during engine installation such that bolts **318***d*, **320***d* may pass therethrough even when there is slight misalignment of engine **26** relative thereto.

[0068] Due to the resilient nature of vibration dampers **318***c*, **320***c*, vibration transfer from engine **26** to heat exchanger **306** is reduced and/or eliminated. Mounting rails **308** extend the lateral direction of snowmobile **10** and have a length that is more than half the lateral length of heat exchanger **306** and, in the illustrated embodiment, have a length of about ninety percent of the lateral length of heat exchanger **306**. As such, mounting rails **308** enhance the structure of heat exchanger **306** thus providing a more robust support for engine **26**. In addition, heat exchanger **306** may include internal reinforcement elements to provide added support for engine **26** such as those positioned in the heat exchanger disclosed in commonly owned U.S. patent application Ser. No. 18/666,651, filed May 16, 2024, the entire contents of which are incorporated by reference herein for all purposes.

[0069] Even though mounting rails **308** have been depicted as described as having mounting location for mounting flanges **318***b*, **320***b*, it should be understood by those having ordinary skill in the art that mounting rails **308** could be used for mounting other or additional snowmobile components thereto including, for example, a bearing hub, such as bearing hub **154** discussed herein, a gearbox assembly associated with driven shaft **138** or another desired component. Also, even though each of vibration dampers **314***c*, **316***c*, **318***c*, **320***c* has been depicted to include a threaded stud **314***d*, **316***d*, **318***d*, **320***d* respectively extending outwardly therefrom and configured to extend through a bolt opening in a respective one of bodies **314***a*, **316***a*, **318***a*, **320***a* and receive a nut, it should be understood by those having ordinary skill in the art that bodies **314***a*, **316***a*, **318***a*, **320***a* may be coupled to vibration dampers **314***c*, **316***c*, **318***c*, **320***c* using bolts that extend through the bolt openings in bodies **314***a*, **316***a*, **318***a*, **320***a* and into vibration dampers **314***c*, **316***c*, **318***c*, **320***c*. In addition, even though the bolts that couple mounting flanges **318***b*, **320***b* to mounting rails **308**, such as bolt **320***g*, have been depicted as having square heads, it should be understood by those having ordinary skill in the art that these bolts could have heads with other shapes and/or these bolts could be used in conjunction with washers to couple mounting flanges **318***b*, **320***b* to mounting rails **308**.

[0070] 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 comprising:

a forward frame assembly defining an engine bay, the forward frame assembly including a nose frame assembly having a nose frame cross member positioned forward of the engine bay;

an engine positioned within the engine bay;

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

a heat exchanger coupled to a forward end of the tunnel;

at least one aftward engine mount configured to couple the engine to the heat exchanger; and

at least one forward engine mount configured to couple the engine to the nose frame cross member.

2. The snowmobile as recited in claim **1** wherein, the forward frame assembly further comprises a base frame assembly coupled to the nose frame assembly; and

wherein, the engine is suspended above the base frame assembly by the aftward and forward engine mounts.

3. The snowmobile as recited in claim **1** wherein, the engine is a four-stroke engine that has exhaust ports positioned on a forward side of the engine and intake ports positioned on an aft side of the engine.

4. The snowmobile as recited in claim **1** wherein, the at least one aftward engine mount is first and second aftward engine mounts configured to couple the engine to the heat exchanger.

5. The snowmobile as recited in claim **1** further comprising at least one aftward engine mount configured to couple the engine to the forward frame assembly.

6. The snowmobile as recited in claim **1** wherein, the at least one forward engine mount is first and second forward engine mounts configured to couple the engine to the nose frame cross member.

7. The snowmobile as recited in claim **1** wherein, the at least one aftward engine mount damps vibration between the engine and the heat exchanger; and

wherein, the at least one forward engine mount damps vibration between the engine and the forward frame assembly.

8. The snowmobile as recited in claim **1** wherein, the at least one aftward engine mount is positioned above the at least one forward engine mount.

9. The snowmobile as recited in claim **1** wherein, the at least one aftward engine mount has a mount axis that is substantially horizontal; and

wherein, the at least one forward engine mount has a mount axis that is substantially parallel to an aftward tilt angle of the engine.

10. The snowmobile as recited in claim **9** wherein, the mount axis of the at least one aftward engine mount extends in a lateral direction.

11. The snowmobile as recited in claim **1** wherein, the heat exchanger includes a mounting system positioned on a forward wall of the heat exchanger; and

wherein, the at least one aftward engine mount is coupled to the mounting system.

12. The snowmobile as recited in claim **1** wherein, the heat exchanger includes a mounting system integrally formed on a forward wall of the heat exchanger; and

wherein, the at least one aftward engine mount is coupled to the mounting system.

13. The snowmobile as recited in claim **1** wherein, the heat exchanger includes mounting rails positioned on a forward wall of the heat exchanger; and

wherein, the at least one aftward engine mount is coupled to the mounting rails.

14. The snowmobile as recited in claim **1** wherein, the heat exchanger includes mounting rails integrally formed on a forward wall of the heat exchanger; and

wherein, the at least one aftward engine mount is coupled to the mounting rails.

15. The snowmobile as recited in claim **14** wherein, the mounting rails include at least one recessed mounting location configured to receive the at least one aftward engine mount therein.

16. The snowmobile as recited in claim **15** wherein, the at least one aftward engine mount includes a mounting flange; and

wherein, the mounting flange is received in the at least one recessed mounting location.

17. The snowmobile as recited in claim **16** wherein, the mounting rails include first and second slots; and

wherein, the mounting flange is coupled to the at least one recessed mounting location using first and second bolts that are respectively received within the first and second slots.

18. The snowmobile as recited in claim **1** further comprising a drive track system that is at least partially disposed within the tunnel, the drive track system including a track driveshaft having an axis of rotation;

wherein, the at least one aftward engine mount has a mount axis that is oriented in a substantially radial direction relative to the axis of rotation of the track driveshaft.

19. A snowmobile comprising:

a forward frame assembly defining an engine bay, the forward frame assembly including a nose frame assembly having a nose frame cross member positioned forward of the engine bay;

an engine positioned within the engine bay;

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

a drive track system positioned at least partially within the tunnel, the drive track system including a track driveshaft having an axis of rotation;

a heat exchanger coupled to a forward end of the tunnel, the heat exchanger including a mounting system positioned on a forward wall of the heat exchanger;

first and second forward engine mounts coupling the engine to the nose frame cross member; and

first and second aftward engine mounts coupling the engine to the mounting system;

wherein, each of the aftward engine mounts has a mount axis that is oriented in a substantially radial direction relative to the axis of rotation of the track driveshaft.

20. A snowmobile comprising:

a forward frame assembly defining an engine bay, the forward frame assembly including a nose frame assembly having a nose frame cross member positioned forward of the engine bay;

an engine positioned within the engine bay;

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

a drive track system positioned at least partially within the tunnel, the drive track system including a track driveshaft having an axis of rotation;

a heat exchanger coupled to a forward end of the tunnel, the heat exchanger including mounting rails integrally formed on a forward wall of the heat exchanger;

first and second forward engine mounts coupling the engine to the nose frame cross member; and

first and second aftward engine mounts coupling the engine to the mounting rails;

wherein, each of the aftward engine mounts has a mount axis that is oriented in a substantially radial direction relative to the axis of rotation of the track driveshaft.

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