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(54) **OFF-ROAD VEHICLE**

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See application file for complete search history.

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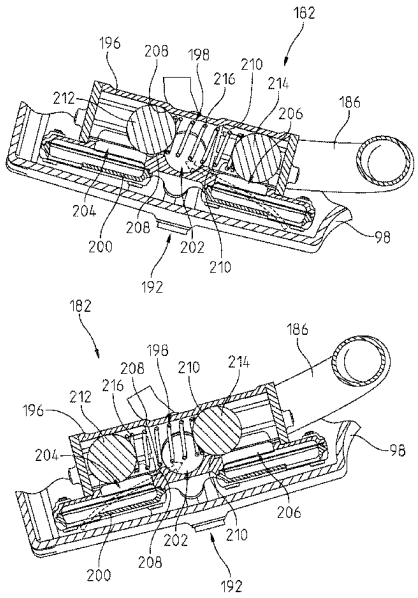
(57) **ABSTRACT**

A utility vehicle comprising a frame, a body supported by the frame, a seating area supported by the frame, front and rear ground engaging members supporting the frame and the body, and a powertrain drivingly coupled to the front and rear ground engaging members, the powertrain including an engine having a cylinder block having a plurality of cylinders, a cylinder head removably coupled to the cylinder block, a crankcase having a first portion and a second portion, the first portion of the crankcase being removably coupled to the cylinder block, and at least one gasket positioned between the cylinder block and the first portion of the crankcase, the at least one gasket configured to individually seal each of the plurality of cylinders relative to the first portion of the crankcase.

15 Claims, 23 Drawing Sheets



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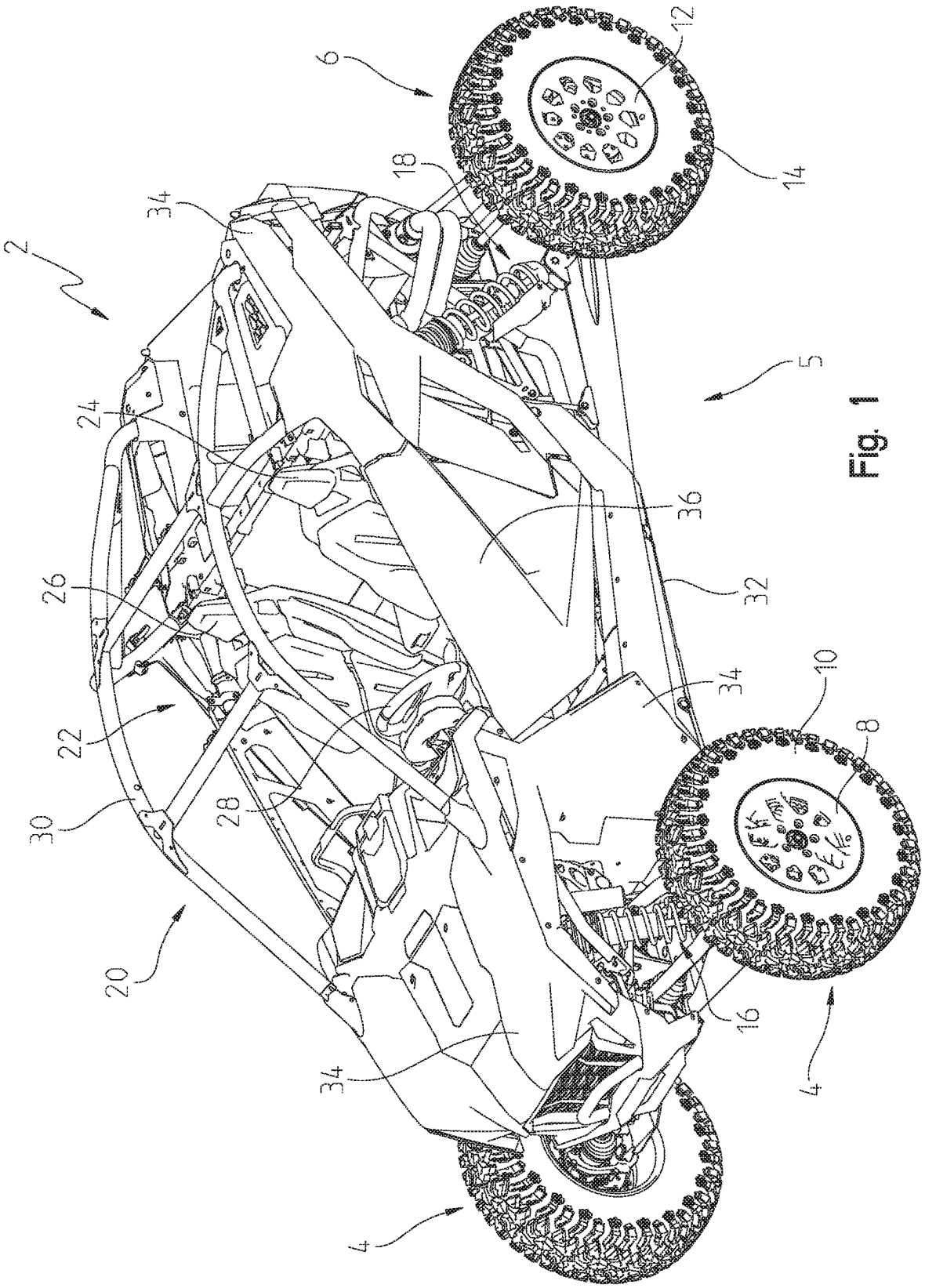

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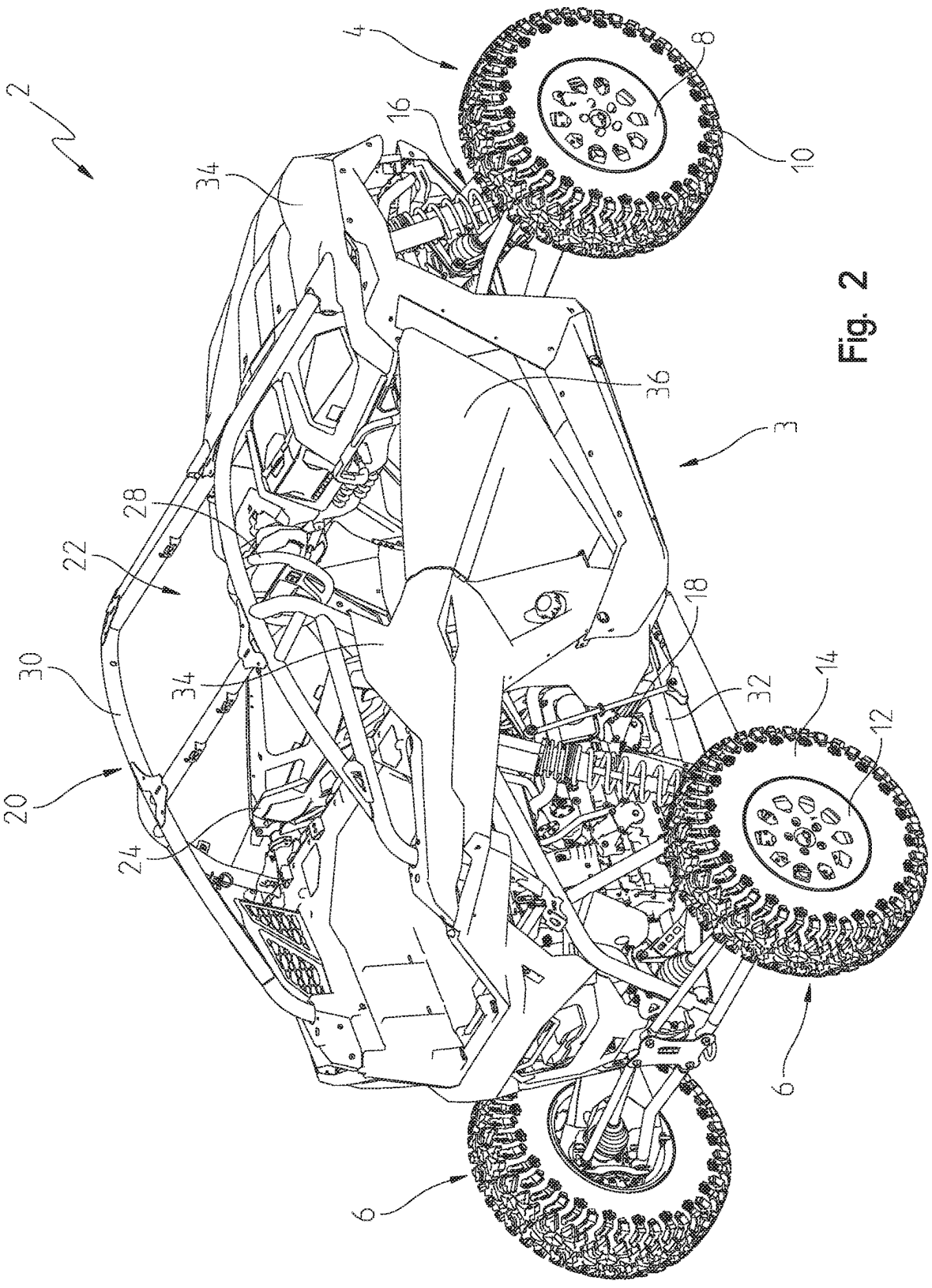

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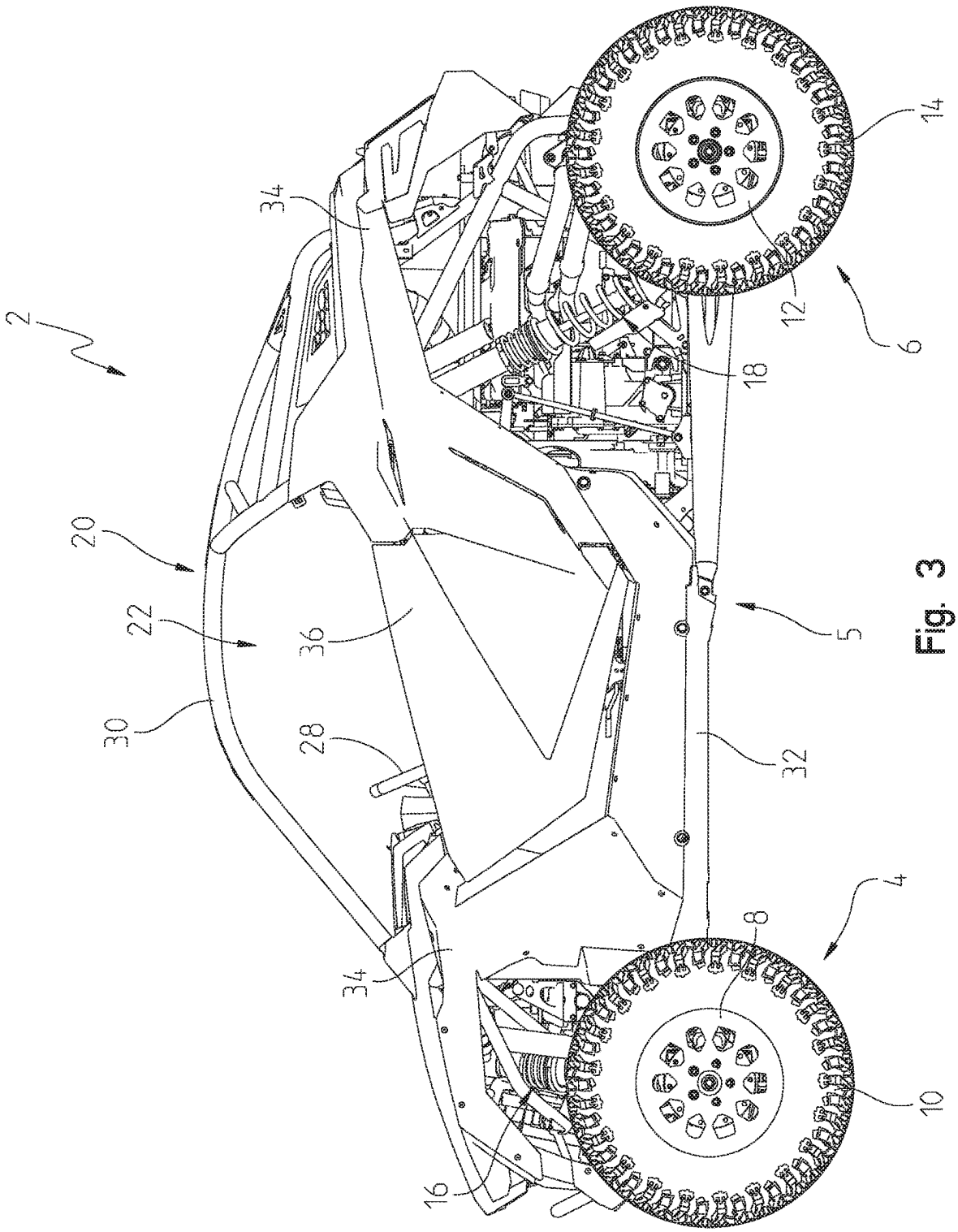

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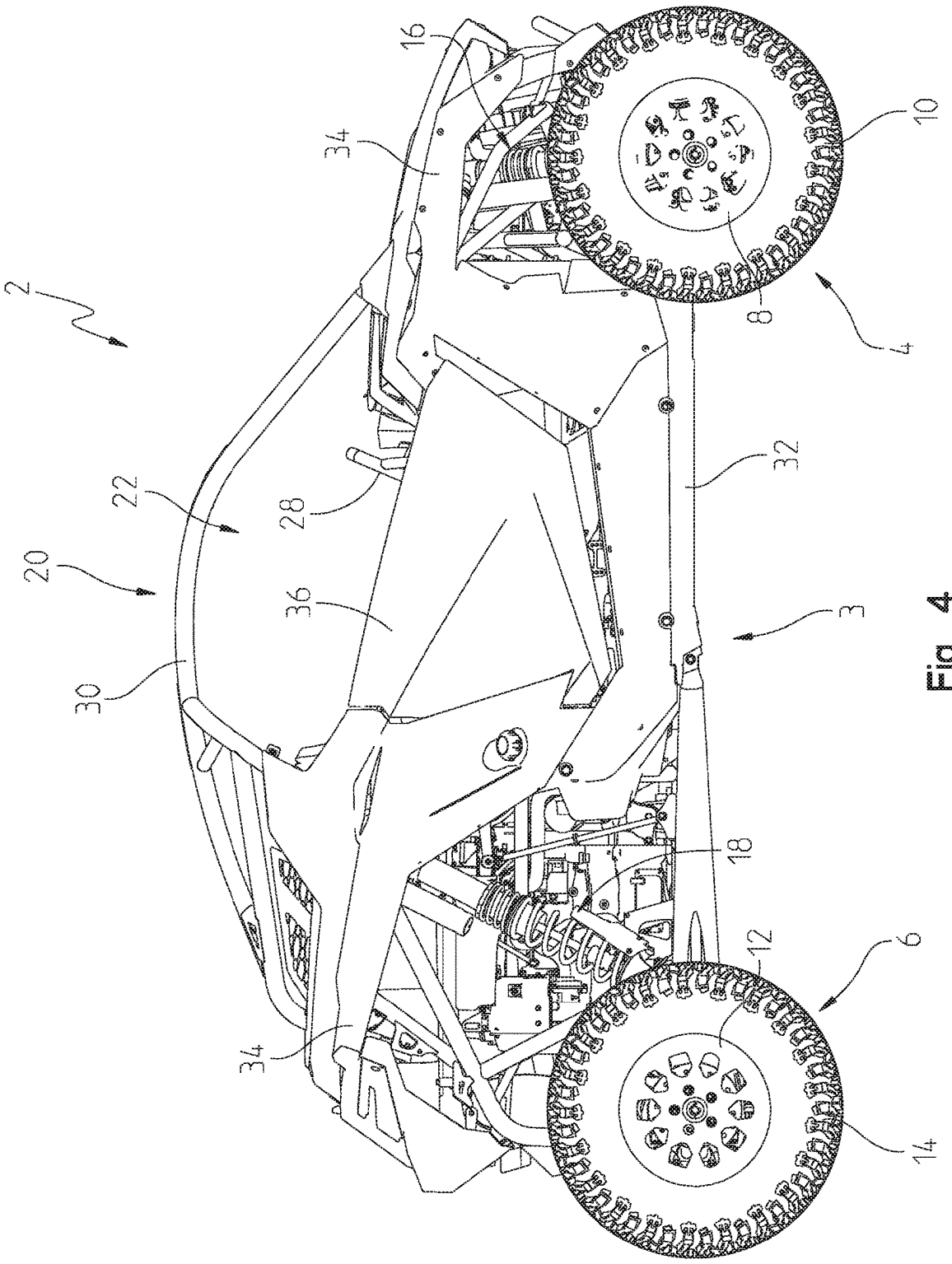

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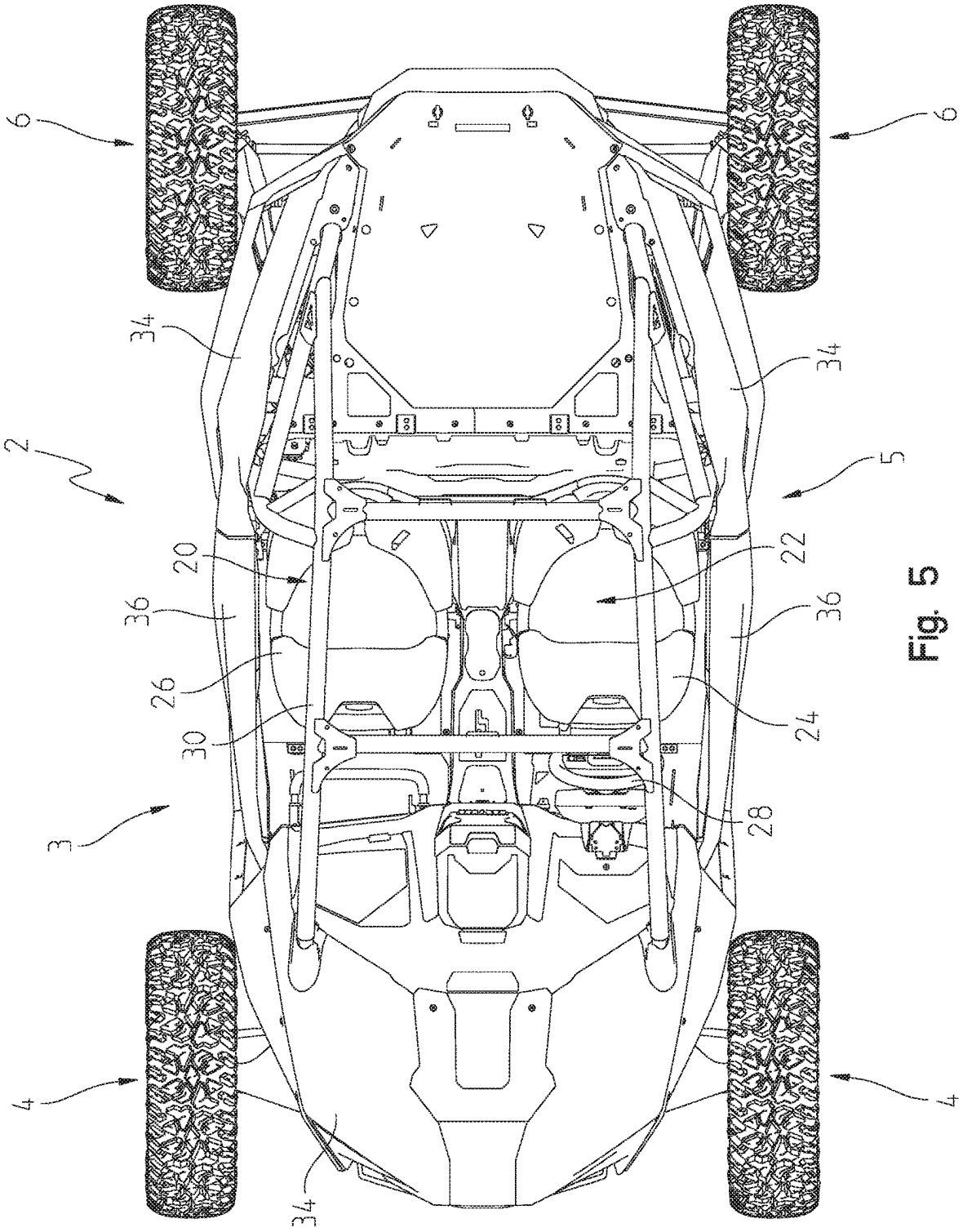

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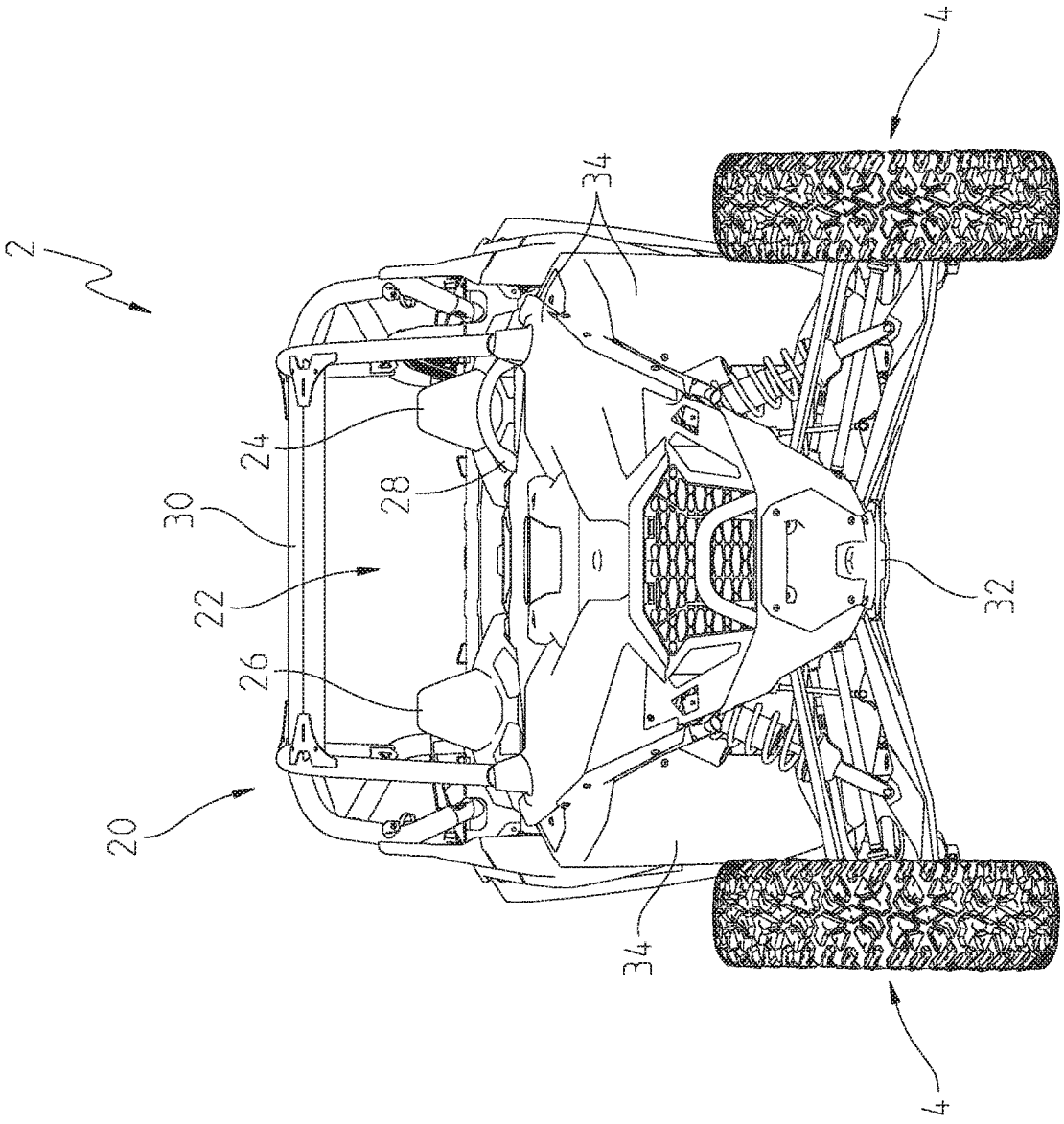

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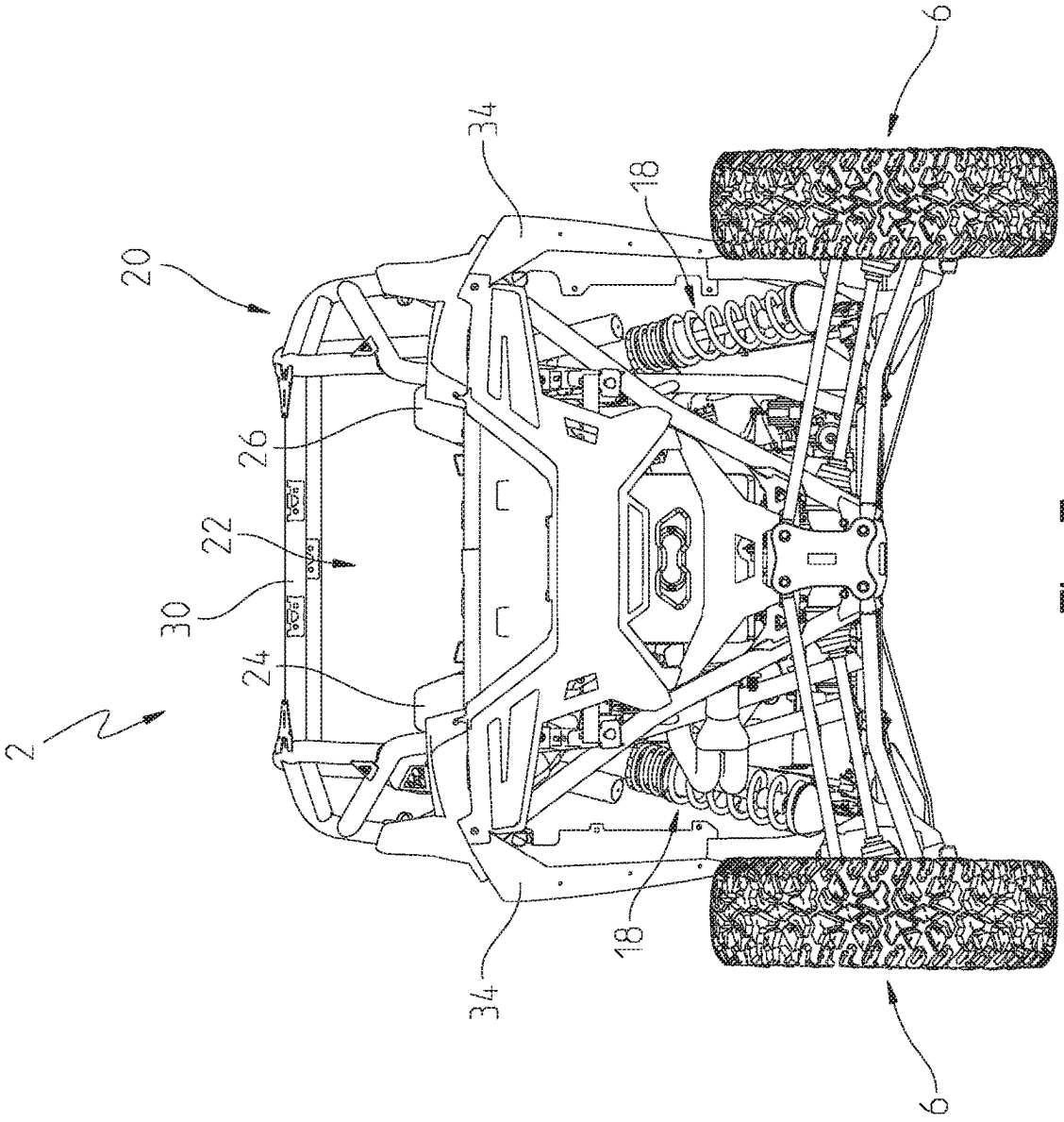

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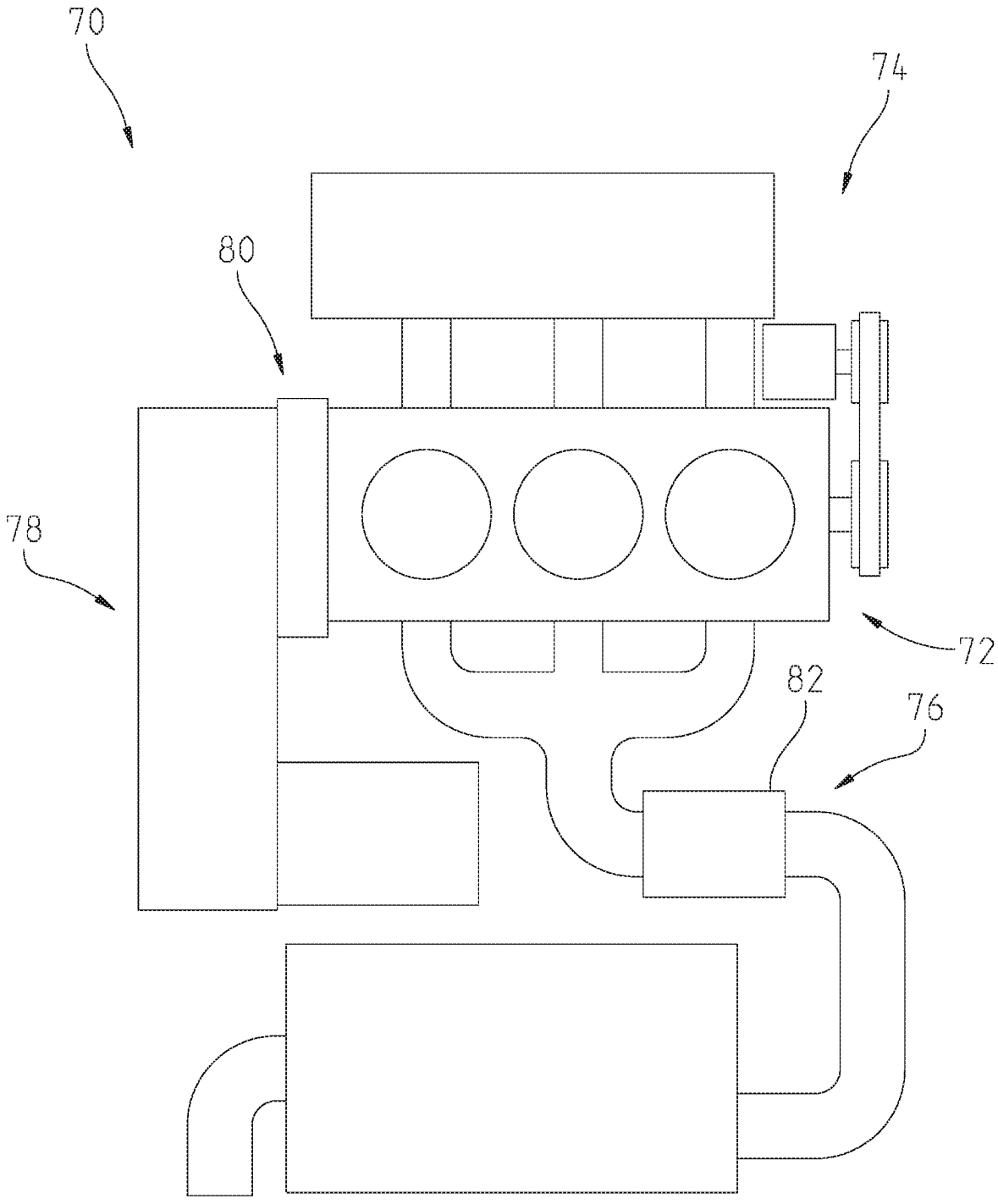

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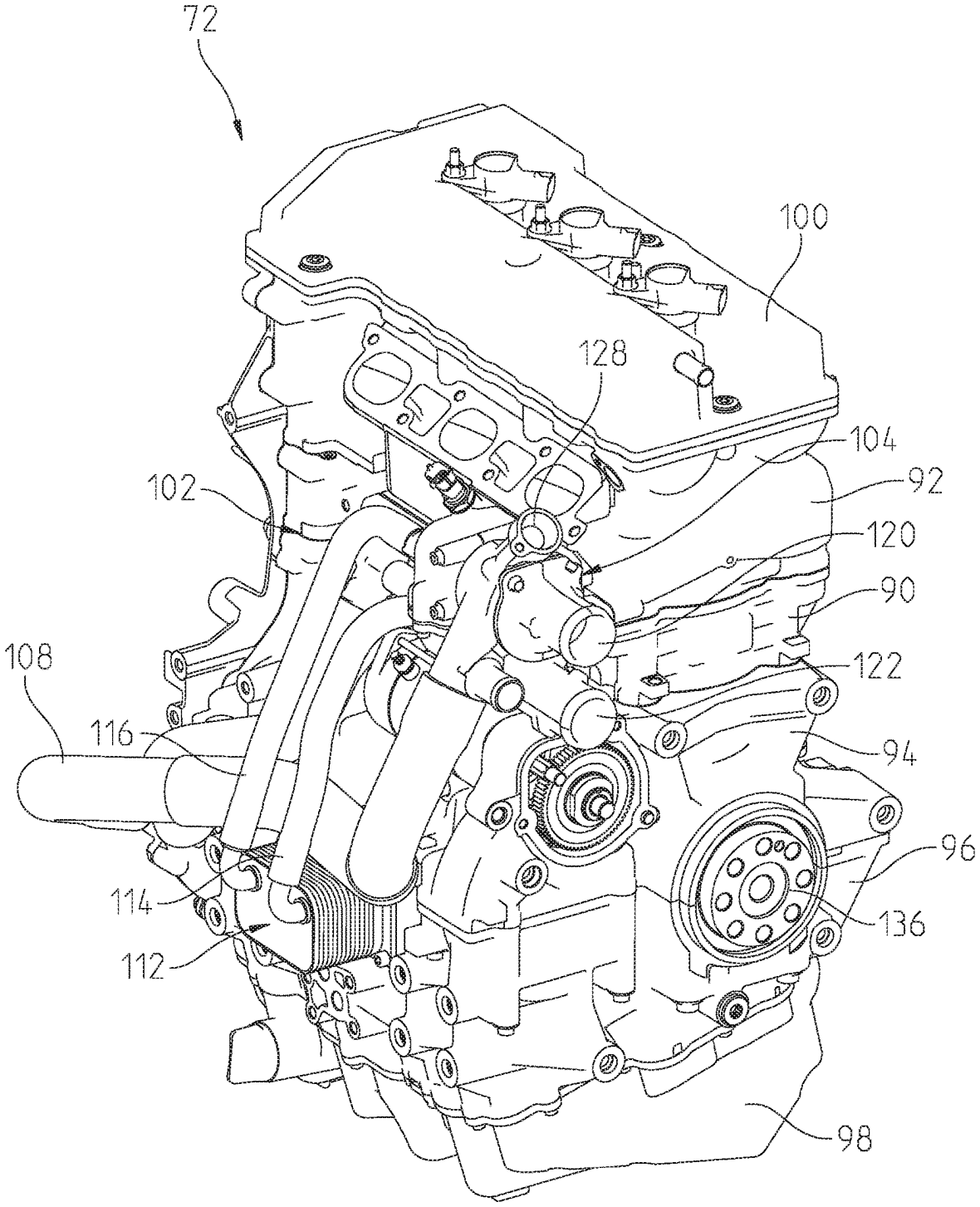
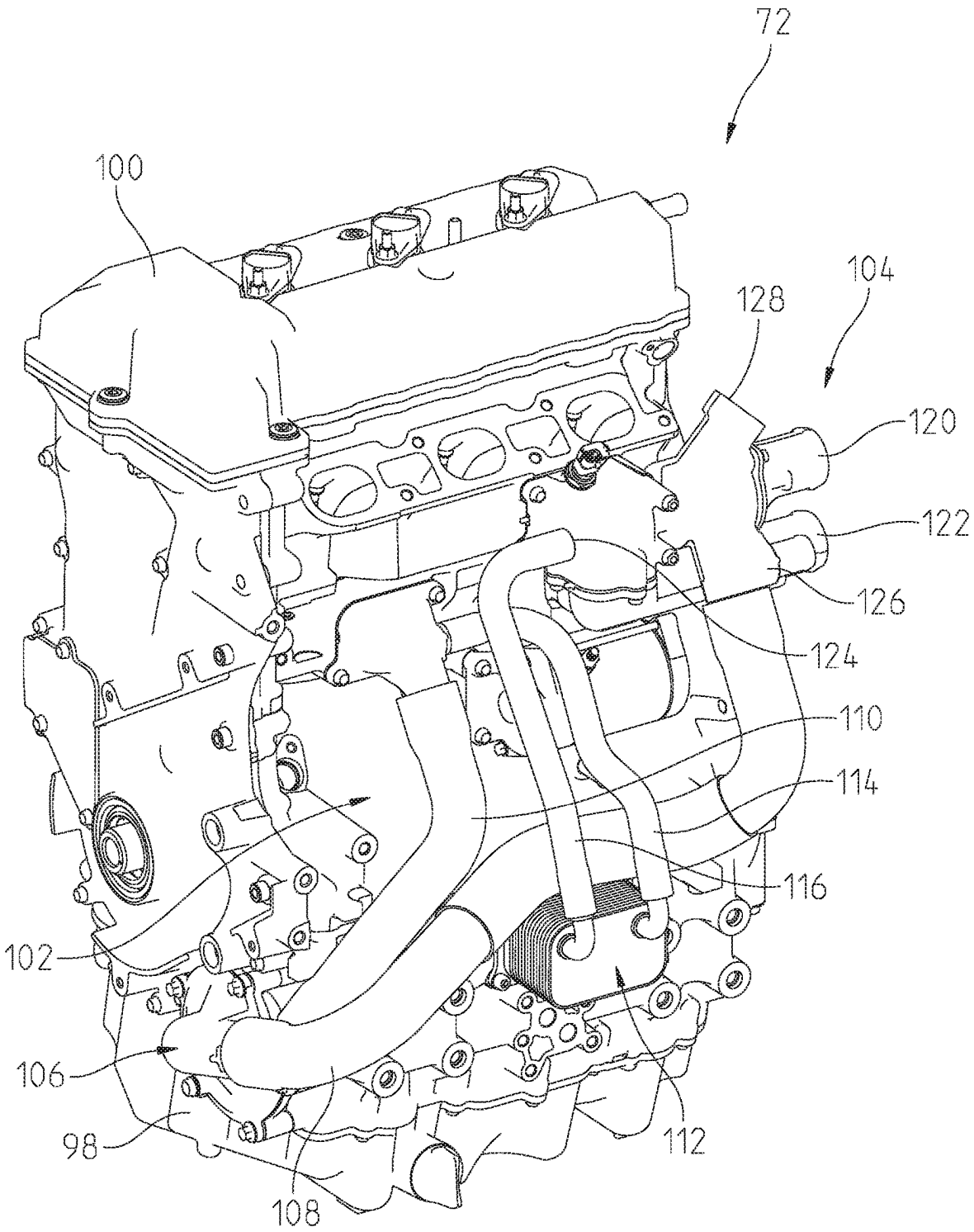


Fig. 9



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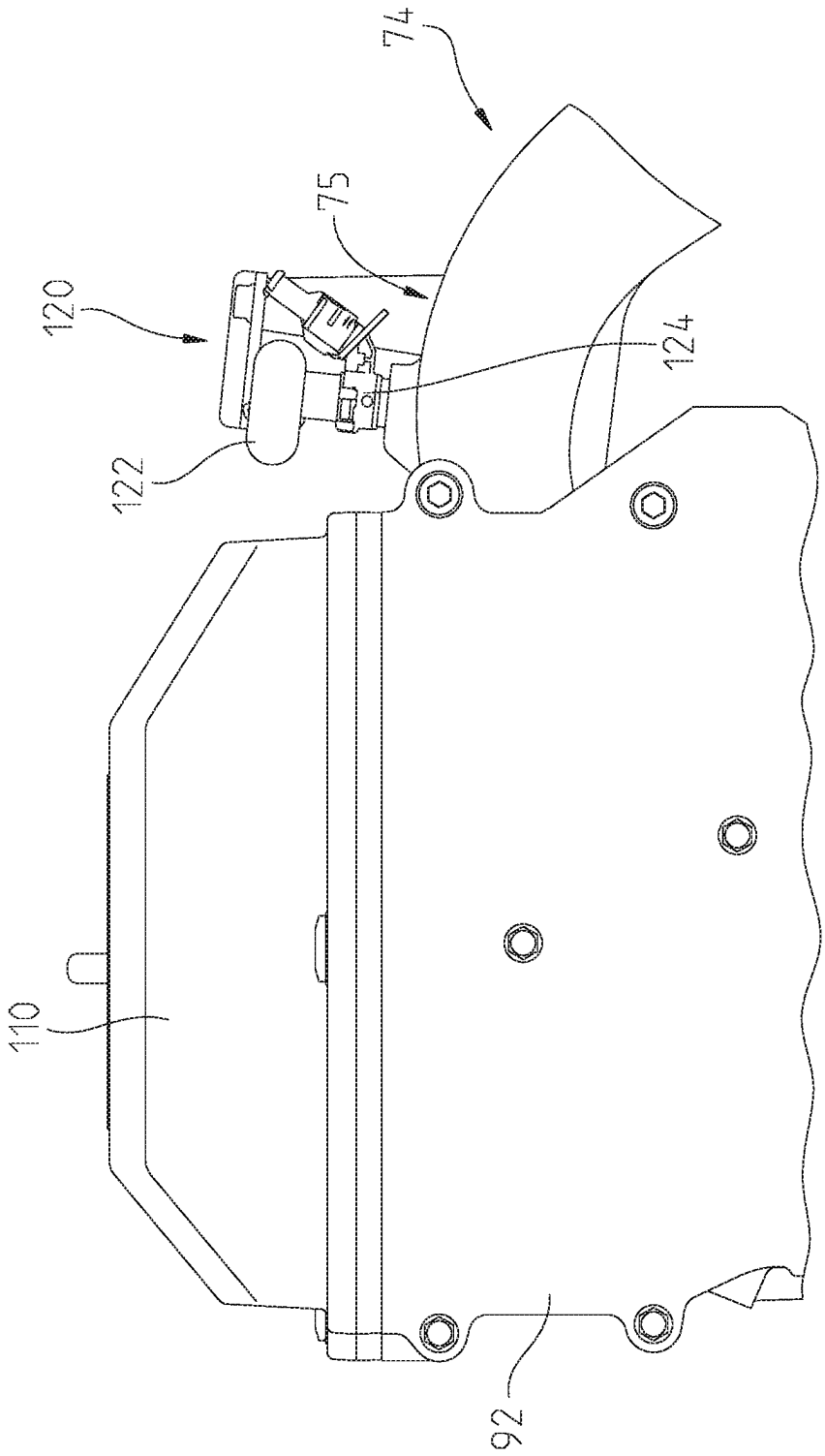


Fig. 11

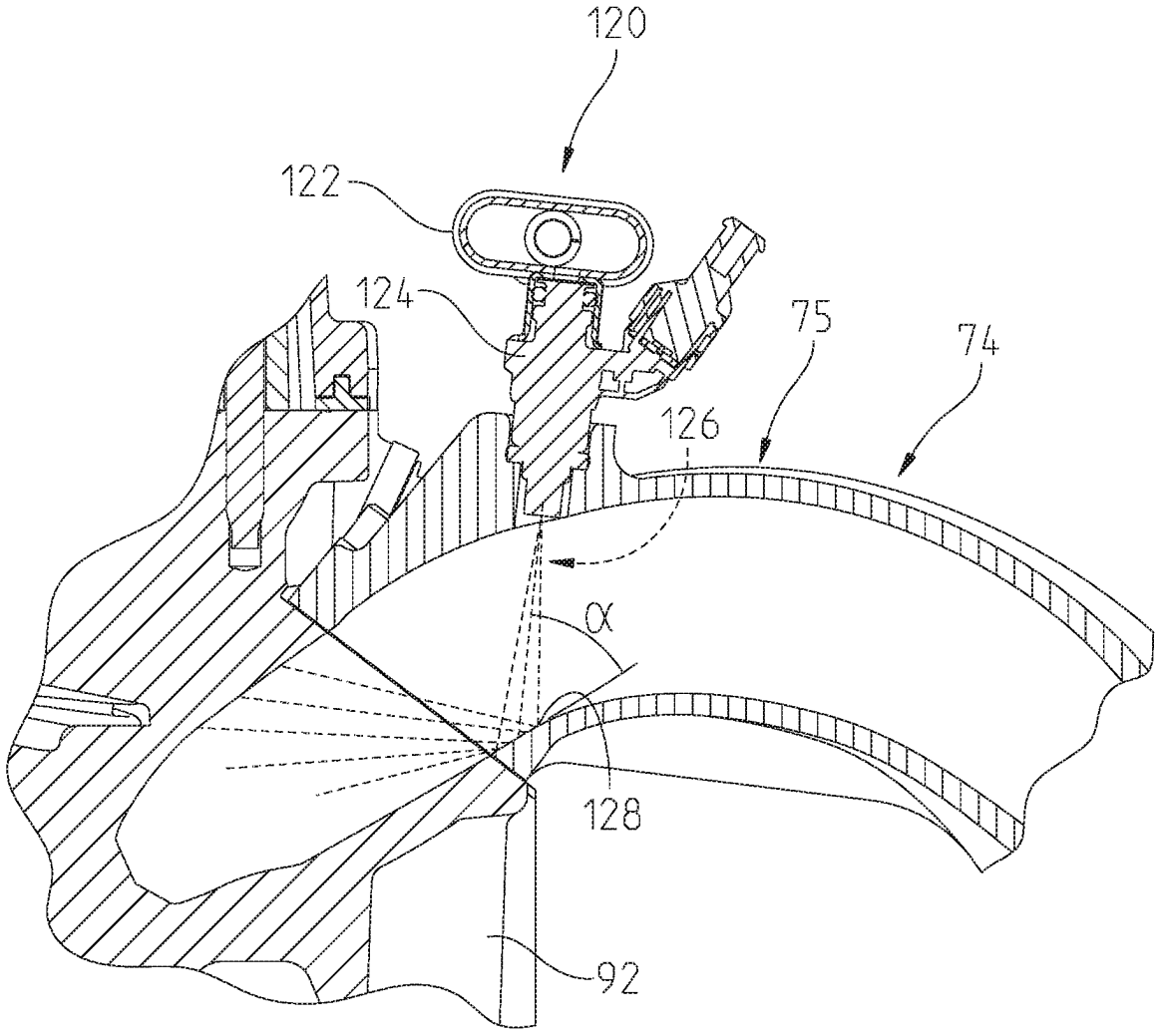
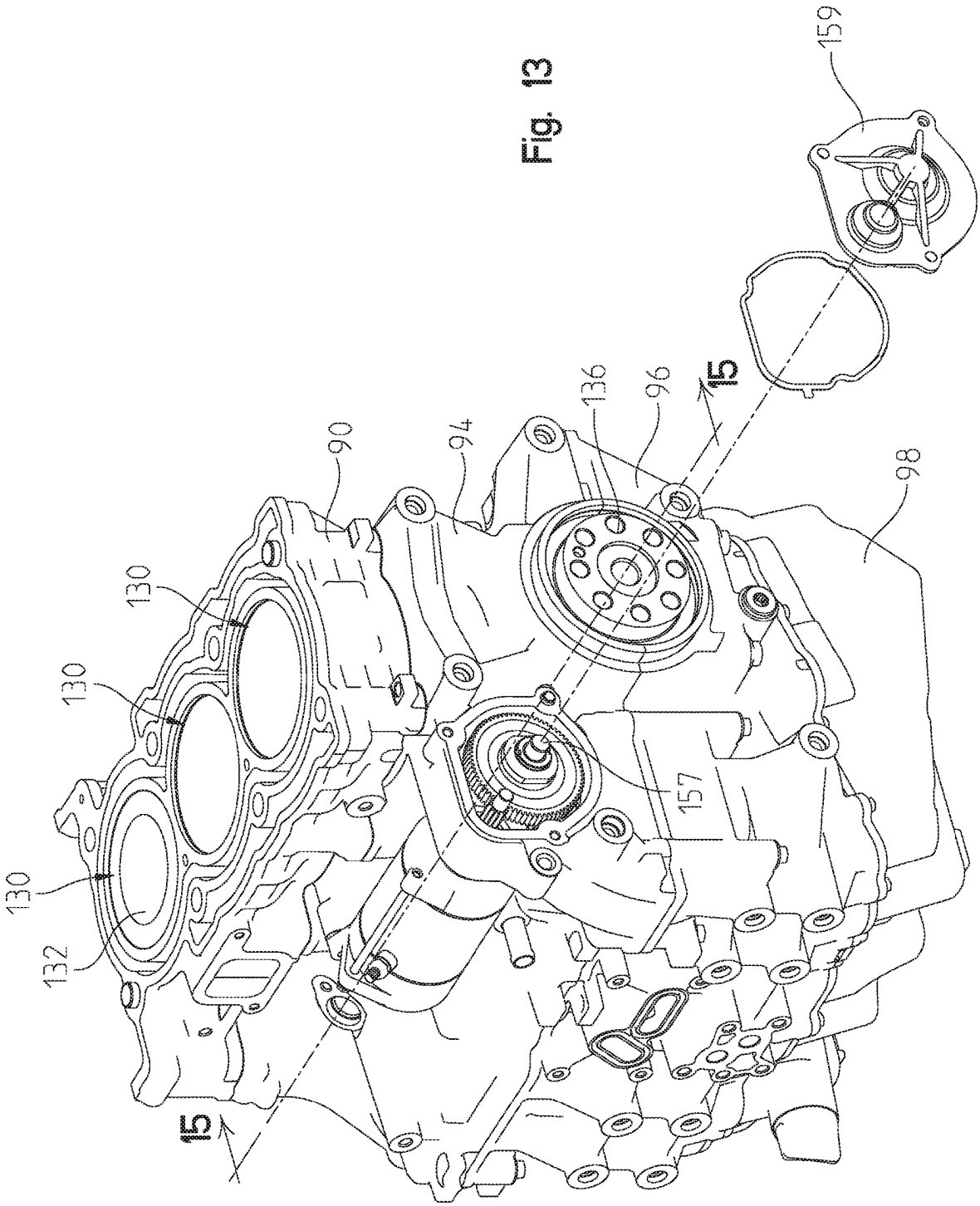
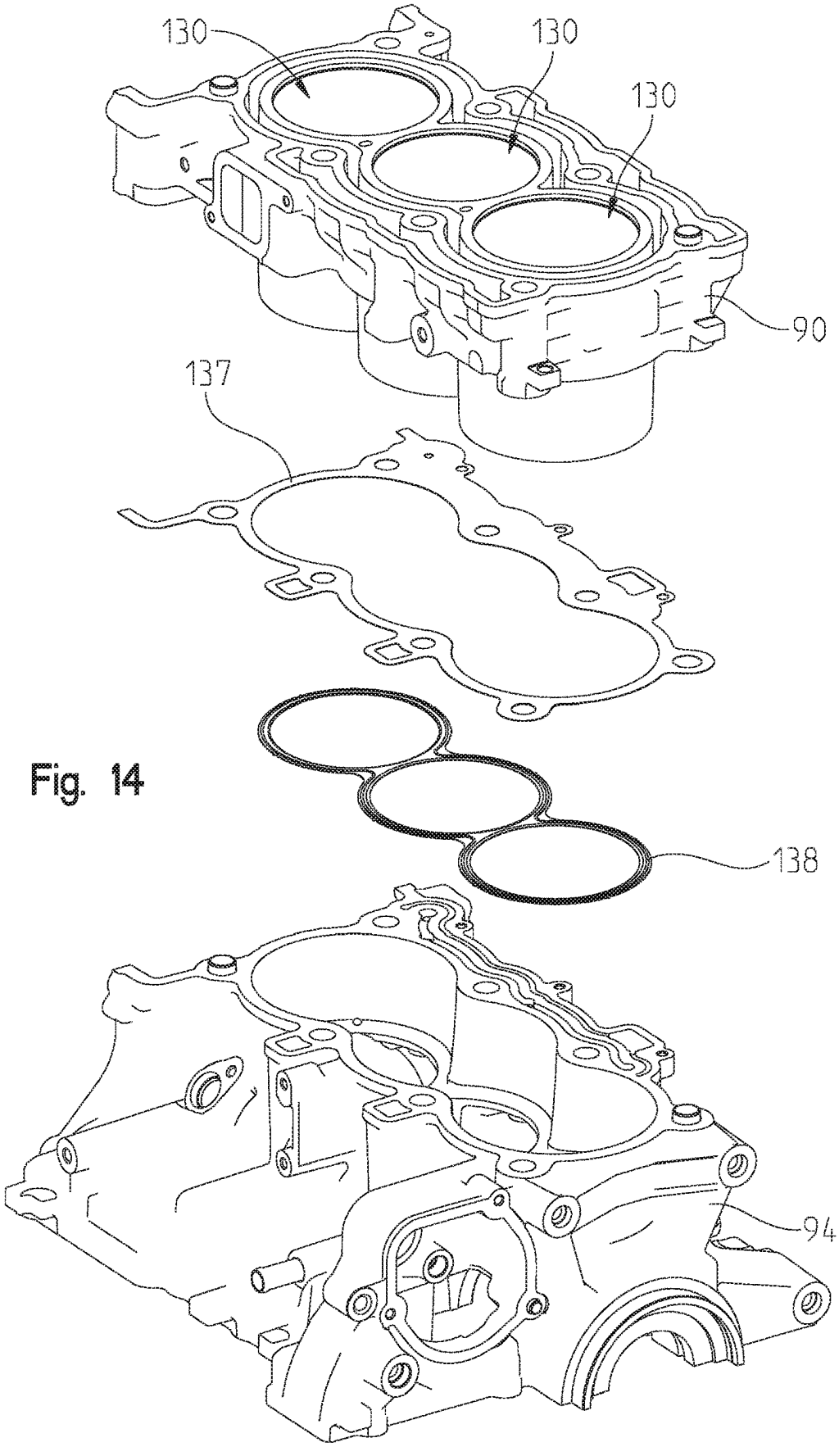


Fig. 12

Fig. 13





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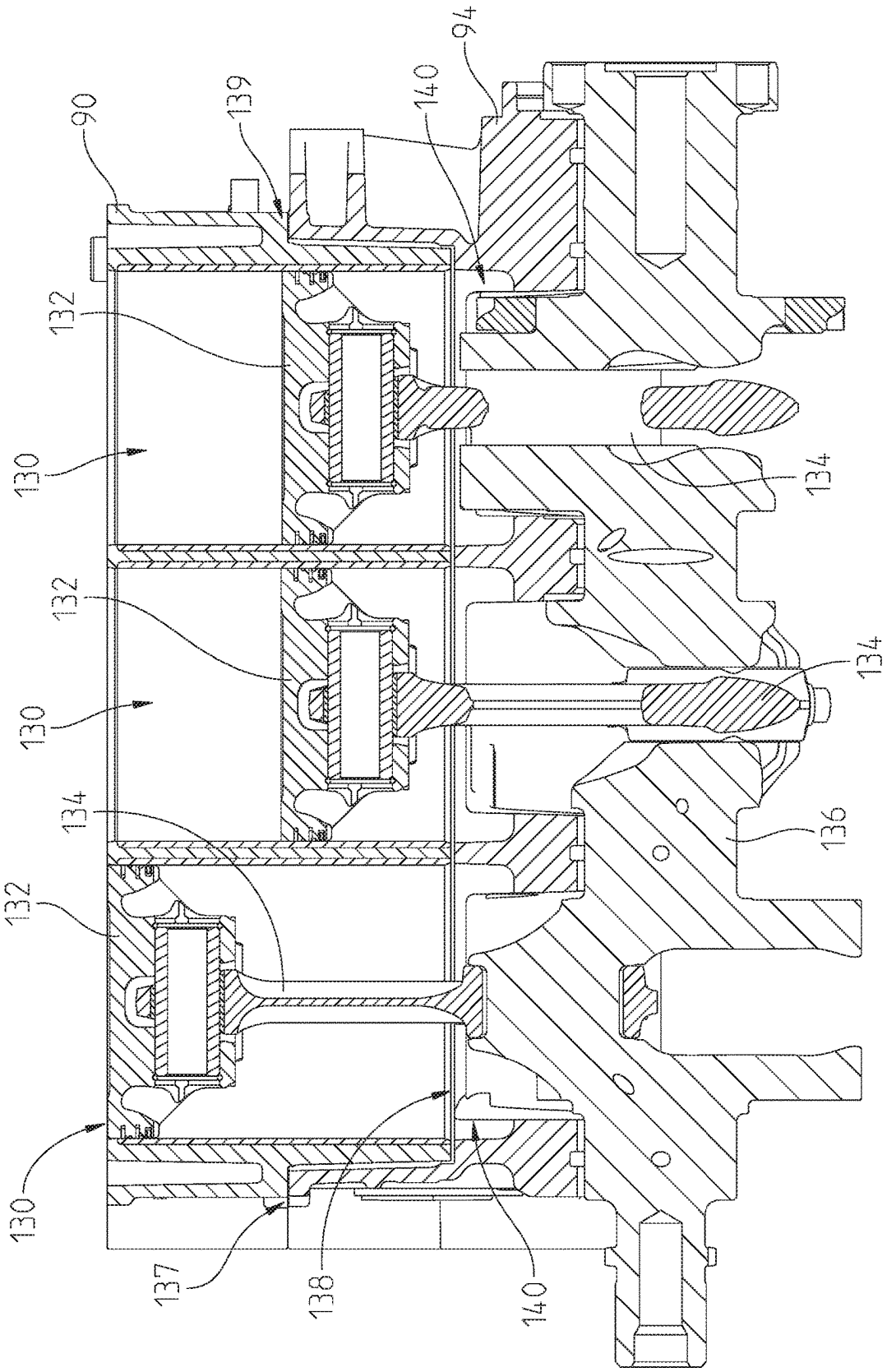

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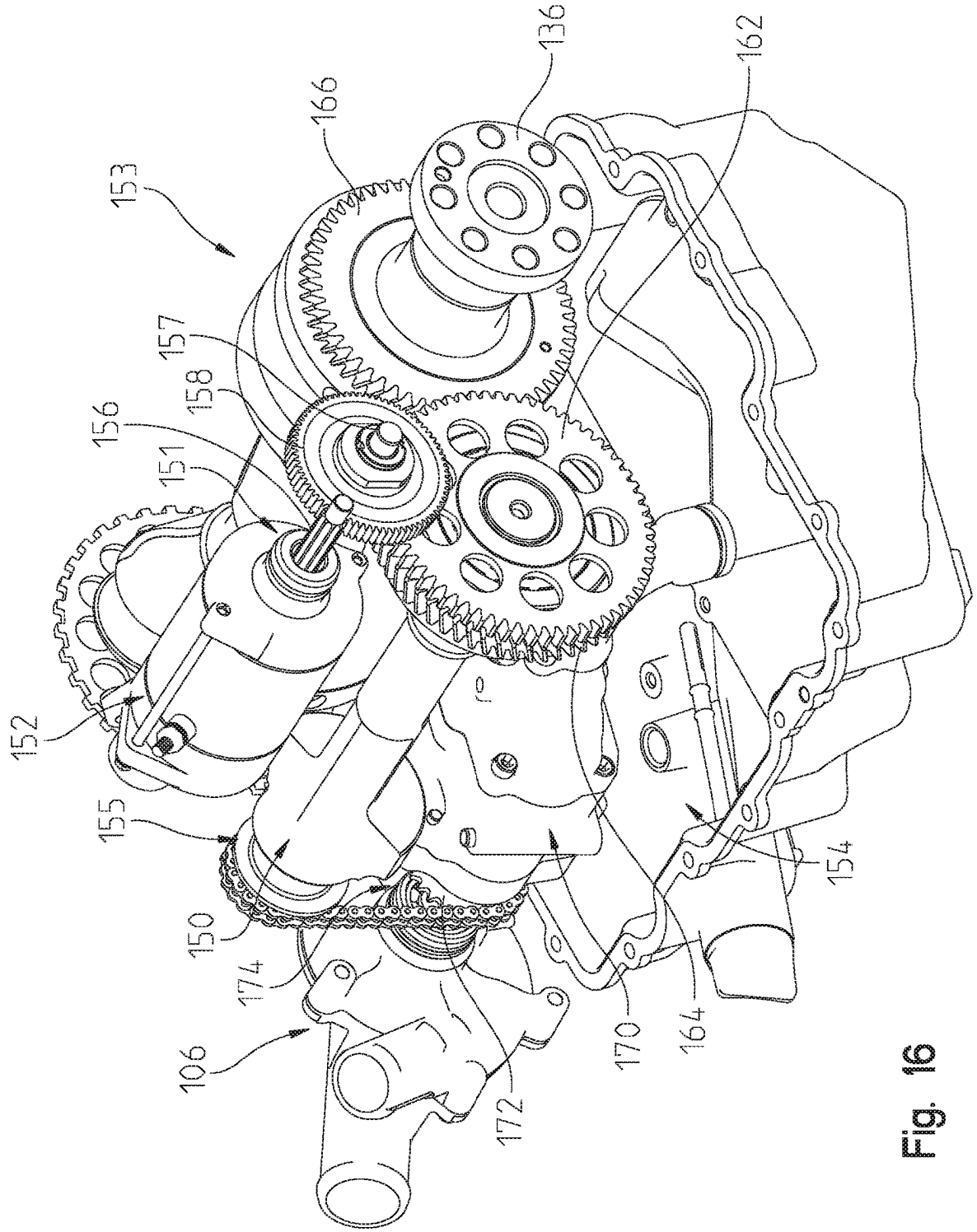
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164
154

Fig. 16

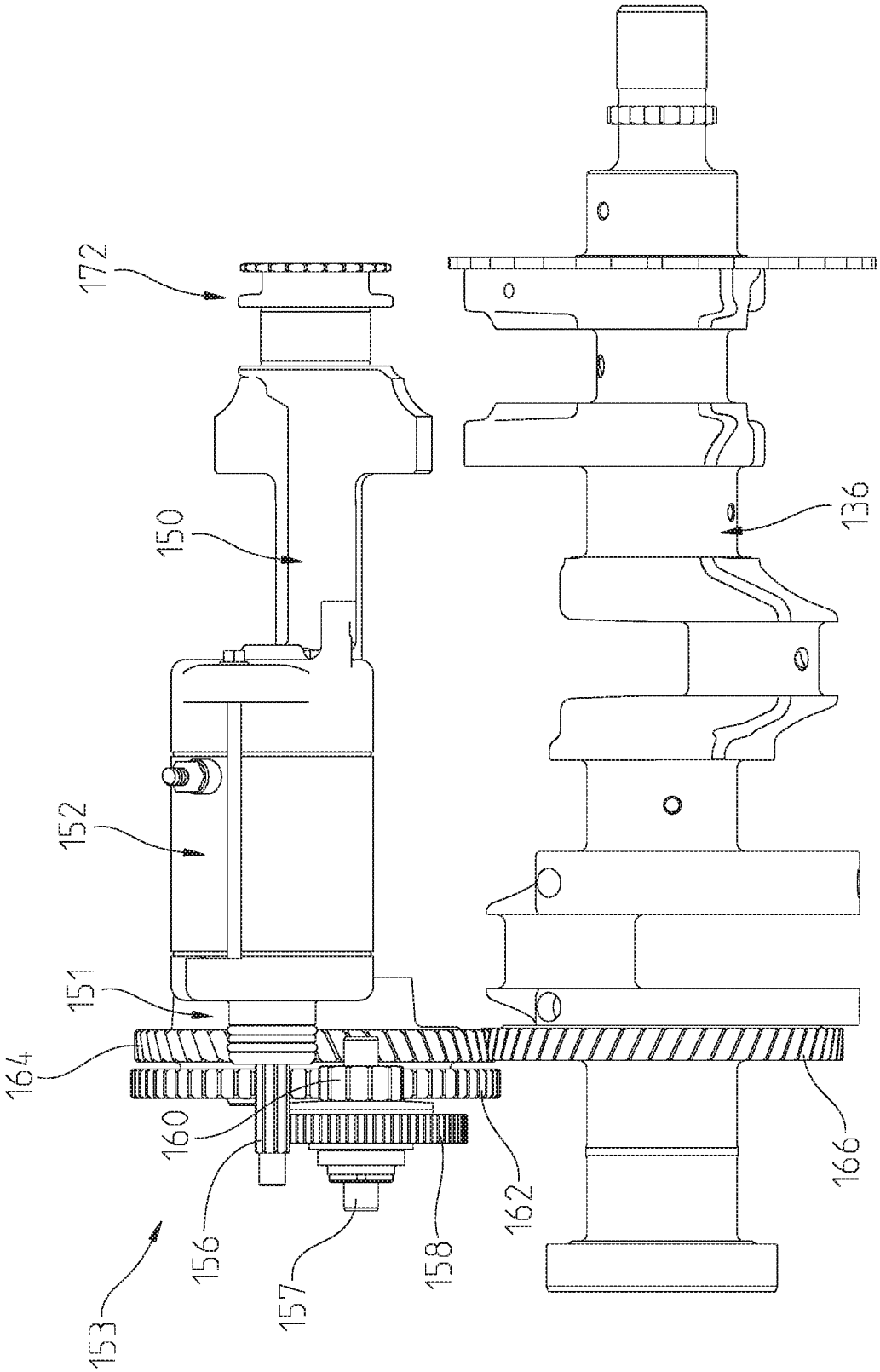
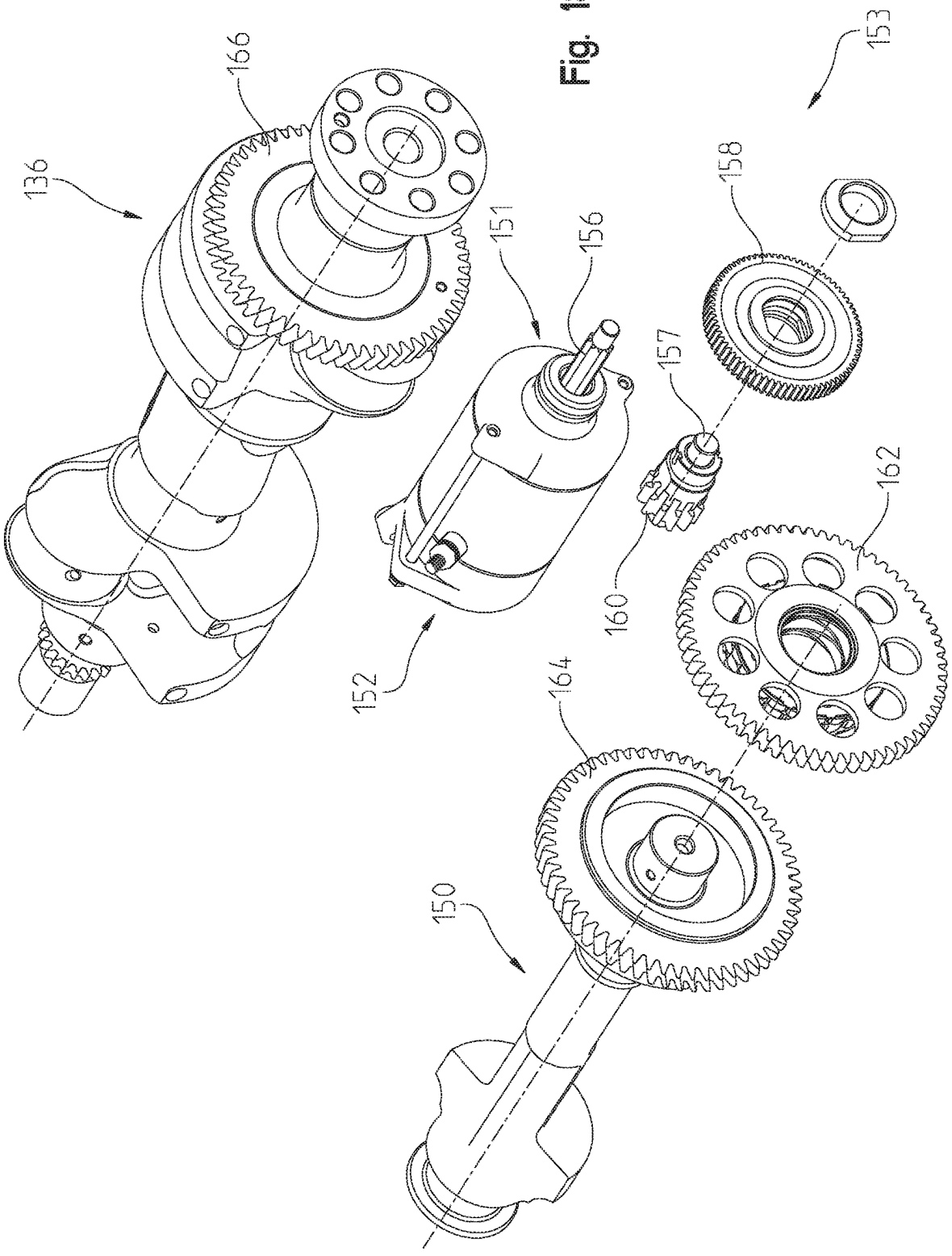


Fig. 17

Fig. 18



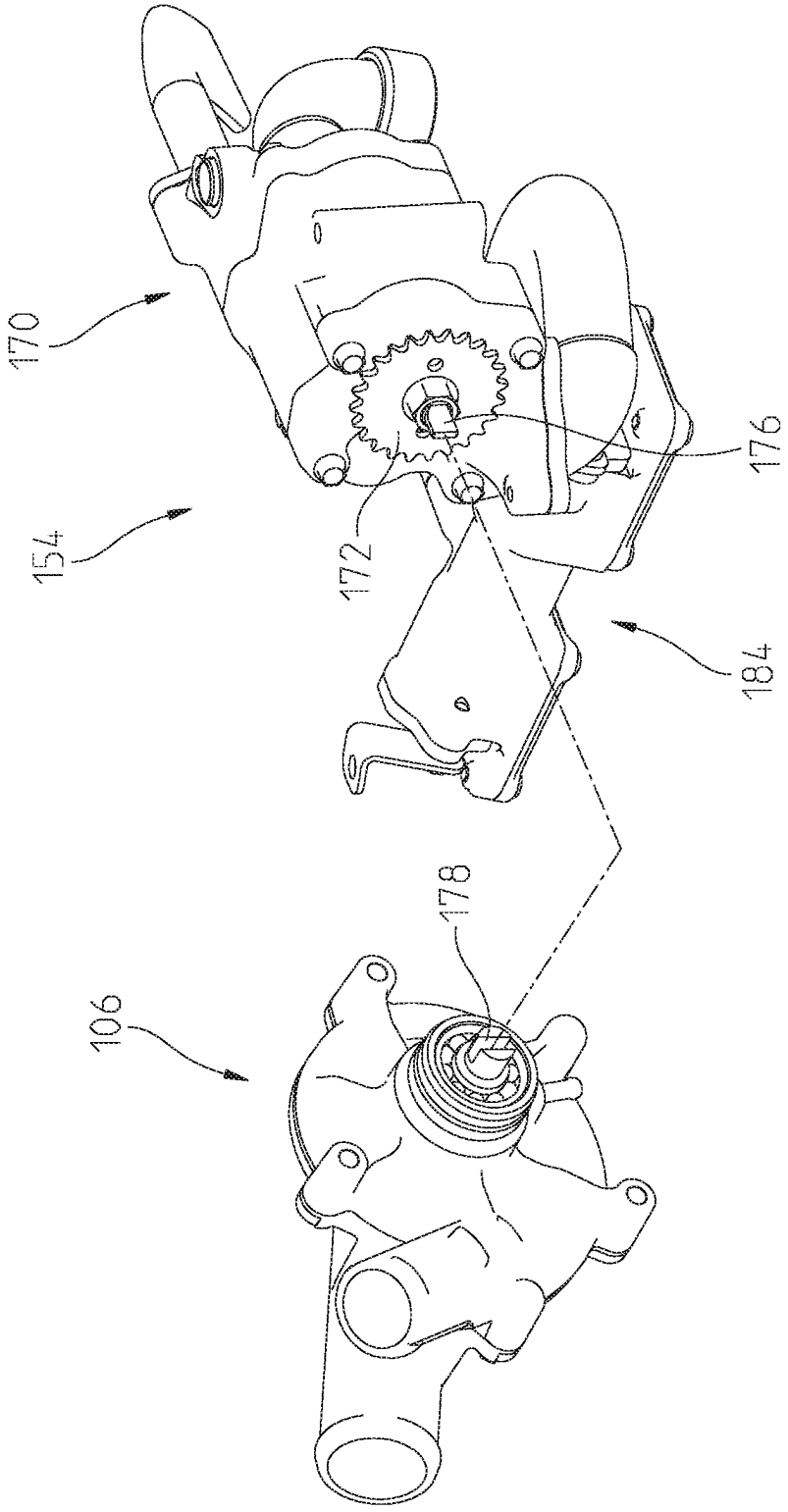


Fig. 19

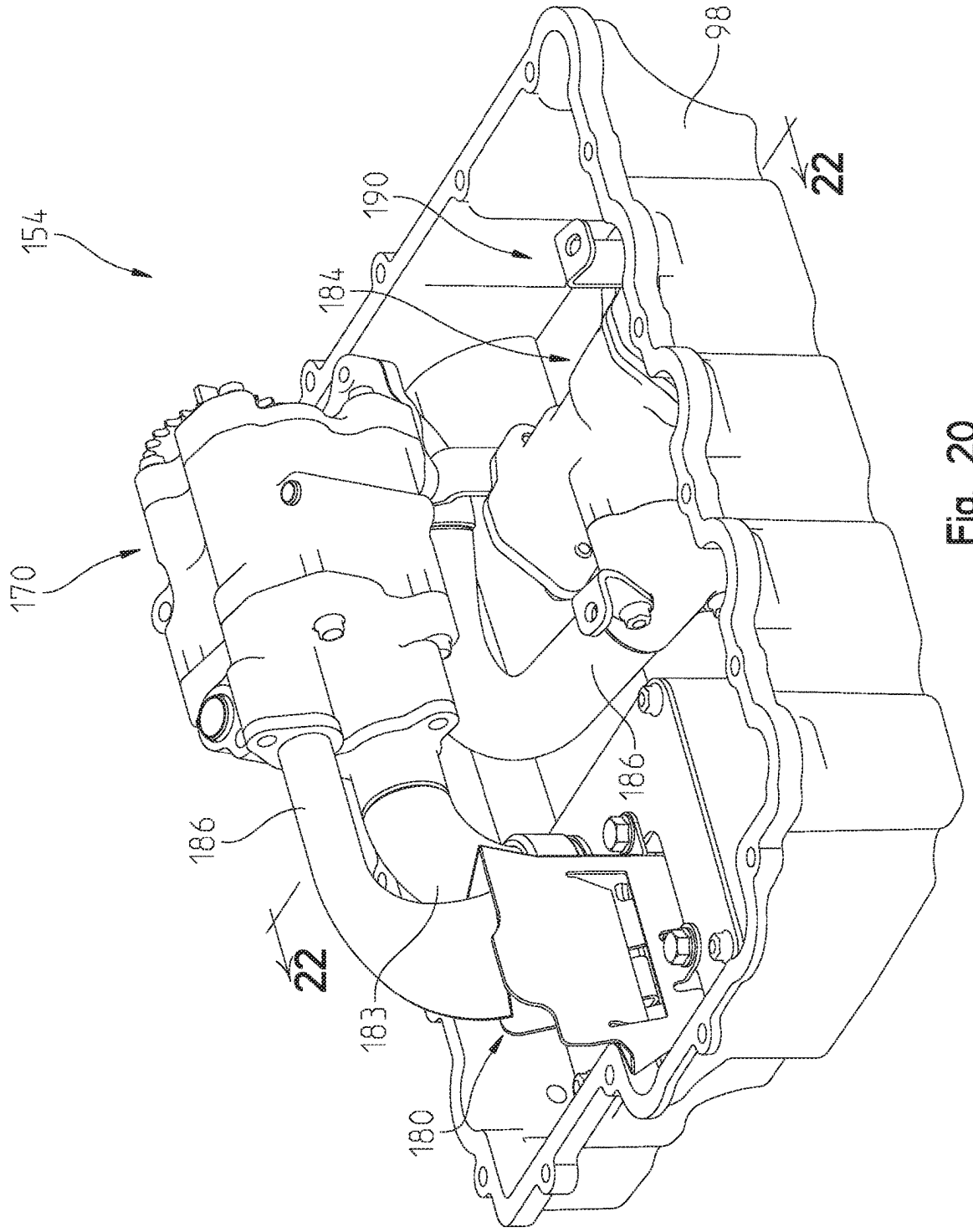


Fig. 20

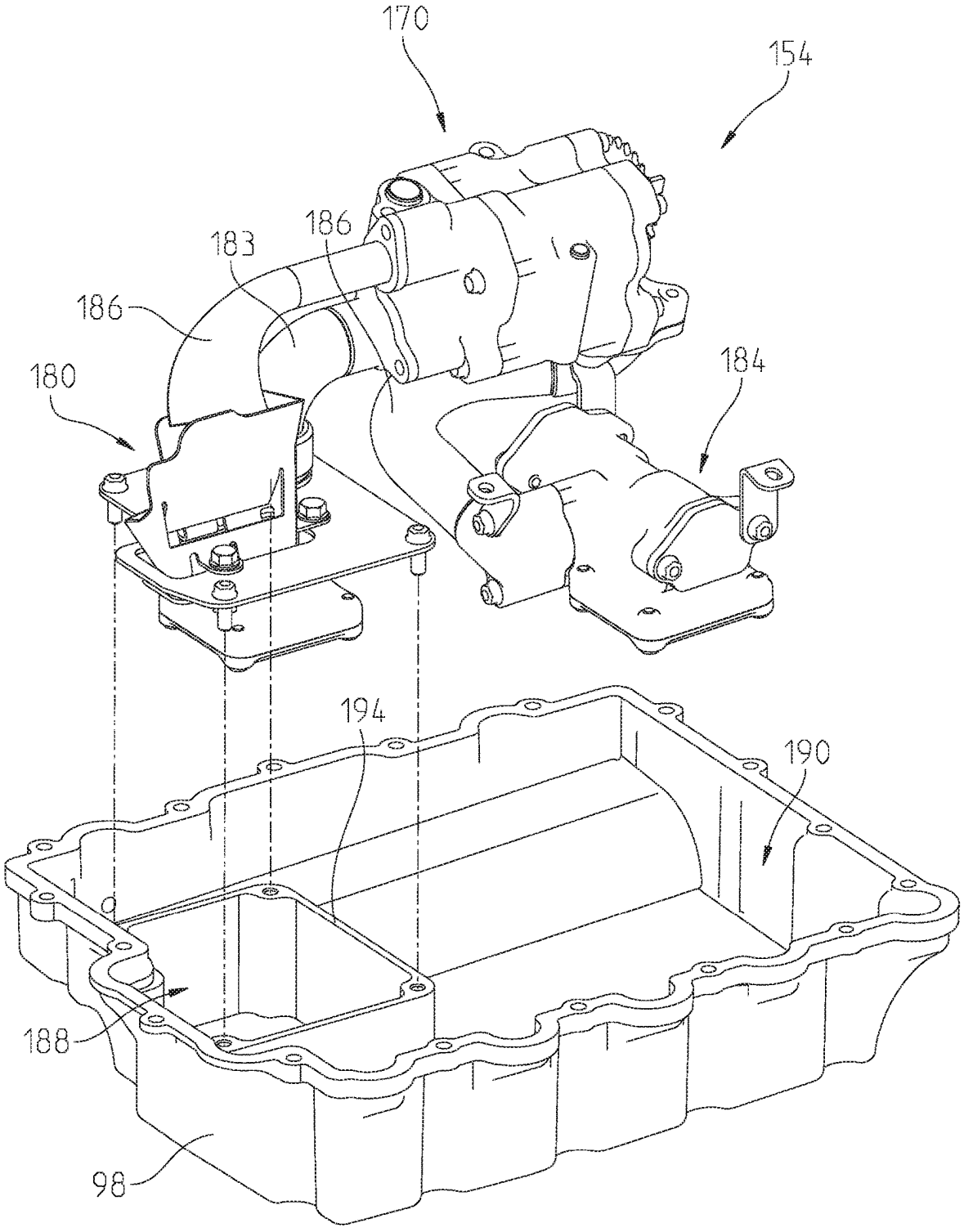


Fig. 21

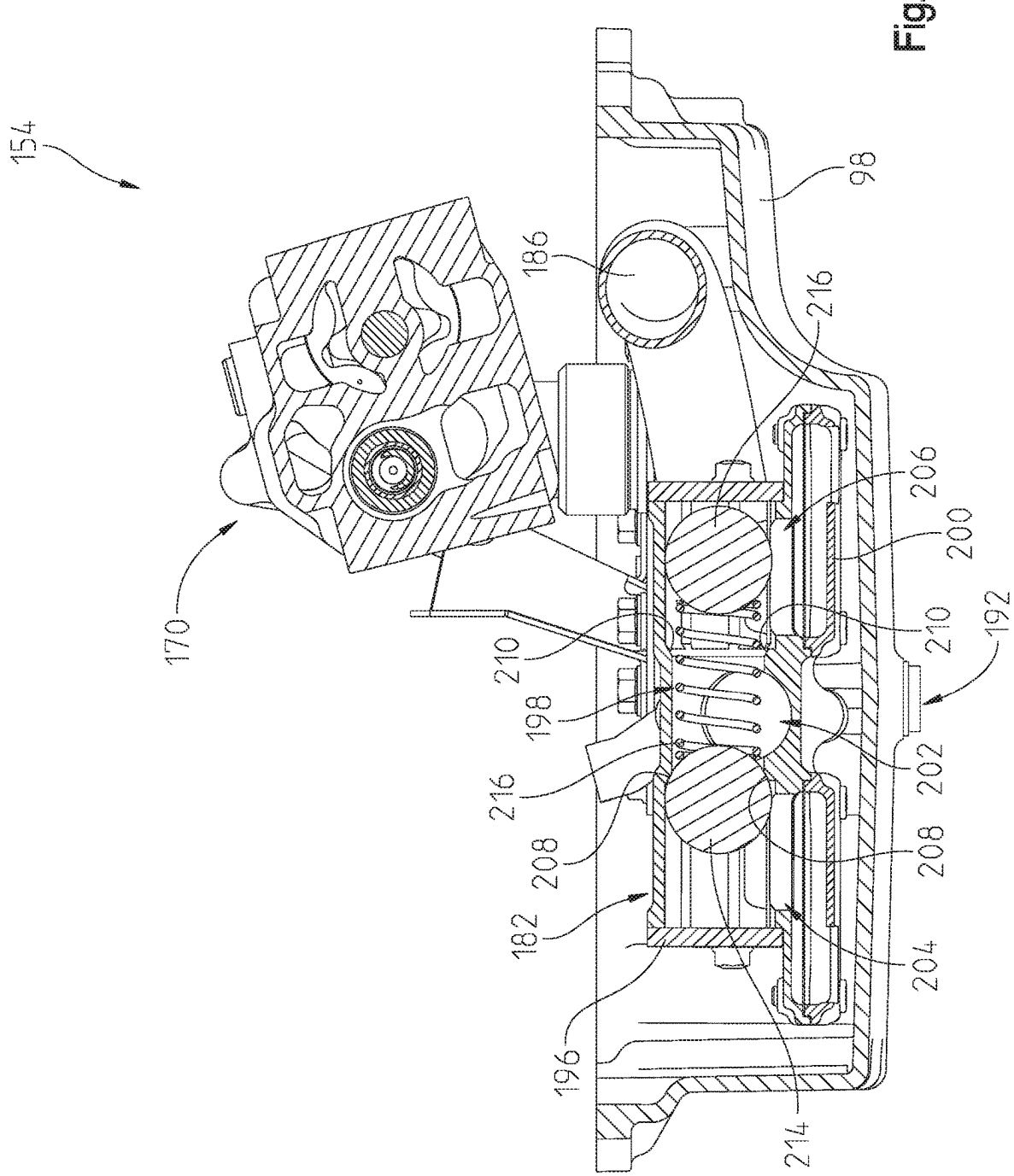

154
170
186
98
216
206
200
210
192
198
202
216
208
208
182
204
196
214

Fig. 22

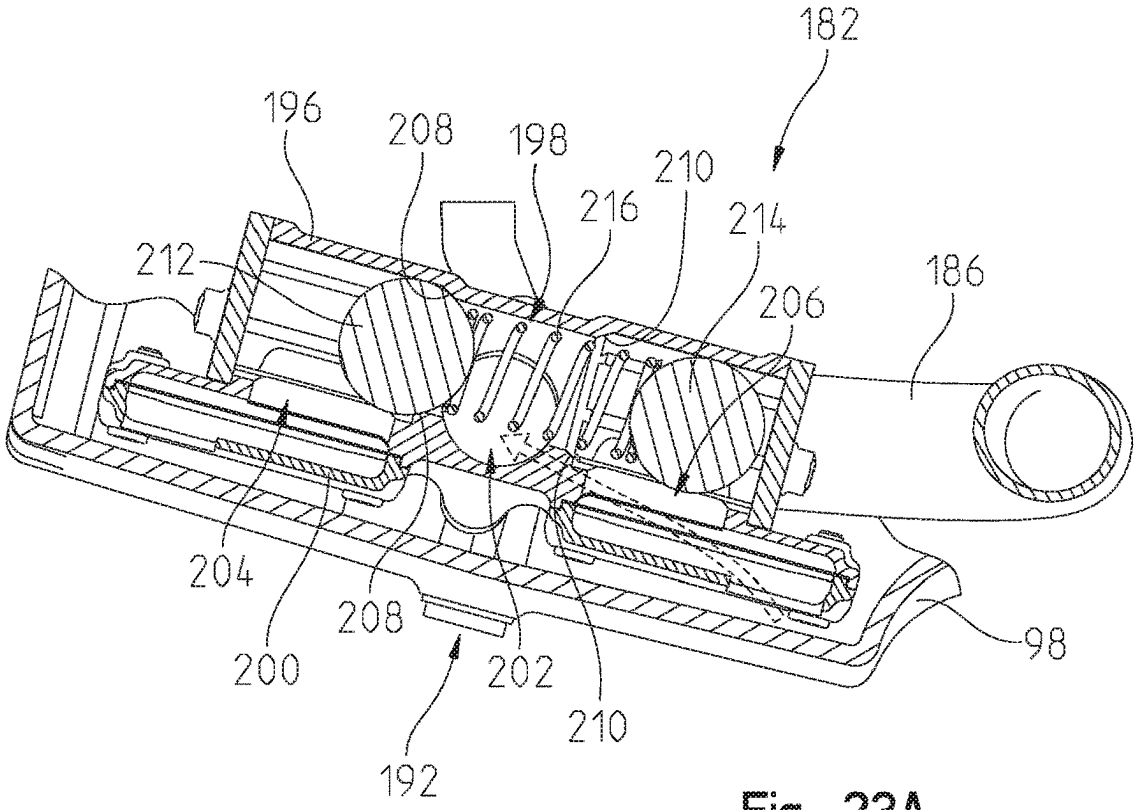


Fig. 23A

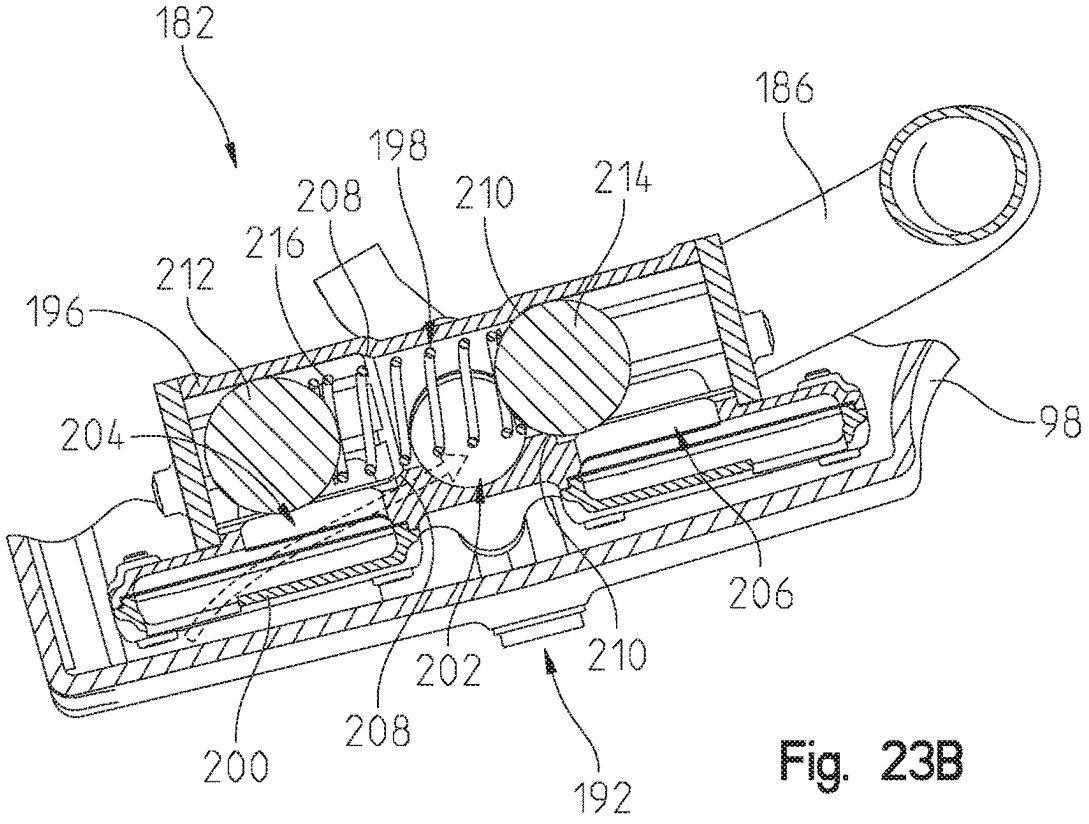


Fig. 23B

OFF-ROAD VEHICLE

CROSS-REFERENCE TO RELATED APPLICATION

The present application is a continuation of U.S. patent application Ser. No. 16/875,494, filed May 15, 2020, the enclosure of which is disclosed herein by reference.

FIELD OF THE INVENTION

The present invention relates to off-road vehicles including all-terrain vehicles ("ATVs") or utility vehicles ("UTVs").

BACKGROUND OF THE INVENTION

Generally, UTVs or ATVs are used to carry one or more passengers and a small amount of cargo over a variety of terrains. Current ATVs and UTVs are typically provided with engines having a unitary engine block housing a plurality of cylinders and a portion of a crankcase. However, for engine modularity purposes, a need exists for an engine in a UTV or ATV that has a cylinder block separate from but sealingly engaged with the portion of the crankcase.

SUMMARY OF THE INVENTION

In one embodiment of the disclosure, a utility vehicle comprises a frame, a body supported by the frame, a seating area supported by the frame, front and rear ground engaging members supporting the frame and the body, and a powertrain drivingly coupled to the front and rear ground engaging members. The powertrain includes an engine having a cylinder block having a plurality of cylinders, a cylinder head removably coupled to the cylinder block, and a crankcase having a first portion and a second portion. The first portion of the crankcase is removably coupled to the cylinder block, and at least one gasket is positioned between the cylinder block and the first portion of the crankcase. The at least one gasket is configured to individually seal each of the plurality of cylinders relative to the first portion of the crankcase.

In another embodiment of the disclosure, an engine for a utility vehicle comprises a cylinder block having a plurality of cylinders, a cylinder head removably coupled to the cylinder block, and a crankcase having a first portion and a second portion. The first portion of the crankcase is removably coupled to the cylinder block. Each of the plurality of cylinders is individually sealed with the first portion of the crankcase via at least one sealing member.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a front left perspective view of a vehicle of the present disclosure;

FIG. **2** shows a right rear perspective view of the vehicle of FIG. **1**;

FIG. **3** shows a left elevational side view of the vehicle of FIG. **1**;

FIG. **4** shows a right elevational side view of the vehicle of FIG. **1**;

FIG. **5** shows a top plan view of the vehicle of FIG. **1**;

FIG. **6** shows a front elevational view of the vehicle of FIG. **1**;

FIG. **7** shows a rear elevational view of the vehicle of FIG. **1**;

FIG. **8** shows a schematic view of a powertrain of the vehicle of FIG. **1**;

FIG. **9** shows a first perspective view of an engine of the vehicle of FIG. **1**;

FIG. **10** shows a second perspective view of the engine of FIG. **9**;

FIG. **11** shows a side plan view of a fuel injection assembly of the vehicle of FIG. **1** coupled to an air intake and an engine of a powertrain of the vehicle of FIG. **1**;

FIG. **12** shows a cross-sectional view of the fuel injection assembly, air intake, and engine of FIG. **11** taken along line **12-12** of FIG. **11**;

FIG. **13** shows a perspective view of the engine of FIG. **9** with a cam cover, a cylinder head, and a coolant assembly of the engine removed;

FIG. **14** shows an exploded view of a portion of the engine of FIG. **13**;

FIG. **15** shows a cross-sectional view of a portion of the engine of FIG. **13** taken along line **15-15** of FIG. **13**;

FIG. **16** shows a perspective view of a starter motor, a balance shaft, an oil pump, a water pump, a crankshaft and an oil pan of the engine of FIG. **9**;

FIG. **17** shows a side plan view of the starter motor, the balance shaft, and the crankshaft of FIG. **16**;

FIG. **18** shows an exploded view of the starter motor, the balance shaft, and the crankshaft of FIG. **17**;

FIG. **19** shows an exploded view of the water pump and the oil pump of FIG. **16**;

FIG. **20** shows a perspective view of a lubrication system of the engine of FIG. **9**;

FIG. **21** shows an exploded view of the lubrication system of FIG. **20**;

FIG. **22** shows a cross-sectional view of lubrication system of FIG. **20** taken along line **22-22** of FIG. **20**;

FIG. **23**A is a detailed cross-sectional view of a scavenge pump of the lubrication system of FIG. **22** when the vehicle of FIG. **1** is tilted in a first direction; and

FIG. **23**B shows a detailed cross-sectional view of the scavenge pump of the lubrication system of FIG. **22** when the vehicle of FIG. **1** is tilted in a second direction.

DETAILED DESCRIPTION OF THE DRAWINGS

With reference to FIGS. **1-7**, the vehicle of the present invention will be described. As shown, the vehicle is generally depicted as reference number **2** which includes front ground engaging members **4** and rear ground engaging members **6**. Front ground engaging members **4** are comprised of wheels **8** and tires **10**, and rear ground engaging members **6** are comprised of wheels **12** and tires **14**. Ground engaging members **4** and **6** support a vehicle frame, which is shown generally at **20**, through front and rear suspension assemblies **16** and **18**.

Vehicle frame **20** supports a seating area **22** comprised of a driver's seat **24** and a passenger seat **26**. Vehicle **2** further includes a steering assembly for steering front ground engaging members **4** whereby the steering assembly includes a steering wheel **28**. Frame **20** of vehicle **2** is comprised of a cab frame **30** that generally extends over the seating area **22**, and a lower frame portion **32** positioned below and supporting cab frame **30**. Frame **20** is configured to support a plurality of body panels **34** and/or doors **36**.

With reference now to FIG. **8**, vehicle **2** further includes a powertrain assembly **70** for providing power to ground engaging members **4** and **6** of vehicle **2**. Powertrain assembly **70** generally comprises an engine **72**, an air intake assembly **74** providing air to engine **72**, an exhaust assembly

76 routing exhaust from engine 72 out of vehicle 2, a transmission 78 coupled to engine 72, and a drivetrain (not shown) coupled to transmission 78. Additional details relating to vehicle 2 including powertrain 70 may be found in U.S. patent application Ser. No. 16/875,448 (now U.S. Pat. No.12,187,127) the subject matter of which is incorporated herein by reference.

Still referring to FIG. 8, in various embodiments, powertrain assembly 70 may further include a starter clutch 80 removably coupled between engine 72 and transmission 78 to allow a starter motor, which may be in constant meshed engagement with starter clutch 80, to crank or start engine 72. Starter clutch 80 is generally sealingly coupled to engine 72 such that starter clutch 80 may receive lubricant from engine 72. Decoupling starter clutch 80 from engine 72 and transmission 78 allows for a more modular engine in that various components of powertrain assembly 70 may be used in different embodiments and orientations due to ability to couple and decouple components from each other, depending on the application on vehicle 2 and the requirements of powertrain assembly 70. Furthermore, in various embodiments, powertrain assembly 70 may include a turbocharger 82 at least fluidly coupled with exhaust assembly 76.

Referring now to FIGS. 9-15, engine 72 of powertrain assembly 70 generally includes a cylinder block 90, a cylinder head which includes an intake port 92 and is coupled to cylinder block 90, a first crankcase portion 94 coupled to cylinder block 90, a second crankcase portion 96 coupled to first crankcase portion 94, an oil pan 98 coupled to second crankcase portion 96, a valve or cam cover 100 depending on the location of valves and cams within engine 72 coupled over intake port 92, and a coolant assembly 102. Coolant assembly 102 may be configured to extend along a side of engine 72 from intake port 92 to second crankcase portion 94. In various embodiments, intake port 92 is positioned above cylinder block 90 and cylinder block 90 itself is positioned above first crankcase portion 94. First crankcase portion 94 is positioned above second crankcase portion 96 and second crankcase portion 96 is positioned above oil pan 98.

With reference to FIGS. 9 and 10, coolant assembly 102 generally includes a coolant manifold 104, a water pump 106 (FIG. 10), a water pump inlet conduit 108 coupling coolant manifold 104 to water pump 106, a water pump outlet conduit 110 (FIG. 10) coupling water pump 106 to engine 72, an oil cooler 112, an oil cooler outlet conduit 114 coupling oil cooler 112 to coolant manifold 104, and an oil cooler inlet conduit 116 coupling engine 72 to oil cooler 112. Coolant manifold 104 generally includes a first inlet 120 configured to receive coolant from a radiator (not shown), a first outlet 122 configured to provide heated coolant to the radiator, a second inlet 124 configured to receive heated coolant from oil cooler 112, a second outlet 126 configured to provide coolant to water pump 106, and a bleed outlet 128. In various embodiments, a thermostat (not shown) may be controlled with return, heated coolant from the radiator.

Referring now to FIGS. 11 and 12, powertrain assembly 70 further includes a fuel injection assembly 120. Fuel injection assembly 120 generally includes a fuel rail 122 and at least one fuel injector 124. In general, fuel injector assembly 120 includes one fuel injector 124 for each cylinder 130 (FIG. 13) of engine 72. Fuel injector(s) 124 are positioned along intake assembly 74 to direct a fuel stream 126 downward such that fuel stream 126 contacts an opposing interior wall 128 of intake assembly 74 and bounces at an angle α into intake port 92. More particularly, opposing interior wall 128 is generally opposite the location of fuel injector 124 such that fuel injector 124 is positioned at one portion of an intake manifold 75 of intake assembly 74 and opposing interior wall 128 is positioned approximately 180° from the location of fuel injector 124. In various embodiments, angle α may be between 30 degrees and 70 degrees. In the illustrative embodiment, angle α is approximately 45 degrees. By hitting wall 128 substantially straight on such that fuel stream 126 defines a linear stream that first contacts wall 128 before contacting any other portion of intake manifold 75, fuel stream 126 hits wall 128 and increases the atomization of fuel stream 126. Fuel stream 126 atomizes better since the entire fuel stream 126 hits wall 128 ensuring full stream 126 atomizes rather than only a portion of fuel stream 126. In general, fuel injector assembly 120 is positioned below a top of engine 72 for protection.

With reference now to FIGS. 13-15, engine 72 generally includes a plurality of cylinders 130, illustratively three but any number of cylinders 130 may be provided, a piston 132 positioned within each cylinder 130, and a connecting rod 134 coupling each piston 132 to a crankshaft 136. Cylinders 130 are generally positioned within cylinder block 90 which is sealingly coupled to and positioned above first crankcase portion 94 with a gasket 138. In various embodiments, gasket 138 is configured such that each cylinder 130 is individually sealed with first crankcase portion 94 at a lowermost end of cylinder block 90. In various embodiments, cylinder block 90 may be sealingly coupled above first crankcase portion 94 with an additional gasket 137 positioned above gasket 138 and between an uppermost end of first crankcase portion 94 and a lip 139 of cylinder block 90. In this way, each cylinder 130 is sealed from each other such that fluid does not flow between cylinders 130.

Crankshaft 136 is generally positioned within first and second crankcase portions 94 and 96, and connecting rods 134 reciprocate within crank bays 140 within first and second crankcase portions 94 and 96 and cylinders 130. Gasket 138 seals individual crank bays 140 to prevent windage created by the reciprocation of connecting rods 134 within crank bays 140 from passing between crank bays 140.

Referring now to FIGS. 16-19, engine 72 may further include a balance shaft 150 and a starter motor 152 for cranking or starting engine 72. In various embodiments, starter motor 152 and balance shaft 150 are coupled to crankshaft 136 such that crankshaft 136 is started by balance shaft 150. For example, and as shown in FIGS. 16-19, crankshaft 136 may be started by balance shaft 150 via a gear assembly 153. Gear assembly 153 generally includes a starter gear 156 coupled to a first end 151 of starter motor 152 which is meshed with a first transfer gear 158 coupled to a shaft 157, which extends between first crankcase portion 94 and a cover 159 (FIG. 13) coupled to first crankcase portion 94. First transfer gear 158 in turn is fixedly coupled to a second transfer gear 160 (FIGS. 18 and 19) which may also be coupled to shaft 157 and positioned between first crankcase portion 94 and cover 159. In this way, gears 158, 160 may rotate together on shaft 157 such that when starter motor 152 drives gear 158, gear 160 drives rotation of a gear 162, as disclosed further herein. In various embodiments, first transfer gear 150 is a torque limiting gear that limits any backfire torque engine 72 sees. Second transfer gear 160 in turn is meshed with an outer gear 162 of balance shaft 150 which is coupled to an inner gear 164 of balance shaft 150 via a one-way or sprag clutch such that outer gear 162 is fixedly coupled to inner gear 164 in a first direction and rotatably coupled to inner gear 164 in a second direction. Inner gear 164 of balance shaft 150, which is fixedly coupled to balance shaft 150, in turn is meshed with a gear 166 of

crankshaft **136**. In this way, crankshaft **136** may be started by balance shaft **150** via gear assembly **153**.

With reference to FIGS. **16** and **19**, engine **72** generally further includes a lubrication assembly **154** coupled to balance shaft **150** such that balance shaft **150** drives an oil pump **170** of lubrication assembly **154**. For example, and as shown in FIG. **16**, a second end **155** of balance shaft **150** may be coupled to a gear **172** of oil pump **170** via a chain **174** such that rotation of balance shaft **150** drives oil pump **170**. In various embodiments, oil pump **170** is coupled directly to water pump **106** such that rotation of gear **172** of oil pump **170** drives water pump **106**. For example, and as shown in FIG. **19**, oil pump **170** may include a protrusion or key **176** fixedly coupled to gear **172** which is received within an indentation or opening **178** in water pump **106** such that rotation of protrusion **176** is transferred to water pump **106** through indentation **178**.

Referring to FIGS. **19-23**B, lubrication system **154** generally further includes a pressure pick-up **180** fluidly coupled to oil pump **170** via a transfer conduit **182**, and a scavenge pump **184** fluidly coupled to oil pump **170** via a pickup conduit **186**, where pressure pick-up **180** and scavenge pump **184** are positioned within oil pan **98**. Oil pan **98** generally includes a pressure pick-up volume **188** (FIG. **21**) within which pressure pick-up **180** is positioned and into which oil from oil pump **170** may be released through oil pump outlet conduit **183**, a scavenge pump volume **190** within which scavenge pump **184** is positioned, and an outlet **192** through which oil within oil pan **98** may be drained. In various embodiments, outlet **192** may be positioned such that oil from pressure pick-up volume **188** and scavenge pump volume **190** may be drained simultaneously. For example, outlet **192** may be positioned below a wall **194** of pressure pick-up volume **188** such that a portion of outlet **192** is in fluid communication with pressure pick-up volume **188** and a portion of outlet **192** is in fluid communication with scavenge pump volume **190**.

Referring to FIGS. **22**, **23**A, and **23**B, in various embodiments, scavenge pump **184** is a shuttle valve scavenge pump **184**. Shuttle valve scavenge pump **184** generally includes a housing **196**, a shuttle valve assembly **198** positioned with housing **196**, and a strainer assembly **200** coupled to housing **196**. Housing **196** includes an outlet **202** fluidly coupled to oil pump **170** via pick up conduit **186**, a first inlet **204** fluidly coupled to strainer assembly **200**, a second inlet **206** fluidly coupled to strainer assembly **200**, a first shoulder **208**, and a second shoulder **210**. Shuttle valve assembly **198** generally includes at least one ball **212** and/or **214** positioned within housing **196**. In various embodiments, and as shown in the illustrative embodiments, shuttle valve assembly **198** may include a first ball **212**, a second ball **214**, and a spring **216** positioned between first ball **212** and second ball **214**. Strainer assembly **200** generally includes a first inlet **215** in fluid communication with first inlet **204** of housing **196** and a second inlet **217** in fluid communication with second inlet **206** of housing **196**.

Shuttle valve assembly **198** is configured to shift within housing **196** such that when vehicle **2** is tilted in a first direction (e.g., to one side), gravity causes the at least one ball **212** and/or **214** to prevent first inlet **215** of strainer assembly **200** and first inlet **204** of housing **196** from fluidly communicating with outlet **202** and/or oil pump **170** such that oil is received through second inlet **206** of housing **196** and second inlet **217** of strainer assembly **200**. Additionally, when vehicle **2** is tilted in a second direction opposite to the first direction (e.g., to the other side), gravity causes the at least one ball **212** and/or **214** to prevent second inlet **206** of housing **196** and second inlet **217** of strainer assembly **200** from fluidly communication with outlet **202** and/or oil pump **170** such that oil is received through first inlet **215** of strainer assembly **200** and first inlet **204** of housing **196**. With reference to the illustrative embodiments, when vehicle **2** is tilted in the first direction, gravity causes first ball **212** to abut first shoulder **208** such that first inlet **204** of housing **196** and first inlet **215** of strainer assembly **200** are no longer in fluid communication with outlet **202** and oil pump **170** and oil is received through second inlet **206** of housing **196** and second inlet **217** of strainer assembly **200** (FIG. **23**A), while when vehicle **2** is tilted in the second direction opposite to the first direction, gravity causes second ball **214** to abut second shoulder **210** such that second inlet **206** of housing **196** and second inlet **217** of strainer assembly **200** are no longer in fluid communication with outlet **170** and oil pump **170** and oil is received through first inlet **204** of housing **196** and first inlet **215** of strainer assembly **200** (FIG. **23**B). When vehicle **2** is not tilted in either direction, the at least one ball, illustratively first ball **212** and second ball **214**, may be spaced apart from first and second shoulders **208** and **210** such that oil may be received through both first and second inlets **204** and **206** of housing **196** and first and second inlets **215** and **217** of strainer assembly **200** simultaneously. However, spring **216** prevents first ball **212** and second ball **214** from being simultaneously engaged with first and second shoulder **208** and **210**, respectively, such that oil is being received through one of inlets **204** and **215** or inlets **206** and **217** at any given time. As such, shuttle valve assembly **198** prevents air from being received within scavenge pump **184** when vehicle **2** is tilted.

While this invention has been described as having an exemplary design, the present invention may be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the invention using its general principles. Further, this application is intended to cover such departures from the present disclosure as come within known or customary practice in the art to which this invention pertains.

The invention claimed is:

1. A vehicle, comprising:

a plurality of ground engaging members;

a frame supported by the plurality of ground engaging members;

an engine supported by the frame, the engine operably coupled to at least one ground engaging member of the plurality of ground engaging members, the engine includes:

an oil pan; and

a lubrication system positioned within the oil pan, the lubrication system includes:

an oil pump;

a housing statically positioned in the oil pan;

a shuttle valve having first and second movable shuttles positioned within the housing, wherein the first and second movable shuttles are configured to move interconnectedly relative to the housing according to vehicle tilting; and

a conduit coupled between the oil pump and the housing.

2. The vehicle of claim **1**, wherein the first movable shuttle is coupled with the second movable shuttle.

3. The vehicle of claim **2**, wherein the housing comprises a first inlet and a second inlet.

4. The vehicle of claim **3**, wherein when the engine is positioned in a first titled orientation, the first movable

shuttle is configured to close the first inlet, and when the engine is positioned in a second titled orientation, the second movable shuttle is configured to close the second inlet.

5. The vehicle of claim **4**, wherein the first movable shuttle is a first ball and the second movable shuttle is a second ball.

6. The vehicle of claim **5**, wherein a spring is positioned between the first ball and the second ball.

7. An engine, comprising:

a cylinder head;

a crankcase coupled to the cylinder head;

a crankshaft positioned within the crankcase;

an oil pan coupled to the crankcase; and

a lubrication system includes:

an oil pump positioned within the oil pan, the oil pump operably coupled to the crankcase;

a shuttle valve scavenge pump fluidly coupled with the oil pan, the shuttle valve scavenge pump including:

a housing having a first inlet and a second inlet,

a strainer coupled to the housing,

a first movable shuttle positioned within the housing and a second movable shuttle positioned within the housing, each of the first and second movable shuttles are interconnected and interdependently movable relative to the housing;

a conduit coupled between the oil pump and the housing; and

wherein the oil pan includes a first tilted configuration and a second tilted configuration:

in the first tilted configuration the second movable shuttle is moved within the housing to open the second inlet to the conduit and the first movable shuttle is moved within the housing to close the first inlet to the conduit according to tilting of the oil pan in a first direction; and

in the second tilted configuration the first movable shuttle is moved within the housing to open the first inlet to the conduit and the second movable shuttle is moved within the housing to close the second inlet to the conduit according to tilting of the oil pan in a second direction.

8. The engine of claim **7**, wherein the strainer includes a first strainer inlet fluidly coupled to the first inlet and a second strainer inlet fluidly coupled to the second inlet.

9. The engine of claim **8**, wherein the strainer is positioned vertically lower than the housing.

10. The engine of claim **7**, wherein when the engine is in a first orientation, the first movable shuttle is configured to close the first inlet, and when the engine is in a second orientation, the second movable shuttle is configured to close the second inlet.

11. The engine of claim **10**, wherein the first orientation is angled relative to a ground level and the second orientation is angled relative to the second orientation.

12. The engine of claim **11**, wherein in a third orientation, each of the first movable shuttle and second movable shuttle are separated from each other to allow access to each of the first inlet and the second inlet.

13. The engine of claim **12**, wherein the third orientation is generally parallel to the ground level.

14. The engine of claim **7**, wherein the housing includes:

a first shoulder;

a second shoulder, the first and second shoulders between the first and second movable shuttles; wherein

in the first tilted configuration the second movable shuttle is spaced from the second shoulder and the first movable shuttle is seated against the first shoulder; and

in the second tilted configuration the first movable shuttle is spaced from the first shoulder and the second movable shuttle is seated against the second shoulder.

15. The engine of claim **7**, wherein the housing of the shuttle valve scavenge pump is static relative to the oil pan.

* * * * *