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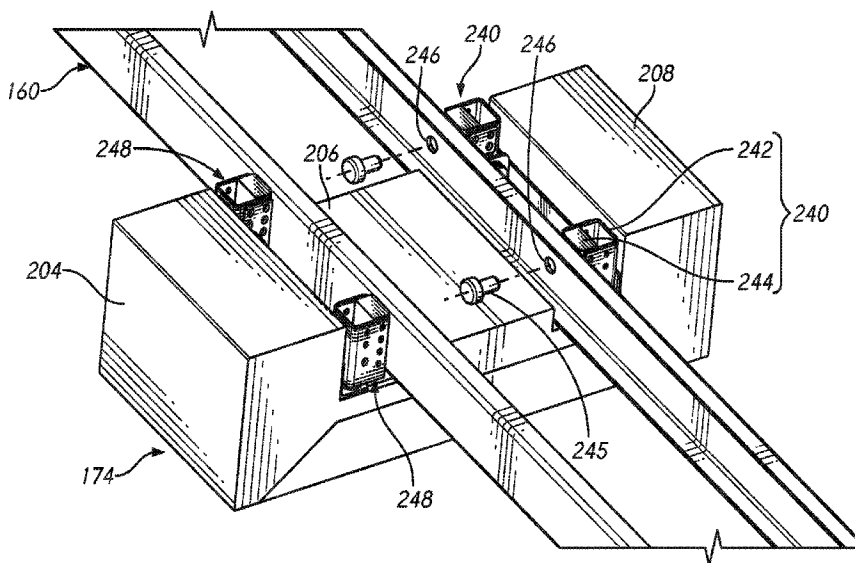
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(57) Abrégé/Abstract:

The present disclosure relates to a battery system for a hybrid or an electric vehicle. Another aspect of the present disclosure provides a battery assembly designed for easy and quick exchange of battery assemblies enabling a vehicle to resume driving much more quickly than traditional charging permits.



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## BATTERY SYSTEM FOR HEAVY DUTY VEHICLES

### BACKGROUND

#### Field

[0001] The present disclosure relates to battery systems for heavy-duty vehicles and a method for equipping heavy-duty vehicles with such systems.

#### Related Art

[0002] The use of alternative fuels for vehicles is becoming more prevalent. Natural gas powered automobiles produce less harmful emissions than do automobiles powered by traditional fossil fuels. A growing trend is the use of electrical motors for propulsion.

[0003] Electric drive systems have become ubiquitous for small passenger vehicles. However, long wait time to charge batteries is an obstacle to wider adoption of electric drive systems.

### SUMMARY

[0004] An aspect of the present invention provides a battery system for a hybrid or an electric vehicle. Another aspect of the present invention provides a battery assembly designed for easy and quick exchange of battery assemblies enabling a vehicle to resume driving much more quickly than traditional charging permits.

[0005] In one embodiment a battery assembly is provided for an electric vehicle. The battery assembly has a housing, one or more battery units and a mounting system. The housing has a first lateral portion, a second lateral portion, and a central portion. The housing forms an upwardly oriented recess between the first and second lateral portions. The mounting system can be disposed at least partially between the first lateral portion and the second lateral portion. A frame member of a vehicle can be disposed between first and second lateral portions. When so disposed, the frame member can be coupled to the mounting system between first and second lateral portions above the central portion.

[0006] In one embodiment, the one or more battery units is or are disposed within the housing at least in the central portion.

[0007] In some variations, at least a portion of the one or more battery units is disposed in the first lateral portion. In some variations, at least a portion of the one or more battery units is disposed in the second lateral portion. In some variations, at least a portion of the one or more battery units is disposed in the first lateral portion and in the second lateral portion.

[0008] In another embodiment the housing comprises a W-shaped housing.

[0009] The housing can be configured to be exposed to the road beneath the vehicle when the battery assembly is coupled to a frame member of a vehicle.

[0010] The mounting system can comprise a first component coupled with the housing and a second component configured to be coupled with the frame member. The first component can be configured to be releasably coupled to the second component. In this context, the releasable coupling can be one that facilitates quick exchange of the battery assembly for another, fully charged, battery assembly.

[0011] Where provided the second component of the mounting system can be configured to be coupled with a lateral portion of, e.g., an outwardly facing side of, the frame member.

[0012] When provided, the second component of the mounting system can include one or more brackets disposed on one or both of a first inside surface of the first lateral portion and on a second inside surface of the second lateral portion.

[0013] Where provided, the brackets of the mounting system can include U-shaped members configured to be disposed around the second component of the mounting system.

[0014] The housing is configured such that a lengthwise frame member of the vehicle can be disposed between the first lateral portion and the second lateral portion.

[0015] In some embodiments, the housing is configured to be coupled to the mounting system from beneath the vehicle. The housing can be moved transversely to the long axis of the vehicle, e.g., between forward and rearward wheels of the vehicle. The housing can be moved longitudinally along the long axis of the vehicle, e.g., under an axle between driver side and passenger side wheels coupled with the axle.

**[0015a]** According to an aspect of the invention is a battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

one or more battery units disposed within the housing at least in the central portion; and

a mounting system disposed at least partially between the first lateral portion and the second lateral portion;

wherein a frame member of a vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion.

**[0015b]** According to a further aspect is a battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming a first recess between the first lateral portion and the central portion, the first lateral portion, the first recess and the central portion forming a first bight and a second recess between the central portion and the second lateral portion, the second lateral portion, the second recess and the central portion forming a second bight;

one or more battery units disposed within the central portion of the housing between the first bight and the second bight; and

a mounting system disposed at least partially in the first bight and in the second bight;

wherein a frame member of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion in or above one or both of the first recess and the second recess.

**[0015c]** According to a further aspect is a method of equipping a vehicle with a battery assembly, comprising:

providing the battery assembly comprising a housing comprising a top side and a bottom side, the top side having a central portion that extends upwardly relative to a recess disposed between the central portion and a lateral portion of the housing, the battery assembly having a housing mounting member coupled therewith at least partially within the recess;

positioning the housing below a frame rail of a frame assembly of the vehicle, the frame rail having a frame rail mounting member coupled therewith, the frame rail mounting member extending transversely to a longitudinal axis of the frame rail;

raising the housing to position the central portion of the housing at least partially above a lower surface of a portion of the frame rail extending along the central portion of the housing;

positioning the housing mounting member forward or rearward of the frame rail mounting member such that a surface of the housing mounting member overlaps a surface of the frame rail mounting member; and

advancing a fastener through the housing mounting member and the frame rail mounting member to secure the housing mounting member to the frame rail mounting member and thereby to secure the housing to the frame rail.

**[0015d]** According to a further aspect is a battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

one or more battery units disposed within the central portion of the housing; and

a mounting system comprising a plurality of brackets attached to an upper surface of the housing and disposed at least partially within the upwardly oriented recess of the housing between the first lateral portion and the second lateral portion;

wherein a frame member of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion to

suspend the housing from the frame member of the electric vehicle at a location above at least a portion of the upper surface of the housing;

whereby the one or more battery units is disposed beneath a lower edge of the frame member of the vehicle when the battery assembly is coupled with the frame member.

**[0015e]** According to a further aspect is a battery assembly for an electric vehicle, comprising:

a housing having a first lateral side, a second lateral side, and a central portion disposed between the first lateral side and the second lateral side, the housing having a top side disposed between the first lateral side and the second lateral side and over the central portion;

one or more battery units disposed within the central portion of the housing; and  
a mounting system comprising a first bracket assembly at least partially disposed between the first lateral side and the central portion and a second bracket assembly at least partially disposed between the second lateral side and the central portion;

wherein the first bracket assembly comprises a first fixed portion attached to a wall of the housing between the central portion and the first lateral side, a first overlapping portion coupled with the first fixed portion and extending in a fore-aft direction over the top side of the housing, and a first connection portion coupled with the first overlapping portion, the first connection portion comprising a first connecting surface;

wherein the second bracket assembly comprises a second fixed portion attached to a wall of the housing between the central portion and the second lateral side, a second overlapping portion coupled with the second fixed portion and extending in a fore-aft direction over the top side of the housing, and a second connection portion coupled with the second overlapping portion, the second connection portion comprising a second connecting surface;

wherein a vehicle frame can be disposed between the first connection portion and the second connection portion and when so disposed can be coupled to the first connecting surface and the second connecting surface between first and second lateral sides.



**[0015f]** According to a further aspect is a battery assembly for an electric vehicle, comprising:

- a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

- one or more battery units disposed within the housing at least in the central portion; and

- a mounting system disposed at least partially between the first lateral portion and the second lateral portion;

- wherein a frame member of a vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion

- wherein the mounting system comprises a first component coupled with a wall of the housing facing the frame member and a second component configured to be coupled with a lateral portion of the frame member.

**[0015g]** According to a further aspect is a method of equipping a vehicle with a battery assembly, comprising:

- providing the battery assembly comprising a housing comprising a top side and a bottom side, the top side having a central portion that extends upwardly relative to a recess disposed between the central portion and a lateral portion of the housing, the battery assembly having a housing mounting member coupled therewith at least partially within the recess and coupled to a wall of the housing facing a frame rail of a frame assembly of the vehicle;

- positioning the housing below the frame rail of the frame assembly of the vehicle, the frame rail having a frame rail mounting member coupled therewith, the frame rail mounting member extending transversely to a longitudinal axis of the frame rail;

- raising the housing to position the central portion of the housing at least partially above a lower surface of a portion of the frame rail extending along the central portion of the housing;

positioning the housing mounting member forward or rearward of the frame rail mounting member such that a surface of the housing mounting member overlaps a surface of the frame rail mounting member; and

advancing a fastener through the housing mounting member and the frame rail mounting member to secure the housing mounting member to the frame rail mounting member and thereby to secure the housing to the frame rail.

**[0015h]** According to a further aspect is a battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

one or more battery units disposed within the housing at least in the central portion; and

a mounting system disposed at least partially between the first lateral portion and the second lateral portion;

wherein a frame member extending along a longitudinal direction of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion.

**[0015i]** According to a further aspect is a battery assembly for an electric vehicle, comprising:

a housing having a first outwardly facing side, a second outwardly facing side, and a central portion, the housing forming an upwardly oriented surface between the first and second outwardly facing sides;

one or more battery units disposed within the housing in the central portion; and

a mounting system disposed at least partially between the first outwardly facing side and the second outwardly facing side;

wherein a lengthwise frame member of the electric vehicle can be disposed between the first and second outwardly facing sides and when so disposed can be coupled to the mounting system between first and second outwardly facing sides; and

wherein the first outwardly facing side faces outwardly relative to a length of the electric vehicle.

**[0015j]** According to a further aspect is a battery assembly, comprising:  
a housing having a first lateral portion, a second lateral portion, and a central portion;  
one or more battery units disposed within the central portion of the housing;  
and  
a mounting system comprising a plurality of brackets coupled with the housing;  
wherein a frame member of a vehicle can be disposed between the first and the second lateral portions and when so disposed can be coupled to the mounting system between the first and the second lateral portions to suspend the housing from the frame member of the vehicle at a location above at least a portion of an upper surface of the housing;  
whereby at least one of the one or more battery units is disposed beneath a lower edge of the frame member of the vehicle when the battery assembly is coupled with the frame member.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The systems, methods and devices may be better understood from the following detailed description when read in conjunction with the accompanying schematic drawings, which are for illustrative purposes only. The drawings include the following figures:

[0017] FIG. 1A is a perspective view of a truck having a fossil fuel system that can be configured with an electric power propulsion system according to an embodiment of the invention;

[0018] FIG. 1B is a side view of the a truck according to an embodiment of the invention;

[0019] FIG. 1C is a bottom view of a truck according to an embodiment of the invention;

[0020] FIG. 1D is a rear view of a truck according to an embodiment of the invention;

[0021] FIG. 2 is a schematic view of a battery assembly of an electric drive system according to an embodiment of the invention;

[0022] FIG. 3 is a perspective view of a battery assembly according to an embodiment of the invention coupled with frame rails of a vehicle;

[0023] FIG. 4 is a top view of the battery assembly of Fig. 3 coupled with frame rails of a vehicle;

[0024] FIG. 5 is a cross-sectional view of one embodiment of the battery assembly of FIGS. 3-4 taken at section plane 5-5 in FIG. 4;

[0025] FIGS. 6A to 7C illustrate apparatuses and processes for mounting a battery assembly according to an embodiment of the invention.

## DETAILED DESCRIPTION

[0026] This application is directed to novel electric vehicle components and assemblies. The components described and claimed herein can be used in vehicles that are powered solely by electric motor(s) and in vehicles that are powered by a combination of power sources including electric motors and fossil fuels, e.g., natural gas fuel systems.

[0027] FIG. 1A illustrates a vehicle 50 with a fossil fuel system 110 disposed within an enclosure behind a cab 104. The fuel system 110 can power a combustion engine.

The vehicle 100 can be powered by an electric motor (not shown) as disclosed herein. In one embodiment, the truck has multiple distinct energy sources that are capable of operating independently. In certain embodiments, the truck has no combustion engine and uses an electric motor for its propulsion power.

[0028] FIG. 1B illustrates a side view of a vehicle 100 according to an embodiment of the invention. The vehicle 100 has a cab 104 and a vehicle frame for loading cargo 108. The vehicle 100 has an electric drive system and at least one battery to power the electric drive system. The fossil fuel system 110 is shown in dash line, indicating that in this embodiment such a system is optional and may not be present.

[0029] In FIG 1B, a first battery assembly 172 is located under the cab 104 and a second battery assembly 174 is located under the cargo frame 150. In certain embodiments, the truck has no battery to power its electric drive system under the cab 104, and instead has one or more battery assemblies under the cargo area of the vehicle. In certain embodiments, the truck has no battery to power its electric drive system under the cargo frame 150 and instead has one or more battery assemblies forward of the cargo area, e.g., under the cab 104.

[0030] In FIG 1B, the two batteries 172, 174 are coupled to a beam 160 that is fixed to the cargo frame 150 and/or a frame of the cab 104. The beam 160 is a structural member that bears the load of the cargo frame 150 and also supports other components directly or indirectly, such as the wheels and axles. The beam 160 is sometimes referred to herein as a rail or frame rail. In certain embodiments, a battery to power the vehicle's electric drive system is fixed to a frame of the cab 104.

[0031] Referring to FIG. 1B, the second battery assembly 174 is sized such that the second battery assembly 174 does not overlap the wheels 181, 183, 185 of the truck. FIG. 1C shows that if the battery assembly 174 is forward of the rear wheels 183, 185, the width dimension of a housing of the battery assembly 174 can be greater than the distance 188 between the inside of the inner wheels. Generally, the battery assembly 174 will not be wider than the distance 189 between the outer sides of the outermost wheels.

[0032] FIG. 1C illustrates a bottom view of the vehicle 100 according to an embodiment of the invention. The truck has at least one beam (or frame rail) 160 installed under the cab 104 and the cargo frame 150. The beam 160 extends generally along a longitudinal direction of the vehicle 100 for holding the cargo frame 150 and other systems

such as the wheels and axles, suspension, exhaust, as well as one or both of the battery assemblies 172, 174. Referring to FIG. 1C, the beam 160 extends to overlap a first rear-wheel axle 184 adjacent to or immediately neighboring the front-wheel axle 182. The beam 160 does not extend beyond the front-wheel axle 182 or beyond the first rear-wheel axle 186 in some embodiments. In certain embodiments, the beam 160 extends to overlap all of the axles 182, 184, 186 or does not overlap any of the axles 182, 184, 186 when viewed from the bottom. FIG. 1C shows that the battery assemblies 172, 174 are located in a space between the front-wheel axle 182 and the rear-wheel axle 184 adjacent to or immediately neighboring the front-wheel axle 182 in one embodiment.

[0033] FIG. 1D illustrates a rear view of the vehicle 100 according to an embodiment of the invention. The beam 160 is installed under the cargo frame 150 between rear wheels 185. The battery assembly 174 is coupled to the beam 160 using mounting systems 240, 248. In certain embodiments, the clearance 194 below the rear axles 184, 186 is greater than the height 192 of the battery assembly 174 such that the battery assembly 174 can move under the rear axles 184, 186 and between the rear wheels 185 for exchanging battery assemblies. Manners of securing the first battery 172 or the second battery 174 to the 160 are discussed below in connection with FIGS. 3-5, FIGS. 6A-6C and FIGS. 7A-7C.

[0034] FIG. 1C is a schematic view of an electric drive system according to an embodiment of the invention. The vehicle 100 uses at least one motor 120 for propulsion. At least one battery assembly 172, 174 of the vehicle 100 provides power in the form of electric current to drive the motor 120. The vehicle 100 comprises an electric current conveyance system 122 for connecting the battery assembly 172, 174 and the motor 120. The vehicle 100 has a transmission system (not shown) to deliver torque generated by the motor 120 to one or more wheel driving axles, e.g., to the axle 184.

[0035] FIG. 2 is a perspective view of the battery assembly 174 according to an embodiment of the invention. FIG. 3 illustrates the battery assembly 174 coupled with the beam 160. FIG. 4 is a top view of the battery assembly 174 coupled with the beam 160.

[0036] Referring to FIG. 2, the battery assembly 174 includes a housing 200 and at least one mounting system 240, 248 for coupling the battery assembly 174 to the beam 160. The housing 200 comprises a first lateral portion 204, a second lateral portion 208, and a central portion 206 interposed between the lateral portions 204, 208 in one embodiment.

The central portion 206 does not extend as far in the vertical direction as the lateral portions 204, 208. A space 210 is provided between the lateral portions 204, 208 to receive the beam 160 as illustrated in FIGS. 4 and 5. The space 210 can be disposed between an inward facing surface of the first lateral portion 204 and an inward facing surface of the second lateral portion 204. The inward facing surface can be surfaces that face toward a central vertical longitudinal plane of the vehicle 100 when the battery assembly 174 is mounted thereto. In other words, the inward surfaces can be closer to the central vertical longitudinal plane than are outward surfaces of the first and second lateral portions 204, 208 which face away from that central longitudinal plane.

[0037] The housing 200 of the battery assembly 174 is generally symmetrical about a central plane A-A. The mounting system 240 and the mounting system 248 are also symmetrical about the central plane A-A. In certain embodiments, the battery assembly 174 is asymmetrical about the plane A-A, and the mounting system 248 connected to the first lateral portion 204 and the mounting system 240 connected to the second lateral portion 208 have different configurations.

[0038] At least one mounting system 240 is provided in a recess 212 between the central portion 206 and the first lateral portion 204. The recess 212 can include a bight formed by the housing 200. The bight can be formed in a concave periphery on the top side of the housing 200. The bight can include a more complex shape such as two U-shaped or concave portions on opposite sides of a central vertical plane of the housing 200. The mounting system 240 includes a first member 242 fixed to a wall of the housing 200 (e.g., to a wall of the second lateral portion 208) that is facing the beam 160 and a second member or component 244 for connecting the first member 242 to the beam 160. In some embodiments, when the battery 174 is lifted to a position where the first member 242 of the mounting system 240 is at a level of the beam, the second member 244 is fixed to the beam by fastening a bolt (that is accessible from the space 206). In certain embodiments, the second member 244 is fixed to the beam using at least one bolt 245, the beam 160 has at least one through hole 246 for receiving the bolt 245, and the second member 244 has at least one screw hole for receiving the bolt 245. In certain embodiments, a procedure to secure the battery assembly 174 to the beam comprises: (1) when the vehicle 100 is parked, moving the battery assembly 174 on or over the ground to place it under the beam 160; (2) lifting the battery assembly 174 to a set position of Fig. 3 where the through hole 246 is aligned with a screw hole of the bracket 244; and (3) fastening the bolt 245 to bracket 244 passing the through hole 246. In various techniques, a motorized screwdriver, impact wrench or other hand tool can

access the bolt 245 in the space 210 over the central portion 206 of the battery assembly 174. In another method, the second member 244 is secured to the beam 160 and the bolt 245 may be advanced through any of the holes in the side of the first member 242. More specifically, the bolt 245 can be advanced through any of the holes in a direction parallel to the central plane A-A and into the second member 244. An impact wrench or other tool can be used to secure the bolt 245 in this direction and in this manner.

[0039] FIG. 5 is a cross sectional view of the battery assembly 174 coupled with the frame rails 160 of a vehicle as shown in FIG. 4. The housing 200 of the battery assembly 174 contains or encloses a plurality of battery units or cells 222. The housing 200 is fixed to the beam (e.g., frame rail) 160 using the mounting system 240, 248 such that some of the battery units 222 are disposed laterally of the frame rails 160 and some are disposed between the frame rails 160. More particularly, the mounting system 240 enables the frame rails 160 to support battery cells over a wide area beneath the vehicle 100, with some battery cells at the central vertical longitudinal plane of the vehicle 100, and some disposed laterally between the central vertical longitudinal plane of the vehicle 100 and the frame rails 160 and with some of the battery cells laterally between the frame rails 160 and the lateral outer extent of the vehicle 100, e.g., such that the frame rails are between at least some of the battery cells 222 and the central vertical longitudinal plane of the vehicle 100. Referring to the at least one battery cell 222 are contained in portions of the housing 200 corresponding to the mounting system 240, e.g., in the central portion 212 of the housing, at a level of, lateral of, and/or below the mounting system 240 to increase the number of contained battery cells while allowing a vacant space 210 between the lateral portions 204, 208.

[0040] FIGS. 6A to 6C illustrate processes for mounting a battery assembly according to an embodiment of the invention. A first bracket 260 fixed to the beam 160 is engaged with a second bracket 250 for coupling the lateral portion 208 of the housing to the beam. The lateral portion 208 and the second bracket 250 can be moved from one side of the vehicle 100 under the frame rails 160 across the central vertical longitudinal plane of the vehicle 100 then lifted to be disposed over at least a portion of the first bracket 260. When the battery cell 174 is lifted from a set position of FIG. 6A to a lifted position of FIG. 6B, a coupling pin 252 of the second bracket 250 is elevated above a recess 262 of the first bracket 260. When

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the battery cell 174 is lifted from a set position of FIG. 6A to a lifted position of FIG. 6B, a coupling pin 252 of the second bracket 250 is elevated above a recess 262 of the first bracket 260. When the battery assembly is in a mounted position of FIG. 6C, the coupling pin 252 is received in the recess 262 of the first bracket 260 such that one side of the battery assembly 174 is coupled to one of the beams 160 of the vehicle. In certain embodiments, subsequent to coupling the lateral portion 208 to the beam 160 in the mounted position of FIG. 6C, another mounting system 248 connected to the lateral portion 204 at the other side of the battery assembly 174 is aligned with the beam 160 and then secured to the beam 160 using a bolt (or other fastening system) to prevent the battery assembly 174 from moving relative to the beam 160 and to prevent the coupling pin 252 from coming out of the recess 262. More details about coupling of the brackets 250, 260 can be found in PCT Application No. PCT/US2016/039363.

**[0041]** FIGs. 7A to 7C illustrate a process for mounting a battery assembly according to an embodiment of the invention. A third bracket 280 fixed to the beam 160 is engaged with a fourth bracket 270 for coupling the lateral portion 208 of the housing to the beam 160. When the battery cell 174 is lifted from a set position of FIG. 7A to a lifted position of FIG. 7B, a coupling protrusion 282 of the third bracket 280 is elevated over a hole 272 of the fourth bracket 270. When the battery assembly is in a mounted position of FIG. 7C, the coupling protrusion 282 is inserted to the hole 272 of the fourth bracket 270 such that the battery cell 174 is coupled to the beam 160. In some embodiments, subsequent to coupling the lateral portion 208 to the beam 160 in the mounted position of FIG. 7C, another mounting system 248 connected to the lateral portion 204 at the other side of the battery assembly 174 is aligned with the beam 160 and then secured to the beam 160 using a bolt (or other fastening system) to prevent the battery assembly 174 from moving relative to the beam 160 and to prevent the coupling pin 252 from coming out of the recess 262. More details about coupling of the brackets 270, 280 can be found in U.S. Application No. 14/057,410.

#### FURTHER DETAILS OF THE FUEL SYSTEM

[0042] FIG. 1A shows the fuel system 110 mounted to the vehicle 50 in a behind-the-cab or back-of-cab configuration. More details of the fuel system 110 can be found in US Application No. 15/014,933.

[0043] While the present description sets forth specific details of various embodiments, it will be appreciated that the description is illustrative only and should not be construed in any way as limiting. Furthermore, various applications of such embodiments and modifications thereto, which may occur to those who are skilled in the art, are also encompassed by the general concepts described herein. Each and every feature described herein, and each and every combination of two or more of such features, is included within the scope of the present invention provided that the features included in such a combination are not mutually inconsistent.

[0044] The above presents a description of systems and methods contemplated for carrying out the concepts disclosed herein, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains to make and use this invention. The systems and methods disclosed herein, however, are susceptible to modifications and alternate constructions from that discussed above which are within the scope of the present disclosure. Consequently, it is not the intention to limit this disclosure to the particular embodiments disclosed. On the contrary, the intention is to cover modifications and alternate constructions coming within the spirit and scope of the disclosure as generally expressed by the following claims, which particularly point out and distinctly claim the subject matter of embodiments disclosed herein.

[0045] Although embodiments have been described and pictured in an exemplary form with a certain degree of particularity, it should be understood that the present disclosure has been made by way of example, and that numerous changes in the details of construction and combination and arrangement of parts and steps may be made without departing from the spirit and scope of the disclosure as set forth in the claims hereinafter.

WHAT IS CLAIMED IS:

1. A battery assembly for an electric vehicle, comprising:
  - a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;
  - one or more battery units disposed within the housing at least in the central portion; and
  - a mounting system disposed at least partially between the first lateral portion and the second lateral portion;
  - wherein a frame member of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion.
2. The battery assembly of Claim 1, wherein the housing comprises a W-shaped housing.
3. The battery assembly of Claim 1, wherein the housing is configured to be exposed to the road beneath the vehicle when the battery assembly is coupled to the frame member of the vehicle.
4. The battery assembly of Claim 1, wherein the mounting system comprises a first component coupled with the housing and a second component configured to be coupled with the frame member, the first component configured to be releasably coupled to the second component.
5. The battery assembly of Claim 4, wherein the second component is configured to be coupled with a lateral portion of the frame member.
6. The battery assembly of Claim 4, wherein the first component comprises one or more brackets disposed on one or both of a first inside surface of the first lateral portion and on a second inside surface of the second lateral portion.
7. The battery assembly of Claim 6, wherein the one or more brackets comprise one or more U-shaped members configured to be disposed around the second component of the mounting system.
8. The battery assembly of Claim 1, wherein at least a portion of the one or more battery units is disposed in the first lateral portion and/or the second lateral portion.
9. The battery assembly of Claim 1, wherein the frame member extends lengthwise along the vehicle.

10. The battery assembly of Claim 1, wherein the housing is configured to be coupled to the mounting system from beneath the vehicle.

11. A battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming a first recess between the first lateral portion and the central portion, the first lateral portion, the first recess and the central portion forming a first bight and a second recess between the central portion and the second lateral portion, the second lateral portion, the second recess and the central portion forming a second bight;

one or more battery units disposed within the central portion of the housing between the first bight and the second bight; and

a mounting system disposed at least partially in the first bight and in the second bight;

wherein a frame member of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion in or above one or both of the first recess and the second recess.

12. The battery assembly of Claim 11, wherein the central portion of the housing extends to an elevation above a lower portion of the frame member of the electric vehicle when the mounting system is coupled with the frame member of the electric vehicle.

13. The battery assembly of Claim 11, wherein the mounting system comprises a plurality of brackets coupled to the housing and positioned to be disposed laterally of one or more frame members of the electric vehicle when the battery assembly is coupled to the electric vehicle, the one or more frame members of the electric vehicle including the frame member of the electric vehicle.

14. The battery assembly of Claim 13, wherein the mounting system comprises:

a first forward bracket coupled to the housing adjacent to the first lateral portion and configured to mount to an outboard side of a first frame rail at a first location of the first frame rail;

a first rearward bracket coupled to the housing adjacent to the first lateral portion and configured to mount to the outboard side of the first frame rail at a second location of the first frame rail rearward of the first location of the first frame rail;

a second forward bracket coupled to the housing adjacent to the second lateral portion and configured to mount to an outboard side of a second frame rail at a first location of the second frame rail; and

a second rearward bracket coupled to the housing adjacent to the second lateral portion and configured to mount to the outboard side of the second frame rail at a second location of the second frame rail rearward of the first location of the second frame rail.

15. The battery assembly of Claim 14, wherein at least one of the first forward bracket and the first rearward bracket is coupled to a side wall of the first lateral portion of the housing facing the first recess and at least one of the second forward bracket and the second rearward bracket is coupled to a side wall of the second lateral portion of the housing facing the second recess.

16. The battery assembly of Claim 14, wherein at least one of the first forward bracket, the first rearward bracket, the second forward bracket and the second rearward bracket is configured to overlap a surface of another member of the mounting system in a direction transverse to a longitudinal axis of the frame member of the electric vehicle to which the mounting system is coupled.

17. A method of equipping a vehicle with a battery assembly, comprising:  
providing the battery assembly comprising a housing comprising a top side and a bottom side, the top side having a central portion that extends upwardly relative to a recess disposed between the central portion and a lateral portion of the housing, the battery assembly having a housing mounting member coupled therewith at least partially within the recess;

positioning the housing below a frame rail of a frame assembly of the vehicle, the frame rail having a frame rail mounting member coupled therewith, the frame rail mounting member extending transversely to a longitudinal axis of the frame rail;

raising the housing to position the central portion of the housing at least partially above a lower surface of a portion of the frame rail extending along the central portion of the housing;

positioning the housing mounting member forward or rearward of the frame rail mounting member such that a surface of the housing mounting member overlaps a surface of the frame rail mounting member; and

advancing a fastener through the housing mounting member and the frame rail mounting member to secure the housing mounting member to the frame rail mounting member and thereby to secure the housing to the frame rail.

18. The method of Claim 17, wherein the frame rail is a first frame rail, the housing mounting member is one of a first plurality of housing mounting members coupled to a first lateral portion of the housing, the frame rail mounting member is one of a first plurality

of frame rail mounting members coupled with a lateral side of the first frame rail, and further comprising a second plurality of housing mounting members coupled with a second lateral portion of the housing and a second plurality of frame rail mounting members coupled to a lateral surface of a second frame rail, the method further comprising:

positioning each of the housing mounting members of the first plurality of housing mounting members on a first lateral side of the first frame rail forward or rearward of a corresponding one of the frame rail mounting members of the first plurality of frame rail mounting members;

positioning each of the housing mounting members of the second plurality of housing mounting members on a lateral side of the second frame rail forward or rearward of a corresponding one of the frame rail mounting members of the second plurality of frame rail mounting members; and

advancing a fastener through corresponding pairs of housing mounting members and frame rail mounting members.

19. The method of Claim 17, wherein at least one battery cell located in the central portion is disposed above a lower portion of the frame rail following advancing the fastener through the housing mounting member and the frame rail mounting member to secure the housing mounting member to the frame rail.

20. The method of Claim 17, wherein raising the housing comprises pivotably coupling a first lateral portion of the housing to a frame portion and pivoting a second lateral portion of the housing about an axis disposed through the pivotable coupling.

21. A battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

one or more battery units disposed within the central portion of the housing; and

a mounting system comprising a plurality of brackets attached to an upper surface of the housing and disposed at least partially within the upwardly oriented recess of the housing between the first lateral portion and the second lateral portion;

wherein a frame member of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion to suspend the housing from the frame member of the electric vehicle at a location above at least a portion of the upper surface of the housing;

whereby the one or more battery units is disposed beneath a lower edge of the frame member of the vehicle when the battery assembly is coupled with the frame member.

22. The battery assembly of Claim 21, wherein the housing comprises a W-shaped housing.

23. The battery assembly of Claim 21, wherein a continuous expanse of a side of the housing from a first lateral side of the first lateral portion to a second lateral side of the second lateral portion is configured to be exposed to the road beneath the electric vehicle when the battery assembly is coupled to the frame member of the electric vehicle.

24. The battery assembly of Claim 21, wherein the mounting system comprises a first component coupled with the housing and a second component configured to be coupled with the frame member, the first component configured to be releasably coupled to the second component.

25. The battery assembly of Claim 24, wherein the second component is configured to be coupled with a lateral portion of the frame member.

26. The battery assembly of Claim 24, wherein the first component comprises the plurality of brackets, wherein the plurality of brackets are disposed on one or both of a first inside surface of the first lateral portion and on a second inside surface of the second lateral portion.

27. The battery assembly of Claim 21, wherein at least a portion of the one or more battery units is disposed in the first lateral portion and/or the second lateral portion.

28. The battery assembly of Claim 21, wherein the housing is configured to be coupled to the mounting system from beneath the vehicle.

29. The battery assembly of Claim 21, wherein the plurality of brackets are attached to a wall of the housing, the wall extending transverse to a top side of the housing.

30. The battery assembly of Claim 21, wherein the upper surface of the housing is located on a top side of the housing.

31. The battery assembly of Claim 21, wherein the housing encloses a continuous space extending from within the first lateral portion to within the second lateral portion through the central portion.

32. The battery assembly of Claim 21, wherein the mounting system is configured to transfer a load to a vertical surface of the housing, the vertical surface extending transverse to a top side of the housing.

33. A battery assembly for an electric vehicle, comprising:

a housing having a first lateral side, a second lateral side, and a central portion disposed between the first lateral side and the second lateral side, the housing having a top side disposed between the first lateral side and the second lateral side and over the central portion;

one or more battery units disposed within the central portion of the housing; and

a mounting system comprising a first bracket assembly at least partially disposed between the first lateral side and the central portion and a second bracket assembly at least partially disposed between the second lateral side and the central portion;

wherein the first bracket assembly comprises a first fixed portion attached to a wall of the housing between the central portion and the first lateral side, a first overlapping portion coupled with the first fixed portion and extending in a fore-aft direction over the top side of the housing, and a first connection portion coupled with the first overlapping portion, the first connection portion comprising a first connecting surface;

wherein the second bracket assembly comprises a second fixed portion attached to a wall of the housing between the central portion and the second lateral side, a second overlapping portion coupled with the second fixed portion and extending in a fore-aft direction over the top side of the housing, and a second connection portion coupled with the second overlapping portion, the second connection portion comprising a second connecting surface;

wherein a vehicle frame can be disposed between the first connection portion and the second connection portion and when so disposed can be coupled to the first connecting surface and the second connecting surface between first and second lateral sides.

34. The battery assembly of Claim 33, wherein the first connection portion is disposed within an internal angle between the first fixed portion and the first overlapping portion.

35. The battery assembly of Claim 33, wherein the first connection portion is configured to be releasably coupled to the first overlapping portion and the second connection portion is configured to be releasably coupled to the second overlapping portion.

36. The battery assembly of Claim 33, wherein the central portion extends upward relative to an adjacent portion of the top side of the housing.

37. The battery assembly of Claim 33, wherein the one or more battery units are disposed within the housing at least partially above an adjacent external portion of the top side of the housing.



38. The battery assembly of Claim 33, wherein the housing comprises a first lateral portion disposed between the first lateral side and the central portion, the first lateral portion extending upward relative to an adjacent portion of the top side of the housing.

39. The battery assembly of Claim 38, wherein the housing comprises a second lateral portion disposed between the first lateral portion and the second lateral side of the housing, the second lateral portion extending upward relative to an adjacent portion of the top side of the housing.

40. The battery assembly of Claim 39, wherein the first lateral portion and the second lateral portion are continuous portions of the housing with the central portion.

41. The battery assembly of Claim 33, wherein the wall that the first fixed portion is attached to extends transverse to the top side of the housing such that the wall is at a different elevation than the top side.

42. The battery assembly of Claim 41, wherein the wall that the first fixed portion is attached to extends to an elevation above the top side of the housing.

43. A battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

one or more battery units disposed within the housing at least in the central portion;  
and

a mounting system disposed at least partially between the first lateral portion and the second lateral portion;

wherein a frame member of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion

wherein the mounting system comprises a first component coupled with a wall of the housing facing the frame member and a second component configured to be coupled with a lateral portion of the frame member.

44. The battery assembly of Claim 43, wherein the housing comprises a W-shaped housing.

45. The battery assembly of Claim 43, wherein the housing is configured to be exposed to the road beneath the vehicle when the battery assembly is coupled to the frame member of the vehicle.

46. The battery assembly of any one of Claims 43 to 45, wherein the first component is configured to be releasably coupled to the second component.

47. The battery assembly of any one of Claims 43 to 46, wherein the central portion does not extend as far in a vertical direction as the first lateral portion and the second lateral portion.

48. The battery assembly of Claim 43, wherein the first component comprises one or more brackets disposed on one or both of a first inside surface of the first lateral portion and on a second inside surface of the second lateral portion, the first inside surface and the second inside surface facing toward a central vertical longitudinal plane of the vehicle when the battery assembly is mounted thereto.

49. The battery assembly of Claim 48, wherein the one or more brackets comprise one or more U-shaped members configured to be disposed around the second component of the mounting system.

50. The battery assembly of Claim 43, wherein at least a portion of the one or more battery units is disposed in the first lateral portion and/or the second lateral portion.

51. The battery assembly of any one of Claims 43 to 50, wherein the frame member extends lengthwise along the vehicle.

52. The battery assembly of Claim 43, wherein the housing is configured to be coupled to the mounting system from beneath the vehicle.

53. The battery assembly of Claim 43, wherein the upwardly oriented recess of the housing comprises a first recess and a second recess, the first recess disposed between the first lateral portion and the central portion, the first lateral portion, the first recess and the central portion forming a first bight, and the second recess disposed between the central portion and the second lateral portion, the second lateral portion, the second recess and the central portion forming a second bight;

the one or more battery units disposed between the first bight and the second bight;  
and

the mounting system disposed at least partially in the first bight and in the second bight;

wherein the frame member of the electric vehicle can be coupled to the mounting system in or above one or both of the first recess and the second recess.

54. A method of equipping a vehicle with a battery assembly, comprising:

providing the battery assembly comprising a housing comprising a top side and a bottom side, the top side having a central portion that extends upwardly relative to a recess

disposed between the central portion and a lateral portion of the housing, the battery assembly having a housing mounting member coupled therewith at least partially within the recess and coupled to a wall of the housing facing a frame rail of a frame assembly of the vehicle;

positioning the housing below the frame rail of the frame assembly of the vehicle, the frame rail having a frame rail mounting member coupled therewith, the frame rail mounting member extending transversely to a longitudinal axis of the frame rail;

raising the housing to position the central portion of the housing at least partially above a lower surface of a portion of the frame rail extending along the central portion of the housing;

positioning the housing mounting member forward or rearward of the frame rail mounting member such that a surface of the housing mounting member overlaps a surface of the frame rail mounting member; and

advancing a fastener through the housing mounting member and the frame rail mounting member to secure the housing mounting member to the frame rail mounting member and thereby to secure the housing to the frame rail.

55. The method of Claim 54, wherein the frame rail is a first frame rail, the housing mounting member is one of a first plurality of housing mounting members coupled to a first lateral portion of the housing, the frame rail mounting member is one of a first plurality of frame rail mounting members coupled with a lateral side of the first frame rail, and further comprising a second plurality of housing mounting members coupled with a second lateral portion of the housing and a second plurality of frame rail mounting members coupled to a lateral surface of a second frame rail, the method further comprising:

positioning each of the housing mounting members of the first plurality of housing mounting members on a first lateral side of the first frame rail forward or rearward of a corresponding one of the frame rail mounting members of the first plurality of frame rail mounting members;

positioning each of the housing mounting members of the second plurality of housing mounting members on a lateral side of the second frame rail forward or rearward of a corresponding one of the frame rail mounting members of the second plurality of frame rail mounting members; and

advancing a fastener through corresponding pairs of housing mounting members and frame rail mounting members.

56. The method of Claim 54, wherein at least one battery cell located in the central portion is disposed above a lower portion of the frame rail following advancing the fastener through the housing mounting member and the frame rail mounting member to secure the housing mounting member to the frame rail.

57. The method of Claim 54, wherein raising the housing comprises pivotably coupling a first lateral portion of the housing to a frame portion and pivoting a second lateral portion of the housing about an axis disposed through the pivotable coupling.

58. A battery assembly for an electric vehicle, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion, the housing forming an upwardly oriented recess between the first lateral portion and the second lateral portion;

one or more battery units disposed within the housing at least in the central portion; and

a mounting system disposed at least partially between the first lateral portion and the second lateral portion;

wherein a frame member extending along a longitudinal direction of the electric vehicle can be disposed between the first lateral portion and the second lateral portion and when so disposed can be coupled to the mounting system between the first lateral portion and the second lateral portion.

59. The battery assembly of Claim 58, wherein the housing comprises a W-shaped housing.

60. The battery assembly of Claim 58, wherein the housing is configured to be exposed to the road beneath the electric vehicle when the battery assembly is coupled to the frame member of the electric vehicle.

61. The battery assembly of Claim 58, wherein the mounting system comprises a first component coupled with the housing and a second component configured to be coupled with the frame member, the first component configured to be releasably coupled to the second component.

62. The battery assembly of Claim 61, wherein the central portion does not extend as far in the vertical direction as the first lateral portion and the second lateral portion.

63. The battery assembly of Claim 61, wherein the first component comprises one or more brackets disposed on one or both of a first inside surface of the first lateral portion and on a second inside surface of the second lateral portion, the first inside surface and the

second inside surface facing toward a central vertical longitudinal plane of the electric vehicle when the battery assembly is mounted thereto.

64. The battery assembly of Claim 63, wherein the one or more brackets comprise one or more U-shaped members configured to be disposed around the second component of the mounting system.

65. The battery assembly of Claim 58, wherein at least a portion of the one or more battery units is disposed in the first lateral portion and/or the second lateral portion.

66. The battery assembly of Claim 58, wherein the frame member extends lengthwise along the electric vehicle.

67. The battery assembly of Claim 58, wherein the housing is configured to be coupled to the mounting system from beneath the vehicle.

68. The battery assembly of Claim 58, wherein the upwardly oriented recess of the housing comprises a first recess and a second recess, the first recess disposed between the first lateral portion and the central portion, the first lateral portion, the first recess and the central portion forming a first bight, and the second recess disposed between the central portion and the second lateral portion, the second lateral portion, the second recess and the central portion forming a second bight;

the one or more battery units disposed between the first bight and the second bight;  
and

the mounting system disposed at least partially in the first bight and in the second bight;

wherein the frame member of the electric vehicle can be coupled to the mounting system in or above one or both of the first recess and the second recess.

69. A battery assembly for an electric vehicle, comprising:

a housing having a first outwardly facing side, a second outwardly facing side, and a central portion, the housing forming an upwardly oriented surface between the first and second outwardly facing sides;

one or more battery units disposed within the housing in the central portion; and

a mounting system disposed at least partially between the first outwardly facing side and the second outwardly facing side;

wherein a lengthwise frame member of the electric vehicle can be disposed between the first and second outwardly facing sides and when so disposed can be coupled to the mounting system between first and second outwardly facing sides; and

wherein the first outwardly facing side faces outwardly relative to a length of the electric vehicle.

70. The battery assembly of Claim 69, wherein the housing comprises an upward oriented recess formed in part by the upwardly oriented surface.

71. The battery assembly of Claim 69, wherein the housing comprises a W-shaped housing.

72. The battery assembly of Claim 69, wherein the housing is configured to be exposed to a road beneath the electric vehicle when the battery assembly is coupled to a frame member of the electric vehicle.

73. The battery assembly of any one of Claims 69 to 72, wherein the mounting system comprises a first component coupled with the housing and a second component configured to be coupled with the lengthwise frame member, the first component configured to be releasably coupled to the second component.

74. The battery assembly of Claim 73, wherein the second component is configured to be coupled with a lateral portion of the lengthwise frame member on an outboard side of the lengthwise frame member.

75. The battery assembly of Claim 73, wherein the first component comprises one or more brackets disposed adjacent to the upwardly oriented surface.

76. The battery assembly of Claim 73, wherein the first component is coupled with the housing and extends away from the upwardly oriented surface to a connection portion configured to couple with the second component to suspend the battery assembly from the lengthwise frame member.

77. The battery assembly of Claim 69, wherein at least a portion of one of the one or more battery units is disposed in a first lateral portion disposed between the central portion and the first outwardly facing side and/or in a second lateral portion disposed between the central portion and the second outwardly facing side.

78. The battery assembly of Claim 77, wherein at least one of the first lateral portion and the second lateral portion extend upwardly along a vertical portion of the mounting system.

79. The battery assembly of Claim 69, wherein the mounting system is configured to couple the housing to the electric vehicle from beneath the electric vehicle.

80. The battery assembly of Claim 69, wherein the mounting system comprises a pin and groove connection facilitating at least partial support of the housing on the lengthwise frame member of the electric vehicle without additional fasteners.

81. The battery assembly of Claim 69, wherein the mounting system is configured to support the battery assembly from only outward sides of a frame assembly.

82. A vehicle assembly, comprising:

a frame assembly comprising a frame rail; and

a frame rail mounting member coupled with the frame rail;

the battery assembly of Claim 69, wherein the mounting system comprises one or more brackets coupled with the housing and coupled with the frame rail mounting member at a location spaced away from the upwardly oriented surface.

83. The vehicle assembly of Claim 82, wherein the frame rail mounting member is coupled with an outboard surface of the frame rail.

84. The vehicle assembly of Claim 83, wherein the frame rail comprises a first frame rail and further comprising a second frame rail, the first and second frame rails extending along a longitudinal axis of the frame assembly, wherein the vehicle assembly further comprises a second frame rail mounting member coupled with an outboard side of the second frame rail, the mounting system comprising one or more brackets coupled with the housing and with the second frame rail mounting member.

85. The vehicle assembly of Claim 84, wherein the mounting system supports the battery assembly from only outboard sides of the first frame rail and the second frame rail.

86. The vehicle assembly of Claim 83, wherein the frame rail comprises a first frame rail and further comprising a second frame rail, the first and second frame rails extending along a longitudinal axis of the frame assembly, wherein the central portion of the housing of the battery assembly is disposed at least partially in a space between the first and second frame rails at an elevation above a bottom portion of at least one of the first and the second frame rails.

87. A battery assembly, comprising:

a housing having a first lateral portion, a second lateral portion, and a central portion;

one or more battery units disposed within the central portion of the housing; and

a mounting system comprising a plurality of brackets coupled with the housing;

wherein a frame member of a vehicle can be disposed between the first and the second lateral portions and when so disposed can be coupled to the mounting system between the first and the second lateral portions to suspend the housing from the frame member of the vehicle at a location above at least a portion of an upper surface of the housing;

whereby at least one of the one or more battery units is disposed beneath a lower edge of the frame member of the vehicle when the battery assembly is coupled with the frame member.

88. The battery assembly of Claim 87, wherein the housing comprises a W-shaped housing.

89. The battery assembly of Claim 87, wherein the housing is configured to be exposed to a road beneath the vehicle when the battery assembly is coupled to a frame member of the vehicle.

90. The battery assembly of Claim 87, wherein at least a portion of one of the one or more battery units is disposed in the first lateral portion and/or in the second lateral portion.

91. The battery assembly of Claim 87, wherein at least one of the first lateral portion and the second lateral portion extend upwardly along a vertical portion of the mounting system.

92. The battery assembly of Claim 87, wherein the frame member of the vehicle is a lengthwise frame member of the vehicle.

93. The battery assembly of Claim 87, wherein the mounting system is configured to couple the housing to the vehicle from beneath the vehicle.

94. The battery assembly of Claim 87, wherein the mounting system comprises a pin and groove connection facilitating at least partial support of the housing on the frame member of the vehicle without additional fasteners.

95. The battery assembly of Claim 87, wherein the mounting system is configured to support the battery assembly from only outward sides of a frame assembly.



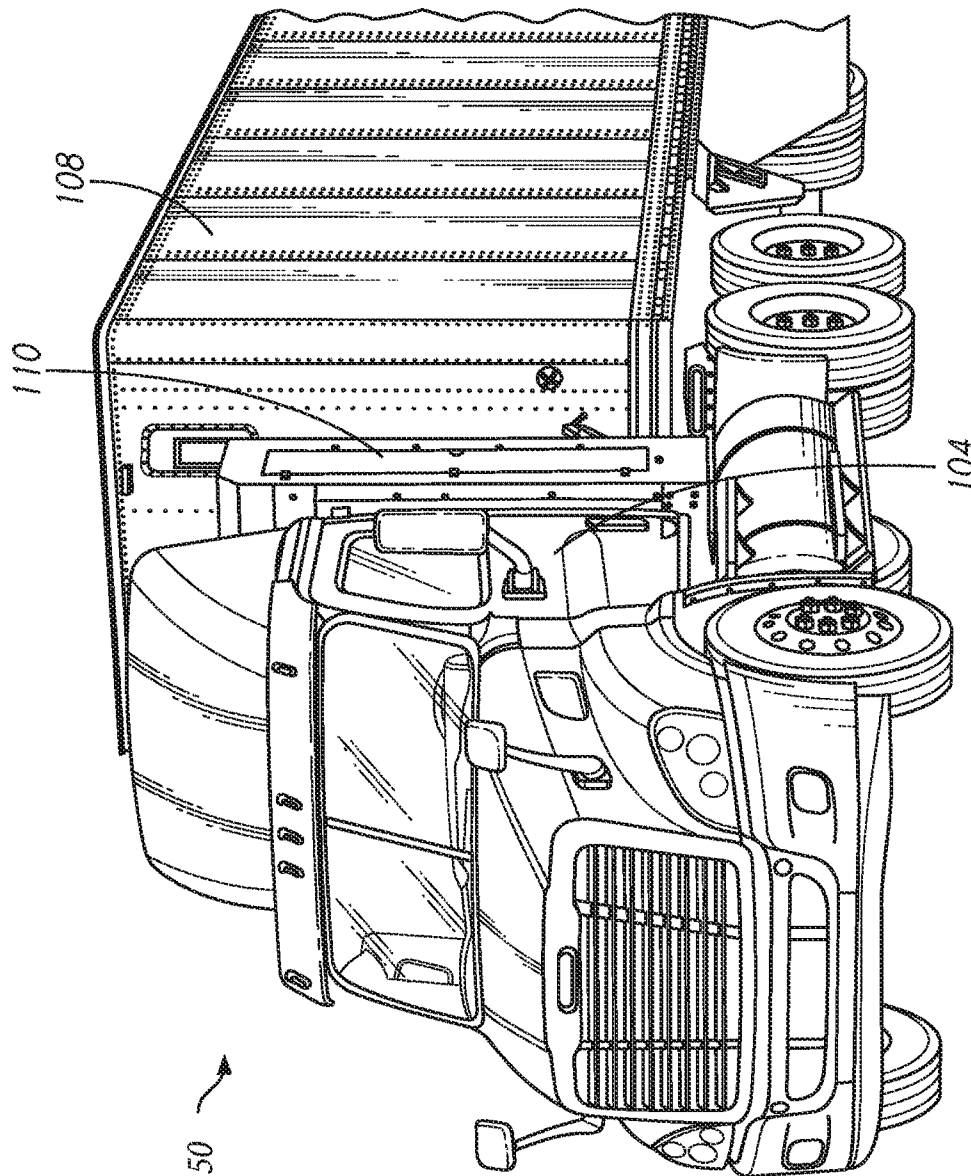


FIG. 1A

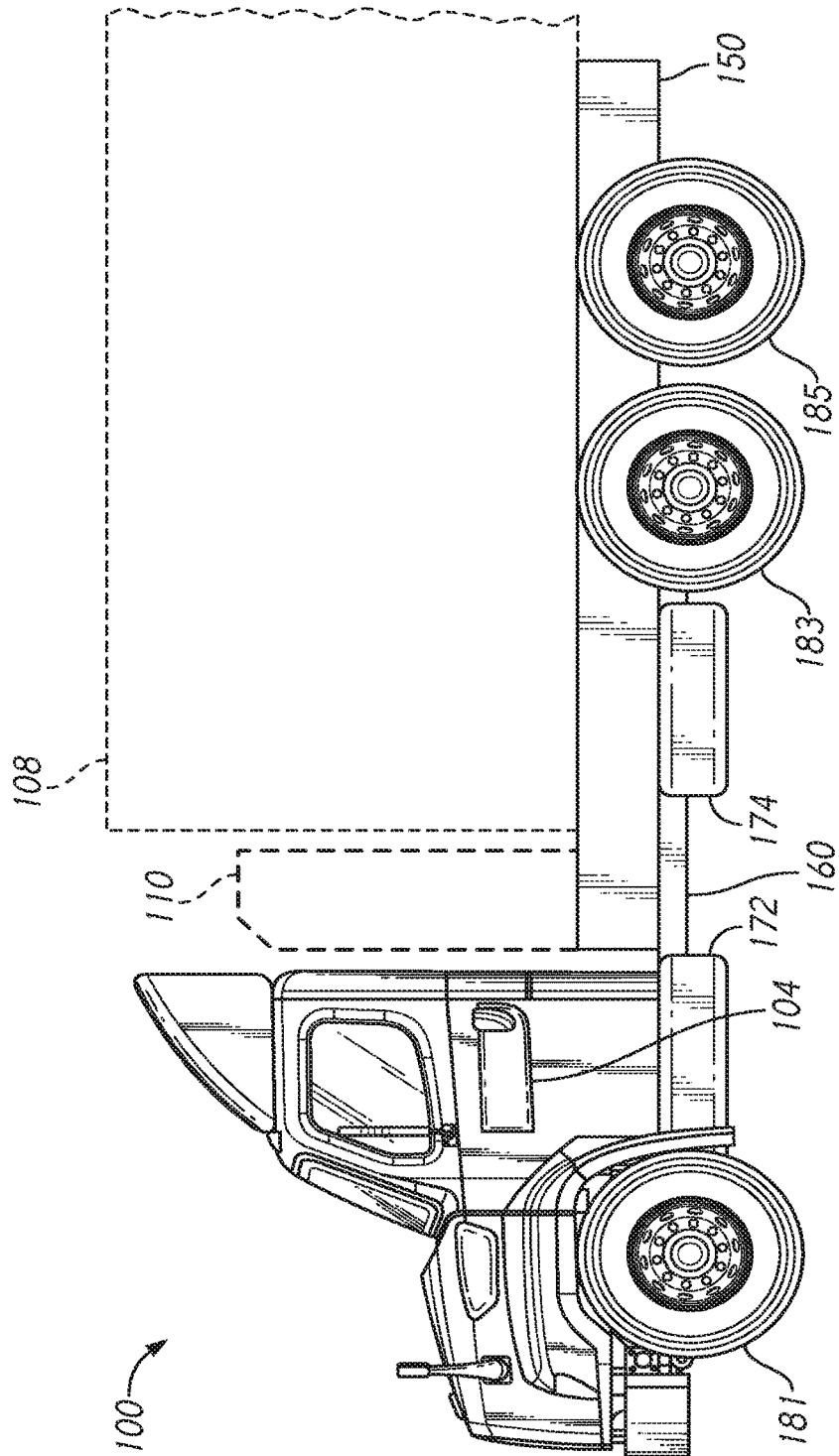


FIG. 1B

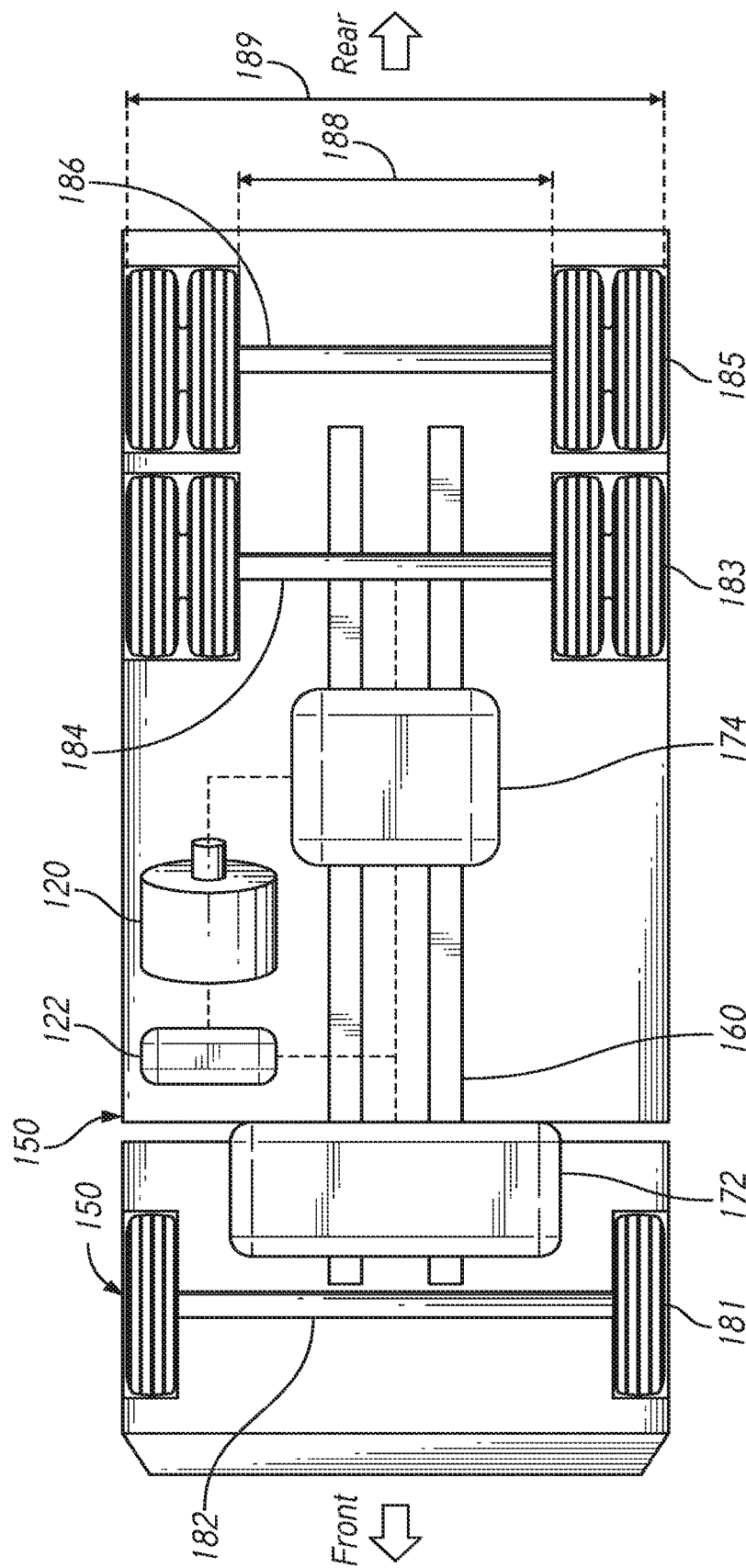


FIG. 1C

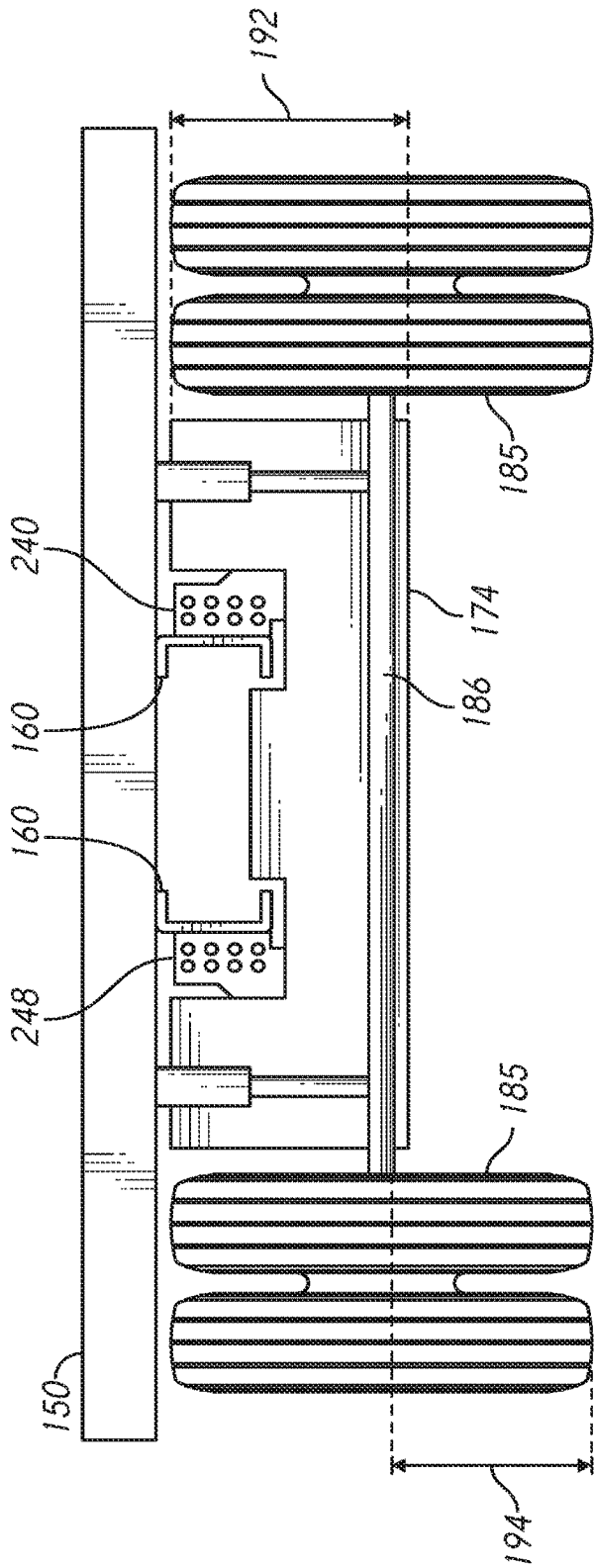


FIG. 1D

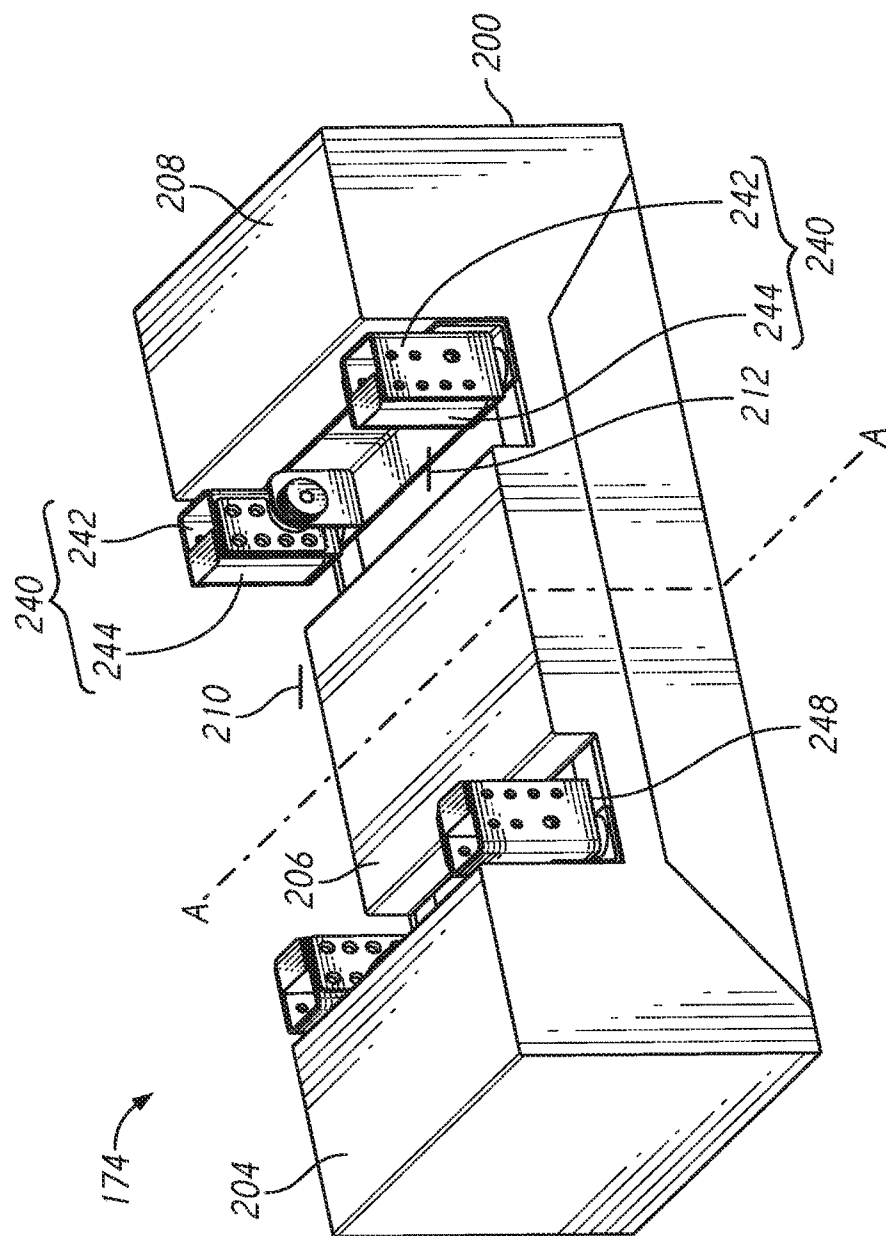


FIG. 2

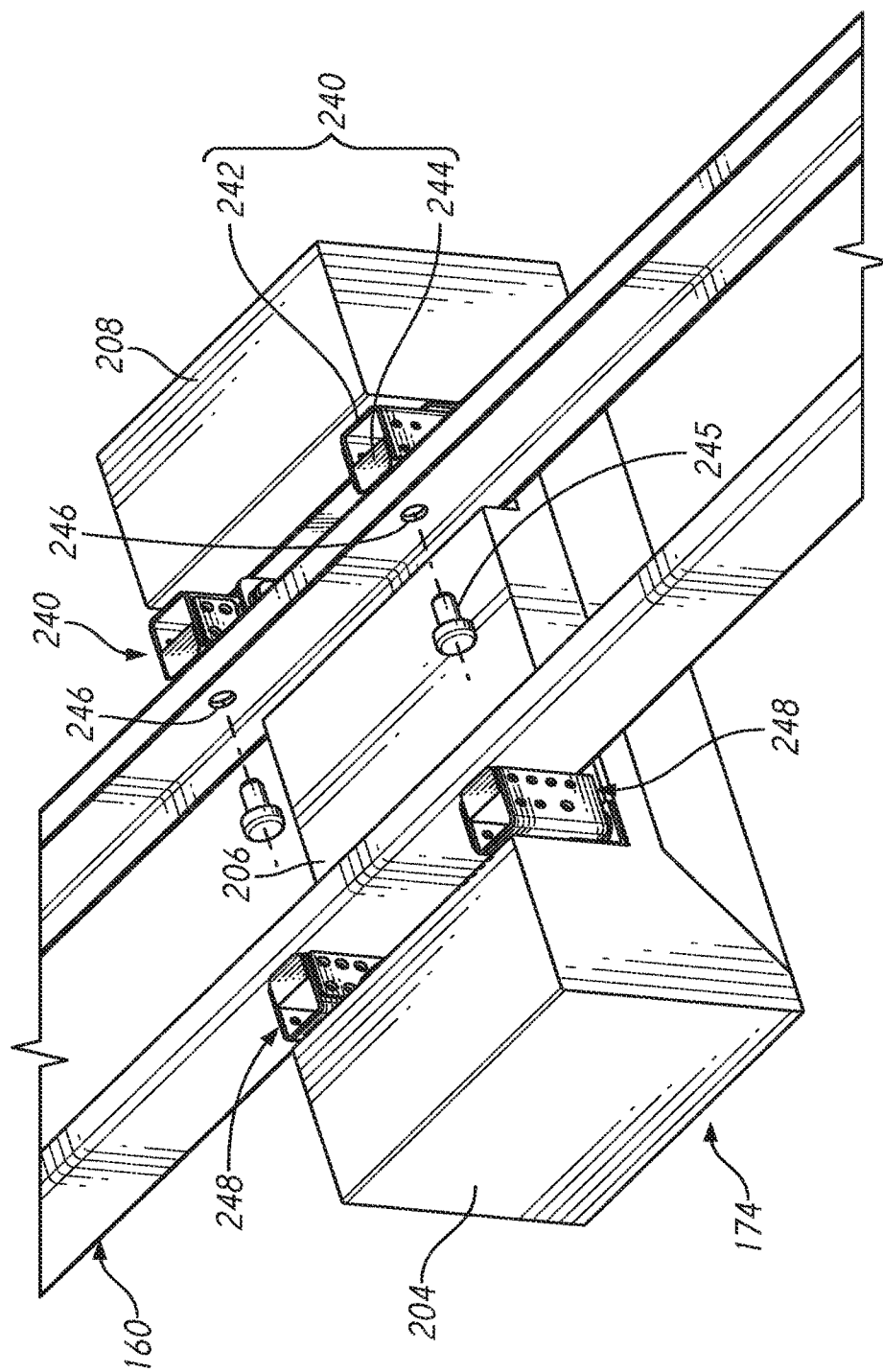


FIG. 3

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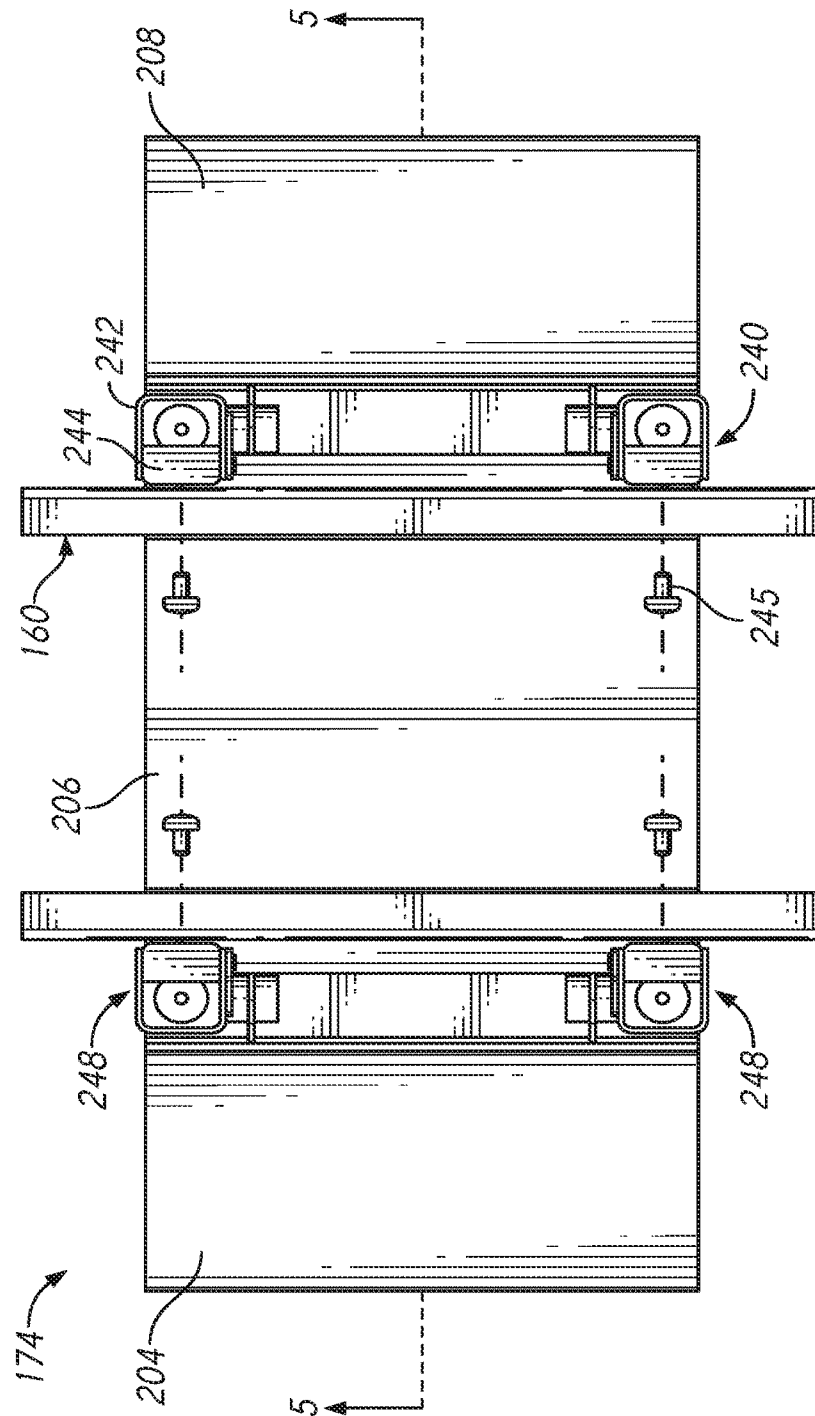


FIG. 4

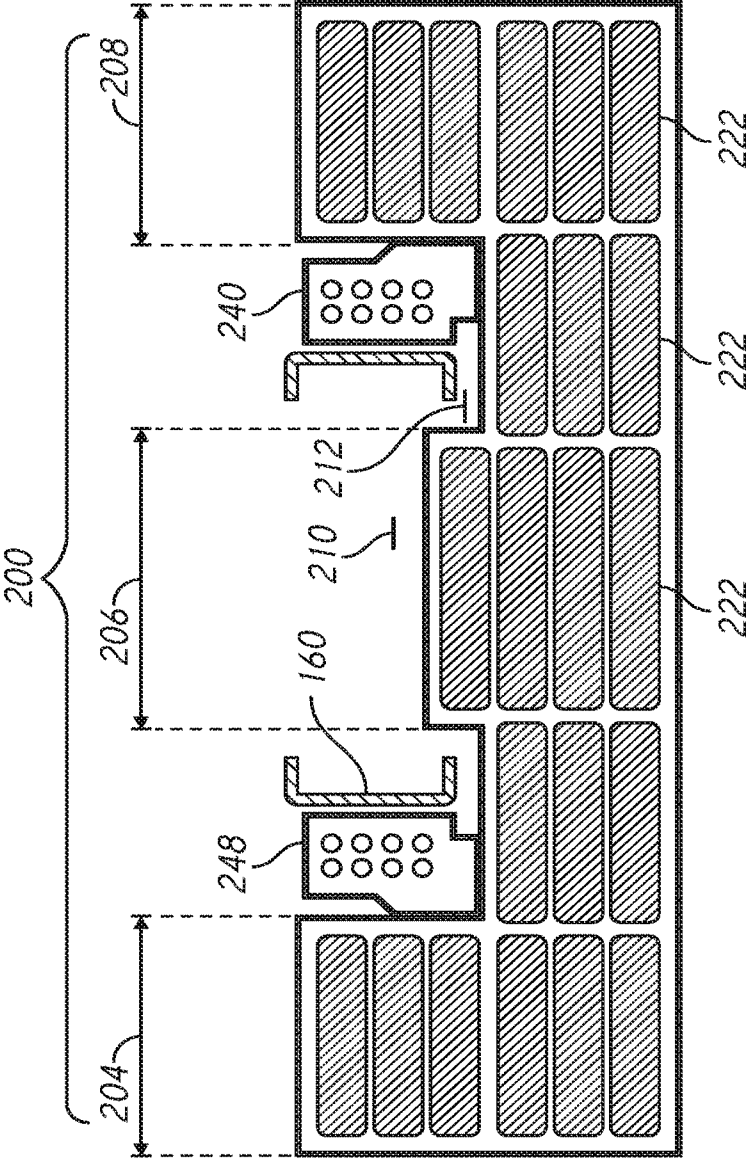


FIG. 5



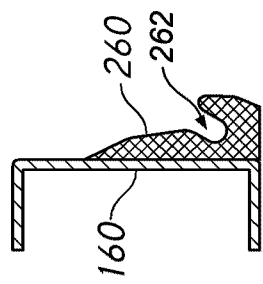


FIG. 6A

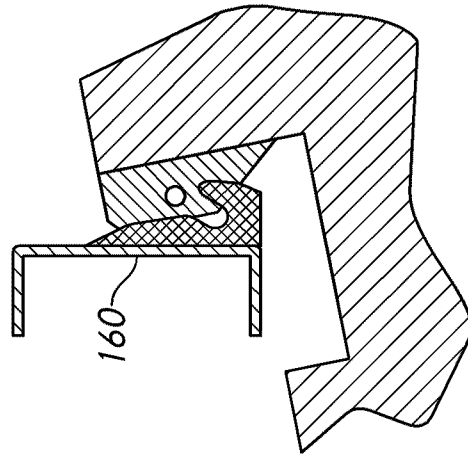


FIG. 6B

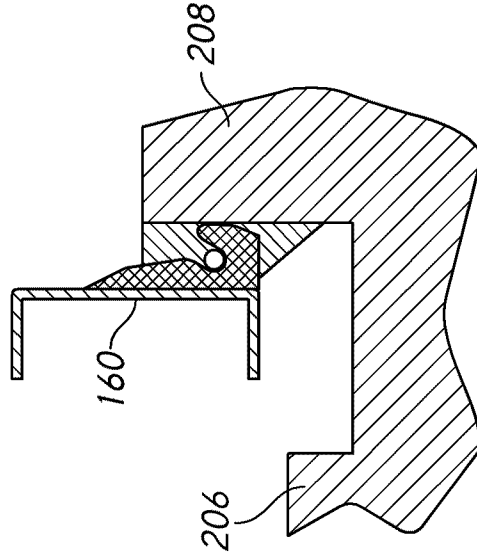


FIG. 6C

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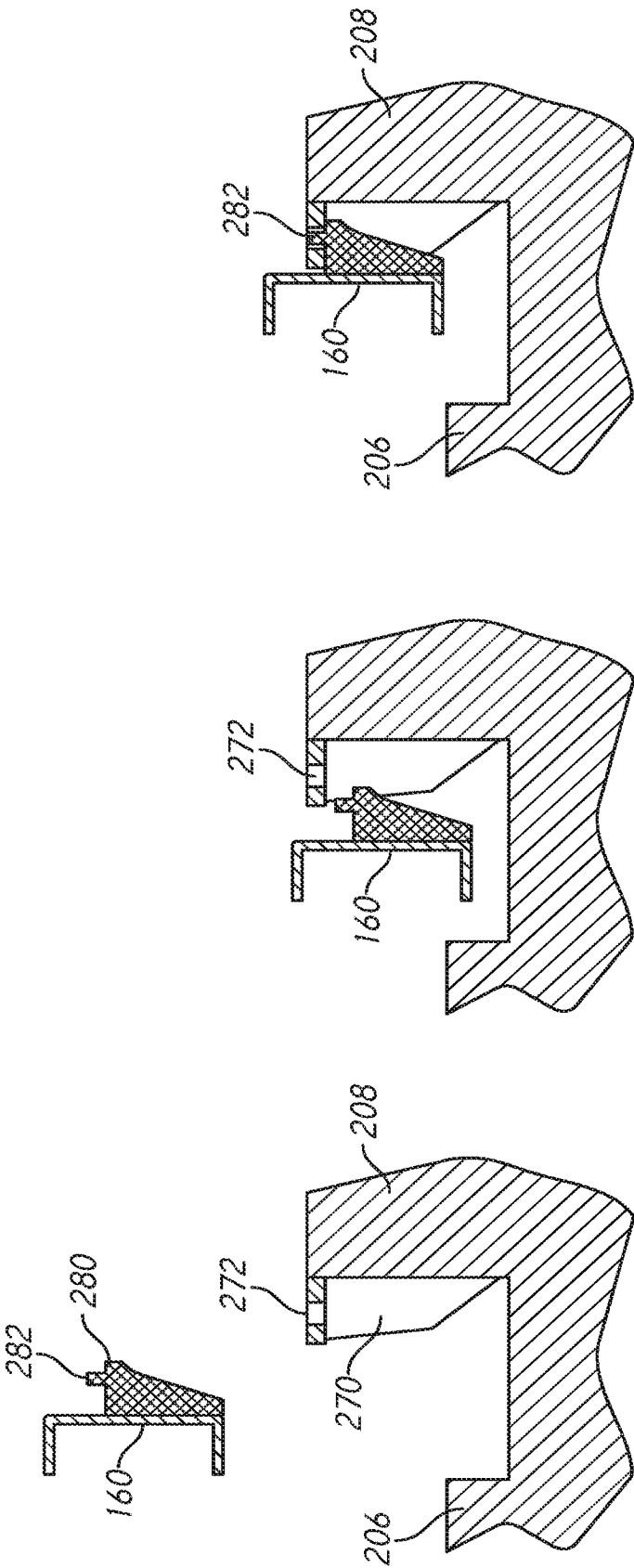


FIG. 7C

FIG. 7B

FIG. 7A

