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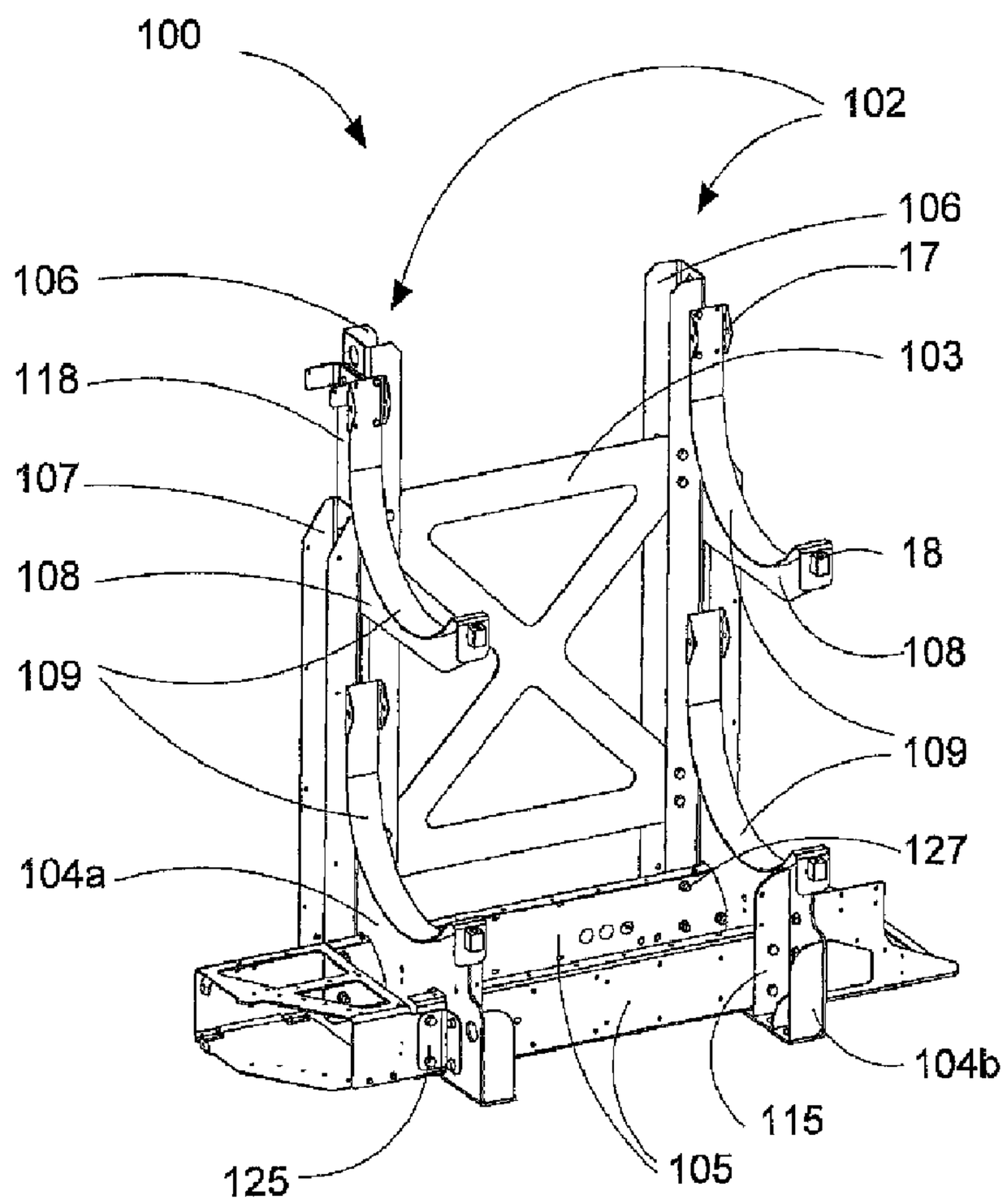

(57) Abrégé/Abstract:
A tank support apparatus and method is disclosed that reduces the space occupied by a tank mounted on a vehicle chassis. In particular, the apparatus reduces the overall height of a tank and frame assembly. The disclosed frame for supporting a tank above

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(57) Abrégé(suite)/Abstract(continued):
a vehicle chassis comprises two vertical support beams laterally spaced apart from one another and two base tank support brackets. Each base tank support bracket attaches to, and extends horizontally from a respective one of the two vertical support beams, and further comprises a bearing surface for supporting the tank and a support member below the bearing surface. Each one of the support members provides a base extending from a respective one of the vertical support beams for distributing loads to the vehicle chassis from the frame and tank.

ABSTRACT

A tank support apparatus and method is disclosed that reduces the space occupied by a tank mounted on a vehicle chassis. In particular, the apparatus reduces the overall height of a tank and frame assembly. The disclosed frame for supporting a tank above a vehicle chassis comprises two vertical support beams laterally spaced apart from one another and two base tank support brackets. Each base tank support bracket attaches to, and extends horizontally from a respective one of the two vertical support beams, and further comprises a bearing surface for supporting the tank and a support member below the bearing surface. Each one of the support members provides a base extending from a respective one of the vertical support beams for distributing loads to the vehicle chassis from the frame and tank.

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TANK SUPPORT APPARATUS AND METHOD

TECHNICAL FIELD

[1] The present disclosure relates to an apparatus and method for supporting a tank on a vehicle chassis aft of a vehicle cab. In particular, the present disclosure relates to an apparatus and method for supporting a tank and reducing the overall height of the tank and tank support apparatus.

BACKGROUND

[2] Presently, most over-the-road heavy vehicles are fuelled by gasoline or diesel fuel. There are certain shortcomings to using such fuels. Such fuels are in limited supply, fuel prices are volatile, and most importantly, they have an adverse impact on the environment because the pollutant gases released into the atmosphere from the combustion of gasoline or diesel fuel are environmentally undesirable.

[3] Related art internal combustion engines can operate efficiently with reduced levels of pollutants in the engine exhaust if fueled with cleaner burning fuels such as natural gas or other combustible gaseous fuels, for example, methane, propane, butane, hydrogen, and blends of such fuels. With equivalence measured on an energy basis, these gaseous fuels can be combusted to produce the same power, with lesser amounts of undesirable emissions such as particulates and greenhouse gases. Such gaseous fuels are stored in fuel tanks carried on board of the vehicle. For example, tanks of compressed natural gas (CNG) can be placed in the trunk or other storage areas of a vehicle and can be interconnected with the vehicle's fuel system for supplying gaseous fuel to the engine. Storing fuel in tanks on board the vehicle is limited by the available space and because gaseous fuel tanks generally occupy more space than liquid fuel tanks carrying the same amount of fuel on an energy equivalent basis. The space required to store gaseous fuels on board a vehicle is larger than for liquid fuels not only because is the energy density is generally lower, but also because gaseous fuels are normally stored at a higher pressure than liquid fuels so the shape of the fuel storage tanks are generally cylindrical and not conformable to the space

available. Space constraints relating to the available storage space can inhibit the distance that the vehicle can travel.

[4] In order to store more fuel in a tank and consequently store more fuel on board the vehicle, gaseous fuels can be stored in liquefied form. For example, liquefied natural gas (LNG) is natural gas which has been cooled to -162° C, a temperature at which point the gas can be stored in liquid form. LNG is stored in special thermally insulated cryogenic fuel tanks to retain the cold temperature. Like CNG tanks, the shape of fuel tanks for storing LNG is still typically cylindrical with domed ends. LNG can be used for all classes of vehicle, but LNG is especially suited for heavy vehicles which require more fuel and for all types of vehicles that require longer travel ranges. For heavy vehicles, the tanks for storing LNG are usually supported on the vehicle chassis. The tank support must withstand the static and dynamic loading requirements imposed by the weight of such tank(s), for example the dynamic loads caused by vehicle acceleration and turning. On a vehicle there are also other preferred characteristics, including a small footprint, lower weight, easy assembly, reduced manufacturing costs, and reduced installation costs.

[5] In the past, supports for supporting tanks on a vehicle have typically been single purpose structures, such as those that use L-brackets or J-brackets attached to the side of a chassis frame. Examples of such arrangements are illustrated in Japanese Patents No. 3695128 and 3695141 by Isuzu Motors®. As described in Japanese Patent No. 3695128, the tank is provided, at its upper and lower sides, with some tie-down plates that are aligned to register with corresponding plates of the L-bracket through a positioning pin and fixed thereto with some bolts. A band for securing the tank to the frame is attached at both of its ends to the L-bracket, as described in Japanese Patent No. 3695141.

[6] Alternatively, tanks have been known to be mounted on heavy vehicles behind the cab. When mounted in this location, it is preferred, and even required in certain countries, that fuel tanks, storing certain fuels, e.g., compressed natural gas, must fit within a prescribed space below a plane extending from the top of the cab to the rear of the vehicle chassis frame, to ensure that the tanks and the supporting frame do not interfere with the trailer and that the tanks carried on board of the vehicle are protected.

[7] The applicant's co-owned Canadian Patent No. 2,621,737, as shown in FIG. 1, relates to frame 1 for supporting a tank on a vehicle chassis, for example LNG fuel tanks aft of a vehicle cab. This design, with its modular, bolted construction has advantages over other frames that

employ a welded construction. For example, a frame on a moving vehicle is subjected to dynamic forces caused by the motion of the vehicle and a structure that is bolted together can withstand more flexing forces compared to a more rigid welded structure that might be more susceptible to cracking. Also a bolted structure is easier to make in a modular design to fit different vehicles, and to combine components made from different materials. For example the tank support brackets 8a, 8b, 8c, 8d can be made from cast or forged pieces and the other frame members such as vertical support beams 2 can be made from structural steel channels. The design of tank support brackets 8a, 8b, 8c, and 8d, provide a bearing surface that cradles a cylindrical fuel tank (not shown), with this bearing surfaces shaped to hold the fuel tank so that it is held in contact with vertical support beams 2 to reduce the distance that frame and the cylindrical tanks extend horizontally from vertical support beams 2. That is, the arc defined by the profile of the cradle is shaped with a radius that matches the radius of the tank and the low point in the arc is spaced a distance from vertical support beam 2 that is equal to the radius of the tank it is designed to hold. In Figure 1, vertical support beams 2 are constructed from two structural members 6 and 7 which have a C-shaped cross section joined with each other back to back. Other constructions are possible but the shown construction allows a modular arrangement with the tank support brackets having connecting tabs sandwiched between structural members 6 and 7. Lower support members 4 transfer forces from the supported fuel tanks and frame to the vehicle chassis, and cross brace 3 and cross brackets 5 connect the two parallel vertical support structures and provide more strength while still providing many open areas for access for maintenance purposes. For a two tank support frame there are manufacturing and cost advantages of using the same support brackets for both the upper and lower tanks. However, for vehicles with frames for supporting one or more tanks, if it is desirable to also reduce the overall height of the frame and tank assembly, there are limits on how low illustrated lower tank support brackets 8c and 8d can be mounted to such a frame without interfering with lower support members 4, which are designed to distribute and transfer the load from the tank and frame assembly to a wider base on the vehicle chassis.

[8] With reference to FIG. 2, frame 1 of FIG. 1 is shown in relation to the outline of a partial view of a vehicle chassis, which comprises longitudinally oriented beams 20. Straps 15 connect to frame 1 at mounting points 17 and 18 for securing tank 19 (shown in dashed outline) to frame 1. A layer between the frame and straps is provided by support bracket liner 14 and strap liner

16, which can provide some cushioning and grip to prevent tank 19 from spinning. Frame attachment members 21 are attached to beams 20 and then frame 1 is attached to frame attachment members 21 by fastening hardware 22, which comprises nuts, bolts and washers.

[9] Heavy vehicles also carry, on board, other equipment that can be attached to the vehicle chassis. One example is equipment for a compressed air system used by the vehicle's brake system. When auxiliary fuel tanks are mounted behind the cab there is also associated fuel system equipment and it would be advantageous to mount such equipment close to the fuel tanks. Rather than a tank support assembly taking away space on the chassis for mounting other components, there can be advantages associated with integrating the tank support assembly with other components and structures for mounting such other components to the vehicle chassis.

[10] Accordingly, a need exists for an improved tank frame mounted on the chassis of a heavy vehicle that not only withstands the loading requirements associated with carrying at least one tank and distributing such loads the vehicle chassis, but that can also reduce the overall height of the tank and support assembly to occupy less space. In addition, for some vehicles it would also be advantageous to integrate such a frame with a structure for mounting other components to the vehicle chassis.

SUMMARY

[11] The present disclosure involves an apparatus and method which provide a solution to foregoing problems experienced in the related art. The present disclosure involves a modular apparatus and method of fabricating and mounting same, for supporting at least one tank and reducing the overall height of the frame and tank assembly.

[12] The disclosed frame for supporting a tank above a vehicle chassis comprises two vertical support beams laterally spaced apart from one another, and two base tank support brackets, each one attached to, and extending horizontally from a respective one of the two vertical support beams. Each one of the base tank support brackets comprises a bearing surface for supporting the tank; and, a support member below the bearing surface, whereby each one of the support members provides a base extending from a respective one of the vertical support beams for distributions loads to the vehicle chassis from the frame and tank.

[13] In preferred embodiments the frame comprises a pair of upper tank support brackets each one having a bearing surface for supporting a second tank from the frame. In such embodiments,

each one of the upper tank support brackets is attached to and extends from a respective one of the two vertical support beams.

[14] The base tank support brackets are preferably shaped to hold the tank in contact against a vertical side of each one of the vertical support beams in order to reduce the depth of the tank and frame assembly on the vehicle chassis. "Depth" is defined herein to mean the distance horizontally on the vehicle chassis that the frame and tank assembly occupies behind the cab in a direction parallel to the chassis beams (beams 20 in FIG. 2).

[15] To increase the structural integrity of the frame it preferably further comprises other structural elements such as cross bracing extending between and attached to each of the two vertical support beams, and/or at least one cross bracket extending between and attached to each of the support members or some other part of the base tank support brackets. In some embodiments at least one of the cross brackets is a mounting plate for supporting equipment associated with vehicle fuel system or other vehicle systems normally mounted on the chassis. For example, such equipment can comprises at least one of a hydraulic cooler, a hydraulic fluid manifold, a hydraulic reservoir, a vaporizer for converting liquefied gaseous fuel into gaseous form, an accumulator tank for storing high pressure gaseous fuel, a fuel filter, an air filter, and an accumulator tank for holding compressed air. In some embodiments at least one cross bracket extends laterally through one of said support members, for example to provide a structural support for an auxiliary mounting structure that extends laterally from said support member. Such auxiliary mounting structures can be attached to cross bracket, and/or to the support member or some other part of the base tank support bracket. An auxiliary mounting structure can be used for providing additional mounting locations for other equipment associated with the tank assembly or other vehicle systems normally mounted to the vehicle chassis, but unlike the enclosed and protected space formed by the cross brackets and base tank support brackets, auxiliary mounting structures extending laterally from the frame are better suited to equipment that requires access, inspection and more frequent maintenance. For example an auxiliary mounting structure provides a convenient location near the tanks on the side of a vehicle where it can be used to support a fill panel with a fill receptacle that is connectable to a fill nozzle for filling the tank. Other equipment such as a hydraulic cooler which requires air flow for cooling the hydraulic fluid can also be mounted to an auxiliary mounting structure. Filters for hydraulic fluid and/or fuel filters are other examples of equipment that require periodic replacement that

benefit by being located in an accessible location, such as that provided by an auxiliary mounting structure. Such structures can also provide protection to the mounted equipment by also providing enclosures, or can serve an addition function as a step for assisting with access to the tanks which can include components such as manual shut off valves mounted directly on the tank.

[16] The lateral spacing between the two vertical support beams and between the support members is determined by alignment with lateral spacing between two longitudinally oriented beams of the vehicle chassis, to which the frame is designed to be attached.

[17] In preferred embodiments, the frame is mountable to the vehicle chassis aft of a vehicle cab. With the frame mounted in this location, the frame assembly preferably has an overall height lower than the vehicle cab, wherein the overall height includes the uppermost portions of the frame and a tank supported by the upper tank support brackets.

[18] Also disclosed is a modular base tank supporting bracket that can be used to manufacture the disclosed frame. The modular base tank supporting bracket being designed for mounting a tank on a vehicle, and comprising: a base for attachment to the vehicle with loads transferred to a chassis of the vehicle over a distance that is substantially the same as a diameter of a tank that the modular base tank supporting bracket is designed to carry; a flange shaped to match the curvature of a cylindrical tank body; and, at least one plate integral with the modular base tank supporting bracket for attachment of the modular base tank supporting bracket to a cross bracket. Such a modular base tank support bracket is designed to be part of a frame for supporting a plurality of tanks in stacked configuration and by being modular it facilitates manufacturing by allowing one part to be used in many different frame configurations. The modular base tank supporting bracket further comprises a tab for attachment of a vertical support beam, whereby a surface of the vertical support beam is tangential to the cylindrical tank body when the tank is mounted in the modular base tank supporting bracket.

[19] Also disclosed is a method of fabricating the disclosed frame for supporting a tank above a vehicle chassis. The method comprises fabricating two vertical support beams; fabricating two base tank support brackets, each have a bearing surface shaped to receive a tank, and an integral support member; attaching each one of the two base tank support brackets to a respective one of the two vertical support beams, such that each the integral support members extends perpendicularly from near the base of one of the two vertical support beams; and spacing the two

vertical support beams a distance that corresponds to the spacing between mounting points on the associated vehicle chassis to which the frame will be mounted, and joining the two vertical support beams to each other with at least one of: cross bracing extending between the vertical support beams and cross brackets extending between the support members.

[20] In preferred embodiments of the method the different pieces of the frame are joined to each other by bolts. Other preferred embodiments of the method comprise fabricating the base tank support brackets by casting or forging.

[21] The method can also comprise fabricating the vertical support beams as composite beams. This allows the beams to be made more modular for different configurations and for mounting tank support brackets which are fabricated with tabs to be sandwiched between two beams to facilitate a strong structure with the cylindrical tank bodies mounted in tangential contact (or near contact) with the vertical support beams.

[22] Some embodiments of the method of fabricating the disclosed frame further comprise attaching at least one auxiliary mounting structure extending laterally from the support members.

[23] The method of mounting the disclosed frame onto a vehicle chassis comprises: installing a resilient member between the frame and the vehicle chassis; and, employing removable fasteners to attach the frame to the vehicle chassis with the resilient member there between. Because the resilient member can be exposed to a severe environment where it is exposed to the outside elements, in preferred embodiments, the resilient member is made from a synthetic rubber. As described elsewhere in this disclosure, while many types of substantially equivalent fasteners can be used within the spirit of the disclosed apparatus, removable fasteners comprising nuts and bolts are a preferred type of fastener.

[24] A method of supporting a tank on a frame above a vehicle chassis is disclosed comprising: providing two vertical support beams laterally spaced apart from one another; and providing two base tank support brackets, each one attached to, and extending from a respective one of the two vertical support beams, and integrating in the two base tank support brackets a bearing surface for supporting the tank and a support member below the bearing surface and extending horizontally from where it is attached to the respective one of the two vertical support beams, whereby each one of the support members is attachable to the chassis to provide a wider base for supporting and transferring loads to the vehicle chassis from the frame and tank. This method can further comprise mounting to the frame at least one auxiliary mounting structure

extending laterally from the support member. Furthermore, the method can comprise mounting a fill panel to the auxiliary mounting structure, the fill panel comprising a fill receptacle that is connectable to a fill nozzle for filling the tank.

BRIEF DESCRIPTION OF THE DRAWING

[25] The above aspects and other aspects, features, and advantages of several embodiments of the present disclosure will be more apparent from the following Detailed Description as presented in conjunction with the following several figures of the Drawing.

[26] FIG. 1 is a perspective view of a frame for supporting two tanks on a vehicle chassis, in accordance with the applicant's prior disclosure in Canadian Patent No. 2,621,737.

[27] FIG. 2 is a perspective semi-exploded view of the prior art frame of FIG. 1 showing where it can be attached to the chassis of a heavy vehicle chassis, this same location being where the frame of the present disclosure can be mounted.

[28] FIG. 3 is a perspective view of a frame for supporting two tanks on a vehicle chassis, in accordance with an embodiment of the present disclosure.

[29] FIG. 4 is an exploded view of the base portion of a frame that shows how auxiliary mounting structures that extend laterally from the support member can be attached, in accordance with an embodiment of the present disclosure.

[30] FIG. 5 is an exploded view of a vertical beam and tank support bracket assembly of a frame, in accordance with an embodiment of the present disclosure.

[31] FIG. 6 is an exploded view of a frame for supporting one tank without auxiliary mounting structures, in accordance with an embodiment of the present disclosure.

[32] FIG. 7 is a perspective view of a modular base tank support bracket, in accordance with an embodiment of the present disclosure.

[33] FIG. 8 is a side view of a frame for supporting two tanks, in accordance with an embodiment of the present disclosure.

[34] FIG. 9 is an exploded view showing an arrangement for attaching the frame to a vehicle chassis, in accordance with an embodiment of the present disclosure.

[35] Corresponding reference characters indicate corresponding components throughout the several figures of the Drawing. Elements in the several figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. Also, common, but well-understood,

elements that are useful or necessary in commercially feasible embodiment are often not depicted in order to facilitate a less obstructed view of these various embodiments of the present disclosure.

DETAILED DESCRIPTION

[36] The following description is not to be taken in a limiting sense, but is made merely for the purpose of describing the general principles of exemplary embodiments. The scope of the disclosure should be determined with reference to the Claims. Reference throughout this specification to "one embodiment," "an embodiment," "a preferred embodiment", or similar language means that a particular feature, structure, or characteristic that is described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, appearances of the phrases "in one embodiment," "in an embodiment," "a preferred embodiment", and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[37] Further, the described features, structures, or characteristics of the present disclosure may be combined in any suitable manner in one or more embodiments. In the Detailed Description, numerous specific details are provided for a thorough understanding of embodiments of the disclosure. People working in the field of the technology will recognize, however, that the embodiments of the present disclosure can be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the present disclosure.

[38] Referring to FIG. 3, shown is a perspective view of frame 100 for supporting two tanks on a vehicle chassis, in accordance with a preferred embodiment. Frame 100 comprises two vertical support beams 102 to which are attached two base tank support brackets 104a and 104b for holding a lower tank (not shown in FIG. 3 but similar to the lower tank shown in dashed lines in FIG. 2) and two upper support brackets 108 for holding an upper tank (not shown in FIG. 3 but similar to tank 19 shown in dashed outline in FIG. 2).

[39] Vertical support beams 102 in this embodiment are composite beams, meaning that they are fabricated from two or more structural members joined together by nuts and bolts, rivets, screws or other like fasteners. In this embodiment two structural members 106 and 107 are

channels, each with a C-shaped cross section, but in other embodiments (not shown) other shapes for these structural members can be employed such as T-shapes, L-shapes and square or rectangular shapes. In preferred embodiments the selected shapes each have a flat side that is arranged opposite to the flat side of the opposing vertically oriented member so that flat tabs 114 (visible in FIGURES 5 and 7) and 118 belonging to respective base tank support brackets 104a, 104b and upper support brackets 108 can be inserted there between, with broad contact surfaces between vertical support members 106 and 107. The spacing between vertical support beams 102 is determined by the spacing needed to align with the mounting points associated with the longitudinally oriented chassis beams onto which frame 100 is to be attached. Cross brackets 105 are attached to base tank support brackets 104a and 104b. Because the main elements of base tank support brackets 104a and 104b are perpendicular to cross brackets 105 the connecting points are reinforced, for example by forming base tank support brackets 104a and 104b with a piece 115 that mates to cross bracket 105, or by using angle brackets 125, In preferred embodiments one of cross brackets 105 is positioned adjacent to the vertical support beams 102 so that the adjacent cross bracket 105 can be attached, as shown, by way of example, by bolt 127, to vertical support beam 102, which is in turn attached to base tank support bracket 104b. In the illustrated embodiment, cross brace 103 is attached to vertical support beams 102 by nuts and bolts.

[40] Both base tank support brackets 104a and 104b, and upper support brackets 108 each respectively comprise flange 109 that provides a bearing surface area for supporting a tank. Flange 109 provides a broader surface area for distributing the loads from a tank to the respective support members that extend from vertical support beams 102. In the preferred arrangement shown in FIG. 3, flanges 109 are shaped with a radius that matches the radius of the tank the frame is designed to support, with allowance for a liner, such as support bracket liner 14 shown in FIG. 2. Shaping flange 109 with this radius, in addition to the width of flange 109 helps to distribute loads from the tank to the support brackets over a larger bearing surface area. In preferred embodiments, the shape of flange 109 has its lowest point spaced from vertical support beams 102 by a horizontal distance that is equal to the radius of the tank that frame 100 is designed to hold. With this geometry, when the tank is mounted in the frame it is in contact with vertical support beams 102 so that the depth of the space occupied by the tank behind the frame

is reduced to the diameter of the tank. The tank support brackets also show mounting points 17 and 18 for attaching a strap (not shown) for holding a tank to each of the support brackets.

[41] An advantage of the presently disclosed embodiments of a tank support frame is that a lower overall height of the frame and tank assembly can be achieved because the base tank support bracket integrates into one piece, a tank support bracket and a base support member, shown as two separate pieces 8c or 8d and 4 respectively, as shown in prior art FIG. 1. While the presently disclosed design prevents standardization of all tank support brackets, which is an advantage of the shown prior art design, in addition to allowing a lower overall height, which allows larger diameter tanks to be mounted within the same spatial limitations, it can allow a lighter overall structure, or compared to prior art designs, when the integrated base tank support bracket is lighter than a separate tank support bracket and base support member. Combining the lower tank support bracket with the base support member also reduces the overall parts count (for these pieces themselves and the number of fasteners needed for assembly), and the reduced number of fasteners also reduces the manufacturing time.

[42] Another advantage of the described fabrication method versus a welded construction is that by using fasteners such as nuts and bolts, rivets, screws, or other like fasteners, the same frame concept can be adapted to different vehicles with different configurations using many of the same components. The same vertical support beams 102, base tank support brackets 104 and upper support brackets 108 can be used for vehicles with different spacing between the vehicle chassis beams by using different cross brackets 105 (or by using different drilling patterns on the same cross brackets 105), or by using different geometries for frame attachment members between frame 100 and the vehicle chassis beams. The modular construction also facilitates the fabrication of frames designed to hold one tank or a plurality of tanks by changing the height of the vertical support beams. In addition, a frame fabricated with such fasteners, compared to a welded frame, is better able to withstand the dynamic loads generated during the normal operation of a vehicle, which can include flexing and twisting loads.

[43] Frame 100 is also shown with auxiliary mounting structures extending laterally from each side of frame 100. These auxiliary mounting structures function as supports for mounting auxiliary equipment and/or as structures for protecting equipment mounted between base tank support brackets 104 and the auxiliary mounting structures. These auxiliary mounting structures are described in more detail below with reference to FIG. 4.

[44] For systems that use a pump to deliver fluid from the tank, it is known in some systems to use a hydraulic drive for a reciprocating piston pump. With such systems it is efficient to locate components associated with the hydraulic system near the pump and tanks. FIG. 4 shows a view of the base portion of a frame with auxiliary support structures 130 and 136 shown in exploded view to illustrate how they can be attached to a modular frame in accordance with this disclosure. First auxiliary support structure 130 can be employed to mount auxiliary equipment such as a hydraulic cooler. First auxiliary support structure 130 has an opening in the horizontal base to allow vertical air flow, for example through an air cooler that can be equipped with a fan to increase air flow and cooling capacity. Plate 132 in an integral part of auxiliary support structure 130 and it provides a mounting location for other equipment, such as a hydraulic filter. First auxiliary support structure 130 provides a location where the mounted equipment is accessible for maintenance purposes and where such equipment close is also close to the pump and tank. Bolts are shown for mounting first auxiliary mounting structure 130 at one side to one of cross brackets 105 and at another side directly to base tank support member 104b. In this embodiment, cross bracket 105 is designed to extend through base tank support bracket 104b, to provide a connection point with auxiliary support structure 130.

[45] FIG. 4 also shows a second auxiliary mounting structure 136 that can be used, for example, to provide a mounting structure that protects a fill panel, which comprises at least one receptacle for connecting to a filling nozzle for filling a tank supported by one of the disclosed frames. A vertical panel door can be mounted on the angled corner to further protect the fill panel from the outside environment, including the weather, gravel, mud, dust or other debris that a vehicle might be exposed to. Other components associated with a fill panel can include instrumentation such as a pressure gauge or other instrument that is indicative of the amount of fuel in an associated tank. For frames that carry a plurality of tanks, the fill panel can comprise separate receptacles and instrumentation for each tank, facilitating the filling process by grouping the receptacles at a convenient location near the side of the vehicle where it is convenient for a person to attach a filling nozzle. In other embodiments, the fill panel can be designed with one receptacle together with valves and sensors configured to divert flow from one tank to another tank when one tank is determined to be full. Tanks typically have other equipment mounted directly on the tank, which can comprise a fuel pump, pressure relief valves, manual shut off valves, and other such components known for such systems. When the tanks are

mounted on a frame of the disclosed type, especially when there are a plurality of tanks in a stacked configuration, it may be necessary to gain access to one of the tanks on the vehicle. In such cases, second auxiliary mounting structure 136 can be designed to be strong enough to support the weight of a person wishing to step on top of it, and the top of second auxiliary mounting structure 136 can be made with an anti-slip surface. Like first auxiliary mounting structure 130, second auxiliary mounting structure 136 is shown in FIG. 4 being attachable to the modular frame by nuts and bolts, in this example, on both sides it is attached to cross brackets 105.

[46] FIG. 5 shows an exploded perspective view of a vertical beam and tank support bracket assembly that more clearly shows how base tank support bracket 104a and upper tank support bracket 108 comprise respective tabs 114 and 118 that are clamped between vertical support members 106 and 107 when the frame is assembled.

[47] In addition to the described auxiliary mounting structures just described, with reference to the overall frame structure shown, for example, in FIGS. 3 and 4, cross brackets 105 can also be employed to provide a useful mounting location for additional equipment associated with the tanks, and auxiliary equipment associated with other vehicle systems. The enclosed structure provided by base tank support brackets 104a, 104b and cross brackets 105 defines a protected space that is suitable for components that do not require frequent maintenance or inspection but that benefit from being near this location on a vehicle. For example, in this location an accumulator vessel for holding high pressure fuel pumped from the tank can be mounted to one of cross brackets 105. Hydraulic manifolds, valves and other piping associated with the hydraulic drives for fuel pumps for delivering fuel from the tank(s) can also be routed through this space and supported from one of cross brackets 105. Also mountable to cross brackets 105 are hydraulic controllers, for example, an electronic control unit for such hydraulic systems. As required by the vehicle, other equipment required to be mounted on the chassis can be mounted to cross brackets 105, either inside the protected space (if such equipment is of a size that will fit therein), or to the outward facing sides of these cross brackets. For example, many work trucks use compressed air for air brake systems, and an accumulator for storing pressurized air can be mounted in the protected space defined by cross brackets 105 and base tank support brackets 104a and 104b.

[48] While the advantage of reducing the overall height of the frame and tank assembly is more beneficial for frames that support a plurality of tanks in stacked configuration, the modular design of the disclosed frame advantageously allows many of the same modular components to be shared by frames that one, two, three or any number of tanks. FIG. 6 shows an exploded view of frame 200 that is for holding only one tank. Using common components with other configurations, a single vertical support member106 is all that is needed for vertical support beam 202, to enable the use of cross brace 123 that is the same piece that can also be used for frames designed to carry a plurality of tanks. In an alternative arrangement (not shown), a different cross brace with a lower height can be used with a shorter vertical support member instead of vertical support member 106, or the cross brace can be attached to base tank support brackets 104a and 104b. The connections between cross brackets 105 and base tank support brackets 104a and 104b can be made with plates 115 and/or angle brackets without requiring a vertical support beam. Depending upon the calculated loads for a specific frame, in still other configurations it can be determined that a cross brace is not required.

[49] It will be understood from this disclosure that the disclosed modular frame pieces can also be used to make frames that can carry one, two, three, or any number of tanks that will fit within the spatial limitations associated with a particular vehicle, and to benefit from the manufacturing advantages of being able to use the same modular components for different frame configurations. Figure 7 shows modular base tank support bracket 104b, with integral plates 115 facing towards the center-line of the frame for connection to a cross bracket. From this view it can be seen that modular base tank support bracket 104b has a flanged base on the bottom with four openings (two at each end) for receiving hardware for mounting the frame to a vehicle chassis. The mounting hardware is described with reference to FIG. 9 below. This flanged base 116 is preferably as wide as the diameter of the tank that the frame is designed to hold, in order to spread the load from the tank and frame assembly over a wider area for better structural strength without taking up more depth on the frame than that occupied by the tank and vertical beams. Base tank support bracket comprises cut away portions to reduce weight in areas where there is no need for structural support and to allow openings through which piping and/or electrical wiring can be routed. This view also shows tab 114 which is provided for attachment to a vertical support beam.

[50] FIG. 8 is a side elevation view of frame 100 configured to hold two tanks in stacked configuration. This view illustrates how in preferred embodiments the bearing surface of the tank supports are shaped to hold the tanks in contact with vertical support beams 102 to reduce depth D of the tanks in relation to vertical support beams 102. Sufficient spacing must still be left between base tank support brackets 104a and upper tank support bracket 108 to permit a tank to be installed and removed from the lower position on the base tank support brackets. However, this view further illustrates how the overall height can be reduced compared to prior art frame 1, shown in FIG. 1, which employs separate lower support member 4 that is not integrated with the lower tank support brackets 8c and 8d. FIG. 8 also shows how the base tank support brackets have a base that is mountable to a vehicle chassis that distributes the transferred loads over a broad area of the chassis. That is, the base of the base tank support brackets preferably takes up about the same depth as that which is occupied by the tanks that it is designed to carry.

[51] FIG. 9 is a detailed perspective view of the arrangement for attaching a frame to a vehicle chassis according to a preferred embodiment. The hardware for attaching the frame to the vehicle chassis is shown in exploded view. This hardware comprises bolt 140, washers 142, lock washer 144, nut 146 and a resilient vibration dampener 148. Resilient vibration dampener 148 is shown with a smaller upper flange and a larger lower flange whereby the smaller flange can be squeezed through hole 150 so that one flange is installed on either side of a flat member of base tank support bracket 104a. In preferred embodiments, similar mounting hardware is employed at each location where the frame is structurally connected to the vehicle chassis. Because the frame is mounted to a vehicle and subjected to steady and irregular vibrations during normal operation, it is helpful to have some dampening between the vehicle chassis and the frame.

[52] Understood is that, although certain details are provided for a thorough understanding of the embodiment described, other embodiments can exclude some of the described features or incorporate additional features. For example, the components of the tank frame are assembled together with nuts and bolts, as described above, or with any other equivalent removable fasteners. A bolted structure has the advantage that it is easy to assemble into different configurations, e.g., a structure comprising more or less pairs of tank support brackets for supporting one or more tanks) or can be easily disassembled into smaller configurations for shipping or parts inventory and storage. While all of these advantages are realized with the preferred bolted construction, there are other advantages of the disclosed method and frame, such

as the compact space arrangement, the strong yet efficient structure that can be achieved by making the frame using other fasteners for joining the structural members of the composite vertical support beam and the tank support brackets. That is, in other embodiments, the disclosed frame can be made using welds, rivets, or a combination of fasteners, and still achieve many of the disclosed advantages.

[53] Information as herein shown and described in detail is fully capable of attaining the above-described object of the present disclosure, the presently preferred embodiment of the present disclosure, and is, thus, representative of the subject matter which is broadly contemplated by the present disclosure. The scope of the present disclosure fully encompasses other embodiments which may become obvious to those skilled in the art, and is to be limited, accordingly, by nothing other than the appended claims, wherein any reference to an element being made in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more." All structural and functional equivalents to the elements of the above-described preferred embodiment and additional embodiments as regarded by those of ordinary skill in the art are hereby expressly incorporated by reference and are intended to be encompassed by the present claims.

[54] Moreover, no requirement exists for a system or method to address each and every problem sought to be resolved by the present disclosure, for such to be encompassed by the present claims. Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. However, that various changes and modifications in form, material, work-piece, and fabrication material detail may be made, without departing from the spirit and scope of the present disclosure, as set forth in the appended claims, as may be apparent to those of ordinary skill in the art, are also encompassed by the present disclosure.

We Claim:

1. A frame for supporting a tank above a vehicle chassis, said frame comprising:

two vertical support beams laterally spaced apart from one another; and

two base tank support brackets, each one attached to, and extending horizontally from a respective one of said two vertical support beams, wherein each one of said base tank support brackets comprises:

a bearing surface for supporting said tank; and,

a support member below said bearing surface, whereby each one of said support members provides a base extending from a respective one of said vertical support beams for distributions loads to said vehicle chassis from said frame and tank.

2. The frame of claim 1 further comprising a pair of upper tank support brackets each one having a bearing surface for supporting a second tank from said frame, each one of said upper tank support brackets being attached to and extending from a respective one of said two vertical support beams.

3. The frame of claim 1 wherein said base tank support brackets are shaped to hold said tank in contact against a vertical side of each one of said vertical support beams.

4. The frame of claim 1 further comprising cross bracing extending between and attached to each of said two vertical support beams.

5. The frame of claim 1 further comprising at least one cross bracket extending between and attached to each of said base tank support brackets.

6. The frame of claim 5 wherein said cross bracket is a mounting plate for supporting equipment associated with vehicle fuel system or other vehicle systems normally mounted on the chassis.

7. The frame of claim 6 wherein said equipment comprises at least one of a hydraulic cooler, a hydraulic fluid manifold, a hydraulic reservoir, a vaporizer for converting liquefied gaseous fuel into gaseous form, an accumulator tank for storing high pressure gaseous fuel, a fuel filter, an air filter, and an accumulator tank for holding compressed air.

8. The frame of claim 5 wherein lateral spacing between said two vertical support beams and between said support members is determined by alignment with lateral spacing between two longitudinally oriented beams of said vehicle chassis, to which said frame is designed to be attached.

9. The frame of claim 5 further comprising at least one cross bracket that extends laterally through said support members.

10. The frame of claim 1 further comprising at least one auxiliary mounting structure extending laterally from said support member of said base tank support brackets.

11. The frame of claim 10 wherein said at least one auxiliary mounting structure is attached to at least one cross bracket.

12. The frame of claim 10 wherein said at least one auxiliary mounting structure supports a fill panel with a fill receptacle that is connectable to a fill nozzle for filling said tank.

13. The frame of claim 2 wherein said frame is mountable to said vehicle chassis aft of a vehicle cab, wherein said frame, when so mounted, has an overall height lower than said vehicle cab, wherein said overall height includes the uppermost portions of the frame and a tank supported by said upper tank support brackets.

14. A modular base tank supporting bracket that can be used to manufacture the frame of claim 1, said modular base tank supporting bracket being designed for mounting a tank on a vehicle and comprising:

a base for attachment to said vehicle with loads transferred to a chassis of said vehicle over a distance that is substantially the same as a diameter of a tank that said modular base tank supporting bracket is designed to carry;
a flange shaped to match the curvature of a cylindrical tank body; and
at least one plate integral with said modular base tank supporting bracket for attachment of said modular base tank supporting bracket to a cross bracket.

15. The modular base tank supporting bracket of claim 26 further comprising a tab for attachment of a vertical support beam, whereby a surface of said vertical support beam is tangential to said cylindrical tank body when said tank is mounted in said modular base tank supporting bracket.

16. A method of fabricating a frame for supporting a tank above a vehicle chassis, said method comprising:

fabricating two vertical support beams;
fabricating two base tank support brackets, each have a bearing surface shaped to receive a tank, and an integral support member;
attaching each one of said two base tank support brackets to a respective one of said two vertical support beams, such that each said integral support members extends perpendicularly from near the base of one of said two vertical support beams; and
spacing said two vertical support beams a distance that corresponds to the spacing between mounting points on the associated vehicle chassis to which said frame will be mounted, and joining said two vertical support beams to each other with at least one of: cross bracing extending between said vertical support beams and cross brackets extending between said support members.

17. The method of claim 16 wherein the different pieces of said frame are joined to each other by bolts.

18. The method of claim 16 wherein said base tank support brackets are fabricated by casting or forging.

19. The method of claim 16 wherein said vertical support beams are fabricated as composite beams.

20. The method of claim 19 wherein said base tank support brackets are fabricated with a tab that is inserted between two members of said composite beams and then attached there between.

21. The method of claim 16 further comprising attaching at least one auxiliary mounting structure extending laterally from said support members.

22. A method of mounting the frame of claim 1 onto a vehicle chassis comprising:

installing a resilient member between said frame and said vehicle chassis; and,

employing removable fasteners to attach said frame to said vehicle chassis with said resilient member there between.

23. The method of claim 22 wherein said resilient member comprises synthetic rubber.

24. The method of claim 22 wherein said removable fasteners comprise nuts and bolts.

25. A method of supporting a tank on a frame above a vehicle chassis, said method comprising:

providing two vertical support beams laterally spaced apart from one another; and

providing two base tank support brackets, each one attached to, and extending from a respective one of said two vertical support beams, and integrating in said two base tank support brackets a bearing surface for supporting said tank and a support member below said bearing surface and extending horizontally from where it is attached to said respective one of said two vertical support beams, whereby each one of said support members is attachable to said chassis to provide a wider base for supporting and transferring loads to said vehicle chassis from said frame and tank.

26. The method of claim 25 further comprising mounting to said frame at least one auxiliary mounting structure extending laterally from said support member.

27. The method of claim 26 further comprising mounting a fill panel to said auxiliary mounting structure, said fill panel comprising a fill receptacle that is connectable to a fill nozzle for filling said tank.

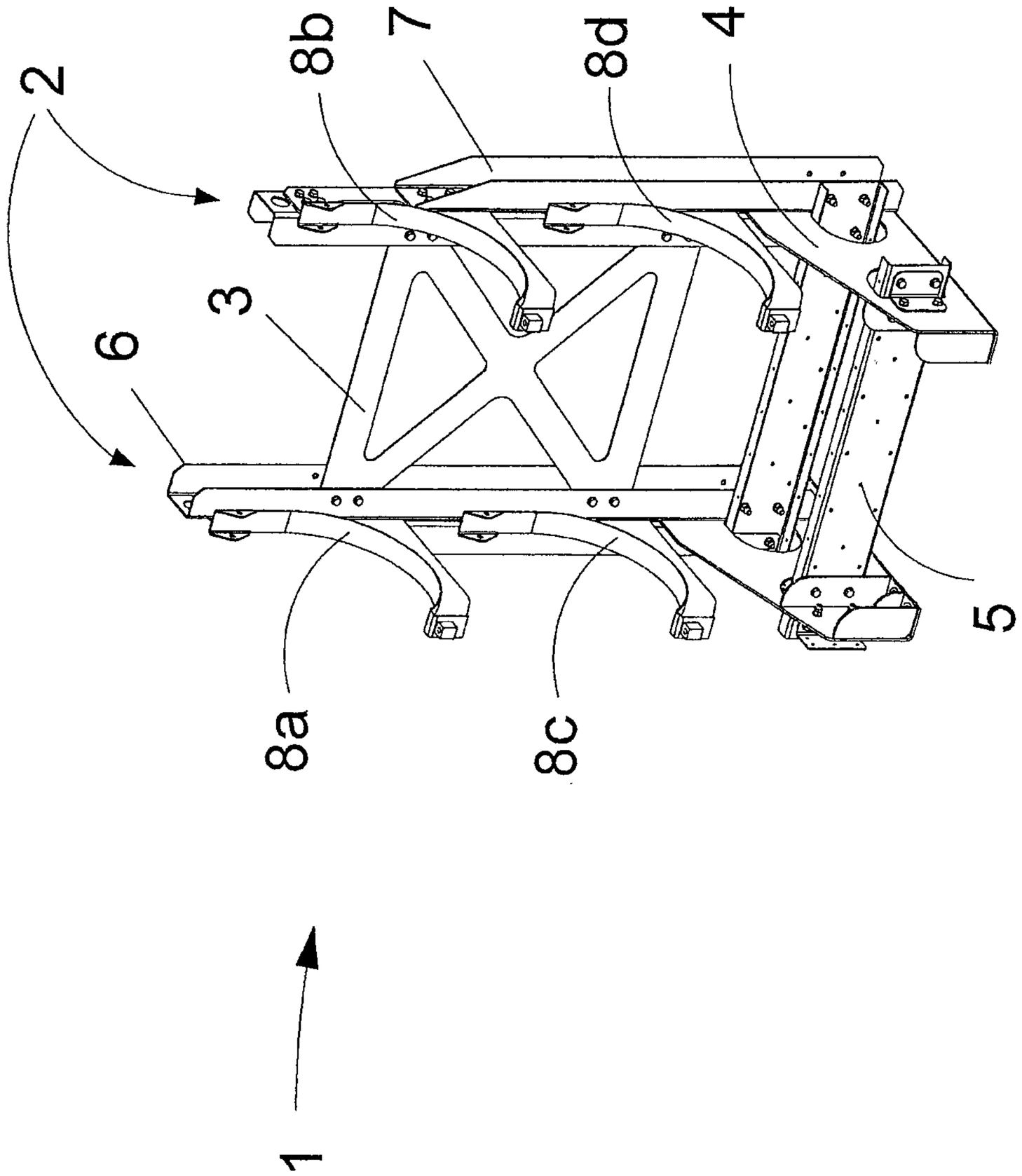

Fig. 1
PRIOR ART

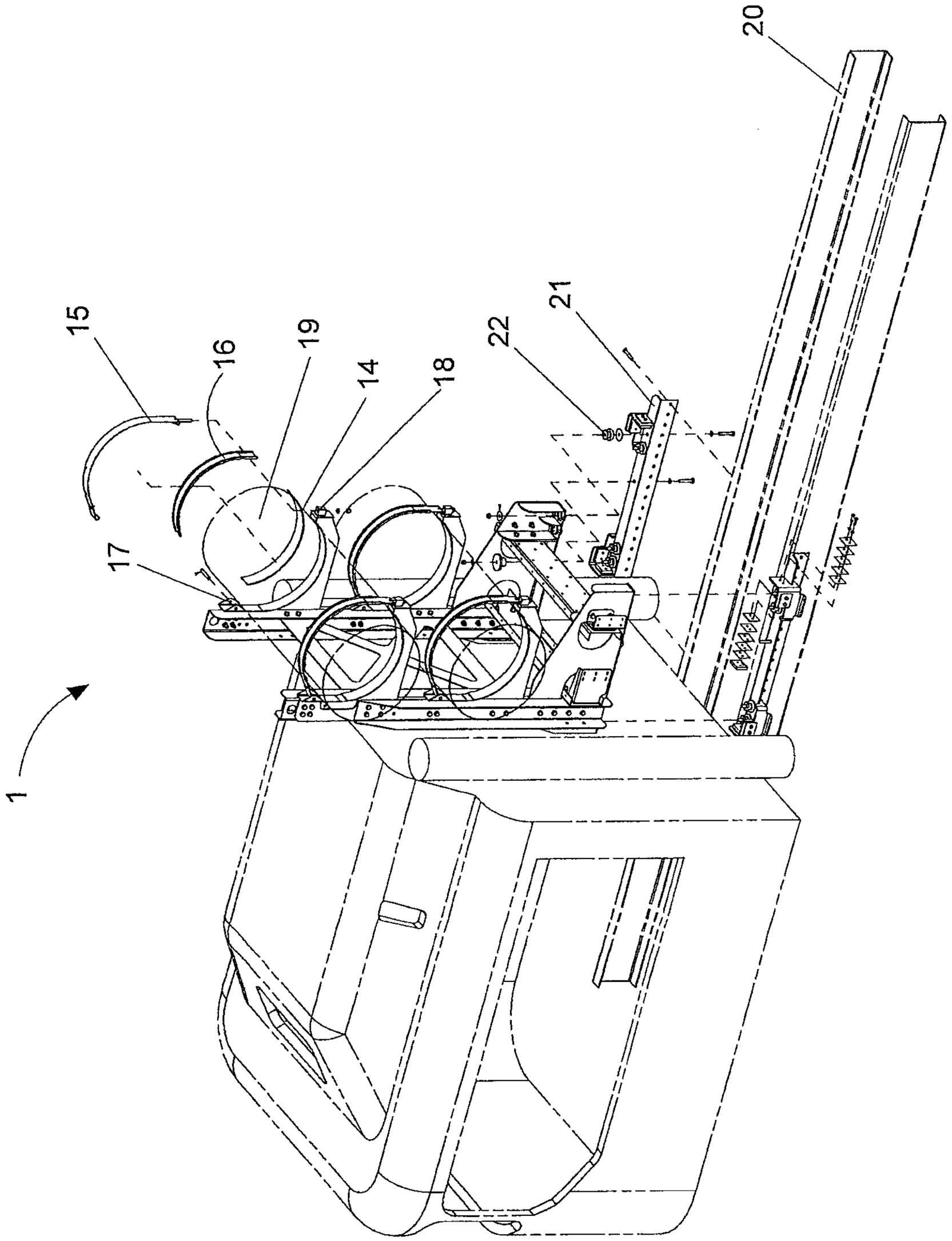

FIG. 2
PRIOR ART

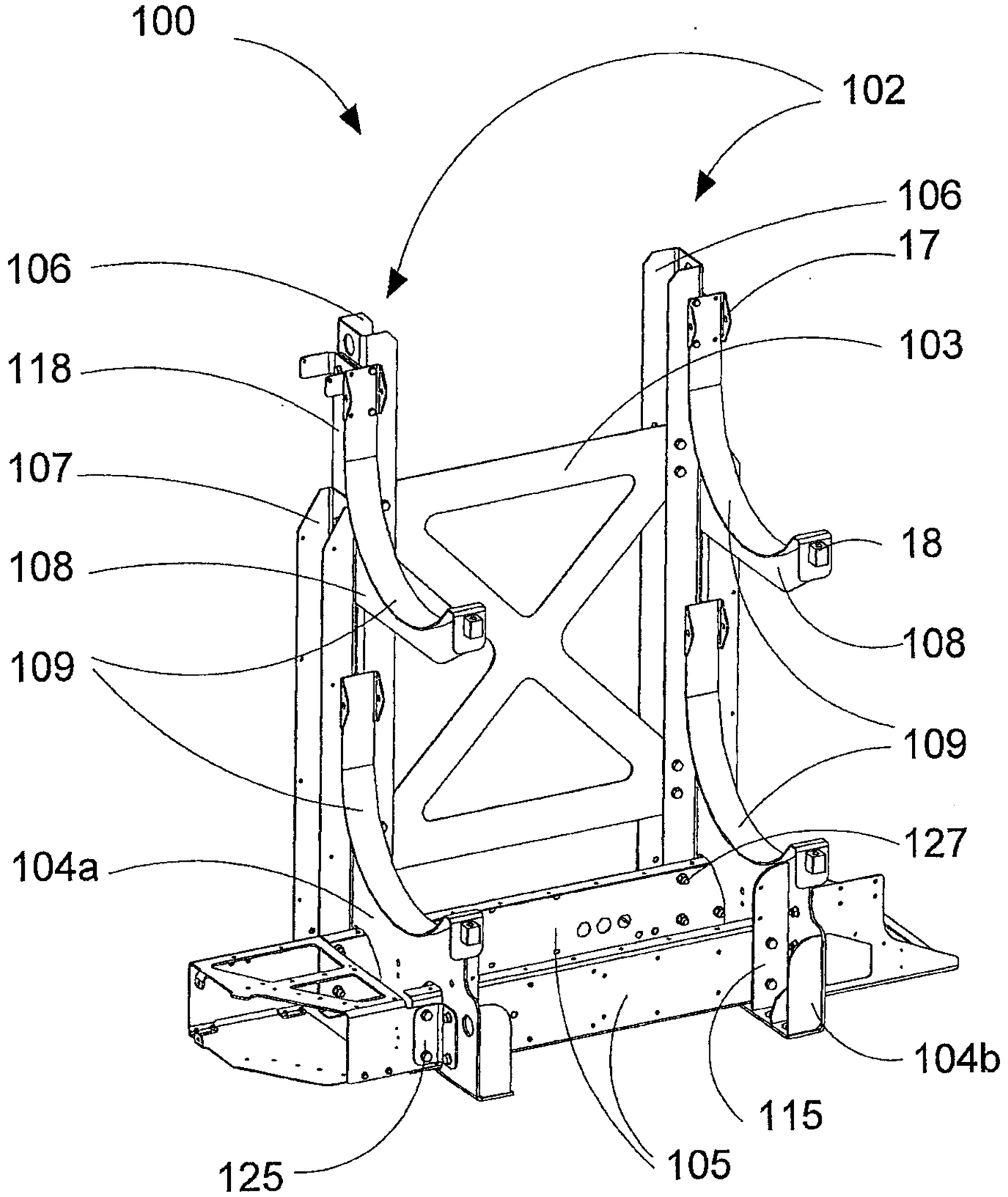
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FIG. 3

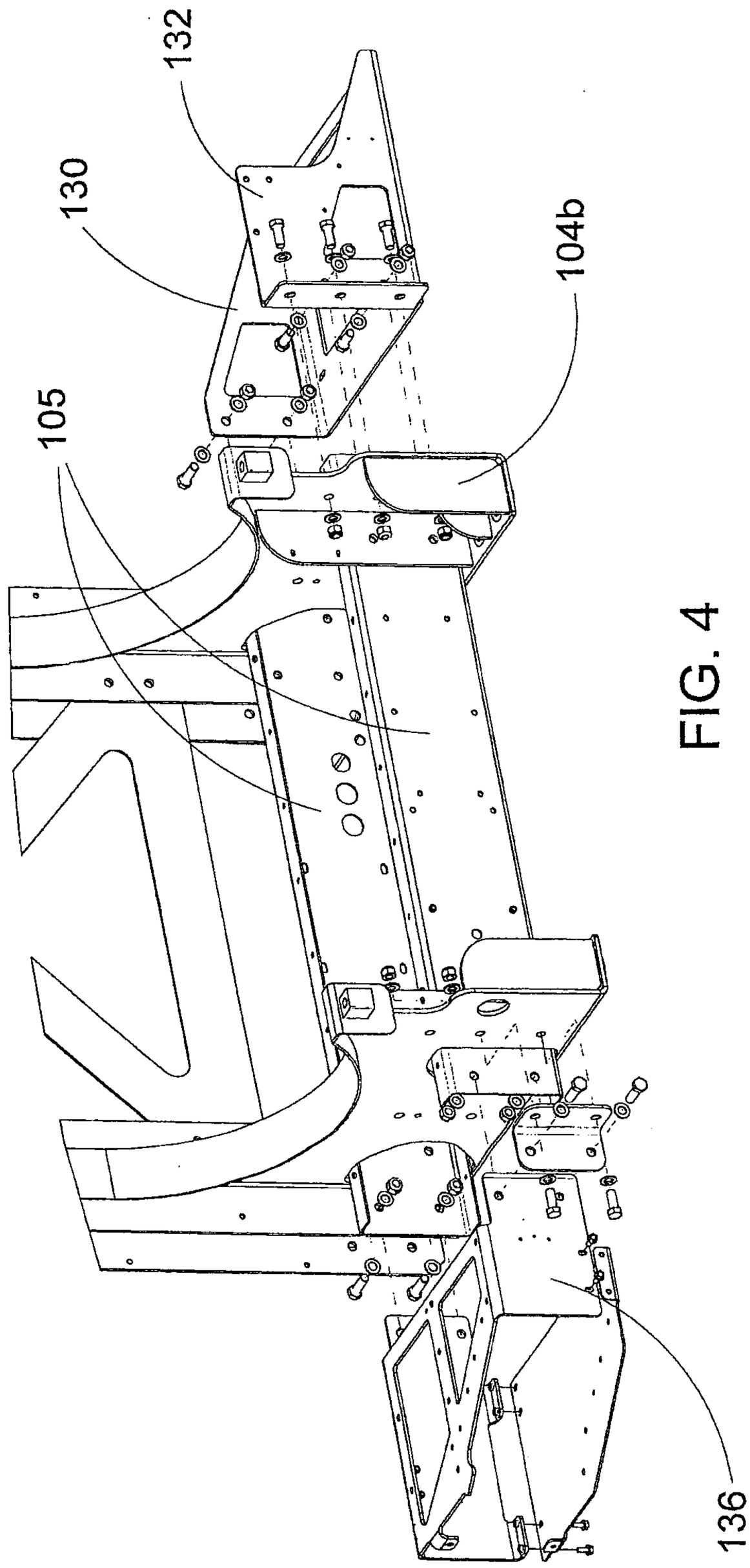


FIG. 4

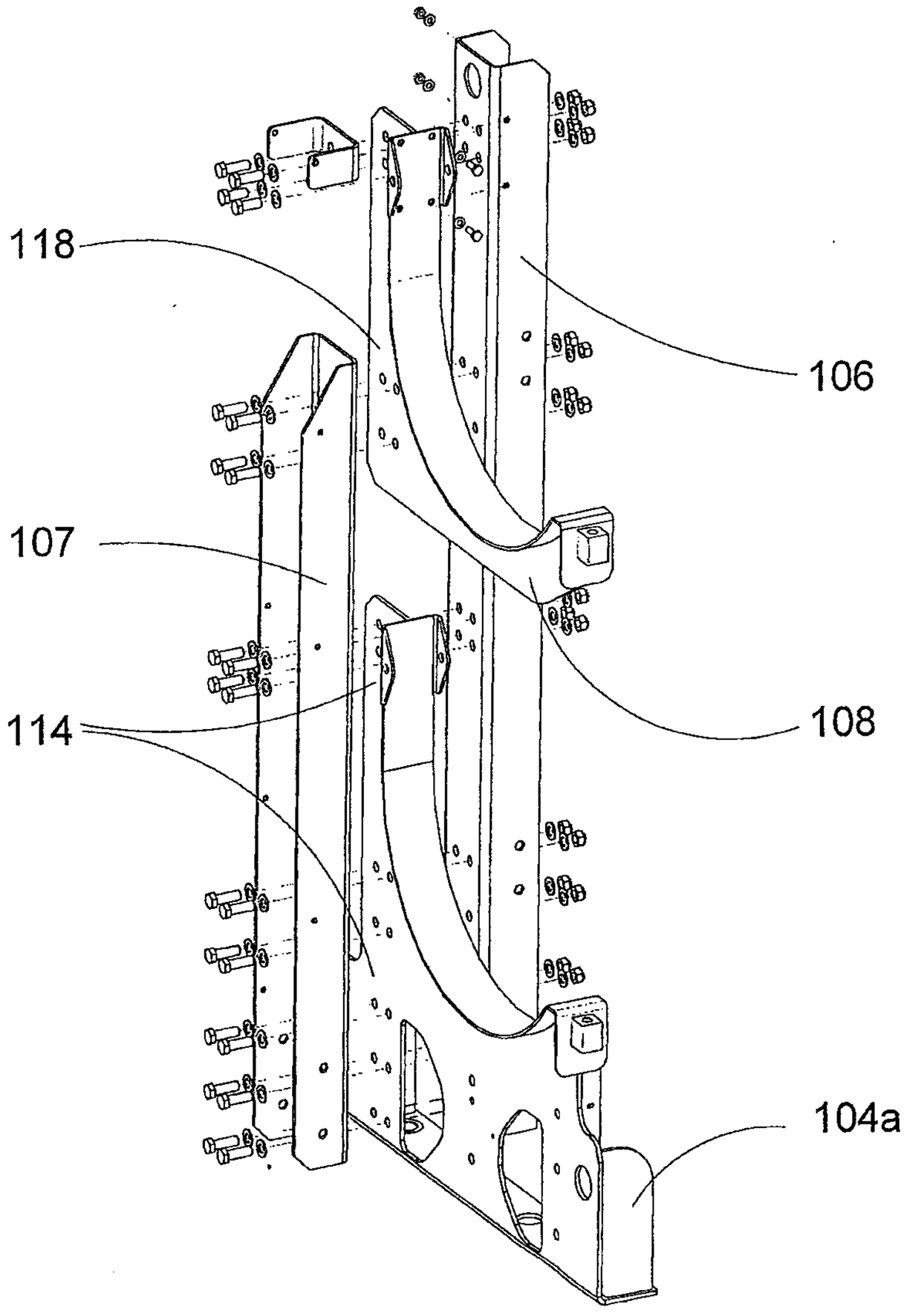


FIG. 5

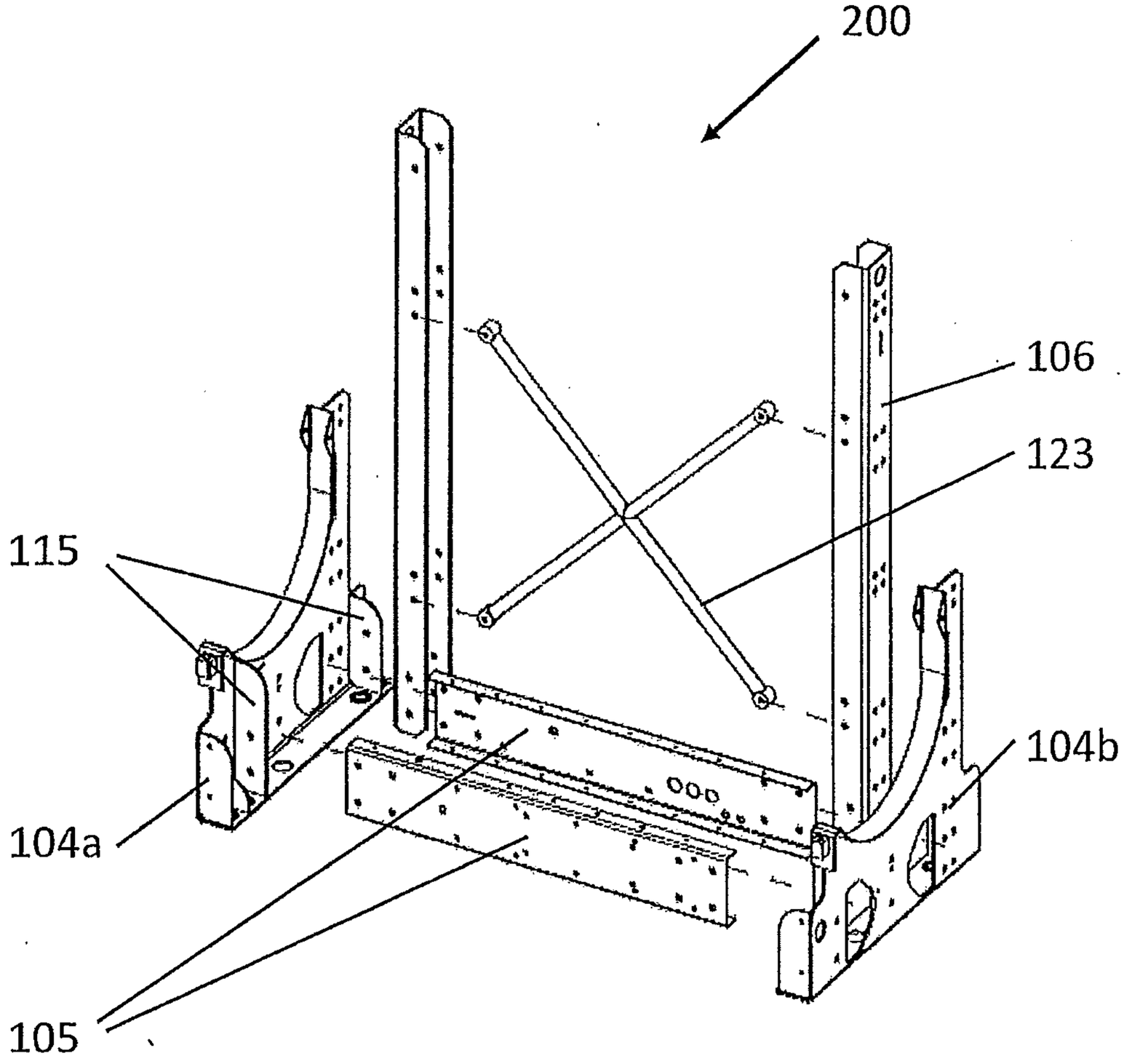


FIG. 6

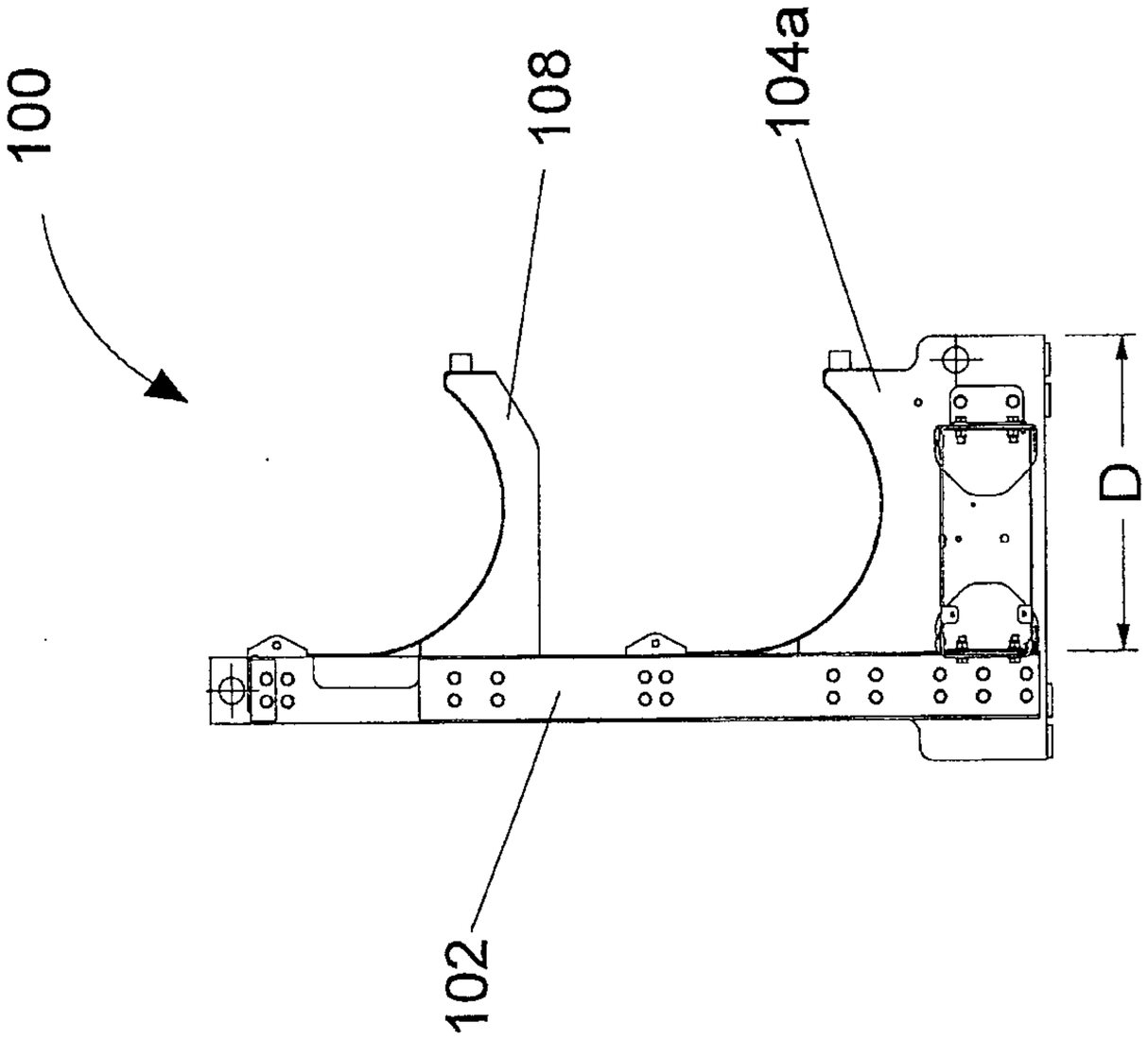


FIG. 8

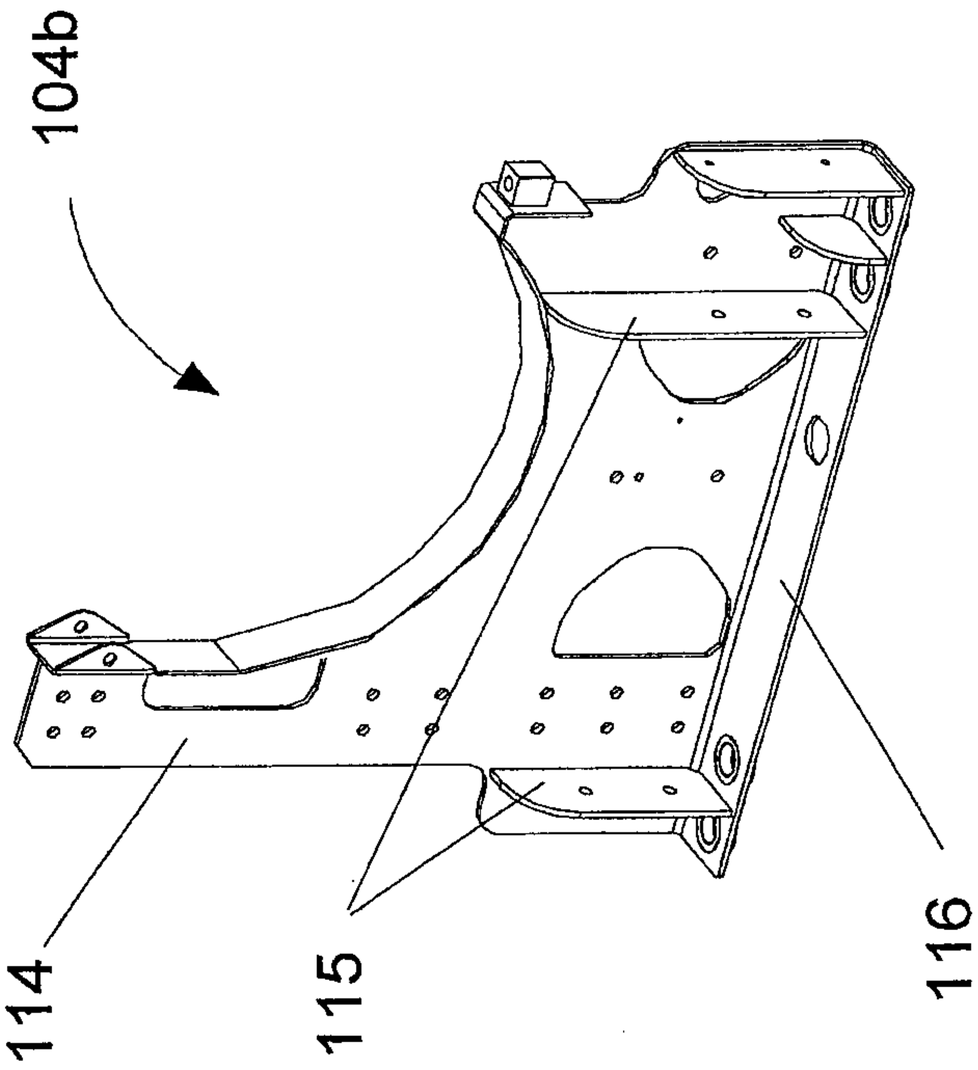


FIG. 7

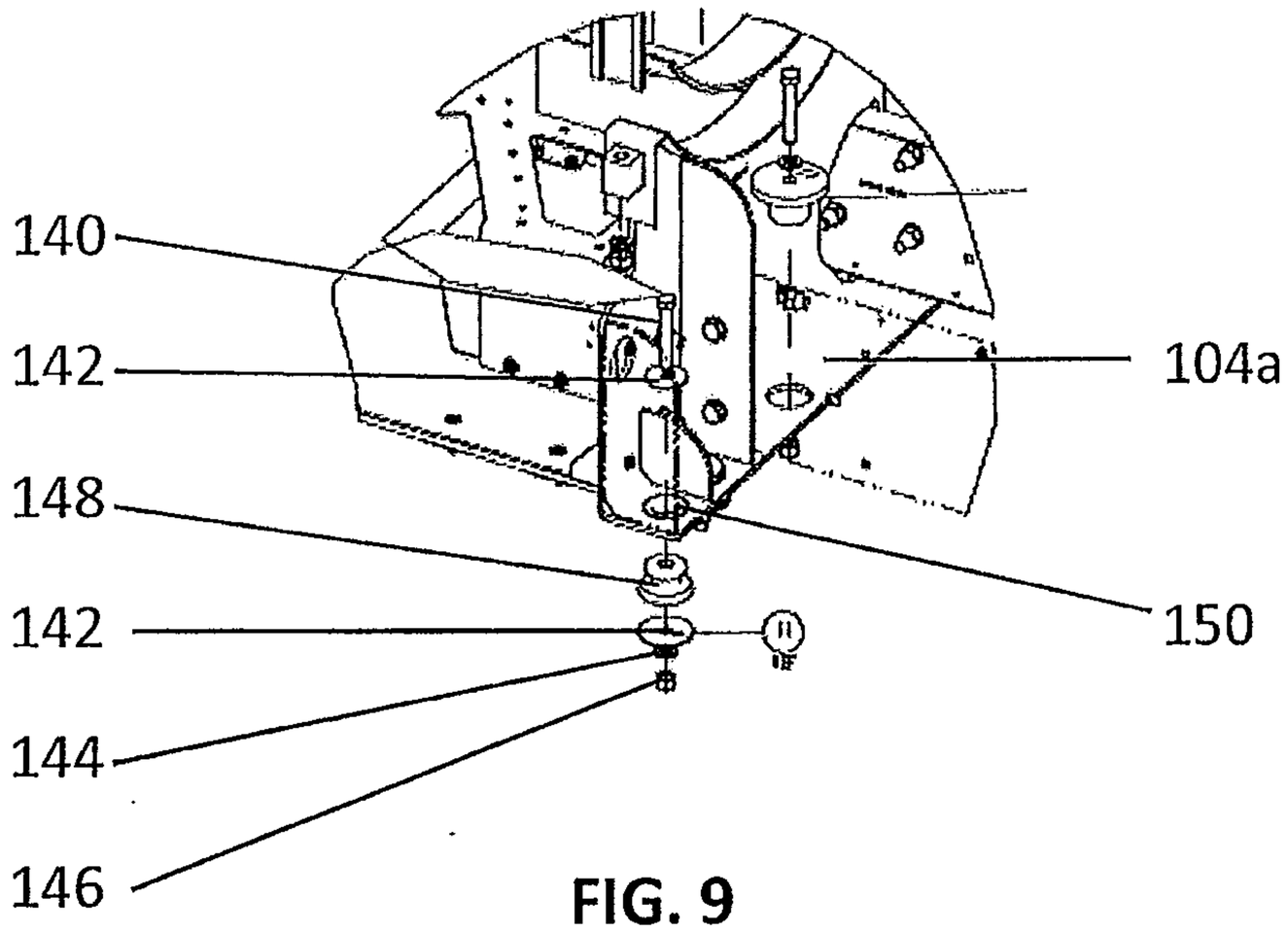
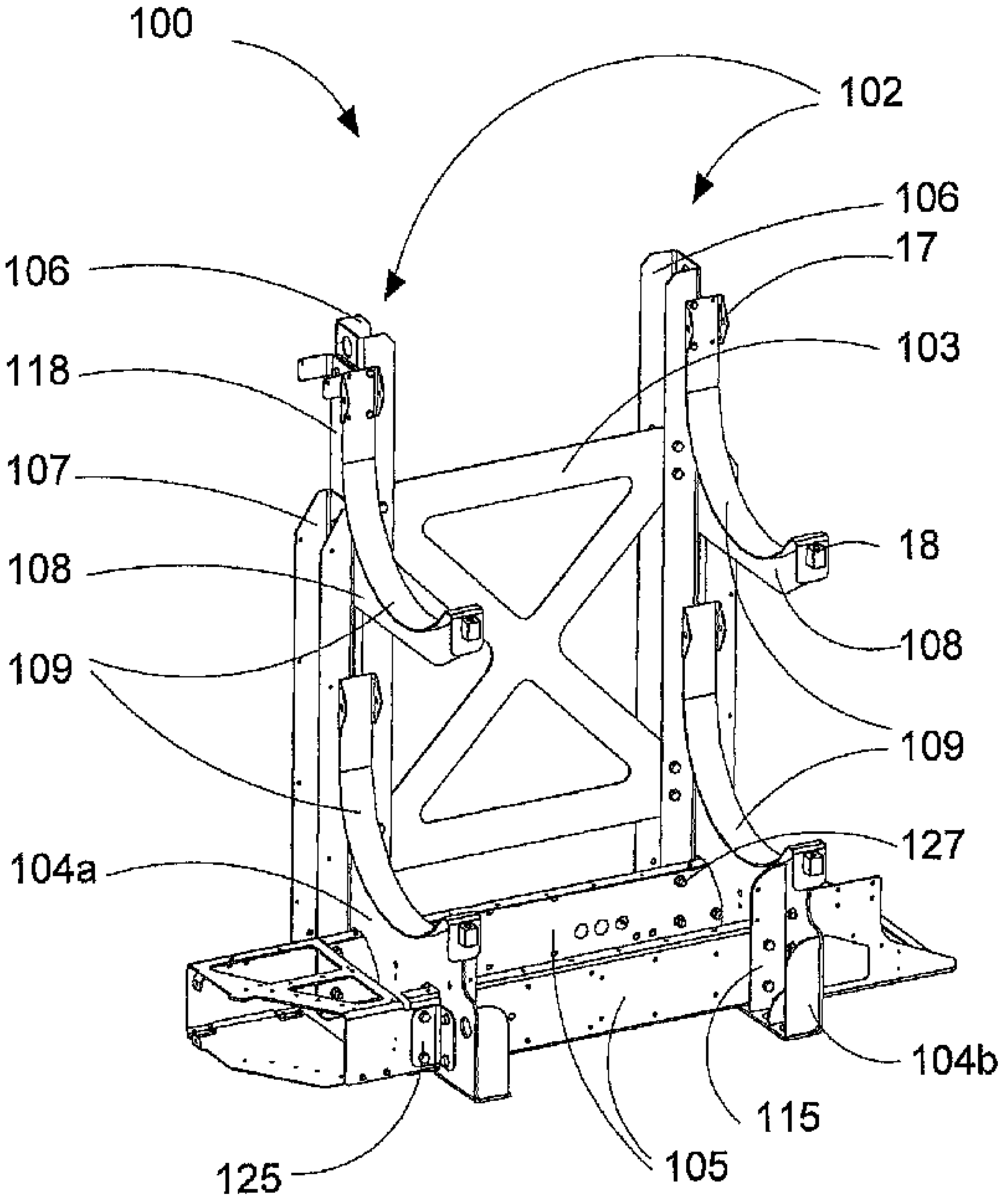


FIG. 9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