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Axle-to-beam connection for heavy-duty vehicle axle/suspension systems

Abstract

An axle-to-beam connection for an axle/suspension system of a heavy-duty vehicle that includes an axle, a beam with an alignment assembly, and an axle mount assembly. The alignment assembly is integrally formed with or is rigidly attached to the beam. The axle mount assembly intimately contacts and captures the axle. The axle is rigidly secured to the axle mount assembly without line welds. The axle mount assembly is removably connected to the alignment assembly to secure the axle to the beam.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
3547215	12/1969	Bird	N/A	N/A
4506910	12/1984	Bierens	N/A	N/A
4566719	12/1985	Van Denberg	N/A	N/A
4615539	12/1985	Pierce	N/A	N/A
5037126	12/1990	Gottschalk et al.	N/A	N/A
5112078	12/1991	Galazin et al.	N/A	N/A
5127668	12/1991	Raidel	N/A	N/A
5328159	12/1993	Kaufman et al.	N/A	N/A
5476251	12/1994	Moses et al.	N/A	N/A
5791743	12/1997	Sitter et al.	N/A	N/A
5921570	12/1998	Lie	N/A	N/A
6508482	12/2002	Pierce et al.	N/A	N/A
8292313	12/2011	Pierce et al.	N/A	N/A
8371596	12/2012	Johnson et al.	N/A	N/A
8419029	12/2012	Muckelrath et al.	N/A	N/A
8454040	12/2012	Westnedge et al.	N/A	N/A
8490989	12/2012	Piehl et al.	N/A	N/A
8764038	12/2013	Piehl et al.	N/A	N/A
9186947	12/2014	Kopplow et al.	N/A	N/A
11118645	12/2020	Gregg	N/A	B60G 11/10
11130379	12/2020	Miller et al.	N/A	N/A
2005/0253351	12/2004	Pan et al.	N/A	N/A
2011/0095501	12/2010	Piehl et al.	N/A	N/A
2015/0014953	12/2014	Pierce et al.	N/A	N/A
2020/0070607	12/2019	Miller et al.	N/A	N/A
2025/0010677	12/2024	Lindsay	N/A	B60G 9/003

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
0625440	12/1993	EP	N/A
1088687	12/2000	EP	N/A
1334848	12/2002	EP	N/A
2253490	12/2009	EP	N/A
2810274	12/2000	FR	N/A

2068856	12/1980	GB	N/A
2001010318	12/2000	JP	N/A
2004110795	12/2003	WO	N/A

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION (1) This application claims the benefit of U.S. Provisional Patent Application Ser. No. 63/469,850 filed on May 31, 2023.

BACKGROUND

Technical Field

(1) The disclosed subject matter is directed to axle/suspension systems for heavy-duty vehicles. In particular, the subject matter is directed to axle-to-beam connections for heavy-duty vehicle axle/suspension systems. More particularly, the subject matter is directed to an axle-to-beam connection for heavy-duty vehicle axle/suspension systems which includes a structure that enables an axle of the axle/suspension system to be accurately aligned with and quickly and securely attached to a beam of a suspension assembly of the axle/suspension system. The axle-to-beam connection of the disclosed subject matter provides a strong and secure connection between the axle and the beam, while eliminating line welds on the axle, thereby minimizing stress on the axle, and providing a stronger, more resilient axle-to-beam connection. Furthermore, the axle-to-beam connection of the disclosed subject matter enables shipment of the axle and suspension assemblies of the axle/suspension system separately and facilitates quick and simplified on-site alignment and attachment of the axle to the beams of the suspension assemblies without the need for welding equipment. Moreover, as the axle-to-beam connection of the disclosed subject matter facilitates quick and simplified alignment and attachment of the axle to the beams without the need for welding equipment, the axle-to-beam connection provides improved field serviceability to the axle, beam, and/or components of the axle-to-beam connection. In addition, the axle-to-beam connection of the disclosed subject matter includes a structure that acts as a mechanical bump stop to prevent potential damage to the beam, axle, frame of the heavy-duty vehicle, and/or components of the axle-to-beam connection during jounce events, and decreases manufacturing costs and complexity of the axle/suspension system.

Background Art

(2) The use of air ride axle/suspension systems in the heavy-duty vehicle industry is known. For purposes of conciseness and clarity, reference shall be made generally throughout to a heavy-duty vehicle with the understanding that such reference includes trucks, tractor-trailers and semi-trailers, trailers, and the like. Although axle/suspension systems can be found in widely varying structural forms, in general their structure is similar in that each system typically includes a pair of suspension assemblies. The suspension assemblies are typically connected directly to the primary frame of the heavy-duty vehicle or to a subframe supported by the primary frame. For those heavy-duty vehicles that support a subframe, the subframe can be non-movable or movable, the latter being commonly referred to as a slider box, slider subframe, slider undercarriage, secondary slider frame, or bogey.

(3) Typically, each suspension assembly of an axle/suspension system includes a longitudinally

extending elongated beam. The beam is located adjacent to and below a respective one of a pair of spaced apart longitudinally extending main members and one or more cross members that form the frame or subframe of the heavy-duty vehicle. For purposes of conciseness and clarity, reference shall be made throughout generally to a main member with the understanding that such reference includes main members of primary frames, movable subframes and non-movable subframes, and the like. Each beam is pivotally connected at one of its ends to a hanger, which in turn is attached to and depends from a respective one of the main members of the heavy-duty vehicle. Each beam may extend rearward or frontward relative to the front of the heavy-duty vehicle, thus defining what are typically referred to as trailing-arm or leading-arm axle/suspension systems, respectively. However, for purposes of the description contained herein, it is understood that the term trailing-arm encompasses beams extending either rearward or frontward with respect to the front end of the heavy-duty vehicle.

(4) An axle extends transversely between and is typically irremovably connected to the beams of the pair of suspension assemblies via axle-to-beam connections, and associated structure, at a selected location from about the mid-point of each beam to the end of the beam opposite the pivotal connection to the hanger. An air spring, or its equivalent, extends between and is connected to the beam at the end of the beam opposite its pivotal connection to the hanger and the main member of the frame of the heavy-duty vehicle. A brake assembly and one or more shock absorbers may also be mounted on each of the beams and/or axle.

(5) It is also common for the axle/suspension system to feature a lift assembly that enables one or more of the axles of the heavy-duty vehicle to be lifted and maintained in a raised position, such that the wheels rotatably mounted on the axles are lifted off of the ground. Such lift assemblies are typically used when the heavy-duty vehicle is free of payload, such that fewer than all the wheels can adequately support the heavy-duty vehicle, or when greater maneuverability of the heavy-duty vehicle is desired. Lifting and maintaining the heavy-duty wheels off of the ground results in reduced wear on the lifted axle and the respective wheels. In addition, lifting one or more axles may provide reduced heavy-duty vehicle operational costs because toll costs are often determined based on only those axles which have wheels in contact with the ground.

(6) The axle/suspension system generally acts to cushion the ride, dampen vibrations, and stabilize the heavy-duty vehicle. More particularly, as the heavy-duty vehicle is traveling over the road, the wheels of the heavy-duty vehicle may encounter road conditions that impart various forces, loads, and/or stresses, to the respective axle on which the wheels are mounted, and in turn, to the suspension assemblies of the axle/suspension system connected to and supporting the axle. More particularly, during jounce events, road conditions may impart an upward force directed to the wheel of the heavy-duty vehicle, which causes the attached axle and respective suspension assembly beam to travel upwardly. In axle/suspension systems that include certain prior art axle-to-beam connections, bump stops are utilized to absorb forces and prevent contact between, and potential damage to, the axle, components of the axle-to-beam connection, and/or the main members of the heavy-duty vehicle during jounce events. Bump stops can be discrete components attached to the axle/suspension system beam and/or main members, or can be incorporated into other components of the axle/suspension system, such as the air spring.

(7) Prior art axle-to-beam connections, while adequately securing the axle to the suspension assemblies of the axle/suspension system, have potential disadvantages, drawbacks, and limitations. For example, prior art axle-to-beam connections typically employ one or more line welds to secure the axle to the beams of the suspension assemblies. In certain configurations of prior art axle-to-beam connections, welding alone is typically inadequate to secure the axle to the beam and maintain the integrity of the rigid axle-to-beam connection due to certain forces acting on the axle-to-beam connection during heavy-duty vehicle operation. As a result, such axle-to-beam connections are fortified with suitable means, such as with U-bolts, U-bolt brackets or axle seats attached to or integrated into the beam, line welds, other additional mounting hardware, and/or the

like, to maintain integrity and prevent separation of the axle from the beams. However, even with such fortification, the prior art axle-to-beam connections, as well as the axle itself, can potentially exhibit less than optimal fatigue strength and service life. In particular, line welds between the axle and the U-bolt bracket/axle seat and areas of the axle near the axle-to-beam connection may exhibit reduced durability in certain heavy-duty vehicle applications, such as operation on harsh road surfaces. More particularly, line welds are discrete welds that start at one point and terminate at a separate point, as is known. The starting and termination points of line welds create areas that are susceptible to stress, known as stress risers, as is also known. Loads and forces acting on the axle are transferred almost entirely through the line welds attaching the U-bolt bracket/axle seats to the axle, such that the forces imposed on the axle-to-beam connection may potentially compromise the axle and/or the axle-to-beam connection due to stress risers.

(8) Moreover, prior art axle-to-beam connections are typically pre-assembled during the manufacturing process of the axle/suspension system, such that the axle is irremovably attached to the U-bolt bracket or axle seats via welds. As a result, the axle/suspension systems must be shipped with the axle attached to the beams of the suspension assemblies, increasing the amount of space and cost of shipment as compared to shipping the axle and suspension assemblies separately. Furthermore, as prior art axle-to-beam connections typically require welds to secure the axle to the beams, if the axle, beam, and/or components of the axle-to-beam connection become damaged during operation of the heavy-duty vehicle, servicing or replacement of such components in the field may be difficult or impossible. More specifically, in order to service or replace such components, the welds of the axle-to-beam connection may have to be removed prior to servicing or replacement, and the axle rewelded to the beam via the axle-to-beam connection subsequent to servicing or replacement of the component(s), which can be difficult to perform in the field and typically requires specialized equipment that the vehicle operator and/or service technician may not have access to in the field. In addition, as described above, bump stops or other discrete protection means are typically required to protect the beam, axle, frame of the heavy-duty vehicle, and/or components of the axle-to-beam connection during jounce events. However, such bump stops or other discrete protection means may undesirably increase the weight of the axle/suspension system.

(9) Thus, a need exists in the art for an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that enables an axle of the axle/suspension system to be accurately aligned with and quickly and securely attached to a beam of a suspension assembly of the axle/suspension system. There is also a need in the art for an axle-to-beam connection that provides a strong and secure connection between the axle and the beam, while eliminating line welds on the axle, thereby minimizing stress on the axle, and providing a stronger, more resilient axle-to-beam connection. Furthermore, there is a need in the art for an axle-to-beam connection that enables shipment of the axle and suspension assemblies of the axle/suspension system separately and facilitates quick and simplified on-site alignment and attachment of the axle to the beams of the suspension assemblies without the need for welding equipment. Moreover, there is a need in the art for an axle-to-beam connection that provides improved field serviceability to the axle, beam, and/or components of the axle-to-beam connection. In addition, there is also a need in the art for an axle-to-beam connection that includes a structure that acts as a mechanical bump stop to prevent potential damage to the beam, axle, frame of the heavy-duty vehicle, and/or components of the axle-to-beam connection during jounce events, and decreases manufacturing costs and complexity of the axle/suspension system.

(10) The axle-to-beam connection for heavy-duty vehicle axle/suspension systems of the disclosed subject matter satisfies these needs and overcomes the above described disadvantages, drawbacks, and limitations, and will now be described.

BRIEF SUMMARY OF THE DISCLOSED SUBJECT MATTER

(11) An objective of the disclosed subject matter is to provide an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that includes a structure that enables an axle of the

axle/suspension system to be accurately aligned with and quickly and securely attached to a beam of a suspension assembly of the axle/suspension system.

(12) Another objective of the disclosed subject matter is to provide an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that provides a strong and secure connection between the axle and the beam, while eliminating line welds on the axle, thereby minimizing stress on the axle, and providing a stronger, more resilient axle-to-beam connection.

(13) Yet another objective of the disclosed subject matter is to provide an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that enables shipment of the axle and suspension assemblies of the axle/suspension system separately and facilitates quick and simplified on-site alignment and attachment of the axle to the beams of the suspension assemblies without the need for welding equipment.

(14) Another objective of the disclosed subject matter is to provide an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that provides improved field serviceability to the axle, beam, and/or components of the axle-to-beam connection.

(15) Yet another objective of the disclosed subject matter is to provide an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that includes a structure that acts as a mechanical bump stop to prevent potential damage to the beam, axle, frame of the heavy-duty vehicle, and/or components of the axle-to-beam connection during jounce events.

(16) Another objective of the disclosed subject matter is to provide an axle-to-beam connection for heavy-duty vehicle axle/suspension systems that decreases manufacturing costs and complexity of the axle/suspension system.

(17) These objectives and other are achieved by the axle-to-beam connection for heavy-duty vehicle axle/suspension systems of the disclosed subject matter, which includes: an axle; a beam including an alignment assembly; and an axle mount assembly, the axle mount assembly intimately contacting and capturing the axle, the axle being rigidly secured to the axle mount assembly without line welds, the axle mount assembly being removably connected to the alignment assembly to secure the axle to the beam.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

- (1) The exemplary embodiment of the disclosed subject matter, illustrative of the best mode in which applicant has contemplated applying the principles, is set forth in the following description and is shown in the drawings.
- (2) FIG. 1 is a top rear driver-side perspective view of a trailing arm beam-type axle/suspension system for a heavy-duty vehicle that includes a pair of suspension assemblies connected to the axle with prior art axle-to-beam connections;
- (3) FIG. 2 is a perspective view of the axle/suspension system shown in FIG. 1 with the axle removed, showing the component parts of the suspension assembly, including the prior art axle-to-beam connection, in exploded view;
- (4) FIG. 2A is an enlarged fragmentary perspective view of a portion of the driver-side suspension assembly shown in FIGS. 1 and 2;
- (5) FIG. 3 is a top rear perspective view of a portion of a driver-side suspension assembly and a fragmentary portion of an axle of a trailing arm beam-type axle/suspension system for a heavy-duty vehicle connected to one another with an exemplary embodiment axle-to-beam connection for heavy-duty vehicle axle/suspension systems of the disclosed subject matter, a portion of the axle being shown in cross-section;
- (6) FIG. 4 is an elevational view of the suspension assembly, axle, and exemplary embodiment axle-to-beam connection of the disclosed subject matter shown in FIG. 3 with the axle in section,

viewed looking in an outboard direction;

(7) FIG. 5 is an elevational view similar to FIG. 4, showing the axle removed and showing the profiles of axle contact surfaces of the axle support brackets of the exemplary embodiment axle-to-beam connection of the disclosed subject matter;

(8) FIG. 6A is a perspective view of one of the axle support brackets of the exemplary embodiment axle-to-beam connection of the disclosed subject matter shown in FIG. 3, showing the concave axle contact surface of the axle support bracket;

(9) FIG. 6B is an enlarged top perspective view of the axle support bracket shown in FIG. 6A, viewed in an opposite direction;

(10) FIG. 7 is a fragmentary enlarged top plan view of a portion of the suspension assembly and axle connected thereto via the exemplary embodiment axle-to-beam connection of the disclosed subject matter shown in FIG. 3, with a top plate of an axle mount assembly and bolts of the exemplary embodiment axle-to-beam connection removed;

(11) FIG. 8 is top rear perspective view of the suspension assembly and a portion of the exemplary embodiment axle-to-beam connection shown in FIG. 3, with the axle of the axle/suspension system and the axle mount assembly and bolts of the exemplary embodiment axle-to-beam connection removed and showing an axle alignment assembly of the exemplary embodiment axle-to-beam connection attached to/integrated into the suspension assembly;

(12) FIG. 9 is a fragmentary top rear perspective view of a portion of the suspension assembly, the axle, and the exemplary embodiment axle-to-beam connection shown in FIG. 3, showing the axle mount assembly and the axle alignment assembly of the exemplary embodiment axle-to-beam connection disconnected from one another; and

(13) FIG. 10 is a fragmentary bottom front perspective view of a portion of the suspension assembly, the axle, and the exemplary embodiment axle-to-beam connection shown in FIG. 3, showing the axle mount assembly and the axle alignment assembly of the exemplary embodiment axle-to-beam connection disconnected from one another.

(14) Similar numerals and characters refer to similar components throughout the drawings.

DETAILED DESCRIPTION OF THE DISCLOSED SUBJECT MATTER

(15) In order to better understand the environment in which the axle-to-beam connection for heavy-duty vehicle axle/suspension systems of the disclosed subject matter is utilized, a liftable trailing arm beam-type axle/suspension system 10 incorporating a pair of prior art axle-to-beam connections 14 is shown in FIGS. 1-2A. Axle/suspension system 10 includes a pair of transversely spaced mirror-image suspension assemblies 11 that depend from respective main members (not shown) of the heavy-duty vehicle (not shown). Inasmuch as suspension assemblies 11 are mirror-images of each other, only one of the suspension assemblies will be described in detail.

(16) Suspension assembly 11 includes a beam 12 having a generally rigid metal box-like structure comprising a pair of transversely spaced vertical sidewalls 66. A bottom wall 38, a first top plate 39, and a second top plate 36 extend between and interconnect with sidewalls 66. Sidewalls 66 and bottom wall 38 are integrally formed as a single-piece that includes a generally U-shaped cross-sectional profile by stamping or bending. First top plate 39 and second top plate 36 are in a longitudinal spaced arrangement along beam 12 and are secured to sidewalls 66 via welding or other suitable means. Beam 12 also includes a mounting tube 42 formed of robust steel that is attached to the front ends of sidewalls 66, bottom wall 38, and first top plate 39.

(17) Beam 12 includes a platform 16, which extends from the rear end of the beam and is rigidly attached to sidewalls 66 by suitable means, such as welding, adjacent second top plate 36 near the rear end of the beam. A conventional bellows-type air spring 9 is attached to and extends between platform 16 and a respective main member of the heavy-duty vehicle, as is known. In particular, air spring 9 has a mounting bracket 13 secured to the air spring by nuts 83. Mounting bracket 13 is secured to the main member with fasteners, as is known. Air spring 9 is secured to platform 16 with bolts 55 and washers 35. An axle 17 extends between and is rigidly connected to the rear end of

each beam **12** utilizing components of prior art axle-to-beam connection **14**, as will be described in greater detail below. For purposes of completeness, axle/suspension system **10** is also shown having a respective wheel end assembly **29** with a drum brake assembly **30** rotatably mounted on each end of axle **17**.

(18) Beam **12** is pivotally mounted by a bushing assembly **40** to a hanger **18**, which depends from and is secured to a respective main member of the heavy-duty vehicle, as is known. Hanger **18** typically includes a generally box-like sturdy metal structure having a pair of transversely-spaced vertical sidewalls **22** extending between a front wall **21** and a rear wall **25**. A top wall **37** extends between and is attached to front wall and rear wall **25**. Bushing assembly **40** includes an elastomeric bushing **44** press fit into mounting tube **42** of beam **12**. Bushing **44** is molded about and adhesively attached to a central metal sleeve **46** formed with an opening **31**, which extends through the sleeve. Sleeve **46** extends completely through bushing **44** and protrudes outwardly from the bushing. Bushing assembly **40** includes a fastener assembly **15** having a bolt **20**, which, together with a nut **26**, is utilized to secure the components of the bushing assembly together and pivotally mount beam **12** to hanger **18**. In particular, bolt **20** passes through a first washer **32**, an eccentric washer **19** disposed adjacent the outboard sidewall **22** of hanger **18**, an opening **47** formed in the outboard sidewall of the hanger, opening **31** of sleeve **46**, an opening (not shown) formed in the inboard sidewall of the hanger, an inboard non-eccentric washer **24** disposed adjacent the inboard sidewall of the hanger, and a second washer **33** to receive nut **26**. Eccentric washer **19** provides a means for adjusting alignment of axle/suspension system **10**, as is known. In addition, a respective one of a pair of conventional spacer discs **34**, formed of ultra-high molecular weight polyethylene, is disposed between bushing **44** and each sidewall **22** of hanger **18** to prevent contact between metal components of mounting tube **42** and the hanger. A shock absorber (not shown) may also be attached to and extend between beam **12** and the respective main member or hanger **18** of the heavy-duty vehicle, as is known.

(19) Suspension assembly **11** also includes a lift assembly **80**, which enables beam **12**, with axle **17**, to be lifted and maintained in a raised position by prior art axle-to-beam connection **14** during certain heavy-duty vehicle operations. Lift assembly **80** generally includes an elastomeric bellows-type air chamber **82** and a lift arm **84**. Lift arm **84** is rigidly attached to mounting tube **42** of beam **12**, such as by welding, and extends upwardly into hanger **18**. The front end of air chamber **82** is attached to the rear surface of lift arm **84** by fasteners **85**. The rear end of air chamber **82** is attached to the front surface of rear wall **25** of hanger **18** by fasteners **87**. As air from an air supply source (not shown) installed on the heavy-duty vehicle is introduced into air chamber **82**, and as air is simultaneously released from air spring **9**, the air chamber expands away from rear wall **25** of hanger **18** and applies a frontward force on lift arm **84**. This frontward force causes arcuate upward movement of beam **12** about bushing assembly **40** that enables suspension assembly **11**, axle **17**, and wheel end assembly **29** rotatably mounted on the axle to be lifted and maintained in a raised position.

(20) As described above, axle **17** is connected to suspension assembly **11** utilizing prior art axle-to-beam connection **14**. Prior art axle-to-beam connection **14** generally includes a front U-bolt bracket/axle seat **28F** and a rear U-bolt bracket/axle seat **28R** connected to or integrated into beam **12**. With particular reference to FIGS. 2-2A, both front and rear U-bolt brackets/axle seats **28F** and **28R** include a generally vertical interconnecting member **41**, a generally horizontal member **61**, and a strengthening web **65**. Interconnecting member **41** includes a lower portion **45**, an upper portion **53** with a terminal edge **59**, and a surface **62**. Each horizontal member **61** includes a pair of openings **72**, each of which is formed through the inboard and outboard side of the respective horizontal member. Lower portion **45** of front U-bolt bracket/axle seat **28F** nests in a pair of transversely-spaced front slots **70F** formed in sidewalls **66** of beam **12** adjacent the rear end of first top plate **39**. Lower portion **45** of front U-bolt bracket/axle seat **28F** extends downwardly adjacent to the front portion of axle **17**, such that surface **62** faces the front portion of the axle, and is rigidly

secured to beam **12** using suitable means, such as welding. Similarly, lower portion **45** of rear U-bolt bracket/axle seat **28R** nests in a pair of transversely-spaced rear slots **70R** formed in sidewalls **66** of beam **12** spaced a longitudinal distance from front slots **70F** and adjacent the front end of second top plate **36**. Lower portion **45** of U-bolt bracket/axle seat **28R** extends downwardly toward and adjacent to the rear portion of axle **17**, such that surface **62** faces the rear portion of the axle, and is rigidly secured to beam **12** using suitable means, such as welding. The upper edges of sidewalls **66** of beam **12** are each integrally formed with an arch **50** between front and rear slots **70F** and **70R**. U-bolt bracket/axle seats **28F** and **28R**, together with arches **50**, form an axle locus **51**, which is generally known or referred to as an axle seat.

(21) Prior art axle-to-beam connection **14** requires a pair of generally identical inboard and outboard connections for attaching axle **17** to beam **12** of the respective suspension assembly **11**. This is typically accomplished by a pair of U-bolts **27**. Each U-bolt **27** is disposed about axle **17** and through openings **72** of front and rear U-bolt brackets/axle seats **28F** and **28R**, respectively. A washer **52** (FIG. **2**) is disposed over each of a respective one of a pair of threaded ends of each U-bolt **27**. A nut **73** threadably engages each one of the pair of ends of each U-bolt **27** and is tightened to secure axle **17** into axle locus **51** of beam **12**.

(22) In addition, axle **17** is also irremovably attached to front and rear U-bolt bracket/axle seats **28F** and **28R** by a front line weld (not shown) and a rear line weld **90R** (FIG. **1**). The front line weld is formed along the interface between terminal edge **59** of upper portion **53** of interconnecting member **41** of front U-bolt bracket/axle seat **28F** and axle **17** at or just beyond the horizontal centerline of the axle. Similarly, rear line weld **90R** is formed along the interface between terminal edge **59** of upper portion **53** of interconnecting member **41** of rear U-bolt bracket/axle seat **28R** and axle **17** at or just beyond the horizontal centerline of the axle. Together, U-bolts **27**, the front line weld, and rear line weld **90R** rigidly attach axle **17** to beam **12** of suspension assembly **11** to complete prior art axle-to-beam connection **14**.

(23) Prior art axle-to-beam connection **14**, while adequately securing axle **17** to beam **12** of suspension assembly **11**, has certain disadvantages, drawbacks, and limitations. For example, during heavy-duty vehicle operation under harsh driving conditions, such as on harsh road surfaces, axle-to-beam connection **14** potentially has reduced fatigue strength and durability. In particular, the starting and the termination points of the front line weld and rear line weld **90R** on axle **17** create stress risers on or near axle-to-beam connection **14**. These stress risers can potentially compromise axle-to-beam connection **14** and axle **17** during heavy-duty vehicle operation under harsh driving conditions due to forces imposed on the axle-to-beam connection, and can potentially cause failure of the line welds. More particularly, during heavy-duty vehicle operation certain forces are imparted from beam **12** substantially through the front line weld and rear line weld **90R** to axle **17**, which may potentially result in failure of axle-to-beam connection **14**, thereby increasing heavy-duty vehicle downtime and repair cost.

(24) In addition, because axle **17** is irremovably connected to beam **12** of suspension assembly **11** during manufacturing, axle/suspension system **10** must be shipped with the axle attached to the beams of the suspension assemblies, increasing the cost of and amount of space required for shipments as compared to separately shipping the axles and the suspension assemblies.

Furthermore, as prior art axle-to-beam connection **14** utilizes the front line weld and rear line weld **90R** to irremovably attach axle **17** to front and rear U-bolt bracket/axle seats **28F** and **28R**, and thus attach the axle to beam **12**, if the axle, beam, and/or components of the axle-to-beam connection become damaged during operation of the heavy-duty vehicle, servicing or replacement of such components in the field may be difficult or impossible. More specifically, in order to service or replace axle **17**, beam **12**, and/or components of axle-to-beam connection **14**, the front line weld and rear line weld **90R** may have to be removed prior to servicing or replacement of the component(s), and the axle subsequently rewelded to front and rear U-bolt bracket/axle seats **28F** and **28R** to reattach axle **217** to beam **212** after servicing or replacement of the component(s),

which can be difficult to perform in the field and typically requires specialized equipment that the vehicle operator and/or service technician may not have access to in the field. Moreover, suspension assemblies **11** require bump stops, or other discrete components to protect contact between and potential damage to prior art axle-to-beam connections **14**, axle **17**, and/or the main members of the heavy-duty vehicle during jounce events, which undesirably increases the weight, manufacturing cost, and complexity of axle/suspension system **10**. The axle-to-beam connection of the disclosed subject matter overcomes the disadvantages, drawbacks, and limitations associated with prior art axle-to-beam connections, such as prior art axle-to-beam connection **14**, and provides additional benefits, and will now be described.

(25) An exemplary embodiment axle-to-beam connection for heavy-duty vehicle axle/suspension systems of the disclosed subject matter is shown in FIGS. **3-10** and is indicated generally at **200**. Exemplary embodiment axle-to-beam connection **200** is shown employed with a suspension assembly **211** and an axle **217** of a liftable trailing arm beam-type axle/suspension system (not shown) for a heavy-duty vehicle similar in structure and function to axle/suspension system **10** (FIGS. **1-2A**) described above. The axle/suspension system includes a pair of transversely-spaced mirror-image suspension assemblies **211** depending from respective main members (not shown) of a frame (not shown) of the heavy-duty vehicle (not shown). Axle **217** extends transversely between and is rigidly connected to each suspension assembly **211** utilizing a respective exemplary embodiment axle-to-beam connection **200**, which will be described in detail below. Inasmuch as suspension assemblies **211** are mirror images of each other, for purposes of conciseness and clarity, only one of the suspension assemblies will be described in detail.

(26) Suspension assembly **211** includes beam **212**, which is a generally rigid metal box-like structure. With reference to FIGS. **3-5** and **8-10**, beam **212** generally comprises a pair of transversely spaced vertical sidewalls **266** interconnected by a longitudinally-extending top plate **239** and a longitudinally-extending bottom plate **238**. Bottom plate **238** is rigidly attached to the bottom edges of sidewalls **266** by any suitable means, such as welding, and extends slightly inboardly and outboardly from the sidewalls. Top plate **239** is rigidly attached to the top edges of sidewalls **266** by any suitable means, such as welding. Beam **212** includes a mounting tube **242** (FIGS. **3-5**, **8**, and **10**) formed of a suitably robust material, such as steel. Mounting tube **242** is rigidly attached to the front ends of sidewalls **266**, top plate **239**, and bottom plate **238** via suitable means, such as welding. Beam **212** is pivotally attached to a hanger (not shown), such as hanger **18** (FIGS. **1-2**) described above, via a bushing assembly **240** disposed within mounting tube **242**. The hanger depends from and is secured to the main member of the heavy-duty vehicle by any suitable means, such as welding or fasteners.

(27) Beam **212** includes a platform **216**, which is rigidly attached to a pair of rearwardly extending beam extensions **266a** integrally formed with sidewalls **266** near the rear end of the beam via suitable means, such as welding. Beam **212** also includes at least one, but, more preferably, a pair of gussets **223** (FIGS. **3-5** and **8-10**), which provide support to platform **216**. In particular, gussets **223** are attached between the bottom surface of platform **216** and the top surface of bottom plate **238**, and extend inboardly from the inboard surface of the outboard beam extension **266a** through a slot (not shown) formed in the inboard beam extension **266a** to a location adjacent the inboard edge of platform **216**. Platform **216** supports a conventional bellows-type air spring (not shown), which is attached to and extends between the platform and a respective main member of the frame of the heavy-duty vehicle.

(28) Beam **212** is connected to a lift assembly **214** (FIGS. **3-5**, **8** and **10**; partially shown) that is similar in structure and function to lift assembly **80** (FIGS. **1-2**) described above. Lift assembly **214** enables beam **212** and axle **217**, attached to the beam via exemplary embodiment axle-to-beam connection **200** in a manner described below, to be lifted and maintained in a raised position during certain heavy-duty vehicle operations. Lift assembly **214** generally includes an elastomeric bellows-type air chamber (not shown) and a lift arm **215**. Lift arm **215** is rigidly attached, such as

by welding, to mounting tube **242** of beam **212** and extends upwardly into the hanger to which the beam is pivotally connected. The front end of the air chamber is attached to the rear surface of lift arm **215** via fasteners (not shown). The rear end of the air chamber is attached to the front surface of a rear wall (not shown) of the hanger by fasteners (not shown). As air from an air supply source (not shown) installed on the heavy-duty vehicle is introduced into the air chamber, and air is simultaneously released from the air spring, the air chamber expands away from a rear wall (not shown) of the hanger, applying force to lift arm **215** and causing arcuate upward movement of beam **212** about bushing assembly **240**, thereby enabling the axle/suspension system, axle **217**, and wheels (not shown) attached to the axle to be lifted and maintained in a raised position.

(29) In accordance with an important aspect of the disclosed subject matter, exemplary embodiment axle-to-beam connection **200** includes a structure that enables axle **217** to be accurately aligned with beam **212** of suspension assembly **211** and quickly and securely attached to the beam. More specifically, axle-to-beam connection **200** comprises a two-part connection, which generally includes an axle alignment assembly **250** and an axle mount assembly **270**. With reference to FIGS. **3-5** and **8-10**, axle alignment assembly **250** is rigidly connected/integrated into beam **212** of suspension assembly **211**. Alignment assembly **250** includes a mounting plate **251** integrally formed with the rear end of top plate **239** of beam **212**. Mounting plate **251** is positioned adjacent the rear end of sidewalls **266** of beam **212** and is rigidly attached to the top edges of the sidewalls via suitable means, such as welding. Mounting plate **251** extends inboardly and outboardly from sidewalls **266** and is formed with a plurality of openings **254** (FIGS. **8-9**), with two openings being positioned longitudinally from one another adjacent the inboard end of the mounting plate and two openings being positioned longitudinally from one another adjacent the outboard end of the mounting plate, the importance of which will be described in detail below. It is to be understood that although mounting plate **251** is shown integrally formed with top plate **239** of beam **212**, it is contemplated that the mounting plate could be a discrete structure that is welded or otherwise rigidly attached to the top plate and/or sidewalls **266** of the beam without affecting the overall concept or operation of the disclosed subject matter.

(30) With reference to FIGS. **3-5** and **8-10**, axle alignment assembly **250** further includes an attachment bracket **260** to accommodate mounting and/or attachment of other components of exemplary embodiment axle-to-beam connection **200** to beam **212**, as will also be described in greater detail below. Attachment bracket **260** has a generally C-shaped structure that includes a front plate **262**, a rear plate **265**, and a pair of bolt brackets **268**. Rear plate **265** is disposed about the rear end of sidewalls **266** and bottom plate **238** of beam **212** and is attached to the sidewalls and bottom plate via suitable means, such as welding. Front plate **262** is also disposed about sidewalls **266** and bottom plate **238** of beam **212** and is spaced a longitudinal distance frontward of rear plate **265** near the longitudinal midpoint of the beam. Front plate **262** is attached to sidewalls **266** and bottom plate **238** of beam **212** via suitable means, such as welding. Each of rear plate **265** and front plate **262** extend axially inboardly and outwardly from the respective inboard and outboard surfaces of the inboard and outboard sidewalls **266** of beam **212**.

(31) Each bolt bracket **268** is integrally formed with front plate **262** and rear plate **265** and extends longitudinally between the front plate and rear plate adjacent a respective inboard and outboard surface of the inboard and outboard sidewalls **266** of beam **212**. Each bolt bracket **268** is rigidly attached to the respective inboard and outboard surface of the inboard and outboard sidewalls **266** via suitable means, such as welding. Each bolt bracket **268** is formed with a pair of longitudinally spaced openings (not shown), the importance of which will be described below. With continued reference to FIGS. **3-5** and **8-10**, alignment assembly **250** further includes a pair of spacers **255**. Each one of spacers **255** is positioned between the bottom of mounting plate **251** and the top of a respective bolt bracket **268** of attachment bracket **260** inboardly or outboardly of a respective inboard or outboard sidewall **266** of beam **212** and is rigidly connected thereto via suitable means, such as welding. Each spacer **255** is formed with a pair of longitudinally spaced openings (not

shown) that align with respective openings formed in mounting plate **251** and bolt bracket **268** of attachment bracket **260**, the importance of which will be described below. It is to be understood that axle alignment assembly **250** of axle-to-beam connection **200** could have different structures than those shown, such as having different forms and/or including different components, without affecting the overall concept or operation of the disclosed subject matter.

(32) With particular reference to FIGS. **3-7** and **9-10**, axle mount assembly **270** of exemplary embodiment axle-to-beam connection **200** includes a multi-component structure that is utilized to capture and secure axle **217** of the axle/suspension system to axle alignment assembly **250**, and thus secure the axle to beam **212** of suspension assembly **211** of the axle/suspension system. More specifically, mount assembly **270** includes a pair of axle support brackets **271** positioned on and attached to respective front and rear sides of axle **217**. Inasmuch as support brackets **271** are identical in structure and function to one another, for purposes of conciseness and clarity, only one of the axle support brackets will be described in detail.

(33) Axle support bracket **271** is formed of a suitable rigid material, such as steel, and includes a generally elongated structure. With particular reference to FIGS. **6A**, **6B**, and **7**, support bracket **271** is formed with a pair of vertically-extending elongated slotted openings **276** located at opposite inboard and outboard ends of the bracket. With reference to FIGS. **4-5**, **6A**, **6B**, and **7**, support bracket **271** is formed with an axially-extending axle contact recess **272**. As best shown in FIGS. **4-5**, axle contact recess **272** includes a generally concave profile that corresponds and is complementary to the convex profile of the front and/or rear of axle **217**, thereby facilitating close or intimate contact between support bracket **271** and the axle when the support bracket is positioned against the axle. Support bracket **271** is formed with a window **274** that extends axially between slotted openings **276** and is defined by a continuous elongated circular, obround, oblong, or oval-shaped continuous inner edge **275**. Support bracket **271** is attached to axle **217** via window **274**. More specifically, the continuous nature of inner edge **275** of window **274** allows a continuous window weld (not shown) to attach support bracket **271** to axle **217**. More particularly, the continuous window weld begins at a point along inner edge **275** of window **274** and is continuously produced around the inner edge; and terminates at the point at which the continuous window weld was initiated. As a result, the continuous window weld has no gaps and lacks separate starting and termination points due to the continuous nature and curved shape of inner edge **275** of window **274**, thereby completely attaching the entirety of the inner edge to axle **217**.

(34) With reference to FIGS. **3-5** and **9-10**, axle mount assembly **270** further includes a top plate **284**. Top plate **284** includes a generally flat structure and is formed of a suitable rigid material, such as steel. Top plate **284** includes an axially-extending recess **285** that corresponds generally to the convex profile of the top of axle **217**. Top plate **284** is formed with four bosses **286**, each one of which is formed with an opening (not shown), the importance of which will be described below. Top plate **284** is positioned on top of axle support brackets **271** such that axle **217** is positioned within recess **285** of the top plate and the openings formed in bosses **286** align with elongated slotted openings **276** of the axle support brackets. Top plate **284** is rigidly attached to the top edge of each support bracket **271** via a weld **287** laid between the top edge of each support bracket and the bottom surface of the top plate. With reference to FIGS. **4-5** and **10**, top plate **284** further includes a pair of shock absorber mounting brackets **294** secured thereto via suitable means, such as welding. Each of shock absorber mounting brackets **294** is formed with a respective one of a pair of transversely aligned openings **296**. Openings **296** enable a shock absorber (not shown) to be mounted and secured to axle mount assembly **270** via suitable means, such as a fastener. The shock absorber in turn is attached to the hanger or the main member of the frame of the heavy-duty vehicle via suitable means, such as a fastener(s).

(35) With reference to FIGS. **3-5**, **7**, and **9-10**, axle mount assembly **270** further includes a bottom plate **282** that includes a generally flat H-shaped structure formed of a suitable rigid material, such as steel. With reference to FIG. **7**, bottom plate **282** is formed with four openings **283**, with each of

the openings being formed in a respective leg of the H-shaped structure of the bottom plate. Bottom plate **282** is positioned below axle **217** and axle support brackets **271** such that openings **283** of the bottom plate are aligned with elongated slotted openings **276** of the axle support brackets and the openings formed in top plate **284**. With reference to FIGS. 3-5, 7, and 9, bottom plate **282** is rigidly attached to the bottom edge of each support bracket **271** via a weld **289** laid between the bottom edge of each support bracket and the top surface of the bottom plate. With particular reference to FIG. 7, because support brackets **271** are connected to axle **217** in the manner described above and include slotted openings **276**, the axle can include varying outer diameters while maintaining vertical alignment of the openings formed in top plate **284**, the slotted openings, and openings **282** of bottom plate **282** upon attachment of the top plate and bottom plate to the support brackets via welds **287** and **289**, respectively, the importance of which will be described below.

(36) As axle support brackets **271** are rigidly secured to the front and rear of axle **217**, and top plate **284** and bottom plate **282** are rigidly secured to the axle support brackets in the manner described above, axle **217** is effectively captured by and secured to axle mount assembly **270** of exemplary embodiment axle-to-beam connection **200**. It is to be understood that axle mount assembly **270** of axle-to-beam connection **200** could have different structures than those shown, such as having different forms and/or including different components, without affecting the overall concept or operation of the disclosed subject matter.

(37) With reference to FIGS. 3-4, 7, and 9-10, openings **283** of bottom plate **282** of axle mount assembly **270** align vertically with respective openings **254** of mounting plate **251** of axle alignment assembly **250**, as well as align vertically with respective elongated slotted openings **276** of axle support brackets **271** and the openings formed in bosses **286** of top plate **284**. Bolts **290** (FIGS. 3-5 and 9-10) are disposed through the openings formed in bosses **286** of top plate **284**, slotted openings **276** of support brackets **271**, and openings **283** of bottom plate **282** of mount assembly **270**, and through openings **254** of mounting plate **251**, the openings in spacers **255**, and the openings (not shown) of bolt brackets **268** of attachment brackets **260** of alignment assembly **250**. Nuts **292** are tightened on respective bolts **209**, thereby securing mount assembly **270** and alignment assembly **250** of exemplary embodiment axle-to-beam connection **200** together, and thus securing axle **217** captured by and secured to the mount assembly to beam **212** of suspension assembly **211** of the axle/suspension system in substantially perpendicular alignment with the longitudinal length of the beam. In this manner, exemplary embodiment axle-to-beam connection **200** enables axle **217** to be accurately aligned with beam **212** of suspension assembly **211** and quickly and securely attached to the beam.

(38) In accordance with another important aspect of the disclosed subject matter, exemplary embodiment axle-to-beam connection **200** provides a strong and secure connection between axle **217** and beam **212**. More specifically, as a continuous weld is laid between inner edge **275** of window **274** of each axle support bracket **271** of axle mount assembly **270** and axle **217** to secure the axle to the axle mount assembly, line welds on the axle are eliminated, which eliminates or greatly reduces the formation of stress risers, providing a generally stronger and more resilient connection capable of effectively reacting torsional and roll forces imparted on axle-to-beam connection **200** compared to prior art axle-to-beam connections that utilize line welds to attach the axle to the beam, such as axle-to-beam connection **14** described above. In addition, as support brackets **271** of axle mount assembly **270** intimately contact axle **217**, and thus extend transversely along and partially encompasses the axle both inboardly and outboardly from the continuous weld at inner edge **275** of window **274**, the axle mount assembly effectively reacts vertical, lateral, and longitudinal forces imparted on axle-to-beam connection **200** during operation of the heavy-duty vehicle, thereby reducing stress on the continuous weld and further strengthening the axle-to-beam connection. Furthermore, because axle alignment assembly **250** is attached to/integrated into beam **212**, axle **217** is captured by and secured to mount assembly **270**, and the axle mount assembly is secured to the axle alignment assembly via bolts **290** and nuts **292**, loads imparted on axle-to-beam

connection **200** are transferred throughout the structure of the beam, providing additional torsional stiffness to, and reducing stress on, the axle-to-beam connection. In this manner, exemplary embodiment axle-to-beam connection **200** provides a stronger, more resilient and secure connection capable of withstanding forces imparted on the axle-to-beam connection during operation of the heavy-duty vehicle in harsh driving conditions, such as on harsh road surfaces. (39) In accordance with yet another important aspect of the disclosed subject matter, exemplary embodiment axle-to-beam connection **200** enables removable attachment of axle **217** to beam **212** of suspension assembly **211**. More specifically, because axle **217** is captured by and secured to axle mount assembly **270** and alignment assembly **250** is rigidly connected/integrated into beam **212** of suspension assembly **211** in the manner described above, axle **217** is secured to beam **212** of suspension assembly via simple tightening of nuts **292** to bolts **290**, and can be removed from the beam simply by untightening the nuts from the bolts. Thus, axle **217** does not need to be welded to beam **212** of suspension assembly **211**. As a result, axle **217** with a pair of mount assemblies **270** attached thereto and suspension assemblies **211** can be shipped separately and assembled on site without welding equipment, thereby decreasing shipping costs as compared to axle/suspension systems utilizing prior art axle-to-beam connections with axles irremovably attached to the suspension assemblies during manufacturing. Moreover, as axle-to-beam connection **200** enables axle **217** to be secured to or disconnected from beam **212** of suspension assembly via simple tightening or untightening of nuts **292** to/from bolts **290**, the axle-to-beam connection eliminates the need for specialized equipment to remove welds and subsequently reweld the axle to the beam while servicing or replacing the axle, the beam, and/or components of the axle-to-beam connection if they become damaged during operation of the heavy-duty vehicle. Thus, axle-to-beam connection **200** provides improved field serviceability to axle **217**, beam **212**, and/or components of the axle-to-beam connection if they become damaged during operation of the heavy-duty vehicle.

(40) In accordance with yet another important aspect of the disclosed subject matter, top plate **284** of axle mount assembly **270** includes a substantially vertically-extending boss **280** integrally formed with or otherwise rigidly attached to the top plate via suitable means, such as welding. Boss **280** is formed, such that it is substantially aligned with the respective main member of the heavy-duty vehicle to which the respective hanger (not shown) is attached. Boss **280** acts as a bump stop capable of sufficiently reacting forces imparted on mount assembly **270**, and thus exemplary embodiment axle-to-beam connection **200**, during extreme jounce events of suspension assembly **211** when the mount assembly strikes the respective main member of the heavy-duty vehicle. Thus, boss **280** prevents potential damage to components of axle-to-beam connection **200**, axle **217**, and/or the main member during extreme jounce events, while eliminating the need for discrete bump stops attached to or incorporated into components of the axle/suspension system and/or the main member of the heavy-duty vehicle, and reducing heavy-duty vehicle manufacturing costs and complexity.

(41) Thus, exemplary embodiment axle-to-beam connection **200** of the disclosed subject matter includes a structure that enables an axle of an axle/suspension system to be accurately aligned with and quickly and securely attached to a beam of a suspension assembly of the axle/suspension system. Exemplary embodiment axle-to-beam connection **200** provides a strong and secure connection between the axle and the beam, while eliminating line welds on the axle, thereby minimizing stress on the axle, and providing a stronger, more resilient axle-to-beam connection. Furthermore, exemplary embodiment axle-to-beam connection **200** enables shipment of the axle and suspension assemblies of the axle/suspension system separately and facilitates quick and simplified on-site alignment and attachment of the axle to the beams of the suspension assemblies without the need for welding equipment. Moreover, as the axle-to-beam connection of the disclosed subject matter facilitates quick and simplified alignment and attachment of the axle to the beams without the need for welding equipment, the axle-to-beam connection provides improved field

serviceability to the axle, beam, and/or components of the axle-to-beam connection. In addition, exemplary embodiment axle-to-beam connection **200** includes a structure that acts as a mechanical bump stop to prevent potential damage to the beam, axle, frame of the heavy-duty vehicle, and/or components of the axle-to-beam connection during jounce events, and decreases manufacturing costs and complexity of the axle/suspension system.

(42) It is understood that exemplary embodiment axle-to-beam connection **200** of the disclosed subject matter can include additional or alternative means for securing the connection between an axle and a beam without affecting the overall concept or operation of the disclosed subject matter. It is contemplated that intimate contact of components of axle-to-beam connection **200** with an axle of a heavy-duty vehicle could create preload or compression at the interface between the outer surface of the axle and the axle contacting surfaces of the components of the axle-to-beam connection to strengthen the axle against loads and resulting stresses encountered during operation of the vehicle. It is further contemplated that exemplary embodiment axle-to-beam connection **200** of the disclosed subject matter could be utilized on heavy-duty vehicles having frames or subframes, which are moveable or non-movable, and having one or more than one axle without changing the overall concept or operation of the disclosed subject matter. It is also contemplated that axle-to-beam connection **200** of the disclosed subject matter could be utilized in conjunction with leading- and/or trailing-arm beam-type axle/suspension system designs with bottom-mount/underslung, top-mount/overslung, or top-mount/underslung beams, including beams made of any suitable material, such as metal, metal alloy, composite, and/or combinations thereof, or with different designs and/or configurations than those shown and described, such as solid beams, shell-type beams, truss structures, intersecting plates, spring beams and parallel plates, without changing the overall concept or operation of the disclosed subject matter. It is yet even further contemplated that axle-to-beam connection **200** of the disclosed subject matter could be utilized in conjunction with axles having any suitable structure, such as straight axles or raised-center axles, and any suitable fixed or varied wall thicknesses or other cross-sectional or overall shapes without changing the overall concept or operation of the disclosed subject matter.

(43) Accordingly, the axle-to-beam connection of the disclosed subject matter is simplified; provides an effective, safe, inexpensive, and efficient structure and method, which achieve all the enumerated objectives; provide for eliminating difficulties encountered with prior art axle-to-beam connections; and solve problems and obtain new results in the art.

(44) In the foregoing description, certain terms have been used for brevity, clarity, and understanding, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are used for descriptive purposes and are intended to be broadly construed. Moreover, the disclosed subject matter has been described with reference to a specific embodiment. It shall be understood that this illustration is by way of example and not by way of limitation, as the scope of the invention is not limited to the exact details shown or described. Potential modifications and alterations will occur to others upon a reading and understanding of the disclosed subject matter, and it is understood that the disclosed subject matter includes all such modifications, alterations, and equivalents thereof.

(45) Having now described the features, discoveries and principles of the disclosed subject matter, the manner in which the axle-to-beam connection is constructed, arranged, and used, the characteristics of the construction and arrangement, and the advantageous, new, and useful results obtained; the new and useful structures, devices, elements, arrangements, parts, and combinations are set forth in the claims.

Claims

1. An axle-to-beam connection for an axle/suspension system of a heavy-duty vehicle comprising: an axle; a beam including an alignment assembly; and an axle mount assembly, said axle mount

assembly intimately contacting and capturing said axle, the axle mount assembly including at least one window, the axle being rigidly secured to said axle mount assembly via a continuous weld formed in said at least one window between said axle and the axle mount assembly, the at least one window being located on a front or a rear portion of the axle, said axle being rigidly secured to said axle mount assembly without line welds, the axle mount assembly being removably connected to said alignment assembly to secure the axle to said beam.

2. The axle-to-beam connection of claim 1, wherein said axle mount assembly is removably connected to said alignment assembly with at least one fastener.

3. The axle-to-beam connection of claim 2, said axle alignment assembly including a mounting plate integrally formed with or rigidly attached to a top plate of said beam, said mounting plate being formed with one or more openings for removably connecting said axle mount assembly to said axle alignment assembly via said at least one fastener.

4. The axle-to-beam connection of claim 3, said axle alignment assembly further including at least one attachment bracket, said at least one attachment bracket being disposed about and secured to said beam, the at least one attachment bracket including at least one opening, said at least one opening being vertically aligned with said one or more openings of said mounting plate for removably connecting said axle mount assembly to the axle alignment assembly via said at least one fastener.

5. The axle-to-beam connection of claim 4, said axle alignment assembly further including a spacer positioned between said mounting plate and said at least one attachment bracket.

6. The axle-to-beam connection of claim 1, said axle mount assembly including at least one axle support bracket, said at least one axle support bracket including a profile that corresponds to and is complementary to a front profile or a rear profile of said axle, thereby facilitating said intimate contact between said axle mount assembly and the axle.

7. The axle-to-beam connection of claim 6, wherein said at least one axle support bracket is formed with said at least one window, said continuous weld being formed in the at least one window between the at least one axle support bracket and said axle to rigidly secure the axle to said axle mount assembly.

8. The axle-to-beam connection of claim 7, wherein said axle mount assembly includes a pair of axle support brackets, each one of said axle support brackets being positioned on opposite sides of said axle.

9. The axle-to-beam connection of claim 6, wherein said profile of said at least one axle support bracket is concave and said front profile or said rear profile of said axle is convex.

10. The axle-to-beam connection of claim 6, said axle mount assembly further including a top plate, said top plate being positioned on top of said axle and including a profile that corresponds to a top profile of the axle, the top plate being rigidly secured to said at least one axle support bracket.

11. The axle-to-beam connection of claim 10, wherein said top plate is rigidly secured to said at least one axle support bracket via welding.

12. The axle-to-beam connection of claim 10, wherein said top plate includes an axially extending recess with a concave profile and said top profile of said axle is convex, said concave profile corresponding to said top profile of said axle.

13. The axle-to-beam connection of claim 10, wherein said axle mount assembly further include a bottom plate, said bottom plate being rigidly attached to said at least one support bracket, the bottom plate, the at least one support bracket, and the top plate capturing said axle.

14. The axle-to-beam connection of claim 13, wherein said top plate includes a plurality of first openings and said bottom plate includes a plurality of second opening, said plurality of first openings and said plurality of second openings being vertically aligned with respective openings formed in said alignment assembly, said axle mount assembly being removably connected to the alignment assembly via fasteners disposed through the plurality of first openings, the plurality of second openings, and the respective openings formed in said alignment assembly.

15. The axle-to-beam connection of claim 14, wherein said at least one axle support bracket includes at least one slotted opening, said at least one slotted opening enabling said axle to include varying outer diameters while maintaining vertical alignment of said first openings, said second openings, and said respective openings formed in said alignment assembly.
16. The axle-to-beam connection of claim 1, said axle mount assembly further comprising a structure to act as bump stop during jounce events.
17. The axle-to-beam connection of claim 16, wherein said structure is a boss integrally formed with or rigidly attached to said axle mount assembly.
18. The axle-to-beam connection of claim 1, wherein said axle mount assembly includes at least one shock absorber mounting bracket for attachment of a shock absorber.
19. An axle-to-beam connection for an axle/suspension system of a heavy-duty vehicle comprising: an axle; a beam including an alignment assembly; and an axle mount assembly, said axle mount assembly intimately contacting and capturing said axle, the axle being rigidly secured to the axle mount assembly without line welds, said axle mount assembly being removably connected to said alignment assembly to secure the axle to said beam, the axle mount assembly including at least one shock absorber mounting bracket for attachment of a shock absorber.
20. An axle-to-beam connection for an axle/suspension system of a heavy-duty vehicle comprising: an axle; a beam including an alignment assembly; and an axle mount assembly, said axle mount assembly intimately contacting and capturing said axle, the axle mount assembly including at least one window, the axle being rigidly secured to said axle mount assembly via a continuous weld formed in said at least one window between said axle and the axle mount assembly, the at least one window being located on a front or a rear portion of the axle, said axle mount assembly being removably connected to said alignment assembly to secure said axle to said beam.
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