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Ehrlich et al.

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(54) **SIDE UNDERRIDE GUARD**

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(52) **U.S. Cl.**

CPC **B62D 35/001** (2013.01); **B60R 19/565**
(2013.01)

(58) **Field of Classification Search**

CPC B62D 35/001; B60R 19/565; Y02T 10/88

USPC 296/180.4

See application file for complete search history.

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Primary Examiner — Pinel E Romain

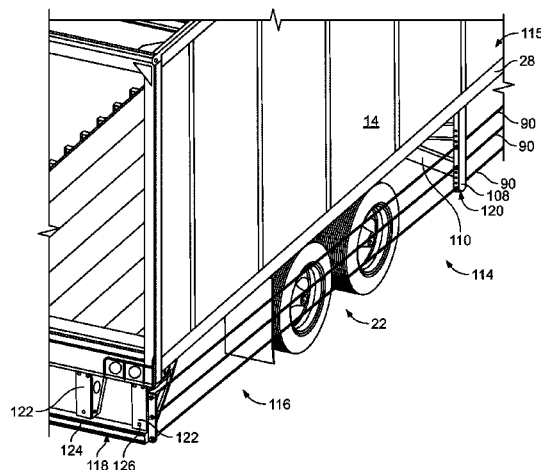
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(57)

ABSTRACT

A side underride system configured to be coupled to a trailer may comprise a first skirt wall coupled to the trailer, and extending along a first length of the trailer between a skirt wall front end and a skirt wall rear end and a cable system including a first cable coupled to the trailer, positioned below the first side wall, and extending along a second length of the trailer between a cable system front end and a cable system rear end, the skirt wall rear end being positioned forward of the cable system rear end.

20 Claims, 30 Drawing Sheets



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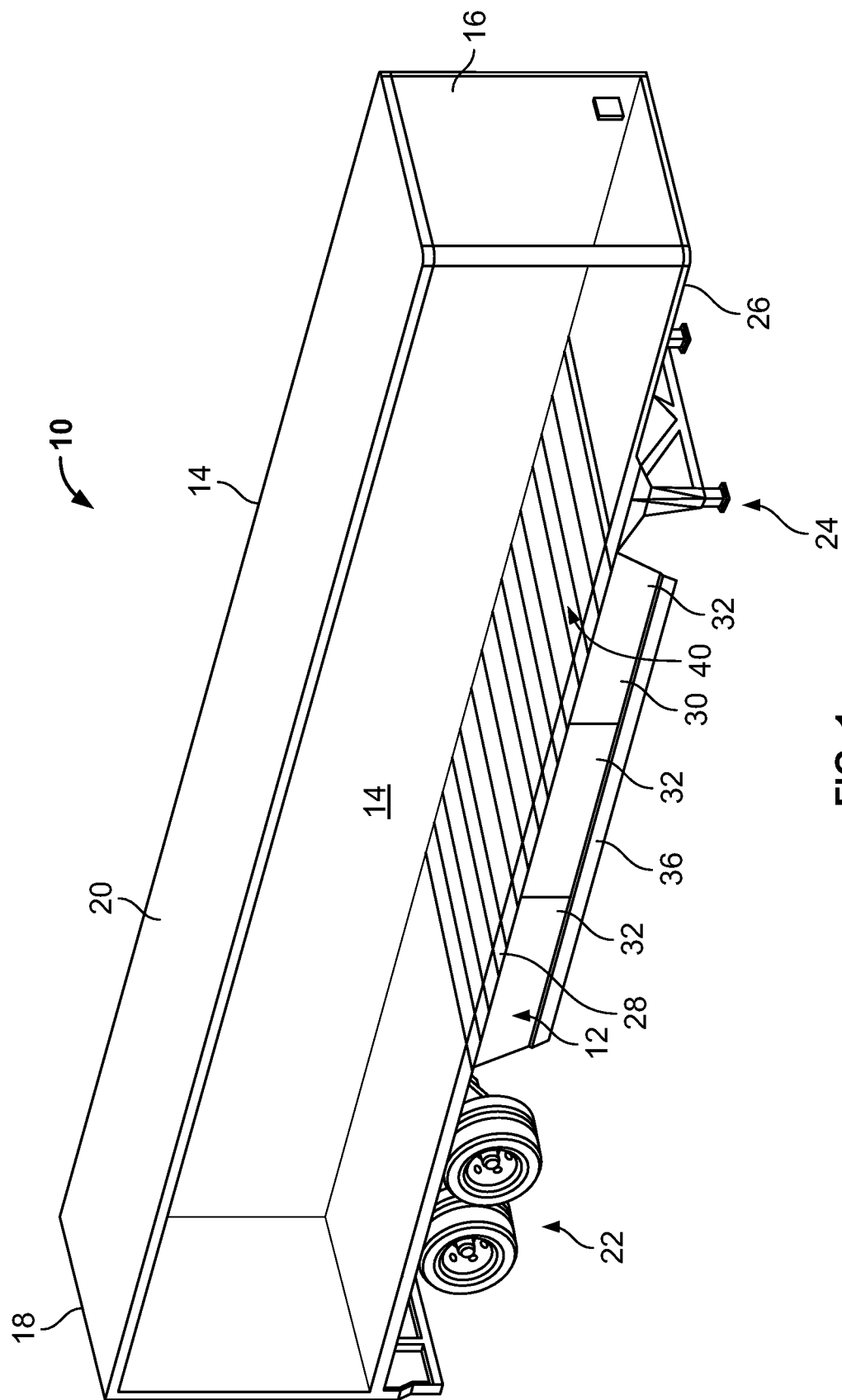
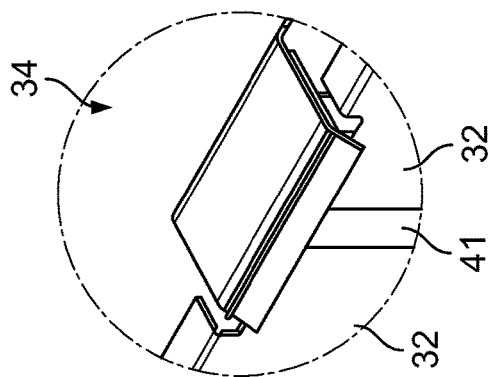
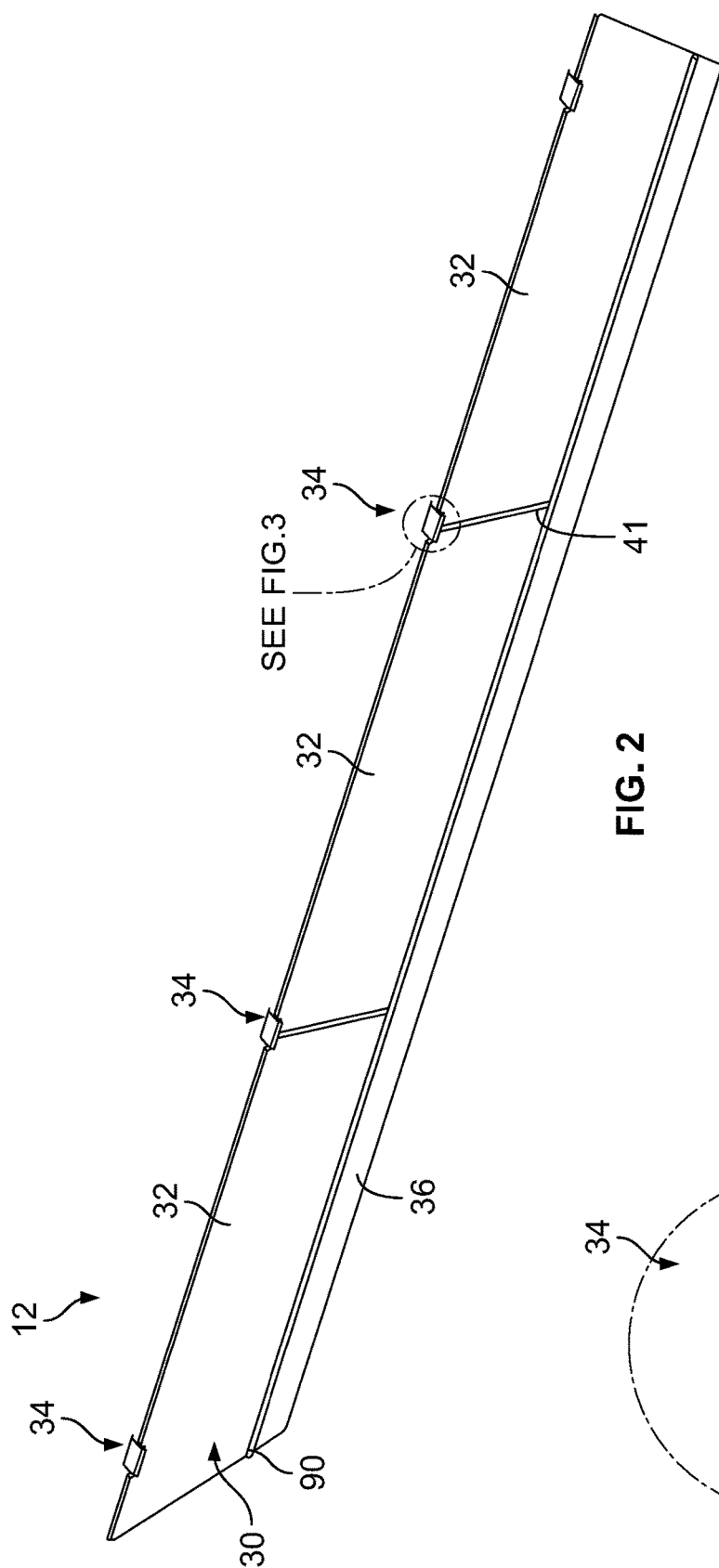


FIG. 1



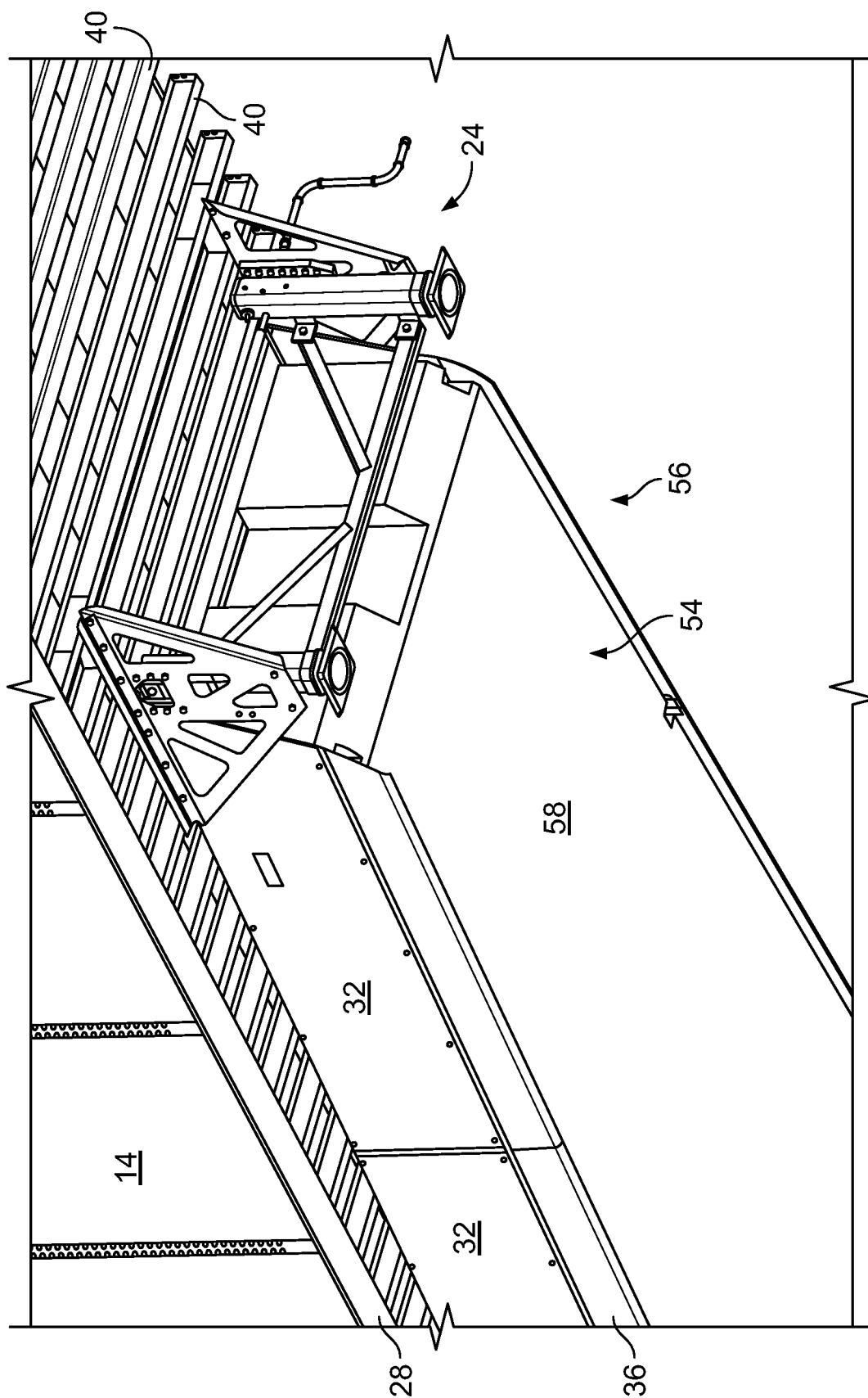


FIG. 4

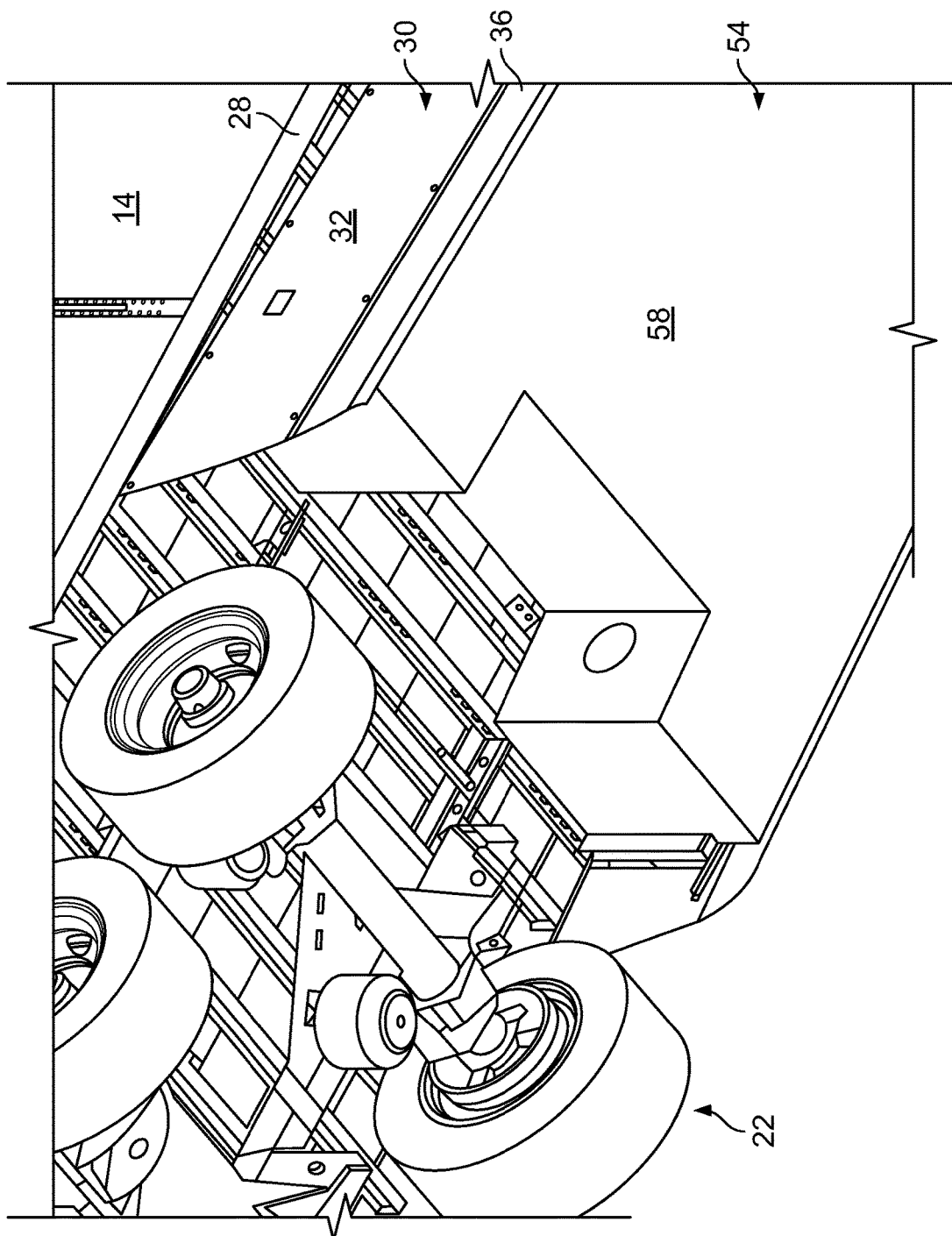


FIG. 5

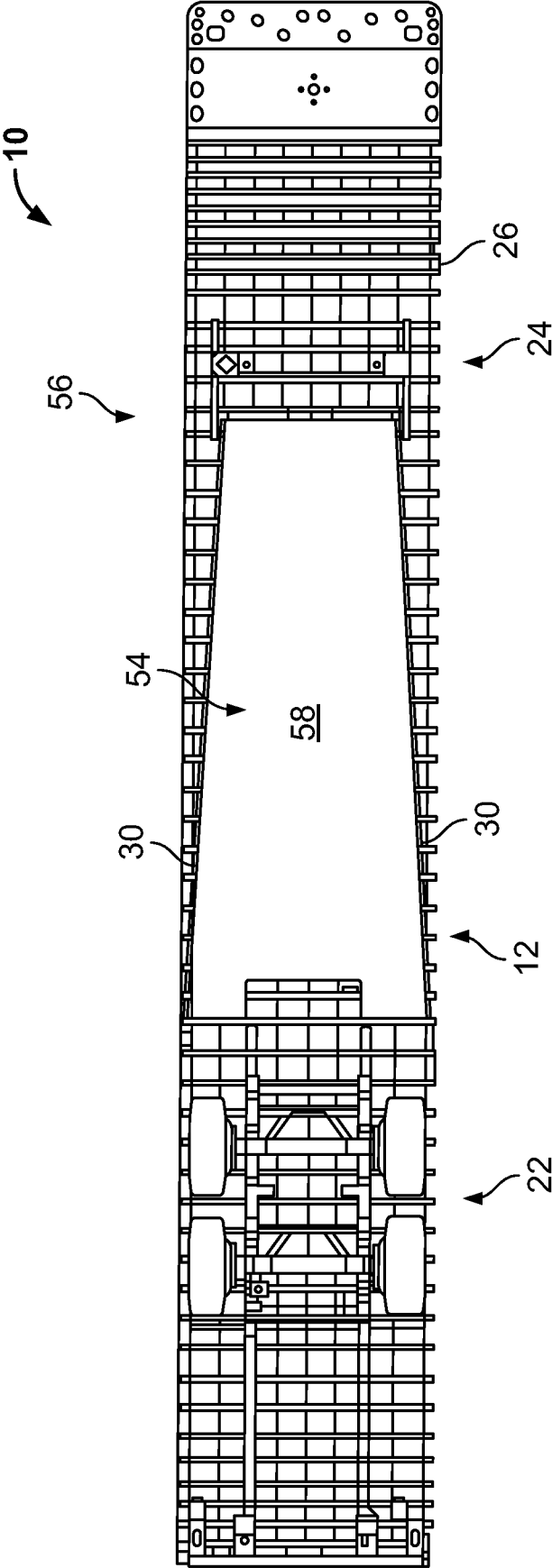


FIG. 6

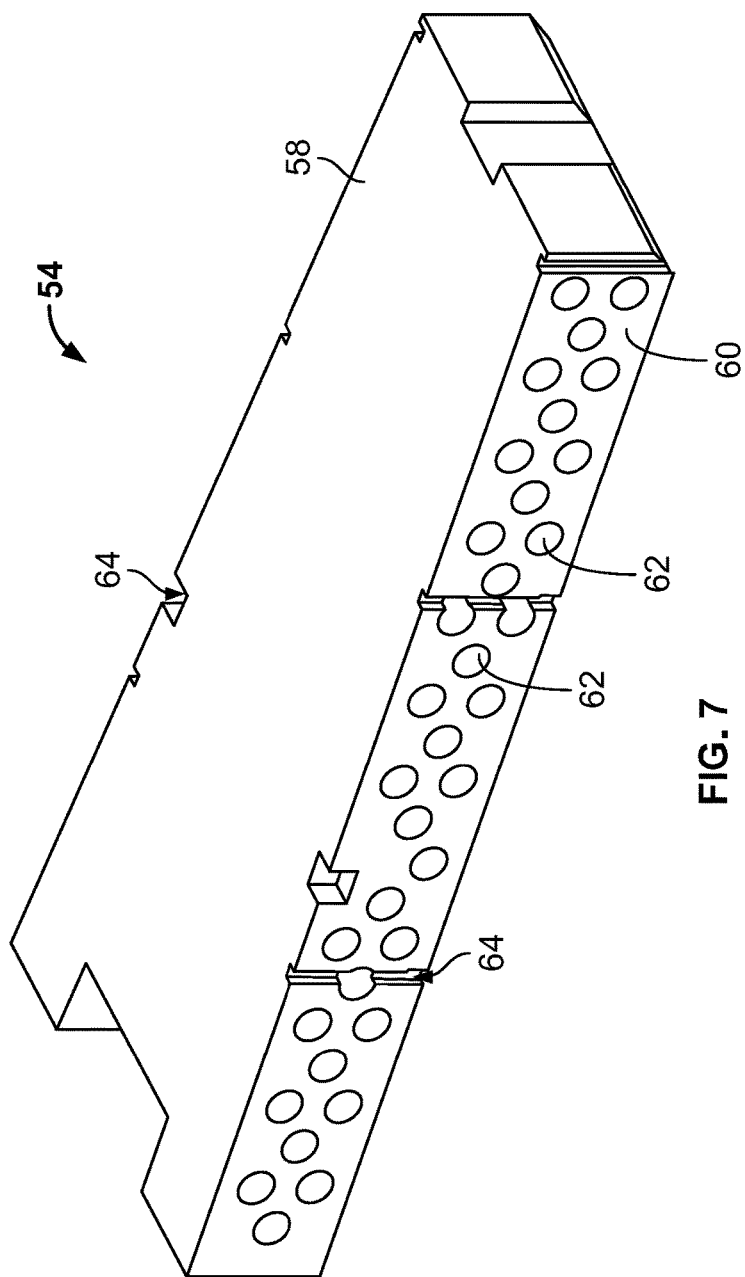


FIG. 7

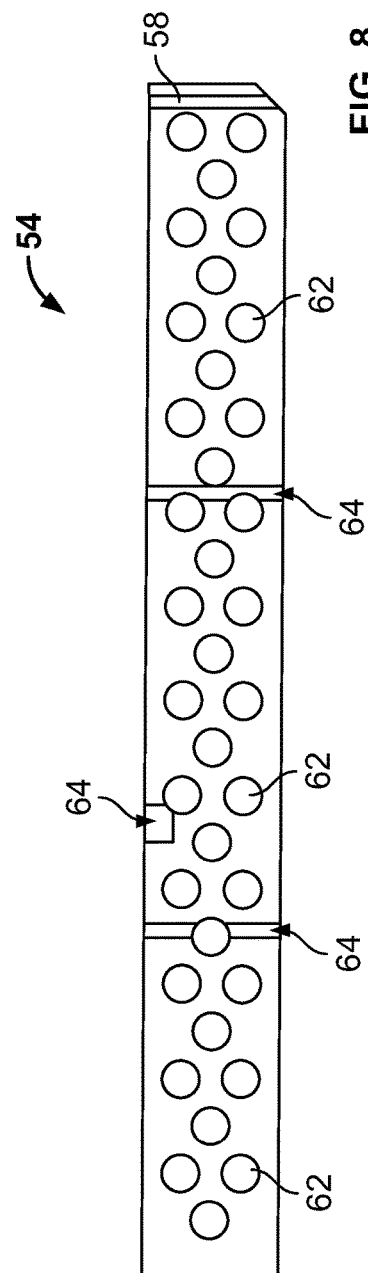
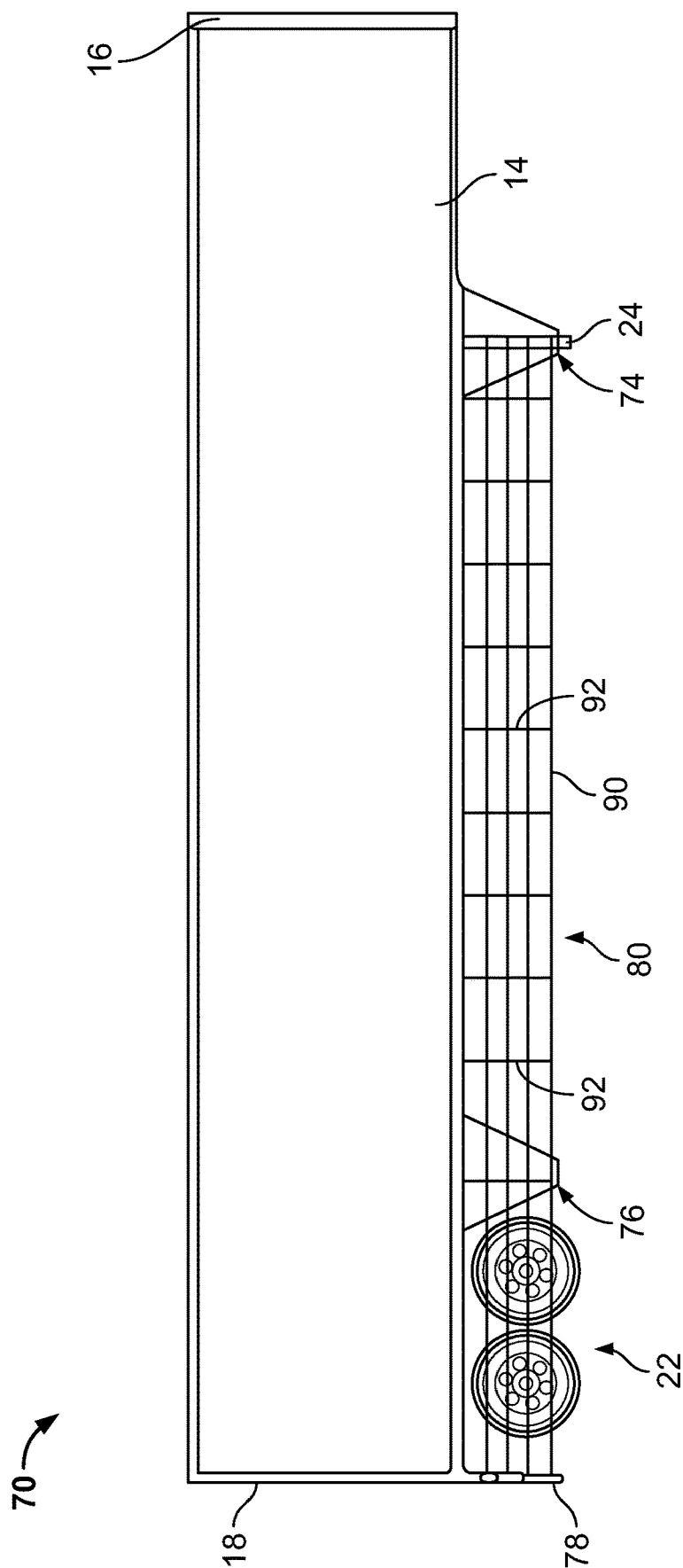


FIG. 8



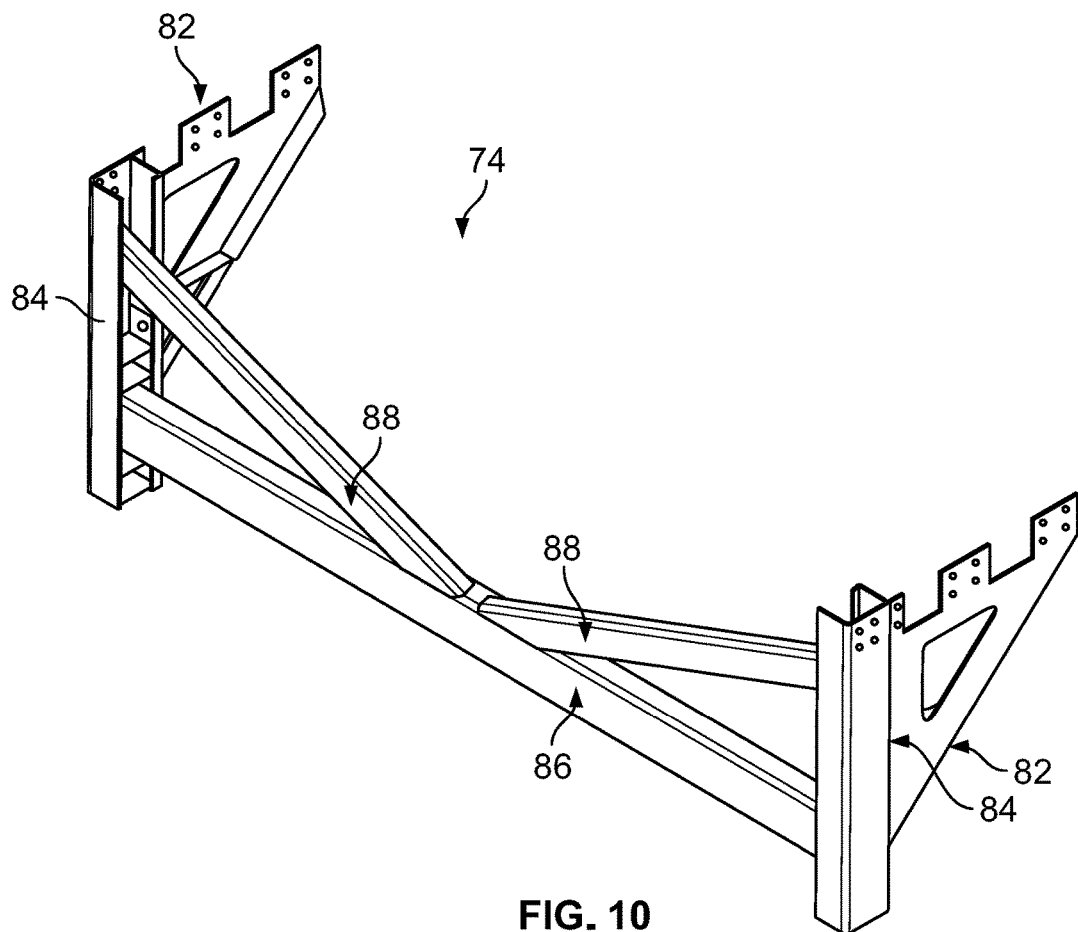


FIG. 10

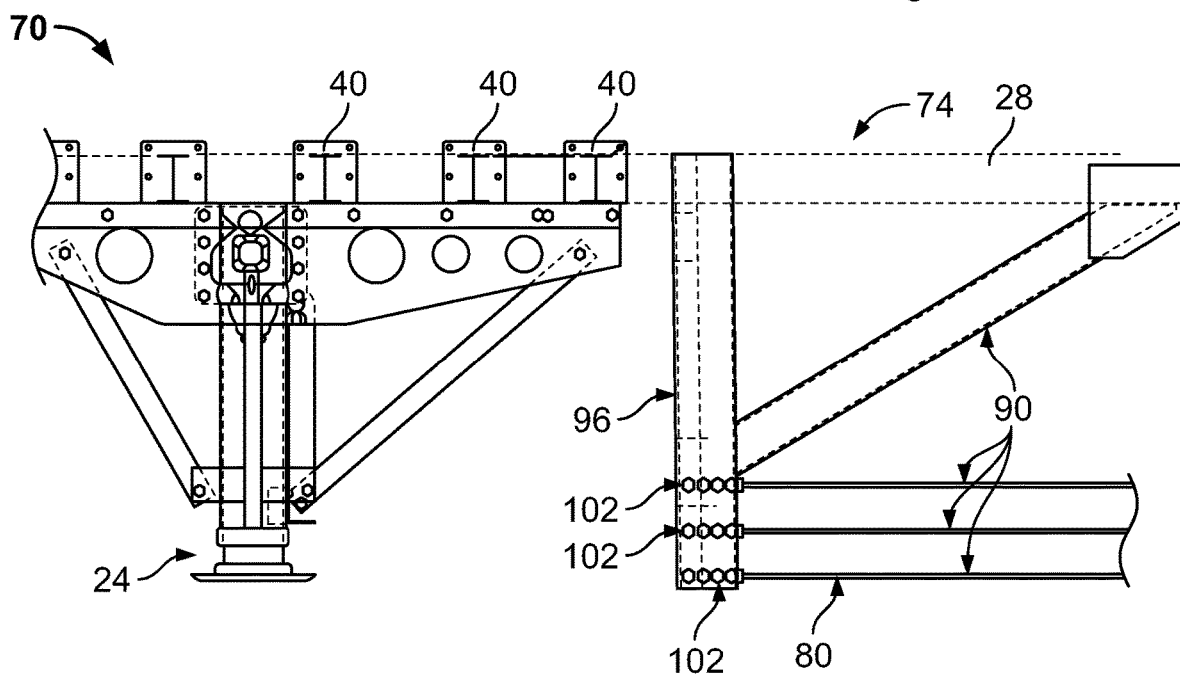


FIG. 11

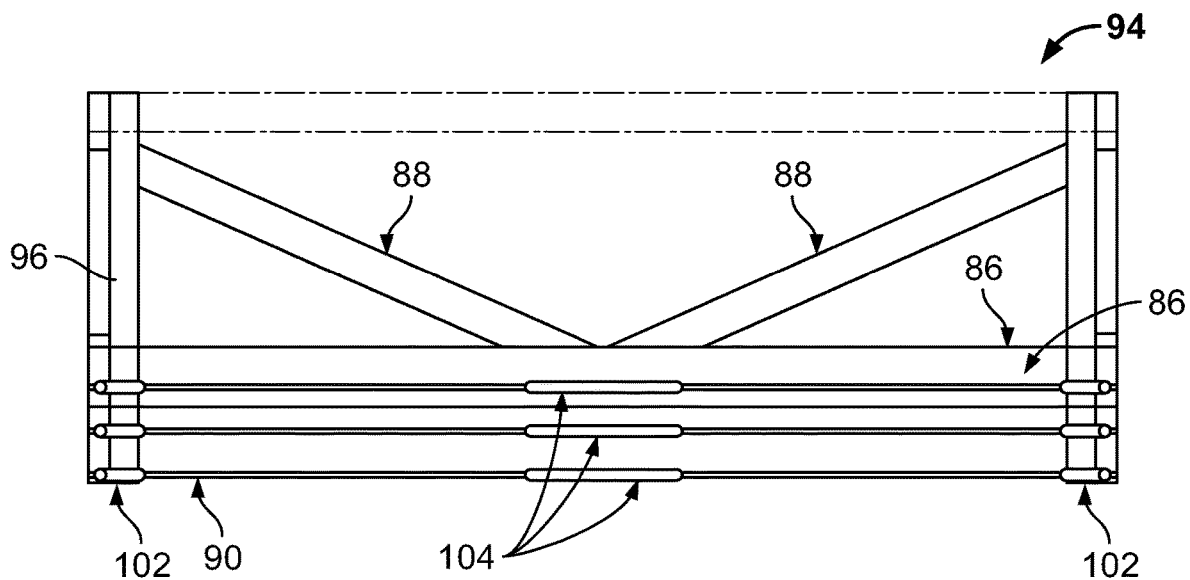


FIG. 12

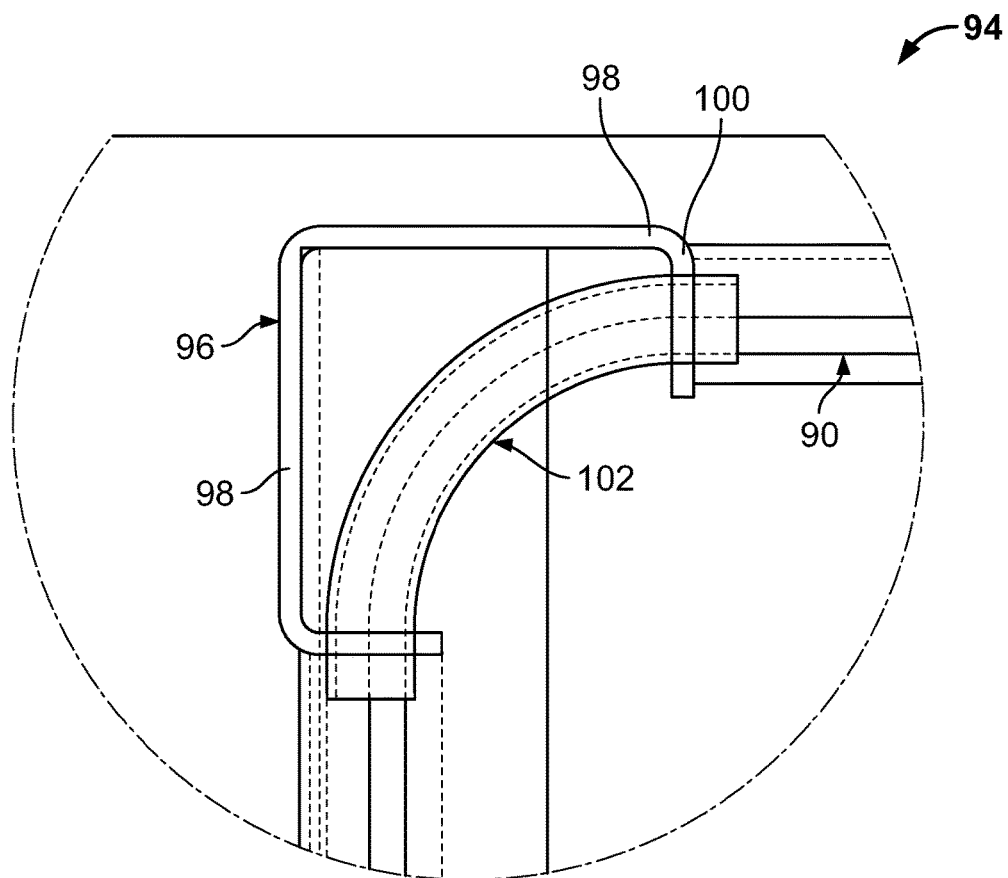


FIG. 13

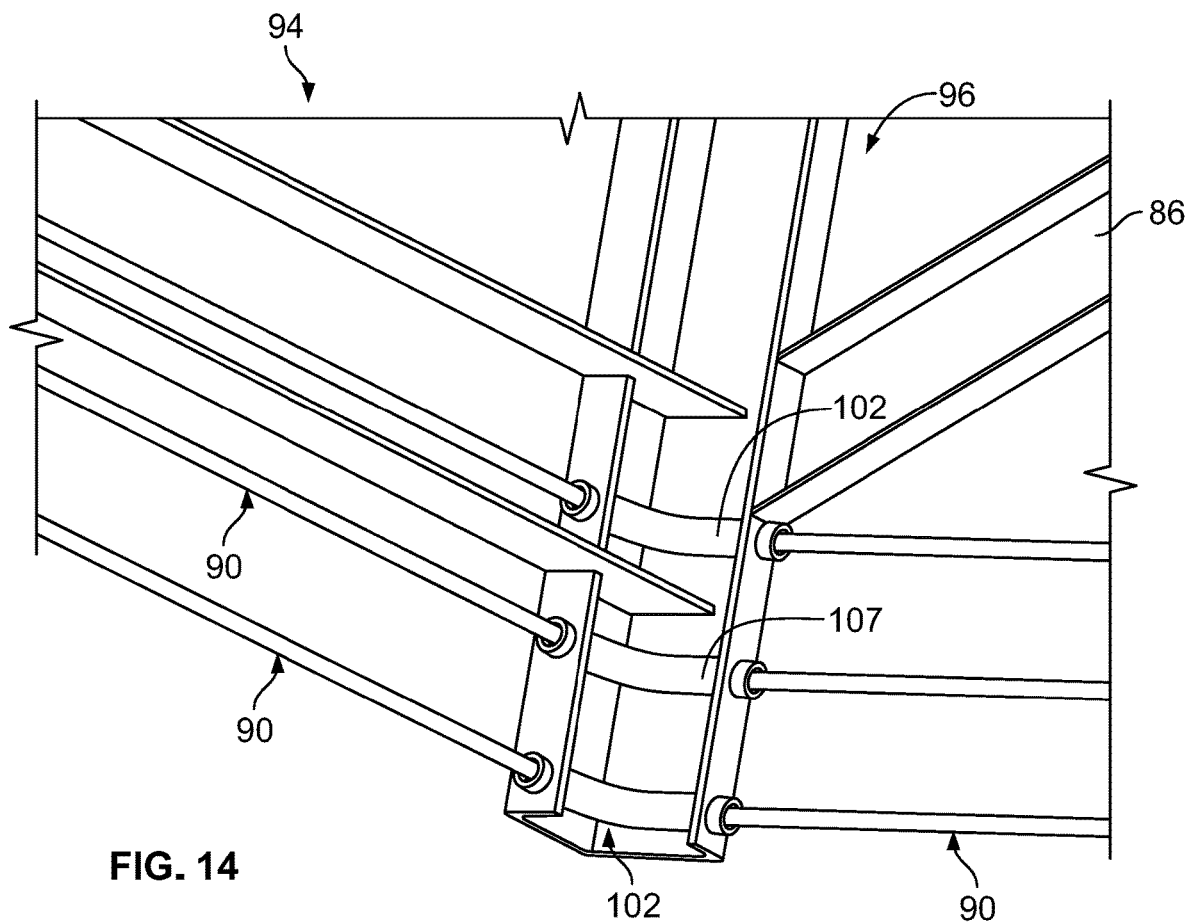


FIG. 14

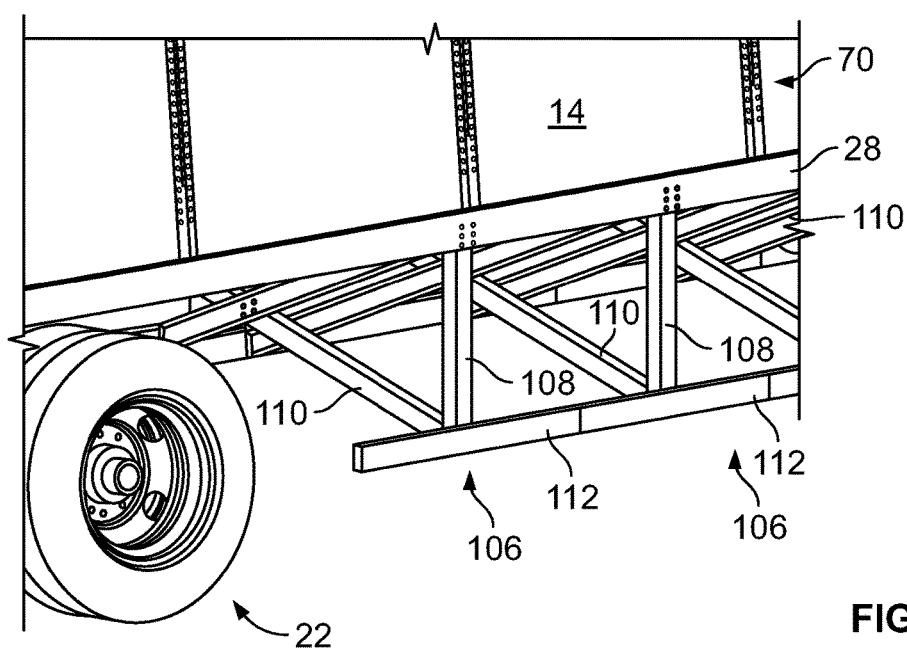


FIG. 15

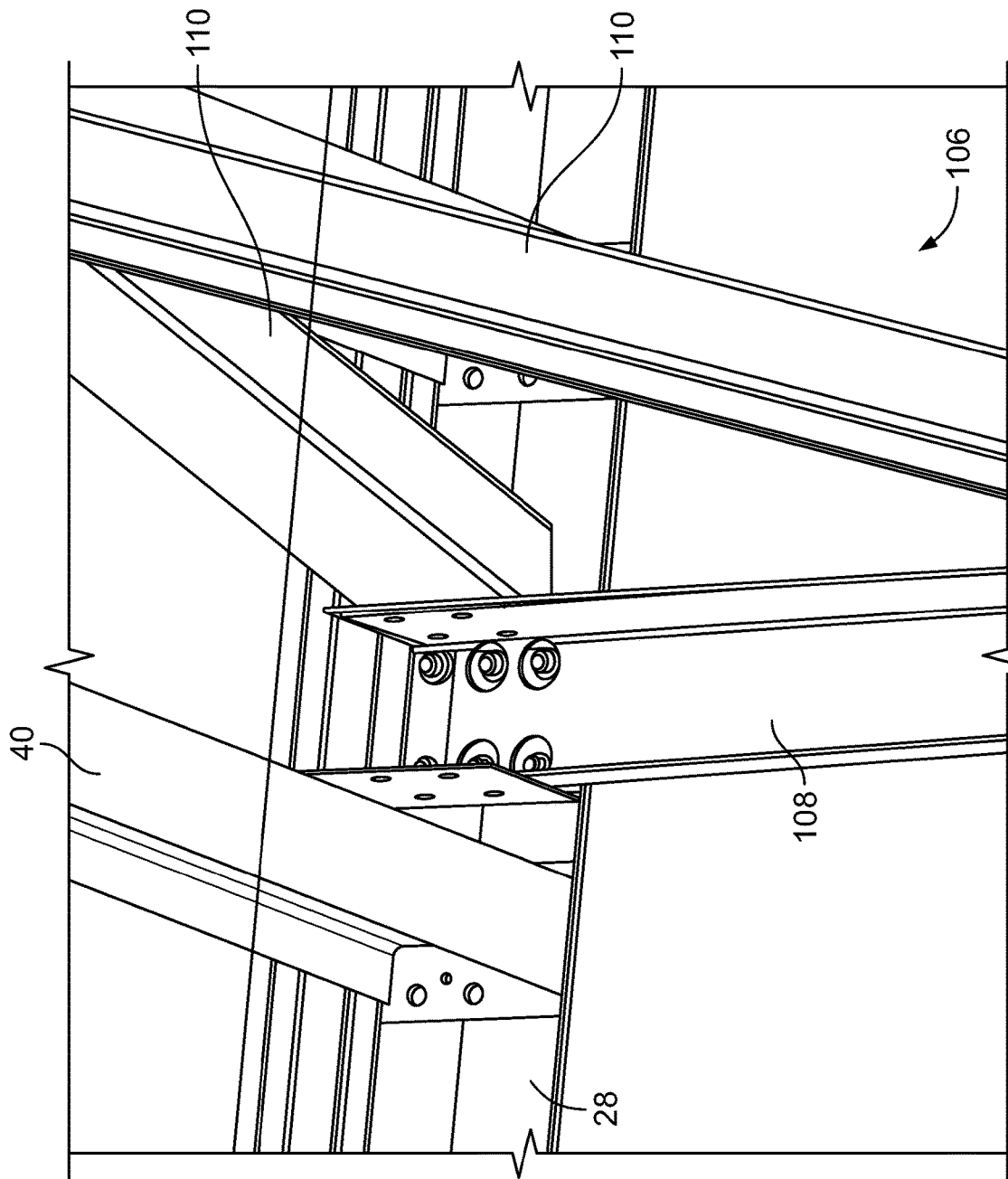
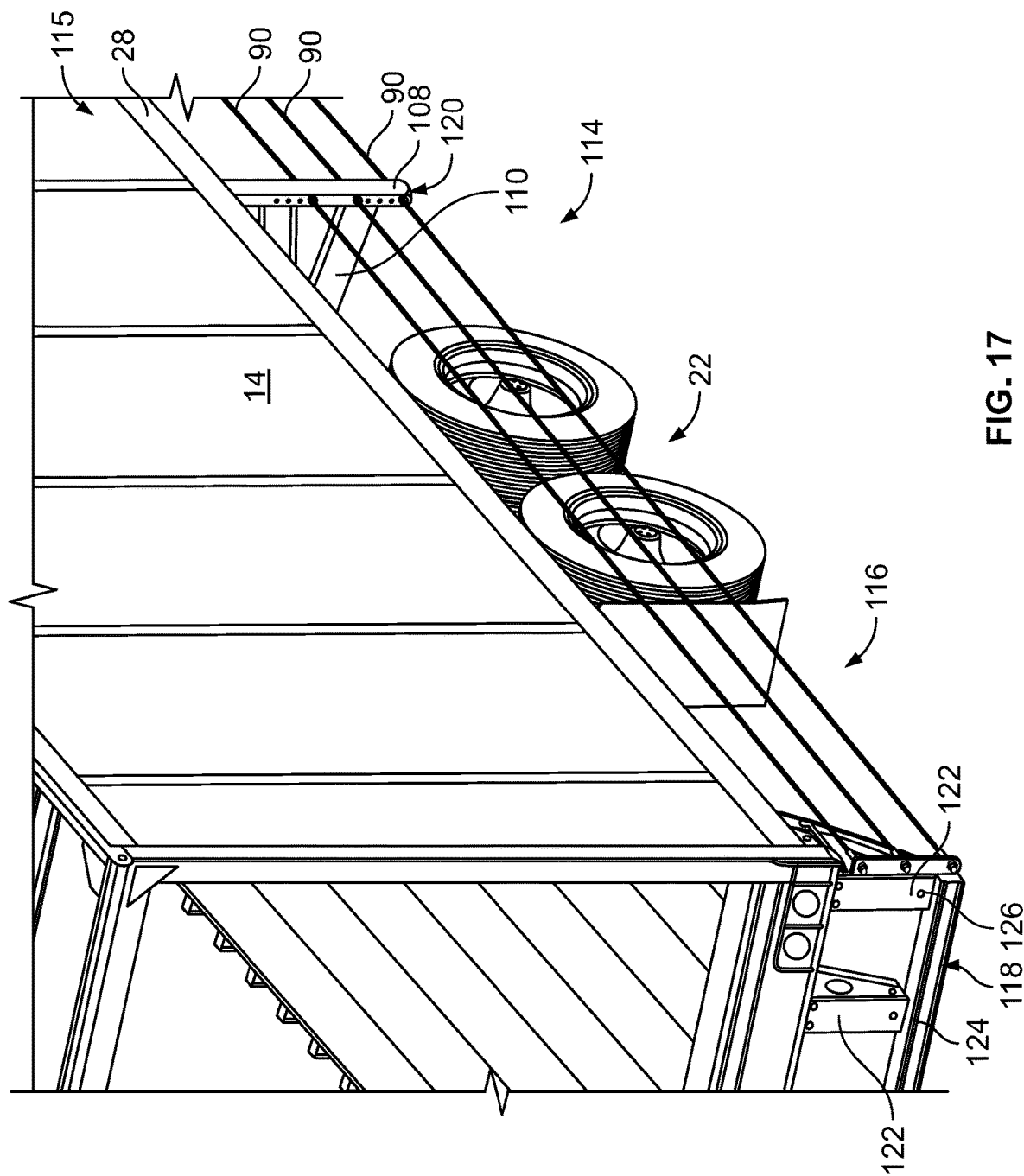


FIG. 16



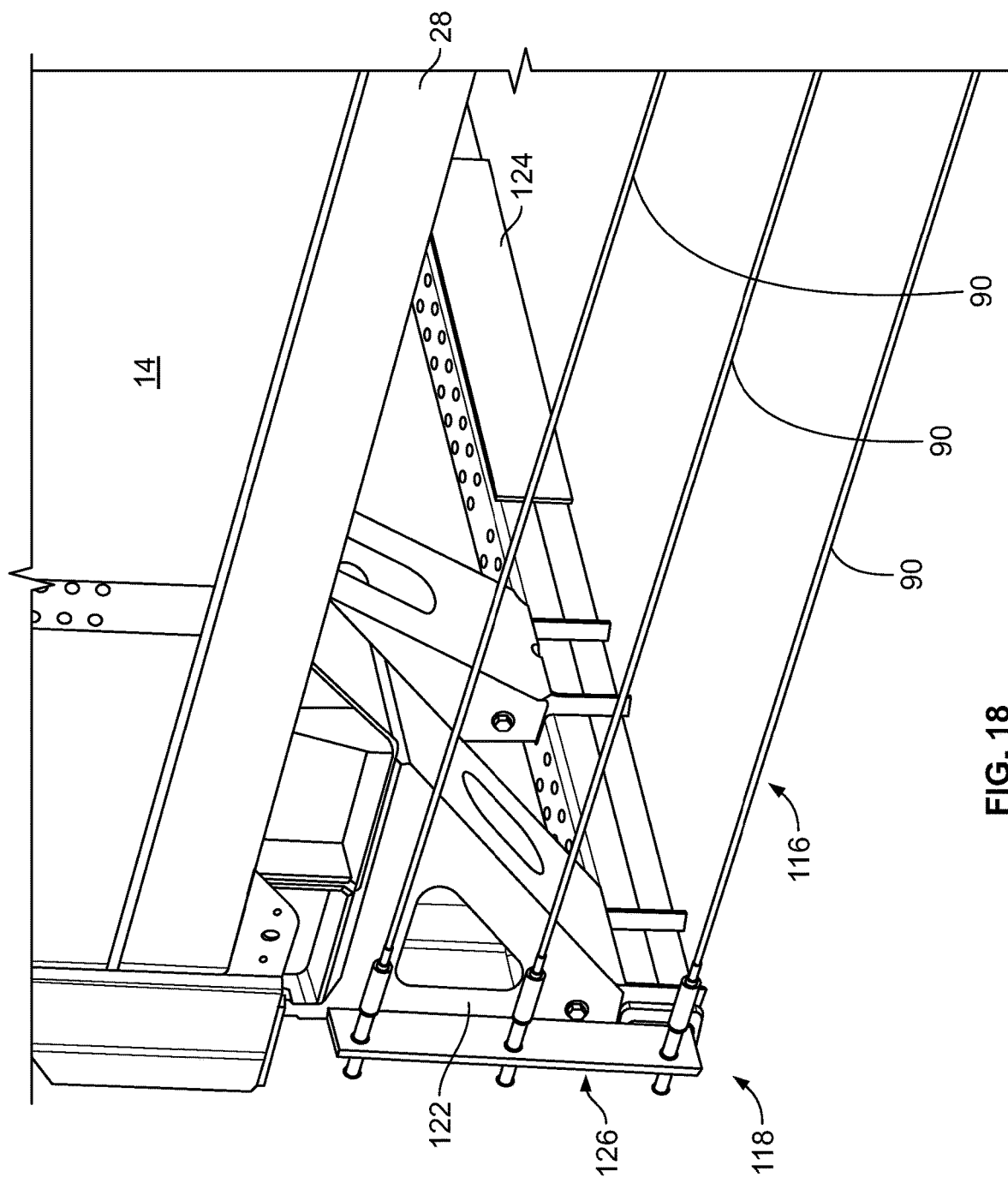


FIG. 18

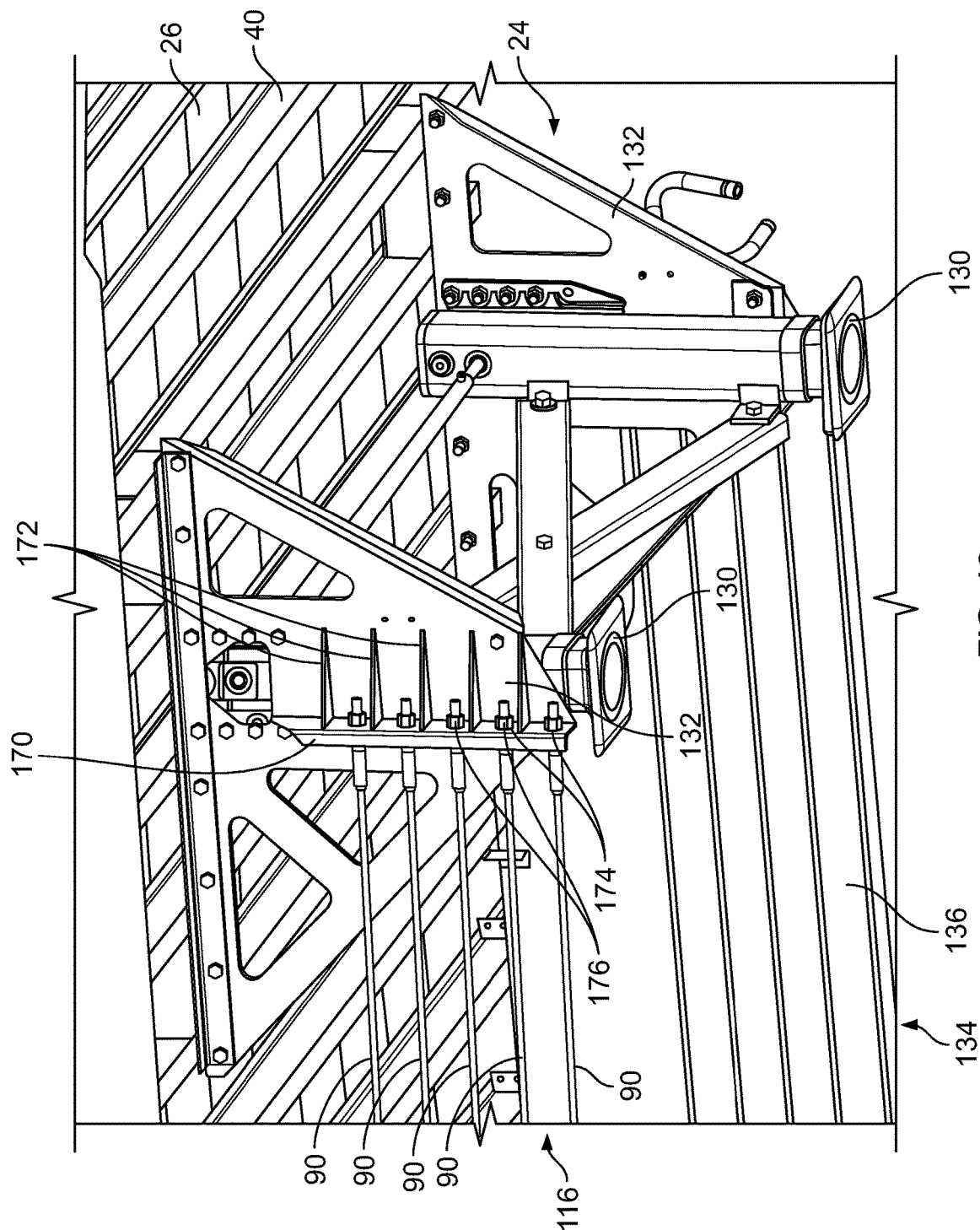


FIG. 19

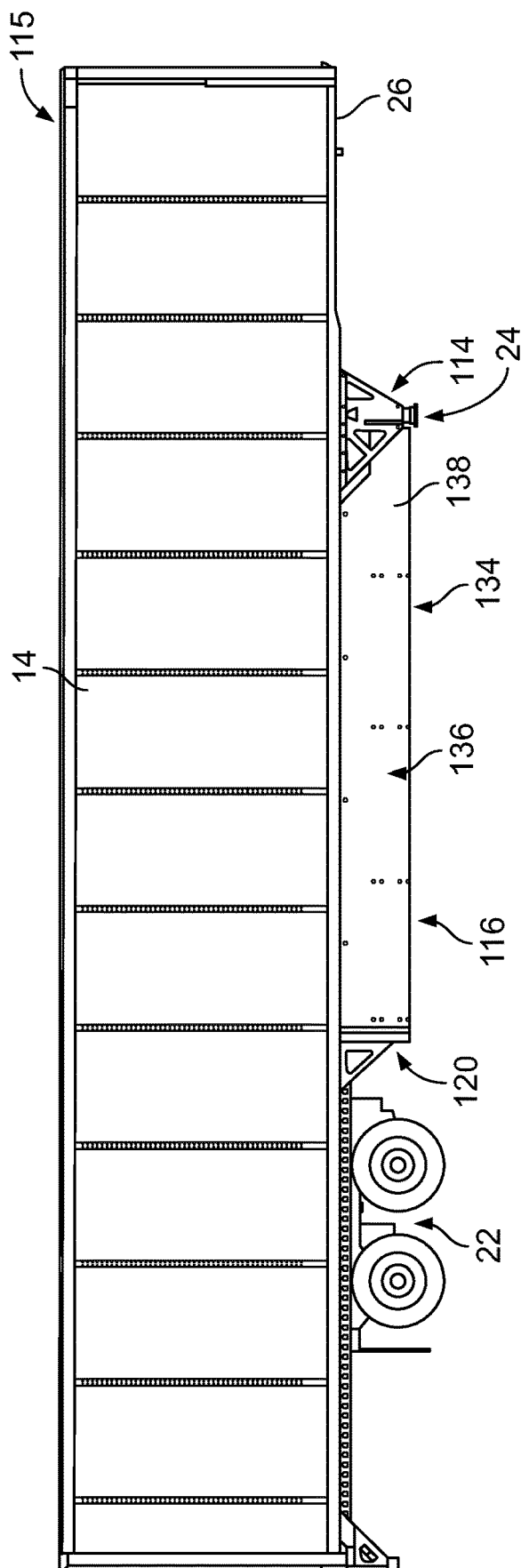


FIG. 21

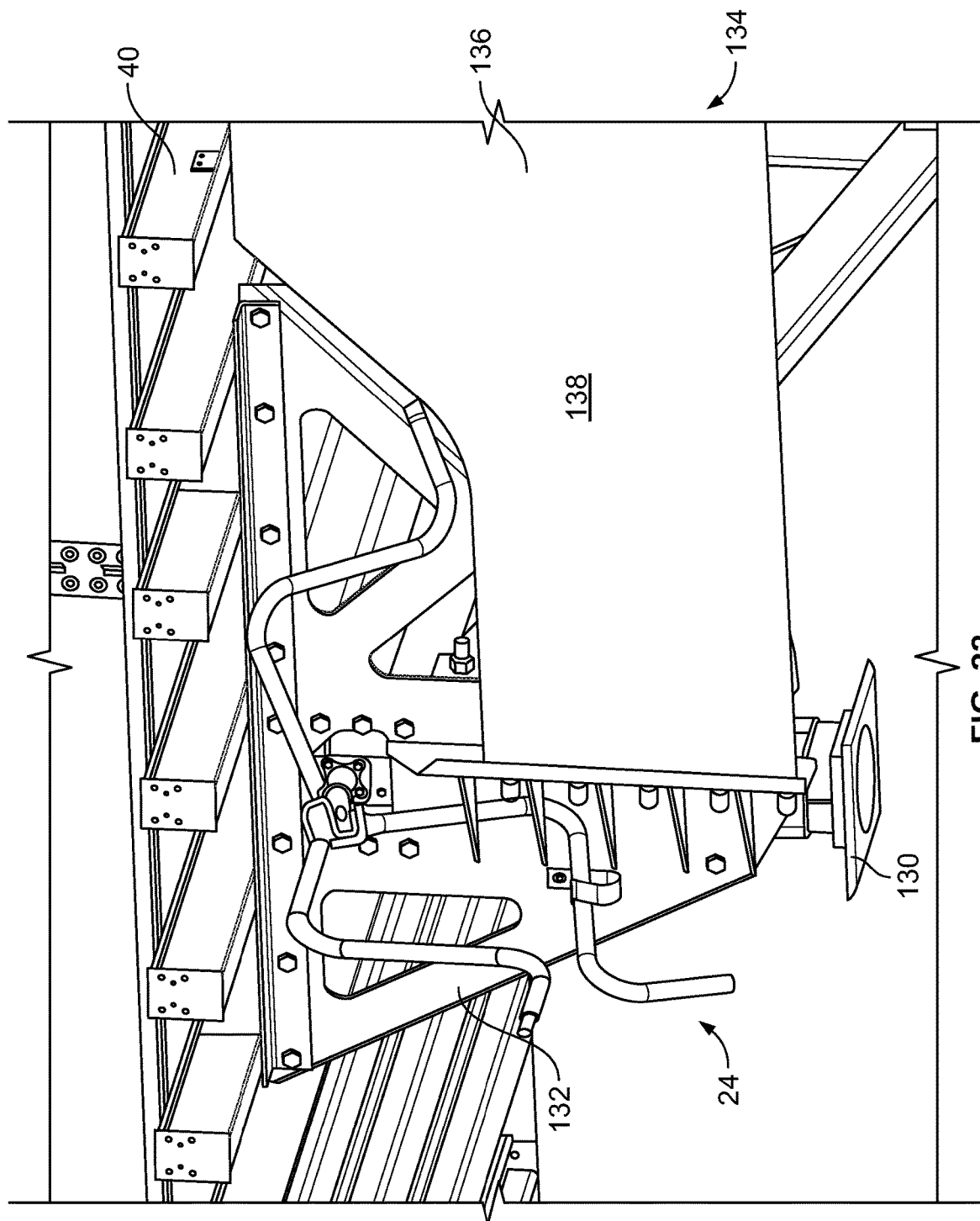


FIG. 22

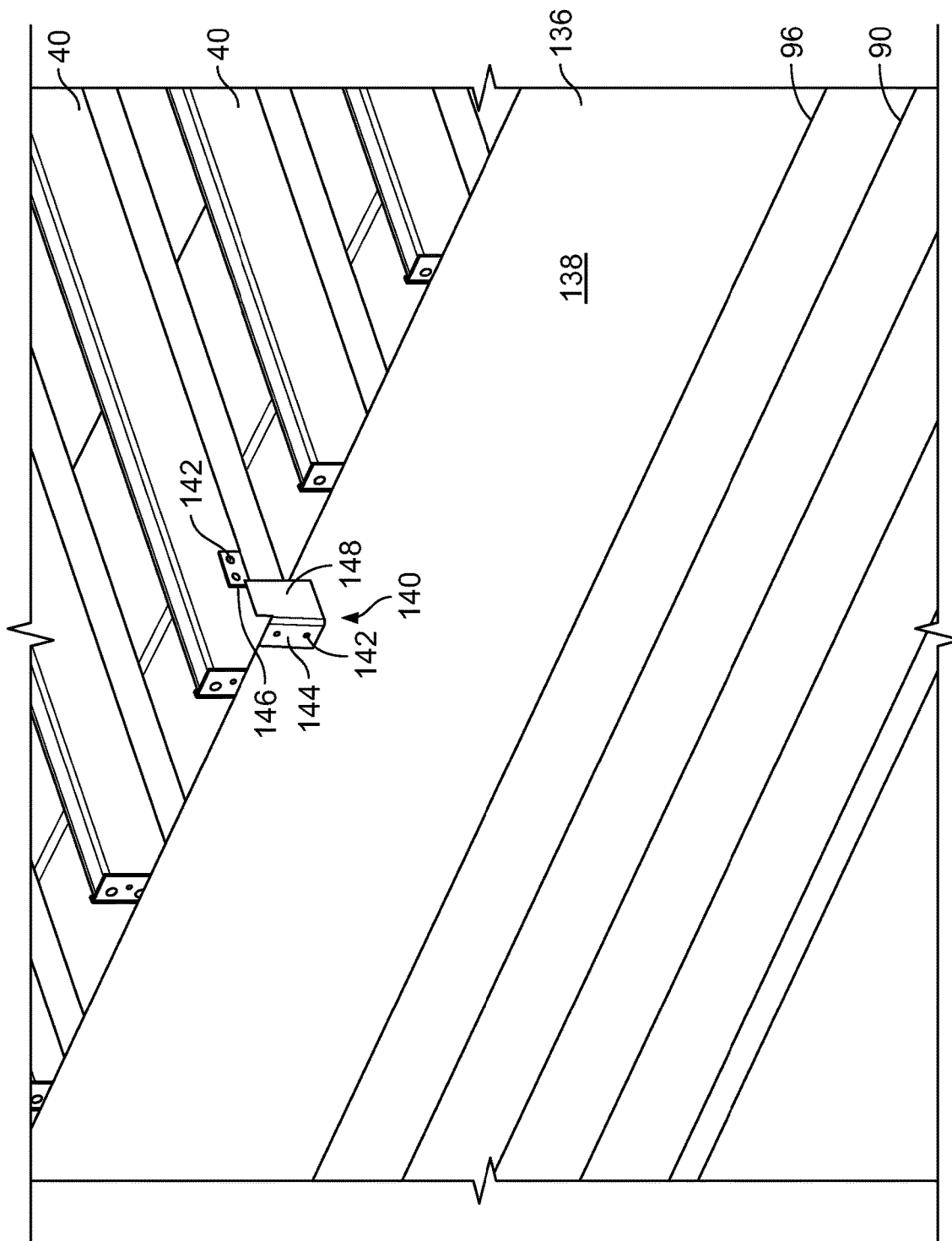


FIG. 23

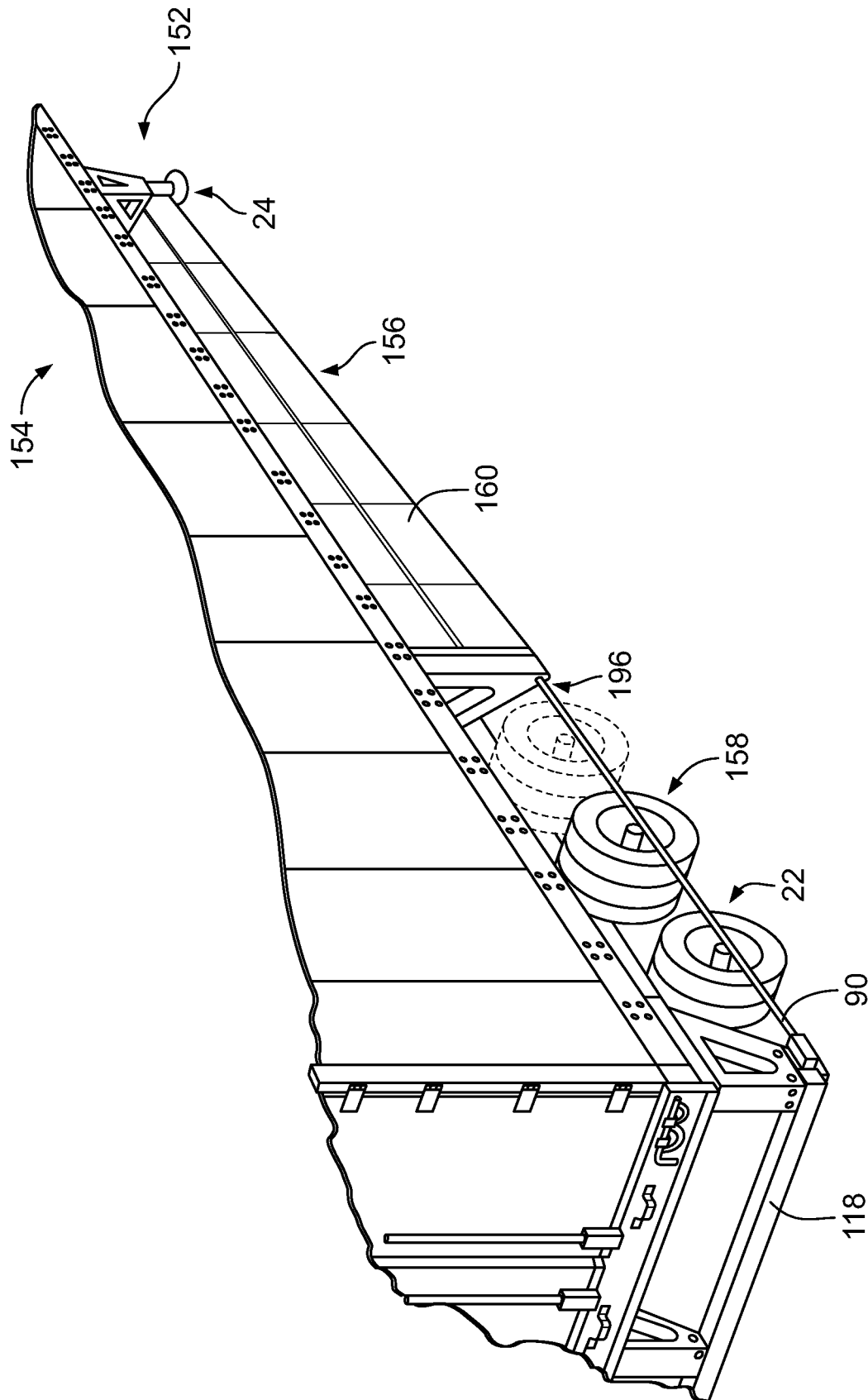


FIG. 24

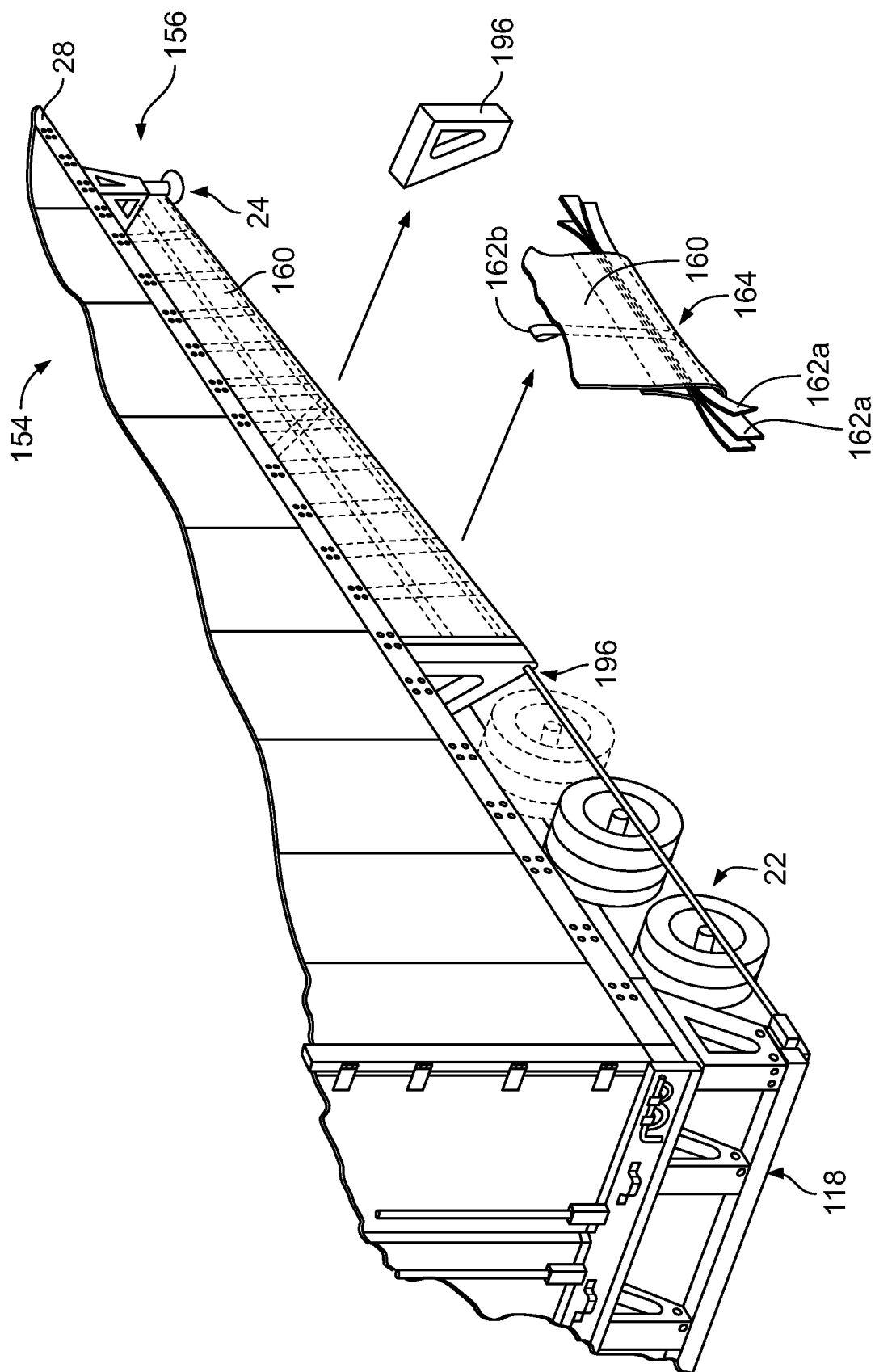


FIG. 25

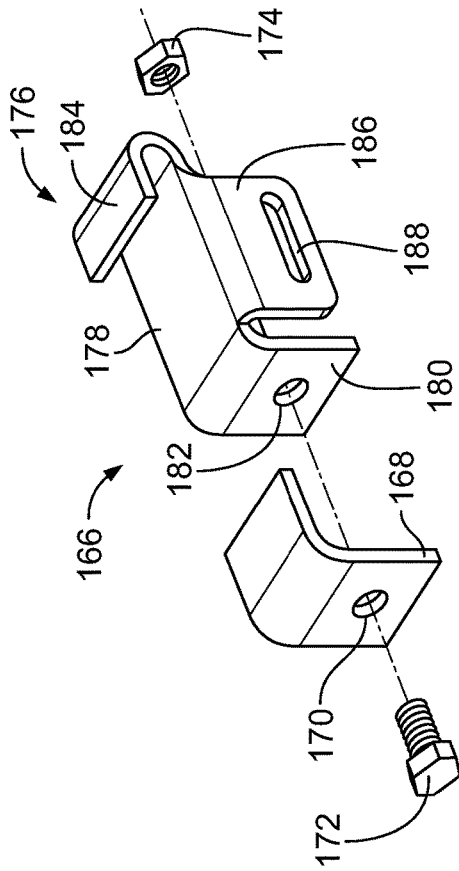


FIG. 27

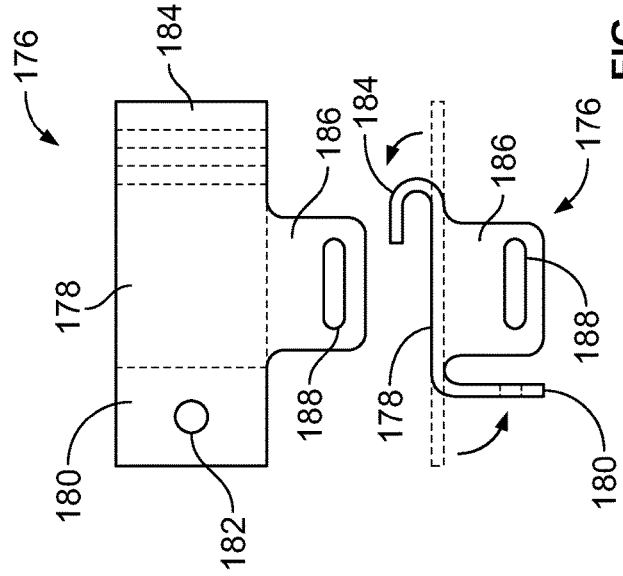


FIG. 28

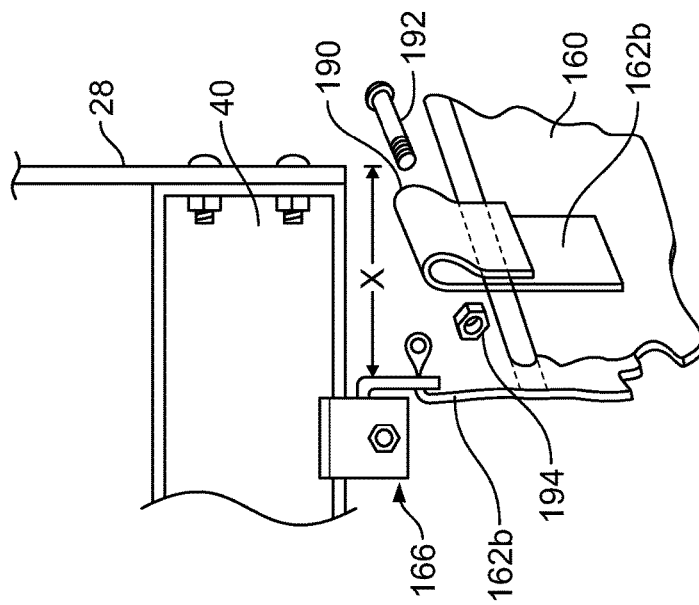


FIG. 26

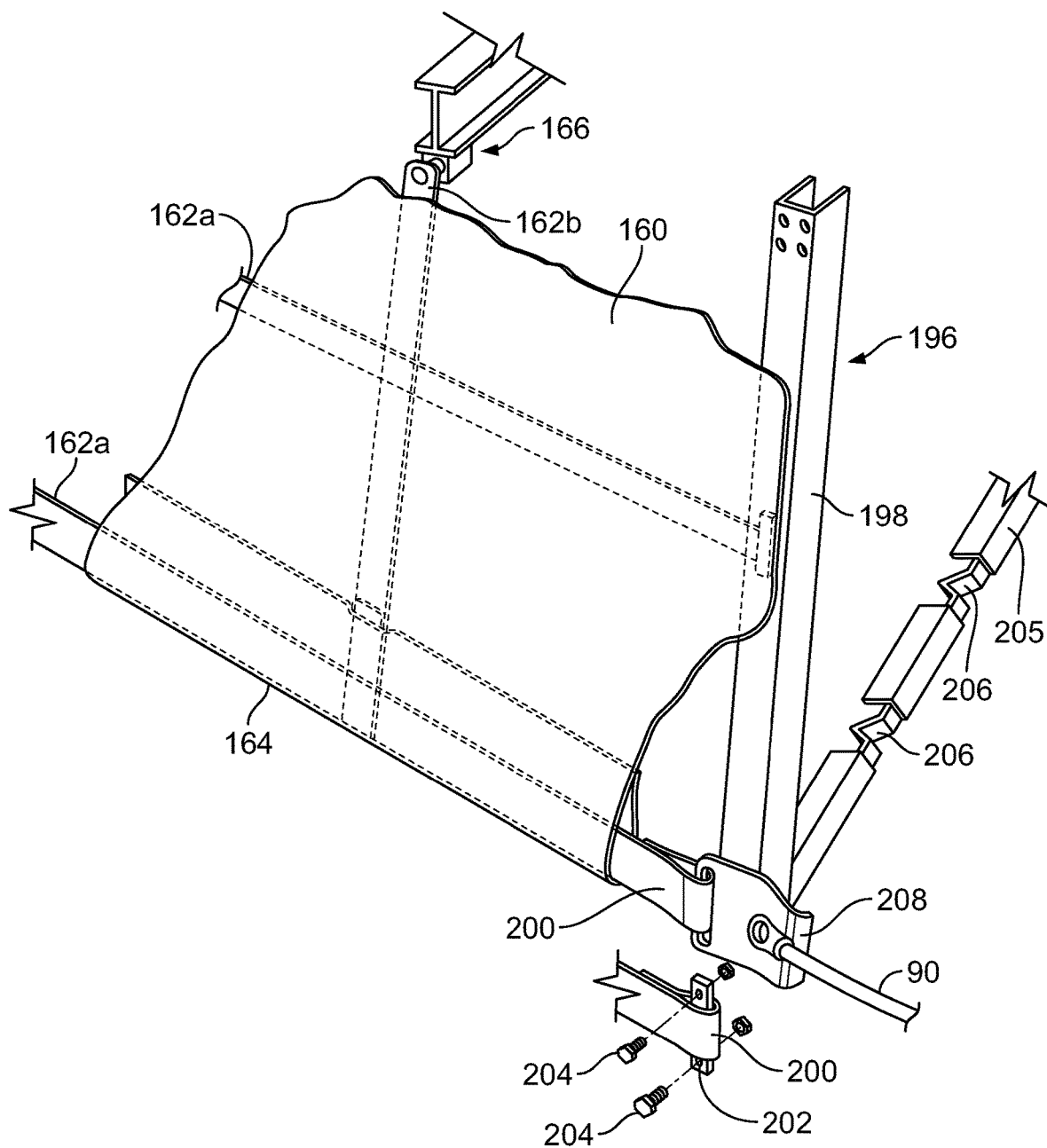


FIG. 29

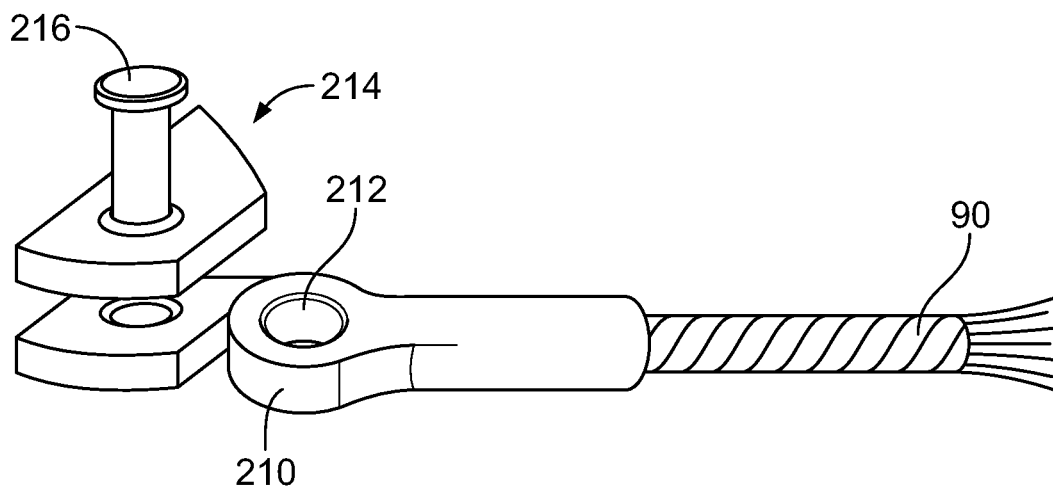


FIG. 30

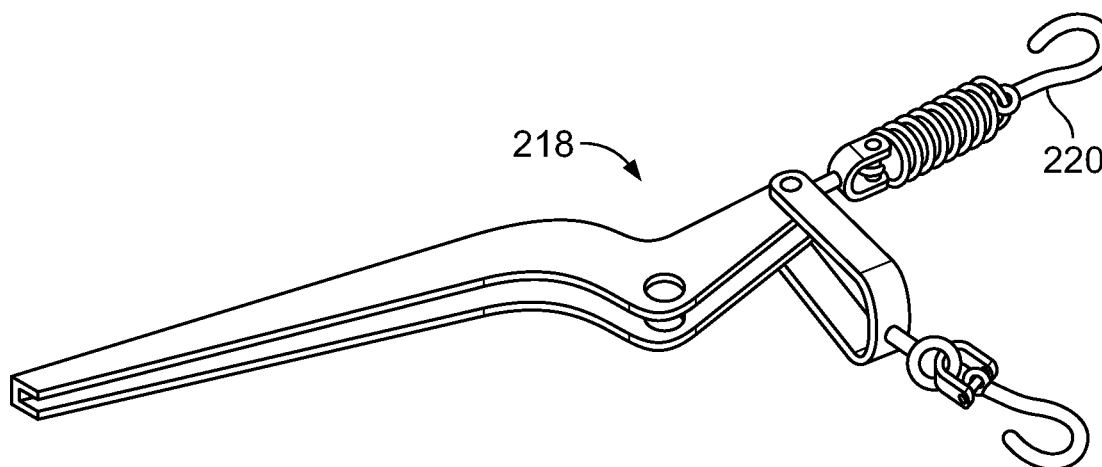


FIG. 31

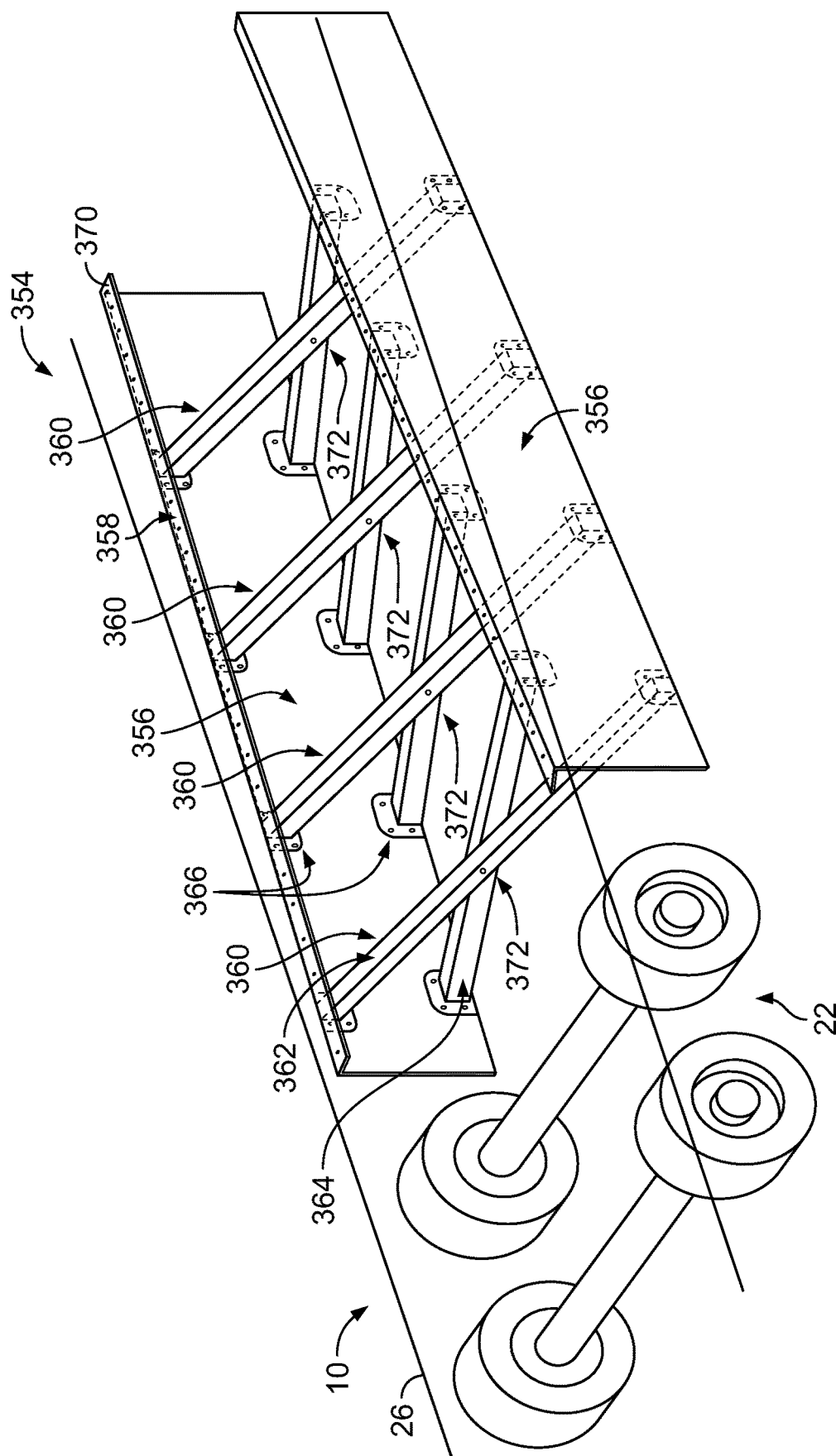


FIG. 32

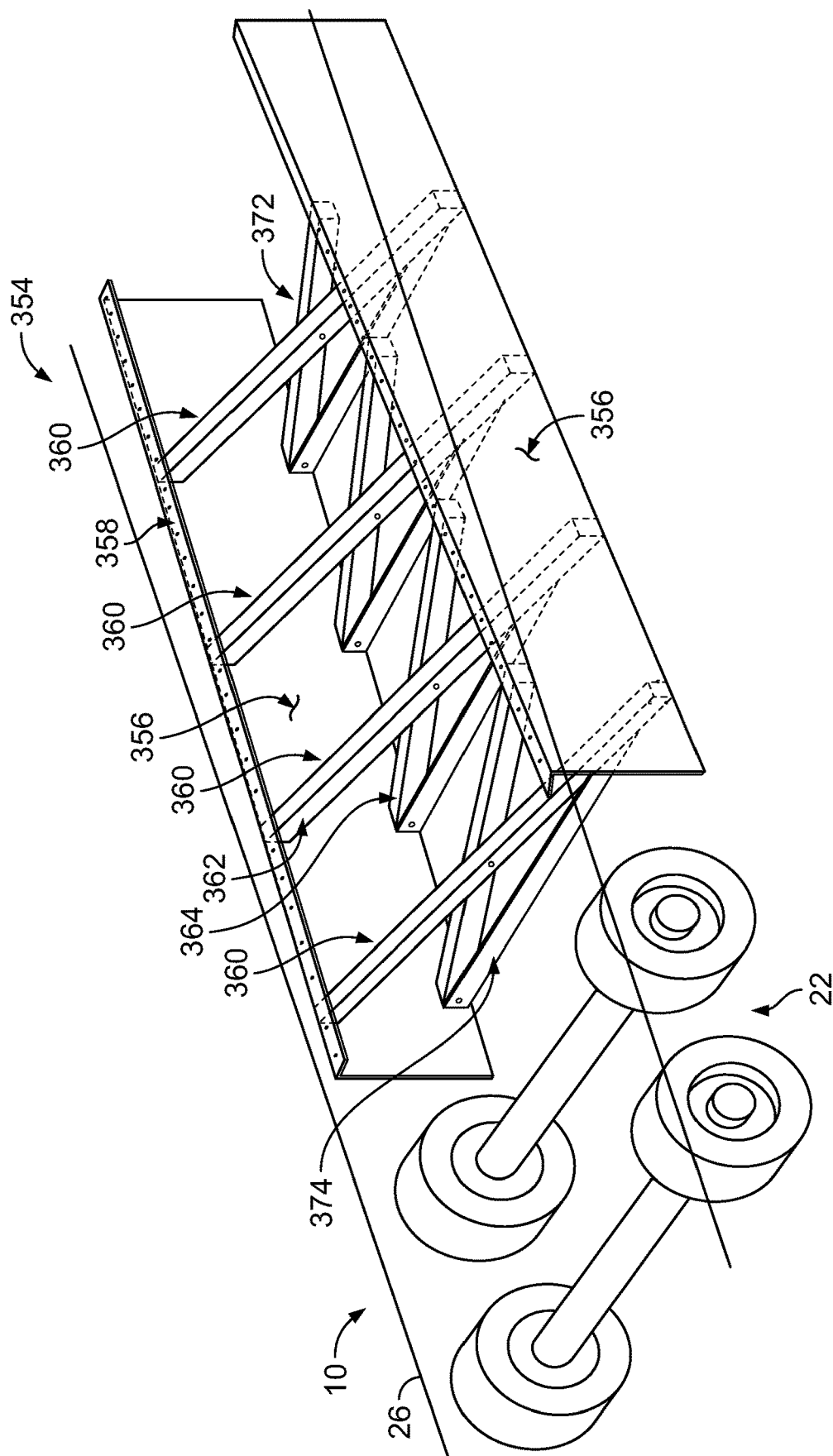


FIG. 33

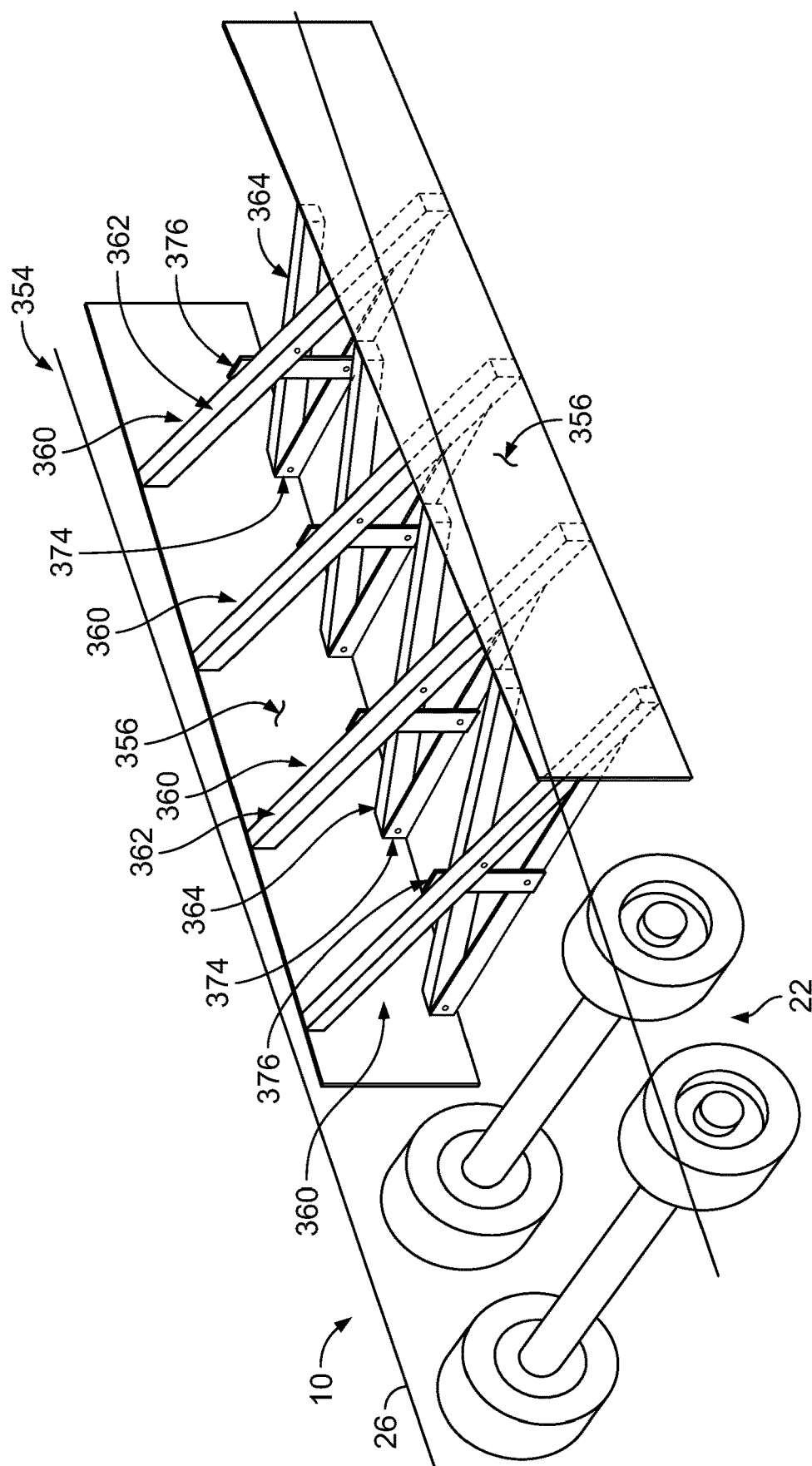


FIG. 34

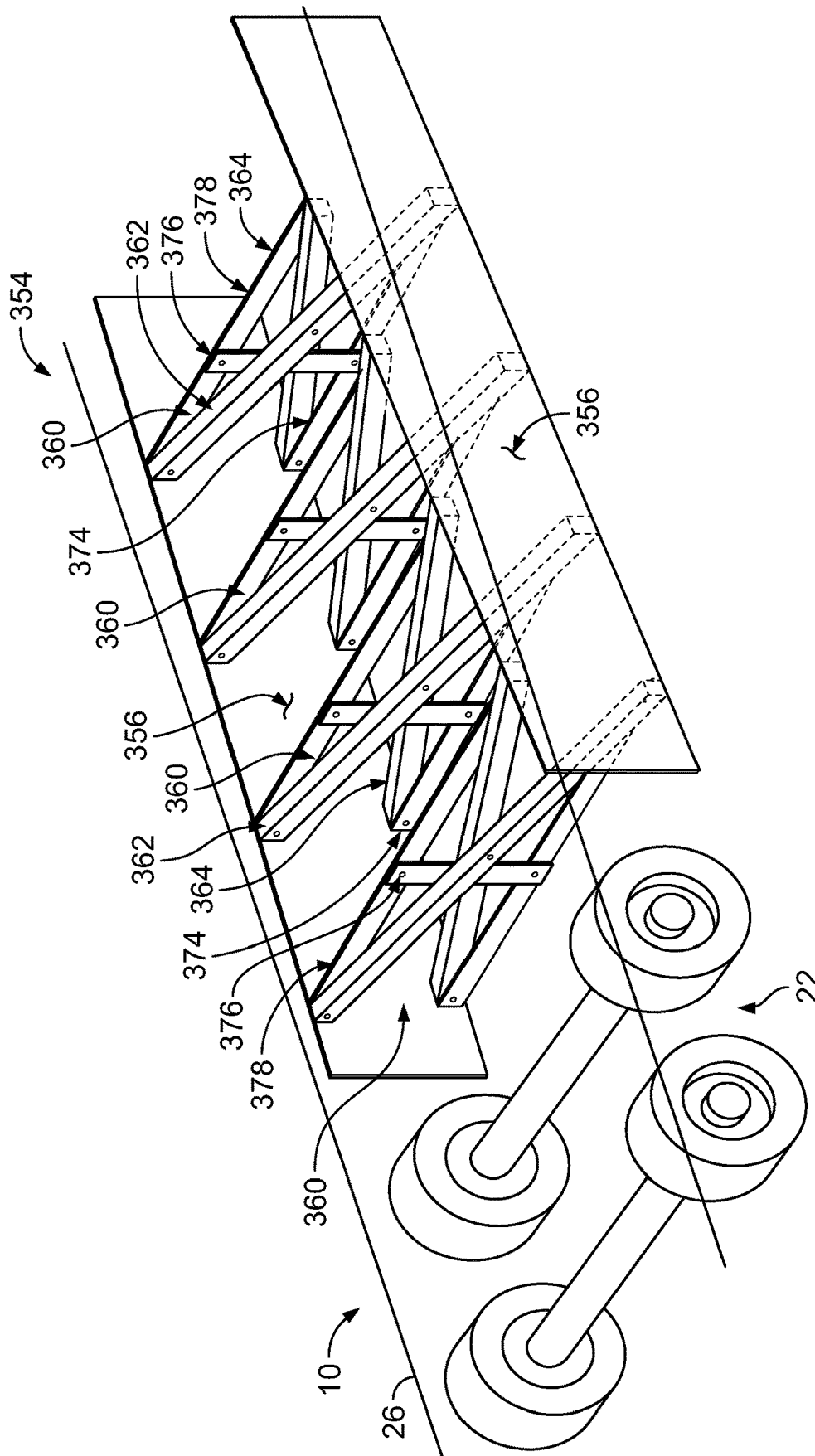


FIG. 35

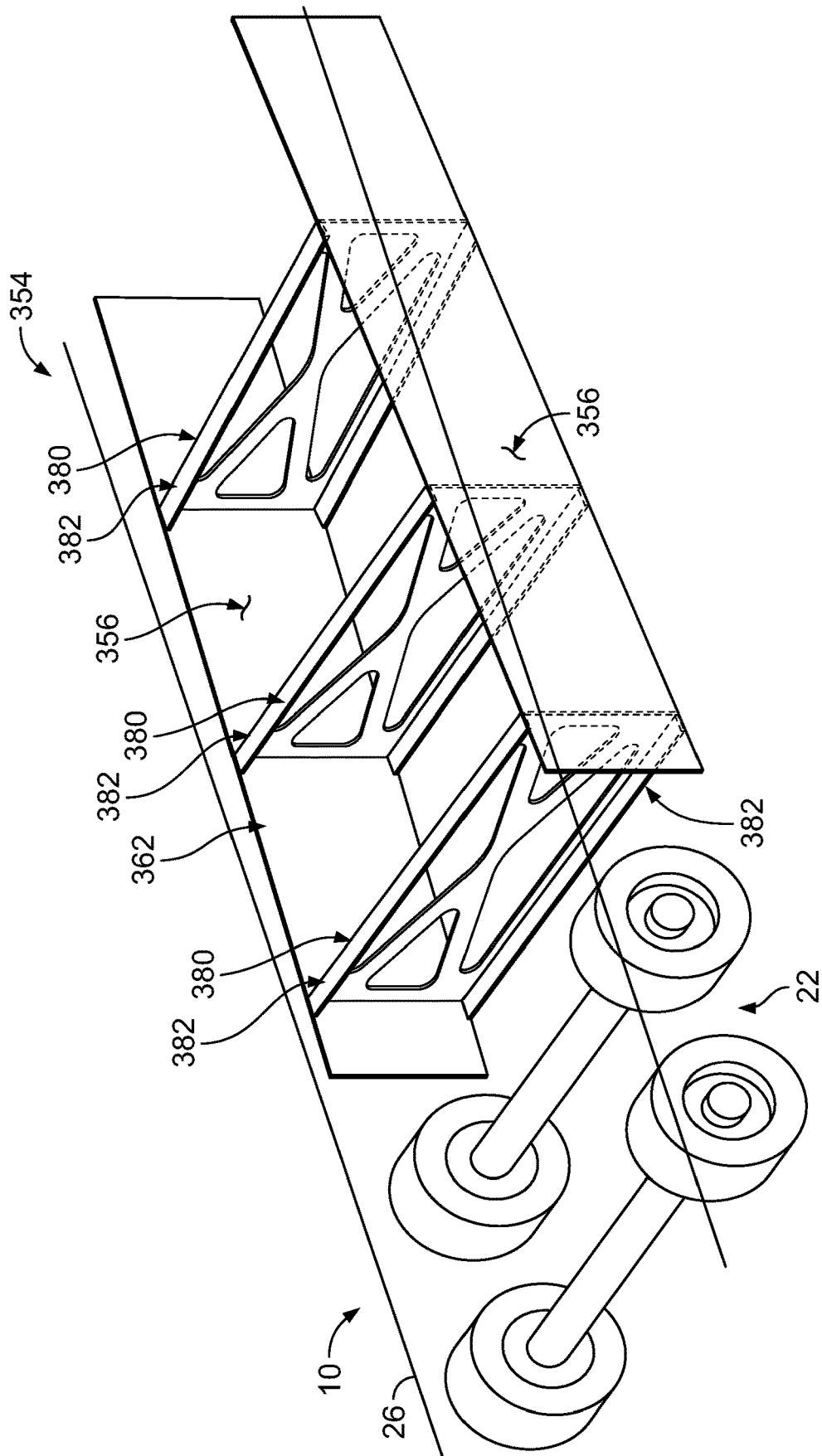


FIG. 36

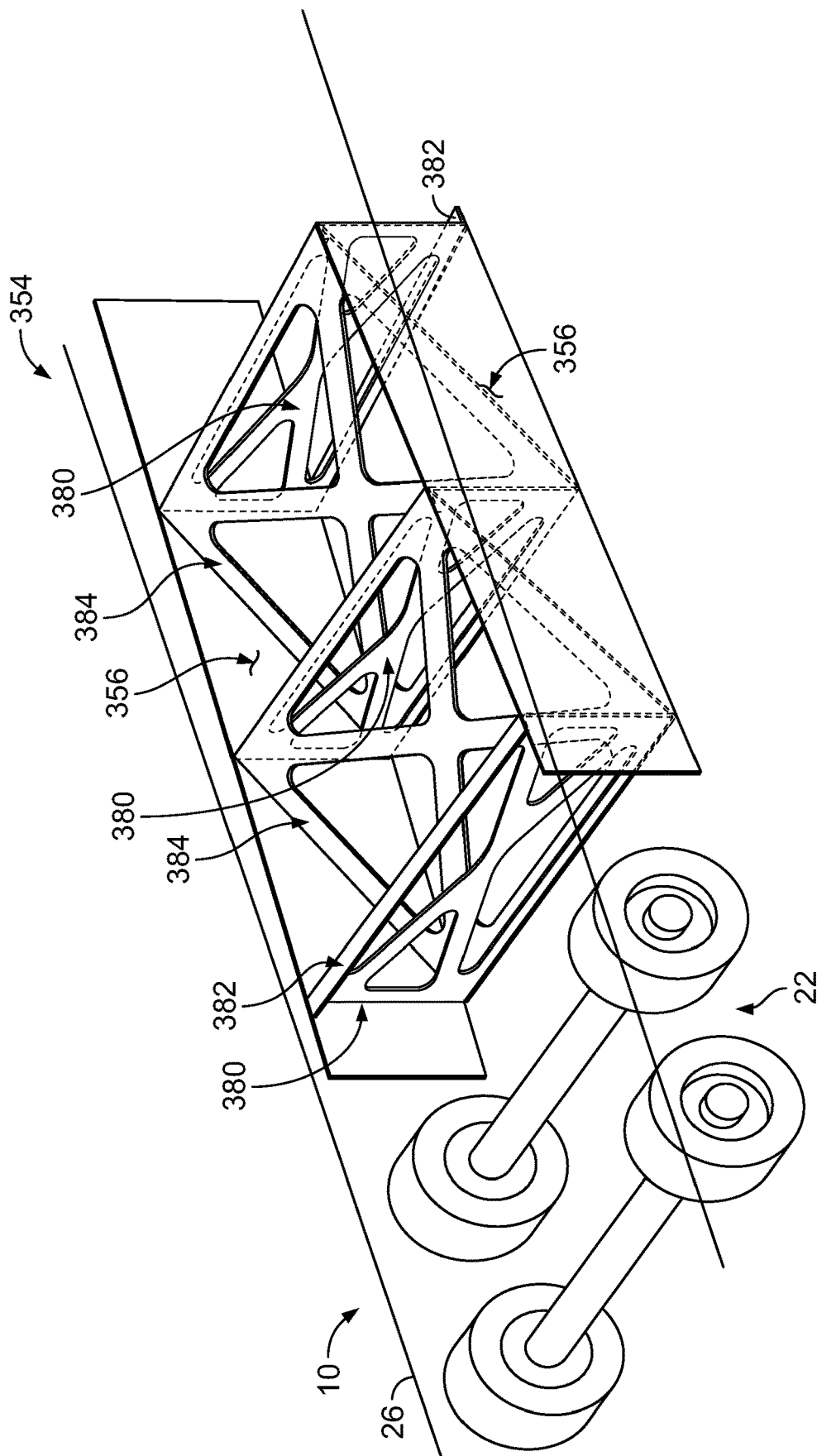


FIG. 37

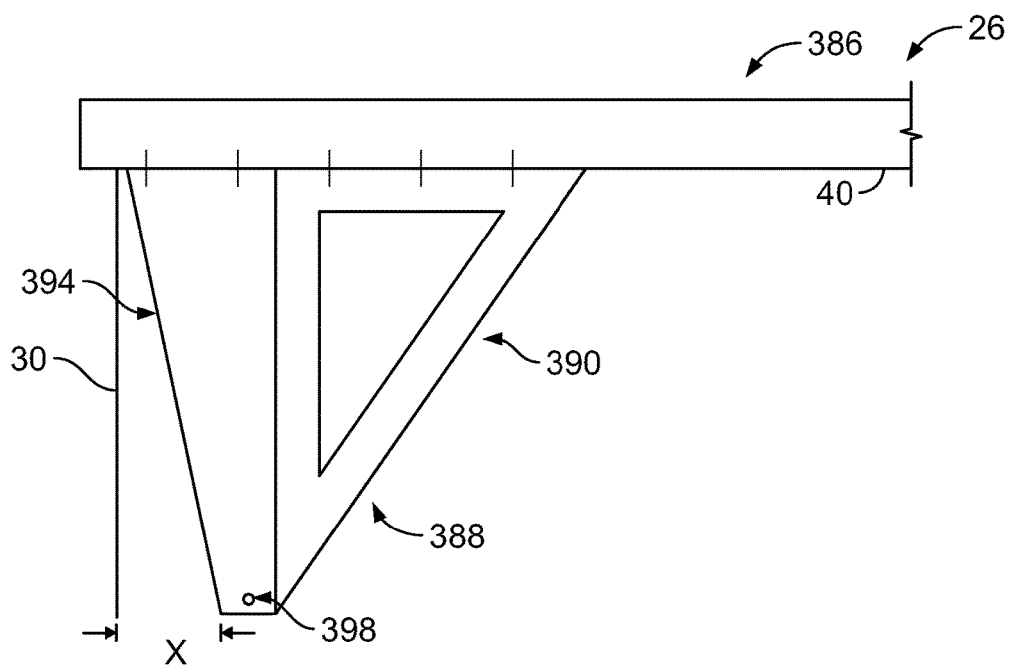


FIG. 38

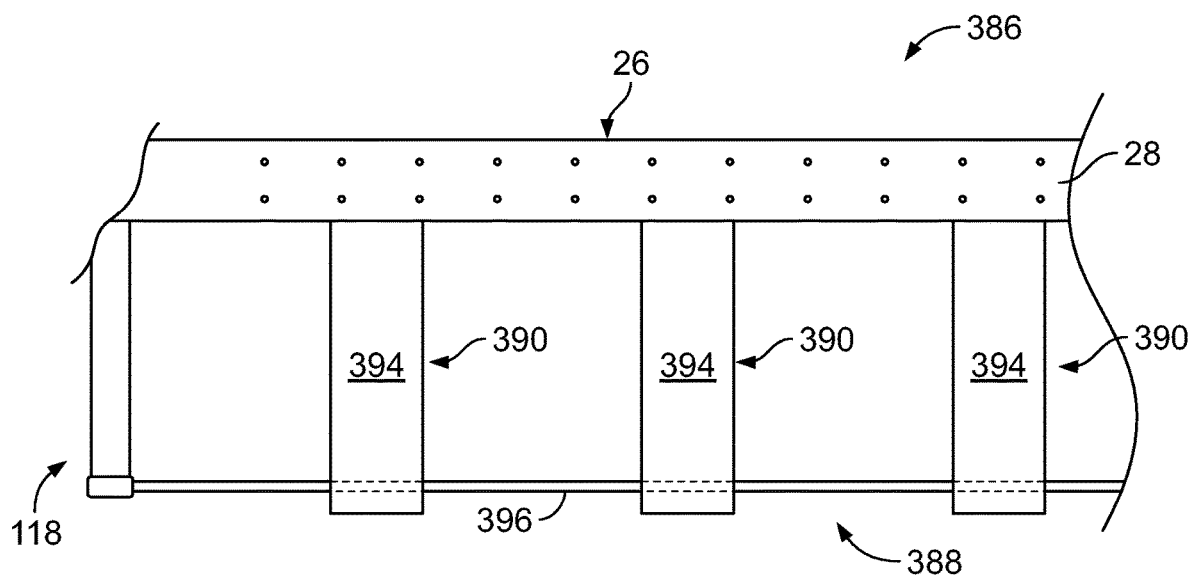


FIG. 39

SIDE UNDERRIDE GUARD**CROSS REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit of U.S. Provisional Application Ser. No. 62/487,743, filed Apr. 20, 2017, and entitled "Side Underride Guard," and U.S. Provisional Application Ser. No. 62/487,775, filed Apr. 20, 2017, and entitled "Side Underride Guard," the disclosures of which are hereby incorporated by reference in their entireties.

FIELD OF THE INVENTION

The present invention relates generally to semi-trailers, such as van-type trailers, for example. In particular, the present invention relates to both an aerodynamic side skirt system for reducing drag on such a trailer as well as a side underride system for preventing or reducing the extent to which an automobile may ride under the trailer in the event of a side impact collision, for example.

BACKGROUND

To reduce wind flow resistance and drag on a trailer, truck, semi-trailer, or other vehicle, side skirts that extend downwardly from a bottom of the trailer and/or chassis toward the roadway to partially enclose the floor assembly and undercarriage have been utilized.

Air flow passing under a ground vehicle imparts a drag force to the vehicle when it impinges on and flows around the vehicle undercarriage components attached to or a part of the underside of a vehicle. Side skirt systems are designed to prevent or control the flow of air from entering the undercarriage region from a side of the ground vehicle, such as a trailer of a tractor-trailer truck system, for example. Such reduction on the drag of the ground vehicle may operate to conserve fossil fuels as well as other sources of vehicle drive power for hybrid vehicles, battery-operated vehicles, and/or alternative fuel-based vehicles, for example.

Truck trailers typically have a higher elevation than passenger vehicles. This presents a risk that a passenger vehicle may underride the trailer in an accident, potentially resulting in damage to the underriding vehicle and injury to occupants therein. Accordingly, a side protection device, or underride guard, may be provided for use with a trailer in order to reduce the risk of such passenger vehicles underriding the trailer. Side protection devices are intended to reduce the extent to which a "passenger vehicle" (as defined in 49 C.F.R. Part 571 §) can intrude under the side of a trailer, diminishing passenger compartment intrusion.

SUMMARY

The present disclosure may comprise one or more of the following features and combinations thereof.

According to one embodiment of the present disclosure, a side underride system configured to be coupled to a trailer is disclosed, the side underride system comprising a first skirt wall coupled to the trailer, positioned below a first side wall of the trailer, and extending along a first length of the trailer between a skirt wall front end and a skirt wall rear end and a cable system including a first cable coupled to the trailer, positioned below the first side wall, and extending along a second length of the trailer between a cable system front end and a cable system rear end, the skirt wall rear end being positioned forward of the cable system rear end.

According to another embodiment, a side underride system configured to be coupled to a trailer comprises a skirt assembly including (i) a first skirt wall coupled to the trailer, positioned below a first side wall of the trailer, and extending between a front of the trailer and a location forward of a rear wheel assembly of the trailer, and (ii) a first cable coupled to the first skirt wall and a cable system including a second cable coupled to the trailer, positioned below the first side wall, and extending from a second location forward of the rear wheel assembly of the trailer to a location rearward of the rear assembly.

According to another embodiment, a side underride system configured to be coupled to a trailer comprises a cable system including (i) a first cable having a first terminal end configured to be coupled to a first side of the trailer forward of a rear wheel assembly of the trailer and a second terminal end configured to be coupled to the trailer rearward of the rear wheel assembly of the trailer and (ii) a second cable having a first terminal end configured to be coupled to a second side of the trailer forward of the rear wheel assembly of the trailer and a second terminal end configured to be coupled to the trailer rearward of the rear wheel assembly of the trailer, the first and second cables extending past the rear wheel assembly inhibiting movement of objects into an area around the rear wheel assembly without material coupled to portions of the first and second cables adjacent the rear wheel assembly.

These and other features of the present disclosure will become more apparent from the following description of the illustrative embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a trailer and an aerodynamic side skirt system coupled to the trailer between rear wheels and a landing gear, or front support, of the trailer.

FIG. 2 is a perspective view of the aerodynamic side skirt system of FIG. 1.

FIG. 3 is an enlarged, perspective view of a portion of the side skirt system of FIG. 2 showing a mounting bracket assembly of the side skirt system.

FIG. 4 is a perspective, underside, forward view of a trailer, an aerodynamic side skirt system coupled to the trailer, and a side underride system coupled beneath the trailer and between portions of the side skirt system.

FIG. 5 is a perspective, underside, rear view of the trailer, the aerodynamic side skirt system, and the side underride system of FIG. 4.

FIG. 6 is an underside view of the trailer, the aerodynamic side skirt system, and the side underride system of FIG. 4.

FIG. 7 is a perspective view of the side underride system of FIG. 4.

FIG. 8 is a side view of the side underride system of FIG. 4.

FIG. 9 is a side view of a trailer including a side underride cable system coupled thereto in order to reduce the risk of vehicles intruding laterally under a floor assembly of the trailer in a side impact collision, for example.

FIG. 10 is a perspective view of a mounting bracket assembly for use with the side underride cable system of FIG. 9.

FIG. 11 is a side view of a portion of another mounting bracket assembly for use with the side underride cable system of FIG. 9.

FIG. 12 is an end view of the mounting bracket assembly of FIG. 11 showing lateral cables extending across a width of the trailer.

FIG. 13 is a plan view of a portion of the mounting bracket assembly of FIG. 11 showing a corner cable guide for threading cable therethrough.

FIG. 14 is a perspective view of a corner portion of the mounting bracket assembly of FIG. 11 showing the corner cable guide.

FIG. 15 is a perspective view of another side underride guard.

FIG. 16 is a perspective underside view of a portion of the side underride guard of FIG. 15.

FIG. 17 is a perspective rear view of a trailer with another side underride system.

FIG. 18 is another perspective rear view of the side underride system of FIG. 17.

FIG. 19 is a perspective, underside, front view of the side underride system of FIG. 17.

FIG. 20 is another perspective, underside, front view of the side underride system of FIG. 17.

FIG. 21 is a side view of a side underride system with a cable system and also including an aerodynamic skirt system.

FIG. 22 is a perspective partial side view of the side underride system and the aerodynamic skirt system of FIG. 21.

FIG. 23 is a perspective underside view of a side skirt wall of the aerodynamic skirt system of FIG. 21.

FIG. 24 is a perspective side view of a trailer and a side underride system coupled to the trailer between rear and front supports of the trailer.

FIG. 25 is another perspective view of the trailer and the side underride system of FIG. 24.

FIG. 26 is a partial rear and perspective view of the side underride system of FIG. 24 coupled to a floor assembly of the trailer with a clip assembly.

FIG. 27 is a perspective, exploded view of the clip assembly of FIG. 26.

FIG. 28 is a front view of the clip assembly of FIG. 26 in blank and formed constructions.

FIG. 29 is a partial perspective view of a tarp assembly of the side underride system of FIG. 24 coupled to the trailer via a mounting bracket.

FIG. 30 is a perspective view of a drop-pin structure for use with the side underride system of FIG. 24.

FIG. 31 is a perspective view of a load binder for use with the side underride system of FIG. 24.

FIG. 32 is a perspective partial view of a further side underride system including an aerodynamic side skirt system and a support system between portions of the side skirt system.

FIG. 33 is a perspective partial view of the side underride system of FIG. 32 with an alternate support system.

FIG. 34 is a perspective partial view of the side underride system of FIG. 32 with another alternate support system.

FIG. 35 is a perspective partial view of the side underride system of FIG. 32 with yet another alternate support system.

FIG. 36 is a perspective partial view of the side underride system of FIG. 32 with yet another alternate support system.

FIG. 37 is a perspective partial view of the side underride system and support system of FIG. 36 with additional cross-braces.

FIG. 38 is a partial plan view of another side underride system including a tiltable aerodynamic side skirt system and a support system between portions of the side skirt system.

FIG. 39 is partial side view of the side underride system of FIG. 38.

DETAILED DESCRIPTION

Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting. The use of "including," "comprising," or "having" and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. Unless specified or limited otherwise, the terms "mounted," "connected," "supported," and "coupled" and variations thereof are used broadly and encompass both direct and indirect mountings, connections, supports, and couplings. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings.

The following discussion is presented to enable a person skilled in the art to make and use embodiments of the invention. Various modifications to the illustrated embodiments will be readily apparent to those skilled in the art, and the generic principles herein can be applied to other embodiments and applications without departing from embodiments of the invention. Thus, embodiments of the invention are not intended to be limited to embodiments shown, but are to be accorded the widest scope consistent with the principles and features disclosed herein. The following detailed description is to be read with reference to the figures, in which like elements in different figures have like reference numerals. The figures, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of embodiments of the invention. Skilled artisans will recognize the examples provided herein have many useful alternatives and fall within the scope of embodiments of the invention.

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to a number of illustrative embodiments shown in the attached drawings and specific language will be used to describe the same. While the concepts of this disclosure are described in relation to a box-type trailer, it will be understood that they are equally applicable to many types of trailers, semi-trailers, and tanks generally, and more specifically to conventional flat-bed and/or box or van type trailers, and/or pup trailers, as well as straight truck bodies, small personal and/or commercial trailers and the like. Accordingly, those skilled in the art will appreciate that the present invention may be implemented in a number of different applications and embodiments and is not specifically limited in its application to the particular embodiments depicted herein.

Looking first to FIGS. 1-6, in a first illustrative embodiment, a trailer 10 includes an aerodynamic skirt system or assembly 12 coupled to and extending downwardly from each side wall 14 of the trailer 10. Illustratively, the skirt system 12 operates to improve the aerodynamic efficiency of the trailer 10 by reducing drag and wind flow under the trailer 10. In particular, the skirt system 12 operates to reduce airflow under the trailer 10 while the trailer 10 is traveling down a road. This reduction of airflow under the trailer 10 may increase the fuel efficiency, or the efficiency

of any other such source of vehicle drive power, of the tractor/trailer combination. Illustratively, the skirt system 12, as well as other skirt systems described herein, extends below a side wall 14 of the trailer 10 at least partially along a length of the trailer. In particular, in some embodiments, the skirt system 12 extends generally between a landing gear 24 and a rear wheel assembly 22 of the trailer 10. However, the skirt systems described herein may be modified to extend along a greater or a lesser length of the trailer 10 than what is illustratively shown in the figures. In other words, the skirt systems disclosed herein may be modified to extend along the entire, or substantially the entire, length of the trailer 10 or may be modified to extend along only a small portion of the length of the trailer 10. Further, any of the skirt systems disclosed herein may be for structural and/or aerodynamic purposes.

As shown in FIG. 1, the trailer 10 includes side walls 14, a front end wall 16, a rear end wall 18, and a roof 20 defining an inside storage portion (not shown) able to store various articles or good therein. The trailer 10 further includes the rear wheel assembly 22 and the front support or landing gear 24 each coupled to a bottom wall or floor assembly 26 of the trailer 10. Illustratively, the floor assembly 26 of the trailer 10 includes various laterally-extending cross members 40 and right and left base rails 28 coupled to the cross members 40 and extending along a length of the trailer 10. The front end of the trailer 10 is configured to be coupled to a tractor (not shown) for towing the trailer 10 thereon, thus providing a tractor-trailer assembly. As shown in FIG. 1, the skirt system 12 is coupled to the floor assembly 26 of the trailer 10 to extend downwardly from the base rail 28 of the trailer 10. Illustratively, the side skirt system 12 is positioned between the rear wheel assembly 22 and the front support 24 in order to prevent air from flowing laterally under the floor assembly 26 of the trailer 10 as the trailer 10 is towed by a tractor. It should be understood that while the aerodynamic side skirt system 12 is shown for use with a trailer 10, the side skirt system 12 may be coupled to any vehicle to reduce the drag thereon. Still further, while the embodiments disclosed herein are shown as being utilized with trailers, any of the embodiments disclosed herein may be coupled to any vehicle.

Illustratively, the trailer 10 includes two aerodynamic skirt systems 12. In particular, one system 12 is coupled to one side of the floor assembly 26 of the trailer 10 to extend downwardly from the floor assembly 26 generally parallel to the corresponding side wall 14 of the trailer 10 while the other system 12 is coupled to the other side of the floor assembly 26 to extend downwardly from the floor assembly 26 generally parallel to the corresponding side wall 14 of the trailer 10. For purposes of the description herein, however, only one skirt system 12 will be described herein. However, it should be understood that the two skirt systems 12 of the trailer 10 are identical in configuration and function. Also, while the skirt systems 12 are shown as being parallel to the corresponding side walls 14, the skirt systems 12 may be angled inwardly at forward (toward the tractor) ends thereof.

As shown in FIGS. 1 and 2, each skirt system 12 includes a side skirt wall 30 having three wall panels 32 coupled to each other by an H-member 41, shown in FIGS. 2 and 3. Illustratively, the H-member 41 is generally H-shaped when viewed in cross-section to define two channels such that adjacent wall panels 32 are each received within one of the channels of the H-member 41. The wall panels 32 are further secured to each other and to the trailer 10 by a mounting bracket assembly 34. For example, the mounting bracket assembly 34 may be similar in structure and function to that

described in U.S. Pat. No. 8,162,384, the entire content of which is incorporated herein by reference.

Illustratively, a first mounting bracket assembly 34 is positioned between and coupled to the middle and rear-most wall panels 32 while a second mounting bracket assembly 34 is positioned between and coupled to the middle and front-most wall panels 32. A third mounting bracket assembly 34 is coupled to the rear-most wall panel 32 while a fourth mounting bracket assembly 34 is coupled to the front-most wall panel 32. Illustratively, while the skirt system 12 includes four mounting bracket assemblies 34 and three wall panels 32, it is within the scope of this disclosure to provide a skirt system 12 having any number of mounting bracket assemblies 34 and any number of wall panels 32. Further, it is within the scope of this disclosure for the skirt system 12 to include a single, unitary wall panel 32.

Generally, the mounting bracket assemblies 34 are configured to couple the wall portions 32 of the skirt system 12 to the floor assembly 26 of the trailer 10. Furthermore, the mounting bracket assemblies 34 may allow the skirt system 12 to tilt laterally both inwardly and outwardly relative to the floor assembly 26 of the trailer 10. The ability of the skirt wall 30 to tilt bi-laterally relative to the cross member 40 (i.e., to tilt both inwardly and outwardly relative to the cross member 40) may allow the skirt wall 30 to potentially avoid damage when the trailer 10 traverses into or over a fixed, immovable obstacle, for example, and thus runs laterally into the obstacle, for example. It should also be understood, however, that the skirt system 12 be sufficiently rigidly mounted to the floor assembly 26 such that the skirt system 12 is generally prevented from tilting under normal wind and road air forces.

Illustratively, each wall panel 32 is made of a composite material. For example, the composite material may include a plastic core and metal outer skins coupled to the plastic core. Such a composite material provides a rigid, but lightweight and durable material. Illustratively, for example, each wall panel 32 may be made of a DURAPLATE® composite panel provided by Wabash National Corporation of Lafayette, Ind. DURAPLATE® composite panels are constructed of a high-density polyethylene plastic core bonded between two high-strength steel skins. It should be understood that other suitable composite materials may alternatively or additionally be used. For example, the wall panels 32 may be made of a sandwich composite including a honeycomb core and metal or plastic outer sheets, or the wall panels 32 may be made of a fiber-reinforced plastic composite. Further, the wall panels 32 may be of any number of suitable, non-composite materials such as metals, metal alloys, and/or plastics, for example.

As shown in FIG. 2, the skirt system 12 further includes a flexible flap 36 coupled to the bottom edge of the wall panels 32. Illustratively, the flexible flap 36 is made of plastic or rubber. However, other suitable materials may be used. As is discussed in greater detail below, the flexible flap 36 further operates to resist airflow and may prevent damage to the skirt wall 30 from forces applied vertically such as in situations where the trailer 10 may traverse over a curb or railroad track where the road surface is not flat. In such instances, for example, the flap 36 is configured to bend, or flex to prevent damage to the skirt wall 30.

As shown in FIG. 2, the skirt system 12 includes a single, unitary flap 36 coupled to the three wall panels 32. However, it is within the scope of this disclosure to include any number of flexible flaps 36. Further illustratively, the wall panels 32 make up approximately 70% of the total height of the skirt wall 30 while the flap 36 makes up approximately

the lower 30% of the total height of the skirt wall 30. Of course, it is within this disclosure to include wall panels and/or flaps having other suitable heights.

In some embodiments, the above skirt system 12 may be structurally reinforced to provide additional side protection that may reduce the risk of an automobile underriding the trailer 10. For example, the skirt system 12 may be combined with a rigid and/or compressible support system 54 positioned underneath the trailer 10 and between the side skirt walls 30. As shown in FIGS. 4-8, a compressible support system is provided under the floor assembly of the trailer to form a side underride system 56. This combination skirt system 12 and support system 54 can thus provide dual functions of potentially improving aerodynamic efficiency and providing side underride protection.

The support system 54 may be retrofit into existing skirt systems 12 or installed with new skirt systems 12 or additional aerodynamic systems other than what is herein described. Alternatively, the support system 54 alone (that is, without a skirt system) may form the side underride system 56. In other words, the support system 54 may be an OEM side underride system design (that is, not for use as a retrofit with an existing skirt system) or, alternatively, may be used as a retrofit with existing skirt systems. For example, the support system 54 alone may potentially improve aerodynamic efficiency (i.e., by reducing air flow under the trailer 10) and may provide side underride protection. In particular, side underride systems may be contemplated within the scope of this disclosure to include side skirts or any other structures of any configuration and shape to provide a first outer surface positioned below the trailer 10 near the first side wall 14 and a second outer surface positioned below the trailer 10 near the second side wall 14 to reduce airflow under the trailer, where the surfaces permit any of the structures described herein to be positioned therebetween to potentially provide side underride protection.

Generally, the support system 54 of FIGS. 4-8 may include a compressible structure 58. The compressible structure may be configured to compress into itself in response to lateral forces, such as when the side skirt walls 30 push laterally inwardly during a side impact collision with a vehicle, for example. The compressible structure 58 may help absorb such forces and may reduce the chances of the vehicle from underriding the trailer 10. Further, the compressible structure 58 may operate to absorb some of the force and energy of any impact thereto to potentially decrease any forces on the passengers within the vehicle during impact.

The compressible structure 58 may be solid, such as a solid foam structure, or holed, such as a holed foam structure, a plastic or metal honeycomb structure, or a truss-like structure. Furthermore, the compressible structure 58 may include a single structure or multiple discrete structures, such as a plurality of gas- or air-filled containers or components. The compressible structure 58 may further include any other type of material or structure capable of compressing. According to one example, as shown in FIGS. 7-8, the compressible structure 58 may be a foam structure with one or more through holes 62. Alternatively, the foam structure may include one or more blind holes. The support system 54 may be substantially resilient and also, in some embodiments, may include an additional material (not shown) wrapped around or surrounding the compressible structure 58. The additional material may protect the compressible structure 58 from the elements (e.g., the additional material may be water resistant and/or substantially resistant to

degradation from the elements) and, in some embodiments, may enhance the aerodynamic efficiency of the system 54.

As described above, the compressible structure 58 may span a width of the trailer 10, filling a space defined between the side skirt walls 30, as shown in FIGS. 4-6. Illustratively, the compressible structure may also follow angled or curved profiles of the side skirt walls 30, as shown in FIGS. 6 and 7. Alternatively, the compressible structure 58 may be substantially rectangular in shape with end walls 60 perpendicular to the side walls 14 of the trailer 10. The compressible structure 58 may also include one or more cutouts 64 on the end walls 60 to accommodate mounting bracket assemblies 34 of the skirt system 12 and/or other components of the trailer 10 or the skirt system 12, as shown in FIGS. 5, 7, and 8. Further, while the compressible structure 58 is shown with a skirt system 12, it is within the scope of this disclosure to provide such compressible support structures on a trailer without the use a skirt structure as well.

Illustratively, the compressible structure 58 may span a length of the trailer 10 substantially equal to or less than the length of the side skirt walls 30. For example, the compressible structure 58 may span substantially the entire length of the side skirt walls 30 (e.g., from the landing gear 24, as shown in FIG. 4, to the rear wheel assembly 22, as shown in FIG. 5), a portion of the length of the side skirt walls 30, or discrete, spaced-apart portions of the length of the side skirt walls 30. For example, FIGS. 4-6 show the compressible structure 58 spanning a portion of the length of the side skirt walls 30, wherein the side skirt walls 30 extend farther forward and rearward than the compressible structure 58. However, it should be understood that the compressible structure 58 may extend farther forward and/or rearward or substantially in line with the side skirt walls 30. The compressible structure 58 may also extend downwardly from the floor assembly 26 a height less than, equal to, or more than a height of the skirt system 12. For example, the compressible structure 58 may extend downward from the side walls 14 a height equal to the side skirt walls 30 (stopping before the flexible flaps 36). In another example, the compressible structure 58 may extend a height past the wall panels 32, but not past the flexible flap 36. As a result, the compressible structure 58 may be of sufficient height to provide clearance when the trailer 10 traverses obstacles, such as a curb or railroad track where the road surface is not flat.

The compressible structure 58 may be coupled to the trailer 10 and/or the skirt system 12 in any suitable manner. In illustrative embodiments, the support system 54 may include one or more connectors (not shown) configured to couple the compressible structure 58 to the trailer 10 and/or the skirt system 10. For example, the compressible structure 58 may be coupled to an underside of the floor assembly 26, such as to one or more cross members 40. Additionally, or alternatively, the compressible structure 58 may be coupled to inner surfaces of the side skirt walls 30 and/or the mounting bracket assemblies 34.

Looking now to FIGS. 9-14, in another illustrative embodiment, a trailer 70 includes another side underride system 72 coupled to the floor assembly 26 of the trailer 70. As is discussed in greater detail below, the side underride system 72 extends below and generally along the side walls 14 of the trailer 70 (shown in FIG. 9) in order to reduce the risk of an automobile riding under the trailer 70 in the event of a side impact collision, for example. Illustratively, the side underride system 72 includes front, intermediate, and rear mounting bracket assemblies 74, 76, 78 coupled to the floor assembly 26 of the trailer 70 and a cable system 80

extending therebetween. As shown in FIG. 9, the front assembly 74 is positioned near—and/or coupled to—the landing gear 24 of the trailer 70, the intermediate assembly 76 is positioned near and forward from the rear wheel assembly 22, and the rear assembly 78 is positioned behind the rear wheel assembly 22. It should be understood, however, that the mounting bracket assemblies 74, 76, 78, as well as any other mounting bracket assemblies disclosed herein, may alternatively be coupled to the trailer 70 at other locations along the length of the trailer 70. In particular, the mounting bracket assemblies 74, 76, 78 may be coupled to the trailer 70 and positioned in spaced-apart relation to each other so that a cable system 80, as well as any other cable system disclosed herein, extends along the entire, or substantially the entire, length of the trailer 70. Alternatively, the mounting bracket assemblies 74, 76, 78 may be coupled to the trailer 70 and positioned in spaced-apart relation to each other such that the cable system 80 extends along only a small portion of the length of the side of the trailer 70. Still further, any suitable number of bracket assemblies may be utilized.

The front mounting bracket assembly 74 is shown in FIG. 10 and includes side flange members 82 configured to be coupled to the base rail 28 (shown in FIG. 9) of the trailer 70, a vertical corner post 84 coupled to each side flange member 82, a cross-brace 86 coupled to and extending between the corner posts 84, and support braces 88 each coupled at one end to a respective corner post 84 and at an opposite end to the cross-brace 86. Illustratively, the flange members 82 are generally triangular in shape and are each welded to the adjacent corner posts 84; however, it is within the scope of this disclosure to couple the flange members 82 and the posts 84 together using fasteners such as rivets, bolts, screws, etc. Similar to the flange members 82, the corner posts 84 are each configured to be coupled to the base rail 28 of the trailer 70 using a fastener such as a rivet, screw, bolt, or another suitable connection. Illustratively, while only the front mounting bracket assembly 74 is shown and described in detail herein, it should be understood that the intermediate and/or rear mounting bracket assembly 76, 78 is the same as or substantially similar to the front mounting bracket assembly 74. Accordingly, the intermediate and rear mounting bracket assemblies 76, 78 also include side flange members and/or vertical posts configured to be coupled to the base rail 28 of the trailer 70.

As shown in FIG. 9, the side underride system 72 further includes the cable system 80 including one or more cables 90 extending at least partially along a length each of the right and left sides of the trailer 70 from the front mounting bracket assembly 74 to the rear mounting bracket assembly 78. The cable system 80 includes three, four, or five cables 90 that are each coupled to and terminate in a bottom portion of the corner post 84 of respective mounting bracket assemblies 74, 76, 78. Illustratively, the cables 90 may be steel cables and may be approximately three-eighths to 1/2 inch in diameter. In the case of fewer cases, for example a single cable, the steel cable(s) may be great in diameter, for example, about 3/4 inch in diameter. Of course, it is within the scope of this disclosure to include any number of cables made from other suitable materials including composite rope, composite fibers, and other suitable high strength, low stretch materials, and having other suitable diameters. Further, the cables 90 may be covered in ballistic nylon or canvas to improve aerodynamic drag reduction thereon.

Cable terminals (not shown) may be used to receive an end of each of the cables 90 therein. Such cable terminals may be formed in and/or coupled to the corner post 84 to

secure the cables 90 thereto. Other suitable fasteners may be used to couple the cables 90 to the mounting bracket assemblies 74, 76, 78, as further described below. In use, the cables 90 are taut and operate as a protective system to reduce the risk of automobiles intruding under the floor assembly 26 of the trailer 70 during a side impact accident. Further, the cables 90 retain some flexibility and thus operate to absorb some of the force and energy of any impact thereto to potentially decrease any forces on the passengers within the automobile that is in the accident with the trailer 70.

As shown in FIG. 9, the cable system 80 includes four cables 90 running in parallel to each other at least partially along a length of the trailer 70 to provide the side underride protection. Illustratively, the cable system 80, as well as other cable systems described herein, may be modified to extend along a greater or a lesser length of the trailer than what is illustratively shown in the figures. The cables 90 may be approximately four to six inches apart from each other. However, the cable system 80 of the side underride system 72 may include any number of cables 90 spaced any distance apart from each other. For example, the cable system 80 may include three cables 90, as shown in FIG. 11. Such cables 90 may be attached to the corner posts 84 and/or the flange members 82 of the mounting bracket assemblies 74, 76, 78.

The intermediate mounting bracket assembly 76 may serve to prevent the cable system 80 from swaying laterally inwardly or outwardly and may operate to prevent the cables 90 from drooping and to assist the cables 90 in working together to take loading from a vehicle impact and reduce the extent to which such a vehicle can intrude under the side or ends of the trailer 70. In particular, the intermediate mounting bracket assembly 76 may serve to prevent the cable system 80 from swaying laterally inwardly and contacting the rear wheel assembly 22.

Furthermore, the side underride system 72 may also include cable supports 92 (shown in FIG. 9) to support the cables 90 along the length of the trailer 70 between the front and rear mounting bracket assemblies 74, 78. As shown diagrammatically in FIG. 9, the cable supports 92 include a plurality of vertical support members coupled to each of the four horizontal cables 90. The vertical support members are spaced-apart from each other along the length of the cables 90 and operate to provide increased stability and rigidity to the cable system 80. Illustratively, each vertical support 92 may include a flexible connection such as a chain, cable, or fabric strap extending from the top cable 90 to the bottom cable 90 such that each of the four cables 90 is threaded through one of the links of the chain. Alternatively or additionally, the vertical support 92 may include a rigid structure, such as a beam, bar, or other structure, having four apertures along a length thereof to receive a respective one of the four horizontally-extending cables 90 therethrough. For example, the rigid structure include plastic, metal, or a composite material. Each of the vertical supports may be coupled to the floor assembly 26 of the trailer 70. In particular, the cable supports 92 may be coupled to the base rail 28 and/or the cross members 40 of the trailer 70 and may operate to prevent the cables 90 from drooping and to assist the cables 90 in working together to take loading from a vehicle impact and reduce the extent to which such a vehicle can intrude under the side or ends of the trailer 70.

As described above and shown in FIG. 9, the cable system 80 includes cables 90 that run along a length of the trailer 70 from the rear mounting bracket assembly 78, through the intermediate mounting bracket assembly 76, to the front mounting bracket assembly 74 along each of the right and left sides of the trailer 70. However, the cable system 80 may

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also include cables 90 that run across a width of the trailer 70 from one vertical post 84 of one of the mounting bracket assemblies 74 or 78, to the other vertical post 84 of the same mounting bracket assembly 74 or 78, as shown in the alternative mounting bracket assemblies 94 of FIGS. 11-14, for example. In particular, the mounting bracket assemblies 94 are similar to the mounting bracket assemblies 74, 76, 78; as such, like reference numbers are used to denote the same or similar components. However, the mounting bracket assemblies 94 shown in FIGS. 11-14 include alternative vertical corner posts 96.

Illustratively, each post 96 includes first and second adjacent side walls 98 and shortened end walls 100 each coupled to one of the side walls 98, as shown in FIG. 13. The cross-section of each corner post 96 defines a partially-formed square tube. The corner posts 96 further include rounded cable guides 102 coupled to each of the end walls 100 in order to guide a cable 90 therethrough to make a 90-degree bend. As shown in FIGS. 12 and 13, the end of each cable guide 102 is received through an aperture in one of the end walls 100 of the post 96. Illustratively, the cable system 80 shown in FIGS. 11-14 includes three cables 90; thus, the post 96 includes three cable guides 102. Accordingly, the cable system 80 coupled to the mounting bracket assemblies 94 of FIGS. 11-14 may include continuous strands of cables 90 extending along a first side of the trailer 70 from the front mounting assembly 94, to the rear mounting assembly (not shown), across the rear width of the trailer 70 (and thus across the rear mounting assembly), along a second side of the trailer 70 from the rear mounting assembly 94 to the front mounting assembly 94, and across the front width of the trailer 70 (and thus across the front mounting assembly 94). Further, the cable system 80 may include turn buckles 104 coupled to each individual cable 90, as shown in FIG. 12, in order to tension the cable 90 as desired. Of course, it should be understood that other suitable tensioning devices may be used and positioned along any portion of the cable system 80 in order to tension the cables 90 as desired.

While the front and rear mounting bracket assemblies 74, 78 are depicted as being independent structures, it is within the scope of the present disclosure to incorporate the concepts described herein as part of or an attachment to any portion of the landing gear or any portion of a rear impact guard, which is attached to a rear end of the trailer, respectively.

Illustratively, front, intermediate, and rear mounting bracket assemblies 74, 76, 78, 94 are described herein. However, it is within the scope of this disclosure to include fewer or more mounting brackets or incorporate additional supports for the cable systems described herein. For example, FIG. 15 illustrates a side underride guard including a plurality of bracing assemblies 106 spaced from one another across the length of the trailer 70. As shown in FIGS. 15-16, the bracing assemblies 106 may include vertical posts 108, cross braces 110 coupled to and extending between the vertical posts 108, and rail members 112 coupled to and extending perpendicular from a lower edge of each vertical post 108 to form a support structure.

Illustratively, the vertical posts 108 are each configured to be coupled to the base rail 28 (or any other suitable component), for example, between the cross members 40 of the floor assembly 26 (and not directly connected to the floor assembly 26) of the trailer 70 using a fastener such as a rivet, screw, bolt, or another suitable connection, as shown in FIG. 16. The cross braces 110 are each welded to the adjacent vertical posts 108; however, it is within the scope of this

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disclosure to couple the cross braces 110 and the vertical posts 108 together using fasteners such as rivets, bolts, screws, or another suitable connection. Further, in some embodiments, the cross braces 110 may be coupled to the floor assembly 26 (such as to the base rail 28 or the cross members 40) instead of, or in addition to, the vertical posts 108. Illustratively, two cross braces 110 are oriented relative to each other and the vertical posts 108 so that the cross braces 110 cross each other at a point between the vertical posts 108. The cross braces 110 may be coupled to each other at this point, such as with rivets, bolts, screws, or another suitable connection, to further reinforce and strengthen the bracing assembly 106. Optionally, as shown in FIG. 16, the bracing assembly 106 may further include another cross brace 110 coupled between the vertical posts 108 in a substantially horizontal orientation directly below the floor assembly 26 or spaced downwardly from the floor assembly 26 (for example, between lower edges of each of the cross braces 110). Furthermore, rail members 112 may be welded or otherwise coupled to a lower edge of each vertical post 108 forming a "T" connection, as shown in FIG. 15. Each rail member 112 of the bracing assemblies 106 may be spatially separated from an adjacent rail member 112, or each rail member 112 may touch or be coupled to adjacent rail members 112 to further reinforce the side underride system 72.

While a specific number of bracing assemblies 106 (i.e., vertical posts and cross braces 110) are depicted, any suitable number of bracing assemblies 106 may be utilized. Further, although uniform spacing is utilized between adjacent bracing assemblies 106, the spacing between adjacent bracing assemblies 106 may not be uniform. In an illustrative example, the spacing between adjacent bracing assemblies 106 may be greater toward a center of the trailer and less toward the landing gear (and front rear wheel assembly) and the rear wheel assembly.

One or more of the bracing assemblies 106 (and, more specifically, the vertical posts 108 and the rail members 112) may support a cable system 80, a skirt system 12, or any other portions of a side underride guard system and/or aerodynamic skirt system. More particularly, any of the cable systems disclosed herein may be utilized in combination with the bracing assembly 106. In an illustrative embodiment, a first end of a cable forming the cable system 80 (or any other cable system disclosed herein) may extend from and be coupled to a rearmost vertical post 108 and/or cross brace 110 or may extend from and be coupled to a rear portion of the rail members 112. A second end of the cable may be coupled rearward of the rear wheel assembly, for example, to a rear impact guard of the trailer. A second cable may be attached on the opposite side of the trailer in the same manner. In some embodiments, the cable system 80 may further include cables with first ends extending from and coupled to a front-most vertical post 108 and/or cross brace 110 or may extend from and be coupled to a front portion of each of the rail members 112. Second ends of the cables may be coupled to a front portion of the trailer, for example, to the landing gear or a structure coupled to the landing gear (for example, as seen in FIGS. 19 and 20).

Alternatively, the bracing assemblies 106 alone may form a side underride system. As such, the bracing assemblies 106 may be an OEM side underride system design (that is, not for use as a retrofit with an existing skirt system) or, alternatively, may be used as a retrofit with existing skirt systems. As the bracing assemblies 106 are attached directly to the base rail 28, for example rather than the floor assembly 26, an installer may make such connections from beside the

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trailer 70 rather than underneath the trailer 70, thus potentially permitting easier installation. However, it is also within the scope of this disclosure to couple the bracing assemblies 106 to the floor assembly 26 of the trailer 70, such as to the cross members 40.

As described above, it is within the scope of this disclosure to include fewer or more mounting brackets 74, 76, 78, 94 or incorporate additional supports for the cable systems described herein. For example, FIGS. 17-20 illustrate another side underride system 114 for a trailer 115. The side underride system 114 may include a cable system 116, like that described above, that extends along the entire, or substantially the entire, length of the trailer 115. Alternatively, the cable system 116 may extend along only a small portion of the length of the side of the trailer 115. In one specific example, the cable system 116 extends from a rear impact guard 118, through an intermediate bracing assembly 120, to the landing gear 24. In other words, the side underride system 114 may utilize the existing rear impact guard 118 and landing gear 24 of the trailer 70. However, it is within the scope of this disclosure for the side underride system 114 to utilize one or more mounting bracket or bracing assemblies described above in addition to or instead of the RIG 118 and landing gear 24.

The rear impact guard (RIG) 118 is a system installed on or near the rear of the trailer 115 so that when the trailer 115 is struck from the rear by a vehicle, the RIG 118 potentially limits a distance that a striking vehicle's front end slides under the rear end of the trailer 115. The RIG 118 thus typically includes sufficient strength and structure to prevent rear vehicle underride. As such, the RIG 118 may be used to provide strength and structure to support to the cable system 116 for preventing side vehicle underride.

Illustratively, the RIG 118 may include one or more bumper support members 122 and a bumper 124. As shown in FIGS. 17 and 18, the bumper support members 122 may be coupled to the floor assembly 26 at the rear of the trailer 115 (e.g., extending downward from the rear end wall 18) and the bumper 124 is coupled across a bottom of the bumper support members 122, thus extending across a width of the rear of the trailer 115. One or more cables 90 of the cable system 116 may be coupled to a plate 126 coupled to or integral with an outer bumper support member 122 (e.g., by welding, fasteners, or other suitable coupling methods). Alternatively, an existing RIG 118 without a vertical support at its outer end may be modified to couple an additional bracket, or bumper support member, to the outer end of the bumper 124.

The cables 90 may be permanently or removably coupled to the plate 126 by any suitable means. Alternatively, the cables 90 may be coupled to other portions of the RIG 118 (such as forward or rear surfaces of the bumper support member 122, for example). Additionally, while three cables 90 are shown in FIGS. 17-20, it is within the scope of this disclosure to provide the cable system 116 with more or less cables 90, such as one, two, three, four, or five cables 90. As described above, the RIG 118 has sufficient strength to provide a suitable anchor point for the cable system 116. Further, using the RIG 118 as an anchor point for the cable system 116 may eliminate the need for a rear bracing system, thus potentially minimizing additional weight (and cost) that the side underride system 114 may add to the trailer 115.

From the RIG 118, the cables 90 may extend forward and through the intermediate bracing assembly 120. Illustratively, the intermediate bracing assembly 120 may be similar in structure and function to the bracing assemblies 106 described above; as such, like reference numbers are used to

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denote the same or similar components. As shown in FIG. 17, the cables 90 may be routed through cable guides or apertures of a vertical post 108 of the intermediate bracing assembly 120. Like the intermediate mounting bracket assembly 76 of FIG. 9, the intermediate bracing assembly 120 may serve to prevent the cable system 116 from swaying laterally inwardly or outwardly and may operate to prevent the cables 90 from drooping and to assist the cables 90 in working together to take loading from a vehicle impact and reduce the extent to which such a vehicle can intrude under the side or ends of the trailer 115. In particular, the intermediate bracing assembly 120 may serve to prevent the cable system 116 from swaying laterally inwardly and from contacting the rear wheel assembly 22 (e.g., so that the cables 90 do not rub against the tires of the rear wheel assembly 22 during normal operation).

Additionally, in some embodiments, the intermediate bracing assembly 120 (and/or the cable connections at the intermediate bracing assembly 120, the landing gear 24, or the rear wheel assembly 22) may be positioned so that the cables 90 are angled or curved relative to the side walls 14 of the trailer 115. For example, the intermediate bracing assembly 120 may extend outward past the plane of the side wall 14 to further ensure that the cables 90 bow outwardly from the front end of the trailer 115 to the back end of the trailer 115 so that the cables 90 do not rub against the tires of the rear wheel assembly 22. In some embodiments, the cables 90 may also be angled inward at the front of the trailer 115. Also, a bottom cable 90 may generally angle upwardly from the intermediate bracing assembly 120 to the RIG 118, for example when the RIG 118 is not positioned as low (or close to the ground) as the landing gear 24.

From the intermediate bracing assembly 120, the cables 90 may extend forward and to the landing gear 24, as shown in FIGS. 19-20. As all trailers include landing gear assemblies, using the landing gear 24 as an anchor point for the cable system 116 may eliminate a need for a front bracing system, thus potentially minimizing additional weight (and cost) that the side underride system 114 may add to the trailer 115. Illustratively, the landing gear 24 includes legs 130 and side braces 132 coupled to the floor assembly 26. The cables 90 may be permanently or removably coupled to the side braces 132. However, it is within the scope of this disclosure for the cables 90 to be coupled to the legs 130.

As seen in FIGS. 19-20, the landing gear 24 may include a transverse brace or bracket 170 that is generally perpendicular to the side braces 132 and a direction of travel of the trailer 115. The transverse brace 170 may include a plurality of fins 172 coupled, for example, integrally coupled or coupled by welding or in any other suitable manner, between the transverse brace 170 and the side brace 132. The fins 172 provide support to the transverse brace 132 to reduce stress on the transverse brace 132 in a direction of travel of the trailer 115. While fins 172 are only shown on a forward side of the transverse brace 132, fins could additionally or alternatively be utilized on a rearward side of the transverse brace 132. Further, while the fins 172 as shown as being spaced between each of the cables 90, any suitable number of fins 172 may be utilized with any suitable spacing.

Still referring to FIGS. 19-20, a plurality of apertures 174 extend through the transverse brace 170. Each of the cables 90 extends through a respective aperture 174 and a nut, bolt, or other suitable fastener 176 is attached to an end of the each cable 90 to attach the cables 90 to the transverse brace 170 and the prevent the cables 90 from being pulled through the aperture 174, while still allowing a user to uncouple the cables 90 from the transverse brace 170. While one particu-

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lar manner of coupling the cables **90** to the transverse brace **170** is shown, the cables **90** may be coupled to the transverse brace **170** in any other suitable manner.

In some embodiments, the landing gear **24** may be reinforced to further support the side underride system **114**. For example, current landing gear assemblies are structured to support the weight of the trailer **115** (i.e., downward forces), wherein the side braces **132** act to maintain the legs **130** in a vertical orientation under heavy loads. Accordingly, in some embodiments, the landing gear **24** may be reinforced to better accommodate lateral loads, such as forces caused by a side collision. Such reinforcement may be accomplished through additional cross-bracing or other methods.

Illustratively, the above-described side underride system **114** may extend below a side wall **14** of the trailer **115** along substantially the entire length of the trailer **115**. Accordingly the side underride system **114** may provide side underride protection along the entire length of the trailer **115**, including from the rear wheel assembly **22** to the RIG **118**. Further, the side underride system **114** may also act as a deflection mechanism for protecting the rear wheel assembly **22**. For example, when a vehicle drifts across its lane toward the trailer **115**, the vehicle may strike the cables **90** before striking the rear wheel assembly **22**. Additionally, although the cable system **116** extends to the rear of the trailer **115**, a driver may still inspect and access the rear wheel assembly **22** between the cables **90**. As further described below, the cables **90** may also be removable from the RIG **118** to permit better access to the rear wheel assembly **22**, if necessary. Still further, a tension in the cables **90** may be adjustable. It is also to be understood that the side underride system **114** may extend a shorter length along the trailer **115**.

The side underride system **114**, or any of the other described side underride systems, may be utilized in combination with an aerodynamic skirt assembly, such as the skirt assembly **12** of FIGS. 1-2. As a result, the side underride systems may be retrofit on trailers with existing aerodynamic skirt systems and may be spaced apart from or coupled to the skirt systems. Alternatively, the side underride system **114** (or any of the other described side underride systems) may incorporate its own aerodynamic skirt system **134**, as shown in FIGS. 19-23. Illustratively, the side underride system **114** may provide primary support for the skirt system **134**, thus potentially reducing the need, cost, and weight of a dedicated skirt system support structure while still providing aerodynamic functions.

For example, as shown in FIG. 21, the skirt system **134** may include a side skirt wall **136** that extends from the landing gear **24** to the intermediate bracing assembly **120**. However, it should be understood that the side skirt wall **136** may extend shorter or longer lengths along the side underride system **114**. The side skirt wall **136** may include a single wall panel **138**, as shown in FIG. 21, or multiple wall panels coupled together (e.g., in a similar manner to that described above with respect to the wall panels **32** of FIGS. 1-3). The side skirt wall **136** may be substantially rigid or flexible. Further, the side skirt wall **136** (and, more specifically, the wall panel **138**) may include suitable composite materials, such as that described above with respect to the wall panels **32**, or any number of suitable, non-composite materials such as metals, metal alloys, plastics, and/or fabrics, for example.

Illustratively, the side skirt wall **136** may be coupled to the floor assembly **26**, the bracing assembly **120**, and the landing gear **24**. For example, as shown in FIGS. 19, 20, and 22, the side skirt wall **136** may be coupled to the side braces **132** of the landing gear **24** and positioned laterally outward from the cable system **116**. However it is with the scope of

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this disclosure to position the side skirt wall **136** laterally inward from the cable system **116**. As shown in FIG. 23, the side skirt wall **146** may be coupled to the cross members **40** of the floor assembly **26** via mounting brackets **140** and fasteners **142**, such as rivets, screws, etc.

Illustratively, each mounting bracket **140** may include a first coupling surface **144** and a second coupling surface **146** separated by an intermediate portion **148**. The first coupling surface **144** may be configured to press against and be coupled to an inner surface of the side skirt wall **136** by the fasteners **142**. The second coupling surface **146** may be oriented perpendicular relative to the first coupling surface **144** and configured to press against and be coupled to a vertical section of the cross member **40** by the fasteners **142**. The intermediate portion **148** may be configured to attach the first coupling surface **144** and the second coupling surface **146**. Furthermore, the intermediate portion **148** can at least partially press against a lower edge of the cross member **40** to provide additional stability to the mounting bracket **140**. Other mounting brackets with different configurations and attachment mechanisms may also be used. Furthermore, it should be understood that, while the side skirt wall **136** is shown and described herein as being coupled to the side braces **132** and the cross members **40**, it is within the scope of this disclosure to include a side skirt wall **136** coupled to any component of the floor assembly **26**, the base rail **28**, the bracing assembly **120**, the landing gear **24**, and/or the RIG **118**.

Generally, the mounting brackets **140** may help support the weight of the side skirt wall **136**. And the landing gear **24**, the intermediate bracing assembly **120**, and/or the RIG **118** may help maintain the side skirt wall **136** in a substantially vertical orientation (i.e., parallel to the trailer side wall **14**) for effective aerodynamic function. Furthermore, optionally, the side skirt wall **136** may be coupled to the cables **90** at one or more locations between the landing gear **24**, the intermediate bracing assembly **120**, and/or the RIG **118** for additional support. While the described connections may hold the side skirt wall **136** substantially rigid, the side skirt wall **136** may be of a height that provides sufficient aerodynamic function while also providing sufficient clearance over obstacles or uneven roads. Also, it is contemplated within this disclosure that the side skirt wall **136** may be coupled in a manner to permit the side skirt wall **136** to tilt laterally inwardly and/or outwardly to potentially avoid damage when the trailer **115** traverses into or over obstacles. Accordingly, the above side underride system **114** may provide both side underride protection as well as aerodynamic functionality.

Looking now to FIGS. 24-31, in another illustrative embodiment, a further side underride system **152** is shown, which may provide dual functions of preventing automobile underride as well as improving the aerodynamic efficiency of the trailer **154** by reducing drag and wind flow under the trailer **154**. Illustratively, the side underride system **152** extends below and generally parallel to the side walls **14** of a trailer **154** in order to prevent an automobile from riding under the trailer **152** in the event of a side impact collision.

Illustratively, the side underride system **152** may include a skirt assembly including a skirt system **12** in the form of a tarp assembly **156**. The side underride system **152** may further include a cable system **158**. As further described below, the tarp assembly **156** and the cable system **158** may extend at least partially along discrete or overlapping lengths of the trailer **154**. For example, the tarp assembly **156** may extend a first length from the front area of the trailer **154** near the landing gear **24** toward the rear wheel assembly **22**,

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while the cable system 158 may extend a second length from an area forward of the rear wheel assembly 22 to the rear of the trailer 154, for example, to a rear impact guard 118.

Illustratively, the tarp assembly 156 may include a tarp member 160 made of a flexible material and one or more belts 162a, 162b. The material may be tarpaulin material, or any other type of cloth, fabric, canvas, plastic, sheeting, or webbing material. The material may be reinforced to withstand tensile forces, for example, permitting the material 160 to stretch or flex under such forces. To further reinforce the tarp member 160, and add structure and support to the tarp assembly 156, one or more belts 162a, 162b may be stitched onto or into, or otherwise coupled to or positioned relative to the material 160. For example, one or more horizontal belts 162a may be coupled to the tarp member 160 and extend along a length of the material 160, while one or more vertical belts 162b may be coupled to the material 160 and extend along a height of the material 160, thus crossing over, under, or weaving between the horizontal belts 162a and creating a matrix of belts 162a, 162b across the tarp member 160.

In other embodiments, the skirt assembly, including specifically the material of the tarp member 160, may include a generally rigid material (i.e., having some flexibility), for example, DURAPLATE® composite panel provided by Wabash National Corporation of Lafayette, Ind. DURAPLATE® composite panels are constructed of a high-density polyethylene plastic core bonded between two high-strength steel skins. It should be understood that other suitable composite materials may alternatively or additionally be used. For example, the material of the tarp member 160 may be made of a sandwich composite including a honeycomb core and metal or plastic outer sheets, or the material of the tarp member 160 may be made of a flexible, rigid, or semi-rigid fiber-reinforced plastic composite. Further, the material of the tarp member 160 may be of any number of suitable, non-composite materials such as metals, metal alloys, and/or plastics, for example. This skirt or tarp material may be both rigid and flexible, or able to bend without deformation, such that it is semi-rigid. If the material of the tarp member 160 is a rigid or semi-rigid material, one or more horizontal and/or vertical belts 162a, 162b may be utilized or no belts may be utilized.

In one example, as shown in FIG. 29, the tarp assembly 156 may include a first horizontal belt 162a and a second horizontal belt 162a. The first horizontal belt 162a may be stitched into or otherwise coupled to, the material of the tarp member 160 across a midsection of the tarp member 160 (e.g., between the base rail 28 and a lower edge of the tarp member 160). The second horizontal belt 162a may be stitched into, or otherwise coupled to, the tarp member 160 across the lower edge of the tarp member 160. Alternatively, the lower edge of the tarp member 160 may be folded up and stitched to itself to create a loop 164, as shown in FIG. 25, and the second horizontal belt 162a may be routed through the loop 164. As a result, the tarp member 160 and the second horizontal belt 162a may freely move forwardly and rearwardly relative to each other. The belts 162a may alternatively include cables or other suitable structures.

Additionally, the tarp assembly 156 may include a plurality of vertical belts 162b spaced apart across the length of the tarp member 160. The vertical belts 162b may be stitched into or otherwise coupled to the tarp member 160 and/or the horizontal belts 162a. For example, the vertical belts 162b may be stitched into or looped around the second horizontal belt(s) 162a. Additionally, the vertical belts 162b may be equally spaced apart or spaced apart at varying distances. In

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one example, the vertical belts 162b may align with one or more cross members 40 of the floor assembly 26. As a result, the tarp assembly 156 may be coupled to the cross members 40 via the vertical belts 162b, as further described below.

While the belts 162a, 162b are described as being coupled to the tarp member 160, it is within the scope of the present invention to have one or more tarp members 160 and belts 162a and/or 162b that work independently of one another. In other words, the belts 162a and/or 162b may not be coupled to the respective tarp member 160. The belts 162a, 162b may be of any size or material, as described below.

The belts 162a, 162b may include nylon, metal, plastic, fabric, rope, cables, webbing, and/or another suitable material. The belts 162 may stretch or flex under tensile forces, for example with 20,000 lb. to 30,000 lb. breaking capacity. In one specific example, each belt 162 may be a four-inch nylon belt. Also, in some embodiments, the second horizontal belt 162a may incorporate a plurality of belts 162a, as shown in FIG. 25, which may provide additional strength and support to the tarp assembly 156. One or more of the other horizontal belts 162a or the vertical belts 162b may also incorporate multiple belts along the same length or height, respectively.

In use, each of the tarp assembly 156 (i.e., the belts 162 and the tarp member 160) and the cable system 158 is taut and operates as a protective system to reduce the risk of automobiles intruding under the floor assembly 26 of the trailer 154 during a side impact accident. Further, the belts 162a, 162b, the tarp member 160 may retain some flexibility and thus may operate to absorb some of the force and energy of any impact thereto to potentially decrease any forces on the passengers within the automobile during impact. Accordingly, the belts 162a, 162b and the tarp member 160 perform a similar function as the cables of the side underride systems described herein. Further, while the tarp assembly 156 is illustrated and described herein as not including cables, it is within the scope of this disclosure to include a tarp assembly 156 with cables in conjunction with or as an alternative to the belts 162a, 162b. For example, the tarp member 160 may include vertically-spaced pockets sewn into it through which cables may be threaded (e.g., in place of or in addition to the vertical belts 162b). Additionally, the tarp assembly 156 (e.g., the tarp member 160) may have aerodynamic properties, thus performing a similar function as the side skirt systems described herein. As such, the system 152 may be an OEM design (that is, not for use as a retrofit with an existing skirt system) or, alternatively, may be used as a retrofit with existing skirt or side underride guard systems. In the case where a current trailer includes a side underride guard or skirt system, one or both of the tarp assembly 156 and the cable system 158 could be coupled thereto. If only a cable system 158 is to be retrofit to an existing side underride guard and/or a skirt, the cable system 158 may be coupled to one or more portions of the side underride guard and/or skirt and/or one or more mounting brackets (as detailed below with regard to at least FIG. 25).

Illustratively, the tarp assembly 156 may be coupled to the trailer 154 to generally extend between the landing gear 24 and the rear wheel assembly 22. As some trailers 154 include sliding suspensions, thereby allowing the rear wheel assembly 22 to be moved between a rearward position and a forward position, the tarp assembly 156 may extend from the landing gear 24 to the forward-most position of the rear wheel assembly 22. In one specific application, this length may be about 27 feet. However, the tarp assembly 156 may extend along a greater or a lesser length of the trailer 154 than what is illustratively shown in the figures. In other

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words, the tarp assemblies disclosed herein may be modified to extend along the entire, or substantially the entire, length of the trailer 154 or may be modified to extend along only a small portion of the length of the trailer 154.

The tarp assembly 156 may be coupled to the trailer 154 along one or more cross members 40, the landing gear 24, one or more bracing assemblies, and/or the base rail 28. For example, the tarp assembly 156 may be coupled to one or more cross members 40 with clip assemblies 166, as shown in FIGS. 26-28, or other mounting brackets. More specifically, as further described below, the clip assemblies 166 may couple vertical belts 162b to the cross members 40. Accordingly, the clip assemblies 166 (and the vertical belts 162b) may be positioned to correspond to each cross member 40 along a length of the tarp assembly 156, at every other cross member 40, or at even or uneven intervals of cross members 40.

As shown in FIGS. 27-28, each clip assembly 166 may include an L-shaped bracket 168 with an aperture 170, a bolt 172, a nut 174, and a clip 176. The clip 176 may include a base wall 178, a first side wall 180 with an aperture 182, a second side wall 184, and a front wall 186 with an opening 188 configured to receive a vertical belt 162b. As shown in FIG. 28, the first side wall 180 and the front wall 186 may each bend or fold downwardly along the illustrative dotted lines so as to be perpendicular with the base wall 178. The second side wall 184 may bend upwardly and inwardly so as to be parallel with the base wall 178 and form a hook shape.

Illustratively, the second side wall 184 is configured to engage an outer edge of a bottom flange of a cross member 40 so that the outer edge is sandwiched between an upper surface of the base wall 178 and a lower surface of the second side wall 184. Once the second side wall 184 is engaged with the bottom flange, the L-shaped bracket 168 may be positioned over an opposite outer edge of the bottom flange so that the apertures 170, 182 align and the opposite outer edge is sandwiched between the upper surface of the base wall 178 and a lower planar surface of the L-shaped bracket 168. Once the L-shaped bracket 168 is positioned, the bolt 172 may be routed through the apertures 170, 182 and the nut 174 may be tightened around the bolt to secure the L-shaped bracket 168 to the clip 176.

Each clip assembly 166 may be coupled to a respective cross member 40 at equal or varying lateral distances from the side wall 14. More specifically, each clip assembly 166 may be coupled to a respective cross member 40 at a distance "X" inward from the side wall 40, as shown in FIG. 26. The distance X may be between, for example, about 0 inches and about 10 inches from the side wall 40. However, it is within the scope of this disclosure to include other suitable distances. Furthermore, the distance X may be longer on cross members 40 located near the front of the trailer 154 compared to cross members 40 positioned near the rear of the trailer 154. As a result, the tarp assembly 156 may be substantially curved or angled from the front of the trailer 154 to the rear of the trailer 154 (similar to the angled profile of the side skirt walls 30 shown in FIG. 6) to enhance aerodynamic properties of the tarp assembly 156. Alternatively, the distance X may be zero inches at each cross member 40 so that the tarp assembly 156 is parallel to and generally co-planar with the side walls 14 of the trailer 156.

As described above, each clip assembly 166 may couple a vertical belt 162 to a respective cross member 40. For example, as shown in FIG. 26, a top of each vertical belt 162b may be folded over, then stitched or otherwise coupled to itself to form a loop 190. The loop 190 may be routed through the opening 188, a bolt 192 may be routed through

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the loop 190, and a nut 194 may be secured to the bolt 192. The weight of the tarp assembly 156 urges the vertical belt 162b back through the opening 188; however, the bolt 192 and the nut 194 may prevent the loop 190 from sliding through the opening 188, thus securing the vertical belt 162b to the clip assembly 166. Accordingly, the vertical belt 162b may be disconnected from the clip assembly 166 by unfastening the nut 194 from the bolt 192 and removing the bolt 192 from the loop 190, thereby allowing the loop 190 to slide through the opening 188. It should be understood that vertical belt 162b may be otherwise removably or permanently coupled to the clip assembly 166 without varying from the scope of this disclosure.

The clip assemblies 166 allow the vertical belt 162b (or optionally a cable or other connecting member) where the belt 162b is connected to the cross member 40 to be slid on the cross member 40 to keep the tarp assembly 156 from rotating and/or folding up upon impact. The bracket assemblies 166 may allow the tarp assembly 156 to slide inwardly when hit.

While the vertical belts 162b may be coupled to the clip assemblies 166, one or more of the horizontal belts 162a and/or the tarp member 160 may be coupled to and/or rest upon the one or more bracket or bracing assemblies, the landing gear 24 and/or the RIG 118. Generally, such couplings may help support the tarp assembly 156 in a substantially vertical orientation and prevent the tarp assembly 156 from swaying too far laterally inward or outward relative to the side wall 14.

The side underride system 152 may incorporate any of the mounting bracket assemblies or bracing assemblies described above. Alternatively, as shown in FIGS. 24 and 25, the side underride system 152 may include a mounting bracket 196 coupled to the base rail 28 or the floor assembly 26 of the trailer 154, and the tarp assembly 156 may extend between the landing gear 24 (or another front bracing or bracket assembly) and the mounting bracket 196. As shown in FIG. 25, the mounting bracket 196 may be coupled to the trailer 154 and include a triangular flange structure with a vertical post 198 (as shown in FIG. 29) configured to be coupled to the tarp assembly 156. Furthermore, as shown in FIG. 29 the mounting bracket 196 may include a cross-brace 205 with spring portions 206. The spring portions 206 may help the mounting bracket 196 compress and absorb forces from a vehicle side impact and reduce the extent to which such a vehicle can intrude under the side of the trailer 154.

As shown in FIGS. 24 and 25, the mounting bracket 196 may be coupled to the trailer 154 and positioned near the rear wheel assembly 22 (that is, forward of the rear wheel assembly 22). It should be understood, however, that the mounting bracket 196, as well as any other bracing or mounting bracket assemblies disclosed herein, may alternatively be coupled to the trailer 154 at other locations along the length of the trailer 154. Furthermore, as shown in FIG. 25, the side underride system 152 may include one or more additional mounting brackets 196 (or intermediate bracing assemblies 120) positioned between the landing gear and the rear-most mounting bracket 196.

FIG. 29 illustrates an example coupling between the tarp assembly 156 and the mounting bracket 196. Illustratively, side edges of the horizontal belts 162a may be folded over and stitched or otherwise coupled to themselves to form loops 200. A bracket 202 may be routed through each loop 200 and fasteners 204 may couple either end of the bracket 202 to the vertical post 198, thus preventing the bracket 202 from sliding out of the loop 200 and securing the horizontal belt 162a to the mounting bracket 196.

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The horizontal belts **162a** may be secured to the additional mounting bracket(s) **196**, the landing gear **24**, and/or the RIG **118** in a similar manner as described above. It should be also understood that horizontal belts **162a** or the tarp member **160** may be otherwise removably or permanently coupled to components of the mounting bracket **196**, or any other mounting bracket or bracing assembly, the RIG **118**, or the landing gear **24**, in any other manner without varying from the scope of this disclosure. In addition or alternatively to the above-described couplings, the tarp assembly **156** may be coupled directly to the side walls **14** of the trailer **154**. In particular, the tarp assembly **156** may be coupled to the base rail **28**.

As described above, the tarp assembly **156** may be coupled to the trailer **154** to extend vertically downwardly from the side walls **14**. The tarp assembly **156** may extend a height longer than, equal to, or shorter than the height of the above-described wall panels **32** of the skirt assembly **12**. For example, the height may be shorter than wall panels **32**, thus allowing the tarp assembly **156** to clear obstacles. As such, lateral movement capabilities (i.e., to traverse such obstacles) may be unnecessary and the tarp assembly **156** may be substantially rigidly coupled to the trailer **154**. However, it is within the scope of this disclosure for the tarp assembly **156** to have lateral tilting capabilities, like that described above with respect to the wall panels **32** of the skirt assembly **12**. Furthermore, the tarp assembly **156** may include a flap (not shown), similar in structure and function to the flap **36** described above with respect to FIGS. 4-5. The flap may be coupled to a lower edge of the tarp assembly **156** and may provide additional aerodynamic properties to the system **154**, while being flexible enough to bend or flex over obstacles.

Accordingly, the tarp assembly **156** may provide aerodynamic functionality (i.e., by way of the tarp member **160**) as well as side underride protection (i.e., by way of the belts **162** and the mounting brackets **196**). Furthermore, the cable system **158** may provide additional side underride protection and/or deflection functionality, for example, from the rear wheel assembly **22** to the rear of the trailer **154**. The cable system **158** may include a single cable **90**, as shown in FIGS. 14, 25, and 29. Alternatively, the cable system **158** may include more than one cable **90**, such as two, three, four, five, or more cables **90**.

Illustratively, the cable system **158** may extend a length that spans from a rear end of the tarp assembly **156** to the rear of the trailer **154**. In one specific application, this length may be about 17 feet. However, the cable system **158** modified to extend along a greater or a lesser length of the trailer **154** than what is illustratively shown in the figures. In other words, the cable system **158** may be modified to extend along the entire, or substantially the entire, length of the trailer **154** (like that described above with respect to the side underride system **72**) or may be modified to extend along only a small portion of the length of the side of the trailer **154**.

For example, as shown in FIGS. 24 and 25, the cable system **158** may extend from the mounting bracket **196** to the RIG **118**. Alternatively, additional mounting bracket or bracing assemblies may be incorporated to support the cable system **158**. For example, in retrofit systems without RIGs, a rear mounting bracket assembly may be coupled to the trailer **154** to receive the cable system **158**. The cable(s) **90** may be coupled to the mounting bracket **196** and/or the RIG **118** as described above with respect to the cable systems **80**, **116**. Alternatively, as shown in FIG. 29, the cable **90** may be coupled to the mounting bracket **196** via a bracket **208**. More

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specifically, the bracket **208** may be coupled to the vertical post **198** and may also be coupled to or integral with the bracket **202** that supports the tarp assembly **156**. The cable **90** may be coupled to the bracket **208** in any suitable manner, such as by clamping, welding, or with suitable fasteners.

Furthermore, the cable **90** may be coupled to the RIG **118** in a removable manner, for example to allow access to the rear wheel assembly **22** (e.g., to inspect the rear wheel assembly **22**, and related bogie or suspension assembly, or to service a tire of the rear wheel assembly **22**). For example, as shown in FIG. 30, a cable terminal **210** may be used to receive the end of the cables **90** therein and may include an aperture **212**. A drop-pin structure **214** may be coupled to the RIG **118** and the cable terminal **210** may be releasably coupled to the drop-pin structure **214** (i.e., by inserting or releasing a pin **216** of the drop-pin structure **214** through the aperture **212**). Alternatively, as shown in FIG. 31, a load binder **218** may be coupled to the RIG **118** and the cable terminal **210** may be releasably coupled to the load binder **218** (i.e., by inserting or releasing a hook **220** of the load binder **218** through the aperture **212**).

Illustratively, the single cable **90** of the cable system **158** may be removably or non-removably coupled to the lower ends of the mounting bracket **196** and the RIG **118**. However, it should be understood that the cable(s) **90** may be positioned at any height along the mounting bracket **196** and the RIG **118**. For example, generally, the cable(s) **90** may be positioned at any height so as to be positioned laterally outwardly from the tires of the rear wheel assembly **22**. Furthermore, the mounting bracket **196** may force the cable **90** outward to prevent the cable **90** from contacting the tires of the rear wheel assembly **22** during trailer operation. In particular, the mounting bracket **196** may help prevent the side underride system from swaying laterally inwardly (or outwardly) and contacting the rear wheel assembly **22**. In one example, the mounting bracket **196** may force the cable **90** about two to three inches outward from the rear wheel assembly **22**, though other lateral distances may be contemplated.

Referring again to FIGS. 24 and 25, in an illustrative embodiment, the tarp assembly **156** includes two opposing tarp members **160** made of a flexible material and first and second cables **162** are routed along lower edges of the tarp members **160**. First ends of the first and second cables **162** (on first and second sides of the trailer) are coupled to a front portion of the trailer, for example, near the landing gear and second ends of the cables **162** (on first and second sides of the trailer) are coupled to the trailer forward of the rear wheel assembly **22**, for example, to rigid mounting brackets or posts **196**. The cable system **158** includes third and fourth cables **90** (on first and second sides of the trailer) with first ends coupled to the trailer forward of a forward-most position of the rear wheel assembly **22**, for example, to rigid mounting brackets or posts, and second ends coupled to a rear end of the trailer, for example, to the rear impact guard or in any manner described herein or any other suitable fashion. In embodiments including mounting brackets **196**, the first ends of the first and second cables **90** may be coupled to the mounting brackets **196**. In other embodiments, the cables **90** may be coupled to any other suitable structure. The first and second cables **162** are separate and distinct from the third and fourth cables **90** such that the third and fourth cables **90** can be easily removed and replaced, for example, to access the rear wheel assembly **22**.

In other illustrative embodiments, the tarp assembly **156** and the cable system **158** may only extend along one side of the trailer.

In another illustrative embodiment, similar to the one detailed immediately above and again referencing FIGS. **24** and **25**, the tarp assembly **156** includes two opposing tarp members **160** made of a rigid material, such as DURA-PLATE®. The tarp assembly **156** may further, but need not, include first and second cables **162** routed along lower edges (or along any other suitable location) of the rigid material **180**. First ends of the first and second cables **162** (on first and second sides of the trailer) are coupled to a front portion of the trailer, for example, near the landing gear and second ends of the cables **162** (on first and second sides of the trailer) are coupled to the trailer forward of the rear wheel assembly **22**, for example, to a rear end of the tarp material or to rigid mounting brackets or posts **196**. The cable system **158** includes third and fourth cables **90** (on first and second sides of the trailer) with first ends coupled to the trailer forward of a forward-most position of the rear wheel assembly **22** and second ends coupled to a rear end of the trailer, for example, to the rear impact guard or in any manner described herein or any other suitable fashion. In embodiments including mounting brackets **196**, the first ends of the first and second cables **90** may be coupled to the mounting brackets **196**. In other illustrative embodiments, the tarp assembly **156** and the cable system **158** may only extend along one side of the trailer.

As referenced above, the removable cables **90** allow for the cables **90** alone to be retrofit onto a trailer having a previously-installed skirt system and/or side underride guard (for example, those show in any of FIGS. **5-8** and **33-38** or any other side underride guard). In this manner, the skirt system **158** may provide side underride protection adjacent the rear wheel assembly for a trailer not previously protected in this area. The cables **90** may be attached to existing structures (e.g., the skirt system, side underride guard, rear impact guard, or any other suitable structure) or a structure, such as post or the mounting brackets **196** of FIG. **24**, may be coupled to the trailer for coupling of the cables **90** thereto.

The cable system **158** may provide deflection functionality to deter impact with the rear wheel assembly **22** when a vehicle drifts toward the trailer **154** (i.e., during passenger compartment intrusion). More specifically, the cable system **158** may serve as an alert to the vehicle driver as the vehicle may contact the cable **90** before reaching the rear wheel assembly **22**. Furthermore, the cable system **158** may include a plurality of cables **90** to provide additional side underride protection near the rear wheel assembly **22** and all the way to the rear of the trailer **154**.

As described above, a trailer may be provided with a side skirt system including any number of mounting bracket assemblies. Further, a trailer may be provided with a side underride system including a variety of different tarp assemblies and cable systems having any number of cables and mounting bracket assemblies in addition to, or independent of, the side skirt systems. Any flexible members of the side underride systems described herein may also allow directional change of the continuous length of the side underride system so that the side underride system may angle, curve, or be positioned inwardly at the front end of the trailer, for example.

Illustratively, any of the above-described concepts may be used together to provide a trailer having both a side skirt system extending along the length of each side of the trailer and a side underride system also extending along the length of each side of the trailer. For example, any of the skirt

systems, skirt assemblies, skirt panels, etc. disclosed herein may be combined with any of the cable systems, support systems, bracket systems, or any other features described herein. Illustratively, when a side skirt assembly and a side underride system are used together, the side underride system may be positioned laterally outwardly from the side skirt assembly in order to allow the side skirt assembly to tilt laterally inwardly a suitable amount. However, it is also within the scope of this disclosure to position the side skirt assembly laterally outwardly from the side underride system when mounting both to the same trailer. Illustratively, the cable system of the side underride system and the side wall of the side skirt assembly may be spaced any suitable distance apart from each other as each are mounted to the floor assembly portion of the trailer.

It should also be understood the side skirt and cable underride systems disclosed herein may be coupled directly to each other. For example, the side skirt of any one of the side skirt systems disclosed herein may be directly coupled to any one of the cable systems of the underride systems disclosed herein. Further, any one of the underride systems may be retrofit with existing skirt systems, may be added with new skirt systems, or may completely replace existing skirt systems. As such, any of the above-described underride system embodiments may be an OEM side underride system design (that is, not for use as a retrofit with an existing skirt system) or, alternatively, may be used as a retrofit with existing skirt systems. The above-described systems may provide underride protection to reduce the risk of passenger vehicle underride in the event of a side impact collision with a vehicle, as well as reduce the risk of pedestrians, bicyclists, motorcyclists, or objects from falling or sliding under the trailer, for example, between the landing gear and the rear wheel assembly or between the landing gear and the rear impact guard.

Referring now to FIG. **32**, according to one illustrative embodiment, a side underride system **354** may include first and second opposing side skirt walls **356**, a hinge assembly **358**, and one or more cross-braces **360** including a first diagonal truss beam **362** and a second diagonal truss beam **364**. The first and second skirt walls **356** may be coupled to a floor assembly **26** of a trailer **10** via the hinge assembly **358**, any other coupling method described herein, or any other suitable coupling method, and/or the cross-braces **360** may be coupled to the skirt walls **356** via connectors **366** to form a support system. Additionally or alternatively, the cross-braces **360** may be coupled to the floor assembly **26**. Still further, the cross-braces **360** may be coupled to a mounting bracket **140**.

Illustratively, the skirt walls **356** may be coupled to the trailer **10** along a length of the trailer **10** and may include similar structure and function as the skirt walls **30** described above. For example, the first skirt wall **356** may be configured to be positioned below the trailer **10** near the first side wall **14** and the second skirt wall **356** may be configured to be positioned below the trailer **10** near the second side wall **14**. Further, the skirt walls **356** may be coupled to the trailer **10** between the landing gear **24** and the rear wheel assembly **22**. In one specific application, this length may be about 16 feet; however shorter or longer lengths may be contemplated within the scope of this disclosure. Also, the skirt walls **356** may each include a single, substantially rigid flat or curved wall panel, or multiple wall panels coupled together. Alternatively, the skirt walls **356** may be made of a sandwich composite including a honeycomb core and metal or plastic outer sheets, or may be made of a fiber-reinforced plastic composite. Further, the skirt walls **356** may be of any

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number of suitable, non-composite materials such as metals, metal alloys, and/or plastics, for example.

The skirt walls 356 may be coupled to the trailer 10 via the hinge assembly 358. Illustratively, the hinge assembly 358 may traverse an entire length of each skirt wall 356 or one or more discrete portions thereof. Generally, the hinge assembly 358 may include a first plate (not shown) coupled to a second plate 370 by a hinge (not shown). The first plate may be coupled to an inner or outer surface of a respective wall skirt 356 and the second plate 370 may be coupled to the floor assembly 26 of the trailer 10, such as to one or more cross members 40 (see FIG. 4) or the base rail 28 (see FIG. 1), with one or more suitable fasteners. The hinge may be moveable so that the first plate and the second plate 370 may be moved relative to one another about the hinge. Alternatively, the hinge may be fixed so that first plate is oriented about 90 degrees—or at any other suitable angle—relative to the second plate 370. In another alternative embodiment, the hinge may permit laterally inward movement (that is, from a position parallel to the side walls 14 laterally inward toward the floor assembly 26), yet prevent laterally outward movement past about 90 degrees (i.e., past a position substantially parallel to the side walls 14). In embodiments where the skirt walls 356 cannot move laterally, the skirt walls 356 may be shorter than the skirt walls 30 described above. Further, the skirt walls 356 may include a longer flexible flap (similar to the above-described flap 36) coupled to lower edges thereof. The flap may operate to resist airflow and may prevent damage to the skirt walls 356 from forces applied vertically such as in situations where the trailer 10 may traverse over a curb or railroad track where the road surface is not flat.

Furthermore, it is within the scope of this disclosure to include other suitable longitudinal straps, bars, or connectors configured to couple the skirt walls 356 to the cross members 40 and/or the base rail 28. It is also contemplated within this disclosure that the base rail 28 may be modified to provide a direct coupling surface for the skirt walls 356. For example, the base rail 28 may extend further downward past the cross members 40 to provide a suitable surface to which the skirt walls 56 may be coupled.

Accordingly, in some embodiments, a single hinge assembly 358 may couple the side underride system 354 to the trailer 10, as opposed to the multiple mounting brackets described above. Furthermore, the hinge assembly 358 may act as a fuse-type assembly such that the hinge assembly 358 or the coupling between the hinge assembly 358 and the trailer 10 may fail before any components of the trailer 10 fail in the event of a side impact collision. As such, when such a collision occurs, the side underride system 354 may be easily uninstalled from the trailer 10 (i.e., by disconnecting the hinge assembly 358 from the trailer 10) so that the trailer 10 may still be drivable.

Referring again to FIG. 32, the cross-braces 360 may act as a support system to provide side underride protection. Illustratively, the cross-braces 360 may be coupled to the skirt walls 356 across a width of the trailer 10. In one specific application where each skirt wall 356 is coupled directly below and parallel to a respective side wall 14, this width may be about 8 feet. However, the cross-braces 360 may be coupled to the skirt walls 356 over various widths, for example, when the skirt walls 356 form an angled or curved profile from the front of the trailer 10 to the rear of the trailer 10. To ensure impact protection across the length of the system 354, as further described below, the cross-braces 360 may be spaced apart along the length of the trailer 10. For example, the cross-braces 360 may be spaced

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apart at specific intervals to ensure that a passenger vehicle colliding with a skirt wall 356 may engage at least one of the cross-braces 360 upon impact. In one specific example, the system 354 may include four cross-braces 360 spaced apart at five-foot intervals.

As mentioned above, each cross-brace 360 may be coupled to the skirt walls 356 via one or more connectors 366. The connectors 366 may be welded or otherwise coupled (such as with suitable fasteners) to the truss beams 362, 364 and/or the skirt walls 356. For example, the connectors 366 may be U-shaped connectors to which the truss beams 362, 364 are slid downward into. Alternatively, the connectors 366 may be T-shaped or L-shaped or include any other suitable shape to receive or be coupled to the truss beams 362, 364.

The truss beams 362, 364 may be coupled to the skirt walls 356 via the connectors 366, then only the skirt walls 356 may be coupled to the trailer 10 via the hinge assembly 358. According to another example, the truss beams 362, 364 may be coupled to both the skirt walls 356 and the floor assembly 26. For example, the truss beams 362, 364 may be first coupled to the floor assembly 26, such as to the cross members 40 and/or the base rail 28, and then the skirt walls 356 may be coupled to the truss beams 362, 364 and/or the floor assembly 26. Accordingly, the system 354 may be coupled to the trailer 10 from beside the trailer 10 or from underneath the trailer 10.

Furthermore, the truss beams 362, 364 may be coupled between the skirt walls 356 in substantially diagonal orientations and, more specifically, in opposing diagonal orientations so that the truss beams 362, 364 cross each other at a location between the skirt walls 56. For example, as shown in FIG. 32, the first truss beam 362 may be coupled to the first skirt wall 356 near an upper edge of the first skirt wall 356 and to the second skirt wall 356 near a lower edge of the second skirt wall 356. The second truss beam 364 may be coupled to the first skirt wall 356 near a lower edge thereof and to the second skirt wall 356 near an upper edge thereof. As a result, the truss beams 362, 364 may cross each other at an intersection point 372. In some embodiments, the truss beams 362, 364 may be loaded in compression, then pinned, bolted, bonded, welded, hinged, or otherwise coupled together at the intersection point 372 to provide further structural integrity to the support system. Illustratively, the relatively shallow angle between the crossing truss beams 362, 364 at the intersection point 372, as well as the compression loading, may help the cross-brace 360 withstand additional forces before buckling from a side impact collision.

In other illustrative embodiments, the system 354 may include additional truss beams. For example, as shown in FIG. 33, the system 354 may include a third truss beam 374 positioned between the skirt walls 356 in a substantially horizontal orientation. The third truss beam 374 may be coupled to the skirt walls 356 and/or the first and second truss beams 362, 364 by a suitable coupling method (e.g., via bonding, welding, suitable fasteners such as pins, bolts, hinges, etc.).

In another example, as shown in FIG. 34, the system 354 may include a fourth truss beam 376 positioned between the skirt walls 356 in a substantially vertical orientation. More specifically, the fourth truss beam 376 may be coupled to one or more of the diagonal truss beams 362, 364 at the intersection point 372 and to the horizontal truss beam 374 directly below the intersection point 372, although other coupling locations may be contemplated within the scope of this disclosure.

In yet another illustrative example, as shown in FIG. 35, the system 354 may include a fifth truss beam 378 positioned between the skirt walls 356 in a substantially horizontal position, parallel to the third truss beam 374. Illustratively, the third truss beam 374 may be coupled to the skirt walls 356 at lower edges thereof, while the fifth truss beam 378 may be coupled to the skirt walls 356 at upper edges thereof. Similar to the third truss beam 374, the fifth truss beam 378 may be coupled to the skirt walls 356 and/or the first and second truss beams 362, 364 by any suitable coupling (e.g., via the connectors 366, welding, other suitable fasteners, etc.). Also, the fourth truss beam 376 may extend from the third truss beam 374, past the intersection point 372 of the diagonal truss beams 362, 64, and to the fifth truss beam 378, thus permitting all truss beams 362, 364, 374, 376, 378 to be coupled together between the skirt walls 356.

The above-described cross-braces 360 may include truss members with various cross-sections that offer suitable column compression and buckling strength. Furthermore, the cross-braces 360 may include material that is substantially rigid, but lightweight. For example, the cross-braces 360 may include any suitable material such as, but not limited to, metallic extrusions (such as extruded aluminum), roll formed high-strength aluminum alloy or high-strength steel, fiber reinforced polymeric matrix pultrusions, galvanized steel sheet stampings, or any other suitable material or materials. Generally, any suitable material includes suitable strength and lightweight features, and is conducive to form strong connections via riveting, bolting, bonding or other methods. According to one specific example, the cross-braces 360 may include pre-made, fiber-reinforced, plastic truss beams.

In any of the embodiments of FIGS. 32-34 (or FIGS. 36-37), it is not necessary to include a rail or other rigid structure connecting bottom ends of the first and second diagonal truss beams 362, 364 (for example, as seen with rail member 112 in FIG. 15). Rather, the first and second skirt walls 356 provide stability, structural support, and an interconnection between lower (and upper) ends of the first and second diagonal truss beams 362, 364, respectively. More particularly, for example, if a rigid skirt is utilized (such as DURAPLATE®), the skirt may be rigid enough to provide the necessary structure support. Further, the first and second diagonal truss beams 362, 364 need not be coupled directly to the floor assembly 26 of the trailer. Rather, the diagonal truss beams 362, 264 and/or the truss beams 378 may be coupled to the base rail 28 (or any other suitable component), for example, between the cross members 40 of the floor assembly 26 (and not directly connected to the floor assembly 26). As shown in FIG. 4, for example, the truss beams 378 are not coupled directly to the floor assembly 26 of the trailer.

Other configurations of truss beams in addition to those illustrated and described herein may be contemplated within the scope of this disclosure. Furthermore, while the cross-braces 360 are illustrated and described herein as having separate interconnected truss beams 362, 364, 374, 376, 378, it is within the scope of this disclosure to include unitary cross-braces. For example, in another illustrative embodiment, a system 354 may include alternate cross-braces 380, 384 as shown in FIGS. 36-37. In particular, the cross-braces 380, 384 may include a unitary structure with truss-like bracing or webbing that extends across a width of the trailer 10 between the skirt walls 356 and includes a height about equal to the height of the skirt walls 356 (though other heights may be contemplated). The cross-braces 380, 384 may be coupled to the skirt walls 356 and/or the floor

assembly 26. For example, the cross-braces 380 may include upper and/or lower mounting surfaces 382, wherein each upper mounting surface 382 may be coupled to a cross member 40 of the floor assembly 26 at one or more locations along the length of the cross member 40 (i.e., along a width of the trailer 10). In other embodiments, the cross-braces 380 may be integral with the cross members 40 of the floor assembly 26, I-beams of the floor assembly 26, or any other structure of the trailer and/or the skirt walls 356.

The cross-braces 380, 384 of FIGS. 36 and 37 may include various cross-sections and specific shapes that provide column compression and buckling strength. Furthermore, the cross-braces 360, 380, 384 may include material that is substantially rigid, but lightweight. For example, the cross-braces 360, 380, 384 may include any suitable material such as but not limited to, a metallic formed sheet from e.g., high-strength aluminum alloy, high-strength steel, fiber reinforced polymeric matrix plate, or other suitable material or materials. For example, the cross-braces 380, 384 may also or alternatively include compression molded composite laminates and/or foam cores structures. Generally, any suitable material includes suitable strength and lightweight features, and is conducive to form strong connections via riveting, bolting, bonding or other methods. According to one specific example, the cross-braces 380, 384 may include compression-molded, fiberglass-reinforced plastic.

As shown in FIG. 36, the system 354 may include first, second, and third cross-braces 380 equally spaced apart and each oriented substantially vertically. However, it is contemplated within this disclosure to include more or fewer cross-braces 80 along a length of the trailer 10. Furthermore, as shown in FIG. 37, the system 354 may include vertical cross-braces 380 as well as one or more diagonal cross-braces 384 positioned between adjacent vertical cross-braces 380. Illustratively, a diagonal cross-brace 384 may be coupled to a lower mounting surface 382 of a first vertical cross-brace 380 and to an upper mounting surface 382 of an adjacent vertical cross-brace 380. The diagonal cross-braces 384 may be similar in structure to the vertical cross-braces 380, though may be shorter or longer in order to traverse the interval between adjacent cross-braces 380.

As described above, the cross-braces 360, 380, 384, via the truss beams or truss-like structures, may provide sufficient strength and support between the skirt walls 356 to help reduce the chances of vehicle underride during a side impact collision. Furthermore, due to the interlocking truss beams or truss-like structures, the cross-braces 360, 380, 384 may operate to absorb some of the force and energy of any impact thereto to potentially decrease any forces on the passengers within an automobile that impacts the trailer 10. The cross-braces 360, 380, 384 may also compress, deflect, or collapse slightly under impact (i.e., under lateral forces) to further absorb such forces. In some embodiments, the movable hinged coupling between the skirt walls 356 and the trailer 10 may also help the system 354 absorb energy upon impact.

The cross-braces 360, 380, 384 may be formed with any suitable number of apertures having any suitable shape. In this manner, the weight and material of the cross-braces 360, 380, 384 is reduced, while maintaining sufficient strength to help reduce the chances of vehicle underride during a side impact collision. In other embodiments, one or more of the cross-braces 360, 380, 384 may be made of an uninterrupted material.

To potentially increase such protection across the length of the system 354 and, more specifically, to potentially increase the chances that a passenger vehicle colliding with

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a skirt wall **356** may engage at least one of the cross-braces **360, 380, 384** upon impact, the cross-braces **360, 380, 384** may be sufficiently spaced apart along the length of the trailer **10** at intervals less than an average car width. However, other interval widths (constant or variable) may be contemplated within the scope of this disclosure. Furthermore, it is within the scope of this disclosure for a side underride system **354** to include one or more combinations of different cross-braces **360, 380, 384**.

Referring now to FIGS. **38** and **39**, according to another illustrative embodiment, a side underride system **386** may be retrofit with an existing skirt system **12** on a trailer **10** and include a support system **388** with one or more brackets **390** positioned behind and spaced-apart from the skirt system **12**. It should be noted that the side underride system **386** may alternatively be a completely new system including a side skirt system **12** with a support system **388**.

The skirt system **12** may be the same as that described above with respect to FIGS. **1-3** (or any other suitable skirt system). In particular, the skirt system **12** may be coupled to the floor assembly **26** in a manner that permits the skirt system **12** to tilt laterally inward and outward with respect to the cross members **40** (e.g., with mounting bracket assemblies or a hinge assembly). The skirt system **12** may extend generally between the landing gear **24** and the rear wheel assembly **22** of the trailer **10**, or may extend along a greater or a lesser length of the trailer **10**. For example, the skirt system **12** may extend along the entire, or substantially the entire, length of the trailer **10** (such as from the landing gear **24** to a rear impact guard **118** (FIG. **18** or **24**) positioned at the rear of the trailer **10** and extending downward from the rear wall **18**) or may be modified to extend along only a small portion of the length of the trailer **10**.

The brackets **390** of the support system **388** may be triangular brackets coupled to the floor assembly **26** behind the skirt walls **30** of the skirt system **12**. For example, the brackets **390** may each be coupled to a respective cross member **40** or to the base rail **28** through welding, bolting, fasteners, and/or another suitable coupling. In some embodiments, the brackets **390** may also be coupled to the rear impact guard **118**, the landing gear **24**, and/or other mounting bracket assemblies.

Furthermore, as shown in FIG. **37**, the brackets **390** may be positioned relative to the skirt walls **30** so that a lower edge of each bracket **390** is spaced a distance "X" laterally inward from a vertical end of the skirt wall **30**. This distance X may be sized to provide substantial clearance to allow the skirt wall **30** to tilt laterally inwardly to potentially avoid damage of the skirt wall **30** when the trailer **10** traverses into or over a fixed, immovable obstacle, for example, as described above. While the bracket **390** is illustrated in FIG. **10** as having an angled side surface **394**, it is within the scope of this disclosure to include brackets **390** with substantially straight side surfaces **394** (e.g., parallel to the side walls **14** of the trailer **10**).

The brackets **390** may further provide strength and energy absorption to the system **386** in the event of a side impact collision. In particular, during a side impact collision, the skirt walls **30** may initially flex inwardly and contact the side surfaces **394** of the brackets **390**. However, the brackets **390** may help prevent the skirt walls **30** from bending or folding further laterally inwardly and, thus, reduce the risk of vehicle underride beneath the trailer **10**. The brackets **390** may include steel (such as high strength steel, HSS), composite material (such as molded structure composites, MSC), or any other suitable material.

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To provide sufficient support, the brackets **390** may be spaced apart across the length of the trailer **10** behind the skirt walls **30**. In one example, the brackets **390** may be spaced apart at about four-foot intervals so that, at any impact location, an impacting vehicle may strike a bracket **390**; however, other constant or varying interval lengths may be contemplated within the scope of this disclosure. Furthermore, as shown in FIG. **39**, the support system **388** may include one or more cables **396** that traverse the intervals between adjacent brackets **390**. For example, each bracket **390** may include an aperture **398** positioned near the lower edge thereof (or at any location along the height of the bracket **390**). The cable(s) **396** may be routed through the apertures **398** to form a support system **388** of connected brackets **390** across a length of the trailer **10**.

As shown in FIG. **39**, the cable(s) **396** may terminate at the rear impact guard **118**. For example, the cable(s) **396** may be permanently or removably coupled to the rear impact guard **118** (such as to a bumper, a bumper support member, or any other component of the rear impact guard **118**). Similarly, the cable(s) **396** may terminate at the landing gear **24**. Alternatively, the cable(s) **396** may also be routed across a width of the trailer **10** through the rear impact guard **118**, the landing gear **24**, or other mounting brackets to generally form a continuous cable loop around the trailer **10**.

Illustratively, the cable(s) **396** may be steel cables and may be approximately three-eighths to ½ inch in diameter. Of course, it is within the scope of this disclosure to include any number of cables made from other suitable materials including composite rope, composite fibers, and other suitable high strength, low stretch materials, and having other suitable diameters. Further, the cable(s) **96** may be covered in ballistic nylon or canvas. Any of the cable concepts disclosed herein may also be utilized with the embodiment of FIGS. **38** and **39**.

As described above, a trailer **10** may be provided with a side underride system including a side skirt system with skirt walls and a support system with any number of cross-braces or brackets between the skirt walls. Any one of the support systems may be retrofit with existing skirt systems, may be added with new skirt systems, or may completely replace existing skirt systems. For example, in replacement systems, the support system may support the skirt walls, thus potentially eliminating the need, costs, and weight of additional mounting bracket assemblies for supporting the skirt system. The above-described side underride system may provide dual functions of potentially improving aerodynamic efficiency (i.e., via the skirt system) and providing side underride protection (i.e., via the skirt system and the support system). Such side underride protection may reduce the risk of passenger vehicle underride in the event of a side impact collision, as well as reduce the risk of pedestrians, bicyclists, or motorcyclists from falling or sliding under the trailer **10**, for example, between the landing gear and the rear wheel assembly.

The cables extending past (i.e., laterally adjacent) the rear wheel assembly may inhibit movement of objects into an area around the rear wheel assembly without material coupled to portions of the first and second cables adjacent the rear wheel assembly. This may enable such movement of objects while allowing some access to the rear wheel assembly and lessening interference between skirt or tarp members that might be caused by such members extending past (i.e., laterally adjacent) the rear wheel assembly.

Any of the skirt systems, skirt walls, skirt members, etc. may be made of a sandwich composite including a honey-

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comb core and metal or plastic outer sheets, or the wall panels **32** may be made of a fiber-reinforced plastic composite. Further, such components may be of any number of suitable, non-composite materials such as metals, metal alloys, and/or plastics, for example.

Any of the support systems and/or side underride guards disclosed herein may be utilized alone or in combination with one or more skirt systems, for example, those described with respect to FIGS. **1-3** or any of the other skirt systems disclosed herein or other suitable skirt systems.

Any of the features of any of the embodiments disclosed herein may be combined with any of the other features disclosed herein or incorporated in any of the embodiments disclosed herein.

While the invention has been illustrated and described in detail in the foregoing drawings and description, the same is to be considered as illustrative and not restrictive in character, it being understood that only illustrative embodiments thereof have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected. For example, any of the features or functions of any of the embodiments disclosed herein may be incorporated into any of the other embodiments disclosed herein.

We claim:

1. A side underride system configured to be coupled to a trailer, comprising:

- a first skirt wall coupled to the trailer, positioned below a first side wall of the trailer, and extending along a first length of the trailer between a skirt wall front end and a skirt wall rear end; and
- a cable system including a first cable coupled to the trailer, positioned below the first side wall, and extending along a second length of the trailer between a cable system front end and a cable system rear end, the skirt wall rear end being positioned forward of the cable system rear end.

2. The side underride system of claim **1**, wherein the first length of the skirt wall extends from an area near landing gear of the trailer to an area forward of a rear wheel assembly of the trailer, and the second length of the cable system extends from an area forward of the rear wheel assembly of the trailer to a point rearward of the rear wheel assembly.

3. The side underride guard of claim **1**, wherein the skirt wall further includes a cable separate from the cable system and extending along at least a portion of the skirt wall.

4. The side underride system of claim **1**, wherein the skirt wall includes:

- a planar material extending along at least a portion of the first length; and
- one or more horizontal cables coupled to and extending along at least a portion of the planar material.

5. The side underride system of claim **1**, wherein the skirt wall is formed of a substantially flexible material.

6. The side underride system of claim **1**, wherein the first and second lengths do not overlap.

7. The side underride system of claim **1**, wherein the skirt wall is coupled directly to a cross-member of a floor assembly of the trailer.

8. The side underride guard of claim **4**, further including a mounting bracket coupled to the trailer near a rear end of the skirt wall, wherein both the skirt wall rear end and the cable system front end are coupled to the mounting bracket, and wherein the one or more horizontal cables is routed through an aperture in the mounting bracket.

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9. The side underride guard of claim **1** further including at least one diagonal truss beam coupled to the skirt wall.

10. A side underride system configured to be coupled to a trailer, comprising:

- a skirt assembly including (i) a first skirt wall coupled to the trailer, positioned below a first side wall of the trailer, and extending between a front of the trailer and a location forward of a rear wheel assembly of the trailer, and (ii) a first cable coupled to the first skirt wall; and
- a cable system including a second cable coupled to the trailer, positioned below the first side wall, and extending from a second location forward of the rear wheel assembly of the trailer to a location rearward of the rear assembly.

11. The side underride system of claim **10**, wherein the skirt wall is formed of a flexible material.

12. The side underride system of claim **10**, further including a mounting bracket coupled to the trailer, a rear end of the first cable and a forward end of the second cable being coupled to the mounting bracket.

13. The side underride system of claim **10**, wherein the second cable is removably coupled to the trailer such that the rear wheel assembly of the trailer may be accessed upon removal of the second cable.

14. The side underride system of claim **10**, wherein the first cable has a first longitudinal length along a length of the trailer, the second cable has a second longitudinal length along the length of the trailer, and the first and second longitudinal lengths do not overlap.

15. The side underride guard of claim **10**, wherein a first end of the second cable is coupled to a mounting bracket forward of the rear wheel assembly and a second end of the second cable is coupled to a rear impact guard positioned rearward of the rear wheel assembly such that the second cable extends over the rear wheel assembly.

16. A side underride system configured to be coupled to a trailer, comprising:

- a cable system including
 - (i) a first cable having a first terminal end configured to be coupled to a first side of the trailer forward of a rear wheel assembly of the trailer and a second terminal end configured to be coupled to the trailer rearward of the rear wheel assembly of the trailer and
 - (ii) a second cable having a first terminal end configured to be coupled to a second side of the trailer forward of the rear wheel assembly of the trailer and a second terminal end configured to be coupled to the trailer rearward of the rear wheel assembly of the trailer, the first and second cables extending past the rear wheel assembly inhibiting movement of objects into an area around the rear wheel assembly without material coupled to portions of the first and second cables adjacent the rear wheel assembly.

17. The side underride system of claim **16**, wherein the second ends of the first and second cables are configured to be attached to and terminate at a rear impact guard of the trailer.

18. The side underride system of claim **16**, wherein the first ends of the first and second cables are configured to be attached to and terminate at a mounting bracket coupled to the trailer or an aerodynamic skirt coupled to the trailer.

19. The side underride system of claim **16**, wherein the first and second cables are configured to be selectively attached to and detached from the trailer.

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20. The side underride system of claim **16**, wherein the first and second cables are sized to extend a distance less than half of a length of the trailer to which the first and second cables are attached.

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