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Relocatable base for elevated power rails and method of deployment

Abstract

A modular structure supports elevated rail segments for delivering electrical power to a moving work machine, such as a hauler at a mining site. Opposite ends of a roadside barrier contain complementary tubular couplers arranged vertically, one having a first diameter supported by an arm and the other having a larger second diameter and a vertical slot. Couplers on adjacent barriers can be mated together concentrically along a central axis. The mated couplers help restrict longitudinal displacement, lateral displacement, slope change, and lateral rotation between adjacent barriers during placement. One barrier may be used as a temporary alignment structure to position barriers spaced alternatingly along a haul route for the work machine.

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Background/Summary

TECHNICAL FIELD

(1) The present disclosure relates to a system and method for supporting rails providing electrical power at a position elevated above ground using barriers. More specifically, the present disclosure relates to a modular support structure for power rails including one or more ground barriers having nested couplers configured to hold support posts and to adjust positioning of adjacent barriers in multiple dimensions.

BACKGROUND

(2) Heavy work machines, such as earth-moving vehicles or hauling trucks, require significant power to carry out their functions. The machines themselves can be of substantial weight, and their loads require large amounts of power to move. Diesel engines typically provide that power, but they can have disadvantages. For instance, in some implementations, heavy work machines may need to travel large distances through rugged terrain. At a remote mining site, for example, groups of these machines are often employed to ferry extreme loads along roadways, or haul routes, extending between various locations within the mining site. Supplies of diesel fuel may be far away from such locations or not easily delivered to such locations. In addition, the groups of diesel machines can generate significant pollution.

(3) A power rail based on the ground may provide electrical power to traveling vehicles such as heavy work machines. In some environments, such as with trains or subways that travel on a fixed track, precise alignment between the fixed track and the power rail can ensure reliable delivery of electrical power as the vehicle moves. For a heavy work machine that is freely steerable, however, establishing and maintaining an electrical connection with a power rail can be particularly challenging.

(4) In some environments, such as a mining site, the terrain can interfere with continuous connection with power rails for a freely steerable work machine along a haul route. The haul route may be uneven, hilly, and pocked, which can lead to steering deviations that could cause the machine to disconnect from the rail. Placement of power rails in some environments is temporary and relocatable, and curvatures and slopes within the haul route can lead to unexpected changes in position by the power rails. These variations can cause the machine to disconnect from the rail, detracting from the value of rail-based delivery of electrical power.

(5) One approach for providing electrical power to a work machine while traveling on a roadway is described in International Patent App. Pub. No. WO 2020/186296A1 (“the '296 application”). The '296 application describes an electrical delivery system at a mine site for a moving vehicle where two or more conductors are anchored on the side of relocatable roadside barriers. According to the '296 application, the barriers may be connected by joints that are either compliant in one or more axes or, as shown in the disclosed embodiment, fully rigid for implementation on a relatively even road surface. The delivery system of the '296 application does not contemplate the angular positioning between barriers, such as with curvatures or slopes in the haul route, and the challenges of maintaining contact with the conductors. As a result, the barrier system of the '296 application is not desirable for delivering electrical power to heavy work machines traveling across a haul route that may vary over diverse terrain.

(6) Examples of the present disclosure are directed to overcoming deficiencies of such systems.

SUMMARY

(7) In an aspect of the present disclosure, a rail support module includes a barrier having a first end, a second end, and a base extending longitudinally between the first end and the second end. A first

coupler is affixed to the first end and has an arm joining a first tubular portion to the first end. The first tubular portion extends about a first axis substantially orthogonal to the base and has an inner diameter and an outer diameter. A second coupler is affixed to the second end and has a second tubular portion extending about a second axis substantially orthogonal to the base. The second tubular portion has a first vertical edge and a second vertical edge extending substantially parallel to the second axis. The first vertical edge is separated from the second vertical edge by a gap, and the second tubular portion has an inner diameter greater than the outer diameter of the first tubular portion.

(8) In another aspect of the present disclosure, a support assembly includes a first barrier having a first end extending substantially perpendicular to a first base and a second barrier having a second end, a third end opposite the second end, and a second base. The second end and the third end extend substantially perpendicular to the second base. The support assembly further includes a nested coupling between the first barrier and the second barrier. The nested coupling includes an exterior tubular structure affixed to the first end and extending with a first inner diameter about a vertical axis substantially perpendicular to the first base and a first vertical edge and a second vertical edge running substantially parallel to the vertical axis. The first vertical edge and the second vertical edge define a gap along the exterior tubular structure. The nested coupling also includes an arm affixed to the second end and positioned within the gap, and an interior tubular structure affixed to the arm. The interior tubular structure extends substantially perpendicular to the second base within the first inner diameter of the exterior tubular structure.

(9) In yet another aspect of the present disclosure, a method includes placing a first support of oblong shape on ground surface substantially parallel to a vehicle travel path defined by the ground surface, where the first support has a first longitudinal axis, and arranging an alignment structure of the oblong shape end-to-end with the first support using a first tubular coupling. The first tubular coupling is configured such that the first longitudinal axis is substantially colinear with an alignment axis passing longitudinally through the alignment structure. The method includes positioning a second support of the oblong shape end-to-end with the alignment structure using a second tubular coupling, where the second tubular coupling is configured such that the alignment axis is substantially colinear with a second longitudinal axis of the second support. Further, the alignment structure is moved past the second support with respect to the vehicle travel path and positioned end-to-end with the second support using a third tubular coupling. The third tubular coupling is configured such that the alignment axis is substantially colinear with a third longitudinal axis of the third support.

Description

BRIEF DESCRIPTION OF DRAWINGS

(1) FIG. **1** is an isometric view of an electrically powered work machine coupled to a roadside power source in accordance with an example of the present disclosure.

(2) FIG. **2** is an isometric view of rail support module with power rails in accordance with an example of the present disclosure.

(3) FIG. **3** is an isometric view of an engagement of an open coupler and a closed coupler between barrier assemblies in accordance with an example of the present disclosure.

(4) FIG. **4** is an isometric view of a coupling between adjacent barrier assemblies in accordance with an example of the present disclosure.

(5) FIG. **5** is a top view of the coupling between adjacent barrier assemblies of FIG. **4** in accordance with an example of the present disclosure.

(6) FIG. **6** is a schematic of a deployment layout for barrier assemblies in accordance with an example of the present disclosure.

(7) FIG. **7** is flowchart depicting a method for deploying barrier assemblies in accordance with an example of the present disclosure.
(8) FIG. **8** is a partial front view of a support assembly with rail segments in accordance with an example of the present disclosure.
(9) FIG. **9** is a partial cross-sectional view of a rail segment in FIG. **2** in accordance with an example of the present disclosure.
(10) FIG. **10** is a flowchart of a method of deploying power rails in accordance with an example of the present disclosure.
(11) FIG. **11**A is an exploded view of a single rail joint of two rail segments within a fishplate in accordance with an example of the present disclosure.
(12) FIG. **11**B is a cross-sectional view of the single rail joint of FIG. **11**A within a fishplate in accordance with an example of the present disclosure.
(13) FIG. **12** is an isometric view of a collective rail joint of three rail segments within three fishplates traversing a curvature in accordance with an example of the present disclosure.
(14) FIG. **13** is a flowchart of a method for joining rail segments in accordance with an example of the present disclosure.

DETAILED DESCRIPTION

(15) Wherever possible, the same reference numbers will be used throughout the drawings to refer to same or like parts. Multiple instances of like parts within a figure may be distinguished using a letter suffix. FIG. **1** illustrates an isometric view of a work machine **100** within an XYZ coordinate system as one example suitable for carrying out the principles discussed in the present disclosure. Exemplary work machine **100** travels parallel to the X axis along a roadway, also termed a haul route **101**, typically from a source to a destination within a worksite. In one implementation as illustrated, work machine **100** is a hauling machine that hauls a load within or from a worksite within a mining operation. For instance, work machine **100** may haul excavated ore or other earthen materials from an excavation area along haul route **101** to dump sites and then return to the excavation area. In this arrangement, work machine **100** may be one of many similar machines configured to ferry earthen material in a trolley arrangement. While a large mining truck in this instance, work machine **100** may be any machine that carries a load between different locations within a worksite, examples of which include an articulated truck, an off-highway truck, an on-highway dump truck, a wheel tractor scraper, or any other similar machine. Alternatively, work machine **100** may be an off-highway truck, on-highway truck, a dump truck, an articulated truck, a loader, an excavator, a pipe layer, or a motor grader. In other implementations, work machine **100** need not haul a load and may be any machine associated with various industrial applications including, but not limited to, mining, agriculture, forestry, construction, and other industrial applications.
(16) Referring to FIG. **1**, an example work machine **100** includes a frame **103** powered by electric engine **102** to cause rotation of traction devices **104**. Traction devices **104** are typically four or more wheels with tires, although tracks or other mechanisms for engagement with the ground along haul route **101** are possible. Electric engine **102** functions to provide mechanical energy to work machine **100** based on an external electrical power source, such as described in further detail below. An example of mechanical energy provided by electric engine **102** includes propelling traction devices **104** to cause movement of work machine **100** along haul route **101**, but electric engine **102** also includes components sufficient to power other affiliated operations within work machine **100**. For instance, in some implementations, electric engine **102** includes equipment for converting electrical energy to provide pneumatic or hydraulic actions within work machine **100**. While electric engine **102** is configured to operate from an external electrical power source, electric engine **102** typically includes one or more batteries for storing electrical energy for auxiliary or backup operations.
(17) In accordance with the principles of the present disclosure, work machine **100** further includes

a conductor rod **106** configured to receive electrical power from a power rail **108**. In some examples, power rail **108** is one or more beams of metal arranged substantially parallel to and at a distance above the ground. In FIG. **1**, power rail **108** is positioned to be substantially parallel to the X axis and the direction of travel of work machine **100**. Support mechanisms hold power rail **108** in place along a distance at the side of haul route **101** for work machine **100** to traverse. The support mechanisms and power rail **108** may be modular in construction, enabling their disassembly and reassembly at different locations or their repositioning along the existing haul route **101**. In many examples, such as within a mining site, power rail **108** will not be configured continuously at a fixed distance along a side of haul route **101** and at a fixed height above the ground due, at least in part, to the variation of the terrain. Therefore, it is expected that the vertical, horizontal, and angular positions of the surface of power rail **108** in the XYZ planes will vary along haul route **101**. Moreover, while shown in FIG. **1** to the left of work machine **100** as work machine **100** travels in the direction of the X axis, power rail **108** may be installed to the right of work machine **100** or in other locations suitable to the particular implementation.

(18) Power rail **108** provides a source of electrical power for work machine **100** as either AC or DC. In some examples, power rail **108** has two or more conductors, each providing voltage and current at a different electrical pole. In one implementation (e.g., an implementation in which the power rail **108** includes three conductors), one conductor provides positive DC voltage, a second conductor provides negative DC voltage, and a third conductor provides 0 volts relative to the other two conductors. The two powered conductors within power rail **108** provide +1500 VDC and 1500 VDC. These values are exemplary, and other physical and electrical configurations for power rail **108** are available and within the knowledge of those of ordinary skill in the art.

(19) Conductor rod **106** enables electrical connection between work machine **100** and power rail **108**, including during movement of work machine **100** along haul route **101**. In the example shown in FIG. **1**, conductor rod **106** is an elongated arm resembling a pole. FIG. **1** shows conductor rod **106** positioned along a front side of work machine **100**, with respect to the direction of travel of work machine **100** in the direction of the X axis. In this arrangement, conductor rod **106** is located in FIG. **1** in the Y-Z plane essentially along the Y axis with a first end near a right side of work machine **100** and a second end at a left side of work machine **100**. Conductor rod **106** may be attached to any convenient location within work machine **100**, such as to frame **103**, in a manner to couple conductor rod **106** to power rail **108**. Shown in FIG. **1** as extending to a left side of work machine **100** toward power rail **108**, conductor rod **106** may alternatively be arranged to extend to a right side and at any desired angle from work machine **100** such that conductor rod **106** may be coupled to power rail **108** for obtaining electrical power.

(20) As embodied in FIG. **1**, conductor rod **106** includes a barrel **109** mounted to frame **103** of work machine **100**. Barrel **109** has a hollow interior and may be a conductive metal having suitable mechanical strength and resiliency, such as aluminum. Within barrel **109**, an arm **110** is retained. Arm **110** is slidably engaged within conductor rod **106** such that it may be extended or retracted axially, i.e., along the Y axis in FIG. **1**, to adjust the reach of conductor rod **106**. Specifically, in a retracted position, arm **110** is caused to slide within barrel **109** of conductor rod **106** such that a length of conductor rod **106** roughly spans the width of work machine **100**. A junction **112** serves as the interface between arm **110** and barrel **109**, which is the main body of conductor rod **106**. When arm **110** is fully retracted or collapsed into barrel **109**, junction **112** essentially becomes the left edge of conductor rod **106**. On the other hand, when arm **110** is extended from barrel **109** of conductor rod **106**, arm **110** may reach from work machine **100** to proximate power rail **108** on the side of haul route **101**.

(21) Within, and possibly including barrel **109**, conductor rod **106** includes a series of electrical conductors passing longitudinally, at least from a head **122** at a proximal end to a tip **124** at a distal end. Typically, the conductors within conductor rod **106** are formed of a metallic material and are rigid. In some examples, the conductors are concentric tubes, or hollow cylinders, of solid metal

such as aluminum nested together and sized to provide electrical capacity sufficient for powering work machine **100**. Tubular conductors within arm **110** slidably engage with corresponding tubular conductors within barrel **109** to maintain electrical continuity as arm **110** is extended or retracted.

(22) At a position away from work machine **100** at tip **124**, a connector assembly **114** provides an interface to power rail **108** via trailing arms **116** and contactor **118**. Power rail **108** is typically arranged along a side of haul route **101**, and work machine **100** is steered so that it traverses haul route **101** substantially in parallel with power rail **108**. Thus, in reference to FIG. **1**, power rail **108** and a travel path for work machine **100** are substantially in parallel with each other, and with the X axis. Contactor **118** is configured to maintain an electrical connection with power rail **108** while sliding along its surface in the direction of the X axis as work machine **100** moves. In some examples, trailing arms **116** are conductors coupled to contactor **118**, each conducting voltage and current at a different electrical pole and corresponding to the conductors within conductor rod **106**. In operation, electrical power is accessed from power rail **108** via contactor **118**, which remain in contact during movement of work machine **100**, and the electrical power is conducted through trailing arms **116** into connector assembly **114**.

(23) From connector assembly **114**, the electrical power is conveyed at tip **124** through the nested tubular conductors within arm **110** and barrel **109** to head **122** of conductor rod **106** and through a head-end interface **120** to work machine **100**. Head-end interface **120** provides at least an electrical connection between conductor rod **106** and work machine **100** for powering electric engine **102** and otherwise enabling operations within work machine **100**. In some examples, head-end interface **120** may also provide an interface for inputs to control mechanical operation of conductor rod **106**, such as passageways for pressurized air of a pneumatic control system to extend and retract arm **110** or signaling for electronic controls.

(24) While FIG. **1** illustrates a general arrangement for work machine **100** to access electrical power from power rail **108** while moving, the reliability of a connection between contactor **118** and power rail **108** can be influenced by stable positioning for power rail **108** along the side of haul route **101**. In some examples, power rail **108** is kept at a relatively constant distance from a side of haul route **101** and height above the ground along haul route **101** to minimize risk of disconnection. Moreover, the positioning of power rail **108** along haul route **101** should be generally impervious to external factors such as rain or wind, as changes in positioning can affect the connection between contactor **118** and power rail **108**. FIG. **2** depicts an exemplary arrangement for stably and safely supporting power rail **108** along a side of haul route **101**.

(25) Compared with FIG. **1**, FIG. **2** provides a view of rail support module **200** from the same side of power rail **108**, but at an angle looking slightly in the direction of forward travel for work machine **100** along haul route **101** (i.e., in the direction of the X axis). As generally embodied in FIG. **2**, rail support module **200** is an example of one instance in a series of support assemblies implemented together for securely positioning power rail **108** along a side of haul route **101**. When implemented for an overall transportation route, such as within a mining site, barrier assembly **202** would be one component within a series or chain of structures providing mechanical stability to power rail **108** along a path for conduction of electrical power. FIGS. **3-6**, discussed below, provide detail regarding the use of multiple ones of rail support module **200** in a series along a path for electrical power along haul route **101**.

(26) In general, rail support module **200** for power rail **108** includes a barrier assembly **202**, which includes a barrier **204**, a closed coupler **216**, and open coupler **218**. As illustrated, barrier **204** is a roadside barrier, such as a so-called “Jersey barrier,” commonly used in highway construction. barrier **204**, however, may be any form of moveable, yet stable support structure typically of a substantially oblong shape. In the illustrated example, barrier **204** includes and/or rests on a base **206** at its bottom that extends between a first end **208** and a second end **210**. The oblong or rectangular shape can help barrier **204** stabilize power rail **108** across a longitudinal distance parallel to base **206**. In the illustrated example, barrier **204** is approximately 20 feet in length along

base **206** and two feet in width across base **206** at first end **208** and at second end **210**. These dimensions, as well as others provided in this disclosure, are representative only. Other values are readily usable for achieving similar results.

(27) In one example, barrier **204** is made primarily of concrete with reinforcing steel bars (not shown) set within the concrete to enhance solidity of barrier **204**. In other examples, barrier **204** is a different composition, such as a plastic filled with weighted material, or a different shape. Various compositions and shapes for barrier **204** may be employed without departing from the principles of the present disclosure. In an example of concrete, barrier **204** weighs about 8,000 pounds. With this substantial weight, which helps deter unintended movement after placement, barrier **204** includes base gap **212** for lifting and placement by a forklift or similar machine. In addition, barrier **204** has at least one strap hole **214**, which may be used for feeding a strap or similar implement to assist in lifting and placing barrier **204**. Additionally, the shape of barrier **204** enables use of commercially available barrier clamp tools, which may grip barrier **204** through a scissor action for machine lifting without need for base gap **212** or strap hole **214**. Therefore, barrier **204** is modular, moveable, and relocatable, yet also stable if impacted by most outside forces such as from movement of power rail **108** or haul route **101** or from weather.

(28) Barrier assembly **202** further includes closed coupler **216** attached to first end **208** and open coupler **218** attached to second end **210**. Discussed in detail below with respect to FIGS. **3-5**, closed coupler **216** and open coupler **218** in some examples have generally tubular configurations in which closed coupler **216** has an outer diameter smaller than an inner diameter of the open coupler **218**, and can fit concentrically within open coupler **218**. In addition, as shown in FIG. **2**, the structure for closed coupler **216** and open coupler **218** enable the insertion and retention of support assembly **219** via support posts within the tubular configurations. Described further below, support assembly **219** includes a variety of components such as posts and plates for supporting power rail **108** at an elevated position above ground from barrier assembly **202**. In the illustrated example, support assembly **219** includes first support pole **220**A mounted via first lower portion **238**A and secured within closed coupler **216**, and second support pole **220**B mounted via second lower portion **238**B and secured within open coupler **218**. Specifically, first coupler pin **224**A, second coupler pin **224**B, and third coupler pin **224**C are made of a pultruded fiberglass-reinforced polymer (FRP) and inserted within horizontal holes (see FIG. **3**) to secure first support pole **220**A in place within closed coupler **216** as part of barrier assembly **202**. Other electrically insulative or dielectric materials may alternatively be used. Although not shown in FIG. **2**, similar attachments may exist between second support pole **220**B and open coupler **218**.

(29) First support pole **220**A and second support pole **220**B, as part of support assembly **219** and rail support module **200**, are rods, poles, posts, cylinders, stanchions, or similar structures made of dielectric material and having a length for elevating and supporting power rail **108** above ground. In some examples, first support pole **220**A and second support pole **220**B are pipes made of a pultruded FRP, or similar dielectric or electrically insulative materials, having lengths sufficient to stabilize power rail **108** about eight feet off the ground. Person **222** in FIG. **2** depicts a relative height of power rail **108** enabled by first support pole **220**A and second support pole **220**B. By elevating power rail **108** above the typical reach of person **222**, first support pole **220**A and second support pole **220**B help improve safety for the delivery of electrical power for work machine **100**. Although power rail **108** may be electrically isolated in a manner to avoid risks of electrocution, the height of power rail **108** also precludes individuals such as person **222** from easily touching power rail **108** while grounded. In addition, the elevated position minimizes the risk of contamination by ground debris or contact from animals or unauthorized individuals on the ground.

(30) At first upper portion **236**A of first support pole **220**A, a first front plate **226**A and a first rear plate **228**A within support assembly **219** provide a bracketing structure for holding power rail **108** in place at a position vertically above first end **208**. A second front plate **226**B and a second rear plate **228**B provide a similar structure and function for power rail **108** at second upper portion

236B of second support pole **220**B vertically above second end **210**. In one example, first front plate **226**A, first rear plate **228**A, second front plate **226**B, and second rear plate **228**B are made of pultruded FRP and may be secured respectively to first support pole **220**A and second support pole **220**B using additional lock pins, such as first plate pin **230**A and second plate pin **230**B shown in FIG. **2**. Additionally, as first front plate **226**A and first rear plate **228**A face each other on opposite sides of first support pole **220**A, in some examples, first lateral pin **232**A and second lateral pin **232**B pass between first front plate **226**A and first rear plate **228**A to provide lateral stability and lock the two plates parallel to each other. First lateral pin **232**A and second lateral pin **232**B pass through fiberglass **233** that can provide a separation or buffer between first front plate **226**A and first rear plate **228**A. Alternative securing mechanisms are within the principles of the present disclosure and known to those of ordinary skill in the field. The bracketing structure, such as formed by first front plate **226**A and first rear plate **228**A, is discussed in more detail below with respect to FIGS. **7** and **8**.

(31) These various components of support assembly **219** function together to hold power rail **108** from below in a position longitudinally along a path between first support pole **220**A and second support pole **220**B formed by base **206** of barrier **204**. In some examples, such as in a mining site, power rail **108** can extend along haul route **101** for miles. Accordingly, in the example of FIG. **2**, power rail **108** is divided into a series of segments associated with a barrier, such as inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C. Although three rail segments are shown and discussed, fewer or more rails are possible. In the example illustrated, inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C are each 41 feet long. Therefore, with an exemplary barrier **204** having a length of 20 feet, about 25% of each of inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C extends beyond first support pole **220**A and second support pole **220**B. These dimensions and ratios are representative only and other lengths are possible for different implementations in achieving similar results. The combination of rail support module **200**, inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C forms a modular unit that can be replicated along haul route **101** to form a collective support structure and continuous path for electrical power. In one example, multiple rail segments such as inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C are connected end-to-end to form power rail **108** in a manner discussed below in the context of FIGS. **9** and **10**.

(32) Combining multiple ones of rail support module **200** in a chain along haul route **101** can be accomplished in many ways. In one example, different ones of barrier **204** can be positioned end-to-end, i.e., longitudinally in a line, and loosely connected via couplers at the ends of the barriers. FIG. **3** illustrates an example of an association between two representative couplers, designated as closed coupler **216-0** and open coupler **218-1**. In FIG. **3** and other drawings, the suffix “-n” designates an association of a part with a barrier or support assembly represented by the suffix. Closed coupler **216-0** refers to a closed coupler **216** associated with a barrier “−0,” while closed coupler **216-1** refers to a closed coupler **216** associated with a different barrier “−1.” As discussed in more detail below with respect to FIG. **6**, in some examples, the barrier having suffix “−0” can be a barrier or similar alignment structure used for deploying other barriers **204** in the system but not necessarily used as part of the installed structure supporting power rail **108** along haul route **101**.

(33) Positioning multiple barriers in a chain can entail, for example, linking multiple ones of barrier assembly **202** together along haul route **101**. FIG. **3** depicts an engagement **300** of two couplers, closed coupler **216-0** and open coupler **218-1**, from associated barriers positioned end-to-end. Closed coupler **216-0** and open coupler **218-1** are depicted without their corresponding barriers, barrier **204-0** and barrier **204-1**, to which they are attached during deployment. As illustrated in FIG. **3**, open coupler **218-1** would reside on a left side of barrier **204-1** (not shown), and closed coupler **216-0** would reside on a right side of barrier **204-0** (not shown).

(34) Open coupler **218-1** generally has a shape of a tube or a hollow cylinder formed about an axis A-A that runs parallel in FIG. **3** to the Z-axis and orthogonal to base **206**. Open coupler **218-1** may be made of any structurally resilient material, such as steel or other metals. On one side, the tubular shape of open coupler **218-1** is attached to a first end plate **302-1**. First end plate **302-1** in some examples is a metal, such as steel, and abuts first end **208-1** (not shown) on barrier **204-1** opposite to open coupler **218-1**. First end plate **302-1** is integrally formed with one or more reinforcement bars that pass within the body of barrier **204-1**, namely, first reinforcement **304-1**, second reinforcement **306-1**, and third reinforcement **308-1**, and provide structural support for open coupler **218-1**. Open coupler **218-1** also includes top hole **310-1** and bottom hole **312-1** positioned vertically along the A-A axis in one implementation. Similarly, alignment hole **314-1** is positioned vertically along the A-A axis and may have an oval or oblong shape for reasons discussed below. Moreover, while open coupler **218-1** is substantially tubular in shape, in some examples, the tube includes a central slot **316-1** that runs vertically in parallel to the axis A-A giving it an open configuration. In this context, "substantially" means that the shape of open coupler **218-1** generally approximates a hollow cylinder, although it may have a cross section that is out of round, such as being an oval, or have various indentations. Central slot **316-1** can be viewed as a gap between parallel edges of open coupler **218-1** (FIG. **5**) or as an open seam within the tubular form of open coupler **218-1**.
(35) Corresponding to open coupler **218-1**, closed coupler **216-0** also has a shape of a tube or a hollow cylinder formed about axis A-A in the illustrated example. On one side, the tubular shape of closed coupler **216-0** is attached to an arm **318-0**, which in turn is attached at substantially a right angle with a second end plate **320-0**. Second end plate **320-0** abuts second end **210-0** (not shown) on barrier **204-0** opposite to arm **318-0**. Second end plate **320-0** is integrally formed with one or more reinforcement bars that pass within the body of barrier **204-0**, namely, first reinforcement **322-0**, second reinforcement **324-0**, and third reinforcement **326-0**, and provide structural support for closed coupler **216-0**. Closed coupler **216-0**, arm **318-0**, second end plate **320-0**, first reinforcement **322-0**, second reinforcement **324-0**, and third reinforcement **326-0** may be made of any structurally resilient materials, such as steel or other metals. Closed coupler **216-0** also includes top hole **328-0** and bottom hole **330-0** positioned vertically along the A-A axis in one implementation. Similarly, alignment hole **332-0** is positioned vertically along the A-A axis.
(36) As indicated by top hole **328** in FIG. **3**, closed coupler **216-0** as part of barrier assembly **202-0** may be moved vertically along axis A-A into engagement with open coupler **218-1**. Although not shown in FIG. **3**, in some examples, barrier **204-1** associated with open coupler **218-1** is resting on the ground, and barrier **204-0** associated with closed coupler **216-0** is lowered from a raised position using a forklift or similar equipment. Dimensions for open coupler **218-1**, central slot **316-1**, closed coupler **216-0**, and arm **318-0** can determine at least the mating relationship for engagement. In the illustrated example, an outer diameter **410** (FIG. **4**) of closed coupler **216-0** is smaller than an inner diameter **412** (FIG. **4**) of open coupler **218-1**, such that closed coupler **216-0** can be lowered vertically along axis A-A into open coupler **218-1**. Moreover, central slot **316-1** has a width between vertical edges of open coupler **218-1**, and arm **318-0** is dimensioned with a thickness less than the width of central slot **316-1**. As a result, as barrier **204-0** is lowered, arm **318-0** may pass freely through central slot **316-1** and closed coupler **216-0** may pass freely into open coupler **218-1**. While engagement **300** in FIG. **3** depicts a lowering of closed coupler **216-0**, movement of open coupler **218-1** relative to closed coupler **216-0** could alternatively occur, such as a lowering of open coupler **218-1** over open coupler **218-0**. Accordingly, closed coupler **216-0** and open coupler **218-1** form complementary connector halves that mate in a loose configuration and help in positioning two barriers, such as barrier **204-0** and barrier **204-1**, in an end-to-end relationship.
(37) While FIG. **3** depicts engagement **300** for closed coupler **216-0** and open coupler **218-1** based on their illustrated shapes as tubes having different diameters, closed coupler **216-0** and open

coupler **218-1** can also help guard against undesired angular positions of barrier **204-0** with respect to barrier **204-1**. In general, sharp deviations in the positioning of power rail **108** can lead to a disconnection of contactor **118** if maneuverability or steering of work machine **100** becomes difficult, and alignment of conductor rod **106** and trailing arms **116** with power rail **108** may erode. Moreover, excess curvature to power rail **108** can impact the installation and life of the rails or require that rail segments have specialized shapes or dimensions. For example, bends in haul route **101** that are sharp, which may correspond to a radius of curvature of about 10 degrees per 20 feet or more, or slopes in haul route **101** that are steep, which may correspond to a slope change of about 3.5 degrees per 20 feet or more, could increase the risk of disconnection between contactor **118** and power rail **108** or otherwise impact the use of power rail **108**. FIGS. **4** and **5** illustrate how closed coupler **216-0** and open coupler **218-1** can avoid extreme bends or slopes for power rail **108**, in some examples, by restricting the angular position of adjacent barriers.

(38) FIG. **4** shows a barrier connection **400** with a completed coupling between closed coupler **216-0** of barrier **204-0** and open coupler **218-1** of barrier **204-1**. As illustrated, an outer diameter **410** of closed coupler **216-0** fits within an inner diameter **412** of open coupler **218-1** such that open coupler **218-1** and closed coupler **216-0** are arranged concentrically about axis A-A. In this position, a barrier separation **402** between barrier **204-0** and barrier **204-1** is established longitudinally, i.e., along the X axis in FIG. **4**, which is driven by the size and shape of closed coupler **216-0** and open coupler **218-1**. In particular, barrier separation **402** will be defined by a distance between first end **208-0** and a center of closed coupler **216-0** along axis A-A plus a distance between second end **210-1** and a center of open coupler **218-1** along the axis A-A. The size of an annular gap **404** between closed coupler **216-0** and open coupler **218-1** provides a tolerance for barrier separation **402** in the event closed coupler **216-0** and open coupler **218-1** are not aligned exactly about the same centerline, as in axis A-A. Annular gap **404** also defines a permitted deviation laterally between barrier **204-0** and barrier **204-1**, i.e., along the Y axis in FIG. **4**. As a result, in one example, barrier connection **400** using closed coupler **216-0** and open coupler **218-1** provides for precise longitudinal and lateral positioning of barrier **204-0** with respect to barrier **204-1** within a tolerance built into the geometry of the coupling.

(39) Barrier connection **400** additionally ensures that barrier **204-0** and barrier **204-1** are not positioned on a surface with too large of a slope change, such as exceeding 3.5 degrees per 20 feet. Slope change in the context of FIG. **4** refers to, for example, rotation or tilt of barrier connection **400** about the Y axis in the X-Z plane, such as if barrier **204-0** were uphill or downhill from barrier **204-1**. In one example, barrier **204-0** could rest on a slope such that barrier **204-0** essentially pivots around an axis B-B with respect to barrier **204-1**, shown in FIG. **4** as being parallel to the Y axis. Barrier **204-0** could rest on a downhill slope relative to base **206-1**, such as shown by downslope angle **406**, or on an uphill slope, such as shown by upslope angle **408**. If barrier **204-0** rests on a downslope, for instance, base **206-0** will be positioned around axis B-B at downslope angle **406**. In that situation, closed coupler **216-0** will likewise be rotated or tilted at an angle similarly as downslope angle **406** with respect to open coupler **218-1**. At a predetermined amount of slope change, closed coupler **216-0** will have rotated sufficiently through annular gap **404** to contact open coupler **218-1** at an upper portion of both tubes. The contact between the tubes will provide an outer limit to the amount of slope change for barrier **204-0** permitted by the coupling. In one example, the size of annular gap **404** and a height for closed coupler **216-0** and open coupler **218-1** are determined such that downslope angle **406** is about 3.5 degrees. This dimensioning of closed coupler **216-0** and open coupler **218-1** may vary based on the configuration chosen for the couplers and is within the knowledge of those of ordinary skill in the art. Similar behavior and dimensioning will apply to a rotation or tilt for barrier **204-0** on an uphill slope across upslope angle **408**. Also, it will be understood that, for the same reasons, the concentric tubes of closed coupler **216-0** and open coupler **218-1** and annular gap **404** also provide a limit to excessive slope changes for barrier **204-1** relative to barrier **204-0** that may occur about axis C-C in FIG. **4**.

(40) In addition to assisting with longitudinal displacement, lateral displacement, and slope change, barrier connection **400** can also ensure that barrier **204-0** and barrier **204-1** are not arranged with too large of a lateral rotation about axis A-A, which may lead to undue stress on power rail **108**. This angle of lateral rotation can translate into a curvature for power rail **108**, which in the context of FIG. **4** refers to, for example, rotation about the Z axis in the X-Y plane. FIG. **5** shows a top view of barrier connection **400** and indicates the positional restrictions provided by closed coupler **216-0** and open coupler **218-1** in the X-Y plane.

(41) Referring to FIG. **5**, while having a general tubular shape overall, open coupler **218-1** at a top view as in FIG. **5** also has a C-shape as its circumference spans from first vertical edge **502-1** to second vertical edge **504-1**. Central slot **316-1** is defined by a first vertical edge **502-1** and a second vertical edge **504-1** and runs vertically and parallel to axis A-A. In the X-Y plane, central slot **316-1** spans the distance between first vertical edge **502-1** and second vertical edge **504-1** and defines a space for accommodating lateral rotation of barrier **204-1** relative to barrier **204-0**, or vice versa. When barrier **204-0** and barrier **204-1** are aligned, such as along axis D-D in FIG. **5**, central slot **316-1** is bisected by arm **318-0** of barrier **204-0**. If barrier **204-1**, for example, is displaced upwards with respect to barrier **204-0** in the X-Y plane in FIG. **5** around axis A-A, open coupler **218-1** will be displaced about axis A-A as well. The portion of central slot **316-1** between first vertical edge **502-1** and arm **318-0** permits angular placement about axis A-A up to a first curvature angle **506**. At first curvature angle **506**, first vertical edge **502-1** will contact arm **318-0** and prevent further lateral rotation of barrier **204-1** relative to barrier **204-0**. Similarly, barrier **204-1** may be displaced downwards in FIG. **5** around axis A-A with respect to barrier **204-0** to a position where second vertical edge **504-1** contacts arm **318-0**, corresponding to a second curvature angle **508**. In one example, closed coupler **216-0** and open coupler **218-1** are dimensioned so that first curvature angle **506** and second curvature angle **508** are both about 3.5 degrees for the 20 feet of barrier **204-1**. Similar behavior and dimensioning will apply to a lateral rotation for barrier **204-1** with respect to barrier **204-0**, as arm **318-0** is displaced into contact with either first vertical edge **502-1** or second vertical edge **504-1** and blocking lateral rotation beyond first curvature angle **506** or second curvature angle **508**.

(42) Referring again to FIG. **4**, in some examples, alignment hole **314-1** within open coupler **218-1** provides an additional feature to assist with alignment of barrier **204-0** with respect to barrier **204-1**. In some examples, alignment hole **314-1** is oblong in shape, such as an elongated circle or an oval. When closed coupler **216-0** is mated with open coupler **218-0**, such as in engagement **300**, and barrier **204-0** and barrier **204-1** are laterally and longitudinally aligned on a level surface, alignment hole **314-1** and alignment hole **332-0** will share a common central axis (not shown). A bolt or plug (not shown) can be inserted through alignment hole **314-1** and alignment hole **332-0** through the common central axis to confirm the alignment. As barrier **204-0** or barrier **204-1** deviate from alignment—whether through longitudinal displacement, lateral displacement, slope change, or lateral rotation—the alignment between alignment hole **314-1** and alignment hole **332-0** will decrease. At a point in which the positional deviation of barrier **204-0** and barrier **204-1** with respect to each other are beyond a designed value, alignment hole **314-1** and alignment hole **332-0** will lose their alignment to the point a bolt or plug cannot be inserted through them. This feature, which may loosely be equated with a keyed relationship between alignment hole **314-1** and alignment hole **332-0**, provides an additional guide for an operator to ensure that barrier **204-0** and barrier **204-1** are properly arranged before mounting additional equipment such as support assembly **219** or power rail **108**.

(43) Accordingly, as illustrated in FIGS. **2-5**, adjacent barriers may be loosely joined through closed coupler **216** and open coupler **218** to set their positioning and adjust as needed their longitudinal displacement, lateral displacement, slope change, and lateral rotation. Following engagement **300**, sequential engagements of other barriers may be accomplished end-to-end along a path intended for power rail **108**. Support posts, such as first support pole **220**A and second

support pole **220**B in FIG. **2**, may be inserted along axis A-A for each coupling. A consistent and stable support structure for power rail **108** can thereby be installed.
(44) FIG. **6** illustrates an exemplary scheme for deploying a support structure using rail support module **200** that reduces the number of barriers employed. As embodied in FIG. **6**, a deployment layout **600** indicates that a line of end-to-end barrier assemblies, coupled in a chain via a closed coupler **216** and an open coupler **218**, could each occupy a select position along haul route **101**. For example, a beginning of the chain may be defined as first location **602**, followed by second location **604**, third location **606**, fourth location **608**, and fifth location **610** moving from the right to the left in FIG. **6**. A method for deploying barrier assemblies within deployment layout **600** is defined by representative steps consistent with the present disclosure in the flowchart of FIG. **7**. For the method of FIG. **7**, as well as other methods described in this disclosure, the steps in which the method is described are not intended to be construed as a limitation. Any number of steps can be combined in any order to implement the disclosed method, can be performed in parallel to implement the processes, and in some embodiments, one or more blocks of the process can be omitted entirely. Moreover, the processes can be combined in whole or in part with other methods.
(45) Referring to FIGS. **6** and **7** together, the method **700** in FIG. **7** begins with a first step **702** of placing a first barrier at a first location. As shown in FIG. **6**, placement of a first barrier may entail situating barrier **204-1** on the ground at first location **602** using a forklift, crane, or similar equipment. barrier **204-1** includes closed coupler **216-1** and open coupler **218-1** at opposing first end **208-1** and second end **210-1** of barrier **204-1**. At a second step **704** in method **700**, an alignment structure is arranged end-to-end with the first barrier in single-file formation using a first tubular coupling between the first barrier and the alignment structure. Specifically, barrier **204-0** may have an identical structure and composition as barrier **204-1** and be placed at second location **604** immediately next to barrier **204-1** at first location **602**. Alternatively, barrier **204-0** may have a different composition than barrier **204-1**, such as being lighter and more easily moved than barrier **204-1**. As with barrier **204-1**, barrier **204-0** includes closed coupler **216-0** and open coupler **218-0** at its opposing first end **208-0** and second end **210-0** (FIG. **2**). Following the teachings of FIGS. **3-5**, closed coupler **216-0** on barrier assembly **202-0** may be lowered vertically into engagement with open coupler **218-1** on barrier assembly **202-1** at second location **604**, forming a coupling of concentric tubes. At this point, the alignment of barrier assembly **202-0** with respect to barrier assembly **202-1** may be checked based on the arrangement of closed coupler **216-0** within open coupler **218-1** as well as the keyed relationship of alignment hole **314-1** and alignment hole **332-0**. Adjustments may be made to the ground or the deployment location in general if the coupling does not indicate an appropriate alignment between barrier assembly **202-0** and barrier assembly **202-1**.
(46) Continuing with method **700**, a step **706** includes positioning a second barrier end-to-end with the alignment structure in the single-file formation using a second tubular coupling between the second barrier and the alignment structure. Following this step, a chain of at least three barriers would be formed including a sequence of barrier **204-1**, barrier **204-0**, and then barrier **204-2**. Barrier **204-0** may be lowered to the left of barrier **204-0** into third location **606** with closed coupler **216-2** engaging with open coupler **218-0**. The coupling formed by the tubular forms within closed coupler **216-2** and open coupler **218-0** may be checked along with alignment hole **314-0** and alignment hole **332-2** to ensure that barrier **204-0** and barrier **204-2** are appropriately aligned with respect to longitudinal displacement, lateral displacement, slope change, and lateral rotation, as discussed above.
(47) In step **708** of method **700**, the alignment structure is moved past the second barrier in the single-file formation and positioned end-to-end with the second barrier. FIG. **6** illustrates with relocation arrow **612** movement of barrier assembly **202-0** from second location **604** to fourth location **608**, leapfrogging over barrier **204-2** at third location **606**. Phantom lines at second location **604** indicate the previous placement of barrier assembly **202-0** at second location **604**. Barrier assembly **202-0** may be moved using a forklift, crane, or similar equipment. Or if barrier

assembly **202-0** is embodied as a lighter structure, movement of barrier assembly **202-0** may be accomplished with lifting force not requiring a powered machine. As the position of barrier **204-1** has been confirmed as acceptable, barrier **204-1** is left in place at first location **602**. Barrier assembly **202-0** in FIG. **6** is lowered to the left barrier **204-2** so that closed coupler **216-0** aligns vertically with open coupler **218-2** to form concentric tubes. As previously discussed for other barrier assemblies, the positioning of barrier **204-2** can be checked relative to barrier **204-0** and, therefore, the ground conditions at third location **606** and fourth location **608** can be confirmed as acceptable for the support structure of power rail **108**.

(48) In step **712** of FIG. **7**, a third barrier is arranged end-to-end with the alignment structure using a fourth tubular coupling. In particular, barrier **204-3** is added, typically using heavy lifting equipment, into fifth location **610** to be longitudinally adjacent barrier assembly **202-0** at fourth location **608**, as shown in FIG. **6**. The fourth tubular coupling in some examples includes the vertical mating of closed coupler **216-3** with open coupler **218-0**. Checking of the alignment through the coupling, such as via alignment hole **314-3**, can indicate whether the positioning of closed coupler **216-3** and barrier assembly **202-0** are acceptable with respect to each other.

(49) The sequence of FIG. **7** may be continued indefinitely along haul route **101**. As a result, method **700** enables positioning of multiple ones of barrier assembly **202** on a path for constant and stable support of power rail **108**. Excesses in at least longitudinal displacement, lateral displacement, slope change, and lateral rotation can be avoided using closed coupler **216** and open coupler **218**. Moreover, using barrier assembly **202-0** as an alignment structure in the manner of FIGS. **6** and **7**, where barrier assembly **202-0** is repeatedly placed between two other barrier assemblies **202** for an alignment check and then moved as with relocation arrow **612**, a support structure for power rail **108** can be built using up to half of the barrier assemblies **202** employed for a continuous wall. The support structure resulting from FIGS. **6** and **7** would in essence be an alternating sequence of barrier assemblies **202** and empty spaces. For example, in a final assembly from FIG. **6**, rail support module **200** would occupy first location **602**, third location **606**, and fifth location **610**, while second location **604** and fourth location **608** would be empty. As will be appreciated, because rail segments **240** in the example of rail support module **200** extend beyond first support pole **220**A and second support pole **220**B by about 25%, ends of the rail segments **240** from one rail support module **200**, such as a rail segment **234-1** of rail support module **200-1** at first location **602**, can be joined with ends of the rail segments **240** in the next rail support module **200**, such as a rail segment **234-2** of rail support module **200-2** at third location **606**. FIGS. **11** and **12** and the discussion about them below explain examples for joining ends of rail segments **240** for this support structure.

(50) Following or during deployment of barrier assembly **202**, first support pole **220**A and second support pole **220**B may be installed within closed coupler **216** and open coupler **218** at opposite ends first end **208** and second end **210** of barrier **204**. In some examples, an inner diameter **412** of closed coupler **216** and an inner diameter of open coupler **218** (FIGS. **3** and **4**) each are sufficient to receive and retain first lower portion **238**A of first support pole **220**A and second lower portion **238**B of second support pole **220**B, respectively. Once installed vertically along axes A-A in closed coupler **216** and open coupler **218**, first support pole **220**A and second support pole **220**B are secured in place using plugs or bolts, such as one or more of first coupler pin **224**A, second coupler pin **224**B, and third coupler pin **224**C.

(51) First upper portion **236**A of first support pole **220**A, for example, distal from barrier **204** includes a mounting structure formed by first front plate **226**A and first rear plate **228**A (FIG. **2**) for holding rail segments **240** safely in place. FIG. **8** is a front view of first support pole **220**A and first front plate **226**A from the perspective looking in the direction of forward travel for work machine **100**, i.e., parallel to the X axis. In some examples, first front plate **226**A is a flat structure made of pultruded FRP, as mentioned above, although other dielectric materials may be alternatives. First front plate **226**A is attached to first support pole **220**A by way of first plate pin **230**A and second

plate pin **230**B. As first support pole **220**A may have a round cross-section and a curved surface, first lateral pin **232**A and second lateral pin **232**B connect first front plate **226**A to first rear plate **228**A (FIG. **2**) and provide lateral stability for first front plate **226**A and second front plate **226**B.

(52) In the example illustrated, first front plate **226**A has a triangular shape residing in the Y-Z plane of FIG. **8**. Parallel to the Y axis and ultimately to base **206** of barrier **204** and ground, top edge **802** forms one side of the triangular shape for first front plate **226**A as a horizontal surface that provides direct support for rail segments **240**. In some examples, top edge **802** includes a series of cuts or openings along its surface. In particular, top edge **802** includes one or more slots for holding rail segments **240**, such as inner rail recess **804**, middle rail recess **806**, and outer rail recess **808** in the example of FIG. **8**. Besides providing a structural base for **234**, the one or more slots are separated sufficiently across top edge **802** to exceed relevant rail-to-rail clearance criteria. In one example, a center-to-center distance between adjacent slots, such as between inner rail recess **804** and middle rail recess **806**, is 200 mm.

(53) FIG. **9** illustrates the structure of example rail segments **240** held within inner rail recess **804**, middle rail recess **806**, and outer rail recess **808** of first front plate **226**A. A representative portion **900** of inner rail segment **234**A has a rail body **902** in the form of a modified I-beam made of aluminum. A rail web **904** in the center of representative portion **900** separates a lower flange **906** from an upper flange **908**, forming a first rail groove **918** and a second rail groove **920** on opposite sides of rail web **904**. A rail bottom **910** is at an underside of rail body **902**. An upper plate **912**, which is stainless steel, is curved into an upside-down U-shape and positioned on lateral sides of upper flange **908**. Crimping, as reflected by crimp pocks **916** in FIG. **9**, can secure upper plate **912** within slots **914**.

(54) Turning back to FIG. **8**, inner rail recess **804** is configured to receive at least lower flange **906** of inner rail segment **234**A and allow rail bottom **910** of inner rail segment **234**A to rest on top edge **802**. In some examples, as shown in FIG. **7**, rail web **904** also rests within inner rail recess **804**, although rail web **904** may also extend above top edge **802**, for instance due to a shallowness of inner rail recess **804** or a height of inner rail segment **234**A. In this configuration, the exposure of upper plate **912** vertically above top edge **802** enables unobstructed engagement by contactor **118** with inner rail segment **234**A without excess maneuvering by conductor rod **106** on work machine **100**. To help stabilize inner rail segment **234**A within inner rail recess **804**, a first inner insert **810**A and a second middle insert **812**B are pressed into grooves in the sides of inner rail recess **804** to frictionally lock inner rail segment **234**A in place. First inner insert **810**A and second middle insert **812**B are made of dielectric material, such as FRP. While depicted in FIG. **8** as angles, first inner insert **810**A and second middle insert **812**B may have other shapes or forms. In some examples, the frictional locking of inner rail segment **234**A provides some pliability to the attachment of rail segments **240** to first front plate **226**A to accommodate small movements that may occur with either inner rail segment **234**A or first front plate **226**A. Similar arrangements exist in FIG. **8** for other ones of rail segments **240** that may be implemented in rail support module **200**, such as first middle insert **810**B and second middle insert **812**B for middle rail segment **234**B within middle rail recess **806** and first outer insert **810**C and second outer insert **812**C for outer rail segment **234**C within outer rail recess **808**. Also, while not depicted in FIG. **8**, a matching configuration is provided for first rear plate **228**A on the opposite side of first support pole **220**A (FIG. **2**).

(55) Between respective recesses, first front plate **226**A includes curvatures within top edge **802**. As shown in FIG. **8**, first concavity **814** is located on top edge **802** between inner rail recess **804** and middle rail recess **806**, and second concavity **816** is located between middle rail recess **806** and outer rail recess **808**. By being curved, first concavity **814** and second concavity **816** provide increased distance through first front plate **226**A between adjacent rail segments. The depth, curvature, and overall shape of first concavity **814** and second concavity **816** may be selected by the skilled artisan to accomplish the objectives of increasing creepage beyond criteria while maintaining mechanical resiliency to first front plate **226**A. While not shown, similar concavities

exist within opposing first rear plate **228**A between inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C.

(56) A method **1000** for deploying power rails for a work machine is defined by representative steps consistent with the present disclosure in the flowchart of FIG. **10**. For method **1000**, as well as other methods described in this disclosure, the steps in which the method is described are not intended to be construed as a limitation. Any number of steps can be combined in any order to implement the disclosed method, can be performed in parallel to implement the processes, and in some embodiments, one or more blocks of the process can be omitted entirely. Moreover, the processes such as **1000** can be combined in whole or in part with other methods. In a first step **1002**, a moveable support structure is placed on the ground. For instance, as described above, a barrier **204** may be located along a side of a haul route **101** using a forklift, crane, or other lifting equipment. barrier **204** may include closed coupler **216** and open coupler **218** at opposite ends that are separated along a horizontal axis by a base **206**. At a step **1004**, a lower portion of a first dielectric stanchion is inserted into a first holder affixed to the support structure, where the first dielectric stanchion has an upper portion supporting first parallel dielectric plates on opposite sides of the first dielectric stanchion. In one example, a first upper portion **236**A of a first support pole **220**A is inserted into closed coupler **216** that is affixed to first end **208** on barrier **204**. first front plate **226**A and first rear plate **228**A are attached in parallel on opposite sides of first support pole **220**A using first plate pin **230**A and second plate pin **230**B, as well as first lateral pin **232**A and second lateral pin **232**B.

(57) In FIG. **10**, method **1000** continues with step **1006** of inserting a lower portion of a second dielectric stanchion into a second holder affixed to the support structure, the second dielectric stanchion having an upper portion supporting second parallel dielectric plates on opposite sides of the second dielectric stanchion. In some examples, a second upper portion **236**B of a second support pole **220**B is inserted into open coupler **218** that is affixed to second end **210** on barrier **204**. second front plate **226**B and second rear plate **228**B are attached in parallel on opposite sides of second support pole **220**B, as shown in FIG. **2**. In step **1008**, a first pair of rail recesses on the first parallel dielectric plates and a second pair of rail recesses on the second parallel dielectric plates are aligned according to the lower portion of the first dielectric stanchion in the first holder and the lower portion of the second dielectric stanchion in the second holder. As indicated for FIG. **8**, first front plate **226**A includes inner rail recess **804**, middle rail recess **806**, and outer rail recess **808**, as do first rear plate **228**A, second front plate **226**B, and second rear plate **228**B.

(58) Alignment of the four sets of inner rail recess **804**, four sets of middle rail recess **806**, and four sets of outer rail recess **808** within support assembly **219** can occur in various means. In one approach, the openings within the recesses may be visually or optically aligned during installation of barrier **204**. In another approach, the alignment of the recesses may be preconfigured into the position of the attachment devices securing the stanchions to the coupling devices as a keyed relationship. For example, top hole **328** and bottom hole **330** on closed coupler **216** and top hole **310** and bottom hole **312** on open coupler **218** may be coordinated in advance with the positions of corresponding holes in first support pole **220**A and second support pole **220**B so that the holes align when the rail recesses at first upper portion **236**A of first support pole **220**A and second upper portion **236**B of second support pole **220**B align. Therefore, attaching first support pole **220**A using first coupler pin **224**A and third coupler pin **224**C and attaching second support pole **220**B using first coupler pin **224**A and third coupler pin **224**C can indicate alignment of the rail recesses. As a result, method **1000** concludes with securing the lower portion of the first dielectric stanchion to the first holder (step **1010**) and securing the lower portion of the second dielectric stanchion to the second holder (step **1012**).

(59) Accordingly, consistent with the principles of the present disclosure, after being situated as desired on the ground, barrier **204** may be enhanced with support assembly **219** to provide a foundation for positioning and holding power rail **108**. first support pole **220**A and second support

pole **220**B enable power rail **108** to be elevated from the ground outside the normal reach of a person **222** to enhance safety for personnel and to protect power rail **108** from debris or undesired manipulation. After two or more second inner insert **812**A, second middle insert **812**B, and second outer insert **812**C are aligned, inner rail segment **234**A, middle rail segment **234**B, and outer rail segment **234**C may be installed within the recesses and lodged into place, for example, using first inner insert **810**A and second inner insert **812**A for inner rail segment **234**A. At this stage, the combination rail segments **240**, support assembly **219**, and **234** results in a complete assembly for rail support module **200**.

(60) In at least one example, rail segments **240** are manufactured, or at least installed, being pre-bent, i.e. having a curvature in the X-Y plane. In this example, rail segments **240** are 41 feet in length and are pre-bent longitudinally to have 10 degrees of curvature in the X-Y plane. When installed along a straight section of haul route **101**, rail segments **240** would be straightened, such as by hand, during installation into rail support module **200** to have 0 degrees of curvature. For installations along a curve in haul route **101**, rail segments **240** could remain pre-bent at 10 degrees of curvature or additionally bent to up to 20 degrees of curvature as required to match the shape of haul route **101**. The same curvatures could be attained by reversing the direction or orientation of the rail segment. As a result, a generic component for rail segments **240** could be used throughout haul route **101** to adapt to degrees of curvature along the path ranging from −20 degrees (e.g., a rail segment pre-bent by 10 degrees in the X-Y plane towards the −Y axis being additionally bent by 10 degrees towards the −Y axis) to +20 degrees of curvature (e.g., a rail segment pre-bent by 10 degrees in the X-Y plane towards the +Y axis being additionally bent by 10 degrees towards the +Y axis). Besides helping to adapt to curvatures in haul route **101**, pre-bending of rail segments **240** can also help accommodate thermal expansion and contraction of power rail **108**.

(61) With each rail support module **200** placed at alternating positions along a path, such as at first location **602**, third location **606**, and fifth location **610** in FIG. **6**, a remaining step to establish continuity for delivering electrical power through power rail **108** is joining ends of rail segments **240** between adjacent ones of rail support module **200**. FIGS. **11-13** illustrate one example for joining ends of rail segments **240**.

(62) FIG. **11**A is an exploded view of a single rail joint **1100** bringing together representative inner rail segment **234**A-**1** and inner rail segment **234**A-**2** within a fishplate **1102**A, while FIG. **11**B is a cross-sectional view of the single rail joint **1100** along the cutaway lines shown in FIG. **11**A. While FIGS. **11**A and **11**B show inner rail segment **234**A and components affiliated with inner rail segment **234**A (also bearing the suffix “A” relating to the inner rail), the arrangement depicted for inner rail segment **234**A would also apply to middle rail segment **234**B and outer rail segment **234**C. Consistent with the nomenclature explained above, in these examples, inner rail segment **234**A-**1** is the rail segment on the inner side of rail support module **200-1** at first location **602** in FIG. **6** (i.e., closest to haul route **101**), while inner rail segment **234**A-**2** is the rail segment in the same position on rail support module **200-2** at third location **606**. Inner rail segment **234**A-**1** includes a main section **1104**A-**1** and a first end **1106**A-**1**, while inner rail segment **234**A-**2** includes a main section **1104**A-**2** and a second end **1108**A-**2** in FIG. **11**A. While not shown in FIG. **6**, inner rail segment **234**A-**1** includes a second end **1108**A-**1** at an opposite tip of its rail segment, and inner rail segment **234**A-**2** includes a first end **1106**A-**2** at an opposite tip of that rail segment.

(63) In one example, main section **1104**A-**1** and main section **1104**B-**2** correspond to representative portion **900** in FIG. **9** with a length (parallel to the X axis in FIG. **11**A) of roughly 39 feet and a width across rail body **902** (parallel to the Y axis in FIG. **11**A) of about 90 mm. First end **1106**A-**1** and second end **1108**A-**2**, as shown, are regions of reduced width along each end of the rail segments. In one example, first end **1106**A-**1** and second end **1108**A-**2** are about 14.5 inches in length from the tip of the respective rail segment and generally half the width of main section **1104**A-**1** and main section **1104**A-**2**, i.e. about 45 mm. These dimensions are representative only and other values may be chosen without departing from the principles of the present disclosure.

First end **1106**A-**1** and second end **1108**A-**2** may be manufactured as shown, formed by dividing a single rail segment, or formed by removing sections from main section **1104**A-**1** and main section **1104**A-**2**, among other options. In some examples, as depicted in FIG. **11**A, first end **1106**A-**1** and second end **1108**A-**2** are symmetrical and include first face **1110**A-**1** and second face **1112**A-**2**, respectively. First face **1110**A-**1** and second face **1112**A-**2** at least in part run longitudinally through each rail segment, i.e., generally parallel to outer sides of the respective rail segment, such as first outer side **1114**A-**1** and second outer side **1116**A-**1** for inner rail segment **234**A-**1**.

(64) FIG. **11**A depicts a main section **1104-1**A on inner rail segment **234**A-**1** and a first end **1106**A-**2** on inner rail segment **234**A-**2** being joined within inner fishplate **1102**A. Inner fishplate **1102**A is divided into a first longitudinal half **1118**A and a second longitudinal half **1120**A. A structurally resilient material such as steel, inner fishplate **1102**A has an inner fishplate base **1122**A along a bottom where first longitudinal half **1118**A and second longitudinal half **1120**A meet and a first edge **1124**A and a second edge **1126**A at opposite longitudinal ends. Resembling a lipped channel in some examples, inner fishplate **1102**A has a first lip **1128**A and a second lip **1130**A defining a fishplate groove **1132**A that extends along the length of inner fishplate **1102**A. One or more attachment devices, such as first bolt **1134**A extends between first longitudinal half **1118**A and second longitudinal half **1120**A through inner fishplate base **1122**A. Engaging first bolt **1134**A helps draw first longitudinal half **1118**A and first lip **1128**A against second longitudinal half **1120**A and second lip **1130**A in a pinching action.

(65) FIG. **11**B shows the cross-section of single rail joint **1100**. As discussed above, a connector such as first bolt **1134**A or similar device pulls first lip **1128**A of first longitudinal half **1118**A and second lip **1130**A of second longitudinal half **1120**A toward each other. Passing beneath inner rail segment **234**A-**1**, first bolt **1134**A thereby urges first lip **1128**A against rail web **904**A-**1** and second lip **1130**A against rail web **904**A-**2**. Rail bottom **910**A-**1** and rail bottom **910**A-**2** rest on inner fishplate base **1122**A, while first face **1110**A-**1** abuts second face **1112**A-**2**. As well, upper plate **912**A-**1** and upper plate **912**A-**2** also abut and form a generally combined surface at the top of single rail joint **1100** for contactor **118**.

(66) In an assembly step, first longitudinal half **1118**A is positioned along first end **1106**A-**1** so first lip **1128**A fits within first rail groove **918** and rail web **904** and lower flange **906** fit within fishplate groove **1132**A. Similarly, second longitudinal half **1120**A is positioned along second end **1108**A-**2** so second lip **1130**A fits within second rail groove **920**. Tightening of first bolt **1134**A draws first longitudinal half **1118**A and second longitudinal half **1120**A together, pinching first face **1110**A-**1** against second face **1112**A-**2**. Accordingly, a single rail joint **1100** or splice between inner rail segment **234**A-**1** and inner rail segment **234**A-**2** is accomplished while maintaining lateral overlap across upper plate **912**A-**1** along first end **1106**A-**1** and second end **1108**A-**2** where first face **1110**A-**1** and second face **1112**A-**2** engage. The overlapping portions of the rails permit slippage longitudinally (parallel to the X axis) between inner rail segment **234**A-**1** and inner rail segment **234**A-**2** in adjusting the length of power rail **108** during installation, while ensuring electrical conductivity between **234**A-**1** and **234**A-**2**.

(67) The split structure of inner fishplate **1102**A can additionally accommodate bends in rail segments **240** that are brought together within single rail joint **1100**. FIG. **12** illustrates this feature with a collective rail joint **1200** as a group of six rail segments **240** being connected through three fishplates. At the right side of FIG. **12**, inner rail segment **234**A-**1**, middle rail segment **234**B-**1**, and outer rail segment **234**C-**1** are provided from rail support module **200-1**, which may be installed at first location **602** (FIG. **6**), for instance. First end **1106**A-**1**, first end **1106**B-**1**, and first end **1106**C-**1** extend beyond rail support module **200-1** at first location **602**, such as to a position in about the middle of second location **604**. At the left side of FIG. **12**, inner rail segment **234**A-**2**, middle rail segment **234**B-**2**, and outer rail segment **234**C-**2** are provided from rail support module **200-2**, which may be installed at third location **606**, for instance. Second end **1108**A-**2**, second end **1108**B-**2**, and second end **1108**C-**2** extend beyond rail support module **200-2** to the position in about the

middle of second location **604** (FIG. **6**) for connection with the rail segments from rail support module **200-1**. Shown in a state just prior to final tightening, inner fishplate **1102**A, middle fishplate **1102**B, and outer fishplate **1102**C combine and pull together first end **1106**A-**1** and second end **1108**A-**2**, first end **1106**B-**1** and second end **1108**B-**2**, and first end **1106**C-**1** and second end **1108**C-**2** in the same manner as discussed above for the inner rail in FIG. **11**A.
(68) The rail segments in the example of FIG. **12** are installed within a curve in haul route **101** of about 20 degrees per 40 feet. The curve bends in the X-Y plane in FIG. **12** with the ends of the rail segments bending in the direction of the −Y axis. This curvature would correspond, for example, to a right turn within haul route **101** of 20 degrees, with inner rail segment **234**A being at an inner position of the curve and outer rail segment **234**C being at an outer position of the curve. With each of the rail segments being pre-bent at about 10 degrees per 40 feet, the rail segments in FIG. **12** would be bent an additional 10 degrees per 40 feet during installation. Typically, this additional bending could be achieved manually, although mechanized assistance for bending is possible. In some examples, the ends of each rail segment, including for instance the first ends **1106** and second ends **1108**, may be kept straight to assist with the splicing into single rail joint **1100** and can extend about 20 inches from the tips of the segments.
(69) As shown in FIG. **12**, the ability to slide rail segments longitudinally with respect to each other within inner fishplate **1102**A, middle fishplate **1102**B, and outer fishplate **1102**C enables refined positioning within collective rail joint **1200** to accommodate curves in haul route **101**. For instance, inner rail segment **234**A-**1** and inner rail segment **234**A-**2**, at the inner position of the 20 degree curvature, can be slid within fishplate groove **1132**A closer together than outer rail segment **234**C-**1** and outer rail segment **234**C-**2** within fishplate groove **1132**C, which are at the outer position of the 20 degree curvature. This positioning leads to more overlap between first face **1110**A-**1** and second face **1112**A-**2** than between second face **1110**C-**1** and second face **1112**C-**2**. Specifically, as shown in FIG. **12**, corresponding to these overlaps, inner longitudinal distance **1202** is longer than middle longitudinal distance **1204**, which is longer than outer longitudinal distance **1206**, as the rails within collective rail joint **1200** form a 20 degree curvature. Thus, the inside rail, the middle rail, and the outer rail have progressively longer distances within the curvature along haul route **101**. While the example of FIG. **12** shows a curvature of 20 degrees per 40 feet, the same principles apply to curvatures of other degrees or directions. For instance, for a joint within a left turn of 10 degrees on haul route **101**, the pre-bent rail segments would not need to be bent additionally on installation and would each be placed to curve in the X-Y plane toward the Y axis in FIG. **12**. In that situation, outer longitudinal distance **1206** would be longer than middle longitudinal distance **1204**, which would be longer than inner longitudinal distance **1202**. Accordingly, the configuration of FIGS. **11** and **12** enable the same rails to be adapted for use in any position or curvature along haul route **101** and avoid the need for rail segments of special shape to be used.
(70) A method **1300** for joining rail segments is defined by representative steps consistent with the present disclosure in the flowchart of FIG. **13**. For method **1300**, as well as other methods described in this disclosure, the steps in which the method is described are not intended to be construed as a limitation. Any number of steps can be combined in any order to implement the disclosed method, can be performed in parallel to implement the processes, and in some embodiments, one or more blocks of the process can be omitted entirely. Moreover, the processes such as **1300** can be combined in whole or in part with other methods. Beginning with a step **1302**, rail segments, such as a first narrowed end of a first rail segment and a second narrowed end of a second rail segment of an inner rail, are positioned within a first fishplate. As explained above, first end **1106**A-**1** and second end **1108**A-**2** may be arranged within inner fishplate **1102**A to be joined. In step **1304**, the first narrowed end and the second narrowed end are contacted laterally across a first longitudinal distance within the first fishplate. FIG. **12** illustrates one example where overlapping narrowed ends, such as first end **1106**A-**1** and second end **1108**A-**2**, are made to contact each other across inner longitudinal distance **1202**. Further, in step **1306**, at least one first

bolt is tightened within the first fishplate and extends beneath at least one of the first rail segment and the second rail segment. The one first bolt may, in some examples, be first bolt **1134**A, which extends through inner fishplate base **1122**A of inner fishplate **1102**A.

(71) Method **1300** continues with step **1308** of positioning other rail segments, such as a third narrowed end of a third rail segment and a fourth narrowed end of a fourth rail segment of an outer rail, within a second fishplate parallel to the first fishplate. For instance, first end **1106**C-**1** and second end **1108**C-**2** may be arranged within outer fishplate **1102**C to be joined, as shown in FIG. **12**. In step **1310**, the third narrowed end and the fourth narrowed end are contacted laterally across a second longitudinal distance within the second fishplate, and in step **1312**, at least one second bolt is tightened within the second fishplate extending beneath at least one of the third rail segment and the fourth rail segment. First end **1106**C-**1** and second end **1108**C-**2** can be placed in contact across outer longitudinal distance **1206**, with third bolt **1134**C being tightened to pull together second face **1110**C-**1** and second face **1112**C-**2**.

(72) Those of ordinary skill in the field will appreciate that the principles of this disclosure are not limited to the specific examples discussed or illustrated in the figures. For example, while rail segments **234** have been discussed in terms of I-beam cross-sections, other configurations for the rails is feasible. Moreover, rail segments **234** are discussed as having a standard shape for all portions of power rails **108**, rail segments **234** may be customized into other types as needed. Moreover, while the present disclosure addresses power rails **108** as having three conductors, implementations have more or fewer conductors are contemplated. In addition, the principles disclosed are not limited to implementation on a work machine. Any moving vehicle deriving electrical power from a ground-based conductor rail could benefit from the examples and techniques disclosed and claimed.

INDUSTRIAL APPLICABILITY

(73) The present disclosure provides systems and methods for supporting and deploying elevated power rails. A modular structure supports elevated rail segments that connected together deliver electrical power to a moving work machine, such as a hauler at a mining site. Roadside barriers provide a base of support for the rails and are relocatable as needed. To help ensure appropriate positioning for the barriers, and thus the rails, complementary tubular couplers are arranged vertically on opposite ends of the barriers. One coupler has a first diameter supported by an arm and the other has a larger second diameter and a vertical slot. Mating the couplers together concentrically along a central axis can help restrict longitudinal displacement, lateral displacement, slope change, and lateral rotation of adjacent barriers during positioning. Moreover, using one barrier as a temporary alignment structure to position barriers spaced alternatingly along a haul route can reduce by half the number of barriers used, significantly decreasing material costs.

(74) As noted above with respect to FIGS. **1-7**, an example rail support module generally includes a barrier **204** having a base **206** extending longitudinally between a first end **208** and a second end **210**. A closed coupler **216** is affixed to the first end and has an arm **318** with a thickness joining a first tubular shape. The first tubular shape extends along a first axis A-A substantially orthogonal to the base **206** and has an inner diameter and an outer diameter **410** across the first axis. An open coupler **218** is affixed to second end **210** and has a second tubular shape substantially orthogonal to base **206**. The open coupler includes a gap **316** within the second tubular shape running vertically with a width greater than the thickness of arm **318**. The second tubular shape for the open coupler **218** has an inner diameter **412** larger than outer diameter **410** of the first tubular shape for closed coupler **216**.

(75) In the examples of the present disclosure, the barrier assemblies **202** enable interchangeable placement of rail support modules **200** to deliver electrical power to a moving work machine **100** through elevated power rail **108**. Rail support modules **200** are relocatable and configurable at a worksite along a desired haul route **101** for the work machine **100**. First support pole **220**A and second support pole **220**B keep power rail **108** elevated above normal reach for a person,

enhancing safety. Couplers **216** and **218** at ends of barrier **204** mate with couplers on similar barriers, ensuring that adjacent barriers are arranged along the haul route **101** within designed limits for longitudinal displacement, lateral displacement, slope change, and lateral rotation. As a result, undue stress on power rail **108** is minimized from curvatures and slopes along haul route **101** and the risk of disconnection of contactor **118** from power rail **108** as work machine **100** is maneuvered is decreased. Also, using couplers **216** and **218** on one barrier as a temporary alignment structure **202-0** can enable rail support modules **200** to be placed alternatingly along haul route **101**, cutting in half the number of support structures otherwise needed for power rail **108**.
(76) Unless explicitly excluded, the use of the singular to describe a component, structure, or operation does not exclude the use of plural such components, structures, or operations or their equivalents. As used herein, the word "or" refers to any possible permutation of a set of items. For example, the phrase "A, B, or C" refers to at least one of A, B, C, or any combination thereof, such as any of: A; B; C; A and B; A and C; B and C; A, B, and C; or multiple of any item such as A and A; B, B, and C; A, A, B, C, and C; etc.
(77) Terms of approximation are meant to include ranges of values that do not change the function or result of the disclosed structure or process. For instance, the term "about" generally refers to a range of numeric values that one of skill in the art would consider equivalent to the recited numeric value or having the same function or result. Similarly, the antecedent "substantially" means largely, but not wholly, the same form, manner or degree, and the particular element will have a range of configurations as a person of ordinary skill in the art would consider as having the same function or result. As an example, "substantially parallel" need not be exactly 180 degrees, but may also encompass slight variations of a few degrees based on the context.
(78) While aspects of the present disclosure have been particularly shown and described with reference to the embodiments above, it will be understood by those skilled in the art that various additional embodiments may be contemplated by the modification of the disclosed machines, systems and methods without departing from the spirit and scope of what is disclosed. Such embodiments should be understood to fall within the scope of the present disclosure as determined based upon the claims and any equivalents thereof.

Claims

1. A rail support module, comprising: a barrier having a first end, a second end, and a base extending longitudinally between the first end and the second end; a first coupler affixed to the first end, the first coupler including a first hollow cylinder and an arm joining the first hollow cylinder to the first end, the first hollow cylinder extending about a first axis substantially orthogonal to the base and having an inner diameter and an outer diameter; and a second coupler affixed to the second end, the second coupler having a second hollow cylinder extending about a second axis substantially orthogonal to the base, the second hollow cylinder having an inner diameter greater than the outer diameter of the first hollow cylinder, the second hollow cylinder having a central slot extending parallel to the second axis, the central slot having a width within the second hollow cylinder less than the outer diameter of the first hollow cylinder.
2. The rail support module of claim 1, further comprising a first rail pole extending about the first axis within the first coupler and a second rail pole extending about the second axis within the second coupler.
3. The rail support module of claim 2, the first coupler defining a hole having a central axis extending substantially perpendicular to the first axis, the rail support module further including an insert at least partially disposed in the hole, the insert affixing the first rail pole to the first coupler.
4. The rail support module of claim 2, further comprising one or more rail segments between upper ends of the first rail pole and the second rail pole, the one or more rail segments extending beyond the first end and the second end of the barrier.

5. A rail support assembly, comprising: a first barrier having a first end extending substantially perpendicular to a first base; a second barrier having a second end, a third end opposite the second end, and a second base, the second end and the third end extending substantially perpendicular to the second base; and concentric tubes positioned between the first barrier and the second barrier, the concentric tubes comprising: an exterior tube having a first wall affixed to the first end and extending with a first inner diameter about a vertical axis substantially perpendicular to the first base, the first wall having a central slot defined by a first vertical edge and a second vertical edge, the central slot running substantially parallel to the vertical axis, an arm affixed to the second end and positioned within the gap central slot, and an interior tube having a second wall affixed to the arm, the interior tube extending substantially perpendicular to the second base within the first inner diameter of the exterior tube, wherein an annular gap separates the first wall from the second wall and permits lateral movement of the first barrier and the second barrier with respect to each other.
6. The rail support assembly of claim 5, wherein the second barrier further comprises: a second exterior tube attached to the third end, the second exterior tube extending perpendicular to the second base and having a same size and shape as the exterior tube attached to the first end.
7. The rail support assembly of claim 5, wherein the interior tube has a second inner diameter dimensioned to receive a pole for supporting elevated power rails.
8. The rail support assembly of claim 5, wherein a distance between the arm and one of the first vertical edge and the second vertical edge limits lateral orientation of the first barrier in a horizontal plane about the vertical axis with respect to the second barrier.
9. The rail support assembly of claim 8, wherein the first base extends along a first longitudinal axis and the second base extends along a second longitudinal axis, and wherein the arm, the first vertical edge, and the second vertical edge limit the lateral orientation between the first longitudinal axis and the second longitudinal axis to between about 170 degrees and 190 degrees.
10. The rail support assembly of claim 5, wherein a radial distance between the inner diameter of the exterior tube and an outer diameter of the interior tube limits slope orientation between the first barrier and the second barrier in a vertical plane about a horizontal axis.
11. The rail support assembly of claim 10, wherein the vertical plane bisects the first barrier longitudinally and the horizontal axis extends along an intersection of the first base and the first end.
12. The rail support assembly of claim 10, wherein the vertical plane bisects the second barrier longitudinally and the horizontal axis extends along an intersection of the second base and the second end.
13. The rail support assembly of claim 5, wherein the exterior tube includes an exterior hole having an oblong shape, and the interior tube includes an interior hole having a central axis extending substantially perpendicular to the vertical axis and through the exterior hole.
14. A method, comprising: placing a first support of oblong shape on ground surface substantially parallel to a vehicle travel path defined by the ground surface, the first support having a first longitudinal axis; arranging an alignment structure of the oblong shape end-to-end with the first support using a first tubular coupling, the first tubular coupling comprising first concentric tubes configured such that the first longitudinal axis is substantially colinear with an alignment axis passing longitudinally through the alignment structure; positioning a second support of the oblong shape end-to-end with the alignment structure using a second tubular coupling, the second tubular coupling comprising second concentric tubes configured such that the alignment axis is substantially colinear with a second longitudinal axis of the second support; moving the alignment structure past the second support with respect to the vehicle travel path; and positioning the alignment structure end-to-end with the second support using a third tubular coupling, the third tubular coupling comprising third concentric tubes configured such that the alignment axis is substantially colinear with a third longitudinal axis of the third support.
15. The method of claim 14, wherein the first tubular coupling, the second tubular coupling, and

the third tubular coupling have a same size and shape.
16. The method of claim 14, wherein arranging using the first tubular coupling comprises mating a first tubular coupler affixed to the first support with a second tubular coupler affixed to a first end of the alignment structure along a first axis parallel to the first end.
17. The method of claim 16, wherein positioning the second support using the second tubular coupling comprises mating a third tubular coupler affixed to a second end of the alignment structure with a fourth tubular coupler affixed to a near end of the second support along a second axis parallel to the second end.
18. The method of claim 17, wherein positioning the alignment structure using the third tubular coupling comprises mating the second tubular coupler of the alignment structure with a fifth tubular coupler affixed to a far end of the second support along the first axis.
19. The method of claim 18, further comprising: moving the alignment structure past the second support with respect to the vehicle travel path; and inserting a rail pole into one of the first tubular coupler, the fourth tubular coupler, and the fifth tubular coupler.
20. The method of claim 14, further comprising splicing first rail segments positioned above the first support with second rail segments positioned above the second support.