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United States Patent Application Publication

20250255231

Kind Code

A1

Publication Date

August 14, 2025

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ALIGNMENT GUIDE FOR AN ALIGNMENT SYSTEM OF A MOBILE IRRIGATION SYSTEM

Abstract

A mobile irrigation alignment system comprising a base mounted on a first span, a linkage system, and a control box. The linkage system includes a driven arm, drive arm, and control arm. The driven arm is pivotably connected to the base about a vertical axis. The drive arm is pivotably connected to the driven arm about a horizontal axis and includes a distal end configured to rest on an adjacent span. The control arm is linked to the driven arm. The control box determines lateral alignment between the spans based on the control arm as governed by the drive arm and driven arm. The drive arm is configured to retain an upright orientation relative to the driven arm regardless of torsional rotation between the spans so that the position of the control arm and hence the lateral alignment determination is not affected by the torsional rotation between the spans.

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Appl. No.: 19/196856

Filed: May 02, 2025

Related U.S. Application Data

parent US division 17591941 20220203 parent-grant-document US 12310298 child US 19196856

Publication Classification

Int. Cl.: A01G25/09 (20060101); A01G25/16 (20060101); F16L3/00 (20060101)

Background/Summary

RELATED APPLICATIONS [0001] The present application is a divisional patent application and claims priority of co-pending application titled “ALIGNMENT GUIDE FOR AN ALIGNMENT SYSTEM OF A MOBILE IRRIGATION SYSTEM”, Ser. No. 17/591,941, filed Feb. 3, 2022, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] Mobile irrigation systems often include alignment systems for monitoring and maintaining lateral alignment between adjacent spans as they advance across a field. Many span joints also have some amount of vertical and torsional freedom to accommodate uneven terrain. Vertical movement and torsional rotation between adjacent spans may cause false or inaccurate misalignment signals or otherwise affect lateral alignment measurements due to physical limitations of the alignment systems. This may result in poor alignment or inefficient operation as the alignment systems needlessly activate drive motors to correct false or inaccurate lateral misalignment.

SUMMARY

[0003] Embodiments of the invention solve the above-mentioned problems and other problems and provide a distinct advance in the art of alignment systems for mobile irrigation systems. More particularly, the invention provides a mobile irrigation system with an improved alignment system that reduces false or inaccurate misalignment determinations.

[0004] An embodiment of the invention is a mobile irrigation system broadly comprising a central pivot, a number of spans, and a number of alignment systems that accommodate movement between adjacent spans in three degrees of freedom while tracking movement in one of the three degrees of freedom without being adversely affected by movement in the other two degrees of freedom.

[0005] The central pivot distributes water or other fluids to the spans and may be a tower, a standpipe, or the like. The central pivot has access to a well, water tank, or other source of water and may also be coupled with a tank or other source of agricultural products to inject fertilizers, pesticides, and/or other chemicals into the water for application during irrigation.

[0006] Each span includes a truss section, a conduit section, a mobile tower, and a joint. The spans are pivotably connected end-to-end from the central pivot.

[0007] Each truss section includes a number of beams rigidly connected to one another to form a framework which carries or otherwise supports the conduit and other fluid distribution mechanisms that are connected in fluid communication to the conduit.

[0008] The conduit sections transport water or other fluids to sprinklers, spray guns, drop nozzles, or other fluid emitting devices spaced along the conduit sections to apply water and/or other fluids to areas underneath the irrigation system. The conduit sections may be or may include metal pipes and flexible liners including outlets to which the fluid emitting devices are connected.

[0009] The mobile towers are positioned at outward ends of the spans and each includes wheels and a drive motor. The drive motor may be an electric motor, such as an alternating current (AC) motor or a direct current (DC) motor, and may one of the wheels directly or through a drive shaft in order to propel the mobile towers forward or backward. Each mobile tower may also include a controller for activating the drive motor according to a position of the mobile tower or a relative angle of the adjacent span.

[0010] The joints connect the spans so that the spans are free to move relative to each other. The

joints allow three degrees of freedom between adjacent spans: lateral (horizontal) pivoting, vertical pivoting, and torsional rotation.

[0011] The alignment systems are substantially identical so only a first alignment system will be described. The first alignment system broadly comprises a linkage system and a control system. The first alignment system determines and dictates lateral alignment between the first and second spans.

[0012] The linkage system converts relative alignment between the first and second spans into an input to electromechanical components of the control system and broadly comprises a driven arm, a drive arm, a control arm, a control arm adjuster, and a biasing element.

[0013] The driven arm is pivotably connected to the first span at a first pivot point and to the control arm via the control arm adjuster. The driven arm also includes a second pivot point to which the drive arm is pivotably connected. Furthermore, the driven arm is linked to the biasing element for reducing hysteresis in the linkage system and hence improving accuracy of alignment measurements.

[0014] The drive arm is pivotably connected to the driven arm at the second pivot point so that the drive arm can pivot relative to the driven arm about a horizontal axis. The drive arm also includes a longitudinal section having a distal end and an alignment guide near the distal end.

[0015] The alignment guide retains the distal end of the drive arm on the second span without the drive arm being fixed to the second span. In one embodiment, the alignment guide has an inverted U-shape and includes left and right downwardly-extending posts configured to engage the second span.

[0016] The control arm is connected to the driven arm via the control arm adjuster and connected to (or configured to engage) electromechanical components of the control system. In one embodiment, the control arm is pivotably connected to the driven arm via the control arm adjuster.

[0017] The control arm adjuster includes nuts, cams, or other components for setting the control arm's range of motion. This allows the alignment system to be calibrated and also accommodates different sizes and configurations of brackets in the base, linkage components in the linkage system, electromechanical components of the control system, and truss components and conduit components in the first and second spans.

[0018] The biasing element connects between the driven arm of the linkage system and a biasing element bracket or other anchor point for reducing hysteresis in the linkage system and hence improving accuracy of alignment measurements. The biasing element may be a coil spring, a leaf spring, an elastic component, or any other suitable biasing element.

[0019] The control system may include electromechanical components and electronic components for determining lateral alignment between the first and second spans based on a position of the control arm as governed by the drive arm and the driven arm. For example, the control system may include a cam, a microswitch, and a processor or controller.

[0020] The above-described invention provides several advantages. For example, the first alignment system is configured to track only lateral pivoting between the first and second spans without detrimental effects from the torsional rotation or the vertical pivoting between the first and second spans. The alignment guide can be attached at one of a plurality of positions on the longitudinal section of the drive arm, which allows for adjusting sensitivity of the linkage system. The control arm can be adjusted relative to the drive arm for calibrating the alignment system and accommodating changes in the alignment system. The stop protects the control system from damage in the event of excessive lateral pivoting between the first and second spans. Furthermore, the alignment system can easily be adapted and retrofitted to virtually any mobile irrigation system.

[0021] Another embodiment of the invention is an alignment guide broadly comprising an upper bar, left and right flexures, and a lower bar. The alignment guide may be used in place of the alignment guide described above.

[0022] The upper bar is configured to extend laterally over a conduit and includes a linkage

connection point and a slide bearing. The upper bar and left and right flexures form a monolithic structure.

[0023] The linkage connection point is configured to connect the alignment guide to a longitudinal section of a drive arm. To that end, the linkage connection point includes an adjuster for effectively changing a length of the longitudinal section of the drive arm and hence calibrating the alignment guide.

[0024] The slide bearing is a low friction surface configured to contact the conduit. The slide bearing may also be curved to complement the curved surface of the conduit.

[0025] The left and right flexures extend downward from opposite ends of the upper bar to bracket the conduit and may each include a slide bearing. The left and right flexures may be pre-loaded to bias the slide bearings against the conduit.

[0026] The slide bearings contact areas configured to slideably contact the conduit. The slide bearings are monolithic with a remainder of the left and right flexures and upper bar.

[0027] The lower bar extends between distal ends of the left and right flexures and are secured to the left and right flexures via opposing fasteners. The lower bar is configured to retain the alignment guide on the conduit.

[0028] Another embodiment of the invention is an alignment guide broadly comprising an upper bar, left and right flexures, and a lower bar assembled via fasteners. The alignment guide may be used in place of the alignment guides described above.

[0029] The upper bar is configured to extend laterally over a conduit and may include a linkage connection point. The upper bar is connected to the left and right flexures via fasteners.

[0030] The linkage connection point is configured to connect the alignment guide to a longitudinal section of a drive arm. To that end, the linkage connection point includes an adjuster for effectively changing a length of the longitudinal section of the drive arm and hence calibrating the alignment guide.

[0031] The left and right flexures extend downward from opposite ends of the upper bar to bracket the conduit and may each include a slide bearing. The left and right flexures are connected to the upper bar and the lower bar via fasteners. The left and right flexures are pre-loaded to bias the slide bearings against the conduit.

[0032] The slide bearings are contact pads configured to slideably contact the conduit. The slide bearings are connected to the left and right flexures via fasteners.

[0033] The lower bar extends between distal ends of the left and right flexures and is secured to the left and right flexures via opposing fasteners. The lower bar is configured to retain the alignment guide on the conduit.

[0034] Another embodiment of the invention is an alignment guide broadly comprising left and right arms, a lower bar, and a biasing element. The alignment guide may be used in place of the alignment guides described above.

[0035] The left and right arms extend diagonally downward relative to each other in an inverted V for cradling a conduit from above the conduit. A linkage connection point may be present near an upper juncture of the left and right arms for connecting the alignment guide to a longitudinal section of a drive arm. To that point, the linkage connection point accommodates an adjuster for effectively changing a length of the longitudinal section of the drive arm and hence calibrating the alignment guide.

[0036] The lower bar is pivotably connected to one of the left and right arms and may be configured to extend at least partially under the conduit. To that end, the lower bar is curved or may have an angled portion.

[0037] The biasing element is configured to connect the lower bar to the opposite one of the left and right arms to which the lower bar is not pivotably connected. The biasing element ensures the left and right arms and lower bar effectively encircle the conduit and the left and right arms remain in cradling engagement with the conduit without creating a significant amount of friction

therebetween. The biasing element may be a spring, elastic cord, or the like. The alignment guide can be disengaged from the conduit by removing or disconnecting the biasing element from at least one of the biasing element and the left or right arm to which it is attached.

[0038] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Other aspects and advantages of the current invention will be apparent from the following detailed description of the embodiments and the accompanying drawing figures.

Description

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0039] Embodiments of the current invention are described in detail below with reference to the attached drawing figures, wherein:

[0040] FIG. 1 is a perspective view of an irrigation system including a plurality of alignment systems constructed in accordance with an embodiment of the invention;

[0041] FIG. 2 is a plan view of the irrigation system of FIG. 1;

[0042] FIG. 3 is a plan view of an alignment system of the irrigation system of FIG. 1;

[0043] FIG. 4 is a perspective view of the alignment system of FIG. 3;

[0044] FIG. 5 is a bottom perspective view of the alignment system of FIG. 3;

[0045] FIG. 6 is another bottom perspective view of the alignment system of FIG. 3;

[0046] FIG. 7 is a perspective view of an alignment guide constructed in accordance with another embodiment of the invention;

[0047] FIG. 8 is a perspective view of an alignment guide constructed in accordance with another embodiment of the invention; and

[0048] FIG. 9 is a perspective view of an alignment guide constructed in accordance with another embodiment of the invention.

[0049] The drawing figures do not limit the current invention to the specific embodiments disclosed and described herein. The drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0050] The following detailed description of the invention references the accompanying drawings that illustrate specific embodiments in which the invention can be practiced. The embodiments are intended to describe aspects of the invention in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments can be utilized and changes can be made without departing from the scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense. The scope of the present invention is defined only by the appended claims, along with the full scope of equivalents to which such claims are entitled.

[0051] In this description, references to “one embodiment”, “an embodiment”, or “embodiments” mean that the feature or features being referred to are included in at least one embodiment of the technology. Separate references to “one embodiment”, “an embodiment”, or “embodiments” in this description do not necessarily refer to the same embodiment and are also not mutually exclusive unless so stated and/or except as will be readily apparent to those skilled in the art from the description. For example, a feature, structure, act, etc. described in one embodiment may also be included in other embodiments, but is not necessarily included. As used in the specification and in the claims, ordering words such as “first” and “second” are used to distinguish between similar components and do not imply specific components. Thus, the current technology can include a variety of combinations and/or integrations of the embodiments described herein.

[0052] Turning to FIGS. **1-6**, a mobile irrigation system **100** in which alignment systems of the present invention may be incorporated is illustrated. The mobile irrigation system **100** is a central pivot irrigation system broadly comprising a central pivot **102**, a plurality of spans **104A-D**, and a plurality of alignment systems **106A-C**. Other irrigation systems such as linear move irrigation systems may also be used without departing from the scope of the invention.

[0053] The central pivot **102** distributes water or other fluids to the spans **104A-D** and may be a tower, a standpipe, or the like. The central pivot **102** may include a support structure for withstanding radial loads, axial loads, and twisting loads, a non-rotatable vertically extending pipe, and a rotatable elbow. The non-rotatable vertically extending pipe carries the fluids to an elevated height. The rotatable elbow connects the first span **104A** to the non-rotatable vertically extending pipe such that the spans **104A-D** are free to pivot about the central pivot **102** while remaining connected thereto.

[0054] The plurality of spans **104A-D** include a plurality of truss sections **108A-D**, a plurality of conduit sections **110A-D**, a plurality of mobile towers **112A-D**, and a plurality of joints **114A-C**. Any number of spans may be used without departing from the scope of the present invention. To that point, spans may be added and removed as an area to be irrigated is increased or decreased.

[0055] Each of the truss sections **108A-D** provides rigidity to or otherwise supports one of the conduit sections **110A-D**. The truss sections **108A-D** may include braces, cross members, cables, and the like.

[0056] Each of the conduit sections **110A-D** transport water or other fluids to a plurality of sprinklers, spray guns, drop nozzles, or other fluid emitting devices spaced along the conduit sections **110A-D** to apply water and/or other fluids to areas underneath the irrigation system **100**. The conduit sections **110A-D** may be or may include metal pipes and flexible liners including outlets to which the fluid emitting devices are connected.

[0057] Each of the mobile towers **112A-D** elevates adjacent truss sections **108A-D** and may include an “A-frame” or similar structure for supporting an end of one of the truss sections **108A-D**, a number of wheels connected to the A-frame for traversing across a field, and a motor for powering the wheels. Each mobile tower **112A-D** may also include a controller for activating the motor according to a position of the mobile tower or a relative angle of the adjacent span **104A-D**.

[0058] The joints **114A-C** connect the spans **104A-D** so that the spans are free to move relative to each other. In one embodiment, the joints **114A-C** are integrated into the conduit sections **110A-D**. Each of the joints **114A-C** may be a ball joint, a swivel joint, a flexible joint, or any other suitable multi-axis joint. For best illustrating the benefits of the present invention, the joints **114A-C** are described and illustrated as allowing three degrees of freedom between adjacent spans: lateral (horizontal) pivoting, vertical pivoting, and torsional rotation. It will be understood the terms horizontal and vertical are relative to general orientation of the irrigation system.

[0059] The alignment systems **106A-C** determine and dictate lateral alignment between adjacent spans. The alignment systems **106A-C** are substantially identical so only alignment system **106A** will be described in detail. The alignment system **106A** broadly comprises a base **116**, a linkage system **118**, and a control system **120**.

[0060] The base **116** supports certain components of the linkage system **118** and the control system **120** and may include a lower mounting bracket **122**, an upper mounting bracket **124**, a linkage bracket **126**, and a biasing element bracket **128**. Alternatively, the base **116** may be omitted, in which case the linkage system **118** and/or the control system **120** may be mounted directly to one of the first and second spans **104A,B**, or another component of the mobile irrigation system **100**.

[0061] The lower mounting bracket **122** clamps the upper mounting bracket **124** to the conduit section **110A** and may be U-shaped or C-shaped for at least partially encircling the conduit section **110A** from below. The lower mounting bracket **122** may also include tabs or flanges having fastener mounting holes for securing the lower mounting bracket **122** to the upper mounting bracket **124** via fasteners.

[0062] The upper mounting bracket **124** clamps to the lower mounting bracket **122** and may be U-shaped or C-shaped for at least partially encircling the conduit section **110A** from above. The upper mounting bracket **124** may also include tabs or flanges having fastener mounting holes for securing the upper mounting bracket **124** to the lower mounting bracket **122** via fasteners.

[0063] The linkage bracket **126** may include a first pivot point **130**, a biasing element aperture **132**, a slide bearing **134**, and a stop **136**. The linkage bracket **126** may be attached to the upper mounting bracket **124** via fasteners. Alternatively, the linkage bracket **126** may be part of the upper mounting bracket.

[0064] The first pivot point **130** connects a driven arm (described below) of the linkage system **118** to the linkage bracket **126** and may include a pin or other fastener. The first pivot point **130** may be configured to allow the driven arm to freely pivot relative to the linkage bracket **126** about a vertical axis. In one embodiment, the first pivot point **130** may be an ultra-high molecular-weight polyethylene (UHMWPE) bearing.

[0065] The biasing element aperture **132** may be sufficiently large for the biasing element **146** to extend through and have unimpeded lateral motion. The location and shape of the biasing element aperture **132** is dictated by the geometry, arrangement, and range of motion of the biasing element **146** and the driven arm, some of which may be limited by the stop **136**.

[0066] The slide bearing **134** contacts the driven arm and ensures low friction lateral motion of the driven arm. In one embodiment, the slide bearing **134** may be a UHMWPE bearing.

[0067] The stop **136** restricts lateral range of motion of the driven arm. In one embodiment, the stop **136** includes opposing posts configured to engage the driven arm **138** if the driven arm is pivoted to a predetermined angle. This protects electromechanical components of the control system **120**.

[0068] The biasing element bracket **128** anchors the biasing element **146** to the base **116**. The biasing element bracket **128** may be adjustable for setting a desired tension and bias direction in the biasing element **146**.

[0069] The linkage system **118** converts relative alignment between the first and second spans **104A,B** into an input to electromechanical components of the control system **120** and broadly comprises a driven arm **138**, a drive arm **140**, a control arm **142**, a control arm adjuster **144**, and a biasing element **146**. More generally speaking, the linkage system **118** is linked between the first and second spans **104A,B**.

[0070] The driven arm **138** may be pivotably connected to the linkage bracket **126** at the first pivot point **130** and to the control arm **142** via the control arm adjuster **144**. The driven arm **138** may also include a second pivot point **148** to which the drive arm **140** is pivotably connected. In one embodiment, the second pivot point **148** may be an ultra-high molecular-weight polyethylene (UHMWPE) bearing. Furthermore, the driven arm **138** may be linked to the biasing element **146** for reducing hysteresis in the linkage system **118** and hence improving accuracy of alignment measurements.

[0071] The drive arm **140** may be pivotably connected to the driven arm **138** at the second pivot point **148** so that the drive arm **140** can pivot relative to the driven arm **138** about a horizontal axis. The drive arm **140** may include a longitudinal section **150** having a distal end and an alignment guide **152** near the distal end.

[0072] The alignment guide **152** brackets (i.e., retains) the distal end of the drive arm **140** on the second span **104** without the drive arm **140** being fixed to the second span **104**. In one embodiment, the alignment guide **152** may have an inverted U-shape and may include left and right downwardly-extending posts **154A,B** configured to engage the second span **104**. In other embodiments, the alignment guide **152** may encircle the second span **104**. The alignment guide **152** may be monolithic or may be comprised of a plurality of connected components. The alignment guide **152** may also be made of UHMWPE for minimizing friction between the alignment guide **152** and the second span **104**. Furthermore, the alignment guide **152** may be adjustably attached to

the longitudinal section **150** of the drive arm **140** via an adjuster **156** for adjusting sensitivity of the linkage system **118**.

[0073] The control arm **142** may be connected to the driven arm **138** via the control arm adjuster **144** and connected to (or configured to engage) electromechanical components of the control system **120**. In one embodiment, the control arm **142** is pivotably connected to the driven arm **138** via the control arm adjuster **144**.

[0074] The control arm adjuster **144** includes nuts, cams, or other components for setting the control arm's range of motion. This allows the alignment system **106** to be calibrated and also accommodates different sizes and configurations of brackets in the base **116**, linkage components in the linkage system **118**, electromechanical components of the control system **120**, and truss components and conduit components in the first and second spans **104A,B**.

[0075] The biasing element **146** connects between the driven arm of the linkage system **118** and the biasing element bracket **128** for reducing hysteresis in the linkage system **118** and hence improving accuracy of alignment measurements. The biasing element **146** may be a coil spring, a leaf spring, an elastic component, or any other suitable biasing element.

[0076] The control system **120** may be mounted on the base **116** and may include electromechanical components and electronic components for determining lateral alignment (i.e., making a lateral alignment determination) between the first and second spans **104A,B** based on a position of the control arm **142** as governed by the drive arm **140** and the driven arm **138**. For example, the control system **120** may include a cam, a microswitch, and a processor or controller.

[0077] In use, the alignment system **106** determines and dictates lateral alignment between the first and second spans **104A,B** while not being negatively affected by torsional rotation or vertical pivoting between the first and second spans **104A,B**. Specifically, the alignment guide **152** (and hence the drive arm **140**) is retained in an upright orientation relative to the driven arm **138** regardless of torsional rotation between the first and second spans **104A,B**. This prevents the torsional rotation from propagating through the linkage system **118** to the control system **120**.

[0078] The drive arm **140** also pivots vertically relative to the driven arm **138** at the second pivot point **148**. In this way, vertical pivoting between the first and second spans **104A,B** is not propagated beyond the second pivot point **148**.

[0079] On the other hand, lateral pivoting between the first and second spans **104A,B** causes the drive arm **140** and driven arm **138** to pivot about the first pivot point **130**. This motion propagates to the control arm **142**, which engages electromechanical components of the control system **120**. Importantly, because the torsional rotation between the first and second spans **104A,B** is not propagated to the drive arm and the vertical pivoting between the first and second spans **104A,B** is not propagated to the driven arm **138**, the lateral alignment measurements of the control electromechanical components and electronic components of the control system **120** are not affected by the torsional rotation or the vertical pivoting between the first and second spans **104A,B**.

[0080] The above-described invention provides several advantages. For example, the alignment system **106A** is configured to track only lateral pivoting between the first and second spans **104A,B** without detrimental effects from the torsional rotation or the vertical pivoting between the first and second spans **104A,B**. The alignment guide **152** can be attached at one of a plurality of positions on the longitudinal section **150** of the drive arm **140**, which allows for adjusting sensitivity of the linkage system **118**. The control arm **142** can be adjusted relative to the drive arm **140** for calibrating the alignment system **106** and accommodating changes in the alignment system **106**. The stop **136** protects the control system **120** from damage in the event of excessive lateral pivoting between the first and second spans **104A,B**. Furthermore, the alignment system **106A** can easily be adapted and retrofitted to virtually any mobile irrigation system.

[0081] Turning to FIG. 7, an alignment guide **200** constructed in accordance with another embodiment of the invention is illustrated. The alignment guide **200** broadly comprises an upper

bar **202**, left and right flexures **204A,B**, and a lower bar **206**.

[0082] The upper bar **202** may be configured to extend laterally over a conduit and may include a linkage connection point **208** and a slide bearing **210**. The upper bar **202** and left and right flexures **204A,B** may form a monolithic UHMWPE structure.

[0083] The linkage connection point **208** may be configured to connect the alignment guide **200** to a longitudinal section of a drive arm. To that end, the linkage connection point **208** may include an adjuster **212** for effectively changing a length of the longitudinal section of the drive arm and hence calibrating the alignment guide **200**.

[0084] The slide bearing **210** may be a UHMWPE surface or other low friction surface configured to contact the conduit. The slide bearing **210** may also be curved to complement the curved surface of the conduit.

[0085] The left and right flexures **204A,B** extend downward from opposite ends of the upper bar **202** to bracket the conduit and may each include a slide bearing (see slide bearings **214A** and **214B**). The left and right flexures **204A,B** may be pre-loaded to bias the slide bearings **214A,B** against the conduit.

[0086] The slide bearings **214A,B** may be contact areas configured to slideably contact the conduit. The slide bearings **214A,B** may be monolithic with a remainder of the left and right flexures **204A,B** and upper bar **202**.

[0087] The lower bar **206** may extend between distal ends of the left and right flexures **204A,B** and may be secured to the left and right flexures **204A,B** via opposing fasteners. The lower bar **206** is configured to retain the alignment guide **200** on the conduit.

[0088] The alignment guide **200** provides several advantages. For example, slide bearings **210** and **214A, B** and left and right flexures **204A,B** ensure the alignment guide **200** smoothly slides relative to the conduit while retaining alignment accuracy. The lower bar **206** also ensures the alignment guide **200** is retained on the conduit. The upper bar **202** and left and right flexures **204A,B** being monolithic reduces part count.

[0089] Turning to FIG. **8**, an alignment guide **300** constructed in accordance with another embodiment of the invention is illustrated. The alignment guide **300** broadly comprises an upper bar **302**, left and right flexures **304A,B**, and a lower bar **306**.

[0090] The upper bar **302** may be configured to extend laterally over a conduit and may include a linkage connection point **308**. The upper bar **302** may be connected to the left and right flexures **304A,B** via fasteners.

[0091] The linkage connection point **308** may be configured to connect the alignment guide **300** to a longitudinal section of a drive arm. To that end, the linkage connection point **308** may include an adjuster **310** for effectively changing a length of the longitudinal section of the drive arm and hence calibrating the alignment guide **300**.

[0092] The left and right flexures **304A,B** extend downward from opposite ends of the upper bar **302** to bracket the conduit and may each include a slide bearing (see slide bearings **312A** and **312B**). The left and right flexures **304A,B** may be connected to the upper bar **302** and the lower bar **306** via fasteners. The left and right flexures **304A,B** may be pre-loaded to bias the slide bearings **312A,B** against the conduit.

[0093] The slide bearings **312A,B** may be contact pads configured to slideably contact the conduit. The slide bearings **312A,B** may be connected to the left and right flexures **304A,B** via fasteners.

[0094] The lower bar **306** may extend between distal ends of the left and right flexures **304A, B** and may be secured to the left and right flexures **304A,B** via opposing fasteners. The lower bar **306** is configured to retain the alignment guide **300** on the conduit. The upper bar **302** and lower bar **306** may be identical structures, which simplifies design and manufacturing.

[0095] The alignment guide **300** provides several advantages. For example, the slide bearings **312** and left and right flexures **304A,B** ensure the alignment guide **300** smoothly slides relative to the conduit while retaining alignment accuracy. The slide bearings may also be adjustable for

accommodating conduits of different sizes. The lower bar **306** also ensures the alignment guide **300** is retained on the conduit. The upper bar **302** and lower bar **306** may be identical structures, which simplifies design and manufacturing.

[0096] Turning to FIG. **9**, an alignment guide **400** constructed in accordance with another embodiment of the invention is illustrated. The alignment guide **200** broadly comprises left and right arms **402A,B**, a lower bar **404**, and a biasing element **406**.

[0097] The left and right arms **402A,B** may extend diagonally downward relative to each other in an inverted V for cradling a conduit from above the conduit. A linkage connection point **408** may be present near an upper juncture of the left and right arms **402A,B** for connecting the alignment guide **400** to a longitudinal section of a drive arm. To that point, the linkage connection point **408** may include an adjuster **410** for effectively changing a length of the longitudinal section of the drive arm and hence calibrating the alignment guide **400**.

[0098] The lower bar **404** may be pivotably connected to one of the left and right arms **402A,B** and may be configured to extend at least partially under the conduit. To that end, the lower bar **404** may be curved or may have an angled portion.

[0099] The biasing element **406** may be configured to connect the lower bar **406** to the opposite one of the left and right arms **402A,B** to which the lower bar **404** is not pivotably connected. The biasing element **406** ensures the left and right arms **402A,B** and lower bar **404** effectively encircle the conduit and the left and right arms **402A,B** remain in cradling engagement with the conduit without creating a significant amount of friction therebetween. The biasing element **406** may be a spring, elastic cord, or the like. The alignment guide **400** may be disengaged from the conduit by removing or disconnecting the biasing element **406** from at least one of the biasing element **406** and the left or right arm **402A,B** to which it is attached.

[0100] The alignment guide **400** provides several advantages. For example, the alignment guide **400** simplifies assembly on the conduit. The alignment guide **400** also automatically works on conduits of virtually any size without the need for adjustment. The biasing element **406** ensures the left and right arms **402A,B** and lower bar **404** create minimal friction with the conduit while retaining alignment accuracy.

[0101] Although the invention has been described with reference to the embodiments illustrated in the attached drawing figures, it is noted that equivalents may be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

[0102] Having thus described various embodiments of the invention, what is claimed as new and desired to be protected by Letters Patent includes the following:

Claims

1. An alignment guide for an alignment system of a mobile irrigation system including first and second spans, the alignment system including a drive arm and being configured to be mounted on the first span, the alignment guide comprising: a connection point configured to attach the alignment guide on the drive arm; an upper bar extending laterally from the connection point; opposing left and right members extending vertically from the upper bar and configured to bracket the alignment guide on the second span; and a lower bar extending laterally between the opposing left and right members opposite the upper bar, the lower bar being configured to retain the alignment guide on the second span.
2. The alignment guide of claim 1, the opposing left and right members being left and right rigid posts.
3. The alignment guide of claim 1, the opposing left and right members being flexures configured to be preloaded against the second span.
4. The alignment guide of claim 3, the flexures extending downward from opposing ends of the horizontal bar, the flexures and upper bar being monolithic.

5. The alignment guide of claim 3, the flexures being resilient aluminum strips.
 6. The alignment guide of claim 1, the lower bar being connectable to the left and right members via one or more fasteners.
 7. The alignment guide of claim 1, the upper bar and lower bar being identical components.
 8. The alignment guide of claim 1, the upper bar including a slide bearing.
 9. The alignment guide of claim 8, the slide bearing being curved to complement a shape of the second span.
 10. The alignment guide of claim 1, the alignment guide being at least partially formed of ultra-high molecular-weight polyethylene (UHMWPE) for minimizing friction between the alignment guide and the second span.
 11. The alignment guide of claim 1, the alignment guide being configured to be adjustably attached at one of a plurality of positions on the drive arm for adjusting sensitivity of the alignment system.
 12. An alignment guide for an alignment system of a mobile irrigation system including first and second spans, the alignment system including a drive arm and being configured to be mounted on the first span, the alignment guide comprising: a connection point configured to attach the alignment guide on the drive arm; and opposing left and right members configured to bracket the alignment guide on the second span, the opposing left and right members forming an upper inverted V-shaped fork.
 13. The alignment guide of claim 12, the alignment guide further comprising a lower link pivotably connected to the first member so that the alignment guide is configured to encircle the second span.
 14. The alignment guide of claim 13, further comprising a biasing element connecting the lower link to the second member.
 15. The alignment guide of claim 13, the lower link having a bent shape.
 16. An alignment guide for an alignment system of a mobile irrigation system including first and second spans, the alignment system including a drive arm and being configured to be mounted on the first span, the alignment guide comprising: a connection point configured to attach the alignment guide on the drive arm; an upper bar extending horizontally from the connection point; opposing left and right members extending vertically from the upper bar and configured to bracket the alignment guide on the second span; and slide bearings attached to the opposing left and right members via fasteners.
 17. The alignment guide of claim 16, the opposing left and right members being flexures configured to be preloaded against the second span.
 18. The alignment guide of claim 16, the flexures being resilient aluminum strips.
 19. The alignment guide of claim 16, further comprising a lower bar connectable to the opposing left and right members opposite the upper bar.
 20. The alignment guide of claim 19, the upper bar and the lower bar being identical components.
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