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APPARATUS FOR LATERAL CABLE PULLING AND PIPE REPLACEMENT

Abstract

A compact, open path vertical cable pulling apparatus, having a low center of gravity and composed of two detachable, single person hand-portable components. The apparatus is competent to pull cable horizontally through space underground with a pulling force in the range of at least about 20 to 100 tons using low pressure flow hydraulics and has utility in the cable pulling industries, including in the drilling and horizontal directional drilling industries, and as part of a method for pulling cable through space, including pulling cable through space in the pipe bursting and trenchless pipe replacement industries.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. patent application Ser. No. 18/424,826, filed Jan. 28, 2024, which claims the benefit of U.S. Ser. No. 16/386,250, filed Apr. 16, 2019, U.S. Patent Application Ser. No. 62/696,785, filed Jul. 11, 2018, and U.S. Patent Application Ser. No. 62/658,723, filed Apr. 17, 2018, the disclosures of which are all hereby expressly incorporated in their entirety by reference herein.

FIELD OF TECHNOLOGY
[0002] Embodiments of the present disclosure find applicability in the field of lateral cable pulling, including any field for pulling cable through space underground. One useful field includes the field of trenchless pipe replacement.
BACKGROUND OF THE INVENTION
[0003] Pipe bursting is a mature and widely used trenchless method for renewal of deteriorated and/or undersized gas, water, sewer, utility conduits and other pipelines throughout the world. The trenchless method provides an economic means for pipe replacement with minimal social disturbance to businesses and residents as compared with open cut or open trench techniques.
[0004] Pipe bursting is defined as a trenchless replacement method in which an existing pipe is broken either by brittle fracture or by splitting, using an internal, mechanically applied force applied by a bursting tool, generally referred to as a bursting head device. At the same time, a new pipe, typically of the same or larger diameter, is pulled in behind the bursting head, replacing the existing pipe. In the method, only two pits need to be dug or provided, one at each end of the underground pipe to be replaced. In some cases the pit can already exist, as in an existing manhole, or a space within a building, such as a basement.
[0005] A pulling cable is threaded through the underground pipe to be replaced, and one free end of the cable, extending into the entry or insertion pit, is attached to the front end of the bursting head device. The bursting head device also has a replacement pipe attached, typically by means of a universal duct puller associated with the back end of the busting head device. The other end of the cable extends into the exit or receiving pit, and is provided to a pulling apparatus located in the pit. The pulling apparatus then pulls the cable and the attached bursting head device through the existing cable, typically by a hydraulic mechanism which may be electrical or gas-powered. The bursting head device bursts or fractures the existing pipe as it is pulled through, and brings with it the replacement or product pipe attached at the back end of the bursting head device.
[0006] It is an on-going desire in the industry to provide fast, efficient and stable cable pulling devices that have few components to transport, are reasonably lightweight, are small in size, are easy to set up and use in the field, and which also require minimal pit size excavation to install. It also is an on-going desire to provide these characteristics at a reasonable cost to the consumer, in a range of pulling force capabilities, including in the range of about 30-100 tons, and for pulling a range of pipe diameters, using a range of cable sizes.
[0007] Useful cable pulling and replacement pipe pulling apparatuses in the art that have value in residential and commercial pipe replacement typically utilize a hydraulically powered cylinder or piston mechanism, also known in the art as a ram puller mechanism, to pull the cable. Many such cable pulling systems in the art utilize a dual cylinder piston assembly with high pressure flow,

typically pressure flows over 3,000 psi, e.g., in the range of 5,000-10,000 psi, to provide the desired pulling forces typically required to pull replacement pipes having diameters in the range of 2-12 inches. Useful pulling forces for this range of pipe diameters can be in the range of about 30-100 tons. Up until now, particularly for providing pulling forces greater than about 30 tons, high pressure flow systems have been preferred because these require substantially lower hydraulic fluid volumes and correspondingly smaller cylinders than low pressure flow systems.

[0008] There are several limitations to high pressure flow systems. One limitation is that the higher the pressure flow, the slower the piston stroke. High pressure flow systems therefore can take substantially longer time to pull a cable through space, as compared with a low pressure flow system, such as one with 3,000 psi or lower. Another limitation is that high pressure flow pulling apparatuses require a special power system to drive them, while a low pressure flow apparatus can be driven by a mini-excavator, tractor, backhoe and the like, which may already be available to an operator in the field. Both these limitations can add significant costs for an operator or owner, in man-hour costs and in equipment purchase costs. Another limitation to high pressure flow devices includes the apparatus weight limitations imposed by the cylinder and rod specifications required to move fluid under high pressure.

[0009] Piston-driven cable pulling apparatuses in the art can comprise a horizontal system, where the ram puller mechanism is parallel to the ground and the cable being pulled, or a vertical system, where the ram puller mechanism is vertical to the ground and the cable being pulled through pipe. Typically the cable being pulled is angled into a vertical position by means of a pulley wheel or similar mechanism and then engaged with the ram puller mechanism.

[0010] Vertical systems can be advantageous as an opportunity for minimizing pit size requirements. However, vertical systems place additional constraints on the cable pulling apparatus. For example, in vertical systems the cable angle has to be managed once it is in the vertical position, to maintain cable integrity, particularly as the pulley wheel wears with use. Another constraint is the limitation on cable size that a pulley wheel imposes. In pulley wheel systems in the art, choosing cables with different diameters typically requires changing the pulley wheel, which requires disassembly of part or all of the pulling system. Still another limitation is ready access to the cable in the pulling apparatus. Many devices in the art are “closed path” devices, requiring the cable to be threaded through the device from below, rather than allowing the cable to slide into position from a vertical side face of the device, as in an “open path” system. Vertical open path systems require an added mechanism to keep the cable from falling out of the device without impacting cable fidelity. Still another limitation includes component vulnerability in the vertical position during operation including, for example, hydraulic components.

[0011] One “open path” system design, described in U.S. Pat. Nos. 6,305,880; 6,524,031; U.S. Pat. Nos. 6,793,442 and 6,799,923, describes vertical and horizontal cable pulling devices using Post Tensioning Rams (PTR) with high pressure hydraulics, namely 5,000 psi and above. In the vertical cable pulling devices described, the PTR, a dual cylinder ram system, sits above the cable pulley wheel. This positioning creates a substantially tall and unstable apparatus with a high center of gravity, requiring significant frame and bracing considerations to maintain apparatus stability during pulling operations in the field.

[0012] Vertical, or semi-vertical cable pulling devices in the industry and representative of the art include the Tric Tool M30, M50 and M100 devices; the Pow-r Mole PD-22, PD-33 and PD-33M devices; the Hammerhead Trenchless “Portaburst” devices; the TT Technologies “GrundoTugger” devices, and the Grolitz & Co.'s GO6000 devices. The Tric Tool devices use the PTR system described in the '880, '031 and '442 patents and rely on high pressure flow hydraulics. The Hammerhead, Grolitz and TT Technologies devices also all rely on high pressure flow hydraulics, and in addition are closed path devices. The Pow-r Mole devices, while using low pressure flow, are multi-component, closed path devices and have a maximum pulling force of 30 tons.

[0013] There remains a need for an improved vertical cable pulling system with a reduced weight and size that is easy to transport and set up and is economical to purchase and use. There also remains a need for a vertical system that reduces component and/or cable damage during operation while maximizing flexibility for hydraulic power sources and cable diameter choices.

[0014] The present disclosure describes improvements in cable pulling systems, components and methods that overcome deficiencies in the systems, devices, components and methods of the prior art.

SUMMARY OF THE INVENTION

[0015] 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 of the claimed subject matter on its own, nor is it intended to be used on its own as an aid in determining the scope of the claimed subject matter.

[0016] In accordance with one embodiment of the present disclosure provided herein is a vertical cable pulling apparatus, competent to pull cable horizontally through space underground with a pulling force in the range of at least about 20 to 100 tons using low pressure flow hydraulics. In another embodiment, the vertical cable pulling apparatus has a pulling force of 30 tons and more using low pressure flow hydraulics. In another embodiment, the apparatus uses a pressure flow rate in the range of at least about 2,400-3,000 psi, including in the range of at least about 2,700-3,000 psi. In still another embodiment, the apparatus is compact both in footprint and overall height, has a low center of gravity, and is not subject to tipping or substantial vertical destabilization when in use.

[0017] In accordance with another embodiment of the present disclosure, the vertical cable pulling apparatus provided herein comprises an open path means for engaging cable with the pulling apparatus. In still another embodiment, the apparatus comprises two detachable, single person hand-portable components, referred to herein as (1) the chassis component, and (2) the cylinder component. In one embodiment, each component can weigh less than about 75 pounds. In another embodiment the chassis component comprises a frame, means for receiving a cable and converting the direction of the cable from horizontal to vertical, means for engaging and holding the cable in a vertical position, and means for receiving the cylinder or cable pulling component. In another embodiment, the chassis component can releasably engage with the cable pulling cylinder component. In another embodiment, the frame can comprise a back plate, two parallel, opposing foot plates projecting forward from the back plate, and two parallel, opposing side walls projecting vertically up from the inside edges of the opposing foot plates, the inside surfaces of the side walls abutting the cable direction converting means. In another embodiment the foot plates can have an overall rectangular shape. In still another embodiment the cable direction converting means can comprise a pulley wheel dimensioned to receive a cable. In still another embodiment, the chassis component can comprise integrated Zerk or grease fittings for lubricating the cable direction converting means. In yet another embodiment, the back plate can comprise an opening dimensioned to receive a cable. In still another embodiment, the frame can comprise one or a plurality of weight-reducing openings, particularly in the back plate or side wall members. In another embodiment, at least one of these openings can function as a handle.

[0018] In another aspect, the cylinder component can comprise two laterally opposing, parallel hydraulic cylinders positioned such that the cylinders span or straddle both the cable direction converting means and the opposing chassis side walls and rest on the foot plate upper surfaces when engaged with the chassis component. In another embodiment, the cylinder component can comprise means for engaging and holding the cable. In another embodiment, the cable engaging means on the cylinder component is interposed between the juxtaposed cylinders. In still another embodiment, the hydraulic cylinders together can provide at least about 30 tons pulling force. In still another embodiment, the cylinders together can provide at least about 50 tons of pulling force. In still another embodiment the cylinders together can provide at least about 90+ tons of pulling force.

[0019] In another aspect, the cylinders can operate with a low pressure flow rate. In still another embodiment the cylinders operate with a pressure flow rate in the range of at least about 2,400-3,000 psi. In still another embodiment, each cylinder can weigh less than about 20 pounds. In another embodiment, one or both cylinders can comprise a substantially hollow piston rod. In another embodiment, the cylinder component can comprise an integrated hydraulic gauge. In still another embodiment, the hydraulic gauge can comprise part of a cylinder in the cylinder component. In still another embodiment, the hydraulic gauge can measure fluid pressure in the cylinder from within a hollow piston rod. In yet another embodiment mechanical means can be provided for retaining the cylinders in position in the apparatus.

[0020] In another embodiment, the vertical cable pulling apparatus of the present disclosure can comprise means for adjusting the cable angle in the vertical position. In another embodiment, the apparatus can accommodate a plurality of cable diameters with a single pulley wheel.

[0021] In another aspect, the cable engaging means in each of the chassis and cylinder components of the present disclosure can comprise an independent cable gripper assembly comprising a central bore or axial channel through which a cable can pass, and a gripper assembly receiver dimensioned to receive the assembly such that outer side edges of the assembly can slide along the inner side edges of the receiver. In still another embodiment, the gripper assembly receiver can comprise means for receiving externally provided lubricant through one or more integrated Zerk or grease fittings for lubricating the gripper assembly engaging surfaces of the receiver.

[0022] In still another embodiment, the gripper assembly receiver can include means for receiving the assembly by vertical insertion and by horizontal or lateral insertion. In another embodiment, the gripper assembly is competent to receive and engage with a lateral surface of a cable. In still another embodiment, the gripper assembly can comprise means for receiving the lateral insertion of a cable into the central cable passage bore. In yet another embodiment, the gripper assembly can comprise a handle to facilitate movement of the assembly in and out of the receiver. In still another embodiment, the gripper assembly can comprise two members with inner, cable-gripping opposing surfaces that together define the central bore. In still another embodiment, the cable gripping members can comprise a coupling means. In still another embodiment the coupling means further can comprise timing means for keeping the gripping members parallel on a cable surface during operation. In still another embodiment, the receiver comprises rotatable means for mechanically retaining the gripper assembly in the receiver. In still another embodiment the cable engaging means can further comprise tensioning means for keeping the gripper members timed and engaged on the cable surface during operation. In yet another embodiment, the cable engaging means can further comprise means for retaining the gripper members in an open position off a cable surface.

[0023] In accordance with another embodiment of the present disclosure, a device, mechanism, method and means are provided for keeping a vertically extended cable, including the terminal free end of a cable, aligned vertically when positioned in a vertical pulling apparatus, including during the pulling operation. The device can comprise an open-path means for receiving a cable side surface laterally provided to the device and means for removably locking the device into a closed, cable-guiding position. In the closed position the device can restrain cable movement, including horizontal or side-to-side movement doing a pulling operation.

[0024] In still another aspect, the present disclosure provides a novel method for pulling cable though space with pulling forces at least about 30 tons using low pressure flow rates and cylinder fluid volumes in the range of about 70-90 cubic inches per cylinder. In another embodiment, the method provides pulling forces in the range of at least about 75 tons using low pressure flow rates and cylinder fluid volumes in the range of about 280 cubic inches per cylinder.

[0025] As described herein, compact, low-weight, vertical, open-path cable pulling systems now can be configured with pulling forces of at least about 28 tons and above, including pulling forces in the range of at least about 25-100 tons, and in the range of at least about 28-80 tons, using high flow, low pressure hydraulics. In one embodiment, the systems, units, methods and components

disclosed herein are hand-portable and can provide a pulling force of at least about 28 tons and above with a stroke speed at 10 gpm in the range of at least about 1.2-2.0 inches per second, including, without limitation, about 1.6 inches per second, or about 8 ft per minute using a cylinder fluid volume of about 85 cubic inches per cylinder and a cylinder weight of about 18 lbs. In another embodiment, the systems, units, methods and components disclosed herein can provide a pulling force of at least about 75 tons and above with a stroke speed at 10 gpm in the range of at least about 0.4-0.8 inches per second, including, without limitation, about 0.66 inches per second, or about 3.3 ft per minute, using a cylinder fluid volume of about 282 cubic inches per cylinder.
[0026] These and other attendant features and aspects of the present disclosure will be apparent from the drawings, detailed description and claims which follow.

Description

BRIEF DESCRIPTION OF DRAWINGS
[0027] The foregoing aspects and many of the attendant advantages of this disclosure will become more readily appreciated as the same become better understood by reference to the following detailed description when taken in conjunction with the accompanying drawings, where like-numbered parts reference like-membered components and wherein:
[0028] FIG. **1** is a perspective view of a vertical dual-cylinder cable pulling apparatus according to one embodiment of the present disclosure;
[0029] FIG. **2** is a rear elevation perspective view of the apparatus of FIG. **1**;
[0030] FIG. **3** is a side view of the apparatus of FIG. **1**;
[0031] FIG. **4** is a rear view of the apparatus of FIG. **1**;
[0032] FIG. **5** is an exploded view of a vertical dual-cylinder cable pulling apparatus according to one embodiment of the present disclosure;
[0033] FIG. **6** is a perspective view of the chassis component of a vertical dual-cylinder cable pulling apparatus according to one embodiment of the present disclosure;
[0034] FIG. **7** is a side elevational perspective view of the chassis component in FIG. **6**;
[0035] FIG. **8** is a rear view of the chassis component in FIG. **6** with the back plate removed;
[0036] FIG. **9** is a side perspective view from below of the chassis component in FIG. **6**;
[0037] FIG. **10** is a side perspective view from below of the chassis component in FIG. **6** with the side wall removed;
[0038] FIG. **11** is a cross-section of the chassis component of FIG. **6**;
[0039] FIG. **12** is a side view of the chassis component of FIG. **6**;
[0040] FIG. **13** illustrates optional shims for use in a chassis component according to one embodiment of the present disclosure;
[0041] FIGS. **14**A and **14**B, respectively, are a side view and cross-section view of a cylinder component according to one embodiment of the instant disclosure;
[0042] FIG. **15**A-**15**C are rear and sectional views of the cylinder component of FIG. **14**;
[0043] FIG. **16** is an exploded view of a cylinder component according to one embodiment of the present disclosure;
[0044] FIG. **17** is a front perspective view from below of a cylinder pulling bridge according to one embodiment of the present disclosure;
[0045] FIG. **18** is a perspective view of a cylinder gland retention mechanism according to one embodiment of the present disclosure;
[0046] FIG. **19** is an exploded view of the bridge of FIG. **17**;
[0047] FIG. **20** illustrates a gripper assembly according to one embodiment of the present disclosure;
[0048] FIG. **21** is an exploded view of the gripper assembly of FIG. **20**;

[0049] FIG. **22** illustrates an open path cable engagement means according to one embodiment of the present disclosure, in an open position for laterally receiving a cable;
[0050] FIG. **23** is a cross-section of the cylinder pulling bridge of FIG. **17**;
[0051] FIG. **24** is another exploded view of the cylinder bridge of FIG. **17**;
[0052] FIGS. **25**A-**25**C are various views of a chassis bridge cable gripper assembly and receiver according to one embodiment of the present disclosure;
[0053] FIG. **26** illustrates elastomer tensioning means according to one embodiment of the present disclosure;
[0054] FIG. **27** is a perspective view of an open-path cable alignment device in the vertical, open position, according to one embodiment of the present disclosure;
[0055] FIG. **28** is a perspective view of an open-path cable alignment device in the horizontal, closed or “guide” position, according to one embodiment of the present disclosure;
[0056] FIG. **29** illustrates an open-path cable alignment device according to one embodiment of the present disclosure on a pulling apparatus and in an open position for laterally receiving a cable;
[0057] FIG. **30** illustrates the cable alignment device of FIG. **30** in a horizontal, closed or “guide” position;
[0058] FIG. **31** is an exploded view of a cable alignment device according to one embodiment of the present disclosure;
[0059] FIGS. **32**A and **32**B illustrate a cross-section of a cable alignment device in the vertical, open position, according to one embodiment of the present disclosure;
[0060] FIGS. **33**A and **33**B illustrate a cross-section of a cable alignment device in the horizontal, closed or “guide” position, according to one embodiment of the present disclosure;
[0061] FIG. **34** is an exploded view of one means for attaching a cable guiding device to a pulling apparatus, according to one embodiment of the present disclosure, and
[0062] FIGS. **35**A-**35**C illustrate components of an open-path cable alignment device according to another embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0063] Embodiments of the present disclosure provide improvements in devices, components, mechanisms and methods of use directed to means for pulling cable through space, particularly through space underground.

[0064] The subject matter defined in the appended claims is not necessarily limited to the benefits described herein. A particular implementation of the advancements to the art disclosed herein may provide all, some or none of the benefits described herein. Although operations for the various techniques may be described herein in a particular sequential order for the sake of presentation, it will be understood that this manner of description encompasses rearrangements in the order of operations, unless a particular ordering is required. For example, operations or acts described sequentially may in some cases be rearranged or performed concurrently.

[0065] For the purposes of the instant disclosure, the cable engaging face of the pulling apparatus is deemed to the front of the system, and the pit wall engaging face is deemed to be the back of the system. When an item is referred to herein as moving laterally or horizontally in the system it is moving along a vertical plane towards the back or the front of the system, as specified. When an item is referred to herein as moving vertically in the system, it is moving along a horizontal plane down towards the bottom or up towards the top of the system, as specified.

I. Cable Pulling Apparatus

[0066] Referring now to FIGS. **1-5**, various views of one embodiment of a cable pulling device or apparatus in accordance with the present disclosure is shown. In the figures, apparatus **10** comprises a vertical pulling system for pulling a cable **12** through space. As illustrated in FIG. **5**, the vertical pulling system comprises two detachable, engageable components: chassis component **100** and cylinder or cable pulling component **300**. Each component includes an open path cable engaging means, competent to receive a cable side surface laterally provided to the cable gripper assembly of the cable engaging means, as described in further detail below. The apparatus is compact, low weight, and occupies a small footprint in operation. The apparatus also has a low center of gravity and is not subject to tipping or vertical instability during pulling operation. As one non-limiting example, an apparatus with about 30 ton pulling force capability can have an overall weight of about 130-150 lbs, with each of the chassis and cylinder components weighing in the range of about 65-75 lbs. and competent to be hand-carried. The apparatus footprint can be about 12 inches wide, about 16 inches long. The overall height of apparatus can have a maximum range of between about 12-26 inches high during a cable pulling operation.

II. Integrated Chassis Component

[0067] FIGS. **6-13** illustrates features of chassis component **100**. Chassis component **100** can be an integrated system comprising a frame; a cable direction converting means; an open-path cable engaging means; an integrated cable vertical angle managing means, and means for receiving and engaging a cable pulling device.

Chassis Frame

[0068] In one embodiment, the chassis component frame can comprise back plate **110** and two parallel opposing foot plates **130** that extend forward from the bottom edge **116** of back plate **110**. Foot plates **130**, also referred to herein as floor plates, can be integral with back plate **110** or attached thereto by any standard means, including by bolting means **108**. Side wall members **120** also extend forward from back plate **110** and vertically upward from foot plates **130**, and can be attached thereto by any standard means, including by a plurality of bolts **118**. In the figures, bolts **118** connect side wall member **120** to the inside edge of foot plate **130**. It will be appreciated that side member wall **120** also can be attached to foot plate **130** by other means, including by bolting to upper surface **132** of foot plate **130**. Channel **140**, which defines the space between opposing foot plates **130** and side wall members **120**, can provide a channel through which cable **10** can be provided to the cable engaging means described below. A front brace **136** can provide support between the front edges of foot plates **130** and associated side wall members **120**.

[0069] Back plate **110** preferably can be a substantially solid plate that acts as a brace and a reaction plate when placed against the pit wall through which the cable protrudes. Opening **114** in back plate **100** provides an aperture through which cable **12** can pass. It will be understood by those having ordinary skill in the art that, if desired, back plate **110** or, alternatively, side member back edges **128**, also can be associated with an extraction cage or frame or other bracing means that can be placed between the pit wall and back plate **110**. An extraction cage or similar bracing means can provide a space for receiving the bursting pipe when it is pulled through the pit wall into the pit interior.

[0070] Side wall members **120** and, optionally, back plate **110** also can have one or more weight reducing openings or cuts **122**. Openings **122** also can serve as one or more handles for lifting and carrying or maneuvering chassis component **100** and/or apparatus **10**.

[0071] Chassis component **100** optionally can include means for receiving and engaging cylinder component **300**. In particular, chassis component **100** can comprise means for supporting and/or bracing hydraulic cylinders **600** of cylinder component **300**. In one non-limiting example, foot plate **130** optionally can include a recess **134** in its upper surface **132** dimensioned to receive and accommodate the circumference of cylinder **600**'s bottom surface.

B. Cable Direction Converting Means

[0072] FIGS. **8-12** illustrate a cable direction converting means useful in the chassis component and cable pulling apparatus of the instant disclosure. In the figures, the cable direction converting means can comprise a pulley wheel **142** having a center bore **154** competent to rotate freely about axle or shaft **170**. It will be appreciated that a bushing **174** can separate wheel bore **154** from shaft **170** and, if desired, a washer **172** can separate bushing **174** from the inner surface of chassis side member wall **120**.

[0073] Shaft **170** spans channel **140** and, in one embodiment, can be made stationary by attaching to side wall members **120** by any standard means. In the figures, side wall members **120** can comprise apertures **160** for receiving shaft terminal ends **150**. Shaft terminal ends **150** can be attached to side wall members **120** by standard bolting means **152**. Bolting means **152** can engage the side wall member directly or via axle cap **162** or other debris inhibiting aperture covering means.

[0074] In one preferred embodiment the cable direction converting means can include integrated lubricating means such that lubricating and/or anti-seize fluid or lubricant can be provided externally to the direction converting means without requiring disassembly of the mechanism. In the example where the direction converting means comprises a pulley wheel, means can be included for providing lubricant from an outside port to the shaft/bore interface, or the shaft/bushing interface. For example, as illustrated in the figures, bolting means **152** can include an integrated grease or Zerk fitting **164** and channel **166** through which a lubricating or anti-seize fluid can be supplied to an outlet or opening **168** on the shaft surface. It now is possible to lubricate the cable direction converting means as needed, before, during, and/or after use, without requiring disassembly of the mechanism. The integrated lubricating means can enhance device performance and efficiency in the field, as well as device maintenance, supporting product longevity.

[0075] Pulley wheel **142** can comprise a central groove or channel **144**, optionally with flanges **178**, and dimensioned to receive cable **12**. Wheel **142** also can include one or more weight reducing openings **146**. It will be appreciated that the position and dimensions of back plate cable opening **114**, the position of wheel shaft **170** on side member **120**, and the diameter of wheel **142** are such that horizontally positioned cable **12** is lifted off the ground when associated with pulley groove **144** and wheel **142** can rotate freely about shaft **170** when cable **12** is pulled vertically about wheel **142**. It also will be appreciated that preferred pulley wheel diameters can be determined and selected by a fabricator based on a number of standard considerations including, without limitation, choice of cable diameter, dimensions of chassis component, and pulling force parameters desired. As one non-limiting example, for low pressure flow vertical pulling systems of the present disclosure pulling cable in the range of at least about 0.5 inches to 0.9 inches in diameter, useful pulley wheel diameters can be in the range of at least about 6-16 inches, including in the range of about 8-14 inches.

[0076] Chassis component **100** also can comprise an open-path cable engaging means described in further detail below. Preferably, the open-path cable engaging means is housed in chassis bridge **200**. Preferably, bridge **200** can comprise a central section housing a cable gripper assembly receiver **204**, and also comprise means for receiving hydraulic cylinders **600**. For example, the cylinder receiving means can comprise concave recesses or brackets **216** at opposing ends of bridge **200**, the recesses dimensioned to mirror and receive at least a portion of the cylinder outer surface. In one preferred embodiment, recess **216** functions as a brace or support for cylinder **600** when integrated cylinder component **300** is in position on apparatus **10**. In the figures, bridge **200** includes an outward facing brace **216** at each opposing lateral terminal end **206** and the brace comprises a concave surface that mirrors the circumference radius of cylinder **600**.

[0077] Bridge **200** can be attached to the chassis frame by any standard means. Referring to FIGS. **12** and **13**, corresponding upper surface edges **121** of each side wall member **120** can be cut to provide a ledge **180** for receiving bridge **200**. Specifically, ledge **180** can comprise a horizontal lower surface or floor **181** on which the bottom surface **208** of bridge **200** can rest, and a vertical surface or wall **182** projecting up from floor **181**, against which the back surface **209** of bridge **200** can abut. Chassis bridge **200** can be attached to ledge **180** by any standard means, including by bolting. In the figure, bolting means **210** project laterally out from chassis bridge back surface **209** and into bolt holes **212** in ledge wall **182**.

C. Integrated Cable Diameter Management Means

[0078] Another feature of chassis component **100** includes integrated means for managing vertical cable angle. For example, given the tension on cable **12** during a pulling operation, cable integrity can become compromised if the cable angle deviates substantially from vertical or is otherwise caused or encouraged to kink or bend during pulling. One example of how cable angle can deviate in a vertical system is by cable wear on the pulley wheel. Specifically, the pulling operation could cause cable **12** to deepen cable groove **144** over time, altering the position of cable **12** relative to the rest of apparatus **10**, including a cable engaging mechanism in apparatus **10**. The shift in position could shift the cable angle from vertical, which could compromise cable integrity.

[0079] In vertical pulling systems in the art, wear on a pulley wheel groove typically has required replacement of the wheel. Another example where cable angle can vary is when the cable diameter is changed. Different pulling operations, for example when pulling different diameter pipe, can require different cable diameters for optimal cable pulling performance. In vertical pulling systems, varying cable diameter changes the relationship of cable **12** to pulley groove **144** and therefore to the vertical angle of cable **12** and the cable's position relative to pulling gripper means. Accordingly, in vertical pulling systems in the art, having the capability to use different cable diameters for different pulling operations generally has required having multiple pulley wheels available with different cable channel **144** radii, and selection of a cable with a different diameter typically has required changing the pulley wheel.

[0080] Apparatus **10** and chassis component **100** can overcome this deficiency in the art by providing a means for modulating vertical cable angle without requiring changing or otherwise altering pulley wheel **142**. In one embodiment, means are provided for modulating the position of chassis bridge **200** and its associated cable engaging mechanism relative to pulley wheel **142**. Referring to FIG. **13**, the position of bridge **200** on ledge **180** can be modified by adding shims **214** at the bridge/frame bolting interface, moving the position of bridge **200** and its associated cable engaging mechanism forward on the frame surface. In the figure, one shim is provided for each of the corresponding side wall members and includes openings for bolts **210** to pass through the shim and engage with bolt holes **212**. It will be appreciated that a desired degree of forward positioning can be achieved by varying the thickness of the shim, by providing a plurality of shims to each bridge/ledge interface, and/or by providing one or a plurality of single shims configured to span both side wall members. Accordingly, in one non-limiting example, an operator using a low pressure flow vertical pulling system of the present disclosure with pulling forces in the range of at least about 28 tons now can utilize cables having diameters in the range of at least about 0.5-0.9 inches, including in the range of at least about 0.56-0.875 inches, without changing the pulley wheel.

III. Integrated Cylinder Component

[0081] Referring to FIGS. **6** and **14-18**, features of integrated cylinder or cable pulling component **300** are described. Cable pulling component **300** can be an integrated system comprising a cable pulling mechanism, an open path cable-engaging mechanism, and a hydraulic system for providing and managing hydraulic power for driving the cable pulling mechanism. In one preferred embodiment, the hydraulic system can be integrated into, and comprises part of, the cable pulling mechanism.

Cable Pulling Cylinders

[0082] The cable pulling mechanism of component **300** can comprise a pair of hydraulic cylinders **600**. In one embodiment, cylinders **600** are coupled such that they are parallel and laterally opposed. In another embodiment, cylinders **600** can be coupled to one another by means of bridge **400**. Bridge **400**, also referred to herein as the “pulling bridge,” preferably can house an open-path cable engaging mechanism described in more detail below. In one preferred embodiment, bridge **400** can comprise a central section **414** housing a cable gripper assembly receiver **416**. Bridge **400** also preferably can include two parallel, opposing extensions **412**, each extension comprising means competent to engage a cylinder **600**. In another embodiment, at least one bridge extension **412** can include an integrated hydraulic pressure gauge display **530** competent to display fluid pressure inside cylinders **600**. In one preferred embodiment, display **530** can be embedded in extension **412** such that the display surface is flush with, or recessed in, an upper surface of extension **412**.

[0083] Hydraulic cylinder **600** can comprise a substantially hollow cylinder body accommodating gland **604**, rod **614**, and piston **616**. It will be appreciated that double-acting, single ended cylinders can be used to advantage in the cable pulling devices of the present disclosure. It also will be appreciated that piston **616** and associated piston seal **618** effectively separate the substantially hollow cylinder body interior into two reservoirs for receiving hydraulic fluid: barrel or rod-end reservoir **612** which occurs above piston **616**, and piston or cap-end reservoir **620**, extending below piston **616**. Gland **604** preferably can include a central aperture or bore **606** on its surface through which rod **614** can pass. Hydraulic cylinders **600** can be coupled with the cable engaging mechanism by standard means, preferably by attaching the top terminal end **608** of rods **614** to pulling bridge **400**. For example, bolting means **470** can engage with bolt holes **628** on top terminal rod end **608**. It will be appreciated that the bottom terminal end of rod **614** can extend into or through piston **616** and include a rod cap **622**.

[0084] In operation, fluid is delivered to and removed from barrel or rod-end reservoir **612** by a barrel reservoir delivery port **522**, also known as a rod-end port. Similarly, fluid is provided to and removed from piston or cap-end reservoir **620** by piston reservoir delivery port **520**, also known as a cap-end port. Typically, the power means for delivering fluid to a desired port is provided by an associated hydraulic pump, which can include an electric or gas-powered motor, and a selector valving means for controlling fluid direction. An external reservoir means also can be included which can house the fluid to be delivered to a port and receive fluid extracted from a port.

[0085] It will be appreciated by those having ordinary skill in the art that fluid delivery into piston reservoir **620** and out of barrel reservoir **612** pushes piston **616** up the cylinder body interior. This action provides the cable pulling stroke, pushing rod **614**, and associated pulling bridge **400** and cable engagement mechanism, upward. When the cable engagement mechanism is engaged with a surface of cable **12** as described in more detail below, the pulling stroke pulls cable **12** upward or vertically. In the recovery stroke, initiated when piston **616** is at or near the top of barrel reservoir **612**, fluid is removed from piston reservoir **620** and provided to barrel reservoir **612**, effectively pushing piston **616** and coupled rod **614** down the cylinder body interior. During the recovery stroke the cable engagement mechanism preferably is disengaged from the surface of cable **12**, and downward movement of rod **614** and associated bridge **400** occurs independent of cable **12**. Preferred pulling and recovery strokes lengths can vary at least by the cylinder volume, hydraulic pressure, rod lengths, and rod and piston weights selected. Useful operational stroke length ranges typically can be in the range of at least about 3-16 inches. One useful stroke length can be at least in the range of about 6-12 inches, including about 10 inches.

[0086] In one preferred embodiment, the hydraulic powered cable pulling system provided herein can provide pulling forces of at least about 28 tons and above and operates under low fluid pressure, typically at least in the range of about 2,400-3,000 psi. It will be appreciated by those skilled in the art that low pressure hydraulics have the advantages of higher flow per power unit output and reduced friction and wear on component parts, as compared with corresponding high pressure units using pressures over 3,000 psi, including pressures in the range of at least about 3,600-10,000 psi. Another advantage of low pressure pulling units is that the power source for moving hydraulic fluid in and out of cylinder body **602**, also known as the hydraulic pump, generally can reliably be supplied completely by standard field equipment motors already intended for use at a job site independent of pipe materials, pipe, diameters, routes and ground conditions of a given cable pulling job. Examples of useful field equipment motors can be found in a compact or mini-excavator, tractor, backhoe, front loader and the like. By contrast, high pressure units, including units requiring pressures over 3,000 psi and/or pressure ranges of at least about 3,600-10,000 psi, require special hydraulic pump motors to reliably run the unit in a range of operational field conditions, including variable ground conditions, and/or having the capacity to accommodate a range of pipe diameters and pipe materials to be pulled. Special hydraulic pumps have several disadvantages for a consumer or operator, including additional equipment purchase expense and maintenance, and constituting an additional component to be transported to and from a job site.

[0087] The hydraulic cylinders disclosed herein can provide desired pulling forces using high flow, low fluid pressures without compromising the compact size and weight that a low flow, high pressure pulling unit potentially can offer. In one embodiment, illustrated in FIGS. **14-15**, the desired compact cylinder size and weight can be achieved by reducing the weight of rod **614**. In one example illustrated in the figures, rod **614** can be fabricated to comprise a substantially hollow interior cavity **630**. Cavity **630** can be created by any standard means, including, for example, by gun-drilling rod **614**. Those skilled in the art can calculate useful parameters for cavity **630** without undue experimentation. Useful rod cavities **630** can be fabricated for example having wall thicknesses in the range of at least about 0.15-0.35 inches. In one non-limiting example, for a cylinder **600** useful for pulling cable with a pulling force in the range of about 28-32 tons as described herein, cylinder **600** can have a volume in the range of about 80-90 cubic inches, including, without limitation, about 80 cubic inches, and a square area in the range of about 9-10 inches, including, without limitation, a square area of about 9.6 inches, and cavity **630** can have a wall thickness of about 0.25 inches. In this example, cylinder **600** can have a weight of less than about 20 lbs, including in the range of about 16-19 lbs, including about 18 lbs. The cylinder pair together can have a weight of less than about 40 lbs, including in the range of at least about 32-38 lbs, including about 36 lbs; a useful combined volume of about 170 cu. inches; combined square area about 19.2 inches; and a stroke speed of about 1.6 inches/second, or about 8 ft/min, at 10 gpm.

[0088] In another non-limiting example, for a cylinder **600** useful for pulling cable with a pulling force at least in the range of about 75-85 tons, the cylinder pair together can have a useful combined volume of about 564 cubic inches, a square area of about 56.4 inches, and a stroke speed of about 0.66 inches/second, or 3.4 ft/min, at 10 gpm.

C. Hydraulics

[0089] Rod cavity **630** also can provide a means for integrating hydraulic pressure measurement means in the interior of pulling component **300** thereby reducing potential damage to the measurement means that can occur with an externally fixed fluid pressure measuring means. In one example illustrated in FIGS. **14-16**, pressure gauge readout display **530** can be embedded in pulling bridge extension **412**, and operationally coupled to pressure gauge channel **532** that extends down through cavity **630** and terminates in gauge port **534**.

[0090] In the non-limiting examples illustrated here, male and female quick-connect coupler ports **516** and **514**, respectively, can transmit fluid delivered by hydraulic pump (not shown) to and from ports **520** and **522**. In one embodiment, a hydraulics manifold **500** can house couplers **516** and **514** and channel means for transmitting fluid between the couplers and the ports. Hose **518** can provide means for transmitting fluid from manifold **500** to cap-end port **520**. It will be appreciated that one quick-connect coupler can be associated with the two cylinder cap-end ports, and the other coupler can be associated with the two rod-end ports such that piston movement through both cylinders is synchronized and in the same direction. Hydraulics manifold **500** can be coupled to cylinder component **300** by any standard means. In one non-limiting example, manifold **500** can be coupled to cylinder gland **604** by standard bolting means including, for example, by bolts **512** that engage with bolt receiving apertures **511** on gland **604**. In one embodiment, the manifold receiving outer surface of gland **604** can include a ledge or shelf **610** dimensioned to receive and mate with the bolting surface of manifold **500**. Engaging manifold **500** with gland **604** can have the added benefit of inhibiting vertical movement of gland **604** during cable pulling operation. Alternatively, other means can be provided for limiting cylinder and/or gland movement if needed. In one non-limiting example, illustrated in FIG. **18**, a rotatable retention arm **426** can be provided on chassis bridge **200**, preferably engaged with a top lateral surface edge of bridge **200** adjacent cylinder **600** such that retention arm can rotate over and extend onto cylinder gland upper surface **609**. When not in use, retention arm **426** can be rotated back over bridge **200**.

IV. Open-Path Cable Engaging Means

[0091] Exemplary open path cable-engaging means and mechanisms now will be described. In the examples, the mechanism is the same for the cable engaging means contemplated for chassis bridge **200** and for the cable engaging means contemplated for cylinder pulling bridge **400**. Accordingly, while the cable engaging means examples illustrated and described hereinbelow are primarily in reference to the mechanism for pulling bridge **400**, the same mechanism and components apply to the cable engaging means on chassis bridge **200**. Further, identically referenced components in the two bridges are understood to be functionally equivalent.

[0092] Referring now to FIGS. **19-26**, an open path cable engaging means is described, competent to receive and engage a cable side surface laterally provided to the engagement means. The open path cable engagement means disclosed herein includes an independent cable gripper assembly **417** and a receiver **416** located on a bridge and dimensioned receive and engage assembly **416**.

[0093] Cable gripper assembly **417** preferably can comprise a cable gripping device **484** comprising two opposing cable gripping members **423**, each member **423** being a mirror image of the other. Each cable gripping member **423** includes: (1) an inner, cable gripping surface **486**, dimensioned to contact and engage a cable surface, and (2) an outer side surface **474** dimensioned to contact and engage with an inner side surface **438** of receiver **417**, as described below. Preferably, inner gripper member surface **486** is substantially concave such that the two inner surfaces **486** of gripper members **423** together define a cable bore or channel **472** dimensioned to receive and engage a cable side surface. It will be appreciated that inner surface **486** preferably is textured to enhance the surface's ability to dig into or “bite” the cable. One common means for creating a “biting” texture on a cable gripping surface is by forming a threaded or grooved texture, also know as “teeth” on the cable gripping surface.

[0094] In one embodiment cable gripping device **484** can comprise a coupling means **464** for tethering gripper members **423** together. Coupling means **464** preferably can include: (1) a moveable joint or hinging means **465** competent to link gripper members **423** and also allow them to come together and move apart; and (2) an attachment means for attaching coupling means **464** to gripper device **484**. In one preferred embodiment coupling means **464** can be configured to have a low profile and/or lie substantially flush with a surface of assembly **417** and/or receiver **416** so as not to interfere with cable pulling operation. In another embodiment, hinging means **465** can be located near or about the back surface of gripper assembly **417**. As illustrated in the figures, one embodiment of coupling means **464** can include a hinge pin **444**, a pair of hinge arms **441** that extend out from hollow, interlocking knuckles or nodes **445** through which pin **444** passes, and bolt holes **448** at the free terminal ends of hinge arms **441** for receiving a bolt **446** that attaches coupler means **464** to gripper device **484**.

[0095] In another embodiment, gripper assembly **417** can include a handle means **432** useful for lifting, maneuvering, and positioning assembly **417** relative to receiver **416**. In one embodiment, handle **432** can extend forward horizontally from the front lateral surface of gripper device **484**. In another embodiment, handle **432** can extend forward horizontally from the front lateral surface of a gripper member **423**. Handle **432** can be integral to gripper member **423** or attached thereto by standard means, including by standard bolting means. In the figures, each gripper member **423** includes a handle **432**. It will be appreciated that, where a handle is desired, only one handle would be needed to maneuver and lift assembly **417**. Providing a handle **432** on each gripper member **423** can be useful for ease of function by an operator in the field. It also will be appreciated by those having ordinary skill in the art that handle **432** can have any shape and size. Preferred handle dimensions and shape considerations include ease of access and function by an operator, durability, and non-interference with other components during a cable pulling operation.

[0096] Gripper member **423** can comprise a single unit or include a gripper insert **420** and a gripper body **422**. A detailed description of gripper inserts is disclosed in co-pending U.S. patent application Ser. No. 15/681,048, filed Aug. 18, 2017, the disclosure of which is incorporated herein by reference. Using cable gripper inserts can be advantageous as it allows the gripper member's cable gripping surface and gripper body to be composed of independent materials best suited for each component's function. In particular, a cable gripper body typically is engineered and fabricated to absorb and sustain loads that cable pulling requires, and the ferrous metal selected, typically steel, preferably is soft enough to absorb these loads. Conversely, cable gripping surfaces preferably comprise a hard metal competent to maintain the texturing or “teeth” on the gripper surface that “bite” into the cable during a cable pulling operation. By selecting individual metals that best match the different function of gripper body **422** and gripper insert **420**, one can fabricate and/or select a gripper member **423** and cable gripping device **484** of enhanced integrity, longevity and stability. In the pipe bursting and trenchless pipe replacement industries, useful insert metals can include metals having a Rockwell rating greater than 62. Carbide steel, for example, may be used to advantage. Gripper bodies can be fabricated of a metal having enhanced load bearing capacity. Such metals may have a Rockwell hardness rating of 41 or below. In addition, a variety of metal curing or heat treatments can be used, particularly for the fabrication of gripper bodies. Moreover, by using removable inserts **420**, the longevity of gripper **423** is enhanced and conserved because only the insert needs to be replaced in the event the textured surface or teeth become worn on the cable gripping surface.

[0097] Referring to FIG. **21**, a gripper insert **420** can be removably coupled to gripper body **422** by, for example, mechanical engaging means. In one example, illustrated in the figure, a projection on one surface engages with a mirroring groove or slot on the other surface, as in a dovetail or key-and-groove type joint. In the figure, the projection, also referred to herein as the joint's key or tongue or dovetail **452** can extend down the outside side surface **453** of insert **420**. In the figure, projection **452** dimensionally matches a slot or groove or channel **450** that extends down the inner side surface **455** of gripper body **423** such that insert **420** is coupled to gripper body **422**. A pin **454**, including a compressible spring or roll pin, can be engaged to limit longitudinal movement of insert **420** relative to body **422**. Pin **454** preferably can engage a pinhole **456** on a front or back surface of gripper body **423** and enter an interior channel formed therein by pinhole **456** and horizontal gap or opening **458** in engaged slot **452**.

[0098] In the figures, cylinder bridge **400** includes a center section **414** that includes a receiver **416**, dimensioned to receive and engage independent cable gripper assembly **417**. Receiver **416** comprises a three-sided recess in center bridge section **414**, comprising laterally opposed side surfaces **438** and a back surface **439**. The three sides together define an overall shape that mirrors the shape of assembly **417** and are dimensioned to contact the corresponding side surfaces **474** and back surface **475** of assembly **417** when assembly **417** is seated in receiver **416**. Specifically, when assembly **417** is seated in receiver **416**, assembly outer side surfaces **474** contact receiver's inner side surfaces **438**, and assembly back surface **475** contacts receiver inner back surface **439**.

[0099] Receiver **416** further is open on its top, bottom and front surfaces. Accordingly, assembly **417** can be provided to, and removed from, receiver **416** by vertical movement through receiver **416**'s top opening, or by horizontal movement through its front opening. Conveniently, movement of assembly **417** in and out of receiver **416** easily can be manipulated by an operator, for example by holding handle **432**. Referring to FIGS. **22** and **23**, as gripper assembly **417** is lifted vertically from receiver **416** by, for example, handle **432**, linked gripper members **423** separate, creating a vertical opening or gap **476** in cable bore **472**. In this gripper device “open” position, also referred to herein as the “open-path” position, a cable can be provided to the cable bore interior by horizontally moving a cable **12** side surface from the bridge front surface, through vertical bore opening **476**, and into the bore interior. In the absence of an available open path positioning mechanism such as described here, providing cable to a cable engaging mechanism in a vertical system can require threading a cable free end **14** up through an available bottom opening. Threading a cable free end through a pulling apparatus can be cumbersome once the apparatus is assembled. The open-path mechanism disclosed herein can simplify the cable insertion process and enhance ease and efficiency of apparatus set up.

[0100] Assembly **417** and receiver **416** further can comprise mechanical coupling means that support their removable engagement with one another when assembly **417** is in position in receiver **416**. In one non-limiting example illustrated at least in FIGS. **19**, **20**, **22** and **23**, the mechanical coupling means can comprise a projection on a surface of the assembly or receiver that engages with a mirroring slot or channel on the engaging surface of the other component. In the figure, assembly **417** back surface **475** can comprise a projection, also referred to herein as a tongue or key **480** that extends at least partway down surface **475** and can engage with a slot or groove or channel **482** in receiver **416** back surface **439**. In one preferred embodiment, both gripper assembly **417** and receiver **416** can have an overall wedge or V-shape, and it will be appreciated that downward movement of assembly **417** through receiver **416** can be limited by this shape.

[0101] Receiver **416** further can comprise gripper assembly retention means that limit horizontal movement of assembly **417** in receiver **416**. Specifically, when in position, gripper assembly retention means are competent to prevent assembly **417** from moving out through receiver **417**'s front surface opening. Useful characteristics and features of gripper assembly retention means can include: (1) hand adjustable means for moving the retention means in and out of position, such that assembly **417** can be horizontally positioned in and out of receiver **416** when desired without requiring any component disassembly; (2) ease of access and function by an operator; (3) durability; and (4) non-interference with other components during a cable pulling operation.

[0102] One non-limiting example of a useful gripper assembly retention means is illustrated in FIGS. **17**, **22** and **23**. In the figures, a gripper assembly retention means comprises an elongated, rotatable retention arm **426** having top, free terminal end **490** and a bottom end **491** that can rotate about a pivot point **430**. Preferably, retention arm **426** can be located on the front surface **415** of bridge center section **414**, substantially adjacent a front edge of receiver **416**. Pivot point **430** also can comprise a bolting means for attaching retention arm **426** to bridge surface **415**. Retention arm **426** can be dimensioned such that, when it is in rotated into position it engages with at least part of the front surface of a gripper member **423**. Top, terminal free end **490** also can comprise a thumb screw **424** or other hand adjustable means for fastening retention arm **426** to gripper member **423** as desired. Thumb screw **424** can also function as a handling means for moving retention arm **426** in and out of position. Retention arm **426** and thumb screw **424** can be used to hold a gripper assembly in an “open path” position for cable insertion and extraction at the start and end of a cable pulling process, as illustrated in the examples below.

[0103] In the figures, a plurality of retention arms are illustrated, specifically a laterally opposing pair of retention arms **426** flanking the front side edges of receiver **416** are shown. In the figures, each arm is competent to rotate about its pivot point to engage at least part of a gripper member front surface. It will be appreciated that a single retention arm, competent to rotate about a pivot point and dimensioned to engage at least part of the front surface of both gripper members **423** also is contemplated. FIGS. **17** and **26** show retention arms **426** in the active, retaining position, engaging with gripper members **423**. FIG. **22** shows retention arms **426** in a storage position on bridge surface **415**, beyond the side edges of receiver **416**, and disengaged from gripper assembly **417**. It will be appreciated that retention arms **426** can comprise a flat solid surface, or include one or more weight reducing cuts.

[0104] Gripper arm **426** further can comprise means for limiting rotation about pivot point **430**. In one non-limiting example, illustrated for example in FIGS. **17**, **19**, **22** and **23**, retention arm **426** can include a cut-out or opening or aperture **494** dimensioned to receive and engage with a post **496** on manifold surface **415**. Aperture **494** can be configured and dimensioned such that, as retention arm **426** rotates about pivot point **430**, a portion of aperture **494**'s inner surface contacts or engages with post **496**, preventing further rotation of retention arm **426**.

[0105] The cable engagement means disclosed herein further can include integrated lubricating means such that lubricating and/or anti-seize fluid or lubricant can be provided externally to the contacting side surfaces of of assembly **417** and receiver **416**, namely sliding surfaces **475** and **438** and reduce friction therebetween, without requiring disengagement of assembly **417** from receiver **416**. In one non-limiting example, an integrated grease or Zerk fitting **418** can be provided to a surface of bridge **400**, preferably to a surface of bridge center section **414**. A lubricating or anti-seize fluid then can be supplied to an outlet or opening **442** on receiver side surface **438**, for example by means of a channel **440**.

[0106] In another non-limiting example, side surface **438** further can comprise a reservoir into which outlet **442** opens, such that lubricant provided through grease fitting **418** collects or is otherwise contained in reservoir **443** and can lubricate surfaces **438** and **475** during cable pulling operation. In the examples illustrated, reservoir **443** can comprise a groove or channel. It now is possible to lubricate the cable engaging means in a vertical pulling apparatus as needed during a cable pulling operation without requiring disassembly of the mechanism, thereby enhancing apparatus performance and efficiency in the field. Integrated grease fitting **418** can be positioned on any surface of the bridge where convenient for access and use. Useful locations can include a top surface of bridge center section **414** as shown, for example, on chassis bridge **200** in FIGS. **6**, **13** and **25**A-**25**C. Another useful location can include a bridge back surface, as shown on cylinder bridge **400** in, for example, FIGS. **23** and **24**.

[0107] The gripper engagement means disclosed herein further can include tensioning means for keeping gripper members **423** timed such that the force they each apply on a cable surface is substantially the same as they engage a cable surface during a cable pulling operation. In one embodiment, tensioning means can be provided by means of a tension-modulatable connection between gripper assembly **417** and manifold **414**. Useful tension-modulatable connections means can include, without limitation, an elastomeric, stretchable or spring-loaded connection means. In another embodiment, tension means can be provided by elastomeric, stretchable or spring-loaded connection between individual gripper members **423** and bridge section **414**. FIG. **26** illustrates one non-limiting example, where an elastomer **428** links handle **432** on gripper member **423** with retention arm pivot point **430** and/or its associated bolting means on bridge front surface **415**.

V. Open-Path Cable Guiding Means

[0108] Exemplary open-path cable-guiding means and mechanisms now will be described. FIGS. **27**-**35** illustrate exemplary, non-limiting open-pathway cable guide devices **700**. In the figures guide **700** can include a brace **710** and a guide body **712**. Extending forward from guide body **712** are two parallel, opposing arms **714** and **716**. Opening **717**, also referred to herein as a space or a gap defined by the distance between arms **714** and **716**, is dimensioned to receive a cable side surface laterally provided to opening **717**.

[0109] With particular reference to cable guiding means examples illustrated in FIGS. **27** and **28**, each arm **714** and **716** can have a top longitudinal surface **718** and a bottom longitudinal surface **720**. On one arm **714**, a cut-out **722** extends down from top longitudinal surface **718**. On opposing arm **716**, cutout **724** extends up from the bottom longitudinal surface **720**. Cut-outs **722** and **724** are each dimensioned to receive a cable side surface laterally provided to the cut-out. In one preferred embodiment, cut-outs **722** and **724** can have an overall concave shape. In another embodiment, the dimensions of cutouts **722** and **724** can be substantially equivalent.

[0110] In still another embodiment, arms **714** and **716** can be substantially inverted mirror opposites of each other. In the figures, cut-out **722** is associated with arm **714** and cut-out **724** is associated with arm **716**. It will be appreciated by those skilled in the art that, alternatively, cut-out **722** could be associated with arm **716**, and cut-out **724** could be associated with arm **714**.

[0111] In a preferred embodiment, guide body **714** can be attached to brace **710** so as to allow guide body **714** to rotate between a vertical, open-path position and a horizontal, closed or "guide" position. In the vertical, open-path position, illustrated in FIGS. **27** and **29**, arms **714** and **716** extend forward from guide body **712** in parallel vertical planes and gap **717** is available to receive the side surface of a vertically extended cable **12**. FIGS. **28** and **30** illustrates guide body **712** rotated into the horizontal, closed, "guide" position. Here, arms **714** and **716** extend forward from guide body **712** in parallel horizontal planes, and gap **717** is not available to receive the side surface of a vertically extended cable, the terminal free ends of arms **714** and **716** effectively blocking access. More particularly, when a vertically extended cable **12** is provided to gap **717** with guide body **712** in the vertical, open-path position, and the guide body then is rotated into the horizontal, guide position, cut-outs **722** and **724** can now receive side surfaces of cable **12**, effectively holding the cable in its vertically extended position. In this position, the terminal free ends of arms **714** and **716** effectively function as hooks that restrain or otherwise limit horizontal movement of a vertically extended cable forwards or backwards, or side to side. The capacity to limit horizontal or side to side movement of a cable, especially during a pulling operation is a valuable feature. Keeping a cable vertically aligned during a pulling operation can minimize unwanted wear or pull on a cable gripping mechanism.

[0112] In the figures, guide body **712** rotates clockwise relative to brace **710**, such that arm **714** is superior to arm **716**. It will be appreciated by those skilled in the art that device **700** also can be fabricated such that guide body **712** rotates counter-clockwise and arm **716** is superior to arm **714** in the horizontal, guide position. Guide body **712** can be connected to brace **710** by any useful rotating means. In one embodiment, illustrated in FIGS. **31-33**, guide body **712** can rotate about a shaft or stem **726** that extends from posterior end **730** of guide body **712** and fits in a bore or aperture **728** in brace **710**. The coupling of brace **710** to guide body **712** also can be by any useful means. In one embodiment illustrated in the figures, the two components can be secured together by a removable bolting means. Specifically, the terminal free end of shaft **726** can include an aperture **762**, which also can be threaded, for receiving bolt **760**. A cover plate **758** dimensioned to cover brace aperture **728** and having a central opening **757** through which a portion of bolt **760** can pass can be added to the bolting face **736** of brace **710**. Bolt **760** then can be threaded into shaft aperture **762** to couple guide body **712** to brace **710**.

[0113] In another embodiment, the rotating connection, coupling or attachment means also can include a locking means, such that guide body **712** can be reversibly locked into its vertical open or horizontal closed position. Characteristics of useful locking means include reversibility, ease of engagement and disengagement, durability and strength, especially to hold guide body **712** in the closed position during a pulling operation. It will also be appreciated that, while the horizontal and vertical positions illustrated here are 909 to one another, the locking mechanism or means also could be fabricated to lock the guide body at positions other than 0° and 90° if desired, including, for example, at 30° or 45°.

[0114] In the figures, an exemplary camming latch, also known as a compression latch or spring-loaded latch, is illustrated as an exemplary, non-limiting locking mechanism. Parts of a spring-loaded latch can include a compressible spring **740**, a spring compressing means **742** associated with spring **740** and competent to compress the spring, a latch or pin **744** having a latching or camming end **746**, and a rotational limiter that defines the maximum rotational path of the guide body. In the embodiment illustrated, the rotational limiter comprises a camming surface **748** on guide body terminal free end **738** along which pin **744** can slide during the rotation process, and a catch means **750** at one end of the camming surface that holds pin **744** in the latched position. In one embodiment, pin **744** also can comprise spring compressing means **742**.

[0115] In the embodiment illustrated, compressible spring **740**, spring compressing means **742** and latch pin **744** are positioned in brace **710** in a channel or recess **732** having a terminal free opening **737** into aperture **728**. In the figures, channel **732** comprises a groove open to bolting face **736** of brace **710** and which can be covered by a plate **754** removably secured to bolting face **736** by any standard means, including by bolts **756**. In another embodiment, at least part of compression spring channel **732** can be internal to brace **710** and spring **740**, compressing means **742** and latch pin **744** provided sequentially to channel **732** through terminal free end opening **737**.

[0116] In one embodiment, the superior end **746** of camming pin **744** comprises the latching means of the illustrated compression latch mechanism or assembly, and the inferior end of pin **744** comprises the spring compressing means **742**. In the embodiment illustrated, compressing means end **742** of pin **744** is in contact with and competent to compress spring **740**, preferably by means of a lever or handle **752** associated with pin **744**. For example, downward movement of handle **752** can push associated pin **744** down recess **732**, contacting and compressing spring **740**.
[0117] The terminal free end **738** of shaft **726** can comprise the rotation limiter means, namely a pin camming surface **748** and catch means **750**. As illustrated in the figures, the camming surface can be provided as a groove or cut along the shaft terminal free end outer edge along which camming pin end **746** can slide when spring **740** is compressed, allowing guide body **712** to rotate about stem **726** (here in a clock-wise direction). The length of groove **748** functionally dictates the degree of guide body rotation allowed. In the figures, camming surface **748** functionally constitutes a quarter or 90° turn. Again, as will be appreciated by those skilled in the art, alternative camming surface lengths and degrees of turn are envisioned and easily fabricated if desired without undue experimentation, in light of the instant disclosure.
[0118] In one alternative embodiment, camming surface **748** can comprise a groove cut into the outer surface of shaft **726** anterior to shaft terminal free end **738**. Similarly, in the figures, locking catch means **750** can comprise a recess cut into the shaft terminal free end from its outer circumference at one end of camping surface **748**, the recess dimensioned to receive pin latch end **746**. In an alternative embodiment, catch means **750** also can be fabricated as an internal recess anterior to shaft terminal free end **738** and accessible from the alternative embodiment camming groove described above.
[0119] In the embodiment illustrated in the figures, guide body **712** can be rotated into the vertical open position to receive a cable side surface as follows. Lever means **752** can be manipulated to push pin **744** down recess **732** and compressing spring **740**, allowing pin camming end **746** to access camming surface **748**. In this position, guide body **712** can be rotated into the vertical, open position, with pin camping end **746** sliding along camming surface **748**, its rotation limited by the camming surface terminus opposite catch means **750**, see, e.g., FIGS. **32**A and **32**B. When the guide body is in the vertical open position, a vertically extended cable can be inserted in the device through gap **717**. To place the device in the horizontal guide, or closed, position, guide body **712** is rotated counter-clockwise, with camming pin end **746** moving along camming surface **748** until pin **744** reaches catch **750**. Catch **750** is dimensioned to receive pin **744** and has a depth longer that the width of camming surface or groove **748**. The longer depth of catch **750** creates space for spring **740** to at least partially decompress when pin **744** is in catch **750**, pushing pin camming end **746** upward into catch **750** and past camping surface **748**. With camming surface **748** no longer accessible to pin **744**, guide body **712** can be functionally locked into the closed position. See, e.g., FIGS. **33**A and **33**B. Moving pin **744** downward into recess **732**, e.g. by means of handle or lever **752** to compress spring **740** can move pin **744** out of catch **750** such that pin camming end **746** is again available to slide along camming surface **748**, allowing guide body **712** to be rotated back into the vertical, open position.
[0120] It will be appreciated that other means and mechanisms for shifting cable guide device **700** between an open and closed position are contemplated and available to those skilled in the art, provided with the instant disclosure. Another exemplary, non-limiting, alternative embodiment is illustrated in FIGS. **35**A and **35**B. Here, an extractable pin mechanism can be used to secure guide body **712** to stem **726**, by means of a pin bore **768** that penetrates both guide body **712** and stem **726**. Extractable pin **770** can be positioned for vertical extraction as shown, or for lateral extraction, by altering the location of the bore hole **768** on guide body stem **726**. In still another embodiment, illustrated in FIG. **35**C, extractable pin **770** can comprise a spring loaded captive pin **771**.
[0121] FIG. **34** illustrates one means for attaching or securing device **700** to a cable pulling apparatus. In the figure, brace **710** is secured to gripper manifold **400** by standard bolting means,

including at least one or, more preferably, a plurality of bolts **766** that pass through bolt apertures **764** in brace **710** and manifold **400**.
[0122] In another embodiment, illustrated for example, in FIGS. **27** and **31**, guide body **712** can include at least one exterior bore or channel **702** through guide body **712** which can serve to reduce overall device weight. Bore **702** also can provide a means for securing a tether for carrying or transporting the device on its own or when it is attached to a cable pulling manifold.
[0123] In still another embodiment, one or more of the outer surfaces of guide **700**, including guide body **712** can be chamfered as illustrated in the figures for ease of manipulation, weight reduction and enhanced durability. Material considerations include durability and strength. Useful materials include: a steel, including a mild steel, such as a 10/18 steel. Other steels, including stainless steel, carbide-steel and heat-tempered steel, can provide the desired characteristics.
VI. Examples
[0124] The examples which follow make reference to components illustrated in the figures described above. It will be appreciated that the order of operations or acts described sequentially in the examples that follow may in some cases be rearranged or performed concurrently.
Apparatus Set Up
[0125] In one non-limiting example, integrated chassis component **100** and integrated cylinder component **300** are hand carried to an exit pit. Chassis back plate **110** is placed against the pit wall comprising a pipe to be replaced and through which a cable **12** has been threaded such that free cable end **14** extends from the wall into the pit. Cable **12** or free end **14** is provided to back plate cable opening **114** and through cable channel **140**. If desired, additional bracing means may be utilized to secure the position of chassis component **100** against the pit wall, including a reaction plate or other bracing means placed between chassis back plate **110** and the pit wall.
[0126] Integrated cylinder component **300** is lifted onto chassis frame of component **100** and positioned thereon such that cylinders **600** straddle chassis side wall members **120** and intervening chassis cable channel **140**, with each cylinder standing on a floor plate top surface **132**, preferably behind front brace **136**. Chassis bridge cylinder brace **216** receives and contacts the outer surface of cylinder gland **610**.
[0127] Hydraulic fluid hoses associated with a hydraulic reservoir and pump are connected to appropriate female and male quick-connect couplers **514** and **516** on hydraulics manifold **500** on integrated cylinder component **300**. If desired, lubricant or anti-seize fluid is provided to pulley wheel **142** and/or to the open path cable engagement mechanisms on chassis bridge **200** and cylinder bridge **200**, using grease or Zerk fittings **164** and **418**.
[0128] On chassis bridge **200** gripper assembly retainment arms **426** are rotated off their associated gripper assembly member **423**. Gripper assembly **417** is lifted vertically from receiver **416** by handle **432** until gripper members **423** separate sufficiently to create cable bore opening **476**. At least one retention arm **426** then is rotated back over its associated gripper member **423** and fastened to it, by means of thumb screw **424** thereby holding gripper assembly **417** in its elevated, open-path position. This operation is repeated with gripper assembly **417** on cylinder bridge **400** to also lift and hold that gripper assembly in an open position.
[0129] Free cable end **14** is pulled through channel **140** and lifted vertically such that cable **12** engages with cable groove **144** on pulley wheel **142** and pulley wheel **142** rotates about shaft **170** as cable **12** is pulled vertically. As cable **12** is lifted past chassis bridge **200** and cylinder bridge **400**, cable **12** can be moved horizontally into each bridge's gripper assembly bore interior through each bore opening **476**. Once in position, fastened retention arm **426** can be disengaged from gripper member **423** by loosening thumb screw **424**, and elevated gripper assembly **417** will be released down into gripper receiver **416**. Gripper handle **432** also can be used to assist moving gripper assembly **417** into position in receiver **416**. Cable **12** now is in position in pulling apparatus **10**.
[0130] Both pairs of gripper retention arms **426** on each of chassis bridge **200** and cylinder bridge

400 now are rotated back into an engaged retaining position. A tension elastomer **428** then is attached to each retention arm pivot point/bolting means **413** and its corresponding gripper member handle **432**, providing support in anchoring gripper members **423** in receiver **416** during pulling operation. The apparatus is now ready to begin a cable pulling operation.

[0131] In the event a cable alignment device **700** is attached to the pulling apparatus, for example to cylinder bridge **400** such that gap **717** aligns with cable bore openings **476** and **486**, cable **12** also can be moved horizontally into gap **717** when guide body **712** is in the vertical, open position. Guide body **712** then can be rotated into the locked horizontal, guide position such that cable **12** lateral side surfaces are received by cut-outs **722** and **724**.

2. Cable Pulling Operation.

Cable Pulling Stroke.

[0132] When an operator begins a cable pulling operation with apparatus **10**, hydraulic fluid is provided to piston or cap-end reservoirs **612** in cylinders **600** by hydraulic hose **518** and delivery port **520**. As piston reservoirs **612** fill with fluid, pistons **616** are forced vertically up their cylinder barrel interiors extending attached rods **614** vertically as well. As rods **614** extend vertically up from cylinders **600**, rods **614** push attached cylinder bridge vertically as well. As cylinder bridge **400** is lifted vertically, engaged cable **12** also is pulled vertically. It will be appreciated that, as cylinder bridge **400** is pushed up, cable gripper members **423**, which are engaged with the cable surface by means of the cable gripping “teeth” on the grippers' inner surface, are forced further down into receiver **416**. This counter-directional action is facilitated by the nested or mirroring V-shapes of receiver **416** and assembly **417**. The action also is facilitated by the preferably lubricated sliding contact between receiver side surfaces **438** and gripper assembly side surfaces **474**, and by the tensioning means provided by engaged elastomers **428**. The effect of the counter-directional action is to bind gripper assembly **417** to the cable so that the cable is pulled vertically as cylinder bridge **400** is lifted vertically.

[0133] It will be appreciated that chassis bridge **200** is stationary. Accordingly, there is no counter-directional action on the chassis gripper assembly and its associated receiver during the cable pulling stroke. As a result, the inner cable gripping surfaces of chassis component gripper assembly **417** do not “bite” down on the cable surface and chassis component gripper assembly **417** does not engage, grip or bind cable **12**. Accordingly, cable **12** can move freely through chassis component gripper cable bore **472** during the vertical cable pulling stroke. It also will be appreciated that vertical movement of cable **12** also is facilitated by pulley wheel **142**, which rotates about a preferably lubricated surface of shaft **170** or bushing **174**.

B. Recovery Stroke.

[0134] When pistons **616** are at or near the top of the cylinder barrel interiors, the hydraulic fluid direction in the cylinders is reversed. Hydraulic fluid is introduced into barrel or rod-end reservoir **612** through delivery port **522**, pushing piston **616** back down the barrel, and hydraulic fluid is released from piston reservoir **620**. As each piston is pushed back down the barrel interior it pulls its associated rod **614** with it, retracting rod **614** back into cylinder **600**. This action is called the recovery stroke.

[0135] As rods **614** are pulled back into cylinders **600**, they also pull down attached cylinder bridge **400** and cylinder bridge gripper assembly receiver **416** which is integral with bridge **400**. The downward movement of receiver **416** releases the counter-direction binding force between receiver **416** and gripper assembly **417**, and also releases the binding action of gripper inner surfaces **486** on cable **12**. As a result, gripper members **423** in cylinder bridge gripper assembly **416** disengage from the cable surface leaving cable **12** free in gripper bore **472** as cylinder bridge **400** travels downward with rods **614**.

[0136] The cable pulling stroke has a tendency to stretch cable **12** along its longitudinal axis as it is being pulled vertically. During the recovery stroke, when there is no pulling tension on cable **12**, the stretched cable can contract back towards its original length. The contraction process has an overall downwards pulling effect on cable **12**. The downward directional contraction of cable **12** has the effect of pulling chassis bridge gripper assembly **417** down into chassis bridge receiver **416** which engages the inner cable gripper surfaces of chassis gripper assembly **417** on the cable surface, binding the cable and preventing downward movement of cable **12** during the recovery stroke. The cable engagement means of chassis bridge **200** are understood to be a "holding" cable engagement means, preventing loss of cable pulling distances gained during the cable pulling stroke.

[0137] When piston **616** is at or near the bottom of cylinder **600**'s barrel interior, the hydraulic fluid direction in the cylinder is again reversed and another pulling stroke begins. As cylinder bridge **400** is pushed vertically by extending rods **614**, and cylinder bridge gripper assembly **417** again engages the cable surface and begins pulling cable **12** vertically. As cable **12** is pulled (and stretched), the downward directional contraction of cable **12** is eliminated, releasing the counter-direction binding force between chassis bridge receiver **416** and its associated gripper assembly **417**, as well as the binding action of gripper inner surfaces **486** on cable **12**. As a result, gripper members **423** in chassis bridge gripper assembly **416** disengage from the cable surface, leaving cable **12** free in chassis bridge gripper bore **472** as cylinder bridge **400** travels upwards with rods **614**.

[0138] The alternating pulling and recovery strokes are repeated until the cable pulling operation is complete. In the case of a pipe replacement operation, cable pulling is complete when a replacement or product pipe, typically introduced at an entry pit behind a bursting head attached to cable **12**, is pulled through the existing pipe to be replaced and into the exit pit.

[0139] While the examples provided herein illustrate the use of the vertical pulling system of the present disclosure in a pipe replacement application, it will be appreciated that the vertical pulling system of the present disclosure has application in any cable pulling operation where providing means for changing cable direction during the pulling operation is advantageous.

[0140] It will be appreciated by those having ordinary skill in the art that a variety of useful, well characterized materials are readily available for fabricating the components and apparatuses of this disclosure. Material choice will depend on the functionality of the item and the corresponding need for durability, strength and weight. For example, choosing an aluminum material, particularly a high strength aluminum, for components benefiting from low weight, including, for example, the chassis frame and pulling cylinders, can be used to advantage. One example of high strength aluminum can include 70/75 aluminum. For other components a steel, including a mild steel, stainless steel, carbide-steel and heat-tempered steel, can provide the desired characteristics.

[0141] Embodiments of this disclosure may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the disclosure being indicated by the appended claims rather than by the foregoing description, and all changes that come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. While illustrative embodiments have been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the disclosure.

Claims

1. A device for pulling cable horizontally through space, comprising: a cable pulling component comprising a pair of juxtaposed piston cylinders linked at the rod end of said cylinders and disposed about a cable gripping mechanism engaged with said rod end linkage, said linked cylinders having free terminal piston ends; a chassis component comprising rotatable means for converting a horizontal cable direction to vertical; a cable gripping mechanism vertically aligned with said rotatable means; and means for receiving said cable pulling component such that said free terminal piston ends straddle said rotatable means and said cable pulling gripping mechanism is vertically aligned with said chassis cable gripping mechanism; wherein each said cable gripping mechanism comprises a central cable passage bore and means for laterally inserting a cable surface into said bore.

2. The device of claim 1 having a cable pulling force of at least about 25 tons.

3. The device of claim 2 having a cable pulling in the range of at least about 28-100 tons.

4. The device of claim 1 wherein said cylinders operate with a low pressure flow rate.

5. The device of claim 1 wherein said cylinders operate with a flow rate in the range of at least about 2400-3000 psi.

6. The device of claim 1 further comprising means for measuring hydraulic fluid pressure from within a cylinder rod.

7. The device of claim 6 wherein said measuring means extends out the piston end of said cylinder rod interior.

8. The device of claim 1 wherein said cable pulling cylinder component further comprises internal means for measuring and displaying hydraulic fluid pressure.

9. The device of claim 8 wherein said measuring means is located within a cylinder rod interior.

10. The device of claim 8 wherein said display means is embedded in said cylinder rod end linkage.

11. The device of **11** wherein each said component has an overall weight in the range of least about 65-78 pounds.

12. The device of claim 1 wherein said cable direction converting means comprises a pulley wheel and shaft assembly.

13. The device of claim 12 further comprising a channel for providing lubricant from an exterior surface of said chassis component to a shaft engaging surface of said wheel.

14. The device of claim 1 wherein each said cable gripping mechanism comprises a stationary receiver attached to said component and a gripper assembly releasably engageable with said receiver.

15. The device of claim 14 wherein said cylinder component gripper assembly receiver is integral to said cylinder linkage.

16. The device of claim 14 wherein said gripper assembly receiver is competent to receive said assembly by vertical or lateral insertion.

17. The device of claim 14 wherein said receiver comprises a receptacle for said assembly comprising a back surface and opposing side walls extending forward therefrom, said walls angled to create a substantially wedge-shaped recess.

18. The device of claim 17 wherein said assembly comprises a central cable passage bore and lateral side walls dimensioned to engage with the opposing side walls of said receiver.

19. The device of claim 18 wherein said receiver further comprises a channel for providing lubricant from an exterior surface of said receiver to a gripper assembly engaging surface in said receiver.

20. An open path cable aligning device comprising: a cable guide body removably coupled to a brace and competent to rotate about said brace, said cable guide body competent to receive a side surface of a vertically extended cable and limit horizontal movement of the cable during a pulling operation.