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Maxwell et al.

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(54) **MECHANICALLY ADVANTAGED BAND CLAMP AND ASSOCIATED METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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US 2006/0205285 A1 Sep. 14, 2006

Related U.S. Application Data

(62) Division of application No. 10/948,328, filed on Sep. 22, 2004, now Pat. No. 7,052,331.

(60) Provisional application No. 60/505,475, filed on Sep. 25, 2003.

(51) **Int. Cl.**
H01R 4/42 (2006.01)

(52) **U.S. Cl.** .... **439/758**; 439/799; 439/764; 24/274 R

(58) **Field of Classification Search** .... 439/758, 439/799, 764, 100, 757, 795, 800; 24/274 R, 24/274 P, 19, 20 LS, 279
See application file for complete search history.

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Primary Examiner—Gary Paumen
(74) *Attorney, Agent, or Firm*—Charles A. Lemaire; Lemaire Patent Law Firm, P.L.L.C.

(57) **ABSTRACT**

An electromechanical connector for use between a power source such as a battery and a device requiring the power such as an automotive electrical system. In some embodiments, the connector includes a radius electrical contact constituting a primary electrical current path, and a band clamp with a slotted band constituting a secondary current path, and a worm drive adjustment assembly for symmetrically tighten the connector to the battery post. A kit is described having an electrical-contact conductor with a concave surface conforming to a battery post, and a band clamp to symmetrically compress the conductor against the post. Some embodiments provide a conductor that conforms to an outer portion of the post, and includes a band clamp mechanism with a band fixed at a non-moving end to the conductor, and at an opposite slotted end interfacing to a worm screw held against the conductor.

21 Claims, 7 Drawing Sheets

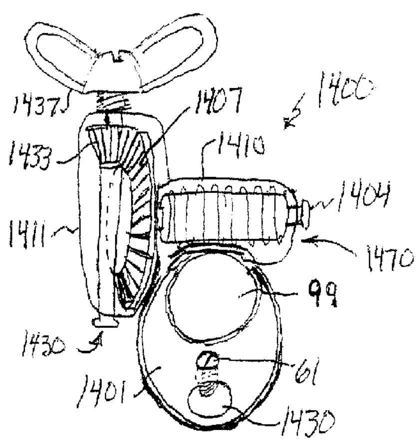

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FIG. 1A

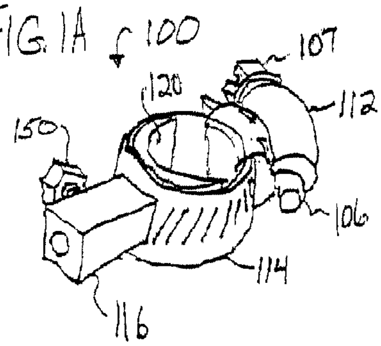


FIG. 1B

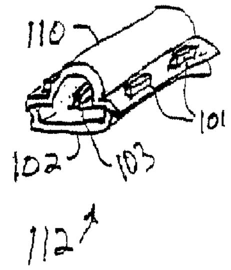


FIG. 1C

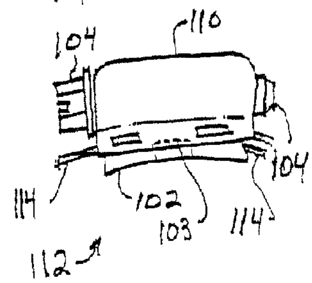


FIG. 1D

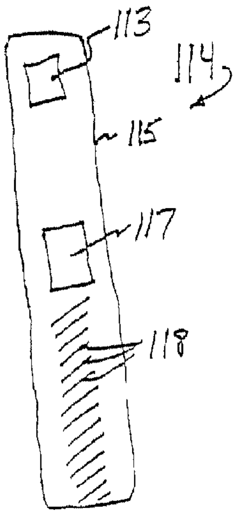


FIG. 1E

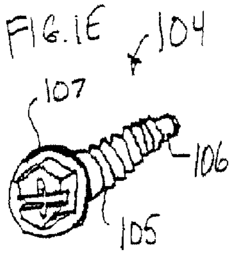


FIG. 1F

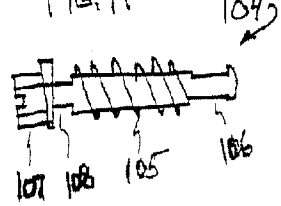


FIG. 1G

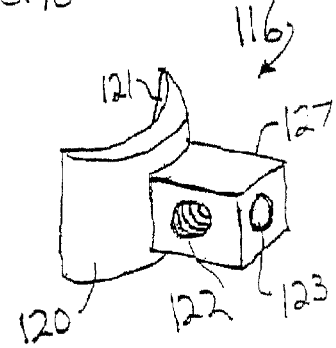


FIG. 2A

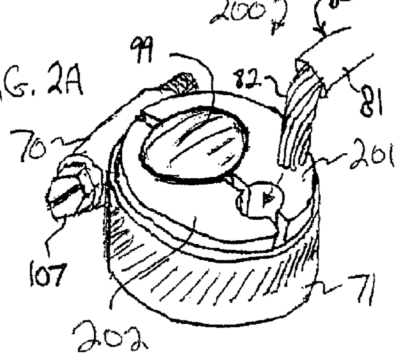
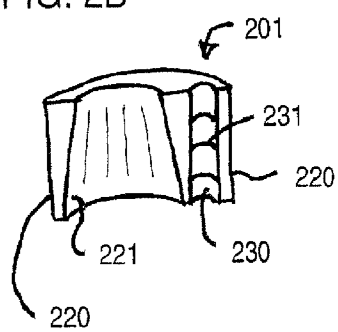


FIG. 2B



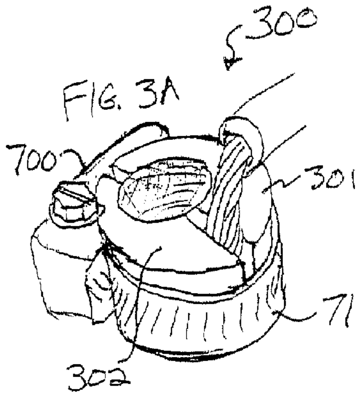


FIG. 3A
300
700
301
71
302

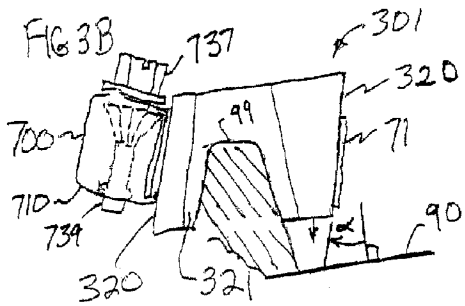


FIG 3B
737
301
320
700
99
71
710
734
90
320
321

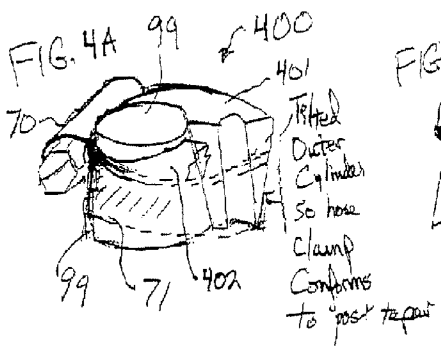


FIG. 4A
99
400
401
70
Tilted Outer Cylinder So hose Clamp Conforms to "post" taper
99
71
402

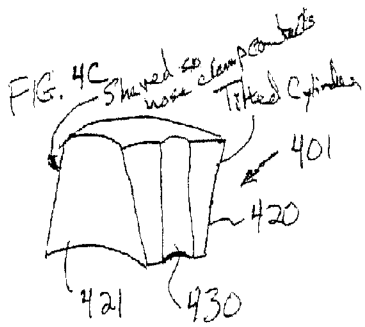


FIG. 4C
Shaved so hose clamp contacts
Tilted Cylinder
401
420
421
430

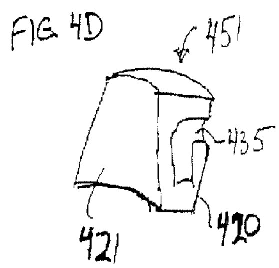


FIG. 4D
451
435
421
420

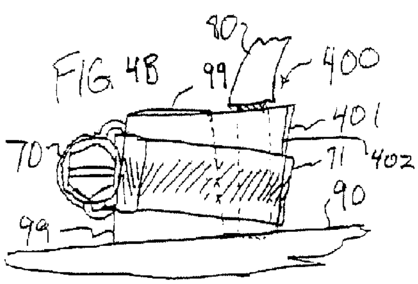


FIG. 4B
90
99
400
401
70
71
402
90
99

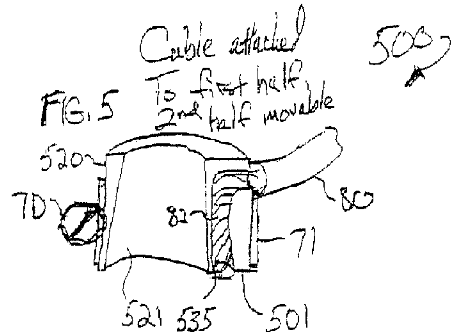

Cable attached To first half, 2nd half movable
500
FIG. 5
520
70
82
80
71
521
535
501

FIG. 6A

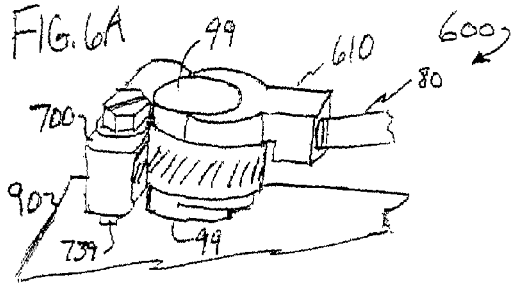


FIG. 6F

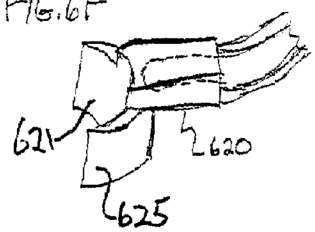


FIG. 6B

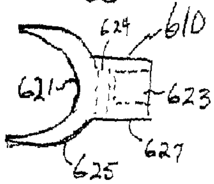


FIG. 6C

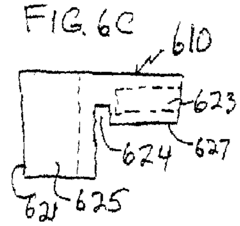


FIG. 6D

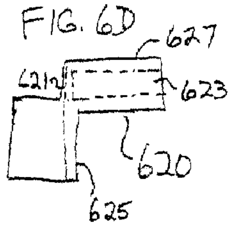


FIG. 6E

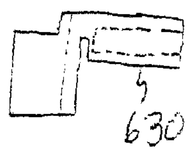


FIG. 7A

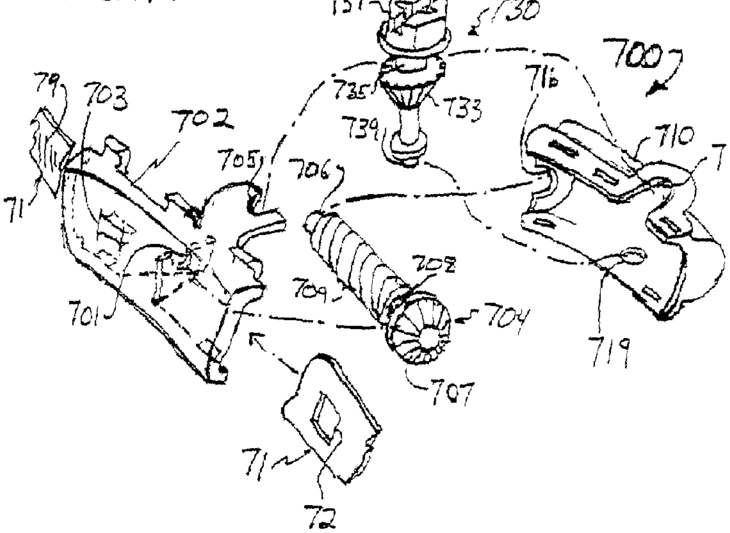


FIG. 7B

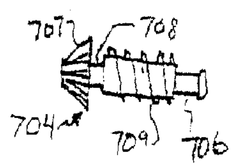


FIG. 7C

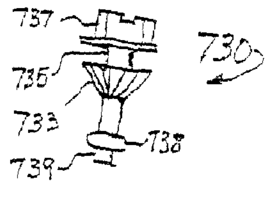


FIG. 8A

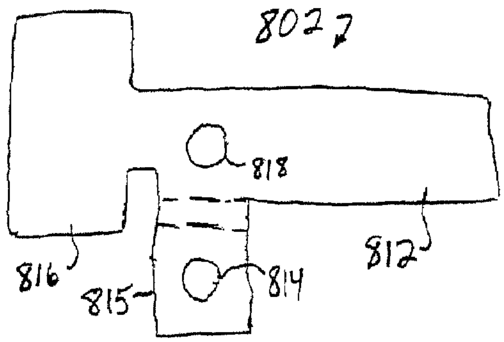


FIG. 8C

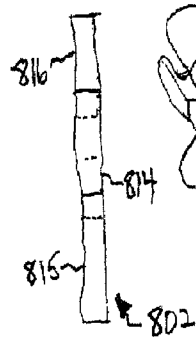


FIG. 8D

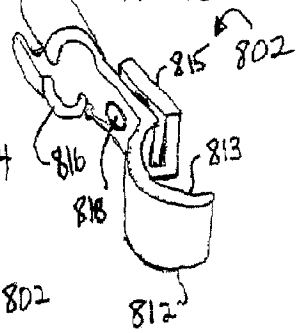


FIG. 8B

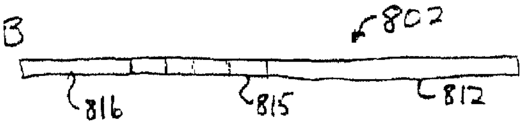


FIG. 8E

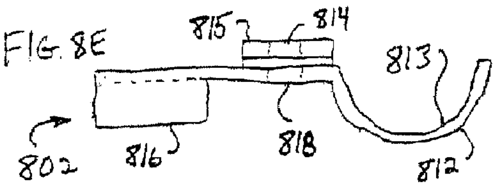


FIG. 8F

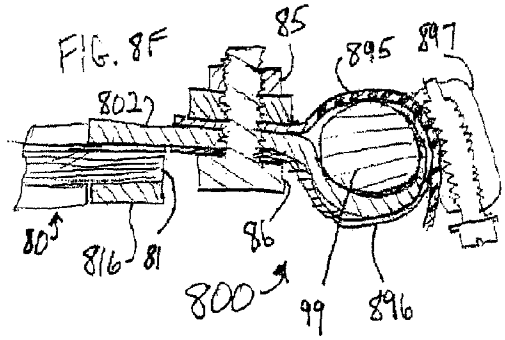


FIG. 8G

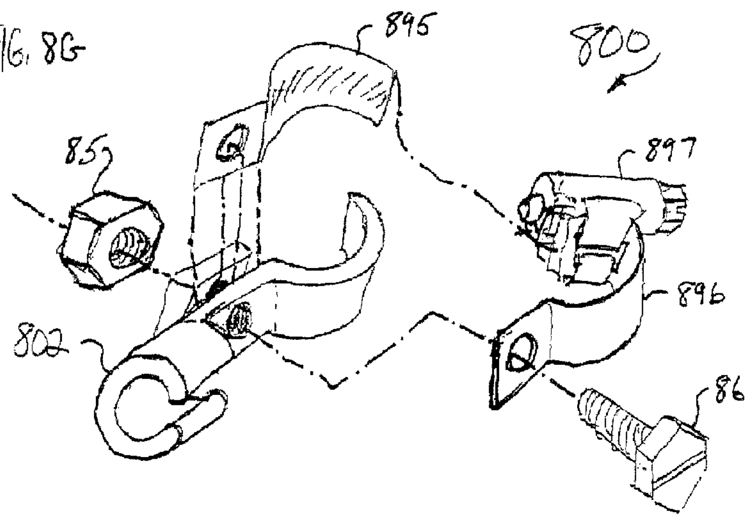


FIG. 9A

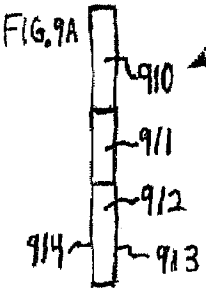


FIG. 9B

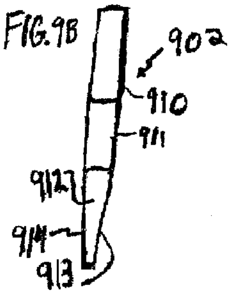


FIG. 9C

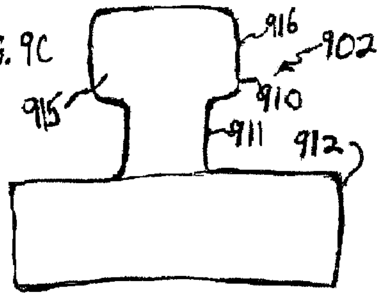


FIG. 9D

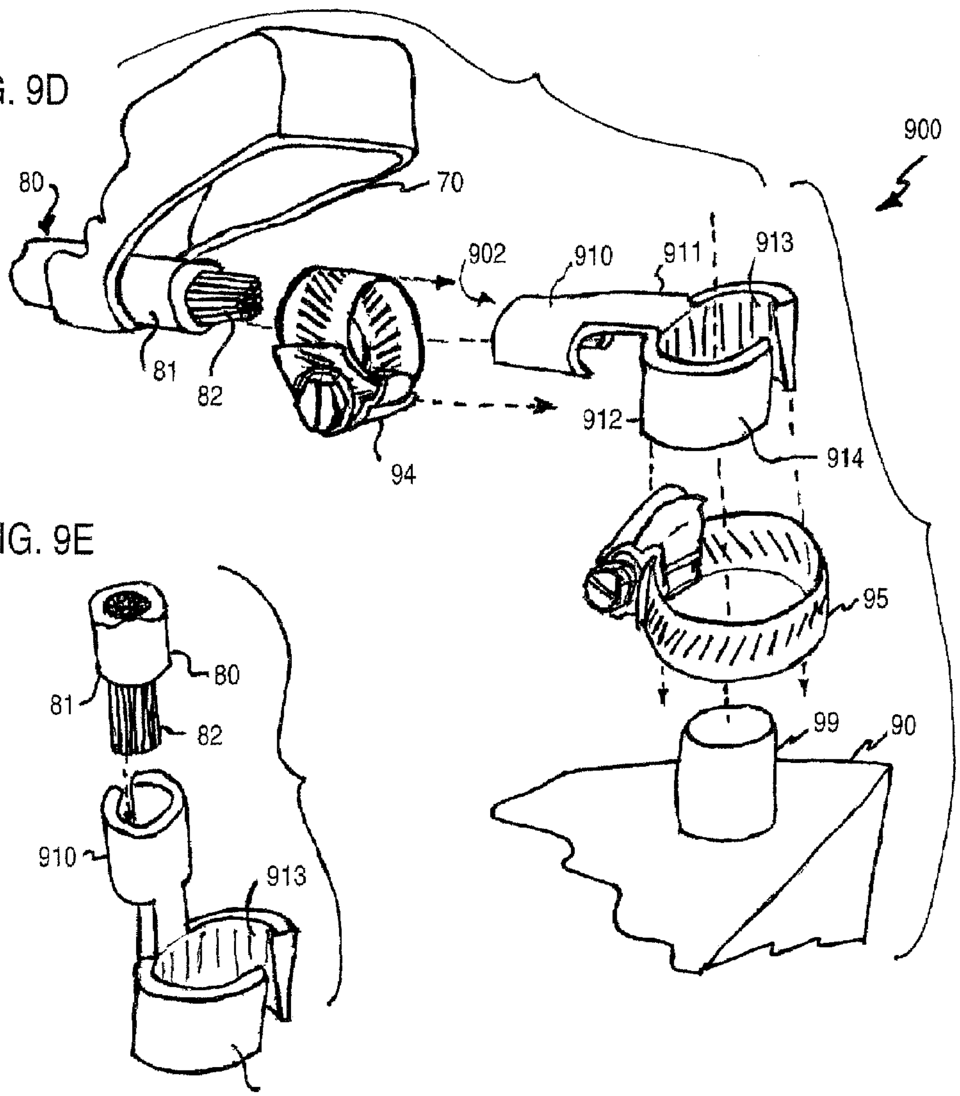


FIG. 9E

FIG. 10A

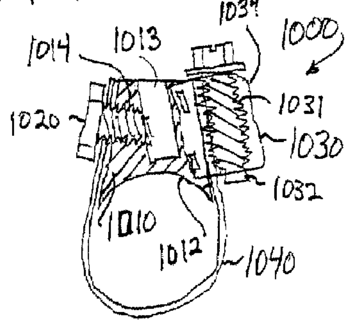


FIG. 10B

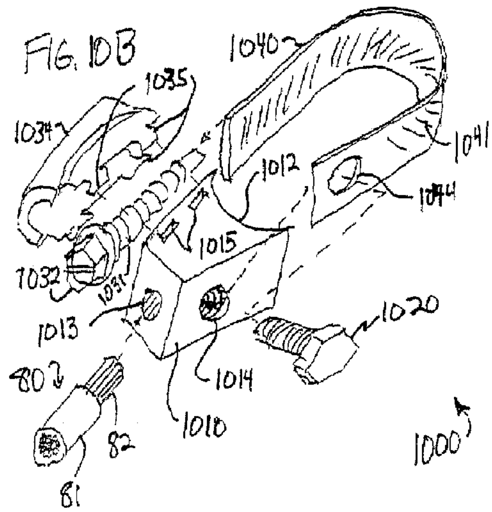


FIG. 11A

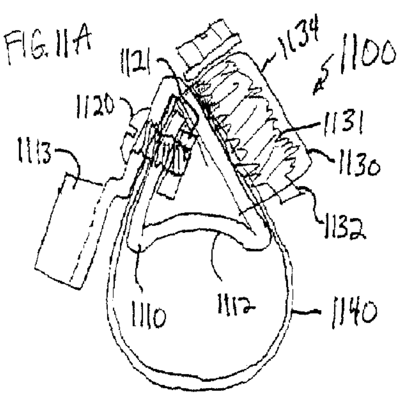


FIG. 11B

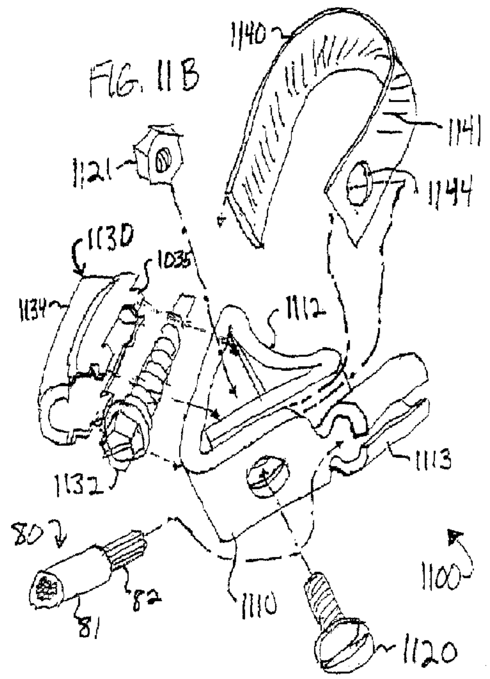


FIG. 11C

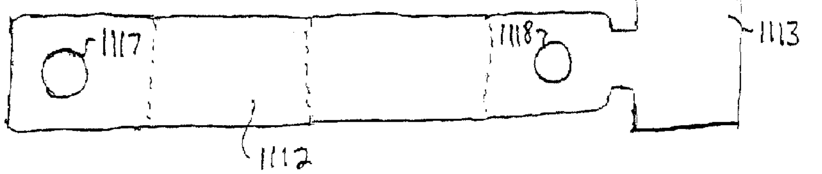


FIG. 12

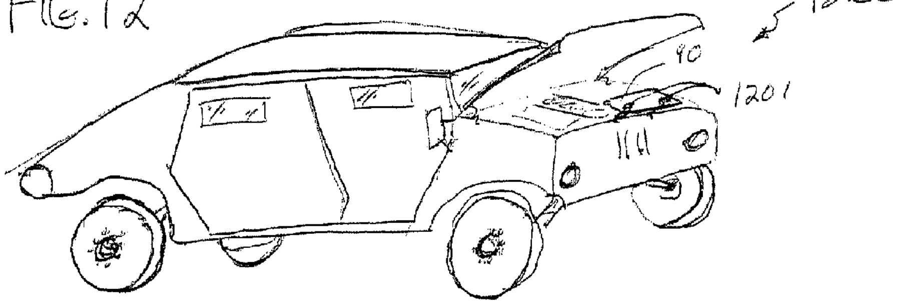


FIG. 13A

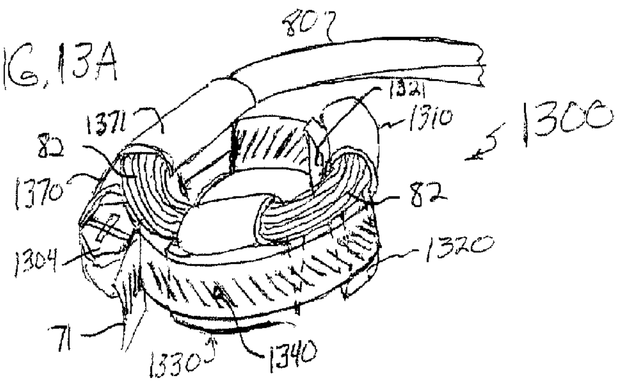


FIG. 13B

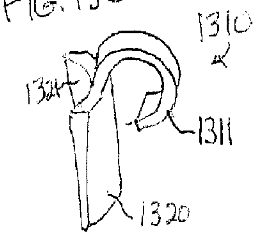


FIG. 14A

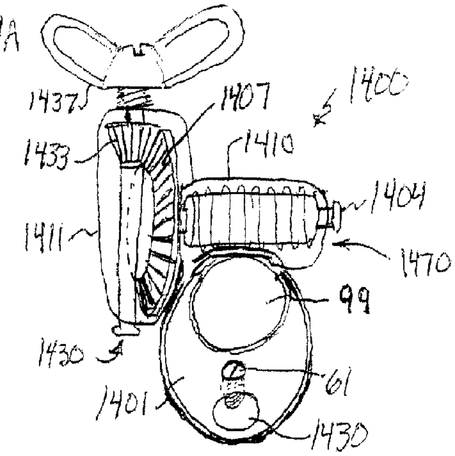
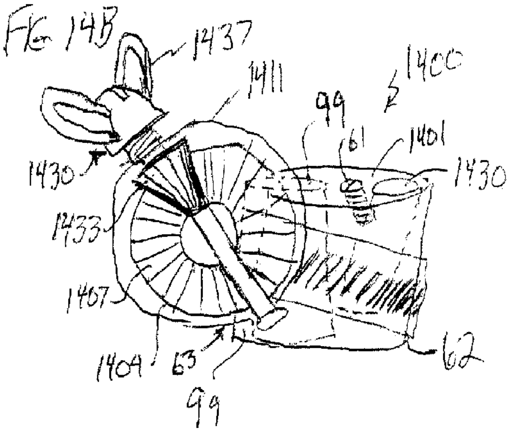


FIG. 14B



MECHANICALLY ADVANTAGED BAND CLAMP AND ASSOCIATED METHOD

RELATED APPLICATIONS

This is a divisional of U.S. patent application Ser. No. 10/948,328 entitled "SYMMETRICALLY ADJUSTABLE CORROSION-RESISTANT BATTERY CABLE CONNECTOR" filed on Sep. 22, 2004, now U.S. Pat. No. 7,052,331, which is incorporated herein by reference in its entirety, and which claims priority to U.S. Provisional Patent Application 60/505,475 with filing date Sep. 25, 2003, which is incorporated in its entirety by reference.

FIELD OF THE INVENTION

This invention relates generally to battery power systems and more specifically to symmetrically adjustable corrosion-resistant battery cable connectors and connection methods for automotive and marine battery power systems.

BACKGROUND OF THE INVENTION

Batteries typically are connected to their loads using a wire of suitable gauge terminated with a connector that is removably connectable to a battery terminal. Some conventional battery-post connectors provide a split-ring connector made of lead metal, having a tapered cylindrical primary opening, connected at a closed end to a cable wire, and having a steel nut-and-bolt fastener that passes through the open end and draws the two edges of the open end together when tightened, in order to provide a tight connection around the tapered cylindrical post of, for example, a lead-acid twelve-volt battery of a vehicle or watercraft.

Such battery-cable terminations historically have had problems with mechanical fit and deformation, material fatigue and breakage with use, and corrosion due to reactions with the battery electrolyte, road salt and fumes, and/or contact of dissimilar metals. Often, the nut and/or bolt will corrode, making removal and reattachment difficult. Even in cases where the bolt can be loosened, the C-shaped lead connector does not loosen by itself, but must be pried apart at its open end in order to remove it from a battery's post or to reinstall it. The loose fit of the cable-end connector on the post allows the interface between post and connector to oxidize, increasing resistance and making the battery difficult to charge and discharge properly. These problems result in either partial or complete failure of the terminal's primary function, which is to distribute adequate power to the battery-powered systems and loads.

Although there have been improvements made to help reduce the above problems by various means in the industry, the problems mentioned above still exist. Therefore, there still exists a need to make further improvements, especially in applications which are deemed critical as with military vehicles and civilian rescue vehicles.

SUMMARY OF THE INVENTION

The present invention addresses the aforementioned problem areas including mechanical fit, material fatigue and corrosive behavior. It also provides features to the connector that make it easier for the user to install, remove, and/or replace in the field.

The present connector provides symmetrical clamping to the battery-terminal post, ensuring good electrical contact. The configuration and the materials used in construction of the connector of the present invention reduce the tendency for it to fail as compared to other battery-terminal connectors. The tendency for corrosion to take place is reduced by the materials used and by limiting chemical seepage routes with the connector's symmetrically tight contact. The present design includes the added benefit of extreme ease of installation and removal with any one of several different tools. In some embodiments, the present invention uses materials that are less toxic and less harmful to the environment, as compared to conventional lead-based connectors.

In some embodiments, a replaceable conventional band clamp is used to surround the connector and the battery post of the lead-acid battery to which it is connected. In some embodiments, the band, the screw holder, and the screw that tightens the clamp are made of stainless steel, while the connector includes tin-coated copper for improved conductivity. In other embodiments, the conductor includes lead-brass alloy, lead-copper alloy, or a beryllium alloy, and optionally includes a radius contact plated with tin, silver, or brass.

As used herein, "band" and "strap" mean the same thing: a strong, relatively thin, strip of metal or other suitable material. In some embodiments, such a band is made of stainless steel and typically has a plurality of crosswise or diagonal slots that interface with a worm-drive screw's threads.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is described in detail below with reference to the following drawings.

FIG. **1**A is a perspective view that illustrates connector assembly **100** of some embodiments, including a worm drive adjustment assembly **112**, a slotted adjustment strap **114**, and a radius electrical contact **116**.

FIG. **1**B is a perspective view that provides detail of the worm drive adjustment assembly **112**, illustrating the worm drive screw housing **110**, and the adjustment strap guide **102**.

FIG. **1**C is a side view illustrating worm-drive screw **104** mounted within assembly **112**.

FIG. **1**D is a plan view that illustrates the slotted adjustment strap **114**.

FIG. **1**E is a perspective view of worm-drive screw **104**.

FIG. **1**F is a side view of worm-drive screw **104**.

FIG. **1**G is a perspective view of radius electrical contact **116**.

FIG. **2**A is a perspective view of a connector assembly **200** of some embodiments of the invention.

FIG. **2**B is a perspective view of electrical contact **201** of connector assembly **200**.

FIG. **3**A is a perspective view of a connector assembly **300** of some embodiments of the invention.

FIG. **3**B is a perspective view of electrical contact **301** of connector assembly **300**.

FIG. **4**A is a partially-cut-away perspective view of a connector assembly **400** of some embodiments of the invention.

FIG. **4**B is a partially-cut-away side view of a connector assembly **400** of some embodiments of the invention.

FIG. **4**C is a perspective view of electrical contact **401** of connector assembly **400**.

FIG. **4**D is a perspective view of electrical contact **451** that can be substituted in connector assembly **400**.

FIG. **5** is a perspective view of electrical contact **501** that can be substituted in connector assembly **200** of FIG. **2**A.

FIG. **6**A is a perspective view of a connector assembly **600** of some embodiments of the invention.

FIG. **6**B is a top view of electrical contact **610** of connector assembly **600**.

FIG. **6**C is a side view of electrical contact **610** of connector assembly **600**.

FIG. **6**D is a side view of electrical contact **620** that can be substituted in connector assembly **600**.

FIG. **6**E is a side view of electrical contact **630** that can be substituted in connector assembly **600**.

FIG. **6**F is a perspective view of electrical contact **620** that can be substituted in connector assembly **600**.

FIG. **7**A is a perspective exploded view of top-driven clamp **700** that allows actuating beveled-gear worm-drive screw **704** with vertically oriented beveled-gear head **730**.

FIG. **7**B is a side view of beveled-gear worm-drive screw **704**.

FIG. **7**C is a side view of vertical beveled-gear head **730**.

FIG. **8**A is a plan view, before folding, of a stamped-metal radius conductor **802**.

FIG. **8**B is an end view, before folding, of a stamped-metal radius conductor **802**.

FIG. **8**C is a side view, before folding, of a stamped-metal radius conductor **802**.

FIG. **8**D is a perspective view, after folding, of a stamped-metal radius conductor **802**.

FIG. **8**E is a top view, after folding, of a stamped-metal radius conductor **802**.

FIG. **8**F is a top cut-away view of a battery connector **800**.

FIG. **8**G is a perspective exploded view of a battery connector **800**.

FIG. **9**A is a side view, before folding, of a stamped-metal radius conductor **901**.

FIG. **9**B is a side view, before folding, of a stamped-metal radius conductor **902**.

FIG. **9**C is a plan view, before folding, of a stamped-metal radius conductor **902**.

FIG. **9**D is a perspective exploded view of a replaceable-clamp battery connector **900**.

FIG. **9**E is a perspective exploded view of a replaceable-clamp battery connector **904**.

FIG. **10**A is a top cut-away view of a battery connector **1000**.

FIG. **10**B is a perspective exploded view of a battery connector **1000**.

FIG. **11**A is a top cut-away view of a battery connector **1100**.

FIG. **11**B is a perspective exploded view of a battery connector **1100**.

FIG. **11**C is a plan view, before folding, of a stamped-metal radius conductor **1110**.

FIG. **12** is a perspective view of a vehicle **1200** that includes one or more battery connectors of the present invention.

FIG. **13**A is a perspective view of a connector assembly **1300** of some embodiments of the invention.

FIG. **13**B is a perspective view of electrical contact **1310** of connector assembly **1300**.

FIG. **14**A is a top perspective view of top-driven clamp connector assembly **1400** that allows actuating beveled-gear worm-drive screw **1404** with a mechanically advantaged gear ratio, vertically or side oriented, beveled-gear head **1430**.

FIG. **14**B is a side perspective view of clamp **1400** showing the gear end of beveled-gear worm-drive screw **1404**.

DETAILED DESCRIPTION OF THE INVENTION

In the following detailed description of the preferred embodiments, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration specific embodiments in which the invention may be practiced. It is understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

The leading digit(s) of reference numbers appearing in the Figures generally corresponds to the Figure number in which that component is first introduced, such that the same reference number is used throughout to refer to an identical component which appears in multiple Figures. Signals and connections may be referred to by the same reference number or label, and the actual meaning will be clear from its use in the context of the description.

FIG. **1**A is a perspective view that illustrates connector assembly **100** of some embodiments, including a worm drive adjustment assembly **112**, a slotted adjustment strap **114**, and a radius electrical contact **116**. Connector assembly **100** illustrates an exemplary battery-cable connector that makes significant improvements to battery power distribution systems in historically problematic areas. The assembly **100** includes a worm-drive adjustment assembly **112** that is mechanically coupled to a slotted adjustment strap **114**. As slotted adjustment strap **114** is tightened, its circumference is reduced and it compresses around a battery's electrical power post **99** (see FIG. **9**D) and a radius electrical contact **120**, which provides a primary electrical current carrying site as well as an attachment site **116** for the battery cable's electrical conductor wires.

One important feature of assembly **100** is its ability to conform to the round battery post. In some embodiments, the opening at the center of this connector assembly **100** is substantially round and cylindrical (or, in some embodiments, a tapered cylindrical shape, such as a conical section). As the worm drive screw **104** (see FIG. **1**E and FIG. **1**F) is rotated, the diameter of the connector is either expanded or contracted maintaining a substantially round opening. The slotted adjustment strap **114** (see FIG. **1**D) has an opening **117** for post **127** of electrical contact **116** to fit through, and is symmetrically expanded or contracted so as to equally distribute the stress of this action across its entirety. This prevents premature material fatigue experienced by some other connectors. In addition, since the shape of the opening can be substantially circular, for battery electrical power posts that are circular, mechanical fit or interfacing is optimized. Further, since a portion of the circumference of the battery post has only the band clamp, this portion can more easily conform to a post that happen not to be cylindrical (for example, if the post has been damaged).

Another important feature of assembly **100** is its ability to release from the battery post when the screw is loosened without having to pry apart the ends of the electrical conductor **116**. Some conventional battery-cable connectors are made from lead which is deformed in the process of attachment. This makes reattachment difficult, and the lead can be an environmental hazard. Some other connectors are assembled into a split-ring arrangement which places high stress 180 degrees from the split when detached. With both of these arrangements, future good fit is not guaranteed as deformation is likely to have taken place. With the connector **100**, deformation is small or does not occur with detachment and reattachment, so good fit is ensured.

To maintain good electrical contact, good fit is very important, since electrical conductance is defined by the resistance of the electrical contact area. Since mechanical fit is ensured by the subject connector **100**, electrical contact is improved.

In addition to mechanical fit, the condition of the interfacing materials influence the electrical resistance of those materials. The subject connector **100** is designed to have a primary and secondary conduction path to ensure conduction. The inner radius **121** of electrical contact **116** is the primary conduction path, and is in direct electrical contact with the battery post. In some embodiments, the material to be used for its construction is tin-coated copper. In other embodiments, brass plated copper, silver plated lead-copper alloy, silver plated copper, silver plated lead-brass alloy, or silver plated beryllium are used. The copper is used to be galvanically compatible with copper wire cables. The battery-contact surface is coated with and/or alloyed with tin so as to be galvanically compatible with a typical lead battery post. These materials reduce the tendency for corrosion to take place due to metal dissimilarity. In some embodiments, the primary contact is a highly electrically conductive material that is galvanically compatible with the battery terminal material and corrosion resistant, and the lug is a highly electrically conductive material that is galvanically compatible with the conductive cable and corrosion resistant.

At end **127** opposite the battery terminal contact surface **121**, the electrical contact **116** is adapted for connection to a wire cable for power distribution such as a solder-in socket, a set screw, a crimp connection, etc.

A secondary conduction path is provided by the slotted adjustment strap **114**. In some embodiments, strap **114** is in contact with the battery terminal over a large surface area. In some embodiments, this strap is made of a material that includes stainless steel. The stainless steel material, though initially having a higher resistivity than the radius electrical contact **116** material, will remain substantially uncorroded, and if the primary path is compromised, will provide a secondary conduction path. Extra assurance of a conduction path is especially important for certain battery-power installations that service human survival issues (i.e., military and emergency vehicles).

Since a tight mechanical fit is ensured, there is less tendency for foreign material to seep into the interfacing surfaces of the connector and the battery terminal. This is another element that ensures good electrical contact and conduction.

The present invention describes connectors that are inexpensive to build and easy to use, and have advantages over other conventional connectors. Embodiments if the invention such as shown in FIGS. **1A**-**1G** and FIGS. **8A**-**8G** have been tested in the vehicle of one of the inventors and been found to function better than other connectors he had encountered in the following ways:

It is extremely easy to install and remove using several different varieties of tools;

It conforms to the battery post better than the other connectors, at least in part because the slots in the clamp allow for some amount of a tapered clamping, so that even if the walls of the conductor (e.g., surfaces **120** and **121** if conductor **116** of FIG. **1G**, or surfaces **912** and **193** of FIG. **9D**) are parallel to one another, the surrounding band clamp (**112** and **114** of FIG. **1A**, or **95** of FIG. **9D**) can tighten to a tapered-cylindrical shape, in some embodiments.

It does not deform like lead connectors and is symmetrically adjustable, which others are not.

The clamp strap distributes the strain around in a hoop, so stress is not concentrated in one location like it is with other non-symmetrically adjusting connectors, and it will not break as soon as they ultimately do.

The copper contact is tin coated which keeps the contact from corroding and tin is close to lead on the galvanometric scale so electrolysis does not appreciably occur.

The stainless clamp provides a secondary electrical current path, which by his own experience in test, stays substantially corrosion-free, so reliability is much improved compared to other connectors. (After a year of test the connector showed “no” visible evidence of corrosion, electrolysis, discoloration due to heat, etc.

It also is environmentally friendly, whereas the popular lead connector is environmentally hazardous (e.g., the popular battery-terminal-cleaning wire brushes, when used to clean the inner surfaces of conventional lead-based connectors, scrape off and drop tiny particles of lead, lead oxides, and other lead corrosion, which end up falling to the floor or a garage or to the ground, where they may be ingested by a child or pet, or contaminate the soil).

Due to these advantages, the “mean time between failure” should be much greater than other connectors and qualify connectors of the invention for service in adverse and critical situations (e.g., military, marine, aircraft, rescue vehicles, etc.).

FIG. **1B** is a perspective view of adjustment housing **112**, showing detail of one embodiment of the worm-drive-screw housing **110** and the adjustment-band guide **102**. These parts hold the worm-drive screw **104** and the slotted-adjustment band **114** in mechanical communication and alignment. As discussed earlier, the rotation of the worm-drive screw **104** expands or contracts the diameter of the connector opening. This arrangement provides a connector that is much more easily attachable and detachable as compared to conventional connectors. To further enhance its ease of use, some embodiments of worm-drive screw **104**, as shown in FIG. **1E**, provide a slot for use with a conventional slotted screw driver, a cross slot for use with a conventional Philips-type screw driver and a hexagonal head for use with conventional hexagonal box end and sockets, open end and/or adjustable wrenches. This ease of use will be important in the field where choice of tools is restricted.

FIG. **1B** is a perspective view that provides detail of the worm-drive adjustment assembly **112**, illustrating the worm drive screw housing **110**, and the adjustment strap guide **102**. In some embodiments, strap guide **102** provides one or more tabs **103** that attach to band **114** through opening **113**. One or more other tabs **101** fasten strap guide **102** to housing **110**.

FIG. **1C** is a side view illustrating worm-drive screw **104** mounted within assembly **112**. Housing **110** has ends that secure to grooves in screw **104** and hold it in place while allowing it to rotate about its longitudinal axis.

FIG. **1D** is a plan view that illustrates the slotted adjustment strap or band **114**. In some embodiments, band **114** includes a thin stainless-steel strap **115** having a plurality of slots or embossed grooves **118** that interface to the threads of screw **104** to tighten or loosen the clamp, a hole **117** through which post **116** is inserted, and a hole **113** through which tabs **103** of strap guide **102** are bent to fixedly attach the band guide **102** to the band **114**.

FIG. **1E** is a perspective view of worm-drive screw **104**. In some embodiments, head **107** is made to allow driving from any one of a plurality of different tools; e.g., by providing a hex outside head, and inner grooves for both flat and Philip's head screwdrivers, in order to allow more flexibility in tool selection in field repairs.

FIG. **1**F is a side view of worm-drive screw **104**, showing hex head **107**, head groove **108** that rides in a slot in one end of housing **110**, and tip groove **106** that rides in a slot in the opposite end of housing **110**. Threads **105** interface to slots **118** in strap **114**.

FIG. **1**G is a perspective view of radius electrical contact **116**. Electrical contact **116** includes an inner radius surface **121** that has a concave cylindrical or tapered cylindrical shape to match the shape of post **99** to which it contacts, and a convex cylindrical shape to conform to the shape of the tightened band **114** while minimizing stresses that can occur if a non-cylindrical shape is used. Post **127** has a shape suitable to fit through hole **117**, while leaving a substantial width of band on either side for band strength. In some embodiments, a rectangular cross section is used, having a hole **123** into which the wire-conductor end **82** (see FIG. **2**A) of the battery cable **80** is inserted, and a threaded hole **122** into which a bolt **150** can be inserted to clamp against the wire-conductor end **82**. In other embodiments, other wire connection means are used, such as, for example, welding, soldering and/or crimping.

FIG. **2**A is a perspective view of a connector assembly **200** of some embodiments of the invention. In some embodiments, connector assembly **200** uses a conventional prior-art worm-drive band clamp **70** having a strap **71** that surrounds two complementary conductors **201** and **202**. In other embodiments, any other suitable types of band clamps (which are well known) can be substituted for worm-drive band clamp **70**.

FIG. **2**B is a perspective view of electrical conductor or contact **201** of connector assembly **200**. In some embodiments, conductor **201** includes a cylindrical or tapered cylindrical groove **221** that conforms to and tightens against a section of battery post **99**, and a cylindrical or tapered cylindrical groove **230** that conforms to and tightens against a section of wire conductor end **82**. In some embodiments, grove **230** includes one or more projecting ridges that help prevent wire end **82** from being pulled out, and enhance the conductivity of the connection. Band clamp **70** tightens conductor **201** towards conductor **202**, tightening against both battery post **99** in groove **221**, and against wire end **82** in groove **230**. In some embodiments, the outer surface **220** of conductors **201** and **202** are formed such that when installed on a post **99** and wire end **82**, the outer circumference forms a cylindrical shape to minimize stress on band clamp **70** and even out the forces applied.

FIG. **3**A is a perspective view of a connector assembly **300** of some embodiments of the invention. Connector assembly **300** is similar to connector assembly **200** of FIG. **2**A, however conductors **301** and **302** do not have a groove (such as **230**) for wire end **82**, but instead present substantially flat surfaces between which the wire end **82** is clamped. In some embodiments, a top-drive band clamp **700**, such as described in FIG. **7**A is used, allowing tightening and loosening from the top using a vertically-oriented screwdriver or other tool. This is particularly useful to enhance safety where geometric considerations preclude safe use of metal tightening tools (which can short electrical current to surrounding metal structures in a car) to a horizontal head **107** such as shown in FIG. **2**A.

FIG. **3**B is a perspective view of electrical contact **301** of connector assembly **300**, according to some embodiments of the invention. Note that in some embodiments, the outer surface **320** is a cylindrical shape, but not oriented around a vertical axis. Rather, the cylinder of the outer surface is tilted at an angle alpha, to provide a more convenient angle to the drive head **737** of clamp **700**, and to provide more clearance between the bottom end **739** of the worm screw and the top surface of the battery **90**. In some embodiments, inner battery-post groove **321** is cylindrical, while in other embodiments, groove **321** is a tapered cylinder to conform to the shape of battery post **99**. Because of the tilt of cylindrical surface **320**, the right-most lower edge of band **71** is closer to the top surface of battery **90** than is its left-most lower edge. Since the right-most upper edge is also lower, this allows the wire **80** to exit towards the left just above the upper edge of band **71**.

FIG. **4**A is a partially-cut-away perspective view of a connector assembly **400** of some embodiments of the invention. In some embodiments, a conventional horizontal-screw worm-drive band clamp **70** is used. In other embodiments, a top-drive band clamp **700**, such as described in FIG. **7**A is used, allowing tightening and loosening from the top using a vertically-oriented screwdriver or other tool. Connector assembly **400** is similar to connector assembly **300** in having a tilted-cylinder outer surface on conductors **401** and **402**, however the left edge of this outer cylinder **420** is shifted (or "shaved") to the right, and thus intersects the inner groove **421** leaving a much smaller portion of surface **421** to contact battery post **99**. This exposes a portion of post **99** to make direct contact to band clamp **70**, and provide an alternate current path through band **71** and other portions of clamp **70**.

FIG. **4**B is a side view of a connector assembly **400** of some embodiments of the invention. Connector assembly **400** includes a conventional band clamp **70** surrounding conductors **401** and **402** that press against post **99** of battery **90**, and against the conductors of wire **80**.

FIG. **4**C is a perspective view of electrical contact **401** of connector assembly **400**. Inner post groove **421** is made to only partially surround its half of post **99**, and intersects with cylinder surface **420** at a line that allows clamp **70** to contact post **99** as well. Groove **430** is provided to clamp against wire **80**.

FIG. **4**D is a perspective view of electrical contact/conductor **451** that can be substituted in connector assembly **400**. Conductor **451** provides a bent grove **435** that allows the sideways exit of wire **80** and provides enhanced holding of the wire which is also bent when inserted. Otherwise, conductor **451** is identical to conductor **401** and can be substituted into the connector assemblies of FIG. **2**A, **3**A, or **4**A.

FIG. **5** is a perspective view of electrical contact/conductor **501** that can be substituted in connector assemblies of FIG. **2**A, **3**A, or **4**A, according to some embodiments of the invention. Conductor **501** is similar to conductor **201**, except that it includes a bent groove to which wire **80** is permanently affixed (e.g., by welding or soldering).

FIG. **6**A is a perspective view of a connector assembly **600** of some embodiments of the invention. Connector assembly **600** includes a top-drive band clamp **700** (or a conventional band clamp **70** can be substituted) surrounding a single-piece conductor **610**. Unlike conductor **116** of FIG. **1**A, conductor **610** does not need a hole in band clamp **700**, but provides a wire connection that passes above band clamp **700**.

FIG. **6**B is a top view of electrical contact/conductor **610** of connector assembly **600**. In some embodiments, conductor **610** includes an inner surface **621** that conforms to a battery post **99**, an outer cylindrical surface **625** that band clamp **700** tightens against, a groove **624** to allow band clamp **700** to ride higher on the battery post, giving more clearance at the bottom for screw end **739**, and a hole **623** in side post **627** for the cable wire end **82**.

FIG. **6**C is a side view of electrical contact/conductor **610** of connector assembly **600**. The features are described above.

FIG. **6**D is a side view of electrical contact/conductor **620** that can be substituted in connector assembly **600**. Conductor **620** eliminates the groove **624** of conductor **610**, but has post **627** higher relative to the top of the battery post **99**.

FIG. **6**E is a side view of electrical contact/conductor **630** that can be substituted in connector assembly **600**. Conductor **630** is a combination of conductor **620** and conductor **610**.

FIG. **6**F is a perspective view of electrical contact/conductor **620** of FIG. **6**D that can be substituted in connector assembly **600**.

FIG. **7**A is a perspective exploded view of top-driven clamp **700** that allows actuating beveled-gear worm-drive screw **704** with vertically oriented beveled-gear head **730**, according to some embodiments of the invention. Top-driven clamp **700** has a tightening mechanism having a vertical head (at right angles to the plane of the band clamp **114**) for connector adjustment. In the event that there is physical interference so that adjustment from the side of the connector is difficult, this embodiment allows the user to adjust the connector from above. A beveled-gear head **730** is employed in the vertical position, in mating contact with the worm drive screw **704** which now has a gear head **707**.

In some embodiments, strap guide **702** permanently holds a conventional slotted band **71** by inserting tabs **703** into hole **72**. Groove **701** mates with groove **708** of screw **704** allowing the screw to rotate, while groove **705** mates with groove **735** of beveled-gear head **730** allowing the beveled-gear head **730** to rotate. The opposite end groove **706** of screw **704** is held and rides in groove **716** of housing **710**, while the opposite end groove **739** of beveled-gear head **730** fits in hole **719** of housing **710**. The slotted end of band **71** is urged against screw **704**, such that the slots **79** of the band interface to the threads **709** of the screw. The tabs of strap guide **701** are attached through corresponding slots in housing **710** to assemble the clamp **700**.

FIG. **7**B is a side view of beveled-gear worm-drive screw **704**, used in some embodiments. Screw **704** includes a bevel gear **707** that meshes with gear **733** of the head **730**. Grooves **708** and **706** provide sleeve-bearing surfaces that rotate within groove **716** of housing **710** and groove **701** of strap guide **702**.

FIG. **7**C is a side view of vertical beveled-gear head **730**. Beveled-gear head **730** includes a bevel gear **733** that meshes with gear **707** of screw **704**. Grooves **735** and **739** provide sleeve-bearing surfaces that rotate within groove **715** of housing **710** and groove **705** of strap guide **702**, and hole **719** of housing **710**. Collar **738** holds the beveled-gear head **730** on top of hole **719**. In some embodiments, a multi-tool capable hex head **737** is provided.

FIG. **8**A is a plan view, before folding, of a stamped-metal radius conductor **802**. Conductor **802** includes ears **816** for bending into a cylindrical opening for wire end **82**, tab **815** for folding into a U-shape to align hole **814** to hole **818** and surround an end of slotted strap **895**. A strap end **812** is bent to a semi-cylindrical shape such that an inner surface **813** conforms to and outer surface of the battery post **99**. In some embodiments, conductor **802** is made of a metal, e.g., primarily or substantially totally copper. In some embodiments, at least inner surface **813** is coated or alloyed with tin. FIG. **8**B is an end view, before folding, of stamped-metal radius conductor **802**. FIG. **8**C is a side view, before folding, of stamped-metal radius conductor **802**. FIG. **8**D is a perspective view, after folding, of stamped-metal radius conductor **802**. FIG. **8**E is a top view, after folding, of a stamped-metal radius conductor **802**.

FIG. **8**F is a top cut-away view of a battery connector **800**, according to some embodiments of the invention, which utilizes conductor **802**. In some embodiments, connector **800** uses a worm-drive screw assembly **897** similar to that of top-drive band clamp **700** or of a conventional band clamp **70**, however the band or strap is split into two parts: strap **896** that is permanently attached to worm-drive screw assembly **897** and is held by bolt **86**, and slotted strap **895** that interfaces with the worm screw of worm-drive screw assembly **897**, and is held at its other end in the U-slot of conductor **802** by bolt **86** as attached to nut **85**. FIG. **8**G is a perspective exploded view of a battery connector **800**.

FIG. **9**A is a side view, before folding, of a stamped-metal radius conductor **901**. When bent and folded, ears **916** and **915** of end **910** form a cylinder to hold wire end **82**, ears **912** form a cylinder having an inner surface **913** to hold battery post **99** and an outer surface **914** around which a band clamp **70** or **700** is placed, and neck **911** that can be left in a vertical orientation as shown in FIG. **9**E, or folded over as shown in FIG. **9**D.

FIG. **9**B is a side view, before folding, of a stamped-metal radius conductor **902** (that can be substituted in some embodiments, for conductor **901**) that includes a beveled surface **913**, which, when bent to form a tapered cylindrical shape to conform to the battery post **99**, allows the outer surface **914** to conform to a cylindrical shape against which a band clamp is applied.

FIG. **9**C is a plan view, before folding, of a stamped-metal radius conductor **902**. This plan view would also be applicable to conductor **901**. Ears **915** and **916** of cable connection end **910** are bet to form a cylindrical opening (see FIG. **9**D).

FIG. **9**D is a perspective exploded view of a replaceable-clamp battery connector **900**, according to some embodiments of the invention. In some embodiments, connector **900** is provided to the user as a kit of parts including some or all of those shown. In some embodiments, connector **900** includes an insulated compliant rubber or plastic cover **70** having an opening for cable **80** to pass through, and sides and a top to cover the connector once installed. Cable **80** includes conductor **82** (such as stranded copper wire) covered by a compliant insulator such as rubber or plastic. Band clamp **94** is fit around cylindrical end **910** to compress it onto wire end **82**, forming a mechanical and electrical connection to cable **80**. In some embodiments, insulator cover **70** is shaped to substantially cover band clamp **94** and **95** once assembled, and to be removable for service, if needed. Inner surface **913** of conductor **902** conforms to battery post **99**, and is urged against post **99** by band clamp **95** (which can be a conventional band clamp **70** as shown, or can be a top-drive band clamp **700** as shown in FIG. **7**A.

FIG. **9**E is a perspective exploded view of a replaceable-clamp battery connector **904**. Connector **904** is identical to connector **900** described above, but is left in a vertical configuration for applications that would benefit from that configuration.

FIG. **10**A is a top cut-away view of a battery connector **1000**, according to some embodiments of the invention. FIG. **10**B is a perspective exploded view of battery connector **1000**. In some embodiments, connector **1000** includes a machined or cast shaped solid block **1010** of copper, that, in some embodiments, is coated with tin, at least on inner radius surface **1012**. Bolt **1020** passes through hole **1044** of slotted strap **1040**, and threads into threaded hole **1014**, such that its tip also presses against and holds wire end **82** of cable **80** into hole **1013**. In some embodiments, screw housing **1034** has tabs **1035** that are stapled into tab slots **1015** in block **1010** to hold it in place. Worm screw **1032** has threads **1031** that interface with slots **1041** in band **1040**, and when rotated, tighten or loosen the band clamp.

FIG. **11**A is a top cut-away view of a battery connector **1100**. FIG. **11**B is a perspective exploded view of battery connector **1100**. In some embodiments, connector **1100** includes a stamped and folded bar **1110** of copper, that, in some embodiments, is coated with tin, at least on inner radius surface **1112**. Bolt **1120** passes through hole **1144** of slotted strap **1140**, and threads into nut **1121** (or, in other embodiments, into a tapped threaded hole **1117** of bar **1110**. Cylindrical bent end **1113** of bar **1110** holds wire end **82** of cable **80** (in some embodiments, this connection is crimped, soldered, spot welded, or compressed by a band clamp **94** as shown in FIG. **9**D. In some embodiments, screw housing **1134** has tabs **1035** that are stapled around conductor **1110** to hold it in place. Worm screw **1132** has threads **1131** that interface with slots **1141** in band **1140**, and when rotated, tighten or loosen the band clamp.

FIG. **11**C is a plan view, before folding, of stamped-metal radius conductor **1110**. Once folded into the shape shown in FIG. **11**B, holes **1117** and **1118** align with each other on either side of hole **1144** of strap **1140**.

FIG. **12** is a perspective view of a vehicle **1200** that includes one or more battery connectors **1201** of the present invention, connecting electrical power from battery **90** to vehicle **1200**. In vehicle embodiments, vehicle **1200** can be a military vehicle as shown (either a land vehicle, or a boat, ship, aircraft, etc.) or a civilian automobile, truck, boat, or airplane. Other applications include connection to the power posts of solar installations, battery-powered backup energy sources such as for computer uninterruptible power supplies.

FIG. **13**A is a perspective view of a connector assembly **1300** of some embodiments of the invention. In some embodiments, connector assembly **1300** includes a plurality of conductor elements **1310**, **1330**, and/or a direct (e.g., stainless-steel) connection **1371** to wire **80**. FIG. **13**B is a perspective view of electrical contact **1310** of connector assembly **1300**. In some embodiments, each one of the plurality of conductor elements **1310** (and **1330**) is a copper (or other suitable conductive material) having an inner concave surface **1321** that conforms to a portion of the outer surface on battery post **80**, and an outer surface **1320** that conforms to the band clamp (e.g., **1370**) when that is tightened, and a formed wire receptacle **1311** (e.g., of stamped copper bent to form a cylindrical opening though which wire end **82** is passed) that can be attached to the wire, such as by crimping, welding, soldering, or band clamping. In some embodiments, the housing of band clamp **1370** includes a cylindrical opening **1371** though which the wire end **82** is passed and attached. In some embodiments, a horizontally oriented worm-drive screw **1304** is provided, while in other embodiments, a top-drive band clamp (such as shown in FIG. **3**A) or a mechanically advantaged top or side drive band clamp (such as shown in FIG. **14**A) is used. In some embodiments, one or more of the plurality of conductors **1310**, **1330** are riveted or welded **1340** to band **71**. Improved reliability is achieved by having a plurality of wire connection points (**1311** and/or **1371**) to the wire end **82**, such that redundant conduction paths and connections are provided.

FIG. **14**A is a top perspective view of mechanically advantaged top-driven clamp connector assembly **1400** that allows hand actuating beveled-gear worm-drive screw **1404** with a mechanically advantaged gear ratio, vertically or side oriented, via beveled-gear head **1430**. FIG. **14**B is a side perspective view of connector assembly **1400** showing the gear end of beveled-gear worm-drive screw **1404**. The gear configuration of bevel gear **1433** and larger bevel gear **1407** provides a mechanical advantage that allows band clamp **1470** to be hand-tightened without tools. In some embodiments, band clamp **1470** includes a first housing **1410** that holds grooves near both ends of worm-drive screw **1404**, and a second housing **1411** that holds grooves near both ends of hand-actuated drive head **1430**, and hold bevel gear **1433** against larger bevel gear **1407**. Head **1437** can be any suitable form, such as a wing nut or a knurled knob, and in some embodiments, includes a feature such as a slot for use with a screwdriver if extra leverage is needed. In some embodiments, band clamp **1470** contacts directly against battery post **99** to provide a redundant current path. In some embodiments, a hole **1430** is provided in conductor **1401** for inserting wire end **82**, and a set screw **61** or other suitable clamp is provided to hold wire end **82** in place. In some embodiments, the outer cylindrical (or oval prism) shape of conductor **1401** is tilted to provide clamping pressure **62** at the lower portion of post **99** (on the lower right side of the FIG. **14**B), while having the worm-screw end **63** raised relative to the battery surface and post **99**, in order to provide more vertical clearance for bevel gear **1407**.

One further consideration of material usage is that of its environmental impact. The materials used here have far less negative environmental impacts in comparison to the traditional lead-containing connectors.

In some embodiments, the invention provides a connector apparatus for use in connecting a battery-power cable to a battery-terminal post. This connector includes a tightenable adjustment band that provides for connector installation, removal and tension adjustment, a band-tightness-adjustment assembly operatively coupled to the band and a radius electrical conductor that provides a primary electrical current path and includes a cable-wire-attachment feature to enable power distribution through a cable, wherein the band-tightness-adjustment assembly, the band, and the radius electrical conductor form a tightenable inner opening that can surround and tighten on the battery-terminal post.

In some embodiments, the adjustment band includes a plurality of slots, and the band-tightness-adjustment assembly includes a worm-drive screw that interfaces with the slots to tighten the banc, the screw having a drive head that includes a slot configured for use with a conventional slot-drive screwdriver, a cross slot configured for use with a conventional Philips screwdriver and a hexagonal head configured for use with a conventional hexagonal wrench.

In some embodiments, the slotted adjustment strap includes slots restricted to about one centimeter or less to maximize mechanical strength and electrical contact.

In some embodiments, the band-tightness-adjustment assembly includes a stainless steel slotted adjustment strap, providing a relatively corrosion resistant secondary electrical current path.

In some embodiments, the radius electrical conductor includes a copper radius contact at least partially coated with tin to make the contact galvanically compatible with the battery-terminal post and copper-wire cable.

In some embodiments, the worm-drive adjustment assembly includes a radius contact bonded in electrical communication with the slotted adjustment strap.

In some embodiments, the band-tightness-adjustment assembly includes a worm-drive screw having a beveled gear head, and a tool-interface head that mates with and provides screw actuation to the screw through a perpendicularly oriented beveled gear drive head.

Some embodiments further include the battery-power cable attached to the connector.

Some embodiments further include a motor vehicle having a battery, the battery having a battery-terminal post, and a battery-power cable connected to the connector to electrically connects the battery to the vehicle.

Another aspect of the invention, in some embodiments, is a connector kit for use in the connection of a power cable to a power terminal post. The kit includes a band clamp and an electrical-contact conductor that provides a primary electrical current path and having a concave surface configured to conform to an outer surface of the post, a convex outer surface that is configured to conform to an inner surface of the band clamp when tightened, and a cable attachment to enable power distribution through the cable.

In some embodiments, the band clamp includes a worm-drive screw with a head providing a slot for use with a conventional slotted screwdriver, a cross slot for use with a conventional Philips screwdriver and a hexagonal head for use with a conventional hexagonal wrench.

In some embodiments, the band clamp includes slots in a slotted adjustment strap that are restricted to about 1.25 cm or less for adjustment to increase mechanical and electrical contact.

In some embodiments, the band clamp includes a stainless-steel slotted adjustment strap, providing a relatively corrosion proof secondary electrical current path.

In some embodiments, the electrical-contact conductor is bonded in electrical communication with the band clamp.

In some embodiments, the electrical-contact conductor includes a tin-coated copper concave electrical contact bonded in electrical communication with the slotted adjustment strap.

In some embodiments, the band clamp includes a worm-drive screw having a beveled gear head that mates with and provides screw actuation through a perpendicularly oriented beveled gear drive head.

Yet another aspect of the invention, in some embodiments, is method of connecting a battery cable to a battery post. The method includes providing an electrical-contact conductor having a concave surface configured to conform to an outer surface of the post, and a convex outer surface that is configured to conform to an inner surface of a band clamp when tightened, attaching a cable to the electrical-contact conductor, and band-clamping the electrical-contact conductor to the battery post to enable power distribution through the cable.

In some embodiments, the band clamping includes providing a mechanically advantaged rotation to a worm screw to tighten the conductor-to-post contact.

In some embodiments, the attaching of the cable further comprises band clamping the electrical-contact conductor to the cable.

Also described, in some embodiments, is a apparatus for use in the connection of a power cable to a power-terminal post, the apparatus including an electrical-contact conductor that provides a primary electrical current path and having a concave surface configured to conform to an outer surface of the post, a convex outer surface that is configured to conform to an inner surface of the band clamp when tightened, and a cable attachment to enable power distribution through the cable; and clamping means to exert force to connect the electrical-contact conductor to the power-terminal post.

It is to be understood that the above description is intended to be illustrative, and not restrictive. Although numerous characteristics and advantages of various embodiments as described herein have been set forth in the foregoing description, together with details of the structure and function of various embodiments, many other embodiments and changes to details will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should be, therefore, determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively. Moreover, the terms "first," "second," and "third," etc., are used merely as labels, and are not intended to impose numerical requirements on their objects.

What is claimed is:

1. An apparatus comprising:

a slotted tightenable adjustment band that provides adjustable compression around an object; and

a band-tightness-adjustment assembly operatively coupled to the band and having a worm screw operable to tighten the adjustment band, the worm screw affixed to a first rotatable shaft affixed to a first gear, and a mechanically advantaged rotation mechanism operatively coupled to rotate the worm screw, wherein the mechanically advantaged rotation mechanism includes a second rotatable shaft having second gear having a plurality of teeth, the first gear having a plurality of teeth that interface to the teeth of the second gear, and wherein the plurality of teeth on the first gear are greater in number than the plurality of teeth on the second gear.

2. The apparatus of claim **1**, wherein the slotted band and the band-tightness-adjustment assembly are made of stainless steel.

3. The apparatus of claim **1**, further comprising at least one housing, wherein the at least one housing holds the worm screw and the mechanically advantaged rotation mechanism in a rotatable configuration to each other.

4. The apparatus of claim **1**, further comprising at least one housing, wherein the at least one housing holds the worm screw and the mechanically advantaged rotation mechanism in a rotatable configuration to each other.

5. An apparatus for use in the connection of a power cable to a power-terminal post, the apparatus comprising:

an electrical-contact conductor that provides a primary electrical current path and has a concave surface configured to conform to an outer surface of the post, and a cable attachment to enable power distribution through the cable; and

clamping means for exerting force to connect the electrical-contact conductor to the power-terminal post, the clamping means including a mechanically advantaged rotation means for tightening the clamping means, wherein the electrical-contact conductor has a convex outer surface that is configured to conform to an inner surface of the clamping means when tightened, wherein the power terminal post is a battery post, wherein the mechanically advantaged rotation means includes

a worm screw having a first gear formed on the worm screw wherein the first gear has a number of teeth;

a second gear interfaced to the first gear wherein the second gear has a number of teeth and the number of teeth on the first gear is greater than the number of teeth on the second gear; and means for finger rotating the second gear with a second rotational torque such that a first rotational torque is applied to the worm screw, the first rotational torque being greater than the second rotational torque.

6. The apparatus of claim **5**, wherein the worm screw has a first longitudinal axis and the first gear rotates around the first longitudinal axis, and the second gear rotates around a second longitudinal axis, wherein the first longitudinal axis is not parallel to the second longitudinal axis.

7. The apparatus of claim **6**, wherein the first longitudinal axis is substantially perpendicular to the second longitudinal axis.

8. The apparatus of claim **5**, wherein the cable attachment includes means for compressing a portion of the electrical-contact conductor to a portion of the cable.

9. The apparatus of claim **8**, wherein the means for compressing includes a worm-gear-activated band-clamp compression mechanism that tightens around a portion of the electrical-contact conductor and a portion of the cable.

10. The apparatus of claim **5**, wherein the mechanically advantaged rotation means is at least partially made of stainless steel.

11. An apparatus comprising:

a slotted tightenable adjustment band that provides adjustable compression around an object; and

a band-tightness-adjustment assembly operatively coupled to the band and having a worm screw operable to tighten the adjustment band and a mechanically advantaged rotation mechanism operatively coupled to rotate the worm screw, wherein the mechanically advantaged rotation mechanism includes a rotatable shaft having a knob configured to be moved by finger pressure to rotate the shaft, and wherein the worm screw has a first gear having a plurality of teeth that interface to a portion of the rotatable shaft such that the rotatable shaft rotates more than one full rotation in order to rotate the worm screw one full rotation.

12. An apparatus comprising:

a slotted tightenable adjustment band that provides adjustable compression around an object; and

a band-tightness-adjustment assembly operatively coupled to the band and having a worm screw operable to tighten the adjustment band and a mechanically advantaged rotation mechanism operatively coupled to rotate the worm screw, wherein the mechanically advantaged rotation mechanism includes a rotatable shaft having a second gear and at least two opposing wings configured to be moved by finger pressure to rotate the shaft, and wherein the worm screw has a first gear that interfaces to the second gear of the rotatable shaft such that the rotatable shaft rotates more than one full rotation in order to rotate the worm screw one full rotation.

13. The apparatus of claim **12**, wherein at least the first gear is beveled.

14. The apparatus of claim **12**, wherein the worm screw has a first longitudinal axis and the first gear rotates around the first longitudinal axis, and the second gear rotates around a second longitudinal axis, wherein the first longitudinal axis is not parallel to the second longitudinal axis.

15. The apparatus of claim **14**, wherein the first longitudinal axis is substantially perpendicular to the second longitudinal axis.

16. An apparatus comprising:

a slotted tightenable adjustment band that provides adjustable compression around an object; and

a band-tightness-adjustment assembly operatively coupled to the band and having a worm screw operable to tighten the adjustment band and a mechanically advantaged rotation mechanism operatively coupled to rotate the worm screw, and

an electrical-contact conductor that provides a primary electrical current path and has a concave surface configured to conform to an outer surface of a battery post, a convex outer surface that is configured to conform to an inner surface of the slotted band when the band is tightened, and a cable attachment to enable power distribution through a cable.

17. A method comprising:

providing a unitary clamp having a plurality of rotatable parts and a slotted tightenable adjustment band configured to provide adjustable compression around an object; and

applying mechanically advantaged rotation force using the plurality of rotatable parts of the clamp to tighten the slotted band, wherein the plurality of rotatable parts includes a first rotatable shaft affixed to a first gear and a worm screw operable to tighten the adjustment band, and a second rotatable shaft affixed to a second gear having a plurality of teeth, the first gear having a plurality of teeth that interface to the teeth of the second gear, wherein the applying mechanically advantaged rotation force includes rotating the second shaft more than one full rotation in order to rotate the worm screw one full rotation, wherein rotating the worm screw one full rotation tightens the slotted adjustment band by one slot.

18. The method of claim **17**, wherein the applying of the mechanically advantaged rotation force includes rotating a first shaft by finger pressure, and wherein the first shaft interfaces with and rotates a worm screw having a first gear that has a plurality of teeth that interface to a portion of the first shaft such that the first shaft rotates more than one full rotation in order to rotate the worm screw one full rotation.

19. A method comprising:

providing a unitary clamp having a plurality of rotatable parts and a slotted tightenable adjustment band configured to provide adjustable compression around an object; and

applying mechanically advantaged rotation force using the plurality of rotatable parts of the clamp to tighten the slotted band wherein the applying of the mechanically advantaged rotation force includes rotating a geared shaft by finger pressure, the geared shaft having a second gear and at least two opposing wings configured to be rotated by the finger pressure, and wherein the worm screw has a first gear that interfaces to the second gear of the geared shaft such that the geared shaft rotates more than one full rotation in order to rotate the worm screw one full rotation.

20. The method of claim **19**, wherein the worm screw has a first longitudinal axis and the first gear rotates around the first longitudinal axis, and the second gear rotates around a second longitudinal axis, wherein the first longitudinal axis is not parallel to the second longitudinal axis.

21. The method of claim **20**, wherein the first longitudinal axis is substantially perpendicular to the second longitudinal axis.

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