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(54) ROTATABLE PLASMA CUTTING TORCH ASSEMBLY WITH SHORT CONNECTIONS

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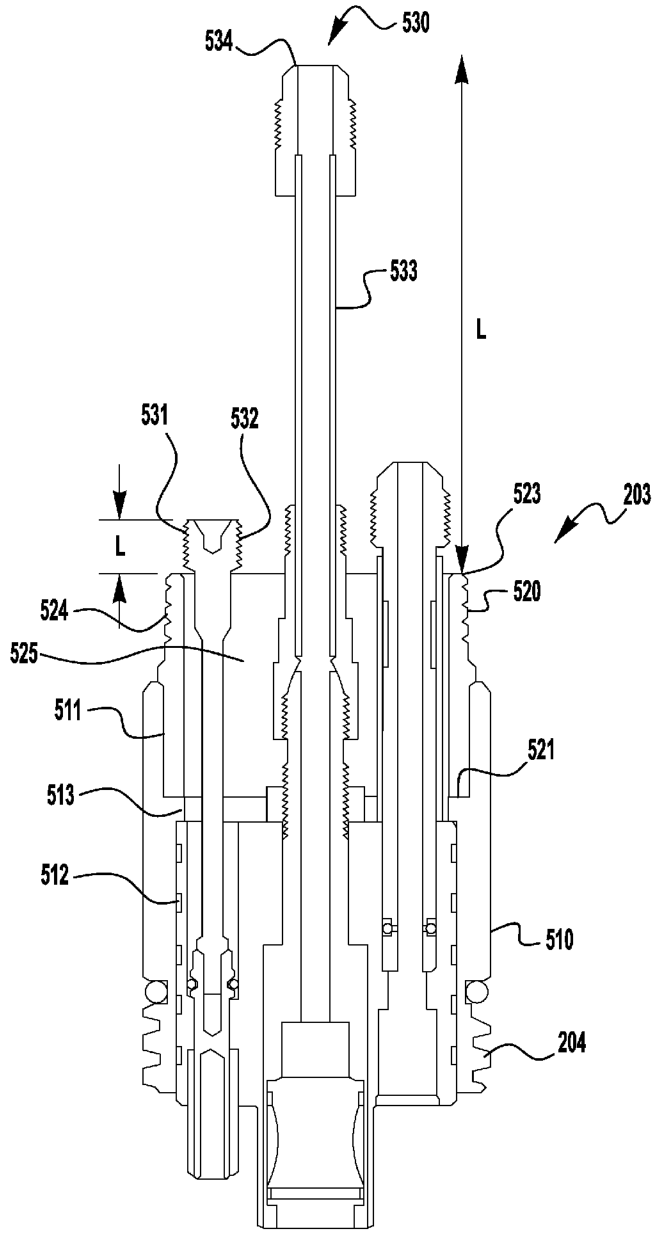
(57) ABSTRACT

A rotatable plasma torch is provided which can easily rotate when used in robotic or automatic cutting system while minimizing damage to internal connections of the torch. The torch is provided with a sleeve structure on the torch handle where there is no structure or component positioned between the sleeve and the exterior of the torch handle.



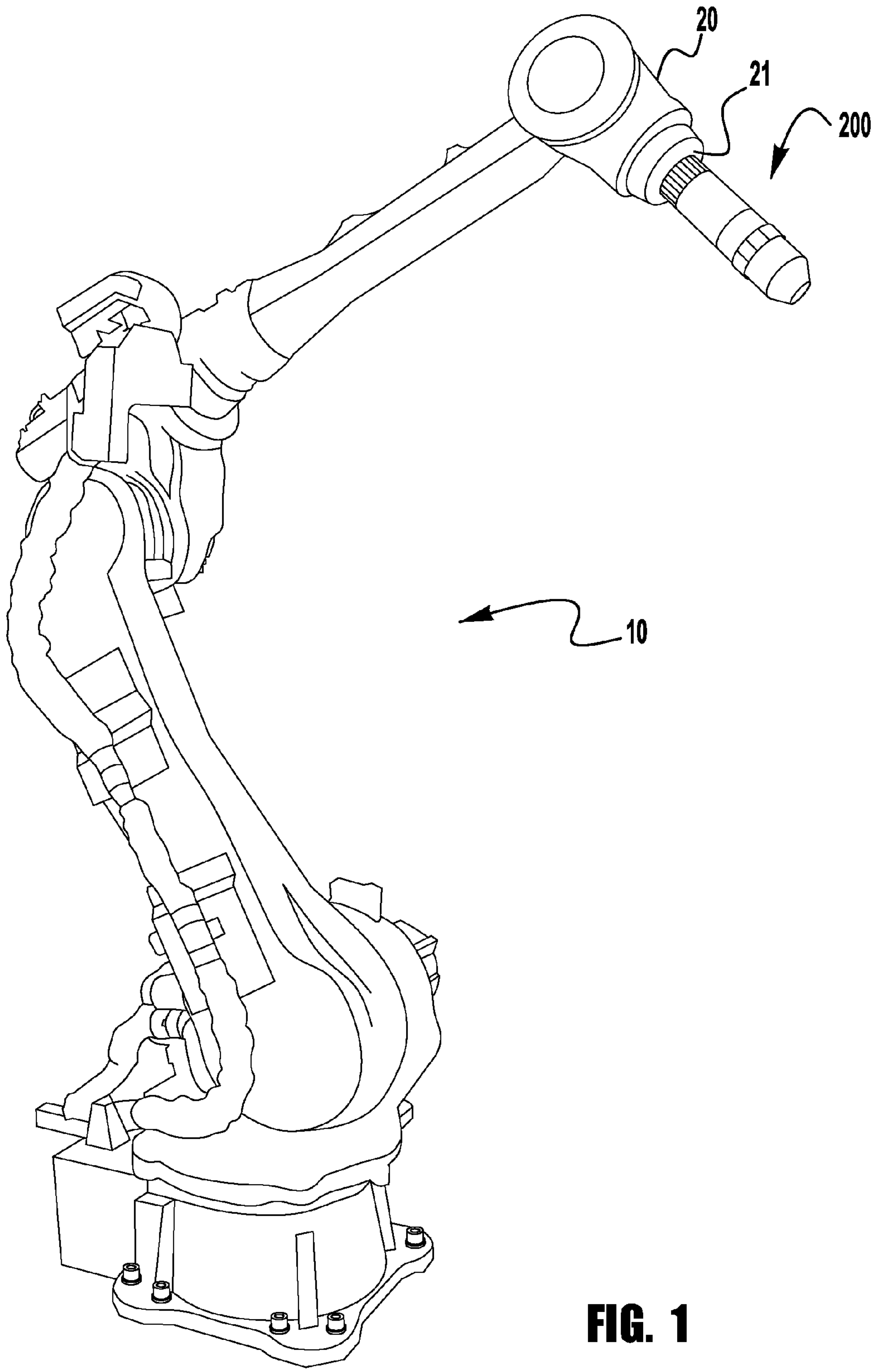


FIG. 1

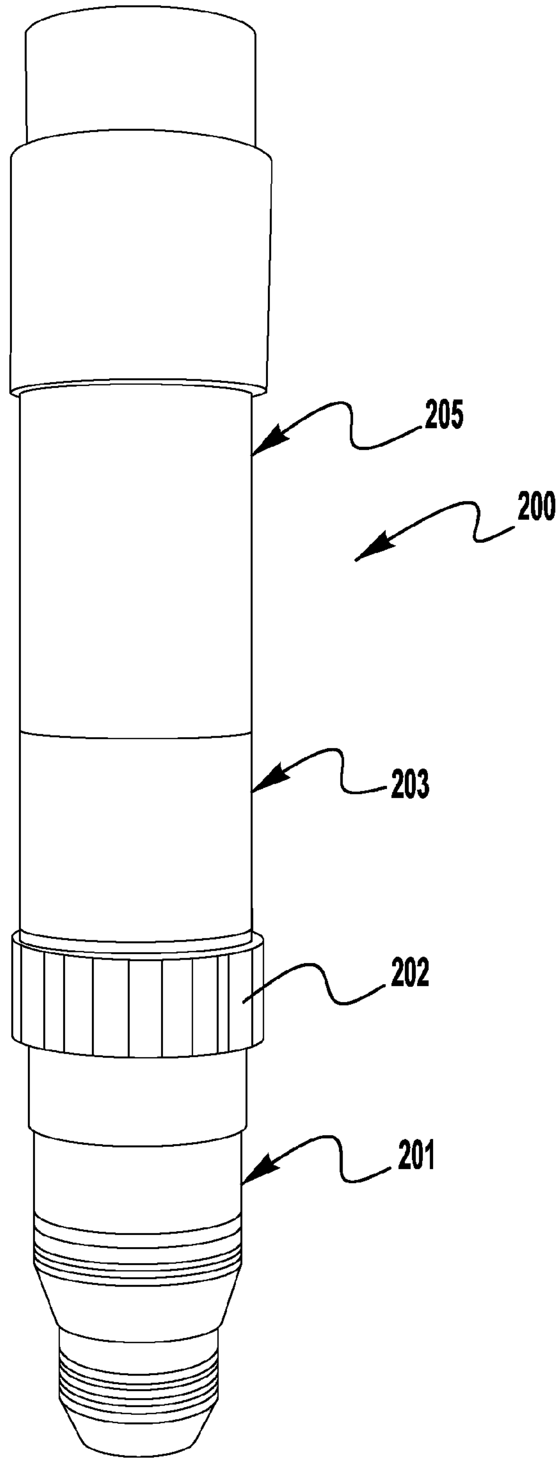


FIG. 2

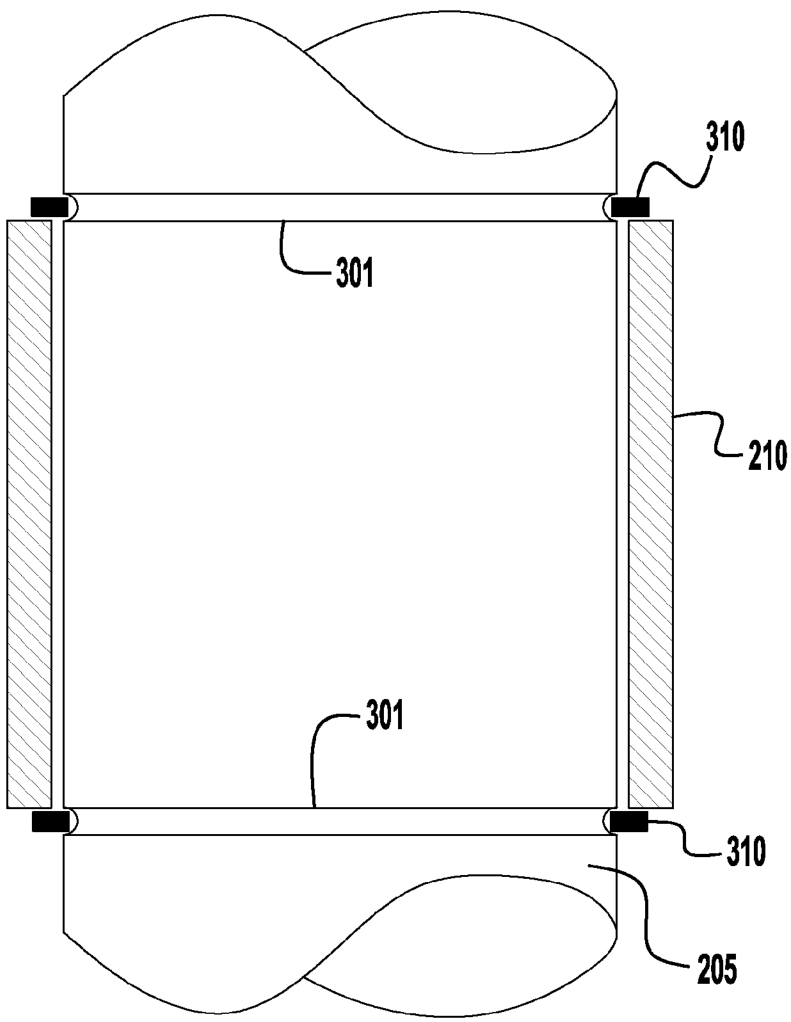


FIG. 3

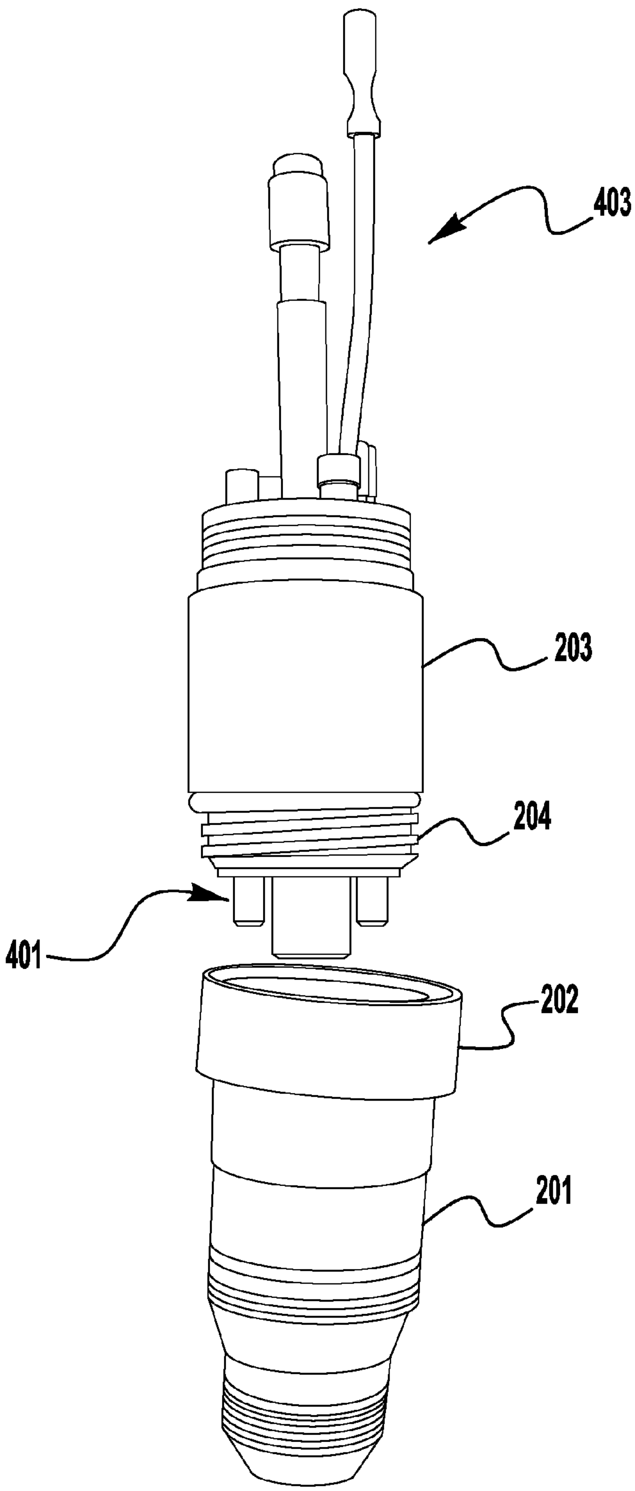


FIG. 4

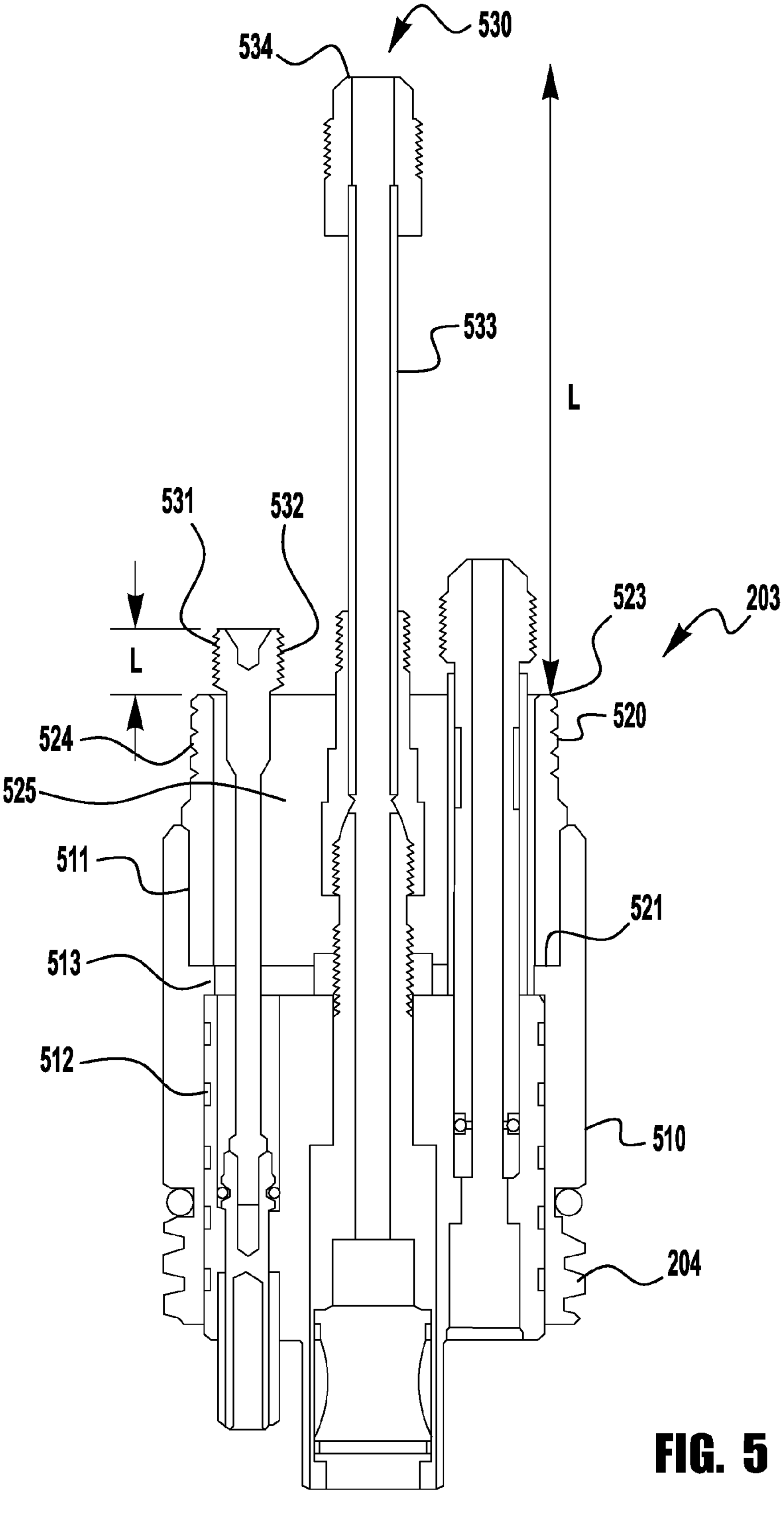

530
534
533
L
531
532
523
203
L
520
524
525
511
521
513
512
510
204

FIG. 5

ROTATABLE PLASMA CUTTING TORCH ASSEMBLY WITH SHORT CONNECTIONS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] Systems and methods of the present invention relate to plasma cutting, and more specifically to arc plasma cutting using a torch assembly that can be mounted in robotic arm systems.

[0003] 2. Description of the Related Art

[0004] The use of plasma cutting systems in various industries has grown, including the use of plasma cutting systems with robotic systems. In such applications, the plasma cutting torch is secured to a robotic arm or motion mechanism which moves the torch in many different directions. In fact, in many robotic applications the robot has many different axis of movement. This complex movement often requires the torch to move relative to the robot arm which imparts a rotational movement. Because of the electrical and cooling liquid connections on the torch this rotational movement must be limited so as to not break these connections. Further, after a certain amount of movement the operation must be stopped so as to allow the robotic arm to unwind—which releases any torque from the torch connections. Therefore, the more complex the movement and control of the torch the more often the operation will have to be stopped to unwind the torch. This increases downtime of the cutting operation and can lead to premature failure of the torch connections through constant loading and unloading of torsional stresses. Therefore, torch construction is needed to mitigate these issues.

[0005] Further limitations and disadvantages of conventional, traditional, and proposed approaches will become apparent to one of skill in the art, through comparison of such approaches with embodiments of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0006] Embodiments of the present invention include equipment and methods for using a plasma cutting system which employs a rotatable plasma torch which can easily rotate when used in robotic or automatic cutting system while minimizing damage to internal connections of the torch. The torch is provided with a sleeve structure on the torch handle where there is no structure or component positioned between the sleeve and the exterior of the torch handle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above and/or other aspects of the invention will be more apparent by describing in detail exemplary embodiments of the invention with reference to the accompanying drawings, in which:

[0008] FIG. **1** is a diagrammatical representation of an exemplary system using an exemplary torch of the present invention;

[0009] FIG. **2** is a diagrammatical representation of an exemplary torch of the present invention;

[0010] FIG. **3** is a diagrammatical representation of a cross-section of a portion of an exemplary torch of the present invention;

[0011] FIG. **4** is a diagrammatical representation of an exemplary torch that has been disassembled; and

[0012] FIG. **5** is a diagrammatical representation of a cross-section of an exemplary torch base of the present invention.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0013] Exemplary embodiments of the invention will now be described below by reference to the attached Figures. The described exemplary embodiments are intended to assist the understanding of the invention, and are not intended to limit the scope of the invention in any way. Like reference numerals refer to like elements throughout.

[0014] FIG. **1** depicts an exemplary robotic system **10** using a torch **200** in accordance with an exemplary embodiment of the present invention. It is noted that for purposes of the following discussion, the system will be discussed as a plasma arc cutting system. However, exemplary embodiments are not limited to being used in arc cutting systems. Embodiments of the present invention can be used with many systems which require complex movement of a torch like assembly, in which rotational movement and forces are imparted. For example, embodiments of the present invention can be used with arc welding, electroslag welding, cladding, joining, hot wire and additive manufacturing systems without departing from the spirit or scope of the present invention. Arc welding systems can be of the GMAW, GTAW, SAW, FCAW type, as an example. Further, exemplary embodiments of the present invention can be used in automatic, robotic, semi-automatic and manual systems. As indicated above, the exemplary embodiments discussed herein will use an arc cutting system as exemplary but this is in no way intended to be limiting.

[0015] As shown in FIG. **1**, the torch **200** is coupled to a robotic arm assembly **10**. The robotic arm assembly **10** can be constructed and operated in accordance with known robotic cutting and welding systems and is not intended to be limiting in any way. As is generally understood, the movement and operation of the arm **10** can be controlled by a computer control system (not shown) and can also be coupled to a power supply (also not shown) which provides the current used to create the plasma arc in the torch **200** for the cutting operation. The general construction and operation of such systems is known and need not be described herein. The robotic arm typically has a tool connection end **20** to which the torch **200** is coupled for the cutting operation. The tool connection end **20** has a tool connection structure **21** which couples to the torch **200** and holds the torch **200** in the tool connection end. The connection structure **21** can be configured in a number of different ways. In many applications the tool connection structure **21** has an interior surface which couples to an outer surface of the torch **200** to hold the torch in place. Of the connection structure **21** can use any number of different connection methodologies to hold the torch **200** in place including fasteners, clamping structure, etc. Embodiments of the present invention are not limited in this regard.

[0016] FIG. **2** depicts an exemplary torch assembly **200** of the present invention. In many respects the torch assembly **200** is constructed and operated similar to known plasma torch constructions, except for the differences described in detail herein. Therefore, many known aspects of the torch construction and operation are not discussed in detail herein. As shown, exemplary embodiments of the present invention have a torch head portion **201**. The torch head portion **201** represents the distal end of the torch **200** from which the plasma is propelled for the cutting operation. In FIG. **2** a shielding is not shown in the distal end, but often a shield is placed over the distal end of the torch head **201**. The torch head **201** is coupled to a torch body **203**. In the exemplary embodiment shown the threaded connection collar **202** couples the torch head **201** to the torch body **203**. The torch body **203** typically has a number of electrical contacts and connections which couple the electrical current and cooling liquids and/or shielding gas from the upstream sources to the torch head. Coupled to the torch body **203** is the torch handle **205**. The torch handle **205** is typically threaded onto the torch body **203** and is used to secure the torch **200** to the robotic system or the connection portion **21**. Because of this if the torch needs to be service or replaced the torch head **201** and torch body **203** can be easily removed from the torch handle **205** without removing the torch handle **205** from its connection. As shown in FIGS. **2** and **3**, the torch handle has an outer casing, which is typically metallic and protects the components internal to the torch handle **205**.

[0017] As shown in the exemplary embodiment, the torch **200** also includes a rotating collar **210** which is free to rotate 360 degrees relative to the surface of the torch handle **205**. When mounted to the robot or other motion control device, the outer surface of the rotating collar **210** is coupled to the connection structure **21**. For example, in the embodiment shown the connection structure can be a clamping mechanism that clamps onto the outer surface of the collar **210** so as to secure the torch **200** to the robot (or gantry, etc.). The collar is a cylindrical structure with an inner diameter that is slightly larger than the outer diameter of the torch handle **205** such that the collar **210** is free to fully rotate relative to the handle **205**. Thus, as the robot, gantry or whatever motion control structure is moved and rotated the torch **200** remains relatively stationary (from a rotational standpoint). Because of this, the robot does not have to be moved to "unwind" the torch and little or no torque forces are applied to the torch connections (not shown in FIG. **2**). Further, as explained more fully below, the collar **210** is secured to the torch handle **205** in a longitudinal direction such that the torch **200** does not slide in and out of the collar **210**—which would affect the cutting accuracy of the torch **200**. This is explained more fully below.

[0018] FIG. **3** depicts a close up view of the collar **210** and the torch handle **205** where the collar **210** is shown in cross-section. As described above the collar **210** is sized such that it's inside diameter is slightly larger than the outside diameter of the outer casing of the torch handle **205**. However, the gap between the collar **210** and the torch handle **205** should not be too large such that the torch **200** is not supported in a stable manner. In exemplary embodiments of the present invention, the gap between the inner surface of the collar **210** and the outer surface of the torch handle **205** is in the range of 0.0005 and 0.002 inches. The gap may be larger in some applications, however, the gap should not be so large such that the accuracy of the cutting operation is compromised. The outer surface of the outer casing of the torch handle has two grooves **301** in its outer surface, where the grooves **301** are positioned at each of the respective distal ends of the collar **210**. In the embodiment shown, the grooves **301** go around the entire diameter of the torch handle **205**, but in other exemplary embodiments, the grooves **301** need no go around the entire diameter. In each of the grooves **301** a lock ring **310** is placed where the inner diameter of the lock rings **310** sit inside the respective grooves **301** while an outer diameter of each of the lock rings **310** protrudes beyond the outer surface of the torch handle **205**. Thus, once positioned in each of their respective grooves **301** the lock rings **310** hold the collar **210** in position longitudinally along the length of the torch handle **205**. With this construction there is no structure or component positioned between the inner surface of the collar **210** and the outer surface of the handle **205**. That is there is no structure or component between the entirety of the inner surface of the collar **210** and the outer surface of the handle **205**. This provides a significant advantage over more complex rotational connections which have numerous rotational elements or do not easily connect with known robotic connections. These elements can wear or otherwise be compromised—particularly in environments normally associated with cutting and metal fabrication. Thus, embodiments of the present invention provide a highly reliable rotational connection which greatly improves the usage and life of a torch **200**.

[0019] The lock rings **310** can be constructed similar to split washers where the rings are nearly circular but have a gap between two ends of the ring, such that the gap allows the rings **310** to be placed into the grooves **301**. The grooves **301** should be of a depth and shape so as to allow for the sufficient seating of the rings so that the rings **310** can hold the collar **210**, and thus the torch **200** in a longitudinally fixed position relative to each other. Each of the collar **210** and the rings **310** can be made of materials such as brass, stainless steel, etc., so long as they have sufficient strength to support the torch **200** during operation.

[0020] It is noted that in the embodiment shown in FIG. **3** a single pair of grooves are shown in the outer casing of the torch handle **205**. However, in other exemplary embodiments the torch handle **205** can a plurality of pairs of grooves **301** in the outer casing of the torch handle **205**. Each respective pair of grooves **301** would be separated by the needed distance to accommodate the collar **210** as shown in FIG. **3**. However, each pair can be displaced from each other by a predetermined increment (for example, 0.5 inch, 1 inch, etc.). Such an embodiment would provide a user with flexibility when mounting the torch assembly **200** to a specific robot or for a specific operation. That is, the user could then adjust the amount the torch assembly protrudes from a robot mount, or the like, by adjusting which pair of grooves **301** in the torch handle is used. This is accomplished by changing the position of the collar **210** along the length of the torch handle **205** casing, using of the pairs of grooves **301** as desired. The user could remove the rings **310** and slide the collar **210** to the desired pair of grooves and then install the rings **310** at the corresponding grooves **301**. This will provide additional flexibility to the use of the torch **200**. Such a configuration can also allow for the use of collars of different lengths depending on a desired application.

[0021] Additionally, in further exemplary embodiments at least one protrusion from the surface of the torch handle **205** casing could be used to restrain the collar **210**. For example, at the upstream end of the collar **210** a protrusion could extend radially out from the surface of the torch handle **205** to engage with the upstream end of the collar **210** and a groove and ring restraining configuration can be used at the downstream end of the collar **210**, to allow for the removal and replacement of the collar **210**.

[0022] FIG. **4** depicts components of an exemplary torch **200** as described herein. As explained previously, the torch **200** is made up of a number of main components. As shown in FIG. **4**, the torch head **201** has a threaded collar **202** which secures the torch head to a threaded portion **204** of the torch body **203**. The torch body **203** also has a plurality of torch connections **401** which align with corresponding connections within the torch head **201**. These connections **401** allow for the transfer of cutting/shielding gas, torch coolant and electrical current from the torch body **203** to the torch head **201**. Also, some of these connections **401** can be used to align the head **201** and the body **203** such that their connection has the proper alignment. Further, the torch body **203** also has a plurality of upstream connections **403** which serve a similar purpose to the torch connections **401** discussed above. However, these connections couple the torch body to connections within the torch handle **205**. Because of the high currents experienced during cutting and plasma arc initiation, in known torch constructions these connections are quite long. That is, these connections **403** are long to prevent sparks or arcing between internal components of the torch during high voltage pulses. However, because these connections are long they are prone to damage from torsional movement of the torch **200** during operation. As further explained below, embodiments of the present invention obviate these concerns and are capable of using much shorter connection lengths which are less prone to wear and damage. This is explained further, with respect to FIG. **5**.

[0023] FIG. **5** is a cross-sectional view of an exemplary torch body **203** of the present invention. Unlike known torches, the torch body **203** is made up of two torch components, a primary torch body portion **510** and a dielectric torch body portion **520**. The primary torch portion **510** is metallic using known materials used for torch body construction, while the dielectric torch body portion **520** is made from a non-conductive dielectric material, such as a plastic resin, or the like. Ideally, the dielectric portion **520** is made from a non-conductive material that is resistant to high levels of heat, due to the cutting environment. The dielectric portion **520** is inserted into a cavity portion **511** of the primary torch body portion **510**. The dielectric portion can be either press fit or threaded into the cavity **511**. Of course other methods can be used so long as the dielectric portion **520** is sufficiently secured into the cavity **511**. Further the primary portion **510** also has a separator portion **513** which separates the cavity **511** from the downstream cavity **512**. The separator portion **513** has a plurality of opening in it to allow the electrical, coolant and shielding connections and tubes to pass through the separator **513** as shown. In exemplary embodiments, a distal end **521** of the dielectric portion **520** abuts against the separator **513** when the portion **520** is inserted into the cavity **511**. The dielectric portion **520** has an upstream end portion **523** which has a threaded portion **524**, where the threaded portion **524** threads into the downstream end of the torch handle **205**.

[0024] As shown in FIG. **5**, in exemplary embodiments the dielectric portion **520** has an upstream end **523** which extends beyond the most upstream end of the primary portion **510**, which provides additional insulative benefits. Further, as shown, the dielectric portion **420** has a length which contacts the separator **513** such that the dielectric portion **520** covers the entirety of the inner surface of the walls of the cavity **511**.

[0025] In some exemplary embodiments of the present invention, the dielectric portion **520** has a cavity **525** which extends through the length of the portion **520** and this cavity is filled with a dielectric material, such as a potting material. This provides added insulation and stability for the torch body and the conduits **530**. Further, the dielectric portion **520** has an overall length which is in the range of 35 to 75% of the overall length of the torch body **203**, as measured from the distal end of the primary portion **510** to the upstream end of the dielectric portion **520**.

[0026] The torch body **203** also has a plurality of conduits **530** which are used to pass electric current, coolant and/or shielding gas through the torch body **203** to the torch head **201** to facilitate a cutting operation. A primary conduit **531** extends the furthest from the upstream end **523** and can be used to deliver electrical current and coolant through the torch body **203**.

[0027] In known torch constructions, which are used for high amperage applications, the high voltage pulse lead **531** is quite long. For example, in known torches the high voltage pulse lead **531** has a length L (measured from the upstream end **523**) of at least 1.5 inches. This length is needed in known torches to provide a sufficient distance between the connection portion **532** of the high voltage pulse lead **531** and the end **523** on the torch body housing. As explained previously, known torch body housings are metallic. Because of this, if the length L was too short, during high voltage electrical pulses (for example during arc initiation) an arc can jump from the connector **532** to the end of the torch body housing. This arc jump can cause significant damage to the torch components. Thus, known torches must have a longer length L to prevent arc jumping events. However, as explained above these longer lengths are prone to bending and torsional damage.

[0028] Unlike known torches, because embodiments of the present invention employ the construction described above the length L can be considerably shorter, meaning that the conduits are less susceptible to torsional and bending damage. For example, in embodiments of the present invention, the length L of the high voltage pulse lead **531** is in the range of 0.25 to 0.075 inches in length. This significantly improves the durability of the lead **531**. This is particularly true in torches whose operational/cutting current levels are 100 amps and higher. Embodiments of the present invention are particularly advantageous in torches and torch systems which are operating at 100 amps or higher as arc initiation is through the use of high voltage pulses. As explained this typically requires longer leads, and as such advantages from embodiments of the present invention can be achieved.

[0029] Further, much like the high voltage pulse lead **531**, the coolant conduit **533** can also be significantly reduced in length, as compared to known torches. In exemplary embodiments of the present invention, the coolant conduit **533** can have a length L in the range of 2 to 6.5 inches, as measured from the end **523** to the tip of the connector **534**—which connects the conduit **533** to the coolant supply connection within the torch handle **205**. In other exemplary embodiments, the length L is in the range of 2 to 4 inches.

[0030] Additionally, because of the advantages of the discussed embodiments, the torch handle **205** can also be significantly reduced in length, greatly reducing the overall length of the torch assembly **200**.

[0031] While the invention has been particularly shown and described with reference to exemplary embodiments thereof, the invention is not limited to these embodiments. It will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. A cutting torch assembly, comprising:

a torch body having a distal end and an upstream end;

a torch head coupled to said distal end of said torch body;

a torch handle coupled to said upstream end of said torch body, said torch handle having an outer casing; and

a rotatable collar secured to said outer casing of said torch handle,

wherein said outer casing has a first retaining structure positioned at an upstream end of said rotatable collar, and a second retaining structure positioned at a downstream end of said rotatable collar,

wherein said torch handle can rotate relative to said rotatable collar, and

wherein no structure is positioned between an inner surface of said rotatable collar and an outer surface of said outer casing of said torch handle.

2. The torch assembly of claim **1**, wherein each of said first and second retaining structures are comprised of a groove in the surface of said outer casing and a ring structure which is partially embedded in said groove such that said rotatable collar is positioned between each of said rings.

3. The torch assembly of claim **1**, wherein said rotating collar can rotate 360 degrees relative to said outer casing.

4. The torch assembly of claim **1**, wherein a gap between an inner surface of said rotatable collar and said outer casing has a maximum distance in the range of 0.0005 to 0.002 inches.

5. The torch assembly of claim **1**, wherein said outer casing has a plurality of pairs of corresponding grooves which are spaced a predetermined distance from each other, where each of said respective pairs of grooves are spaced from each other by a distance to accommodate said rotatable collar and use a retaining structure in each of said grooves to secure said rotatable collar in a fixed position on said outer casing, and

wherein each retaining structure is removable to allow for the changing of the position of said rotatable collar along a length of said outer casing.

6. A torch handle assembly for a cutting torch, comprising:

a torch handle body having an outer casing; and

a rotatable collar secured to said outer casing of said torch handle body,

wherein said outer casing has a first retaining structure positioned at an upstream end of said rotatable collar, and a second retaining structure positioned at a downstream end of said rotatable collar,

wherein said torch handle can rotate relative to said rotatable collar, and

wherein no structure is positioned between an inner surface of said rotatable collar and an outer surface of said outer casing of said torch handle.

7. The torch assembly of claim **6**, wherein each of said first and second retaining structures are comprised of a groove in the surface of said outer casing and a ring structure which is partially embedded in said groove such that said rotatable collar is positioned between each of said rings.

8. The torch assembly of claim **6**, wherein said rotating collar can rotate 360 degrees relative to said outer casing.

9. The torch assembly of claim **6**, wherein a gap between an inner surface of said rotatable collar and said outer casing has a maximum distance in the range of 0.0005 to 0.002 inches.

10. The torch assembly of claim **6**, wherein said outer casing has a plurality of pairs of corresponding grooves which are spaced a predetermined distance from each other, where each of said respective pairs of grooves are spaced from each other by a distance to accommodate said rotatable collar and use a retaining structure in each of said grooves to secure said rotatable collar in a fixed position on said outer casing, and

wherein each retaining structure is removable to allow for the changing of the position of said rotatable collar along a length of said outer casing.

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